

**Chapter 1, Ref 08 — Resin and Filter
Handbook - Primers and Product
Information**

RESIN / FILTER REFERENCES

Dow Chemical Resin Primers.....	002
Purolite Product Information.....	035
Pall Corporation Product Information.....	043
Diversified Technologies Products.....	045
Graver Technologies Products.....	075
Rohm and Hass Company Products.....	105
Siemens Products.....	130

DOW Chemical

Resin Primers

Fundamentals of Ion Exchange.....	003
Guide to Condensate Polishing.....	012

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Ion Exchange Resins

Fundamentals of Ion Exchange

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Fundamentals of Ion Exchange

Ion exchange is the reversible interchange of ions between a solid (ion exchange material) and a liquid in which there is no permanent change in the structure of the solid. Ion exchange is used in water treatment and also provides a method of separation in many non-water processes. It has special utility in chemical synthesis, medical research, food processing, mining, agriculture and a variety of other areas.

The utility of ion exchange rests with the ability to use and reuse the ion exchange material. For example, in water softening:

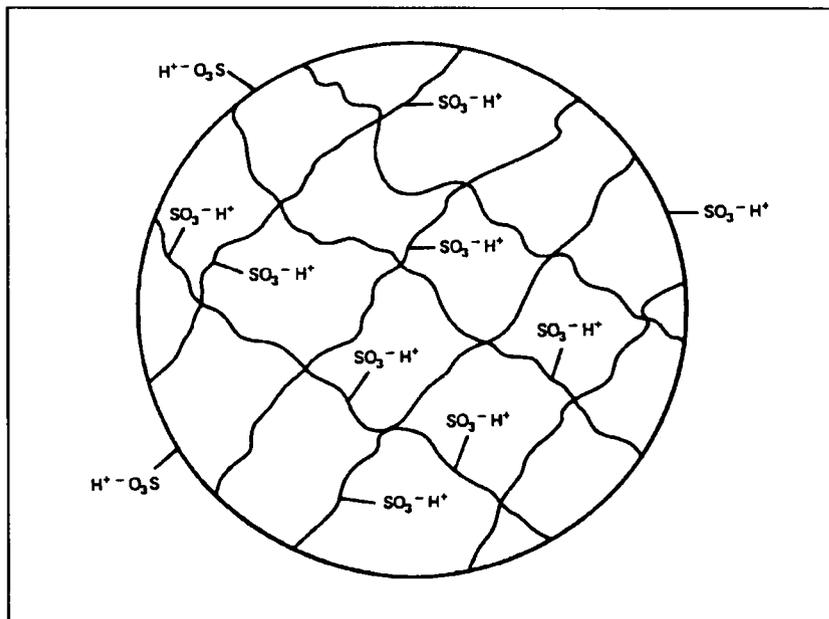


The exchanger \bar{R} in the sodium ion form is able to exchange for calcium and thus, to remove calcium from hard water and replace it with an equivalent quantity of sodium. Subsequently, the calcium loaded resin may be treated with a sodium chloride solution, regenerating it back to the sodium form, so that it is ready for another cycle of operation. The regeneration reaction is reversible; the ion exchanger is not permanently changed. Millions of liters of water may be softened per cubic meter of resin during an operating period of many years.

Ion exchange occurs in a variety of substances and it has been used on an industrial basis since circa 1910 with the introduction of water softening using natural and later, synthetic zeolites. Sulfonated coal, developed for industrial water treatment, was the first ion exchange material that was stable at low pH. The introduction of synthetic organic ion exchange resins in 1935 resulted from the synthesis^[1] of phenolic condensation products containing either sulfonic or amine groups which could be used for the reversible exchange of cations or anions.

A variety of functional groups have been added to the condensation or addition polymers used as the backbone structures. Porosity and particle size have been controlled by

Figure 1. Cation Exchange Resin Schematic Showing Negatively Charged Matrix and Exchangeable Positive Ions



conditions of polymerization and uniform particle size manufacturing technology. Physical and chemical stability have been modified and improved. As a result of these advances, the inorganic exchangers (mineral, greensand and zeolites) have been almost completely displaced by the resinous types except for some analytical and specialized applications. Synthetic zeolites are still used as molecular sieves.

Physical Properties of Resins

Conventional ion exchange resins consist of a cross-linked polymer matrix with a relatively uniform distribution of ion-active sites throughout the structure. A cation exchange resin with a negatively charged matrix and exchangeable positive ions (cations) is shown in Figure 1. Ion exchange materials are sold as spheres or sometimes granules with a specific size and uniformity to meet the needs of a particular application. The majority are prepared in spherical (bead) form,

either as conventional resin with a polydispersed particle size distribution from about 0.3 mm to 1.2 mm (50-16 mesh) or as uniform particle sized (UPS) resin with all beads in a narrow particle size range. In the water-swollen state, ion exchange resins typically show a specific gravity of 1.1-1.5. The bulk density as installed in a column includes a normal 35-40 percent voids volume for a spherical product. Bulk densities in the range of 560-960 g/l (35-60 lb/ft³) are typical for wet resinous products.

Chemical Properties of Resins

Capacity. Ion exchange capacity may be expressed in a number of ways. Total capacity, i.e., the total number of sites available for exchange, is normally determined after converting the resin by chemical regeneration techniques to a given ionic form. The ion is then chemically removed from a measured quantity of the resin and quantitatively determined in solution by conventional analytical methods. Total capacity is expressed on a dry weight, wet weight or wet volume

Figure 2. Total Capacity vs. Cross-Linkage (Percent DVB) Polystyrene Sulfonic Acid Resin, H⁺ Form

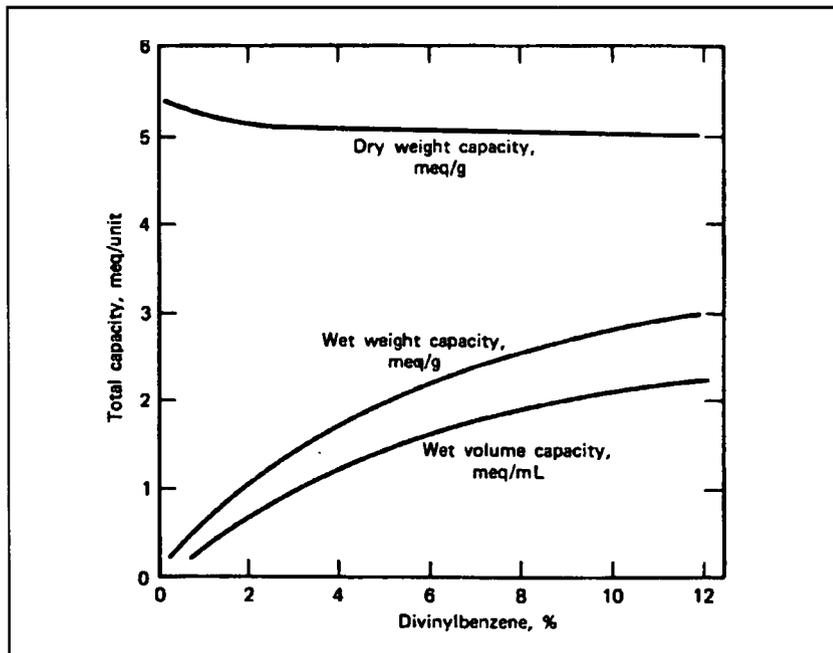
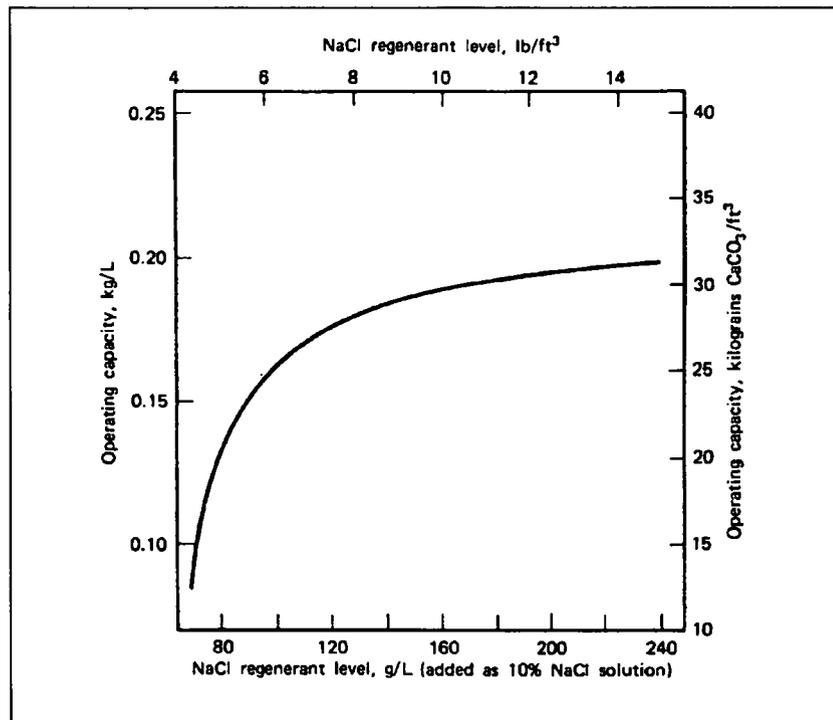


Figure 3. Operating Capacity vs. Regenerant Level for Sodium-Cycle Operation, Sulfonic Acid Resin

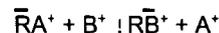


basis. The water uptake of a resin and therefore its wet weight and wet volume capacities are dependent on the nature of the polymer backbone as well as on the environment in which the sample is placed. Variations of dry weight and wet volume capacities with cross-linkage are shown in Figure 2 for a sulfonic resin.

Operating capacity is a measure of the useful performance obtained with the ion exchange material when it is operating in a column under a prescribed set of conditions. It is dependent on a number of factors including the inherent (total) capacity of the resin, the level of regeneration, the composition of solution treated, the flow rates through the column, temperature, particle size and distribution. An example is shown in Figure 3 for the case of water softening with a standard sulfonic resin at several regenerant levels.

Swelling. Water swelling of an ion exchanger is primarily a hydration of the fixed ionic groups and increases with an increase in capacity to the limits imposed by the polymer network. Resin volumes change with conversion to ionic forms of differing degrees of hydration; thus, for a cation exchanger, there is a volume change with the monovalent ion species, $Li^+ > Na^+ > K^+ > Cs^+ > Ag^+$. With polyvalent ions, hydration is reduced by the cross-linking action; therefore, $Na^+ > Ca^{2+} > Al^{3+}$. In more concentrated solutions, less water is taken up owing to greater osmotic pressure.

Selectivity. Ion exchange reactions are reversible. By contacting a resin with an excess of electrolyte (B^+ in the following reaction), the resin can be converted entirely to the desired salt form:



However, with a limited quantity of B^+ in batch contact, a reproducible equilibrium is established which is dependent on the proportions of A^+ and B^+ and on the selectivity of the

resin. The selectivity coefficient, K_A^B , for this reaction is given by:

$$K_A^B = \frac{\bar{m}_B \cdot m_A}{\bar{m}_A \cdot m_B}$$

where m and \bar{m} refer to ionic concentrations in solution and resin phase, respectively. Resin selectivity coefficients have been determined for a range of ionic species and related to H^+ for cations and OH^- for anions, which are assigned selectivity values of 1.00.

Kinetics. The speed with which ion exchange takes place. The ion exchange process involves diffusion through the film of solution that is in close contact with the resins and diffusion within the resin particle. Film diffusion is rate-controlling at low concentrations and particle diffusion is rate-controlling at high concentrations. Whether film diffusion or particle diffusion is the rate-controlling mechanism, the particle size of the resin also is a determining factor. Uniform particle sized resins exhibit enhanced kinetic performance compared to conventional polydispersed resins due to the absence of kinetically slow larger beads.

Stability. Strong oxidizing agents, such as nitric or chromic acid, rapidly degrade ion exchange resins. Slower degradation with oxygen and chlorine may be induced catalytically. For this reason, certain metal ions, for example, iron, manganese and copper, should be minimized in an oxidizing solution. With cation exchangers, attack is principally on the polymer backbone. Highly cross-

linked cation resins have an extended useful life because of the great number of sites that must be attacked before swelling reduces the useful volume based capacity and produces unacceptable physical properties, for example, crush strength reduction and pressure drop increase. With anion exchangers, attack first occurs on the more susceptible functional groups, leading to loss of total capacity and/or conversion of strong base to weak base capacity.

The limits of thermal stability are imposed by the strength of the carbon-nitrogen bond in the case of anion resins. This strength is sensitive to pH and low pH enhances stability. A temperature limitation of $60^\circ C$ ($140^\circ F$) is recommended for hydroxide cycle operations. Cation resin stability also is dependent on pH; the stability to hydrolysis of the carbon-sulfur bond diminishes with a lowering of pH. They are much more stable than anions however and can be operated up to $150^\circ C$ ($300^\circ F$).

Resin Structure and Manufacture

The manufacture of ion exchange resins involves the preparation of a cross-linked bead copolymer followed by sulfonation in the case of strong acid cation resins, or chloromethylation and the amination of the copolymer for anion resins.

Cation Exchange Resins. Weak acid cation exchange resins are based primarily on acrylic or methacrylic acid that has been cross-linked with a di-functional monomer

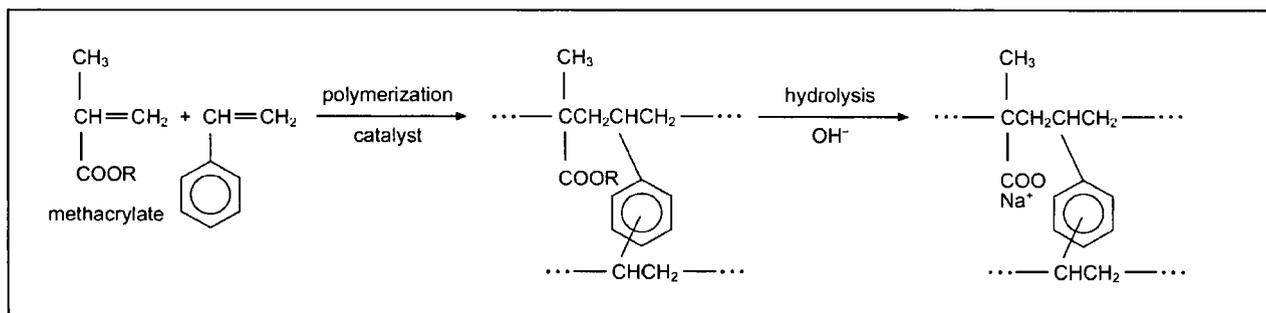
(usually divinylbenzene [DVB]). The manufacturing process may start with the ester of the acid in suspension polymerization followed by hydrolysis of the resulting product to produce the functional acid group.

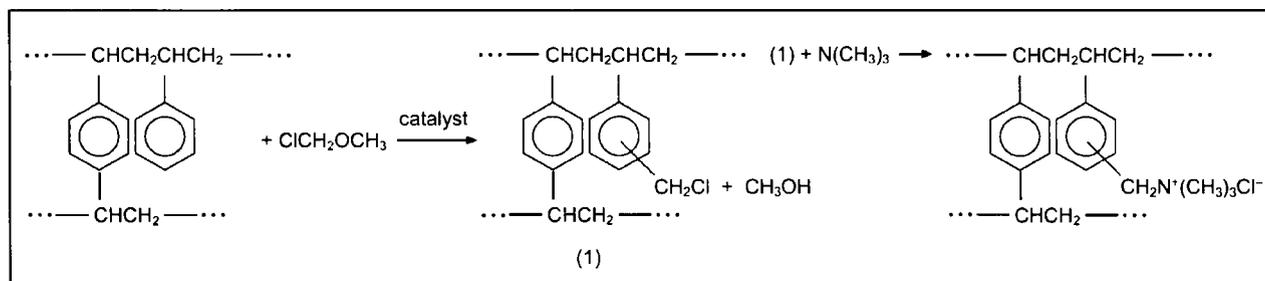
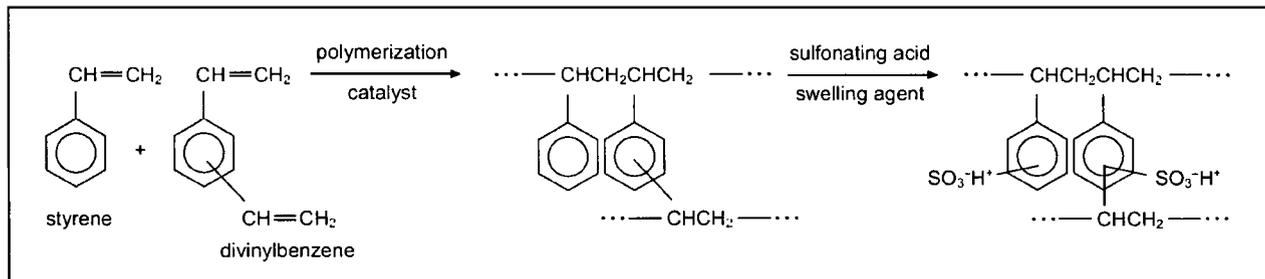
Weak acid resins have a high affinity for the hydrogen ion and are therefore easily regenerated with strong acids. The acid-regenerated resin exhibits a high capacity for the alkaline earth metals associated with alkalinity and a more limited capacity for the alkali metals with alkalinity. No significant salt splitting occurs with neutral salts. However, when the resin is not protonated (e.g., if it has been neutralized with sodium hydroxide), softening can be performed, even in the presence of a high salt background.

Strong acid resins are sulfonated copolymers of styrene and DVB. These materials are characterized by their ability to exchange cations or split neutral salts and are useful across the entire pH range.

Anion Exchange Resins. Weak base resins do not contain exchangeable ionic sites and function as acid adsorbers. These resins are capable of sorbing strong acids with a high capacity and are readily regenerated with caustic. They are therefore particularly effective when used in combination with a strong base anion by providing an overall high operating capacity and regeneration efficiency.

Strong base anion resins are classed as Type 1 and Type 2. Type 1 is a





quaternized amine product made by the reaction of trimethylamine with the copolymer after chloromethylation. The Type 1 functional group is the most strongly basic functional group available and has the greatest affinity for the weak acids such as silicic acid and carbonic acid, that are commonly present during a water demineralization process. However, the efficiency of regeneration of the resin to the hydroxide form is somewhat lower, particularly when the resin is exhausted with monovalent anions, such as chloride and nitrate. The regeneration efficiency of a Type 2 resin is considerably greater than that of Type 1. Type 2 functionality is obtained by the reaction of the styrene-DVB copolymer with dimethylethanolamine. This quaternary amine has lower basicity than that of the Type 1 resin, yet it is high enough to remove the weak acid anions for most applications. The chemical stability of the Type 2 resins is not as good as that of the Type 1 resins, the Type 1 resins being favored for high temperature applications.

Other Functional Groups. Ion exchange resins with special functional groups have been made for specific applications. Of interest to the hydrometallurgical industry are a variety of resins having chelating ability and which are particularly applicable for the selective exchange of various heavy metals from alkaline earth and alkali metal solutions^[2].

Polymer Matrix. The structure and porosity of an ion exchange resin are determined principally by the conditions of polymerization of the backbone polymer. Porosity determines the size of the species, molecule or ion, that may enter a specific structure and its rate of diffusion and exchange. There also is a strong interrelationship between the equilibrium properties of swelling and ionic selectivity.

For example, a conventional gel type, styrenic ion exchanger is built on a matrix prepared by co-polymerizing styrene and DVB. In these systems, porosity is inversely related to the DVB cross-linking. Gel resins exhibit microporosity with pore volumes typically up to 10 or 15 Ångstroms.

Macroporous (macroreticular) ion exchange resins have pores of a considerably larger size than those of the gel type resins with pore diameters up to several hundred Ångstroms. Their surface area may reach 500 m²/g or higher. Macroporous polymers are generally highly cross-linked and therefore exhibit little volume change (swelling). Because of the high cross-linkage in the matrix, the apparent oxidation stability of macroporous resins is improved. However, at similar cross-linkages, macroporous resins have greater exposure to potential oxidants than gel resins due to their greater porosity and surface area.

Poorer regeneration efficiencies, lower capacities and higher regeneration costs are the penalties paid for the use of the macroporous resins. Macroporous resins may be used as catalysts, particularly in non-polar media where gel resins do not perform satisfactorily because of their inaccessibility to the reactants.

Ion Exchange Regeneration Technologies

Ion exchange regeneration technology has developed over the years from the early co-flow regenerated systems to counter-flow block systems and through to packed bed technology, including the Dow UPCORE[®] process. Counter-current regeneration systems have reduced chemical costs, improved water quality and less waste volumes compared to traditional co-flow regenerated systems. They are also more productive, utilizing smaller vessels, faster regenerations and fewer mechanical failures.

Co-Current Regeneration System. This is the simplest system where a resin is regenerated in the same direction as the service flow (downwards). The vessel has a large freeboard to allow expansion of the resin bed when backwashing is

carried out to remove suspended solids and resin fines.

Counter-Current Regeneration Systems. In these systems, the regenerant is applied in the opposite direction to the service flow. This has the advantage of providing better water quality (lower ionic leakage), higher chemical efficiency and reduced waste water. In order to obtain low leakage levels from a counter-flow regenerated resin system, the contaminating ions must be kept from the effluent end of the column during re-generation and rinse. This requires avoidance of conditions that would disrupt the resin bed configuration. Backwash frequency also must be minimized.

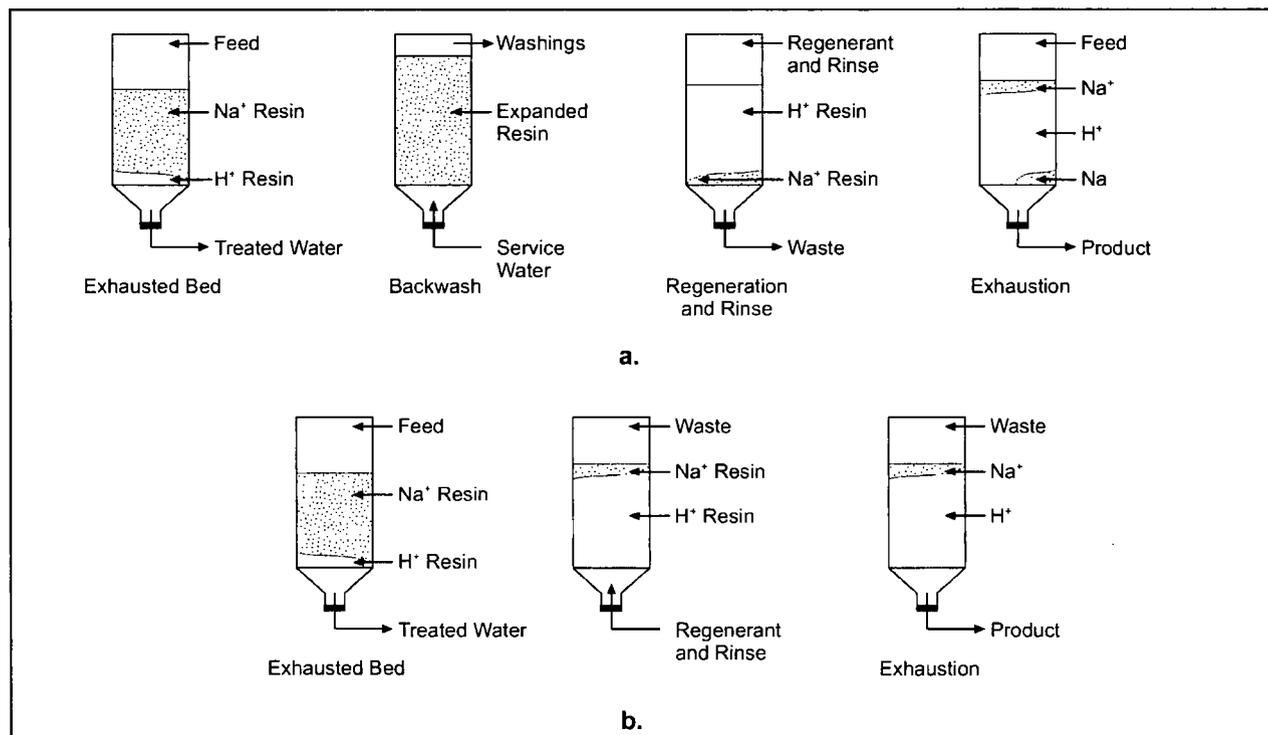
The difference between ion leakage for co-current and counter-current regeneration is illustrated in Figure 4. Re-exchange of the contaminating Na⁺ ion occurs from the base of the co-flow regenerated bed when the

incoming salt solution (feed) is converted to the corresponding dilute acid. When this acid solution contacts the sodium ion, re-exchange of hydrogen ions for sodium ions occurs and the sodium ions exit the column as leakage (Figure 4a). Leakage in counter-flow regeneration is substantially reduced as the resin bed is predominantly in the regenerated form at the bottom of the vessel (Figure 4b).

There are two main types of counter-current systems:

Blocked Systems. This includes air hold down, water hold down and inert mass blocked. The service flow is downwards and regeneration upflow. To avoid disturbance of the resin polishing zone at the bottom of the vessel, the resin bed is held down (blocked) during regeneration by air pressure, water flow or an inert mass in the top part of the vessel. The regenerant passes up through the

Figure 4. Ion Leakage: a. Co-flow and b. Counterflow Regenerated Fixed-Bed Column Contractors (H⁺ Form Cation Resin; Na⁺ Removal)



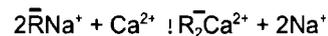
resin and out of a collector system in the middle part of the vessel.

Packed Bed Systems. These may be up-flow service with down-flow regeneration or down-flow service with up-flow regeneration, such as the Dow UPCORE system.

Semi-Continuous and Continuous. Semi-continuous and continuous contactors operate as intermittently moving packed beds as typified by the Higgins contactor^[3] or as fluidized staged (compartmented) columns such as the Himsley contactor^[4-6]. Flow is counter-current and their use is in increased resin utilization and high chemical efficiency. Commercial installations include those for phosphoric pickle acid recovery, water softening and ammonium nitrate recovery.

Resin Applications

Water Softening. Water softening accounts for the major tonnage of resin sales. Hard waters, which contain principally calcium and magnesium ions, cause scale in power plant boilers, water pipes and domestic cooking utensils. Hard waters also cause soap precipitation which forms an undesirable gray curd and a waste of soap. Water softening involves the interchange of hardness for sodium on the resin. Typically, hard water is passed through a bed of a sodium cation exchange resin and is softened.



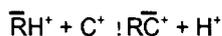
Regeneration of the exchanger involves the passage of a fairly concentrated (8-12 percent) solution of sodium chloride through the resin.

$$\bar{R}_2Ca^{2+} + 2Na^+ \rightarrow 2\bar{R}Na^+ + Ca^{2+}$$

Dealkalization. Many industrial processes require that hardness and alkalinity be removed from a raw water before the water is used in the process. Two main processes involving ion exchange are used for dealkalizing:

1. Dissolved solids are removed to the extent of the alkalinity in the raw water by passing the raw water through a bed of weak acid cation resin in the hydrogen form. The 100 percent utilization of regenerant acid that is characteristic of this process decreases operating costs and greatly minimizes the waste disposal problem. A weak acid cation resin creates no free mineral acidity in the effluent when regenerated at a level of not more than 105-110 percent of the theoretically required amounts for the cations picked up.
2. Chloride anion dealkalizing involves passing the raw water through a Type 2 anion exchange resin that is in the chloride form to remove alkalinity.

Deminerlization. Ion exchange deminerlization^[7] is a two step process involving treatment with both cation and anion exchange resins. Water is passed first through a column of strong acid cation exchange resin that is in the hydrogen form ($\bar{R}H^+$) to exchange the cation in solution for hydrogen ions:



where C^+ represents common cations, for example, Ca^{2+} , Mg^{2+} and Na^+ . This effluent is passed to a column of anion exchange resin in the hydroxide form ($\bar{R}OH^-$) to replace anions in solutions with hydroxide:



where A^- represents common anions, for example, Cl^- , SO_4^{2-} and NO_3^- . The hydrogen ions from the cation resin neutralize the hydroxide ions from the anion resin:



The net effect is the removal of electrolytes and a yield of purified water.

Alternatively, the impure water may be passed through an intimately mixed bed of cation and anion

exchange resins where both types of exchange occur simultaneously:



The choice of the ion exchange system for deminerlization depends on the water quality desired, operating and capital economics and composition of the raw water.

Condensate Polishing. Single or mixed bed ion exchange resins are used in deep bed filter deminerlizers for reduction of particulate matter and dissolved contaminants in utility power plant condensates.

Ultra Pure Water. Ultra pure water (UPW) is essential to the proper fabrication of integrated circuit boards in the semiconductor industry. As the degree of integration becomes increasingly more complex, the semiconductor industry requires higher levels of water purity. Single beds, mixed beds and also reverse osmosis are used in the production of ultra pure water.

Nitrate Removal. Ion exchange is used for the removal of nitrates from nitrate polluted waters^[8]. Strong base anion exchange resins operating in the chloride ion form (salt solution regenerated) have been successfully used for this service.

Waste Treatment. Radioactive. Radiation waste systems in nuclear power plants include ion exchange systems for the removal of trace quantities of radioactive nuclides from water that will be released to the environment. The primary resin system used is the mixed bed.

Chemical Processing – Catalysis. Since ion exchange resins are solid, insoluble (but reactive) acids, bases, or salts, they may replace alkalis, acids and metal ion catalysts in hydrolysis, inversion, esterification, hydration or dehydration, polymerization, hydroxylation and epoxidation reactions. The advantages of ion exchange resins as catalysts include easy separation from the products of reaction,

repeated reuse, reduction of side reactions and lack of need for special alloys or lining of equipment.

Purification. Purification by ion exchange is used to remove contaminating acids, alkalis, salts or mixtures from non-ionized or slightly ionized organic or in-organic substances. Examples include formic acid removal from 50 percent formaldehyde solutions, removal of amines from methanol, removal of iron from steel pickling operations, purification of aluminum bright dip baths and removal of iron in the purification of hydrochloric acid^[9].

Metal Extraction, Separation and Concentration. In aqueous or solvent mixtures containing large amounts of contaminants and small amounts of a desired solute, ion exchange resins can be used to selectively isolate and concentrate the desired solute, for example, the recovery of uranium from sulfuric acid leach solution with strong base anion resins. Other specific chelating resins can be used for metals recovery such as copper, nickel, cobalt and precious metals.

Desiccation. Ion exchange resins, particularly strong acid cation exchange resins in the dry state, are useful as desiccants^[10]. Ion exchange resins show their greatest capability as desiccants in the drying of hydrophobic solvents, for example, hydrocarbons and chlorinated hydrocarbons.

Sugar Separations and Purifications. Ion exchange resins are used as an integral part of corn syrup, high-fructose corn syrup (HFCS) processing and other starch based syrups. In sucrose processing, the resins are often used for softening feed streams, recovering sugar from molasses streams, or decolorization. They are also used in the production of non-nutritive sweeteners such as sorbitol or mannitol. Resins and adsorbents are used in four major unit processes in corn sweetener processing: deashing, chromatographic separation of

glucose and fructose, mixed bed polishing and color removal. In deashing, a bed of strong acid cation resin is typically followed by a bed of weak base anion resin. The resins used are macroporous, as their large porous structure allows syrup components to move freely into the bead.

Chromatographic Separation. Chromatographic separation is a manufacturing process using ion exchange resins to separate one dissolved component from another. It is applied in the sugar industry for the purification of compounds such as sucrose, glucose, fructose, oligosaccharides, sorbitol and mannitol. It can be used to separate salt from glycerol and in purifying amino acids and various organic acids. Most industrial chromatography today utilizes simulated moving bed (SMB) technology to minimize solvent use, leading to a significantly reduced cost of operation when compared to traditional batch chromatography.

Pharmaceuticals and Fermentation. Ion exchange resins are useful as carriers for medicinal materials and in slow release applications. In some cases, the ion exchange resin has the medicinal affect desired, for example, Cholestyramine, a dried and ground strong base anion resin used to bind bile acids for reducing blood cholesterol. Ion exchange resins also are used in a variety of fermentation and biotechnology processes, such as the isolation and purification of lysine, streptomycin and neomycin and other similar antibiotics.

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¹ Toll-free telephone number for the following countries: Belgium, Denmark, Finland, France, Germany, Ireland, Italy, The Netherlands, Norway, Spain, Sweden, Switzerland, and The United Kingdom

WARNING: 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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**Dow
Liquid Separations**

**DOWEX
Ion Exchange Resin**

Guide to Condensate Polishing

May 2003

Table of Contents

An Introduction to Condensate Polishing	
Condensate Polishing—A Preventative Approach	3
The Role of Ion Exchange in Condensate Polishing	3
The Purpose of This Guide	4
The Type of Condensate Polishing Operation Depends on the Operating Parameters	
Boiler Pressure	4
Condensate Polishing Systems Currently Used or Proposed for Operation	
Cation Exchange—“Condensate Scavenging”	5
Cation/Anion Mixed Bed	5
Lead Cation Resin Followed by Mixed Bed of Strong Cation/Strong Anion Resins	7
Cation-Anion Stacked Bed (Tripol System)	7
Operating Cycle Options	
DOWEX* Resin Selections for Condensate Polishing	8
Hydrogen Cycle Operation	9
BWR Primary Cycle—Neutral pH Condensate	9
Hydrogen Cycle with All Volatile Treatment (AVT)	10
The Ammonia Cycle with All Volatile Treatment (AVT)	10
Morpholine, Ethanolamine and Other Alternative Amines	11
Use of Boric Acid in PWR Secondary Cycles for Intergranular Attack and Stress Corrosion Cracking Control	13
Factors Affecting Resin Performance	
Resin Characteristics (Cation and Anion)	13
Particle Size Uniformity	13
Particle Size Uniformity and Separability for Regeneration	15
Filtration	15
Capacity	15
Selectivity	15
Bead Integrity	16
Kinetics	16
Oxidative Stability	17
Rinse and Regeneration Efficiency	17
Color	17
Resins Specifications Can Help You Select the Right Resin	17
System Operating Considerations	
Temperature	18
Organics	18
Regeneration	18
Separation	18
Regenerants	20
Remixing Resin	20
System Operation	20
Dow Technical Backup	
References	
Figures	
Figure 1. Typical Steam Turbine Loop	3
Figure 2. Particulate Filtration in a Typical Cation/Anion Mixed Bed	5
Figure 3. Battery of Condensate Polishers	6
Figure 4. Typical External Regeneration System	6
Figure 5. Lead Cation Resin with Mixed Bed Condensate Polisher	7
Figure 6. Cation-Anion-Cation Stacked Bed	7
Figure 7. Effluent Iron from New Resin Beds vs. Control Resin Bed—Nine Mile Station Unit 2	9
Figure 8. Cation Resin Selectivity vs. Cross-Linkage	10
Figure 9. Resin Beads with Gaussian and Narrow Size Distributions	13
Figure 10. Condensate Polisher Performance—DOWEX MONOSPHERE* Resin— Simulated Condenser Seawater Leak Studies	14
Figure 11. Condensate Polisher Performance—DOWEX MONOSPHERE Resin— During Actual Condenser Leak	14
Figure 12. Sodium Ion Leakage Based on Equilibria with Hydrogen Ion	16
Figure 13. Chloride Ion Leakage Based on Equilibria with Hydroxide Ion	16
Figure 14. Anion Rinse Down Curves—DOWEX MONOSPHERE Resins vs. Gaussian Gel Resins	17
Figure 15. Terminal Settling Velocity Distributions and After-Backwash Column Profiles for Gaussian and Narrow Size Distribution Resins in Mixed Beds	19
Tables	
Table 1. EPRI Guidelines to Maximum Impurity Levels in PWR Steam Generator and BWR Reactor Water Systems	5
Table 2. Typical Bulk Properties (H ⁺ Form) for DOWEX Cation Exchange Resins	8
Table 3. Typical Bulk Properties (OH ⁻ Form) for DOWEX Anion Exchange Resins	8
Table 4. Typical Ratios of Cation to Anion Resin Used in Mixed Bed Condensate Polishing	8
Table 5. Results Summary for the Controlled Aging Studies (150° F/65° C) for Several Prototypes of the DOWEX MONOSPHERE 575C versus the DOWEX MONOSPHERE 650C Cation Resins	12

An Introduction to Condensate Polishing

Condensate Polishing – A Preventative Approach

Condensate polishing is an important part of water treatment for any utility or industrial power generating system. This includes power generating facilities using once-through steam generators (OTSG), critical and supercritical steam generators, nuclear-fueled boiling water reactors (BWR) and pressurized water reactors (PWR).

Figure 1 is a block diagram of a typical steam-condensate loop. As shown in this diagram, steam from the boiler passes through a series of turbines and expends most of its' energy. The low-pressure steam is then condensed in a heat exchanger system where it is recovered in hotwells and routed to storage tanks. This condensed water or "condensate" is then recycled to the boiler and converted back into steam. The continuous cycling or re-circulation of the steam and condensate is commonly referred to as the steam-condensate loop or steam-condensate cycle. Recovering and recycling the return condensate stream is an obvious way to significantly reduce the cost of operation.

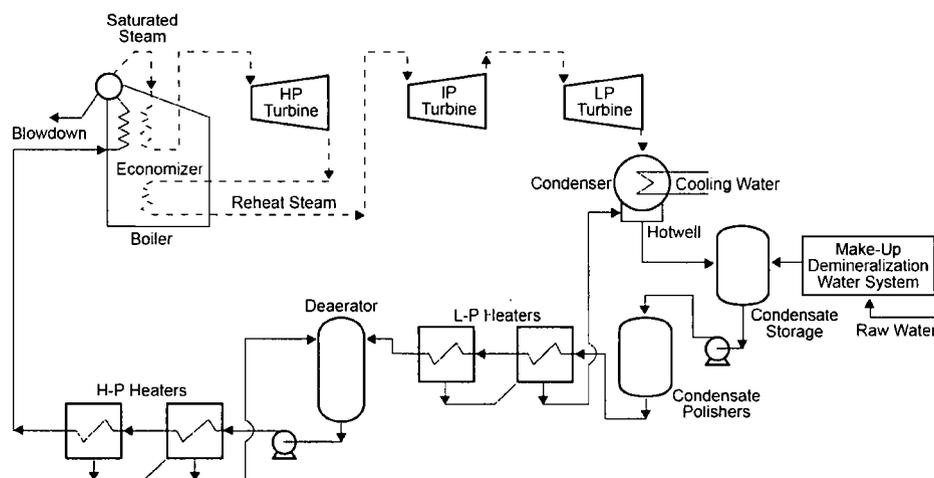
Within this cycle, some water is lost due to leaks and boiler blowdown, so a continuous make-up water source is required to maintain the total energy within the cycle. A local river, lake or well is used as the source for make-up water. In order to maintain a feedwater stream with a low level of dissolved solids the raw water is demineralized using ion exchange (IX) resins, reverse osmosis (RO) membranes or a combination thereof. In some cases, demineralization of the make-up water is accomplished via evaporation. Regardless of the technology, the operation is commonly referred to as the "make-up water demineralizer" system. In most cases, the make-up water is injected into the condenser hotwells or storage tanks.

The boiler make-up water is only one determinant of feedwater purity, the other being the condensate return stream. In fact, condensate purity is of greatest concern in high-pressure utility units, where condensate represents the bulk of boiler feedwater, making it the major potential source of contaminant introduction. To this end, purification or "polishing" of the return condensate is an essential ingredient to guarantee a high quality feedwater stream to the downstream boiler.

The Role of Ion Exchange in Condensate Polishing

The role of ion exchange technology is fundamental to condensate polishing. And condensate polishing is a unique application for ion exchange resins. Unlike treatment of make-up water, the condensate polishing system must deal principally with impurities that arise inside the steam system itself, rather than those that figure in the raw water analysis. These include a return condensate stream with a limitless inventory of impurities – solid, gel-like, and dissolved. These impurities originate from a host of sources, such as vacuum-induced leaks, corrosion of metal surfaces and careless repair work. Under normal conditions the raw condensate is considered high quality with respect to dissolved contaminants, however, corrosion products are picked up as the steam and condensed water pass through piping, heat exchangers and other associated equipment in the steam-condensate loop. A far more serious threat is the inleakage of dissolved contaminants that occurs when cooling water in the condenser system leaks into the condensate stream. For these reasons, condensate polishing is an operation that cannot be taken casually or ignored.

Figure 1. Typical Steam Turbine Loop



Another aspect of condensate polishing is high flow rate design, because full-flow polishing of the large flows of condensate may be necessary. In addition, water temperatures are often high and in some systems can approach the temperature limits of the resins.

The original designs for condensate polisher systems incorporated two approaches: 1) the use of deep beds of bead type ion exchange resins, and 2) the use of powdered ion exchange resin presented as a precoat on a filter element. A more recent development is the combination of a non-precoat filter system followed by a deep-bed ion exchange resin system. In all designs the purpose of the condensate polisher is twofold: removal of suspended solids by filtration and removal of dissolved solids by ion exchange.

For deep-bed systems the removal of suspended corrosion products occurs by in-depth filtration. This means the suspended particulates penetrate deep into the bed of the ion exchange beads instead of their accumulation on the top surface of the bed. The filtration capacity of a deep bed is increased via this mechanism. High flow rates and proper bead size are critical to obtain in-depth filtration. Part of the requirement of "condensate grade" resins include a specification on bead size distribution to balance the pressure drop and filtration characteristics with those of the surface area available for mass transfer and ion exchange kinetics.

Even under high flow rate conditions the dissolved ionic contaminants should be easily removed by deep-beds of ion exchange resins. Normally the mixed bed consists of cation resin initially in the hydrogen form and anion resin in the hydroxide form. In some cases, the cation resin is used in an amine form after an initial period in the hydrogen form. This provides a means of extending the service cycle run length and reducing the costs associated with regeneration. More discussion on this topic is provided in the section on "Operating Cycle Options".

Powdered resin precoat systems offer good filtration but are limited in their demineralization capacity since the resins volume are restricted by the available precoat depth on the septum filter. No additional information is presented in this publication for powdered resin systems.

The Purpose of This Guide

The primary emphasis in this publication is on the application of ion exchange resins to deep bed condensate polishing operations. Included are operating cycle options and a section on the factors that affect resin performance. Also presented are the various condensate polishing systems in use or under development and the types of steam generator systems most likely to use them.

The Type of Condensate Polishing Operation Depends on the Operating Parameters

Boiler Pressure

Low Pressure. At steam pressures below 600 psig (41 bar), condensate polishing is normally not required. In these low pressure systems, boiler feedwater is treated to prevent hard scale formation and corrosion in the boiler. Some type of chemical addition, such as phosphate addition, is used. Boiler water salts are kept from the steam cycle by control of the entrainment carryover and by boiler blowdown. Gross particulate filtration and decarbonation are also employed.

Medium Pressure. For boiler pressures of 600 to 2,400 psig (41 to 165 bar), control of silica, control of corrosion, and removal of particulate matter are required. Control of silica is necessary to prevent silica from volatilizing with the steam and depositing on the turbine blades. Makeup feedwater demineralization with an anion bed can control silica levels in the water if it cannot be controlled economically with boiler blowdown.

Depending on the feedwater composition and concentration, chemicals may be added to the boiler water to control corrosion. Phosphates are typically used, but all volatile treatment (AVT) may also be used. AVT uses ammonia or other volatile amines to adjust water pH and control corrosion. Condensate "scavenging" is often used to remove corrosion products from condensate returning from the turbine. Condensate scavenging uses a cation resin deep bed operated in the sodium or amine form to filter the particulate matter. This method also removes hardness ions.

While many systems in the 600 to 2,400 psig (41 to 165 bar) pressure range do not require condensate polishing, there are exceptions. For example, nuclear-fueled boiling water reactors (BWR) have historically been "zero solids" systems, even though the boilers used are typically in the range of 1,250 psi (86 bar). They have stringent feedwater quality requirements and full-time condensate polishing requirements. Neither AVT nor phosphate chemistry is practical in BWR primary systems since condensate circulating through the nuclear reactor has the potential for induced radioactivity.

High Pressure. As pressure increases beyond 2,450 psi (169 bar), water chemistry becomes “zero solids chemistry”. Demineralization of make-up water becomes mandatory to satisfy the water quality requirements of the major contaminant ions, such as sodium and silica. Chemical treatment of the boiler or steam generator system shifts from phosphate to AVT using ammonia or amines such as morpholine or monoethanolamine to elevate pH and control corrosion in the high temperature and wet-steam areas of the steam-condensate loop. The optimum pH range depends on the materials of construction; at least 9.3 for all-ferrous systems and 8.8-9.2 for systems containing copper. Full-flow condensate polishing is a critical operation for the removal of soluble and insoluble corrosion products, and for the removal of contaminant ions as a result of condenser leakage.

In North America, pressurized water reactor (PWR) plants using recirculating-type steam generators (RSG's) have focused their secondary cycle water chemistry program on the minimization of insoluble corrosion product transport and sodium-to-chloride molar ratio control in the tubesheet crevice areas of the steam generator. A shift to the use of organic amines (monoethanolamine in most cases) for pH control and procedural changes in the resin regeneration process have been instrumental in achieving the desired improvements in secondary cycle water chemistry. In addition to AVT chemistry, hydrazine is added to scavenge trace amounts of dissolved oxygen and maintain reducing conditions.

The Electric Power Research Institute (EPRI) continues to work closely with the utility industry to help define the water quality requirements for PWR secondary cycles and BWR primary cycles. Table 1 provides a summary of the year 2000 revision by EPRI for the recommended guidelines of the major contaminant ions in PWR steam generator and BWR reactor water systems. Recognize that the values shown in Table 1 represent the maximum allowable levels to satisfy Action Level 1 status. In actual practice, plant chemists are striving for less than 1 ppb concentration levels for all contaminant ions listed in Table 1. An understanding of the design and operational limitations of the deep-bed condensate polishing system becomes the most critical aspect of that effort.

Condensate Polishing Systems Currently Used or Proposed for Operation

Ion exchange resins can be used in a number of ways to treat condensate. Several of the most widely used approaches will be presented in some detail and the main features and limitations of each will be described.

Cation Exchange — “Condensate Scavenging”

Used mainly with industrial low- and medium-pressure boilers, a deep bed of a strong acid cation exchange resin operated in the sodium or amine form can act as a “condensate scavenger.” This type unit is primarily for the removal of corrosion products from the condensate. Insoluble particulate corrosion products are filtered in-depth on the resin bed and some hardness ions are interchanged with the cation on the resin. The choice of cation resin ionic form depends on the chemistry of the circulating water system.

Cation/Anion Mixed Bed

The most common ion exchange system used in condensate polishing is a mixed bed of strong acid cation exchange resin and strong base anion exchange resin. Mixed beds produce very high quality demineralized water, because ion leakage from either cation or anion resin is quickly removed from the water by the other resin. Deep-bed, in-depth filtration (see Figure 2) is accomplished by maintaining the flow rate high enough to keep surface filter cakes from forming. Typically, the flow velocity is about 50 gpm/ft² (120 meters/hr.). Using a bed depth of approximately 3 feet (1 meter) allows pressure drop across the bed to be maintained at economically acceptable levels. In most cases, a mixed bed condensate polishing system consists of several vessels operating in parallel (see Figure 3). Used resins are transferred to a separate system for cleanup and regeneration. In some cases, systems employ disposable mixed bed resins.

Table 1. EPRI Guidelines for Maximum Impurity Levels in PWR Steam Generator and BWR Reactor Water Systems

Parameter	Action Level 1 PWR Steam Generator	Action Level 1 BWR Reactor Water
Sodium	5 ppb	—
Chloride	10 ppb	5 ppb
Sulfate	10 ppb	5 ppb

Figure 2. Particulate Filtration in a Typical Cation/Anion Mixed Bed

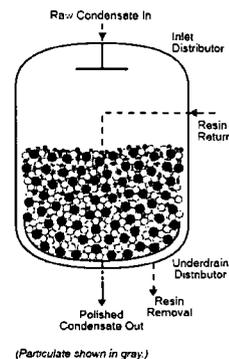
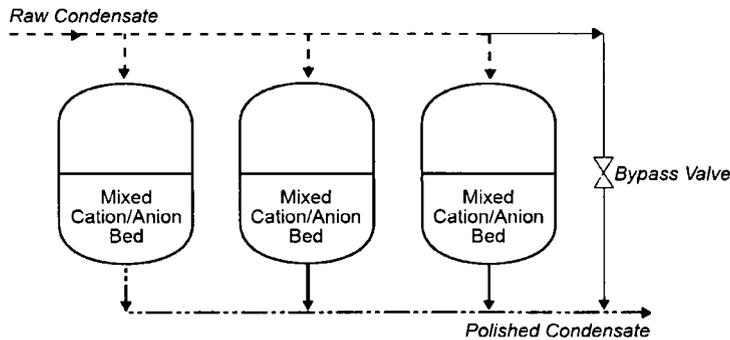


Figure 3. Battery of Condensate Polishers



External regeneration or regeneration of each resin outside of the condensate polishing vessel has proven to be the most practical approach. Isolation of the regenerant chemicals from the recirculating water loop significantly reduces the incidence of condensate contamination by regenerants. The amount of time that the polisher is offline is reduced, as well. In external regeneration, the only interruption in polisher service is for transfer of the used resin to the regeneration system and the introduction of newly regenerated resin to the condensate vessel. One regeneration system can service multiple condensate polisher vessels. A typical external regeneration system is shown in Figure 4. This is the most widely used system today in North America and requires these basic steps.

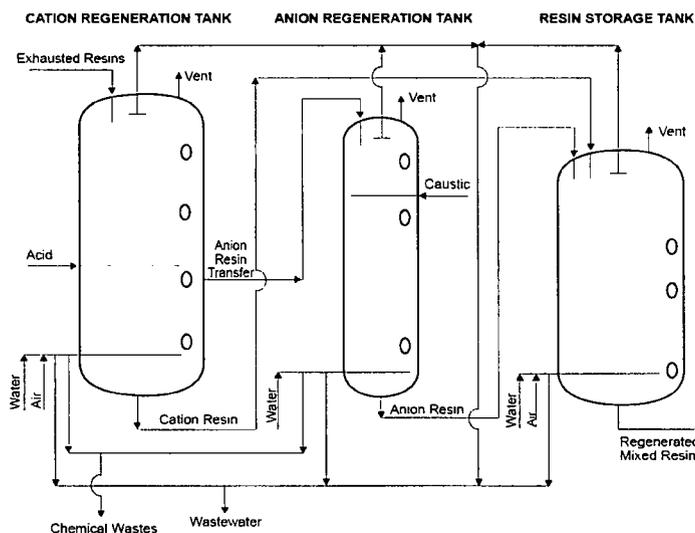
The used resins must be:

- (1) transferred completely from the operating vessel to the regeneration system;
- (2) cleaned to remove the particulate contaminants collected by filtration from the condensate;
- (3) separated as completely as possible for the regeneration;
- (4) regenerated independently with the appropriate chemical solution;
- (5) rinsed thoroughly with demineralized water;
- (6) remixed carefully;
- (7) transferred to the next available condensate polisher while exercising care to minimize resin separation.

To accomplish these steps, many types of resin transfer and separation systems have been developed over the years. Several systems and techniques will be discussed in a later section covering system design parameters.

A second approach, which eliminates resin separation, resin regeneration crossover, and regenerant quality problems, is the use of a disposable mixed bed. This approach requires the manufacture and shipment of very clean, and highly regenerated resins by the resin supplier. Disposable mixed bed systems are commonly used for condensate polishing in BWR's, where disposal costs of radioactive waste regenerants would be prohibitive.

Figure 4. Typical External Regeneration System



Lead Cation Resin Followed by Mixed Bed of Strong Cation/Strong Anion Resins

When AVT is used to control pH and corrosion in a steam-condensate cycle the amine will carry overhead and transport with the steam. Ultimately the amine-laden steam condenses thereby creating a condensate with amine levels ranging from 0.2 to 1 ppm depending on the plant chemistry program. When this condensate is processed through a condensate polisher the amine involved is readily exchanged onto the cation resin. Eventually, the cation resin becomes sufficiently exhausted to the amine form resulting in an amine breakthrough in the condensate polisher effluent stream. In most cases, the service cycle run time is terminated at the amine break and the polisher bed is taken off-line for resin regeneration back to the active (H/OH) form.

One suggested technique for increasing the run time on the mixed bed polisher is to treat the condensate with a hydrogen form cation resin to remove the amine prior to contact with the mixed bed (see Figure 5). By taking this amine load off the mixed bed, mixed bed run lengths can be extended to months. Corrosion products are also removed by the lead cation bed, eliminating solids contamination of the mixed bed. Regeneration of the lead cation can be done on a more frequent basis than the mixed bed, thereby reducing the difficulties of mixed bed regeneration.

Cation-Anion-Cation Stacked Bed (Tripol System)

This process uses a single tank with compartments to contain separate layers of cation, anion, and cation resins (see Figure 6). The resins are never mixed, with each resin going to its own external regeneration vessel. The lead cation resin is typically not run past the ammonia break in AVT systems. Leakage from the lead cation is polished in the trailing cation resin. Final water quality produced depends on the trailing cation resin regenerant rinse-down, and on the leachable characteristics of both cation resins.¹

Figure 5. Lead Cation Bed with Mixed Bed Condensate Polisher

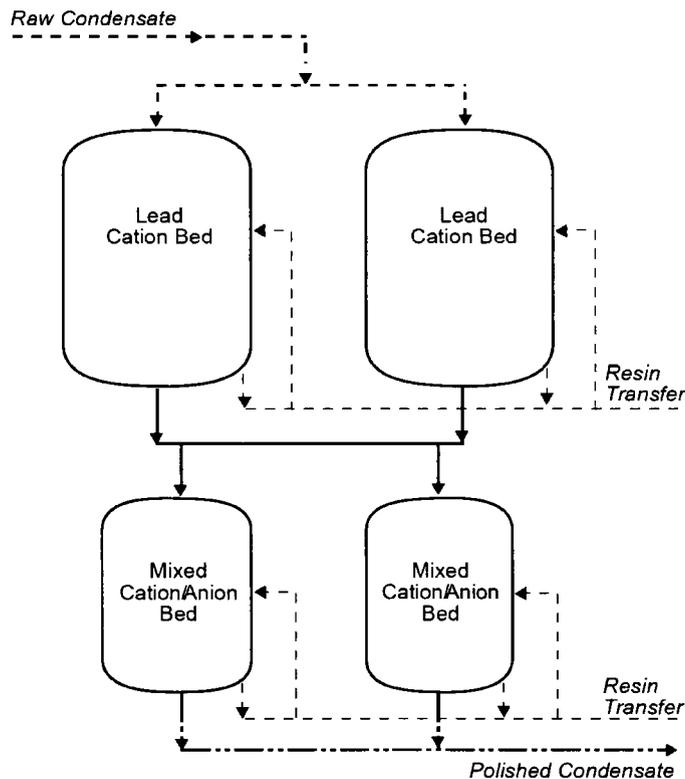
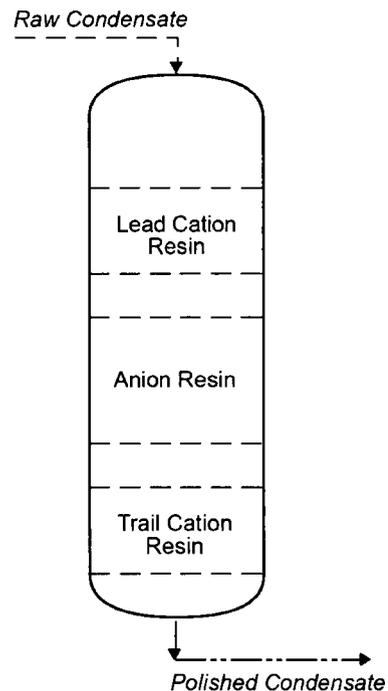


Figure 6. Cation-Anion Stacked Bed



Operating Cycle Options

DOWEX Resin Selections for Condensate Polishing

Tables 2 and 3 provide a listing of the DOWEX cation and anion exchange resins that are commercially available for use in condensate polishing. The best choice of resins will depend on the chemistry of the operating cycle and the design and operating characteristics of the specific plant. In some situations, there may be more than one choice and an actual field trial would be necessary to determine the best resin selection.

Table 2. Typical Bulk Properties (H⁺ Form) for DOWEX Cation Exchange Resins

	Resin	Copolymer Type	Total Exchange Capacity (eq/liter)	Water Retention Capacity (%)	Avg. Diameter (microns)
<i>Uniform Size Resins</i>	MONOSPHERE 575C	12% gel	2.15	41 – 46	550
	MONOSPHERE 650C	10% gel	2.0	46 – 51	650
	MONOSPHERE 750C	10% gel	1.9	46 – 51	750
	GUARDIAN* CR-1	8% gel	1.7	51 – 57	550
	MONOSPHERE MP-525C	20% macro	1.6	50 – 54	500
<i>Gaussian Size Resins</i>	HGR-W2	10% gel	2.0	47 – 51	750 – 850
	HCR-W2	8% gel	1.8	48 – 54	750 – 850
	MSC-1 C	20% macro	1.6	50 – 56	750 – 850

Table 3. Typical Bulk Properties (OH⁻ Form) for DOWEX Anion Exchange Resins

	Resin	Copolymer Type	Total Exchange Capacity (eq/liter)	Water Retention Capacity (%)	Avg. Diameter (microns)
<i>Uniform Size Resins</i>	MONOSPHERE 550A	gel	1.1	55 – 65	590
	MONOSPHERE 700A	gel	1.1	55 – 65	700
	MONOSPHERE MP-725A	macro	0.8	65 – 75	690
<i>Gaussian Size Resins</i>	SBR-C	gel	1.1	50 – 60	700 – 800
	SBR-P-C	gel	1.0	60 – 68	700 – 800
	MSA-1-C	macro	0.8	65 – 72	700 – 800

Table 4 gives examples of the different ratios of cation and anion resin used in condensate polishing applications. In some cases the ratio is based on volume, while in others it is based on a 1:1 (H/OH) ratio by equivalents. As indicated in Table 4, the ratio selection depends on the type of operating cycle and source of condenser cooling water.

Table 4. Typical Ratios of Cation to Anion Resin Used in Mixed Bed Condensate Polishing

Cation/Anion Ratio By Volume (H ⁺ /OH ⁻)	Cation/Anion Ratio By Equivalent (H ⁺ /OH ⁻)	Plant Type	Notes
2:1	1:1	Nuclear BWR	Hydrogen Cycle with Neutral pH Feed
1:1 or 2:3		Nuclear PWR/Fossil	Hydrogen Cycle with Elevated pH Feed
		Nuclear PWR	For plants with seawater or high TDS Cooling water source

Hydrogen Cycle Operation

Hydrogen cycle operation literally means the cation resin in the mixed bed always has some hydrogen exchange capacity – even at the endpoint that triggers the end of the service cycle. When cations, such as sodium, are exchanged onto the cation resin, hydrogen ions are released and acids are formed, i.e., HCl, etc. These acids are immediately exchanged onto the anion exchange resin in the mixed bed and hydroxide ions are released. The hydrogen and hydroxide ions combine to form water. The result: effluent water of exceptional quality.

BWR Primary Cycle – Neutral pH Condensate

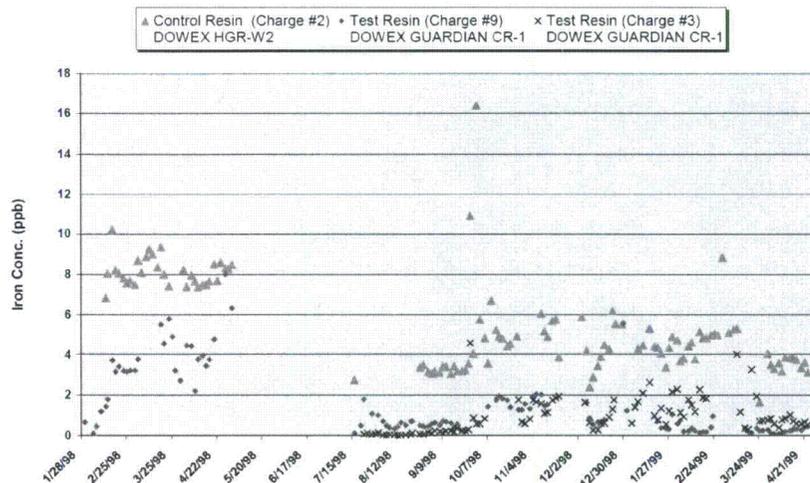
In BWR primary cycles the condensate is kept near neutral pH conditions. Because the quantities of insoluble corrosion products (crud) are much higher in relation to dissolved solids, the condensate polisher serves primarily as a filter for crud removal. The filtering ability of a deep-bed of cation and anion exchange resin is considerably greater than that of inert media, such as sand or coal, of the same particle size. This is due to the highly charged surface of the resin particle.

Under normal conditions, the low concentration of dissolved solids in the condensate results in very little exhaustion of the ion exchange resin. Despite this, thirty days is a typical service cycle run time of a BWR condensate polisher bed and after removal from service the resin is transferred to an external cleaning station. The cleaning method most common in North America employs ultrasonic energy. In an ultrasonic resin cleaner (URC) the resins pass downward through a tall, slender vessel having ultrasonic transducers on its wall. Energy input must be sufficient to break crud loose from the surfaces of the resin beads, but low enough to avoid bead breakage. Crud and resin fines are drawn off at the column top.

In general, the URC method enables polishers to reduce insoluble iron to about 2.5 to 3 ppb. Note that this falls short of the 0.5 to 1.5 ppb level now targeted by North American industry guidelines. A promising alternative system – the Advanced Resin Cleaning System (ARCS) – is a vibrating screen assembly for separating cleaned resin beads and fines from transfer and cleaning water. Recycle of the cleaning water minimizes wastewater generation. Results from a full-scale installation at a BWR station in the southeastern region of the United States indicate that ARCS, used consistently, can remove more insoluble iron from the resin resulting in an improvement in feed water iron to less than 1.5 ppb.²

Another area of development in BWR condensate polishing relates to a different design for the cation resin. Over a decade of Dow research has been dedicated to the manufacture of cation resin beads with enhanced crud removal capability. Activity continues in Japan and the U.S. for the evaluation of several lower cross-linked cation resins. The DOWEX GUARDIAN CR-1 is a commercially available cation resin product used in the U.S. BWR market because of its enhanced crud removal characteristics (see Table 2). The manufacturing process incorporates a proprietary technology to chemically “stabilize” this product. A full-scale field trial at a BWR station in the northeastern region of the United States began in January 1998. The trial³ clearly showed a significant improvement in iron removal capability compared to a conventional cation resin, such as DOWEX HGR-W2 (see Figure 7).

Figure 7. Effluent Iron Comparison from Field Trial at Nine Mile Station, Unit II



Hydrogen Cycle with All Volatile Treatment (AVT)

With AVT in the steam-condensate cycle, the load on the cation exchange resin is near a 1 ppm concentration level which under normal conditions is many orders of magnitude greater than the steady-state amount of contaminant ions, such as sodium, in the condensate return stream. The amine used in AVT exchanges onto the functional site of the cation exchange resin. When the service cycle run time is terminated at or before the onset of amine breakthrough, the operation of the condensate polisher is referred to as the "hydrogen cycle". Hydrogen cycle operation is necessary to prevent the occurrence of the sodium "spike". This spike occurs because residual sodium left on the cation resin after regeneration will be displaced from the resin by the amine. The concentration of sodium in the spike is a function of the amine type and its' concentration in the condensate, the amount of sodium on the cation resin, and the selectivity of the cation resin for the amine relative to the sodium.

In order to extend the service run time of the condensate polishers in hydrogen cycle operation, a resin volume ratio of 2:1 cation to anion resin has been employed. Extending the run time reduces the frequency of regeneration thereby reducing the costs associated with regeneration chemicals, manpower and waste disposal. If the TDS of the cooling water is high, as with seawater, an increase in the percentage of anion resin in the mixed bed may be necessary to provide more protection from influent anions (see Table 4).

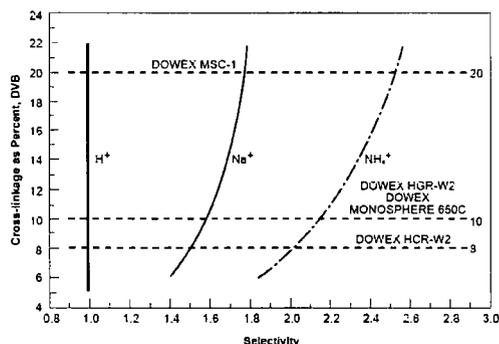
With hydrogen cycle operation the utilization of the cation resin is limited. A 1996 survey⁴ of PWR stations in North America indicated that only 45-65% of the cation resin converts to the amine form prior to the onset of amine breakthrough. A cation resin with higher capacity and smaller diameter is now available commercially as DOWEX MONOSPHERE 575C (see Table 2). The combination of greater surface area and density of exchange sites enables greater utilization of the fixed volume of cation resin.

The Ammonia Cycle with All Volatile Treatment (AVT)

Operating the polishers past the ammonia break is one way to reduce the operating costs in a system with AVT chemistry. When operating in the ammonia cycle, ion exchange shifts from H⁺/OH⁻ chemistry to NH₄⁺/OH⁻ chemistry. The cation resin, now in the ammonium form, exchanges ammonium ions for contaminating ions, such as sodium. Because this on-line ammoniation competes with the selectivity for sodium, it is essential to minimize the sodium residual on the cation resin during the regeneration cycle. This can be achieved with the proper choice of resin products and regeneration procedures. More discussion on this topic is provided in the section on "Factors Affecting Resin Performance." Some operations start with pre-ammoniated resins to eliminate step-change increases in sodium leakage. The drawback of this method is loss of hydrogen capacity as part of the total run length.

While increased run length and reduced regeneration costs are very attractive, there is a risk. Namely, the driving force for the uptake of contaminant ions is significantly reduced by virtue of hundredfold increases in the competing ion concentrations. For instance, in the ammonia cycle, the competing ion, NH₄⁺, is at a solution concentration near 10-5 equivalents per liter. In contrast, the competing ion, H⁺, in the hydrogen cycle is at a solution concentration of only 10⁻⁷ equivalents per liter. Consequently, sodium leakages will be much greater (as much as 100x) with ammonia cycle operation. Many stations that choose to operate in the ammonia cycle use a 20% cross-linked macroporous cation resin due to a belief that this resin offers a higher selectivity coefficient for sodium relative to ammonia. The literature⁵ contains data that states the resin's preference for one cation over another is a function of the degree of cross-linkage within the resin matrix. Figure 8 shows this data as the relationship between the cross-linkage and ion selectivity. However, as shown in this figure, the selectivity for sodium relative to ammonia is about 0.71 to 0.72 for both the 20% macroporous and the 10% gel cation resins. Suffice to say, a lot more work is still required to truly understand the selectivity properties in multi-component systems.

Figure 8. Cation Resin Selectivity vs. Cross-Linkage



Operating in the ammonia cycle also affects the operation of the anion exchange resin. In the presence of the ammonium ion, dissolved carbon dioxide ionizes to form the carbonate ion. Carbonate is a divalent ion, and consequently it is much more selectively held by the anion resin in dilute solutions of monovalent ions (i.e., service cycle where the OH⁻ ion is at a solution concentration near 10⁻⁵ equivalents per liter). As a result, the carbonate ion will selectively displace chloride and sulfate ions from the strong base functional sites of the anion resin.

The anion resin in a condensate polisher also serves to protect against silica contamination sourced from condenser inleakage and/or make-up water. But with operation in the ammonia cycle, the concentration of hydroxide ions is roughly 100 times greater than that in the hydrogen cycle. So the already low silica selectivity of the anion resin is further compounded by the high pH conditions. Consequently, silica leakages may be much greater with ammonia cycle operation.

The anion resin's selectivity for silica is also affected by temperature. At temperatures in excess of 120°F (49°C), silica leakage may increase due to lower selectivity. At temperatures above 140°F (60°C), silica can hydrolyze from the resin, leaving little, if any, effective capacity for silica. Any of these conditions may dictate a condensate polisher design with a higher percentage of anion resin.

Aging is another consideration of anion exchange resin, particularly with respect to surface kinetics, and therefore, leakage of sulfate ions. The deterioration of strong base anion exchange resin usually results in the formation of some weak base functionality. Weak base sites are kinetically slower than strong base sites. If sulfuric acid comes in contact with the anion resin due to cross-contamination during the regeneration, then the anion resin is converted to the bisulfate form. In the subsequent rinse steps, sulfuric acid can be hydrolyzed from either two adjacent bisulfate ions or from the weak base sites of the resin, resulting in increased sulfate leakage. In addition, the accumulation of any of the variety of aromatic-based organic species on the anion resin surfaces can eventually impact the resins' surface kinetic properties. This phenomenon, too, will cause impaired performance of the anion resin during rinse-down operations, not to mention the ability to manage condenser inleakage situations.

Morpholine, Ethanolamine and Other Alternative Amines

The preferred amine for pH control, formerly ammonia, depends on the system – component materials, use of condensate polisher, etc – as well as steam-turbine design features. The amines protect the metal surfaces by disassociation to form OH⁻ ions, which then neutralize feed water acids. For a wider pH control over all parts of the cycle, many PWR stations have switched to using organic amines, such as morpholine or monoethanolamine. With lower volatility compared to ammonia, organic amines have a greater preference for water than for steam in a two-phase fluid. Consequently, organic amines yield higher pH and provide greater protection for extraction lines, heater shells and other wet-steam regions where flow-accelerated corrosion (FAC) is likely to occur.

Morpholine has been used with very good success in nuclear plants and in some industrial boiler applications without condensate polishing. Improvement in corrosion protection throughout the steam-condensate circuit has been demonstrated in PWR stations in France and the United States by raising the pH by one unit. Data is available on the use of morpholine in systems using condensate polishers.⁶ Morpholine is exchanged onto a cation exchange resin in much the same manner, as is ammonia. The selectivity, which the cation resin exhibits for morpholine, in reference to the sodium ion, is still a subject of much debate. In work reported by Sadler, a 10% cross-linked cation gel resin had approximately equal selectivity for morpholine and sodium.⁷ In other EPRI workshops for condensate polishing it has been reported that cation resins with a 20% cross-linked macroporous structure have a much greater selectivity for sodium relative to morpholine compared to gel resins. However, other studies have provided data to indicate the sodium selectivity of a cation resin in a morpholine environment depends on many factors including the quantity of sodium on the cation resin and the presence of other cationic species, such as ammonia. One study⁸ in particular used pilot-size column experiments and a 10:1 equivalent ratio of morpholine to ammonia as the influent stream. Interestingly, the 10% gel cation resin performed equal to the 20% macroporous cation resin with respect to sodium breakthrough.

Despite this demonstrated superiority of morpholine over ammonia, even broader protection was deemed necessary. This situation was especially true of plants using deep-bed polishers, because of morpholine adsorption and exchange onto the cation resin. Today, the most popular amine selection for PWR stations in North America is monoethanolamine (ETA), adopted by some two dozen plants.

While ETA has provided enormous benefits in reducing the transport of corrosion products to steam generating and downstream components, some stations continue to experience difficulty in maintaining the desired secondary cycle chemistry under full-flow condensate polishing conditions. Although different stations appear to have different problems, a few common pitfalls exist. Following a chemical regeneration of the cation and anion resins, steam generator sulfate excursions and long, sluggish rinses of the anion resin have become more commonplace. The severity of these steam generator sulfate disturbances vary depending on the length of the pre-service rinse, the rate of flow velocity change when switching to the full-flow service condition, and other system related factors. Resin sampling and analysis from polisher systems at many PWR stations clearly show that long rinse time is symptomatic of anion resin with impaired surface kinetic properties. As a result, many PWR stations have moved to operating without the deep-bed polishers (100% by-pass), operating with a long, extended pre-service rinse, or have begun intentionally skipping the regeneration of their anion resin.

Even still, not all stations fell victim to resin performance difficulties following their switch to ethanolamine chemistry. In fact, a 1996 survey⁹ of all U.S. PWR stations indicated that the stations processing higher temperature condensate (>130°F, 54°C) were the ones that reported more of the resin performance problems. This finding prompted a research effort in accordance with EPRI to study the properties of DOWEX MONOSPHERE 650C resins under controlled laboratory conditions in separate environments of deionized water, ammonia and ethanolamine.¹⁰ Each resin system was sampled at regular intervals over a period of 12 weeks. TOC leachables from the cation resin and surface kinetic properties of the anion resin were the key parameters of interest. All experiments were controlled at 150°F (66°C) and kept under deoxygenated conditions. Several samples of the DOWEX MONOSPHERE 575C cation exchange resin were included in this study to measure the impact, if any, of a resin with higher cross-linkage. As shown in Table 5, the ethanolamine environment is clearly the most unfavorable resulting in the greatest impairment of anion surface kinetics and all the cation resins showing the highest degree of TOC leachable release. In comparing the two cation resin types, all prototype samples of the DOWEX MONOSPHERE 575C resin showed improved compatibility in both the ammonia and ethanolamine environments. Work is still in progress, however, to identify the root cause of premature impairment of anion resin kinetics for systems with ethanolamine chemistry and elevated condensate temperature.

Table 5. Results Summary for the Controlled Aging Studies (150°F/65°C) for Several Prototypes of the DOWEX MONOSPHERE 575C versus the DOWEX MONOSPHERE 650C Cation Resins

Resin designation	Aging time (weeks)	Cation resin ionic form	Net cation TOC (ppb)	Anion kinetic MTC (10^{-4} m/s)	Cation resin ionic form	Net cation TOC (ppb)	Anion kinetic MTC (10^{-4} m/s)	Cation resin ionic form	Net cation TOC (ppb)	Anion kinetic MTC (10^{-4} m/s)
DOWEX MONOSPHERE 650C	0	Hydrogen	0	2.14	Ammonium	0	2.14	Ethanolamine	0	2.14
	6	"	834	2.02	"	1,068	2.07	"	3,343	1.82
	9	"	1,236	2.03	"	1,494	2.02	"	7,309	1.58
	12	"	2,041	1.88	"	2,405	1.84	"	18,054	1.43
DOWEX MONOSPHERE 575C	0	Hydrogen	0	2.14	Ammonium	0	2.14	Ethanolamine	0	2.14
	6	"	785	2.09	"	925	2.09	"	2,386	1.95
	9	"	1,192	2.06	"	1,319	2.06	"	5,410	1.79
	12	"	1,905	2.01	"	2,118	1.92	"	13,191	1.64
DOWEX MONOSPHERE 575C	0	Hydrogen	0	2.14	Ammonium	0	2.14	Ethanolamine	0	2.14
	6	"	797	2.09	"	913	2.11	"	2,505	1.90
	9	"	1,206	2.06	"	1,310	1.99	"	5,423	1.71
	12	"	2,110	2.02	"	2,092	1.89	"	13,330	1.59
DOWEX MONOSPHERE 575C	0	Hydrogen	0	2.14	Ammonium	0	2.14	Ethanolamine	0	2.14
	6	"	745	2.03	"	972	2.00	"	2,795	1.92
	9	"	1,155	1.94	"	1,386	1.93	"	6,214	1.82
	12	"	1,892	1.92	"	2,190	1.85	"	15,160	1.63

Use of Boric Acid in PWR Secondary Cycles for Intergranular Attack and Stress Corrosion Cracking Control

Another key aspect of secondary-side chemistry optimization relates to corrosion within the steam generator. While significant progress has been made, degradation in performance of this costly component continues to limit secondary-cycle reliability. Specifically, incidents of intergranular attack (IGA) combined with stress corrosion cracking (SCC) continue to increase. Flow-restricted regions such as tube intersections with support plates and tubesheets are likely trouble spots. Crud transported to these crevice regions aggravates the problem by further constricting these narrow openings. This promotes concentration of impurities in these crevice regions and sets the stage for IGA. Under the right conditions – extreme local pH, disruption of the protective metal oxide film, etc. – SCC ensues.

Laboratory studies from several years back indicated that boric acid could help control IGA and/or SCC – possibly by neutralizing a caustic environment or reinforcing the oxide film. Although results have been modest, many plants have adopted this inhibitor by maintaining 5-10 ppb boron in the steam generator. With boric acid addition to the secondary cycle, the strong base anion resin seems to undergo partial conversion to the borate form. In general, the anion resin shows a relatively low selectivity for borate species, consequently, the borate break occurs early on in the service cycle. The breakthrough of boric acid creates acid pH conditions, and therefore, a larger driving force for sodium ion displacement. Figure 12 illustrates the dependence of sodium leakage on effluent pH.

Factors Affecting Resin Performance

The performance of an ion exchange resin in a particular system is strongly dependent on the inherent characteristics of the resin itself, the design parameters of the system within which it will operate, and on the manner in which the operation is controlled.

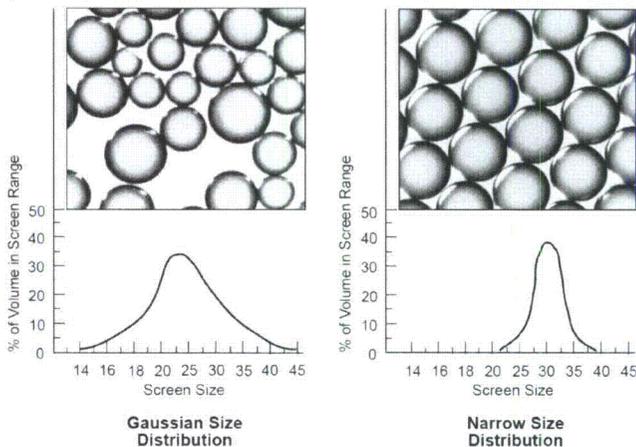
Resin Characteristics (Cation and Anion)

Resin characteristics having the most significant impact on performance in a condensate polisher include particle size and bead uniformity, ionic capacity and filtration, selectivity, bead integrity, kinetics, oxidative stability, rinse and regeneration efficiency, and color. These characteristics are to some degree interrelated and some overlap may occur in the description.

Particle Size Uniformity

Particle size uniformity affects a number of resin characteristics including the kinetics of reaction, the separability of one resin from another, and the pressure drop across the resin. The introduction of resins with a narrow bead size distribution has been shown to offer many advantages over Gaussian distribution resins. These advantages will be discussed in detail in later sections. Figure 9 illustrates the difference in the particle size distribution between the Gaussian and uniform bead types.

Figure 9. Resin Beads with Gaussian and Narrow Size Distributions



In high flow rate applications, the ability of ion exchange resins to remove ionic impurities to extremely low levels depends in part on kinetics. Kinetics are determined by both the rate at which ions are transported across the surface of the resin bead and the rate of diffusion of the ion into the resin particle.

At the very low ionic concentrations encountered in the condensate, the surface exchange rate and surface area become important. Since smaller beads have greater specific surface area, their kinetics are faster. In addition, by selecting resins with high bead size uniformity, the larger, kinetically slower beads are eliminated. Figures 10 and 11 illustrate the excellent kinetic behavior of uniformly sized resins during simulated and actual seawater condenser leaks at two utilities.

To simulate the effects of a seawater condenser leak, a fossil fuel facility injected a sulfate solution into the feedwater to their condensate polisher. The polisher contained uniformly sized resins. A solution containing 120 ppb sulfate was injected at two times during the service run, first toward the end of the hydrogen cycle and again toward the end of the ammonia cycle.

Figure 10 shows that the sulfate leakage remained very low when the system was operating in the hydrogen cycle due to the fast kinetics of the uniformly sized resins. In the ammonia cycle the resins response to the simulated sulfate was also rapid. The higher sulfate peak (exaggerated by the log scale on the graph) is caused by the higher pH during the ammonia cycle.

Figure 10. Condensate Polisher Performance – DOWEX MONOSPHERE Resin – Simulated Condenser Seawater Leak Studies

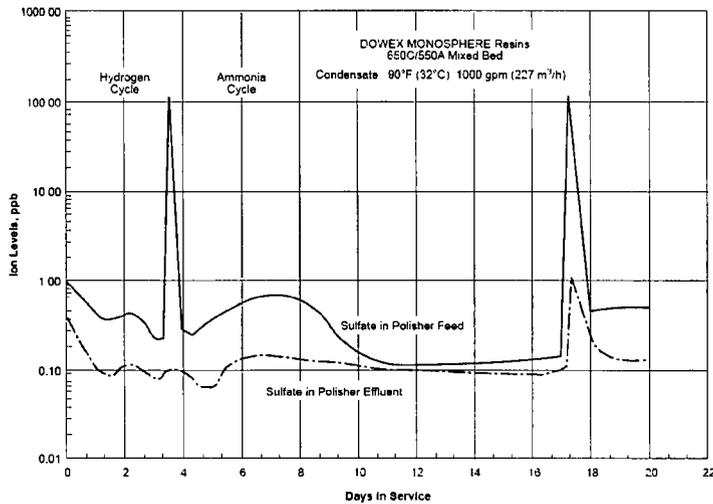
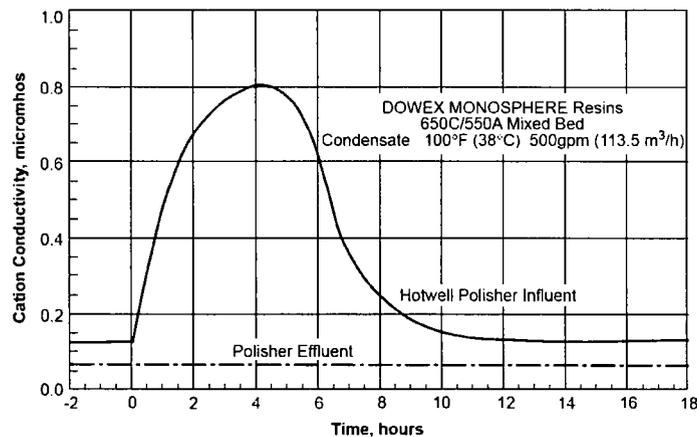


Figure 11 presents data obtained during an actual condenser leak in a Southeast fossil fuel plant. Cation conductivity, which effectively measures anion concentrations, shows the excellent kinetic response even more clearly.

Figure 11. Condensate Polisher Performance – DOWEX MONOSPHERE Resin – During Actual Condenser Leak



In any particle size distribution, the larger beads will be kinetically slower than the smaller beads. The better the particle size uniformity for a given average particle size, the fewer number of large, slow-acting beads present. Therefore, the overall kinetics will be better.

Particle Size Uniformity and Separability for Regeneration

Complete separation of the anion and cation resin components of a mixed bed is desirable to facilitate the independent regeneration of each. Resin cross-contamination causes ion leakage problems during the subsequent operating cycle.

The ability to separate one resin from another by backwash depends on differences in their particle size and density. Large, low-density anion beads can fluidize during backwash at the same level as small, more dense cation beads. This can make separation difficult or impossible. By controlling the uniformity of the particle size within each of the resin types, it is possible to optimize the resin separability by backwash fluidization. More details on resin separability will be presented later under "System Operation Considerations."

Filtration

In a condensate polisher, the function of the ion exchange resin is twofold: to provide ion exchange capacity and to provide filtration.

Filtration is a function of the particle size and particle size distribution. The number of "pinch points" between resin beads in a given volume of resin is related to the ability of the resin to filter. Smaller resins provide more pinch points and greater filtration.¹¹ Resins with uniform particle size distribution and smaller average diameter can provide better filtration than larger diameter resins with a Gaussian distribution.

Capacity

Ionic capacity is defined by two classifications, total and operating. Total capacity is inherent in the resin type, but can vary with changes in resin cross-linkage and water retention capacity. More highly cross-linked gel resins have higher total capacities (see Table 2). Operating capacity is not only a function of total capacity but is also dependent on the regenerability of the resin which relates to resin particle size uniformity. The operating capacity can be affected by flow rates, regenerant dosage and concentration, and bed configuration.

Selectivity

The selectivity of an ion exchange resin is a measure of preference the resin exhibits for the various ions of the appropriate charge. For example, a gel cation exchange resin having 10% cross-linkage, will exhibit a selectivity of about 1.5 for sodium ion relative to hydrogen ion, at 25°C.

Figure 12 presents sodium leakage calculations for a cation resin that yields a sodium selectivity coefficient of 1.5 in pH environments from 6.0 to 7.0. This data shows the dependence on the amount of resin in the sodium form. This demonstrates the importance of effectively separating the cation from the anion resin and minimizing the cross-contamination of cation resin with regenerant NaOH.

Figure 13 presents this same type of data for chloride leakage based on its equilibrium with the hydroxide ion. Because of the high selectivity that the anion resin has for chloride ion, effective removal of chloride during regeneration is essential to minimize subsequent chloride leakage during the service. This becomes especially true following a service cycle with condenser leakage, whereby the anion resin has been subjected to a higher than normal amount of chloride.

Figure 12. Sodium Ion Leakage Based on Equilibria with Hydroxide Ion

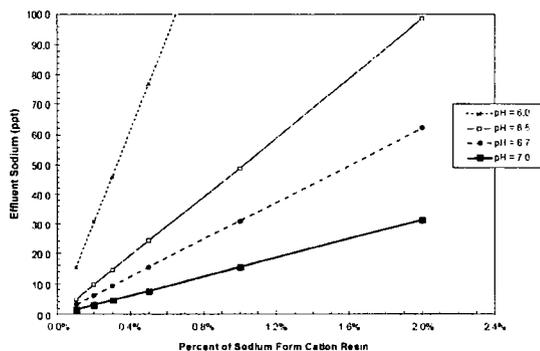
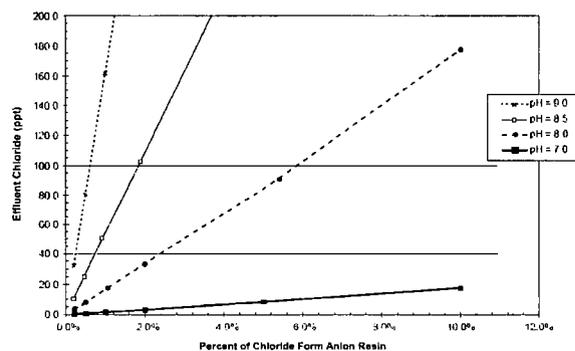


Figure 13. Chloride Ion Leakage Based on Equilibria with Hydroxide Ion



Selectivity is an important consideration in both regeneration and exhaustion operations. The ease with which a given ion can be stripped from a resin is affected by the resin's selectivity for that ion relative to the displacing ion in the regenerant. The more difficult the removal, the more likely ions will be left behind for subsequent leakage during exhaustion. The leakage pattern during exhaustion will reflect the relative affinity the resin has for the exhausting ion and the ion left behind during the previous regeneration. Operating capacity is also greater at a given regeneration dosage for ions less selectively held.

Bead Integrity

Bead integrity in an ion exchange resin must match the needs of the application. Resin beads must be strong enough to remain unbroken under the conditions of operation during the entire cycle. Anion resin fines which develop as the result of broken beads are lost from the system during backwash. Cation resin fines contaminate the anion resin layer during backwash separation. The end result of both these breakage situations is loss of effective capacity and water quality.

In deep bed condensate polishing, operating conditions can be quite severe. High flow rates are typical. Pressure drop increases across the bed as particulate crud is filtered from the condensate. Resin is transported hydraulically for considerable distances from the service vessel to the regeneration system. Osmotic forces are encountered during regeneration.

To assure that resins meet these needs, crush tests and attrition tests have been implemented to define resin strength parameters.

Kinetics

As discussed earlier, the rate at which a resin exchanges one ion for another is a combination of the surface film diffusion rate and the internal bead diffusion rate. Kinetics also relate to the leakage of ions from the resin. Of particular interest in condensate polishing are the kinetics of sulfate ion reaction on strong base anion exchange resins. Sulfate exchange is slower than chloride exchange. Furthermore, deterioration of the anion resin with age, due to oxidation or organic fouling, affects sulfate kinetics more than chloride.

Tests of the kinetic properties of resins have been devised by various groups. Although no standard method exists, ASTM recently approved a standard practice for kinetics testing of ion exchange resins. Regardless of the method type, a comparison of effluent water quality results from kinetic testing is only valid when using the same procedure and experimental conditions. Of particular interest is one of the original studies¹² for anion resin kinetics. This report discusses the impact of the anion bead size, condensate flow rate and the volume ratio of the cation and anion resin on the removal rate of sulfate and chloride. Moreover, it compares the ability of mixed bed resins to control sudden changes in the concentration of influent ions.

The anion kinetic properties are most important simply because the primary function of anion exchange resin in condensate polishing is the removal of sulfate and/or chloride ions from the condensate stream. While these ions are normally present at very low levels, their concentration in the condensate can rise abruptly in the event of a condenser leak. Because of the low ion concentrations and high flow rates involved in condensate polishing, the rate-limiting step in ion removal is diffusion across the resin surface "film." Organic molecules attracted to or adsorbed on the bead surfaces can impair ion exchange across those surfaces. While this resin contamination may not impact normal polisher operation, it may result in poor effluent water quality in the event of a condenser leak or other ionic ingress.

Along these same lines, cation resin kinetic properties also contribute to condenser inleakage management. A previous laboratory study¹³ reported the results of mixed bed performance testing using different combinations of new and "fouled" cation and anion resins. From the data, fouled cation resin paired with new anion resin gave higher sulfate slippage than fouled anion resin paired with new cation resin. This supports the hypothesis that sulfate removal kinetics of the mixed bed depends to a large extent on the salt splitting kinetics of the cation resin.

Oxidative Stability

Oxidative stability of ion exchange resin affects the performance of cation resins in a different manner than anion resins in condensate polishing use. Anion resins deteriorate by oxidation to form weak base functionality. Oxidative attack is primarily on the functional group. This results in a resin that is lower in strong base capacity and is kinetically slower.

Because cation resins are predominantly attacked at the backbone structure, various low and high molecular weight leachables can form. Most of these leachables are removed, reversibly, by exchange on the anion resin in the system. Some high molecular weight leachables may not be picked up by the anion resin and could contaminate the condensate. For this reason, it is important to understand the molecular weight of leachables when selecting cation resin.

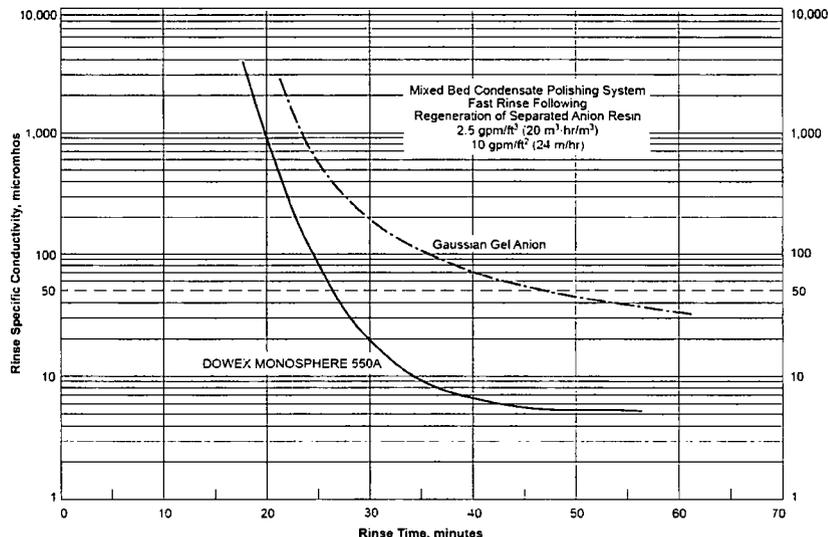
A comparison of the leachables from various gel and macroporous cation resins¹⁴ was presented at the International Water Conference (IWC) and in the publication *Ultrapure Water*.¹⁵

Rinse and Regeneration Efficiency

The rinse and regeneration efficiency of resins can directly impact the ionic leakage. Better regeneration results in more complete removal of ionic contaminants from the anion and cation resins. This leads to longer run time and lower total ionic leakage. Regeneration efficiency is significantly improved when resins with uniform particle size distribution are used versus resins with a broader Gaussian particle size distribution.

Rinsedown of a resin following regeneration is dependent on the rate of diffusion of the regenerant chemical from the bead interior to the surface of the bead. Thus, rinse efficiency is adversely affected by the larger beads in the resin particle size distribution. Uniform particle size distribution improves the rinse efficiency of a resin due to the absence of larger beads. The effect is illustrated in Figure 14, which shows a comparison of rinsedown curves for a uniformly sized resin vs. a resin with a broad size distribution taken at a U.S. fossil fuel plant.

Figure 14. Anion Rinse Down Curves – DOWEX MONOSPHERE Resins vs. Gaussian Gel Resins



Color

The performance of a resin in a condensate polishing system can be affected by color. To make it easy for the operator to verify backwash separation, the cation and anion resins should have sharply contrasting colors.

Resin Specifications Can Help You Select the Right Resin

The resins you purchase should reflect the requirements of your condensate polishing system. The resin specifications describe the characteristics that were discussed in this section. Most manufacturers will provide you with resin specifications to help you select the resin that will meet the requirements of your polishing system.

System Operating Considerations

The mechanical/hydraulic design of a condensate polishing system must assure good fluid distribution across the resin bed. It must also provide the ability to completely remove a charge of resin for regeneration in another vessel. In addition, there are several other system factors which deserve special attention. Included are condensate temperature, organic sources, resin separability, regeneration procedures, and resin ratios used in the system.

Temperature

Condensate temperature has a definite effect on the resin performance. The removal of weak acids such as silica and dissolved CO₂ decreases with increasing temperature. At about 140°F (60°C), the affinity of the strong base anion resin for silica is significantly reduced. Every effort should be made to control the silica and carbonate levels of the makeup water with the makeup demineralizer. For the cation resin, sodium leakage increases with increasing temperature.

Organics

Organics in condensate can be a source of ion exchange resin fouling. Thermal decomposition of organics can also be a source of system corrosion. Organic materials which are oily in nature and are not necessarily water soluble tend to coat the resin beads, both cation and anion. This severely limits the diffusion of ions into the resin structure. Contamination by oily organics can occur during startup of new equipment and by oil incursions into the system during operations. All reasonable attempts should be made to keep these materials from contacting the resins. Oily materials also cause severe problems with systems employing inert resins for separation enhancement. Oil films collect on the inert bead surface and tend to trap air during the separation, causing the inert resin to float.

Regeneration

Regeneration of condensate polishing resin requires several steps to minimize leakage of ions during the next cycle. The exhausted resin bed is typically loaded with crud. Physical cleanup of the resin is required before chemical regeneration can be effective. Several techniques have been developed to accomplish crud removal.

Standard procedures call for an air scrub step. This involves bubbling of air into the base of the column containing the resin transferred from the condensate polisher. Since crud is usually a combination of iron and copper oxides, the air scrub operation must be vigorous enough to break the crud down to fine particulate materials, capable of being fluidized above the resin. This is followed by backwash of the bed for removal of the crud overhead. Proper flow during this backwash operation is critical. The rate of flow must be great enough to fluidize the contaminating particles into a zone above the resin particles. The crud takeoff point should be at a level six inches above the recommended backwash expansion level for the resins involved.

Some forms of the particulate crud tend to be sticky, making loosening by abrasion time consuming. Ultrasonic cleaners have been developed to loosen crud from the bead surface. These cleaners are combined with backwashing to separate crud from the resin.

Another system designed to clean particulate matter from the resin and to separate the resins efficiently for regeneration combines vibrating screens and backwash for cleaning and separation. This system can also be used in conjunction with ultrasonic cleaning.

Separation

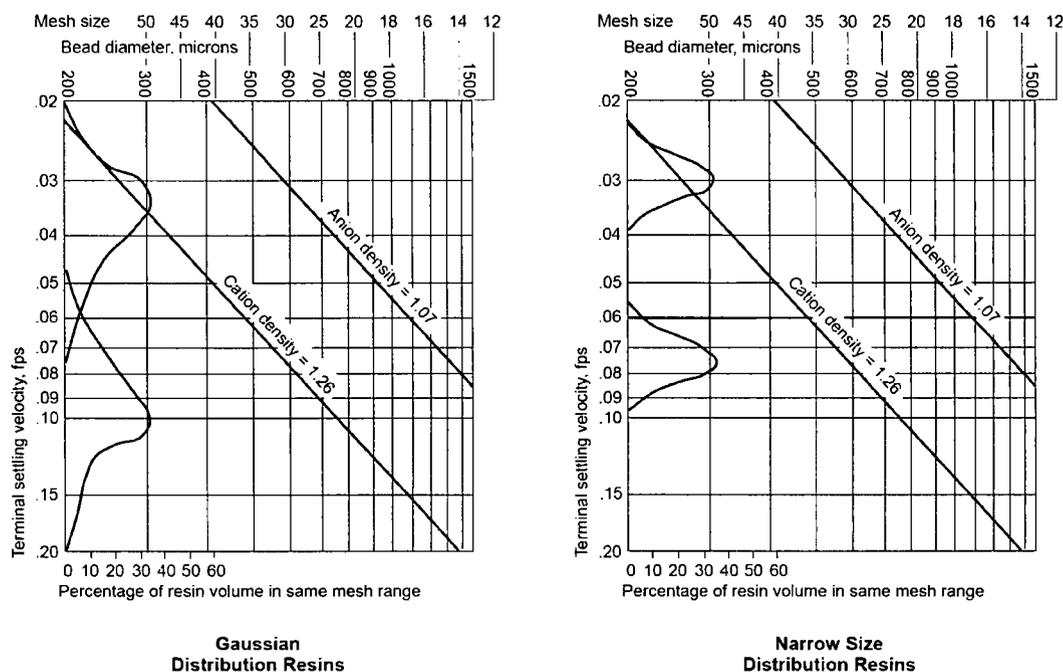
Resin separability in a condensate polishing system is affected by the inherent settling velocity of the resin particles and the hydraulics of the equipment used to carry out the fluidization and resin transport. If the cation and anion resins are not completely separated, some of each resin will be contaminated by the wrong regenerant and leakage of ions will occur during operation.

Complete separation of the cation and anion resins during backwash is dependent on the density of the resins, the size difference between the two types of resin, and the size distribution of resin beads within each resin type.

Most resins today achieve easy separation by making the denser cation beads larger than the less dense anion beads. Beyond this density difference, size distribution becomes the determining factor in further improving separation. If there is a broad range of bead sizes within the cation and anion resins, separability can suffer. That is, oversized anion beads may mix with the under sized cation beads at the interface during separation. The result is cross-contamination and leakage.

To get the best possible separation, the nominal size of the denser cation resin beads should be larger than the nominal size of the anion beads. This accentuates the density difference between the resin types. Within each resin type, all of the beads should be as close to the nominal size as possible. This bead size uniformity will minimize the cross-contamination discussed earlier. Figure 15 shows the importance of bead size uniformity in achieving good separation. The resin separation, in terms of terminal settling velocity, is projected based on bead density, bead size, and size distribution.

Figure 15. Terminal Settling Velocity Distributions and After-Backwash Column Profiles for Gaussian and Narrow Size Distribution Resins in Mixed Beds



It has been the practice in some operations to add a third, inert resin layer between the two active resins in the mixture. With Gaussian resins this practice dilutes the crosscontamination region but does not eliminate it. It may be useful in systems where the interface is isolated from the other resins during regeneration or when equipment design requires an inert layer. However, use of an inert resin will reduce the capacity in the mixed bed due to the space taken by the inert resin. Inert resin is not necessary when using uniform particle size resins.

Equally as important as the inherent separability of a resin pair is the separation equipment and support systems. The equipment and systems must provide the hydraulics necessary to obtain and maintain the separation achieved. Resin transport tends to remix resins, particularly at or near the interface between them due to the development of eddy currents near exit ports. A number of approaches have been taken to prevent remixing and subsequent leakage.

Early designs used a system which transported the anion resin from the separation vessel, generally through a side port or ports near the interface level. In many cases, internal collectors are used to minimize the remixing of the resins during removal. The cross-contamination level in some cases is still significant, resulting in subsequent sodium leakage levels which are unacceptable.

Reduction of the sodium leakage in some systems can be accomplished by one of two chemical processes.

The first process involves treating the separated and regenerated anion resin layer with ammonia. The ammonium ions displace sodium from the cation resin still present in the anion resin. The process has been most successful in systems using ammonia for pH control. The sodium leakage level depends on the amount of ammonia used to treat the anion resin layer.

In the second process, lime (calcium hydroxide) is used. The calcium which replaces the sodium could potentially leak from the resin during the loading cycle. However, the selectivity the resin has for calcium is much greater than for sodium. If free calcium or lime is adequately cleaned from the system, low calcium leakage can be expected. Sodium leakage levels are better than obtained without the chemical treatment.

Removal of the cation resin contaminating the anion resin layer has been accomplished with a process that involves regenerating the anion resin in concentrated caustic. After regeneration the anion resin has a lower density than the caustic solution and the anion resin floats. The cation resin contaminating the anion resin is denser than the solution and settles to the bottom. The cation resin is then recycled to the cation regeneration tank.

The hydraulic difficulties associated with removal of the anion resin from above the cation resin in the separation vessel led to development of processes designed to remove the cation resin from the bottom of the separation vessel.

One commercial process incorporates a conical base on the separation vessel. The cation resin is removed through this conical base. The interface between the cation and the anion resin is reduced as the cation resin is removed, leaving only a small cross-sectional area when the interface reaches the exit port. The cross-contamination zone is small enough to be contained in the transfer piping. Good separation has been maintained with this approach.

Much effort has been expended by resin manufacturers and equipment vendors to reduce the sodium leakage caused by regenerant cross-contamination. A system can be chosen most suited to a particular need.

Regenerants

Regeneration of the resins, as typically practiced in the United States, uses sulfuric acid solution for the cation exchange resin and sodium hydroxide solution for the anion exchange resin. Regeneration of the cation exchange resin with hydrochloric acid is a more common practice outside the United States.

The quality of the effluent water immediately following each regeneration is affected by the regenerant conditions as well as the degree of resin separation obtained. Both cross-contamination and impure regenerant chemicals can cause higher than average leakage initially after regeneration.

High levels of salt contamination in the sodium hydroxide regenerant should be avoided. When salt is present, competition from the chloride ions reduces the effectiveness and efficiency of regeneration with hydroxyl ions and reduces the capacity of the anion resin.

Remixing Resin

The final steps in the regeneration procedure include rinsing each resin to remove excess regenerant, remixing the anion and cation resins, rinsing the mixture to quality, and transporting the resin mix to the condensate polishing vessel.

Remixing resins which have been designed to give optimum separation upon backwash fluidization requires considerable care in the system design and operation. Even properly mixed resins will tend to separate when hydraulically transported to the condensate polishing vessel. Serious consideration should be given to the addition of a remixing capability in the condensate polishing vessel. In fact, a PWR nuclear power station in the Northeast recently retrofit all service vessels with re-mixing capability and immediately realized a dramatic improvement to both effluent water quality and operational efficiency.¹⁶

System Operation

Successful operations require good analytical tools. Instrumentation has become increasingly important as the water quality requirements have become more stringent. In the past, some ions were hard to detect and measure. As a result, leakage of these ions was seldom checked. Many of these same ions have now been found to be significant factors in system damage.

The development of new analytical instrumentation has made it possible to follow the quantity and nature of leakage of many contaminants both on-line and off-line. Used in conjunction with highly reliable continuous on-line pH and conductivity methods, techniques such as ion chromatography allow specific cations and anions to be analyzed in a semi-continuous mode.

Other measurement methods include soluble silica analysis, a colorimetric method, total organic carbon analysis, atomic absorption spectrometry, flame-emission photometry, cation and anion exchange chromatography and specific ion electrodes.

The usefulness of conductivity has also been expanded by the perfection of techniques to measure cation conductivity and degassed cation conductivity.¹⁷

Finally, successful operation of even the best designed plant depends on operators who are committed to getting the best out of the system.

Dow Technical Backup

The Dow Chemical Company manufactures and sells a full line of DOWEX ion exchange resins designed for use in condensate polishing systems. In addition, DOWEX ion exchange resins are supported by responsive technical people and the most advanced resources available. Your Dow technical sales representative, along with our Technical Service and Development group, can help you keep your water system running at peak efficiency.

We can help you select the resins you need for all of your water treatment requirements. We can help you determine the optimum time to replace resins. We can even help you set up your own resin testing and monitoring program. In short, we offer the kind of extensive technical support you would expect from the leader in ion exchange technology.

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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.

Notice: No freedom from any patent owned by Seller or others is to be inferred. Because use conditions and applicable laws may differ from one location to another and may change with time, Customer is responsible for determining whether products and the information in this document are appropriate for Customer's use and for ensuring that Customer's workplace and disposal practices are in compliance with applicable laws and other governmental enactments. Seller assumes no obligation or liability for the information in this document. NO WARRANTIES ARE GIVEN; ALL IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE ARE EXPRESSLY EXCLUDED.

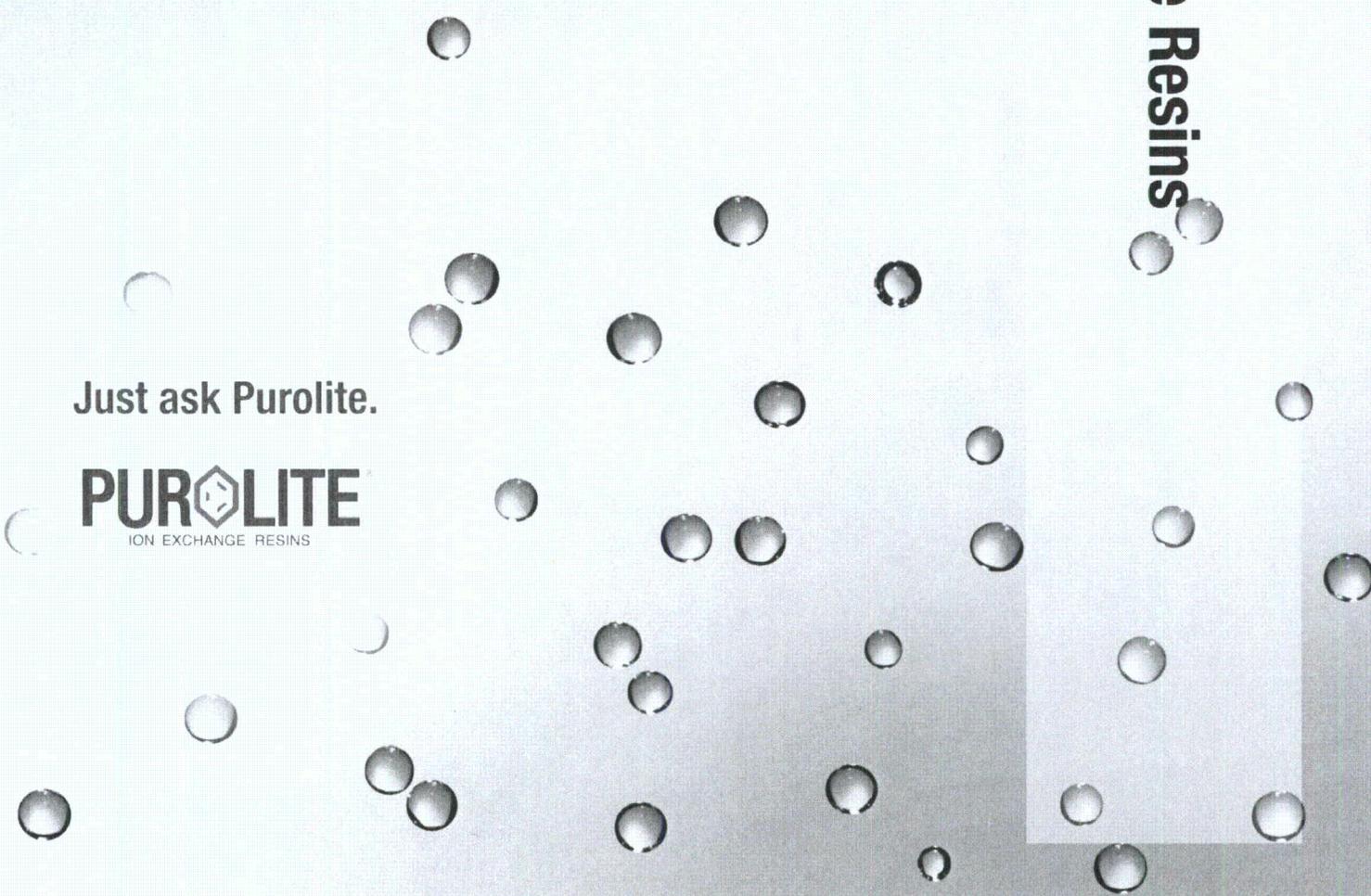


Nuclear Grade Ion Exchange Resins for Power Generation

Nuclear Grade Ion Exchange Resins

Just ask Purolite.

PUROLITE
ION EXCHANGE RESINS



1. Introduction

The need for polishing impurities from coolant in reactor circuits became apparent with the introduction of nuclear power in the 1950's. Since then, ion exchange resins have played an important part in nuclear power generation and the application of special resins has continued to grow.

Nuclear power stations in the Americas, Europe and Asia now operate with a number of Purolite resins. Changes in nuclear reactor design by power utilities around the world and in operations such as power up-rates and reactor life extensions have fueled the need for new resins with greater selectivity, higher purity and improved filtration. The **Purolite NRW** product range meets the latest published requirements for the new generation of nuclear power stations.



Purolite continue to develop and upgrade the "NRW" nuclear grade resins to meet or exceed the standards set within the nuclear industry with regard to purity, integrity and performance. **Purolite NRW** products are manufactured at our three production plants located in the USA, Europe and Asia. Each manufacturing plant is fully accredited to international standards for quality control at all stages of production.

2. Nuclear Power Applications

The **Purolite® NRW** product range includes a diverse collection of chemically and mechanically stable cation, anion and mixed bed resins allowing designers and end users to choose the optimum product for their requirements. Most engineers think of ion exchange only in terms of demineralization. Purolite's view is more dynamic and we have developed and introduced a nuclear grade colloid

removal resin which provides enhanced filtration which is needed to achieve increasing quality requirements and meet new and existing discharge specifications.

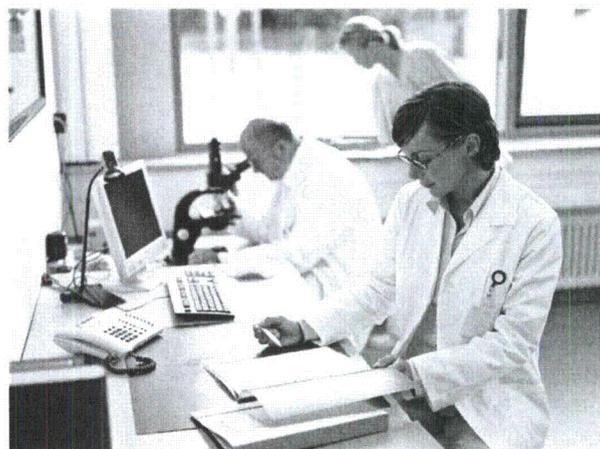
Purolite® NRW products allow power plants to properly address needs in all areas of operations including:

- **Polishing requirements for makeup water (MU)**
- **Deep bed condensate polishing (CP)**
- **Chemical volume control (CVCS) during full power**
- **Reactor water cleanup (RWC)**
- **Radioactive waste cleanup**
- **Outage cleanup with high ionic loads and fine colloids**
- **Steam generator blow down (SGBD) recovery**
- **Spent fuel pool (SFP) cleanup**

Nuclear grade resins required in nuclear power systems must be free of trace contaminants that may support chemical corrosion of system metals and deposition within the plant which will impact system life. Hence strict control of trace impurities is essential. Additionally, resins must be manufactured with high capacity and the highest achievable degree of conversion to the desired ionic form in order to ensure maximum ionic loading and minimum equilibrium and kinetic leakage.

Bead integrity with both good resistance to osmotic shock and high breaking weight is essential to minimize attrition and pressure drop issues. Modern nuclear power designs also expect resins to be produced with an optimum particle size range. Such resins are expected to result in minimum pressure drop and minimum flow restriction helping to optimize performance and achieving full utilization of the resin bed. These characteristics allow power stations to achieve the highest quality and operating efficiency from their plants while minimizing the generation of solid radioactive waste.

Purolite offers products for all nuclear demineralizer applications, including both regenerable and non-regenerable, separate bed and mixed beds products. Equipment designers and end users should consult the nearest Purolite Sales Office for assistance on product selection.



3. Nuclear Grade Strong Acid Cation Resins

The Purolite range of nuclear grade strong acid cation (SAC) resins comprises four products, three gel and one macroporous resin. Gel resins are designed to meet a variety of applications and include the cost effective and easily regenerable **Purolite NRW1000**, the higher capacity, kinetically efficient and more selective product **Purolite NRW1100** and, finally, **Purolite NRW1160**, the highest cross linked gel resin available. **Purolite NRW1160** tolerates aggressive oxidizing environments commonly found in spent fuel pools, and also performs well as a very highly selective polishing resin for high purity waters. **Purolite NRW1160** is not recommended for regenerable applications.

Table 1 – Strong Acid Cation (SAC) Products for Nuclear Power Generation

Product Name	Matrix	Total Capacity eq/l (H ⁺)	Moisture Retention (H ⁺)	Mean Diameter	Uniformity Coefficient	Application
Purolite NRW1000*	Gel	1.8	51 - 55%	570 ± 50 µm	≤ 1.2	Separate bed demineralization cation and radwaste
Purolite NRW1100*	Gel	2.0	46 - 50%	650 ± 50 µm	≤ 1.2	All nuclear plant applications where cation resins are used
Purolite NRW1160	Gel	2.5	36 - 41%	625 ± 75 µm	≤ 1.2	Polishing cation for high purity water in secondary circuits and layering on polishing mixed beds
Purolite NRW1600*	Macro	2.1	43 - 48%	570 ± 50 µm	≤ 1.2	Cation resin vessels or layering for added cation capacity

**Nuclear Grade Cation resins also available in lithiated form
All the above Purolite NRW cation resins are shipped in the H⁺ form. Unless specified.*

Purolite also offers a very special macroporous cation resin, **Purolite NRW1600**, which is unique in the industry. This macroporous, highly specialized resin has a high loading capacity with good kinetics, yet has high selectivity and is known for greater loading of cesium, cobalt, nickel, and other metal ions. This product is ideal for use during plant outage for maintenance when special cleanup is required as well as in some full power operations.

Purolite NRW1600 is also highly selective for sodium in the presence of amines, therefore, making it a highly effective resin for use in steam generator blow down, allowing for longer service runs, minimal sodium leakage and fewer resin changes during the life of the power station.

Several nuclear grade cation resins are available in natural lithium-6 or high purity lithium-7 form for

primary coolant water pH control in (CVCS) demineralizers (i.e. in PWR Power Stations).

4. Nuclear Grade Strong Base Anion Resins

Purolite nuclear grade strong base anion (SBA) resins complement the selection of nuclear grade cation resins, beginning with the Type I porous gel, **Purolite NRW4000**, which provides an economic polishing solution and is recommended for use in regenerable systems (usually following a cation column with **Purolite NRW1000**). **Purolite NRW6000** and **Purolite NRW8000**, two Type I non-porous clear gel anion resins, offer increasingly higher capacity than **Purolite NRW4000**, with **Purolite NRW8000** providing the highest capacity at 1.3 eq/l in the OH⁻ form. These latter two resins offer

greater ionic loading, greater selectivity and potentially longer operating life in non-regenerable applications. These higher capacity anion resins offer durability and solid performance in difficult rigorous environmental conditions where selectivity and good kinetics are essential. **Purolite NRW6000** and **Purolite NRW8000** are not recommended for regenerable systems.

A high capacity macroporous anion resin, **Purolite NRW5050**, is also available for use where specialty amines surface fouling may contribute to premature loss of kinetic performance. For example, prior to an outage, Purolite NRW5050 can be used to remove fouling precursors from the condensate stream or boron from the circuit.

Table 2 – Strong Base Anion (SBA) Products for Nuclear Power Generation

Product Name	Matrix	Total Capacity eq/l (OH ⁻)	Moisture Retention (Cl ⁻)	Mean Diameter	Uniformity Coefficient	Application
Purolite NRW4000	Gel	1.0	48 - 54%	570 ± 50 µm	≤ 1.2	Separate bed demineralizer anion and radwaste
Purolite NRW6000	Gel	1.1	43 - 48%	570 ± 50 µm	≤ 1.2	All nuclear plant anion applications. Anion resin vessels or underlay
Purolite NRW8000	Gel	1.3	40 - 45%	570 ± 50 µm	≤ 1.2	Extreme polishing applications and underlay for sulfate control
Purolite NRW5010	Macro	0.4	70 - 75%	775 ± 125 µm	≤ 1.8	Ultra polishing overlay for fine colloidal particulate from primary coolant and radwaste
Purolite NRW5050	Macro	0.9	53 - 58%	570 ± 50 µm	≤ 1.2	Anion for high organics water and boron removal

Nuclear grade anion resins Purolite NRW6000 and Purolite NRW5050 are also available in boronated form. All the above Purolite NRW Anion resins are shipped in the OH⁻ form. Unless specified.

5. Nuclear Grade Strong Base Anion Colloid Removal Resin

The macroporous nuclear grade anion resin **Purolite NRW5010** is a signature product that functions, primarily, as a special polishing filter media and, secondarily, as an ion exchange media. This highly specialized macroporous resin removes colloidal material, and has been successfully used in

removing radioactive isotopes (0.10 µm and smaller) from primary coolant water. These colloidal corrosion products, which do not settle and cannot be filtered successfully by conventional media or filter, will pass or plug conventional cartridges filters. This will contribute significantly to resolve source term and treatment difficulties. **Purolite NRW5010** can be installed in its own unique unit or can be layered on other cleanup beds during refueling outages in conjunction with **Purolite NRW1600**, the

macroporous cesium and cobalt selective SAC resin, to enhance performance. The layered approach can also be used with final polishing mixed bed resins such as **Purolite NRW3560** and **Purolite NRW3460**. **Purolite NRW5010** can also be used on CVCS beds during full power, on reactor water and spent fuel cleanup beds.

6. Nuclear Grade Mixed Bed Resins

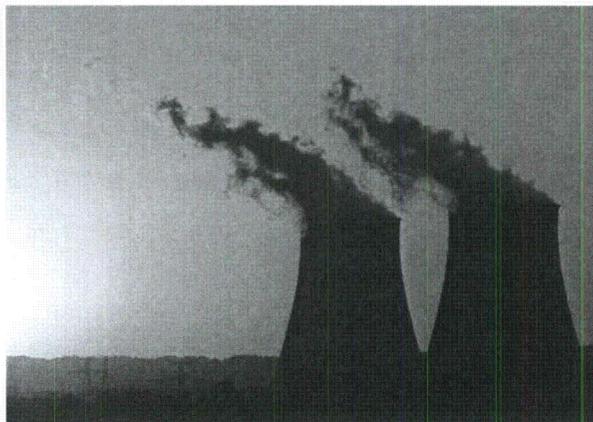
Purolite nuclear grade mixed bed resins incorporate the same diversity demonstrated in our range of nuclear grade cation and anion resins. This allows users to economically achieve conventional polishing objectives, or to address the more rigorous applications found in steam generator blow down, condensate polishing, and spent fuel pool demineralization.

The mixed bed products include the economical **Purolite NRW3240**, a combination of gel SAC and porous gel SBA, and **Purolite NRW3260**, a combination of gel SAC and non-porous, clear SBA. These products are recommended for use in makeup and radwaste final polishing, and are used in systems where regeneration may be required. **Purolite NRW3460** is recommended for polishing applications where higher capacity and good kinetics are required to control low level impurities such as in RWC and CVCS. **Purolite NRW3670** is a combination of a very high capacity gel SAC and a Type I non-porous clear gel anion for use in high purity polishing systems such as BWR condensate polishing and RWC.

Purolite NRW3540 and **Purolite NRW3560** are signature products of Purolite, incorporating a combination of the macroporous SAC with either porous or non-porous clear gel anion resins. These products are well established in the industry and are used in all demineralizers within the primary and secondary systems especially CVCS, cleanup beds, SFP, RWC, SGBD. **Purolite NRW3550** consists of macroporous SAC and macroporous SBA resins and is used where anion resins require good kinetics and resistance to potential organic fouling such as in condensate polishing and radwaste treatment.

Purolite nuclear grade polishing mixed bed components are combined in chemical equivalent ratios (unless otherwise specified) for maximum operating capacity. Other cation-to-anion ratios are available on request for condensate polishing and other specialty applications.

Purolite NRW3562 is a 2:1 ratio by volume (approx 4:1 equivalent) mixed bed resin composed of the macroporous SAC and the non-porous, clear gel anion and is designed for use in SGBD and special polishing of radwaste streams



7. Purolite Services and Support

The Purolite field sales and support team is the largest in the ion exchange industry. With extensive worldwide coverage, via a network of fully supported local sales offices, the technical support offered to our clients is enhanced by production flexibility and product availability. This has allowed Purolite to become a leading resin producer for the worldwide nuclear industry.

Purolite field sales and technical support teams are available to assist with resin selection, product application, plant problems troubleshooting, optimizing efficiency and developing cost effective solutions. Manufacturing and processing facilities are globally positioned to assure security of supply for safe and efficient nuclear plant operation. Global sourcing contracts are in place to secure raw materials along with confirmed secondary source of supply. Quality control and assurance are backed by the latest ISO 9001 certified operations and are regularly audited by nuclear support organizations. Continual assessment and updating of testing facilities and methodology is addressed across all manufacturing and processing areas. Worldwide research laboratories support quality control and state of the art manufacturing.

Table 3 – Mixed Bed (MB) Products for Nuclear Power Generation

Product Name	Cation Capacity eq/l	Anion Capacity eq/l	Equivalent Ratio	Matrix	Application
Purolite NRW3240*	1.8	1.0	1:1	gel/gel	Makeup demineralization and radwaste
Purolite NRW3260*	1.8	1.1	1:1	gel/gel	Primary polishing and radwaste
Purolite NRW3460*	2.0	1.1	1:1	gel/gel	Primary polishing and cleanup systems
Purolite NRW3540*	2.1	1.0	1:1	macro/gel	Primary polishing and cleanup systems, steam generator blow down demineralization
Purolite NRW3550*	2.1	0.9	1:1	macro/macro	Primary polishing and cleanup systems, steam generator blow down demineralization. For high organics water and boron removal
Purolite NRW3560*	2.1	1.1	1:1	macro/gel	Primary polishing and layered cleanup systems, steam generator blow down and spent fuel pool demineralization.
Purolite NRW3562	2.1	1.1	2:1 Volume Ratio	macro/gel	Steam generator blow down, radwaste cleanup
Purolite NRW3670*	2.5	1.15	1:1	gel/gel	High purity condensate polishing, reactor water cleanup

*Nuclear Grade Mixed Beds also available with the cation component in the lithium form.
All the above Purolite NRW Mixed Bed resins are shipped in the H⁺/OH⁻ form. Unless specified

Glossary**Acronyms:**

<i>BWR</i>	<i>Boiling Water Reactor</i>
<i>CP</i>	<i>Condensate Polishing</i>
<i>CVCS</i>	<i>Chemical Volume Control System</i>
<i>MB</i>	<i>Mixed Bed</i>
<i>MU</i>	<i>Makeup</i>
<i>NRW</i>	<i>Nuclear Grade Resin</i>
<i>PWR</i>	<i>Pressurized Water Reactor</i>
<i>RWC</i>	<i>Reactor Water Cleanup</i>
<i>SAC</i>	<i>Strong Acid Cation</i>
<i>SBA</i>	<i>Strong Base Anion</i>
<i>SFP</i>	<i>Spent Fuel Pool or Pond</i>
<i>SGBD</i>	<i>Steam Generator Blow Down</i>

Purolite was founded in 1981 and is a leading manufacturer of ion exchange, catalyst, adsorbent and specialty resins. Headquartered in Bala Cynwyd, PA, the company has ISO-9001 certified manufacturing facilities in the USA, China, and Romania and operates dedicated R&D centers in the USA, China, Romania, Russia, and the UK. Purolite, the only company focused exclusively on the ion exchange market, has 40 sales offices in more than 30 countries.

Please call one of the main regional offices on the following page to obtain full contact details for the nearest Purolite office responsible for your area.

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**For further information on Purolite products & services
visit www.purolite.com**

Just ask Purolite.

PUROLITE
ION EXCHANGE RESINS



Ultipor® GF Plus Series Filter Elements

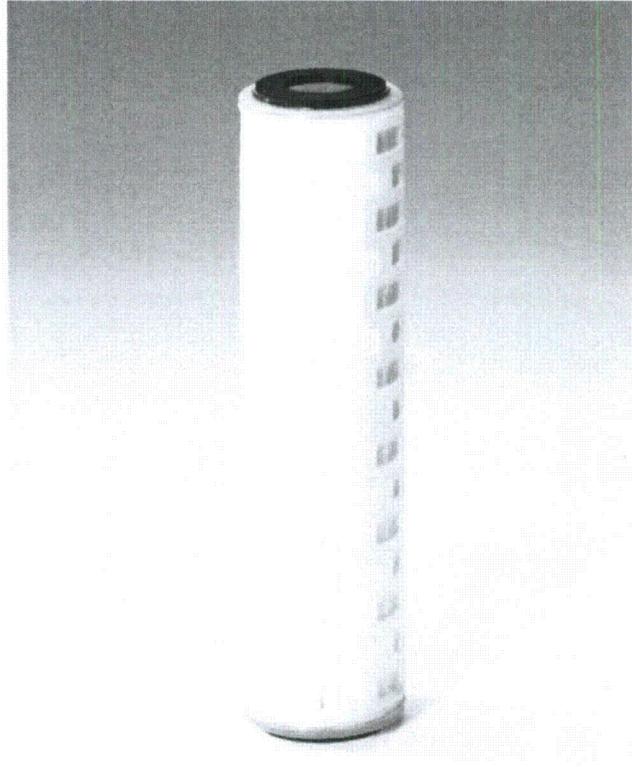
Description

Ultipor® GF Plus filters have a pleated high area construction for long service life. The medium uses a binder resin which coats the glass fibers, imparting a positive zeta potential in aqueous service. The resin also bonds the glass fibers to a polyester substrate, producing a rugged composite medium. Applications for such filters are numerous as most suspensions are negatively charged in aqueous solution, including not only particles but bacteria and viruses. Some Ultipor GF Plus filter grades efficiently remove sub-microscopic haze from a wide variety of pharmaceuticals and cosmetics, including colognes.

Ultipor GF Plus filters have a fixed pore construction which precludes unloading or media migration.

Ultipor GF Plus elements with polypropylene hardware in a double open-ended UNI CAP configuration are rated to withstand differential pressures of 5.2 bard (75 psid) @ 38°C (100°F) and 3.1 bard (45 psid) @ 82°C (180°F).

When constructed in a single open-ended AB configuration, the element can withstand differential pressures of 5.2 bard (75 psid) @ 27°C (80°F) and 3.8 bard (55 psid) up to 82°C (180°F).



Ultipor GF Plus Filter

Removal ratings

Cartridge Grade	Liquid Service ³ Rating in Microns at % Efficiency		Aqueous Clean Pressure Drop Per 25.4 cm (10 in) Module (MBARD/LPM) / (PSID/GPM) ⁴	Typical Aqueous Flow Per 25.4 cm (10 in) Cartridge (LPM/GPM)
	99%	99.98%		
U010Z	0.6 ²	1	3.09 / 0.17	7.6 - 11.4 / 2-3
U2-20Z	0.8 ²	2	2.55 / 0.14	7.6 - 11.4 / 2-3
U030Z	2.0	3	1.82 / 0.10	7.6 - 11.4 / 2-3
U6-40Z	3.2	6	0.91 / 0.05	11.4 - 18.9 / 3-5
U100Z	6.0	10	0.55 / 0.03	11.4 - 18.9 / 3-5
U200Z	17.0	20	0.36 / 0.02	11.4 - 18.9 / 3-5
U400Z	25.0	40	0.27 / 0.015	15.1 - 26.5 / 4-7

Ordering Information

DOE - Pall Part Number = PUY

SOE - Pall Part Number = AB

Table 1

Code	Cartridge lengths (cm/in)
10	25.4 / 10
20	50.8 / 20
30	76.2 / 30
40	102 / 40

Table 2

Code	Cartridge
U010Z	U010Z
U2-20Z	U2-20Z
U030Z	U030Z
U6-40Z	U6-40Z
U100Z	U100Z
U200Z	U200Z
U400Z	U400Z

Table 3

Code	Gasket option
J	Ethylene propylene (std)
H13	Nitrile
H	Fluorocarbon elastomer

Table 4

Code	End Fittings	
	O-ring fitting I.D. (in)	O-ring replacement size
3, 8	1 ¼	-222
7	1 ½	-222

Table 5

Code	O-ring option
JH4	Silicone
H	Fluorocarbon elastomer
J	Ethylene propylene

Housing Information

Housings are available in either polypropylene, carbon steel, or stainless steel and can accommodate 1 to 152, 10 in modules per housing.

¹ These grades are particularly useful as prefilters, in addition to providing absolute removal efficiency.

² Extrapolated value.

³ Liquid service ratings are based on a modified OSU F-2 protocol for recording removal efficiency based on particle counting techniques.

⁴ Pressure drop in MBARD/LPM (PSID/GPM) for water for a single 25.4 cm (10 in) module. Multiply this value by the required flow to determine the total aqueous pressure drop. Next, for fluids other than water, multiply by viscosity in centipoise. If this calculated pressure drop is excessive, then divide this value by the number of 25.4 cm (10 in) modules required to reduce this pressure drop to an acceptable level.



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Diversified Technologies

DT-10	
Product Sheet.....	046
MSDS.....	047
DT-20	
Product Sheet.....	049
MSDS.....	050
DT-30	
Product Sheet.....	052
MSDS.....	053
DT-47	
Product Sheet.....	057
MSDS.....	058
DT-60	
Product Sheet.....	060
MSDS.....	061
DT-70	
MSDS.....	063
DT-90	
MSDS.....	067
DT-99	
Product Sheet.....	071
DT-2010	
Product Sheet.....	072
MSDS.....	073

PRODUCT TECHNICAL BULLETIN

Revised 1/98 Page 1 of 1

DT-10 SERIES CARBON PRODUCTS

DT-10F, DT-10M, DT-10C

RECOMMENDED	Liquid purification, aqueous and non-aqueous solutions. Chlorine APPLICATIONS removal, deodorizing, decolorizing, and elimination of undesirable tastes. Removal of lignins and tannins from water.						
BASE MATERIAL	Natural grain, coconut shell carbon						
ACTIVATION METHOD	High temperature steam						
ADSORPTION CHARACTERISTICS	Good efficiency and capacity for removal of trace contaminants from water and liquid						
ADSORPTION CAPACITY <small>†<u>ASTM D-3467</u></small>	65% carbon tetrachloride						
PARTICLE SIZE <small>†<u>ASTM D-2862</u></small>	<table><tr><td><u>DT-10F</u></td><td><u>DT-10M</u></td><td><u>DT-10C</u></td></tr><tr><td>50 x 100 mesh</td><td>30 x 50 mesh</td><td>12 x 30 mesh</td></tr></table>	<u>DT-10F</u>	<u>DT-10M</u>	<u>DT-10C</u>	50 x 100 mesh	30 x 50 mesh	12 x 30 mesh
<u>DT-10F</u>	<u>DT-10M</u>	<u>DT-10C</u>					
50 x 100 mesh	30 x 50 mesh	12 x 30 mesh					
HARDNESS <small>†<u>ASTM D-3802</u></small>	95% minimum by ball abrasion test						
BULK DENSITY <small>†<u>ASTM D-2834</u></small>	Approx. 0.49 - 0.56 g/ml (31-35 lbs/cu.ft.), as packed						
ASH CONTENT <small>†<u>ASTM D-2866</u></small>	5% maximum						
MOISTURE CONTENT <small>†<u>ASTM D-2867</u></small>	5% maximum, by weight as packed						
REACTIVATION	Can be reactivated after drying						
PACKAGING	50 lb. (22.7 kg) net weight, 51 lb. (23.2 kg) gross weight, multi-wall paper bag						

Diversified Technologies Services, Inc.

2680 Westcott Blvd., Knoxville, TN 37931 PHN 865-539-9000 FAX 865-539-9001 E-Mail info@dts9000.com

MATERIAL SAFETY DATA SHEET

Revised 10/21/99 Page 1 of 2

DT-10 & DT-11 SERIES CARBON PRODUCTS

DT-10XF, DT-10F, DT-10M, DT-10C

DT-11XF, DT-11F, DT-11M, DT-11C

Diversified Technologies PHONE 865-539-9000

2680 Westcott Blvd., Knoxville, TN 37931

I. PRODUCT IDENTIFICATION

Product **DT-10XF, DT-10F, DT-10M, DT-10C,
DT-11XF, DT-11F, DT-11M, DT-11C Carbon**
Chemical Name **Activated Carbon**

II. HAZARDOUS INGREDIENTS

None - Exposure should be treated as any nuisance dust particulates (5 mg cu. meter Respiratory TWA. Total exposure not to exceed 15 mg per cu. meter).

III. PHYSICAL DATA

A. Boiling Point	Not Applicable
B. Melting Point	Not Applicable
C. Specific Gravity	1.8 - 2.1
D. Vapor Pressure	Not Applicable
E. Vapor Density	Not Applicable
F. Solubility in Water	Insoluble
G. Evaporation Rate	Not Applicable
H. Appearance	Black Granules or Powder
I. Odor	None

IV. HEALTH HAZARD DATA

A. Eyes: Particles may cause irritation of the eye.

V. FIRST AID PROCEDURES

A. Eyes: As with any particulate, flush with water for at least 15 minutes.

VI. FIRE AND EXPLOSION HAZARD DATA

- A. Flash Point: None, Non-flammable
- B. Unusual Fire and Explosion Hazards: Contact with strong oxidizers such as ozone or liquid oxygen may cause rapid combustion.
- C. Special Fire Fighting Procedures: Exercise caution when responding to any chemical fire. Respiratory protection is essential.

VI. FIRE AND EXPLOSION HAZARD DATA Cont'd

- D. Extinguishing Media: In case of fire, may use foam, CO₂, or dry chemical.

VII. REACTIVITY DATA

- A. Stability: Stable
- B. Conditions to Avoid: None
- C. Incompatibility: Avoid Contact With: N/A
- D. Hazardous Decomposition or Byproducts: N/A
- E. Hazardous Polymerization: Will not occur

VIII. SPILL OR LEAK PROCEDURES

- A. Steps to be taken in case material is spilled: Sweep up spill and discard in protected refuse container.
- B. Waste Disposal Method: Dispose in accordance with local, state, and federal regulations. No precautions required for disposal of shipping containers.

IX. SPECIAL PRECAUTIONS

- A. Avoid contact with eyes.
- B. Dehydrating product; wear gloves while handling.
- C. Wet activated carbon depletes oxygen from air. Whenever workers enter a vessel containing carbon, all precautions must be taken, since dangerously low levels of oxygen may be encountered. Atmosphere sampling and work procedures for potentially low oxygen areas should be followed.

X. SPECIAL PROTECTION INFORMATION

- A. Eye Protection: Safety goggles or glassed recommended.
- B. Protective Gloves: Recommended.
- C. Respiratory Protection: Standard protection against dust: particulate respirator.
- D. Ventilation: No special requirement

**THE INFORMATION HEREIN IS GIVEN IN GOOD FAITH,
BUT NO WARRANTY, EXPRESS OR IMPLIED, IS MADE.**

PRODUCT TECHNICAL BULLETIN

Revised 6/11/90 Page 1 of 1

DT-20 SERIES CATION RESIN (Nuclear Grade)

DT-20 & DT-20N

PRODUCT DESCRIPTION

DT-20 and DT-20N are premium grade cation exchangers that can be used in water demineralization. These materials are produced using a crosslinked styrene divinylbenzene polymer matrix with 8% crosslinking.

Bead stability and a minimum of 95% whole clear beads make these media premium grade gels, without the added cost of buying an upgraded cation product. The data presented herein are applicable for hydrogen cycle cation exchange operation only.

TYPICAL CHEMICAL AND PHYSICAL CHARACTERISTICS

Polymer Structure	Polystyrene crosslinked with divinylbenzene
Functional Groups	R-SO ₃ ⁻
Physical Appearance	Clear Spherical Beads
Ionic Form (as shipped)	Hydrogen
Screen Size, U.S. Std. Mesh (Wet)	16-45
Particle Size	+16 mesh <5%, -40 mesh <1%
Water Retention	49-55%
pH Limitations	None
Temperature Limitations	280°F (140°C)
Whole Bead Count	95% minimum
Shipping Weight	50 lbs./ft ³ (800 g/l)
Total Capacity	1.9 meq/ml Minimum Volumetric 4.9 meq/gm Minimum Weight
Standard Packaging	5 ft ³ double polyethylene-lined fiber drums
D.V.B Content	8%
Color	Black or amber

STANDARD OPERATING CONDITIONS

Operation	Rate	Solution	Minutes	Amount
Service	1-5 gpm/ft ³	Influent Water		
Backwash	3-5 gpm/ft ² (40-60°F)	Influent Water	5-20	10-25 gal/ft ³
Regeneration	0.2-0.8 gpm/ft ³	0.5-5% H ₂ SO ₄ 4-10% HCL	30	4-10 lbs.
Rinse (slow)	0.2-0.8 gpm/ft ³	Decationized	60	20 gal/ft ³
Rinse (fast)	1-5 gpm/ft ³	Decationized	30	30 gal/ft ³
Backwash Expansion - 50-75%		Design Rising Space - 100%		

Diversified Technologies Services, Inc.

2680 Westcott Blvd., Knoxville, TN 37931 PHN 865-539-9000 FAX 865-539-9001 E-Mail info@dts9000.com

MATERIAL SAFETY DATA SHEET

Revised 11/4/02 Page 1 of 2

DT-20 SERIES CATION RESIN **DT-20 & DT-20N (Nuclear Grade)**

Diversified Technologies PHONE 865-539-9000
2680 Westcott Blvd., Knoxville, TN 37931

I. PRODUCT IDENTIFICATION

Product **DT-20 & DT-20N Resins**
Chemical Name **Strong Acid Cation Exchange Resin**

II. HAZARDOUS INGREDIENTS

None

III. PHYSICAL DATA

A. Boiling Point Not Applicable
B. Melting Point Not Applicable
C. Specific Gravity 1.26
D. Vapor Pressure Not Applicable
E. Vapor Density Not Applicable
F. Solubility in Water Insoluble
G. Evaporation Rate Not Applicable
H. Appearance Amber to mahogany spherical beads
I. Odor Odorless

IV. HEALTH HAZARD DATA:

A. Eyes: Particles may cause irritation of the eye.

V. FIRST AID PROCEDURES

A. Eyes: Flush with large amounts of water for at least 15 minutes. Consult physician if irritation persists.

VI. FIRE AND EXPLOSION HAZARD DATA

A. Flash Point: None
B. Unusual Fire and Explosion Hazards: None
C. Special Fire Fighting Procedures: Wear MSHA/NIOSH approved, pressure demand, self-contained breathing apparatus.
D. Extinguishing Media: CO₂, dry chemical, water fog

VII. REACTIVITY DATA

- A. Stability: Stable
- B. Conditions to Avoid: Avoid temperatures over 220°C, (428°F).
- C. Incompatibility: Avoid Contact with: Concentrated nitric acid or strong oxidizing agents.
- D. Hazardous Decomposition or Byproducts: SO₂, SO₃, CO, CO₂, styrene monomer, divinylbenzene
- E. Hazardous Polymerization: Will not occur

VIII. SPILL OR LEAK PROCEDURES

- A. Steps to be Taken in Case Material is Spilled: Resin beads on floor will mechanically cause the floor to be slippery. Use care to avoid falls. Sweep up and transfer to containers for recovery or disposal.
- B. Waste Disposal Method: This material can be disposed of as ordinary trash.

IX. SPECIAL PRECAUTIONS

- A. Store below 49°C (120°F) and above 0°C (32°F)
- B. Keep drums and plastic bag liners sealed to prevent drying or moisture loss.

X. SPECIAL PROTECTION INFORMATION

- A. Eye Protection: Safety glasses (ANSI Z87.1)
- B. Protective Gloves: None
- C. Respiratory Protection: None
- D. Ventilation: Local exhaust - normal plant ventilation

**THE INFORMATION HEREIN IS GIVEN IN GOOD FAITH,
BUT NO WARRANTY, EXPRESS OR IMPLIED, IS MADE.**

PRODUCT TECHNICAL BULLETIN

Revised 11/8/12 Page 1 of 1

DT-30 EXCHANGER

PRODUCT DESCRIPTION

DT-30 Ion Exchanger is an alkali metal alumino silicate primarily of the chabazite structure type supplied in the mixed ionic (Na⁺, Mg⁺⁺, Ca⁺⁺) form.

TYPICAL APPLICATION

DT-30 Ion Exchanger has been found to be effective for recovery and storage of radionuclides, and for cation exchange from acid solutions.

TYPICAL CHEMICAL AND PHYSICAL CHARACTERISTICS

Particle Size	Mesh (20 X 50)
Pore Openings	3.7 X 4.2A and 2.6A
Ion Exchange Capacity	2.0 - 2.5 meq/gm (anhydrous)
Bulk Density	
Hydrated, packed	46 lbs/cu.ft. (740 kg/cu.m.)
BS&D Density (hydrated).....	38 lbs/cu.ft. (610 kg/cu.m.)
H ₂ O Content	
Hydrated	12 - 17 wt. %

REGENERATION

Typically, regeneration may be accomplished by the use of NaCl solution as the regenerating fluid.

PROCESS FLOW CONDITIONS

Flow conditions:
1-2 gpm/ft³
3-6 gpm/ft²

Media Limitations:

Di- and tri-valent cations will reduce the total capacity of the media. Removal using softening techniques such as IX or nano filtration to extend the life if these are present. Mono-valent cations have little or no effect on the media unless very high concentrations are present.

Diversified Technologies Services, Inc.

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MATERIAL SAFETY DATA SHEET

Revised 9/8/04 Page 1 of 4

DT-30 EXCHANGER

Diversified Technologies PHONE: 865-539-9000
2680 Westcott Blvd., Knoxville, TN 37931

I. PRODUCT IDENTIFICATION

PRODUCT.....
Chemical Name.....
Formula.....
Chemical Family.....

DT-30 Ion-Exchanger (inorganic)
Metal oxide
Proprietary
Inorganic Oxide

HMIS™ Rating		
HAZARD RATING		SCALE
Health	1	4 - Extreme
Flammability	0	3 - High
Reactivity	0	2 - Moderate
Special	-	1 - Slight
		0 - Insignificant

II. HAZARDOUS INGREDIENTS

Material (CAS #)	Wt(%)	1984-85 ACGIH TLV-TWA (OSHA-PEL)
Sodium Oxide	<5	None currently established (None currently established)
Silicon Oxide (7631-86-9)	<65	10 mg/m ³ Total Dust (20 mppcf) 5 mg/m ³ Respirable Dust (None currently established)
Aluminum Oxide (1344-28-1)	<40	Nuisance Particulate (Nuisance Dust) 10 mg/m ³ mg/m ³ Total Dust (15 mg/m ³ Total Dust) 5 mg/m ³ Respirable Dust (5 mg/m ³ /Respirable fraction)
Calcium Oxide (1305-78-8)	<10	2 mg/m ³ (5 mg/m ³)
Iron Oxide (1309-37-1)	<5	5 mg/m ³ Respirable Fume (none currently established)
Magnesium Oxide (1309-48-4)	<5	10 mg/m ³ Respirable Fume (none currently established)
Potassium Oxide (12136-45-7)	<5	None currently established (None currently established)

III. PHYSICAL DATA

A. Boiling Point	Not Applicable
B. Freezing Point	Not Applicable
C. Specific Gravity	1.1
D. Vapor Pressure	Not Applicable
E. Vapor Density	Not Applicable
F. Solubility in Water	Not Applicable
G. % Volatiles by Volume	Not Applicable
H. Evaporation Rate	Not Applicable
I. Appearance	Mesh (granules) or powder
J. Odor	Odorless
K. pH Range	8-11 (in aqueous slurry)

IV. HEALTH HAZARD DATA

Threshold Limit Value: $5\text{mg}/\text{m}^3$ (ACGIH 1984-85) for respirable dust.

A. Eyes: May cause irritation and seen and excess redness of the conjunctiva.

B. Skin Contact: May cause irritation and reddening. Skin absorption: No evidence of adverse effects from available information.

C. Inhalation : May cause irritation of the nose and throat, accompanied by cough and chest discomfort. Prolonged inhalation may cause lung damage. Breathing of dust may aggravate asthma and inflammatory or fibrotic pulmonary disease.

D. Ingestion: No evidence of adverse effects from available information.

V. FIRST AID PROCEDURES

A. Eyes: Eye - Flush eyes with water for 15 minutes.

B. Skin: Wash with soap and water.

C. Inhalation: Inhalation - Remove to fresh air.

D. Ingestion: If ingested in large quantities, drink 2 glasses of water. Induce vomiting if the patient is conscious.

E. Note to Physician: This product is a desiccant and generates heat as it absorbs water. The used product can contain material of a hazardous nature. Identify that material and treat accordingly.

VI. FIRE AND EXPLOSION HAZARD DATA

A. Flash Point: Does not burn

B. Unusual Fire and Explosion Hazards: In their fresh unused state, molecular sieves are not flammable. When exposed to water, however, they can get quite hot. When first wetted they can heat to the boiling point of water. Flooding will reduce the temperature to safe limits.

C. Special Fire Fighting Procedures: Depends on the use of the material. Used material may contain products of a hazardous nature. The user of this product must identify the hazards of the retained material and inform the fire fighters of these hazards.

D. Extinguishing Media: Unused material will not burn. Use media appropriate for surrounding fire.

VII. REACTIVITY DATA

A. Stability: Stable

B. Conditions to Avoid: Moisture (water) can cause rise in temperature which may result in burn.

C. Incompatibility: Avoid Contact with: Sudden contact with high concentrations

D. Hazardous Decomposition Products: Hydrocarbons and other materials that contact the molecular sieve during normal use can be retained on the sieve. It is reasonable to expect that decomposition products will come from these retained materials of use. The molecular sieve itself does not readily decompose unless subjected to extreme temperature or chemical conditions. If such decomposition did occur, product would include the mix of oxides listed in Section II.

E. Hazardous Polymerization: Will not occur

VIII. SPILL OR LEAK PROCEDURES

A. Steps to be Taken in Case Material is Spilled: Sweep the spill area, collect and place the spilled material in a waste disposal container. Avoid raising dust.

B. Waste Disposal Method: Discard any product, residue, disposable container or liner in an environmentally acceptable manner, in full compliance with federal, state and local regulations.

IX. SPECIAL PRECAUTIONS

A. As shipped, contents can become hot when first exposed to water. Prior to handling, saturate with water as follows:

1. Pour contents of one pint can into open tray to about 1/4" depth and place in humidity chamber with several open trays of water for 24 hours. The water trays should contain a total of at least 100 ml of water. (This procedure is recommended for batch ion-exchange); or,

2. Pour contents of one pint can into at least two (2) pints of distilled water contained in PYREX beaker and allow to cool to ambient temperature.

B. Caution: Causes eye irritation. Breathing dust may be harmful. May cause skin irritation. Open container slowly to avoid dust. Do not get in eyes. Avoid breathing dust and prolonged contact with skin. Use with adequate ventilation. Keep container closed. Wash thoroughly after handling. Do not ingest.

C. Before using, you should know the hazards of the products to be adsorbed on the molecular sieve. The products could be flammable or toxic. You should know and follow all the safety precautions related to the adsorbed products.

X. SPECIAL PROTECTION INFORMATION

A. Eye Protection: Safety glasses or goggles as per OSHA 20 CFR 1910.133.

B. Protective Gloves: Recommended

C. Respiratory Protection: Where there is excessive dustiness, wear a respirator selected as per OSHA 29 CFR 1910.134 and approved by NIOSH/MSHA.

D. Ventilation: Local exhaust - as appropriate to minimize dust.

E. Other Protective Equipment: Eyewash Fountain

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PRODUCT TECHNICAL BULLETIN

Revised 9/12/07 Page 1 of 1

DT-47 EXCHANGER

PRODUCT DESCRIPTION

DT-47 Ion Exchanger is a metal oxide form.

TYPICAL APPLICATION

DT-47 Ion Exchanger has been found to be effective for recovery and storage of antimony and some other radionuclides.

TYPICAL CHEMICAL AND PHYSICAL CHARACTERISTICS

Particle Size	Mesh (20 X 50)
Ion Exchange Capacity	>1.0 meq/gm (anhydrous)
Bulk Density	
As shipped	40 lbs/cu.ft. (640 kg/cu.m.)
Hydrated, packed	46 lbs/cu.ft. (740 kg/cu.m.)
BS&D Density (hydrated).....	38 lbs/cu.ft. (610 kg/cu.m.)
H ₂ O Content	
As shipped	1 - 10 wt. %
Hydrated	12 - 17 wt. %

MATERIAL SAFETY DATA SHEET

Revised 8/11/04 Page 1 of 2

DT-47A Antimony Selective Ion Exchange Sorbent

Diversified Technologies Services, Inc.
2680 Westcott Blvd., Knoxville, TN 37931
PHONE 865-539-9000

I. PRODUCT IDENTIFICATION

Product **DT-47A Ion Exchange Sorbent**
Chemical Name **Proprietary Metal Oxide**

II. INGREDIENTS

Proprietary

III. PHYSICAL DATA

A. Boiling Point Not Applicable
B. Melting Point > 3000°F
C. Specific Gravity 1.3 to 1.5
D. Vapor Pressure Not Applicable
E. Evaporation Rate Not Applicable
F. Solubility in Water Insoluble
G. Appearance Brown Crystalline Granules
H. Odor None

IV. HEALTH HAZARD DATA

- A. May cause irritation to the skin, eyes, and respiratory tract.
- B. All materials present a risk by inhalation and should be treated as a nuisance dust, as specified by the American Conference of Governmental Industrial Hygienists (ACGIH).

V. FIRST AID PROCEDURES

- A. Inhalation: Special precautions should be exercised when handling material to reduce or eliminate the possibility of exposure by inhalation of airborne particles. If exposure by inhalation occurs, remove to fresh air and seek medical attention immediately.
- B. Skin: If contact with skin occurs, wash skin with a mild soap and warm water.
- C. Eye: Mild to moderate irritation may occur due to contact with eyes. If contact occurs, irrigate affected eye(s) with copious amounts of sterile water to avoid further irritation. If irritation persists, seek medical attention immediately.

VI. FIRE AND EXPLOSION DATA

- A. Flash Point: N/A
- B. Auto-ignition: N/A
- C. Flammability Limits in air: N/A
- D. Unusual Fire and Explosion Hazards: Product is nonflammable. Not an explosion hazard.

VII. REACTIVITY DATA

- A. With water: Small exotherm
- B. With air: None
- C. With heat: None
- D. With strong oxidizers: None

VIII. SPILL OR LEAK PROCEDURES

- A. Steps to be Taken in Case Material is Spilled: Vacuum or sweep up spills; avoid dusting. Collect in containers or bags. Consult federal, state, and local regulations to determine proper disposal procedures.
- B. RCRA Hazardous Waste No. N/A material is non-hazardous per 40 CFR 261.

IX. SPECIAL PRECAUTIONS

- A. Chemical substance components have been reported to the EPA Office of Toxic Substances in accordance with the requirements of the Toxic Substances Control Act (Title 40 CFR Part 710).

- B. SARA TITLE III

311/312 Hazardous Categories: Adverse effect to target organs
313 Reportable Ingredients: None

X. SPECIAL PROTECTION INFORMATION

- A. Eye Protection: Use safety glasses with side shields and/or chemical goggles.
- B. Ventilation: Use adequate ventilation to meet the exposure limits as listed in Section II.
- C. Respiratory Protection: Where the exposure limit is or may be exceeded, use NIOSH approved respiratory protection. Select the appropriate respiratory device (dust respirator, dust eliminating masks, etc.) based on actual or potential airborne contaminants and their concentrations present.

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BUT NO WARRANTY, EXPRESS OR IMPLIED, IS MADE.**

PRODUCT TECHNICAL BULLETIN

Revised 7/30/90 Page 1 of 1

DT-60 SERIES ANION

RESIN

DT-60 & DT-60N

(Nuclear Grade)

Capacity	1.2 meq/ml
Water Retention	60% maximum
Percent Conversion	90 minimum, or as requested
Percent Chlorides	3 maximum, or as requested
Particle Size	
+16 Mesh	2% maximum
-50 Mesh	0.5% maximum, or as requested
Heavy Metal Content (Dry Weight)	
Iron	50 ppm
Copper	20 ppm
Lead	20 ppm
Sodium	50 ppm
Friability	350 gram average

Diversified Technologies Services, Inc.

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MATERIAL SAFETY DATA SHEET

Revised 12/12/12 Page 1 of 2

Diversified Technologies PHONE 865-539-9000
2680 Westcott Blvd., Knoxville, TN 37931

DT-20/60 MIXED BED RESIN

I. PRODUCT IDENTIFICATION

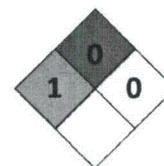
Product
Chemical Name

DT-20/60 Resin
Mixed Bed Strong Acid Cation/
Strong Base Anion Resin

II. HAZARDOUS INGREDIENTS

None

HEALTH	1
FIRE	0
REACTIVITY	0
SPECIAL	



III. PHYSICAL DATA

A. Boiling Point Not Applicable
B. Melting Point Not Applicable
C. Specific Gravity 1.2
D. Vapor Pressure Not Applicable
E. Vapor Density Not Applicable
F. Solubility in Water Insoluble
G. Evaporation Rate Not Applicable
H. Appearance Amber spherical beads
I. Odor Odorless
J. pH Aqueous Slurry 5-7

IV. HEALTH HAZARD DATA:

A. Eyes: Like other foreign bodies, particles may cause irritation of the eye.

V. FIRST AID PROCEDURES

A. Eyes: Flush with large amounts of water for at least 15 minutes. Consult physician if irritation persists.

VI. FIRE AND EXPLOSION HAZARD DATA

A. Flash Point: None
B. Flammable Limits: Auto/Ign. 427°C/800°F (Estimated)
C. Unusual Fire and Explosion Hazards: None
D. Special Fire Fighting Procedures: Wear MSHA/NIOSH approved, pressure demand, self-contained breathing apparatus.
E. Extinguishing Media: CO₂, dry chemical, water fog

VII. REACTIVITY DATA

- A. Stability: Stable
- B. Conditions to Avoid: Avoid temperatures over 220°C, (428°F)
- C. Incompatibility: Avoid Contact with: Concentrated nitric acid or strong oxidizing agents
- D. Hazardous Decomposition or Byproducts: SO₂, SO₃, CO, CO₃, styrene monomer, divinylbenzene
- E. Hazardous Polymerization: Will not occur

VIII. SPILL OR LEAK PROCEDURES

- A. Steps to be Taken in Case Material is Spilled: Resin beads on floor will mechanically cause the floor to be slippery. Use care to avoid falls. Sweep up and transfer to containers for recovery or disposal.
- B. Waste Disposal Method: This material can be disposed of as ordinary trash.

IX. SPECIAL PRECAUTIONS

- A. Store below 49°C (120°F) and above 0°C (32°F)
- B. Keep drums and plastic bag liners sealed to prevent drying or moisture loss.

X. SPECIAL PROTECTION INFORMATION

- A. Eye Protection: Safety glasses (ANSI Z87.1)
- B. Protective Gloves: None
- C. Respiratory Protection: None
- D. Ventilation: Local exhaust - normal plant ventilation

**THE INFORMATION HEREIN IS GIVEN IN GOOD FAITH,
BUT NO WARRANTY, EXPRESS OR IMPLIED, IS MADE.**

MATERIAL SAFETY DATA SHEET

Revised 7/18/90 Page 1 of 4

DT-70 SERIES TREATED CARBON PRODUCTS

Diversified Technologies PHONE 865-539-9000
2680 Westcott Blvd., Knoxville, TN 37931

I. PRODUCT IDENTIFICATION

Product **DT-70 Cobalt Selective Carbon Product**
Chemical Name **Treated (Impregnated) with Carbon Base**

II. COMPOSITIONAL INFORMATION

<u>Material</u> <u>(CAS #)</u>	<u>Wt(%)</u>	<u>TLV (ADGIH)</u>
Activated Carbon (CAS 7440 44 0) (U.N. 1362)	85-95	Not Listed*

* Product normally contains 5-15% treatment solution. Composition of this solution is a trade secret.

III. PHYSICAL DATA

A. Boiling Point	NA
B. Specific Gravity	400-600 g/l
C. Vapor Pressure	(mmHg at 20°C): 0
D. Vapor Density	NA
E. Solubility	Carbon insoluble in water and organic solvents, treatment solution soluble in water
F. pH	NA
G. % Volatile by Volume	<5% (proprietary treatment solution only)
H. Appearance	Black granules or powder
I. Odor	No taste or odor

IV. HEALTH HAZARD DATA:

- A. General: No toxicity data are available. Physical and chemical properties of activated carbon are used for the health hazard assessment.
- B. Carcinogenicity: Activated carbon is not listed in the National Toxicology Program (NTP) Annual report on carcinogens, nor has it been found to be a potential carcinogen in the International Agency for Research on Cancer (IARC) monographs, or by OSHA. The same is true for the proprietary treatment solution.

IV. HEALTH HAZARD DATA Cont'd:

- C. **Eyes:** This material will probably cause physical irritation and injury if contact is made with human eyes.
- D. **Skin Contact:** This material can be a primary irritant on human skin with allergenic reactions.
- E. **Skin Absorption:** Activated carbon is not known to be absorbed through the human skin. Long-term exposure may result in absorption of harmful amounts of proprietary storage solution.
- F. **Inhalation:** Acute toxic effects are not likely to develop after inhalation from this material. Repeated and prolonged exposure may result in respiratory irritation, asthmatic symptoms, sensitization, pulmonary edema, nausea and vomiting.
- G. **Ingestion:** The acute oral LD₅₀ values for activated carbon are not available. Relative to other materials, a single dose of this product is relatively harmless by ingestion. Hodge, H.C., and Sterner, J.H., American Industrial Hygiene Association Quarterly, 10:4, 93, Dec. 1949.

LD₅₀ for proprietary treatment solution in rats, oral - 1160 MG/Kg.
- H. **Effect of Overexposure:** No adverse clinical effects have been associated with exposures to activated carbon. Extreme cases of exposure to proprietary treatment solution may result in muscle weakness and convulsions.

V. FIRST AID PROCEDURES

- A. **Eyes:** Immediately flush with copious amounts of water. If redness, itching, or a burning sensation develops, have eyes examined and treated by medical personnel.
- B. **Skin:** Wash material off the skin with soap and water. If redness, itching, or a burning sensation develops, get medical attention.
- C. **Inhalation:** Remove victim to fresh air. If cough or other respiratory symptoms develop, consult medical personnel.
- D. **Ingestion:** Give one or two glasses of water to drink. If gastrointestinal symptoms develop, consult medical personnel. (Never give anything by mouth to unconscious person.)

VI. FIRE AND EXPLOSION HAZARD DATA

- A. Flash Point: NA
- B. Autoignition Temperature:
 - Powdered - No generally accepted test method available.
 - Granular - About 350°C (ANSI/ASTM D3466)

All carbonaceous materials will burn under certain conditions, and activated carbons are no exception. Activated carbons, however, are not highly flammable, and burn slowly without producing smoke or flame. Can produce toxic NO_x fumes when exposed to high temperatures.

- C. Unusual Fire and Explosion Hazards: Airborne dust is a weak explosion hazard.
- D. Special Fire Fighting Procedures: Use self-contained breathing apparatus.
- E. Extinguishing Media: Water (fog or fine spray), CO₂. Avoid methods which may stir up dust clouds.

VII. REACTIVITY DATA

- A. Stability: Stable under normal conditions.
- B. Conditions to Avoid: High temperatures.
- C. Incompatibility: Avoid Contact with: Strong oxidizing agents, fluorine. Proprietary treatment solution can react violently with acids and oxidizers.
- D. Hazardous Decomposition or Byproducts: CO₂, carbon monoxide, nitrogen compounds including toxic NO_x fumes.
- E. Hazardous Polymerization: Will not occur

VIII. SPILL OR LEAK PROCEDURES

- A. Steps to be Taken in Case Material is Spilled: Extinguish sources of flame or spark; wear respiratory protection during cleanup. Sweep up and recover or mix material with water and shovel into waste container. Wash down spill area with water containing detergent and flush away with plenty of water.
- B. Waste Disposal Method: Dispose of virgin (unused) carbon (waste or spillage) in a facility for non-hazardous wastes.
- C. Container Disposal: Do not reuse empty bags. Dispose of in a facility permitted for non-hazardous waste.

IX. SPECIAL PRECAUTIONS

- A. Activated carbon can be safely stored in any normal storage area, but away from sources of direct heat.
- B. An oxygen deficiency may be created when activated carbon is stored in an enclosed space/silo. Ventilate or wear self-contained breathing apparatus.

X. SPECIAL PROTECTION INFORMATION

- A. Eye Protection: Safety glasses with side shields. Contact lenses should not be worn when working with activated carbon.
- B. Protective Clothing: For personal hygiene purposes, use adequate clothing to prevent skin contact.
- C. Respiratory Protection: If needed, use MSHA-NIOSH approved respirator for dusts, mists, and fumes whose TLV is greater than 0.05 mg/m³.
- D. Ventilation: Provide adequate general and local exhaust ventilation to meet suggested control value requirements.
- E. Other Protective Equipment: Eyewash station in work area.

**THE INFORMATION HEREIN IS GIVEN IN GOOD FAITH,
BUT NO WARRANTY, EXPRESS OR IMPLIED, IS MADE.**

MATERIAL SAFETY DATA SHEET

Revised 7/18/90 Page 1 of 4

DT-90 SERIES TREATED CARBON PRODUCTS

Diversified Technologies PHONE 865-539-9000
2680 Westcott Blvd., Knoxville, TN 37931

I. PRODUCT IDENTIFICATION

Product **DT-90 Cobalt Selective Carbon Product**
Chemical Name **Treated (Impregnated) with Carbon Base**

II. COMPOSITIONAL INFORMATION

<u>Material</u> <u>(CAS #)</u>	<u>Wt(%)</u>	<u>TLV (ADGIH)</u>
Activated Carbon (CAS 7440 44 0) (U.N. 1362)	85-95	Not Listed*

* Product normally contains 5-15% treatment solution. Composition of this solution is a trade secret.

III. PHYSICAL DATA

A. Boiling Point	NA
B. Specific Gravity	400-600 g/l
C. Vapor Pressure	(mmHg at 20°C): 0
D. Vapor Density	NA
E. Solubility	Carbon insoluble in water and organic solvents, treatment solution soluble in water
F. pH	NA
G. % Volatile by Volume	<5% (proprietary trtmnt solutn only)
H. Appearance	Black granules or powder
I. Odor	No taste or odor

IV. HEALTH HAZARD DATA:

- A. General: No toxicity data are available. Physical and chemical properties of activated carbon are used for the health hazard assessment.
- B. Carcinogenicity: Activated carbon is not listed in the National Toxicology Program (NTP) Annual report on carcinogens, nor has it been found to be a potential carcinogen in the International Agency for Research on Cancer (IARC) monographs, or by OSHA. The same is true for the proprietary treatment solution.

IV. HEALTH HAZARD DATA Cont'd:

- C. Eyes: This material will probably cause physical irritation and injury if contact is made with human eyes.
- D. Skin Contact: This material can be a primary irritant on human skin with allergenic reactions.
- E. Skin Absorption: Activated carbon is not known to be absorbed through the human skin. Long-term exposure may result in absorption of harmful amounts of proprietary storage solution.
- F. Inhalation: Acute toxic effects are not likely to develop after inhalation from this material. Repeated and prolonged exposure may result in respiratory irritation, asthmatic symptoms, sensitization, pulmonary edema, nausea and vomiting.
- G. Ingestion: The acute oral LD₅₀ values for activated carbon are not available. Relative to other materials, a single dose of this product is relatively harmless by ingestion. Hodge, H.C., and Sterner, J.H., American Industrial Hygiene Association Quarterly, 10:4, 93, Dec. 1949.

LD₅₀ for proprietary treatment solution in rats, oral - 1160 MG/Kg.
- H. Effect of Overexposure: No adverse clinical effects have been associated with exposures to activated carbon. Extreme cases of exposure to proprietary treatment solution may result in muscle weakness and convulsions.

V. FIRST AID PROCEDURES

- A. Eyes: Immediately flush with copious amounts of water. If redness, itching, or a burning sensation develops, have eyes examined and treated by medical personnel.
- B. Skin: Wash material off the skin with soap and water. If redness, itching, or a burning sensation develops, get medical attention.
- C. Inhalation: Remove victim to fresh air. If cough or other respiratory symptoms develop, consult medical personnel.
- D. Ingestion: Give one or two glasses of water to drink. If gastrointestinal symptoms develop, consult medical personnel. (Never give anything by mouth to unconscious person.)

VI. FIRE AND EXPLOSION HAZARD DATA

- A. Flash Point: NA
- B. Autoignition Temperature:
 - Powdered - No generally accepted test method available.
 - Granular - About 350°C (ANSI/ASTM D3466)

All carbonaceous materials will burn under certain conditions, and activated carbons are no exception. Activated carbons, however, are not highly flammable, and burn slowly without producing smoke or flame. Can produce toxic NO_x fumes when exposed to high temperatures.

- C. Unusual Fire and Explosion Hazards: Airborne dust is a weak explosion hazard.
- D. Special Fire Fighting Procedures: Use self-contained breathing apparatus.
- E. Extinguishing Media: Water (fog or fine spray), CO₂. Avoid methods which may stir up dust clouds.

VII. REACTIVITY DATA

- A. Stability: Stable under normal conditions.
- B. Conditions to Avoid: High temperatures.
- C. Incompatibility: Avoid Contact with: Strong oxidizing agents, fluorine. Proprietary treatment solution can react violently with acids and oxidizers.
- D. Hazardous Decomposition or Byproducts: CO₂, carbon monoxide, nitrogen compounds including toxic NO_x fumes.
- E. Hazardous Polymerization: Will not occur

VIII. SPILL OR LEAK PROCEDURES

- A. Steps to be Taken in Case Material is Spilled: Extinguish sources of flame or spark; wear respiratory protection during cleanup. Sweep up and recover or mix material with water and shovel into waste container. Wash down spill area with water containing detergent and flush away with plenty of water.
- B. Waste Disposal Method: Dispose of virgin (unused) carbon (waste or spillage) in a facility for non-hazardous wastes.
- C. Container Disposal: Do not reuse empty bags. Dispose of in a facility permitted for non-hazardous waste.

IX. SPECIAL PRECAUTIONS

- A. Activated carbon can be safely stored in any normal storage area, but away from sources of direct heat.
- B. An oxygen deficiency may be created when activated carbon is stored in an enclosed space/silo. Ventilate or wear self-contained breathing apparatus.

X. SPECIAL PROTECTION INFORMATION

- A. Eye Protection: Safety glasses with side shields. Contact lenses should not be worn when working with activated carbon.
- B. Protective Clothing: For personal hygiene purposes, use adequate clothing to prevent skin contact.
- C. Respiratory Protection: If needed, use MSHA-NIOSH approved respirator for dusts, mists, and fumes whose TLV is greater than 0.05 mg/m³.
- D. Ventilation: Provide adequate general and local exhaust ventilation to meet suggested control value requirements.
- E. Other Protective Equipment: Eyewash station in work area.

**THE INFORMATION HEREIN IS GIVEN IN GOOD FAITH,
BUT NO WARRANTY, EXPRESS OR IMPLIED, IS MADE.**

DT-99 Cobalt-Selective Resin

PRODUCT DESCRIPTION

DT-99 are premium, nuclear grade weak-acid macroporous cation exchangers with a surface treatment that is designed to be preferential for low and sub-micron particulate removal. These materials are produced using a cross-linked styrene divinylbenzene polymer matrix with 16% cross-linking.

The functional groups of carboxylic give high chemical efficiency in many applications with excellent uptake of alkaline metals and particulate materials.

TYPICAL CHEMICAL AND PHYSICAL CHARACTERISTICS

Polymer Structure	Polyacrylic
Functional Groups	R-COOH
Physical Appearance	Clear Spherical Beads
Ionic Form (as shipped)	Hydrogen (99.9%)
Screen Size, U.S. Std. Mesh (Wet)	+1200 <10%, -300 <1%
Particle Size	16-50 mesh
Water Retention	53-58%
pH Limitations	None
Temperature Limitations	120°C
Whole Bead Count	NA
Shipping Weight	46-48 lbs./ft ³ (750g/l)
Total Capacity	3.7 meq/ml Minimum Volumetric
Standard Packaging	5 ft ³ double polyethylene-lined fiber drums
Color	White/tan translucent

STANDARD OPERATING CONDITIONS

Operation	Rate	Solution	Minutes	Amount
Service	1-5 gpm/ft ³	Influent Water		
Backwash	3-5 gpm/ft ² (40-60°F)	Influent Water	5-20	10-25 gal/ft ³
Regeneration	NA			
Rinse (slow)	NA			
Rinse (fast)	NA			

Diversified Technologies Services, Inc.

2680 Westcott Blvd., Knoxville, TN 37931 PHN 865-539-9000 FAX 865-539-9001 E-Mail info@dts9000.com



Quality Systems & Services for Waste Management

2680 Westcott Blvd.
Knoxville, TN 37931-3111

PHN 865-539-9000
FAX 865-539-9001
Email info@dts9000.com

PRODUCT TECHNICAL BULLETIN

Diversified Technologies' DT-2010

DT-2010 is a solid, granular Superabsorbent Polymer. This cross-linked polyacrylate material swells and absorbs many times its weight in aqueous solutions. DT-2010 has been engineered to absorb under pressure and has properties that make it ideally suited for the absorption and solidification of Low Level Radioactive Waste (LLRW) and Other types of waste sludge.

Product Attributes:

- ✓ **Reduces Waste Disposal Costs** – Expands in Volume by Less Than 1%.
- ✓ Non-Biodegradable Polymer (40 CFR 264.314 (e)(ii))
- ✓ Polycarboxylate Polymer Will Not Release Trapped Ionic Contaminants If Solute Evaporation Occurs.
- ✓ Strong Ion Exchange Capability Allows For Heavy Metal Binding For Many Solidified Wastes To Pass TCLP.
- ✓ When Used Properly, Waste Sludge Will Pass Paint Filter Test (EPA 9095).
- ✓ Polymer is approved by Energy Solutions for Incineration.
- ✓ Freeze-Thaw Tested. The Polymer Will Not Release Free Liquids.
- ✓ Polymer Will Easily Absorb Aqueous Wastes of pH > 4. For Highly Acidic Wastes, Neutralization (pH Adjustment) Is Recommended.
- ✓ **Approved Sorbent at Hanford (WA) & WIPP (TRUCON Codes)**

Typical Absorptive Properties:

Free Swell in DI Water	400 – 500 X
Free Swell in 1% NaCl	45 - 55 X
Free Swell in 2% NaCl	35 - 40 X
Free Swell in 10% NaCl	19 - 25 X
Free Swell in 1% CaCl ₂	20 -25X
Free Swell in 8N NaOH	24 - 30 X

Liquid Release Test (EPS 9096):

DT-2010 has the ability to both absorb under pressure and to retain absorbed liquids at high pressures:

At 25X Hydration, PASSES at 50 psi
At 10X Hydration, PASSES at 75 psi

Bulk Density = 5.4 to 6.0 lbs/gallon

MATERIAL SAFETY DATA SHEET

Revised 11/16/2012 Page 1 of 2

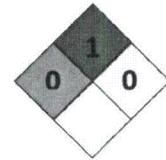
DT-2010 Granular Absorbent Material

Diversified Technologies PHONE 865-539-9000
2680 Westcott Blvd., Knoxville, TN 37931

I. PRODUCT IDENTIFICATION

Product..... **DT-2010**
Chemical Name Proprietary

HEALTH	1
FIRE	0
REACTIVITY	0
SPECIAL	



II. HAZARDOUS INGREDIENTS

None

SARA Section 313 Reportable Toxic Chemicals: None

NFPA/HMIS: Health – 2 Fire – 1 Reactivity – 0 Specific Hazard - None

Guideline for Respirable Particulate: 0.05 mg/m³

III. PHYSICAL DATA

A. Boiling Point Not Applicable
B. Melting Point Not Applicable
C. Bulk Density 0.5-0.7
D. Vapor Pressure <10
E. Vapor Density Nil
F. Solubility in Water..... Insoluble
G. Evaporation Rate <1
H. Appearance White crystals
I. Odor..... Odorless
J. pH..... Aqueous Slurry 5-7

IV. HEALTH HAZARD DATA:

- A. Eyes: Like other foreign bodies, particles may cause irritation of the eye.
- B. Acute inhalation may cause irritation of upper respiratory tract

V. FIRST AID PROCEDURES

- A. Eyes: Flush with large amounts of water for at least 15 minutes. Consult physician if irritation persists.

VI. FIRE AND EXPLOSION HAZARD DATA

- A. Flash Point: None
- B. Flammable Limits: Not available LEL: NE UEL: NE
- C. Unusual Fire and Explosion Hazards: None
- D. Special Fire Fighting Procedures: None
- E. Extinguishing Media: CO₂, dry chemical, water

VII. REACTIVITY DATA

- A. Stability: Stable
- B. Conditions to Avoid: Material forms very slippery gel when wet with water.
Avoid uptake of dust.
- C. Incompatibility: None
- D. Hazardous Decomposition or Byproducts: None
- E. Hazardous Polymerization: Will not occur

VIII. SPILL OR LEAK PROCEDURES

- A. Steps to be Taken in Case Material is Spilled: Media on floor will combines with water will cause the floor to be extremely slippery. Use care to avoid falls. Sweep up and transfer to containers for recovery or disposal, do not use water to mop, vacuuming is appropriate.
- B. Waste Disposal Method: This material can be disposed of as ordinary trash.

IX. SPECIAL PRECAUTIONS

- A. Keep drums and plastic bags sealed to prevent moisture uptake.

X. SPECIAL PROTECTION INFORMATION

- A. Eye Protection: Safety glasses (ANSI Z87.1)
- B. Protective Gloves: None
- C. Respiratory Protection: None
- D. Ventilation: Local exhaust - normal plant ventilation

**THE INFORMATION HEREIN IS GIVEN IN GOOD FAITH,
BUT NO WARRANTY, EXPRESS OR IMPLIED, IS MADE.**

Graver Technologies

GR 1-9 N	
Product Sheet.....	076
GR 2-0 N	
Product Sheet.....	077
GR 2-1 N	
Product Sheet.....	078
GR 2-16 N	
Product Sheet.....	079
GR 3-9 N	
Product Sheet.....	080
GR 3-16 N	
Product Sheet.....	081
MSDS.....	082
GR 4-7 N	
Product Sheet.....	088
GR 4-9 N	
Product Sheet.....	089
MSDS.....	090
GR 7-16 N	
Product Sheet.....	096
GR 7-99 N	
Product Sheet.....	097
POWDEX Products	
Information Sheet.....	098
POWDEX PAO	
Product Sheet.....	100
POWDEX PCM	
Product Sheet.....	101
POWDEX PCN	
Product Sheet.....	102
High Flow Series Filter Cartridges	
Product Sheet.....	103



Graver Technologies

Quality Department

**GRAVEX GR 1-9 N
HYDROXIDE FORM
NUCLEAR GRADE**

SPEC NO	GTS-19-N
REV NO	2
DATE	July 20, 2007

PROPERTIES

Resin Type

Functionality

Matrix

Total Exchange Capacity

Percent of Sites

Particle Size

Friability

Metals (mg/dry kg)

<u>Na</u>	<u>Fe</u>	<u>Cu</u>	<u>Pb</u>	<u>Al</u>	<u>Ca</u>	<u>Mg</u>	<u>K</u>	<u>Zn</u>	<u>SiO₂</u>
50	50	10	10	50	50	50	50	50	50

Water Extractables

Shipping Weight

SPECIFICATIONS

Strongly Basic Type 1 Gel Anion Exchange Resin

Quaternary Ammonium

Styrene-Divinylbenzene

1.2 meq/mL (min)

97% Hydroxide (min)

3% Carbonate (max)

0.1% Chloride (max)

5% plus 16 mesh (max)

5% minus 40 mesh (max)

0.5% minus 50 mesh (max)

350 g/bead average (min)

5% < 200g/bead (max)

(max)

(max)



Graver Technologies

Quality Department

**GRAVEX GR 2-0 N
HYDROGEN FORM
NUCLEAR GRADE**

SPEC NO	GTS-20H-N
REV NO	2
DATE	June 23, 2006
QA APPROVAL	<i>Keith Platoff</i>

PROPERTIES

Resin Type

Functionality

Matrix

Total Exchange Capacity

Conversion

Particle Size

Friability

SPECIFICATIONS

Strongly Acidic Gel Cation Exchange Resin

Sulfonic Acid

Styrene-Divinylbenzene

2 meq/mL (min)

99% Hydrogen (min)

5 % plus 16 mesh (max)

5 % minus 40 mesh (max)

0.5% minus 50 mesh (max)

350 g/bead average (min)

5% <200g/bead (max)

Metals (mg/dry kg)

(max)

Na Fe Cu Pb Al Ca Mg K Zn SiO₂

50 50 10 10 50 50 50 50 50 50

Water Extractables

0.1% (max)

Shipping Weight

50 lbs/ft³ (801 g/L)



Graver Technologies

Quality Department

**GRAVEX GR 2-1 N
HYDROGEN FORM
NUCLEAR GRADE**

SPEC NO	GTS-21H-N
REV NO	1
DATE	July 10, 2001
QA APPROVAL	<i>Keith Platoff</i>

PROPERTIES

Resin Type
Functionality
Matrix
Total Exchange Capacity
Conversion
Particle Size

Whole Uncracked Bead
Whole Cracked Bead
Friability

SPECIFICATIONS

Strongly Acidic Gel Cation Exchange Resin
Sulfonic Acid
Styrene-Divinylbenzene
1.9 meq/mL (min)
99% Hydrogen (min)
5% plus 16 mesh (max)
5% minus 40 mesh (max)
0.5% minus 50 mesh (max)
95% (min)
5% (max)
350 g/bead average (min)
5% <200g/bead (max)

Metals (mg/dry kg) (max)

<u>Na</u>	<u>Fe</u>	<u>Cu</u>	<u>Pb</u>	<u>Al</u>	<u>Ca</u>	<u>Mg</u>	<u>K</u>	<u>Zn</u>	<u>SiO₂</u>
50	50	10	10	50	50	50	50	50	50

Water Extractables 0.1% (max)

Shipping Weight 50 lbs/ft³ (801 g/L)



Graver Technologies

Quality Department

GRAVEX®
GR 2-16 N
HYDROGEN/HYDROXIDE
FORMS

SPEC NO	GTS-216-N
REV NO	0
DATE	August 20, 2002
QA APPROVAL	<i>Keith Platoff</i>

PROPERTIES

Resin Type

Functionality

Matrix

Total Exchange Capacity

Percent of Sites

Particle Size

Friability

Metals (mg/dry kg)

Na

Fe

Cu

Pb

Al

Ca

Mg

K

Zn

SiO₂

50

50

10

10

50

50

50

50

50

50

Water Extractables

0.1%

(max)

Shipping Weight

52 lbs/ft³ (704 g/L)

SPECIFICATIONS

Strongly Acidic Gel Cation Exchange Resin

Sulfonic Acid

Styrene-Divinylbenzene

Cation 2.4 meq/mL

(min)

99% Hydrogen

(min)

5 % plus 16 mesh

(max)

5% minus 40 mesh

(max)

0.5% minus 50 mesh

(max)

350 g/bead average

(min)

5% <200g/bead

(max)

(max)



Graver Technologies

Quality Department

**GRAVEX®
GR 3-9 N
HYDROGEN/HYDROXIDE**

SPEC NO	GTS-39-N
REV NO	2
DATE	July 20, 2007

PROPERTIES

SPECIFICATIONS

Resin Type	Strongly Acidic Gel Cation Exchange Resin									
	Strongly Basic Type 1Gel Anion Exchange Resin									
Functionality	Sulfonic Acid									
	Quaternary Ammonium									
Matrix	Styrene-Divinylbenzene									
Cation : Anion Ratio	1:1 Equivalents									
Total Exchange Capacity	Cation 2 meq/mL									(min)
	Anion 1.2 meq/mL									(min)
Percent of Sites	99% Hydrogen									(min)
	97% Hydroxide									(min)
	0.1% Chloride									(max)
Particle Size	5 % plus 16 mesh									(max)
	5% minus 40 mesh									(max)
	0.5% minus 50 mesh									(max)
Friability	350 g/bead average									(min)
	5% <200g/bead									(max)
Metals (mg/dry kg)										(max)
	<u>Na</u>	<u>Fe</u>	<u>Cu</u>	<u>Pb</u>	<u>Al</u>	<u>Ca</u>	<u>Mg</u>	<u>K</u>	<u>Zn</u>	<u>SiO₂</u>
	50	50	10	10	50	50	50	50	50	50
Water Extractables	0.1%									(max)
Shipping Weight	43 lbs/ft ³ (689 g/L)									



Graver Technologies

Quality Department

**GRAVEX®
GR 3-16 N
HYDROGEN/HYDROXIDE
FORM MIXED BED**

SPEC NO	GTS-316-N
REV NO	1
DATE	July 27, 2006
QA APPROVAL	<i>Keith Platoff</i>

PROPERTIES

SPECIFICATIONS

Resin Type	Strongly Acidic Gel Cation Exchange Resin Strongly Basic Type 1Gel Anion Exchange Resin								
Functionality	Sulfonic Acid Quaternary Ammonium								
Matrix	Styrene-Divinylbenzene								
Cation : Anion Ratio	1:1 Equivalentents								
Total Exchange Capacity	Cation 2.4 meq/mL (min) Anion 1.2 meq/mL (min)								
Moisture Content	Cation 36 - 42% Anion 53 - 59%								
Percent of Sites	99% Hydrogen (min) 97% Hydroxide (min) 0.1% Chloride (max)								
Particle Size	5 % plus 16 mesh (max) 5% minus 40 mesh (max) 0.2% minus 50 mesh (max)								
Friability	350 g/bead average (min) 5% <200g/bead (max)								
Metals (mg/dry kg)	(max)								
<u>Na</u>	<u>Fe</u>	<u>Cu</u>	<u>Pb</u>	<u>Al</u>	<u>Ca</u>	<u>Mg</u>	<u>K</u>	<u>Zn</u>	<u>SiO₂</u>
50	50	10	10	50	50	50	50	50	50
Water Extractables	0.1%								(max)
Shipping Weight	44 lbs/ft ³ (704 g/L)								



Graver Technologies

MATERIAL SAFETY DATA SHEET

Emergency Phone: 800-533-6623
Information Phone: 800-533-6623
Fax Number: 973-690-5808

HAZARD RATING		
Toxicity	1	4=EXTREME
Fire	1	3=HIGH
Reactivity	0	2=MODERATE
Special	N/A	1=SLIGHT 0=INSIGNIFICANT

PRODUCT IDENTIFICATION

Product Name: GRAVEX® GR 3-16N
Ionic Form: Cation/Anion exchange resins (Hydrogen/Hydroxide forms)
MSDS Code: MS-GR316N
Effective Date: 6/13/02

1. COMPONENT INFORMATION

<u>No.</u>	<u>CAS No.</u>	<u>AMT.(%)</u>
1) Sulfonated copolymer of styrene and divinylbenzene in the hydrogen form.	Not Assigned	15-21
2) Trimethylamine functionalized, chlormethylated copolymer of styrene and divinylbenzene in the hydroxide form.	069011-18-3	25-34
3) Water	007732-18-5	45-60

2. PHYSICAL DATA

MELTING POINT: Not applicable
BOILING POINT: Not applicable
VAPOR PRESSURE (mm Hg): 17mm Hg @20°C/68°F
VAPOR DENSITY (Air=1): Not applicable
SOLUBILITY IN WATER: Insoluble

2. PHYSICAL DATA (continued)

SPECIFIC GRAVITY (water=1): 1.1 - 1.3
EVAPORATION RATE (Butyl acetate=1): < 1 Water
PERCENT VOLATILITY: 45-60% Water
APPEARANCE: Light tan to dark amber solid (beads).
ODOR: Slight amine odor

3. EXPOSURE LIMIT INFORMATION

<u>COMPONENT NO.</u>	<u>OSHA</u>		<u>ACGIH</u>	
	<u>TWA</u>	<u>STEL</u>	<u>TLV</u>	<u>STEL</u>
1	None	None	None	None
2	None	None	None	None
3	None	None	None	None

4. FIRE AND EXPLOSION HAZARD DATA

FLASH POINT: Not Applicable

METHOD USED: Not Applicable

AUTO-IGNITION TEMPERATURE: 500°C/932°F. Product is not combustible until moisture is removed, then resin starts to burn in flame at 230°C/446°F.

LOWER EXPLOSIVE LIMIT: Not Applicable

UPPER EXPLOSIVE LIMIT: Not Applicable

FIRE FIGHTING EQUIPMENT: Wear positive pressure self-contained breathing apparatus.

EXTINGUISHING AGENTS: Use the following extinguishing media when fighting fires involving this material: 1) carbon dioxide 2) dry chemical 3) water spray

5. REACTIVITY DATA

STABILITY: Stable under normal handling and storage conditions.
(see incompatibility statement).

5. REACTIVITY DATA (continued)

INCOMPATIBILITY: (SPECIFIC MATERIALS TO AVOID) WARNING:
Oxidizing agents such as nitric acid attack organic ion exchange resin under certain conditions and could result in a slightly degraded resin up to an explosive reaction. Before using strong oxidizing agents, consult sources knowledgeable in handling such materials.

HAZARDOUS DECOMPOSITION PRODUCTS: Thermal decomposition may yield the following: Alkylbenzenes, vinylbenzenes, naphthalene, benzaldehydes, phenol, sulfur oxides, organic sulfates, organic amines, carbon dioxide, hydrochloric acid, carbon monoxide, nitrogen oxides, ammonia, chlorine, methyl chloride, water

HAZARDOUS POLYMERIZATION: Product will not undergo polymerization.

6. ENVIRONMENTAL AND DISPOSAL INFORMATION

ACTION TO TAKE FOR SPILLS/LEAKS: Sweep up. Caution: May be slippery.

DISPOSAL METHOD: DO NOT DUMP INTO ANY SEWERS, ON THE GROUND OR INTO ANY BODY OF WATER. Bury resin in licensed landfill, or burn in approved incinerator according to local, state, and federal regulations. For resin contaminated with hazardous material, dispose of mixture as hazardous material according to local, state, and federal regulations. Waste characterizations and compliance with applicable laws are the responsibility solely of the waste generator. GRAVER TECHNOLOGIES, INC. HAS NO CONTROL OVER THE MANAGEMENT PRACTICES OR MANUFACTURING PROCESSES OF PARTIES HANDLING OR USING THIS MATERIAL.

7. HEALTH HAZARD DATA

EYE: May cause severe eye irritation. May cause moderate corneal injury. Effects are likely to heal. Flush with water for a minimum of 15 minutes. Consult a physician if irritation persists.

SKIN CONTACT: Prolonged or repeated exposure may cause skin irritation. If irritation occurs, wash affected area with water. Consult a physician if irritation persists.

SKIN ABSORPTION: Skin absorption is unlikely due to physical properties.

INGESTION: Single dose oral LD50 has not been determined. Single dose oral toxicity is believed to be low. No hazards anticipated from ingestion incidental to industrial exposure. If swallowed, call a physician.

7. HEALTH HAZARD DATA (continued)

INHALATION: Vapors are unlikely due to physical properties.

SYSTEM & OTHER EFFECTS: No specific data available, however, repeated exposures are not anticipated to cause any significant adverse effects.

8. PERSONAL PROTECTION MEASURES

EXPOSURE GUIDELINES: None established.

VENTILATION: Good general ventilation should be sufficient.

RESPIRATORY PROTECTION: A respiratory protection program meeting **OSHA 1910.134** and **ANSI Z88.2** requirements must be followed whenever workplace conditions warrant a respirator's use. None required under normal operating conditions.

EYE PROTECTION: Use safety glasses **ANSI Z87.1** or approved equivalent.

SKIN & HAND PROTECTION: Avoid skin contact. When using this substance, use skin protection (clean body-covering clothing). Cotton, latex, rubber or canvas gloves for the hands.

OTHER PROTECTIVE EQUIPMENT: Facilities storing or utilizing this material should be equipped with an eyewash facility.

9. STORAGE AND HANDLING INFORMATION

STORAGE CONDITIONS: The minimum recommended storage temperature for this material is 3°C/38°F. The maximum recommended storage temperature for this material is 60°C/140°F. Avoid repeated freezing; beads may fracture.

9. STORAGE AND HANDLING INFORMATION (continued)

HANDLING PROCEDURES: The maximum recommended operating temperature for this material is 60°C/140°F. **NOTE:** This product as supplied is a whole bead ion exchange resin and may produce slight eye irritation. However, the ground form of this resin should be treated as a severe eye irritant. Worker exposure to ground resins can be controlled with local exhaust ventilation at the point of dust generation, or the use of suitable personal protective equipment (dust/mist air-purifying respirator and safety goggles). Properly designed equipment is vital if these ion exchange resins are to be used in conjunction with strong oxidizing agents such as nitric acid to prevent a rapid build up of pressure and possible explosion. Consult a source knowledgeable in the handling of these materials before proceeding. **Do not pack column with dry ion exchange resins.** Dry beads expand when wetted; this expansion can cause glass columns to shatter.

10. REGULATORY INFORMATION

WORKPLACE CLASSIFICATIONS: This product is considered non-hazardous under OSHA Hazard Communication Standard (29CFR 1910.1200).

This product is not a 'Controlled Product' under the Canadian Workplace Hazardous Materials Information System (WHMIS).

TRANSPORTATION CLASSIFICATIONS: US DOT Hazard Class - Non-regulated

EMERGENCY PLANNING & COMMUNITY RIGHT-TO-KNOW (SARA TITLE 3):

Section 311/312 Categorizations (40CFR 370) This product is not a hazardous chemical under 29CFR 1910.1200, and therefore is not covered by Title III of SARA.

Section 313 Information (40CFR 372) This product does not contain a chemical which is listed in Section 313 above de minimis concentrations.

EMERGENCY PLANNING & COMMUNITY RIGHT-TO-KNOW (SARA TITLE 3):

CERCLA Information (40CFR 302.4) Releases of this material to air, land, or water are not reportable to the National Response Center under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) or to state and local emergency planning committee under the Superfund Amendments and Reauthorization Act (SARA Title III Section 304).

RCRA Information When a decision is made to discard this material as supplied, it does not meet RCRA's characteristic definition of ignitability, corrosivity, or reactivity, and is not listed in 40CFR 261.33. The toxicity characteristic (TC), however, has not been evaluated by the Toxicity Characteristic Leaching Procedure (TCLP).

Chemical Control Law Status All components of this product are listed or are excluded from listing on the U.S. Toxic Substance Control Act (TSCA) Chemical Substance Inventory.

GRAVEX® is a trademark of Graver Technologies

Abbreviations:

ACGIH - American Conference of Governmental Industrial Hygienists
OSHA - Occupational Safety and Health Administration
TLV - Threshold limit Value
TWA - Time Weighted Average
STEL - Short Term Exposure Limit

The above information contained herein relates to the specific material identified. Graver Technologies believes that such information is accurate and reliable as of the date of this material safety data sheet, but no representation, guarantee or warranty, express or implied, is made as to the accuracy, reliability, or completeness of the information. Graver Technologies urges persons receiving this information to make their own determination as to the information's suitability and completeness for their particular application. Consult Graver Technologies for further information.



Graver Technologies

Quality Department

GRAVEX®
GR 4-7 N
LITHIUM-7/HYDROXIDE FORMS

SPEC NO	GTS-47-N
REV NO	0
DATE	August 21, 2006

PROPERTIES

Resin Type

Functionality

Matrix

Cation : Anion Ratio

Total Exchange Capacity

Percent of Sites

Particle Size

Metals (mg/dry kg)

Shipping Weight

SPECIFICATIONS

Strongly Acidic Gel Cation Exchange Resin

Strongly Basic Type 1 Gel Anion Exchange Resin

Sulfonic Acid

Quaternary Ammonium

Styrene-Divinylbenzene

1:1 Equivalent

Cation 2.4 meq/mL (Lithium-7 Form)

Anion 1.1 meq/mL (Hydroxide Form)

99% Lithium-7

1% Hydrogen

97% Hydroxide

0.1% Chloride

5 % plus 16 mesh

5% minus 40 mesh

0.5% minus 50 mesh

50 Na

50 Fe

10 Cu

10 Pb

50 Al

43 lbs/ft³ (689 g/L)

(min)

(min)

(min)

(max)

(min)

(max)

(max)

(max)

(max)

(max)

(max)

(max)

(max)

(max)



Graver Technologies

Quality Department

**GRAVEX®
GR 4-9 N
LITHIUM-7/HYDROXIDE
FORMS**

SPEC NO	GTS-49-N
REV NO	5
DATE	April 25, 2001
QA APPROVAL	<i>Keith Platoff</i>

PROPERTIES

Resin Type

Functionality

Matrix

Cation : Anion Ratio

Total Exchange Capacity

Percent of Sites

Particle Size

Metals (mg/dry kg)

<u>Na</u>	<u>Fe</u>	<u>Cu</u>	<u>Pb</u>	<u>Al</u>	<u>Ca</u>	<u>Mg</u>	<u>K</u>	<u>Zn</u>	<u>SiO₂</u>
50	50	10	10	50	50	50	50	50	50

Shipping Weight

SPECIFICATIONS

Strongly Acidic Gel Cation Exchange Resin

Strongly Basic Type 1 Gel Anion Exchange Resin

Sulfonic Acid

Quaternary Ammonium

Styrene-Divinylbenzene

1:1 Equivalentents

Cation 1.6 meq/mL (Lithium-7 Form) (min)

Anion 1.1 meq/mL (Hydroxide Form) (min)

99% Lithium-7 (min)

97% Hydroxide (min)

0.1% Chloride (max)

5 % plus 16 mesh (max)

5% minus 40 mesh (max)

0.5% minus 50 mesh (max)

(max)

43 lbs/ft³ (689 g/L)



Graver Technologies

MATERIAL SAFETY DATA SHEET

Emergency Phone: 800-533-6623
Information Phone: 800-533-6623
Fax Number: 973-690-5808

HAZARD RATING		
Toxicity	1	4=EXTREME
Fire	1	3=HIGH
Reactivity	0	2=MODERATE
Special	N/A	1=SLIGHT 0=INSIGNIFICANT

PRODUCT IDENTIFICATION

Product Name: GRAVEX® GR 4-9 N
Ionic Form: Cation/Anion exchange resins (Lithium-7/Hydroxide forms)
MSDS Code: MS-GR49N
Effective Date: 4/22/02

1. COMPONENT INFORMATION

<u>No.</u>	<u>CAS No.</u>	<u>AMT.(%)</u>
1) Sulfonated copolymer of styrene and divinylbenzene in the Lithium-7 form.	068584-06-5	15-20
2) Trimethylamine functionalized, chlormethylated copolymer of styrene and divinylbenzene in the hydroxide form.	069011-18-3	20-30
3) Water	007732-18-5	50-65

2. PHYSICAL DATA

MELTING POINT: Not applicable
BOILING POINT: Not applicable
VAPOR PRESSURE (mm Hg): 17mm Hg @20°C/68°F
VAPOR DENSITY (Air=1): Not applicable
SOLUBILITY IN WATER: Insoluble
SPECIFIC GRAVITY (water=1): 1.1 - 1.4

2. PHYSICAL DATA (continued)

EVAPORATION RATE (Butyl acetate=1): < 1 Water
 PERCENT VOLATILITY: 50-65% Water
 APPEARANCE: White to dark amber solid (beads).
 ODOR: Slight amine odor

3. EXPOSURE LIMIT INFORMATION

<u>COMPONENT NO.</u>	<u>OSHA</u>		<u>ACGIH</u>	
	<u>TWA</u>	<u>STEL</u>	<u>TLV</u>	<u>STEL</u>
1	None	None	None	None
2	None	None	None	None
3	None	None	None	None

4. FIRE AND EXPLOSION HAZARD DATA

FLASH POINT: Not Applicable

METHOD USED: Not Applicable

AUTO-IGNITION TEMPERATURE: 500°C/932°F. Product is not combustible until moisture is removed, then resin starts to burn in flame at 230°C/446°F.

LOWER EXPLOSIVE LIMIT: Not Applicable

UPPER EXPLOSIVE LIMIT: Not Applicable

FIRE FIGHTING EQUIPMENT: Wear positive pressure self-contained breathing apparatus.

EXTINGUISHING AGENTS: Use the following extinguishing media when fighting fires involving this material: 1) carbon dioxide 2) dry chemical 3) water spray

5. REACTIVITY DATA

STABILITY: Stable under normal handling and storage conditions.
(see incompatibility statement).

5. REACTIVITY DATA (continued)

INCOMPATIBILITY: (SPECIFIC MATERIALS TO AVOID) WARNING:
Oxidizing agents such as nitric acid attack organic ion exchange resin under certain conditions and could result in a slightly degraded resin up to an explosive reaction. Before using strong oxidizing agents, consult sources knowledgeable in handling such materials.

HAZARDOUS DECOMPOSITION PRODUCTS: Thermal decomposition may yield the following: Alkylbenzenes, vinylbenzenes, naphthalene, benzaldehydes, phenol, sulfur oxides, organic sulfates, organic amines, carbon dioxide, hydrochloric acid, carbon monoxide, nitrogen oxides, ammonia, chlorine, methyl chloride, water

HAZARDOUS POLYMERIZATION: Product will not undergo polymerization.

6. ENVIRONMENTAL AND DISPOSAL INFORMATION

ACTION TO TAKE FOR SPILLS/LEAKS: Sweep up. Caution: May be slippery.

DISPOSAL METHOD: DO NOT DUMP INTO ANY SEWERS, ON THE GROUND OR INTO ANY BODY OF WATER. Bury resin in licensed landfill, or burn in approved incinerator according to local, state, and federal regulations. For resin contaminated with hazardous material, dispose of mixture as hazardous material according to local, state, and federal regulations. Waste characterizations and compliance with applicable laws are the responsibility solely of the waste generator. GRAVER TECHNOLOGIES, INC. HAS NO CONTROL OVER THE MANAGEMENT PRACTICES OR MANUFACTURING PROCESSES OF PARTIES HANDLING OR USING THIS MATERIAL.

7. HEALTH HAZARD DATA

EYE: May cause severe eye irritation. May cause moderate corneal injury. Effects are likely to heal. Flush with water for a minimum of 15 minutes. Consult a physician if irritation persists.

SKIN CONTACT: Prolonged or repeated exposure may cause skin irritation. If irritation occurs, wash affected area with water. Consult a physician if irritation persists.

SKIN ABSORPTION: Skin absorption is unlikely due to physical properties.

INGESTION: Single dose oral LD50 has not been determined. Single dose oral toxicity is believed to be low. No hazards anticipated from ingestion incidental to industrial exposure. If swallowed, call a physician.

7. HEALTH HAZARD DATA (continued)

INHALATION: Vapors are unlikely due to physical properties.

SYSTEM & OTHER EFFECTS: No specific data available, however, repeated exposures are not anticipated to cause any significant adverse effects.

8. PERSONAL PROTECTION MEASURES

EXPOSURE GUIDELINES: None established.

VENTILATION: Good general ventilation should be sufficient.

RESPIRATORY PROTECTION: A respiratory protection program meeting OSHA 1910.134 and ANSI Z88.2 requirements must be followed whenever workplace conditions warrant a respirator's use. None required under normal operating conditions.

EYE PROTECTION: Use safety glasses ANSI Z87.1 or approved equivalent.

SKIN & HAND PROTECTION: Avoid skin contact. When using this substance, use skin protection (clean body-covering clothing). Cotton, latex, rubber or canvas gloves for the hands.

OTHER PROTECTIVE EQUIPMENT: Facilities storing or utilizing this material should be equipped with an eyewash facility.

9. STORAGE AND HANDLING INFORMATION

STORAGE CONDITIONS: The minimum recommended storage temperature for this material is 3°C/38°F. The maximum recommended storage temperature for this material is 60°C/140°F. Avoid repeated freezing; beads may fracture.

HANDLING PROCEDURES: The maximum recommended operating temperature for this material is 60°C/140°F. **NOTE:** This product as supplied is a whole bead ion exchange resin and may produce slight eye irritation. However, the ground form of this resin should be treated as a severe eye irritant. Worker exposure to ground resins can be controlled with local exhaust ventilation at the point of dust generation, or the use of suitable personal protective equipment (dust/mist air-purifying respirator and safety goggles). Properly designed equipment is vital if these ion exchange resins are to be used in conjunction with strong oxidizing agents such as nitric acid to prevent a rapid build up of pressure and possible explosion. Consult a source knowledgeable in the handling of these materials before proceeding. **Do not pack column with dry ion exchange resins.** Dry beads expand when wetted; this expansion can cause glass columns to shatter.

10. REGULATORY INFORMATION

WORKPLACE CLASSIFICATIONS: This product is considered non-hazardous under OSHA Hazard Communication Standard (29CFR 1910.1200).

This product is not a 'Controlled Product' under the Canadian Workplace Hazardous Materials Information System (WHMIS).

TRANSPORTATION CLASSIFICATIONS: US DOT Hazard Class - Nonregulated

EMERGENCY PLANNING & COMMUNITY RIGHT-TO-KNOW (SARA TITLE 3):

Section 311/312 Categorizations (40CFR 370) This product is not a hazardous chemical under 29CFR 1910.1200, and therefore is not covered by Title III of SARA.

Section 313 Information (40CFR 372) This product does not contain a chemical which is listed in Section 313 above de minimis concentrations.

EMERGENCY PLANNING & COMMUNITY RIGHT-TO-KNOW (SARA TITLE 3):

CERCLA Information (40CFR 302.4) Releases of this material to air, land, or water are not reportable to the National Response Center under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) or to state and local emergency planning committee under the Superfund Amendments and Reauthorization Act (SARA Title III Section 304).

RCRA Information When a decision is made to discard this material as supplied, it does not meet RCRA's characteristic definition of ignitability, corrosivity, or reactivity, and is not listed in 40CFR 261.33. The toxicity characteristic (TC), however, has not been evaluated by the Toxicity Characteristic Leaching Procedure (TCLP).

Chemical Control Law Status All components of this product are listed or are excluded from listing on the U.S. Toxic Substance Control Act (TSCA) Chemical Substance Inventory.

GRAVEX® is a trademark of Graver Technologies

Abbreviations:

ACGIH - American Conference of Governmental Industrial Hygienists

OSHA - Occupational Safety and Health Administration

TLV - Threshold limit Value

TWA - Time Weighted Average

STEL - Short-Term Exposure Limit

The above information contained herein relates to the specific material identified. Graver Technologies believes that such information is accurate and reliable as of the date of this material safety data sheet, but no representation, guarantee or warranty, express or implied, is made as to the accuracy, reliability, or completeness of the information. Graver Technologies urges persons receiving this information to make their own determination as to the information's suitability and completeness for their particular application. Consult Graver Technologies for further information.



Graver Technologies

Quality Department

GRAVEX[®]
GR 7-16 N
LITHIUM-7 FORM

SPEC NO	GTS-716-N
REV NO	0
DATE	February 10, 2004
QA APPROVAL	<i>Keith Platoff</i>

PROPERTIES

Resin Type

Functionality

Matrix

Total Exchange Capacity

Percent of Sites

Particle Size

Metals (mg/dry kg)

<u>Na</u>	<u>Fe</u>	<u>Cu</u>	<u>Pb</u>	<u>Al</u>	<u>Ca</u>	<u>Mg</u>	<u>K</u>	<u>Zn</u>	<u>SiO₂</u>
50	50	10	10	50	50	50	50	50	50

Shipping Weight

52 lbs/cu. ft. (832 g/L)

SPECIFICATIONS

Strongly Acidic Cation
Exchange Resin

Sulfonic Acid

Styrene-Divinybenzene

2.4 meq/mL (Lithium-7 Form) (min)

99% Lithium-7 (min)

5 % plus 16 mesh (max)

5% minus 40 mesh (max)

0.5% minus 50 mesh (max)

(max)



Graver Technologies

Quality Department

GRAVEX[®]
GR 7-99 N
LITHIUM-7 FORM

SPEC NO	GTS-799-N
REV NO	1
DATE	May 7, 2004
QA APPROVAL	<i>Keith Platoff</i>

PROPERTIES

Resin Type

Functionality

Matrix

Total Exchange Capacity

Percent of Sites

Particle Size

Metals (mg/dry kg)

<u>Na</u>	<u>Fe</u>	<u>Cu</u>	<u>Pb</u>	<u>Al</u>	<u>Ca</u>	<u>Mg</u>	<u>K</u>	<u>Zn</u>	<u>SiO₂</u>
50	50	10	10	50	50	50	50	50	50

Shipping Weight

50 lbs/cu. ft. (801 g/L)

SPECIFICATIONS

Strongly Acidic Cation
Exchange Resin

Sulfonic Acid

Styrene-Divinylbenzene

1.6 meq/mL (Lithium-7 Form) (min)

99% Lithium-7 (min)

5 % plus 16 mesh (max)

5% minus 40 mesh (max)

0.5% minus 50 mesh (max)

(max)



Graver Technologies

POWDEX® SELECTION GUIDE

PRODUCT	TYPE	MATRIX	FUNCTIONALITY	IONIC FORM	TOTAL CAPACITY meq/dryg	% MOISTURE	% IONIC CONVERSION
POWDEX							
PAO	SBA TYPE I	Styrene DVB Gel	-N ⁺ -(CH ₃) ₃	OH ⁻	4	50-60	95
PACL	SBA TYPE I	Styrene DVB Gel	-N ⁺ -(CH ₃) ₃	Cl ⁻	3.8	40-60	99
PAS	SBA TYPE II	Styrene DVB Gel	-N ⁺ -(CH ₃) ₂ CH ₂ CH ₂ OH	Cl ⁻	4	55-75	99
PCH	SAC	Styrene DVB Gel	-SO ₃ ⁻	H ⁺	5	45-62	99
PCN	SAC	Styrene DVB Gel	-SO ₃ ⁻	NH ₄ ⁺	4.5	40-60	95
PCM	SAC	Styrene DVB Gel	-SO ₃ ⁻	Morpholinium	4.8 H Form	40-60	90
PCNA	SAC	Styrene DVB Gel	-SO ₃ ⁻	Na ⁺	4.8	40-60	95
PKH	WAC	Acrylic DVB Macro	-COOH	H ⁺	7.5	40-60	95
POWDEX PREMIX							
Wt Ratio							
22 H	SAC-H	Styrene DVB Gel	-SO ₃ ⁻	1:1	2.5	50-70	99
	SBA-OH		-N ⁺ -(CH ₃) ₃		2		95
32 H	SAC-H	Styrene DVB Gel	-SO ₃ ⁻	1.5:1	2.9	50-70	99
	SBA-OH		-N ⁺ -(CH ₃) ₃		1.6		95
42 H	SAC-H	Styrene DVB Gel	-SO ₃ ⁻	2:1	3.2	50-70	99
	SBA-OH		-N ⁺ -(CH ₃) ₃		1.3		95
62 H	SAC-H	Styrene DVB Gel	-SO ₃ ⁻	3:1	3.7	50-70	99
	SBA-OH		-N ⁺ -(CH ₃) ₃		1		95
82 H	SAC-H	Styrene DVB Gel	-SO ₃ ⁻	4:1	3.9	50-70	99
	SBA-OH		-N ⁺ -(CH ₃) ₃		0.8		95
45 H	SAC-H	Styrene DVB Gel	-SO ₃ ⁻	1:1	2.2	50-70	99
	SBA-OH		-N ⁺ -(CH ₃) ₃	Capacity	2.2		95
46 H	SAC-H	Styrene DVB Gel	-SO ₃ ⁻	2:3	2	50-75	99
	SBA-OH		-N ⁺ -(CH ₃) ₃		2.4		95
24 H	SAC-H	Styrene DVB Gel	-SO ₃ ⁻	1:2	1.6	50-75	99
	SBA-OH		-N ⁺ -(CH ₃) ₃		2.6		95
28 H	SAC-H	Styrene DVB Gel	-SO ₃ ⁻	1:4	1	50-75	99
	SBA-OH		-N ⁺ -(CH ₃) ₃		3.2		95
22 N	SAC-NH ₄	Styrene DVB Gel	-SO ₃ ⁻	1:1	2.3	50-75	95
	SBA-OH		-N ⁺ -(CH ₃) ₃		2		95
32 N	SAC-NH ₄	Styrene DVB Gel	-SO ₃ ⁻	1.5:1	2.7	50-75	95
	SBA-OH		-N ⁺ -(CH ₃) ₃		1.6		95
42 N	SAC-NH ₄	Styrene DVB Gel	-SO ₃ ⁻	2:1	3	50-70	95
	SBA-OH		-N ⁺ -(CH ₃) ₃		1.3		95
62 N	SAC-NH ₄	Styrene DVB Gel	-SO ₃ ⁻	3:1	3.4	50-70	95
	SBA-OH		-N ⁺ -(CH ₃) ₃		1		95

POWDEX® AND POWDEX PREMIX™

Powdex ion exchange resins and premixed versions are powdered bead resins. The cation and anion exchange resins are typically cross-linked styrene divinylbenzene copolymers. They are commonly referred to as strongly acidic and strongly basic ion exchange resins. The beads are specially processed and highly regenerated prior to grinding. The grinding process is precisely controlled to achieve target particle sizes. The small particles provide rapid kinetic response.

When the negatively charged cation exchange resin and the positively charged anion exchange resin powders are mixed in an aqueous slurry, they agglomerate to form large floc particles. The slurry is then precoated on filter septa such as, Aegis®, DualGuard® and AFA® filters, among others. Excellent hydraulic properties are achieved with much higher flux rates than can be attained with similarly sized media. The precoat depth is typically 1/4" to 3/8" (~ 6 to 9 mm) although even thinner layers may be used to achieve some high-purity deionization.

The large surface area provided by the fine particles and the resultant floc structure of the agglomerate, permit the filtration of suspended solids while maintaining the rapid kinetics necessary for dissolved solids removal at fast flow rates. The electrokinetic nature of the resin precoat enables the attraction and adsorption of colloids and color bodies. Both Powdex and Powdex Premix products are recommended for high-purity polishing applications, when the concentrations of soluble and particulate impurities are relatively low.

APPLICATIONS

Condensate Polishing

High flow rate condensate polishing was the original application for Powdex products. They were developed to provide an economical means of providing simultaneous filtration and deionization for start-up and steady-state operation. Water quality is maintained during small condenser leaks as shown in the simulated leak test in Figure 1.



Graver Technologies

200 Lake Drive,
Glasgow, DE 19702 U.S.A.

800-249-1990
302-731-1700
Fax: 302-731-1707

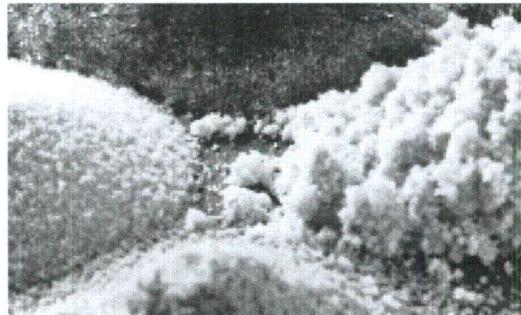
e-mail: info@gravertech.com
web site: www.gravertech.com

Fuel Pool and Reactor Water Cleanup

Silica and other dissolved solids are easily removed from the reactor. Fuel pool parameters are maintained by the Powdex System continuously filtering and cleaning. New products include very high content anion premixes for silica and thermally stable anion for higher temperature operation.

Radwaste

Powdex resin operating capacity is up to 90% or more of the total ion exchange capacity. In addition to filtration, ionic species such as iodine, cobalt and silica as well as organics are removed.



Bead Resin, Powdex and Premix

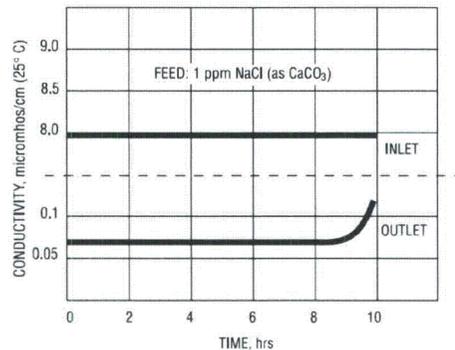


Figure 1: Simulated condenser leak test with POWDEX

Please contact Graver Technologies today at
1-800-249-1990 (24-hour service) or
E-mail: info@gravertech.com
Visit our website: www.gravertech.com

All Graver Technologies resins are manufactured in accordance with a quality assurance program meeting the requirements of Title 10 of the Code of Federal Regulations, Part 50, Appendix B (10CFR50 App. B). Our resins are all individually QC tested assuring quality and purity.



Graver Technologies

Quality Department

POWDEX[®]
PAO
HYDROXIDE FORM

SPEC NO	GTS-PX1000
REV NO	3
DATE	June 23, 2005

PROPERTIES

SPECIFICATIONS

Resin Type	Strongly Basic Anion Exchange Resin	
Functionality	Quaternary Ammonium	
Matrix	Styrene-Divinylbenzene	
Total Moisture	50 – 60%	
Total Exchange Capacity	4 meq/dry g	(min)
Percent of Sites	95% Hydroxide	(min)
	0.5% Chloride	(max)
	0.5% Sulfate	(max)
Metals (mg/dry kg)	50 Sodium	(max)
	50 Iron	(max)
	10 Copper	(max)



Graver Technologies

Quality Department

**POWDEX[®]
PCM
MORPHOLINIUM FORM**

SPEC NO	GTS-PX4000
REV NO	1
DATE	May 2, 2001
QA APPROVAL	<i>Keith Platoff</i>

PROPERTIES

Resin Type

Functionality

Matrix

Total Moisture

Total Exchange Capacity

Percent of Sites

Metals (mg/dry kg)

Percent Bead

SPECIFICATIONS

Strongly Acidic Cation Exchange Resin

Sulfonic Acid

Styrene-Divinylbenzene

40 - 60%

4.8 meq/dry g (Hydrogen Form)

90% Morpholinium

100 Sodium

50 Iron

10 Copper

7%

(min)

(min)

(max)

(max)

(max)

(max)



Graver Technologies

Quality Department

POWDEX[®]
PCN
AMMONIUM FORM

SPEC NO	GTS-PX3000
REV NO	2
DATE	May 2, 2001
QA APPROVAL	<i>Keith Platoff</i>

PROPERTIES

Resin Type

Functionality

Matrix

Total Moisture

Total Exchange Capacity

Percent of Sites

Metals (mg/dry kg)

Percent Bead

SPECIFICATIONS

Strongly Acidic Cation Exchange Resin

Sulfonic Acid

Styrene-Divinylbenzene

40 - 60%

4.5 meq/dry g

95% Ammonium

100 Sodium

50 Iron

10 Copper

7%

(min)

(min)

(max)

(max)

(max)

(max)



Graver Technologies

Filtration | Separation | Purification

High Flow Series Filter Cartridges

Large Geometry Pleated Filters for High Flow

Graver High Flow Series filters feature a larger geometry to handle higher flows with fewer filter elements. The result is much faster, easier filter changeouts. In addition, the inside to outside flow allows for excellent dirt holding capacity, extending the time between filter changeouts. Filter housings are also available and because of the filters high flow and dirt holding capacity, smaller systems are possible, reducing upfront capital costs.

Features - Benefits

- 6" diameter, large geometry for high flow rates
- Absolute retention ratings from 1 to 100 microns
- Capable of flow rates up to 500 GPM in a single 60" element
- Inside-out flow retains contaminant even during changeout
- Multi layer pleated construction with optimized surface area
- Outer cage prevents media extrusion problem experienced with some competitive offerings
- Unique Quad Seal gasket provides maximum seal integrity
- Retrofits competitive high flow filter housings
- Thermally bonded construction

Product Specifications

Media/Support/Cage:	Polypropylene
End caps:	Polypropylene
O-rings:	EPDM, Silicone, Buna-N, Viton
Micron ratings:	1, 3, 5, 10, 20, 40, 60, 100 μ m

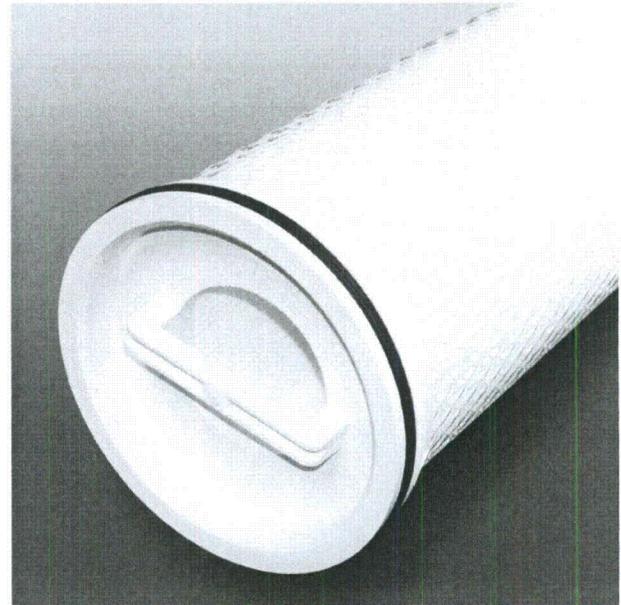
Dimensions

Nominal lengths:	20", 40", 60" (50.8, 101.6, 152.4 cm)
Outside diameter:	6.0" (15.2 cm)
Surface area:	24 ft ² . (2.2 m ²) per 20" element 49 ft ² . (4.6 m ²) per 40" element 73 ft ² . (6.8 m ²) per 60" element

Operating Parameters

Maximum operating temperature:	180°F @ 20 psid (82°C @ 1.4 bar) 160°F @ 30 psid (71°C @ 2.1 bar) 77°F @ 50 psid (25°C @ 3.4 bar)
Recommended changeout differential pressure:	35 psid (2.4 bar)
Maximum flow rates*:	60" element up to 500 GPM (1892 lpm) 40" element up to 350 GPM (1325 lpm) 20" element up to 175 GPM (662 lpm)

* Consult factory for sizing assistance based on particle loads.



Certifications

FDA Listed Materials - All Materials comply with FDA Title 21 of the Code of Federal Regulations Sections 174.5, and 177.1520, as applicable for food and beverage contact.

NSF 61 - Certified to NSF/ANSI STD 61 for materials requirements only - Component.



Certified to
NSF/ANSI Standard 61 for
materials requirements only.

COMPONENT

Typical Applications

- Water Systems
- Chemicals
- Food and Beverage
- Pre RO

High Flow Nomenclature Information

High Flow	5	-60	E
Filter Type High Flow Series Filters	Retention Rating (microns) 1 20 3 40 5 60 10 100	Length (inches) -20 -40 -60	O-Ring S Silicone B Buna-N E EPDM V Viton

Example: HF 5-60E

High Flow Pressure Drop

Micron	Element Pressure Drop psid/gpm			Element Pressure Drop Mbar/M ³ /Hr		
	20"	40"	60"	20"	40"	60"
1	0.0200	0.0097	0.0065	6.0845	2.9395	1.9820
3	0.0167	0.0081	0.0054	5.0705	2.4495	1.6516
5	0.0076	0.0037	0.0025	2.3179	1.1198	0.7550
10	0.0046	0.0022	0.0015	1.3908	0.6719	0.4530
20	0.0021	0.0010	0.0007	0.6374	0.3079	0.2076
40	0.0017	0.0008	0.0006	0.5215	0.2520	0.1699
60	0.0015	0.0007	0.0005	0.4552	0.2199	0.1483
100	0.0010	0.0005	0.0003	0.3035	0.1466	0.0989

Note: For chemical compatibility, flow rates, and temperature requirements please consult the factory or your local Graver distributor.

Removal Efficiency

Micron Rating	99.9% Beta 1000	99% Beta 100	90% Beta 10
1 micron	1	0.6	0.2
3 micron	3	2	1.5
5 micron	5	4	3
10 micron	10	8.5	6.5
20 micron	22	19	14
40 micron	38	18	15
60 micron	60	35	20
100 micron	100	75	45

$$\text{Beta Ratio} = \frac{\text{Upstream particle counts}}{\text{Downstream particle counts}}$$

The micron ratings shown at various efficiency and beta ratio value levels were determined through laboratory testing, and can be used as a guide for selecting cartridges and estimating their performance. Under actual field conditions, results may vary somewhat from the values shown due to the variability of filtration parameters.

Testing was conducted using the single-pass test method, water at 3 gpm/10" cartridge. Contaminants included latex beads, coarse and fine test dust. Removal efficiencies were determined using dual laser source particle counters.

For more information

Graver Technologies Customer Service: **1-888-353-0303**

Technical Support: **1-888-353-0303**

E-mail us at info@gravertech.com

Graver Technologies Europe (UK): **+44-1424-777791**

DISTRIBUTED BY:

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Rohm and Hass Company

AMBERLITE IRN77	
Product Sheet.....	106
AMBERLITE IRN78	
Product Sheet.....	108
AMBERLITE IRN97 H	
Product Sheet.....	110
AMBERLITE IRN99	
Product Sheet.....	112
AMBERLITE IRN150	
Product Sheet.....	114
MSDS.....	116
AMBERLITE IRN160	
Product Sheet.....	122
AMBERLITE IRN170	
Product Sheet.....	124
AMBERLITE IRN217	
Product Sheet.....	126
AMBERLITE IRN317	
Product Sheet.....	128

PRODUCT DATA SHEET

AMBERLITE™ IRN77
Nuclear Grade Strong Acid Cation Resin

AMBERLITE IRN77 resin is a uniform particle size strongly acidic gel type polystyrene cation exchanger supplied in the hydrogen form. This resin is Nuclear Grade and processed to the highest purity standards to meet the most stringent requirements of the nuclear power industry. AMBERLITE IRN77 resin

contains a minimum of 99 % of its exchange sites in the hydrogen form.

The uniform particle size and the absence of fine resin beads results in a lower pressure drop compared to conventional resins.

PHYSICAL CHARACTERISTICS

Physical form _____	Spherical amber beads
Matrix _____	Styrene divinylbenzene copolymer
Functional group _____	Sulfonic acid
Ionic form as shipped _____	H ⁺
Total exchange capacity ^[2] _____	≥ 1.90 eq/L (H ⁺ form)
Moisture holding capacity ^[1] _____	49 to 55 % (H ⁺ form)
Shipping weight _____	800 g/L
Particle size	
Uniformity coefficient ^[1] _____	≤ 1.2
Harmonic mean size ^[1] _____	0.600 to 0.700mm
< 0.300 mm ^[1] _____	0.2 % max
Whole beads _____	≥ 95 %
Breaking weight (average) _____	≥ 350 g/bead
> 200 g/bead _____	≥ 95 %
Ionic conversion ^[1] _____	≥ 99 % H ⁺

^[1] Contractual value

^[2] Average value calculated from statistical quality control

SUGGESTED OPERATING CONDITIONS

Maximum operating temperature _____	120 °C
Minimum bed depth _____	800 mm
Service flow rate _____	8 to 50 BV*/h
Service velocity _____	60 m/h maximum

* 1 BV (Bed Volume) = 1 m³ solution per m³ resin

PURITY

The manufacturing process for this resin is controlled to keep inorganic impurities at the lowest possible level. Special treatment procedures are also used to remove traces of soluble organic compounds. These high standards of resin purity will help keep nuclear systems free of contaminants and deposits, and prevent increases in radioactivity levels due to activation of impurities in the reactor core.

Purity	mg/kg dry resin
Al	≤ 50
Ca	≤ 50
Co	≤ 30
Cu	≤ 10
Fe	≤ 50
Hg	≤ 20
K	≤ 40
Mg	≤ 50
Na	≤ 50
Pb	≤ 10

APPLICATIONS

AMBERLITE IRN77 resin has proved highly effective in the following applications:

Primary water treatment:

Removal of fission products, activated corrosion products, and suspended matter. It is also used to control the pH of the reactor coolant stream by removing the excess ⁷Lithium.

Radwaste treatment:

Removal of radioactive cations such as ¹³⁷Cesium from waste streams.

Decontamination:

Removal of cationic radioactive material from spent decontaminating solutions.

HYDRAULIC CHARACTERISTICS

Resin handling

To maintain the high purity of nuclear grade resins, deionised water should be used for all resin handling. If the resin requires backwashing, the bed should be expanded a minimum of 50%. See figure 1.

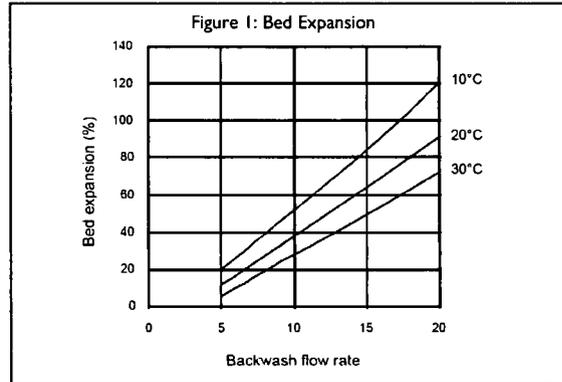
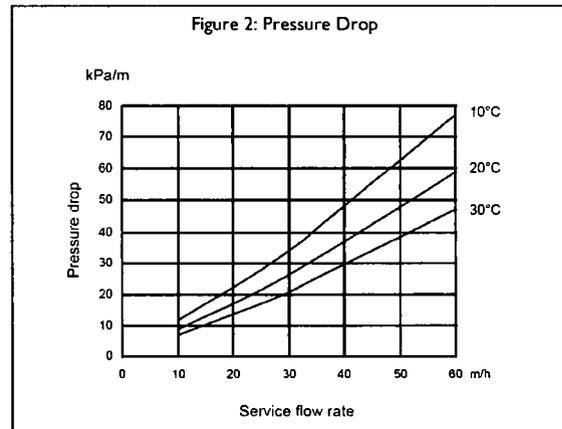


Figure 2 shows the approximate pressure drop for each meter of bed depth of AMBERLITE IRN77 resin in normal downflow operation at various temperatures and flow rates. Pressure drop data are valid at the start of the service run with clear water.



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PRODUCT DATA SHEET

AMBERLITE™ IRN78 Nuclear Grade Strong Base Anion Resin

AMBERLITE IRN78 resin is a uniform particle size strongly basic gel type polystyrene anion exchange resin supplied in the hydroxide form. This resin is nuclear grade and processed to the highest purity standards required for treating water in the nuclear power industry.

AMBERLITE IRN78 resin contains a minimum of 95% of the exchange sites in the hydroxide form and a maximum of 0.1 % in the chloride form. The uniform particle size and the absence of fine resin beads results in a lower pressure drop compared to conventional resins.

PROPERTIES

Physical form _____	Yellow spherical beads
Matrix _____	Styrene divinylbenzene copolymer
Functional group _____	Trimethylammonium
Ionic form as shipped _____	OH ⁻
Total exchange capacity ^[2] _____	≥ 1.20 eq/L (OH ⁻ form)
Moisture holding capacity ^[1] _____	54 to 60 % (OH ⁻ form)
Shipping weight _____	690 g/L
Particle size	
Uniformity coefficient ^[1] _____	≤ 1.2
Harmonic mean size ^[1] _____	0.580 to 0.680 mm
< 0.300 mm ^[1] _____	0.2 % max
Whole beads _____	≥ 95 %
Breaking weight (average) _____	≥ 350 g/bead
> 200 g/bead _____	≥ 95 %
Ionic conversion ^[1] _____	≥ 95 % OH ⁻
	≤ 5 % CO ₃ ⁼
	≤ 0.1 % Cl ⁻
	≤ 0.1 % SO ₄ ⁼

^[1] Contractual value

^[2] Average value calculated from statistical quality control

Test methods and SQC charts are available on request.

SUGGESTED OPERATING CONDITIONS

Maximum operating temperature _____	60 °C
Minimum bed depth _____	800 mm
Service flow rate _____	8 to 50 BV*/h
Service velocity _____	60 m/h maximum

* 1 BV (Bed Volume) = 1 m³ solution per m³ resin

PURITY

The manufacturing process for this resin is controlled to keep inorganic impurities at the lowest possible level. Special treatment procedures are also used to remove traces of soluble organic compounds. These high standards of resin purity will help keep nuclear systems free of contaminants and deposits, and prevent increases in radioactivity levels due to activation of impurities in the reactor core.

Purity	mg/kg dry resin
Al	≤ 50
Ca	≤ 50
Co	≤ 30
Cu	≤ 10
Fe	≤ 50
Hg	≤ 20
K	≤ 40
Mg	≤ 50
Na	≤ 50
Pb	≤ 10
Total Cl	≤ 500
SiO ₂	≤ 100
Total SO ₄	≤ 600

APPLICATIONS

AMBERLITE IRN78 resin has proved highly effective in the following applications:

Primary water treatment:

AMBERLITE IRN78 resin is very effective in removing ¹³¹Iodine and ¹³⁵Iodine as well as traces of chloride contamination from reactor coolant systems. It is also useful to control the boron level in the primary system.

Radwaste treatment:

AMBERLITE IRN78 resin is very effective in removing radioactive anions such as ¹³¹Iodine and ¹³⁵Iodine from waste systems.

Decontamination:

AMBERLITE IRN78 resin removes anionic radioactive material from spent decontaminating solutions.

Steam generator blow down purification:

AMBERLITE IRN78 resin is effective in removing anionic impurities from secondary streams in the presence of ammonia, morpholine or other amines at elevated pH.

HYDRAULIC CHARACTERISTICS

Resin handling

To maintain the high purity of nuclear grade resins, deionized water should be used for all resin handling. If the resin requires backwashing, the bed should be expanded a minimum of 50 %. See figure 1.

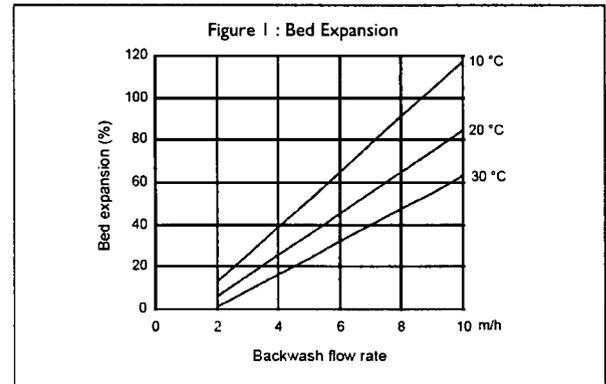
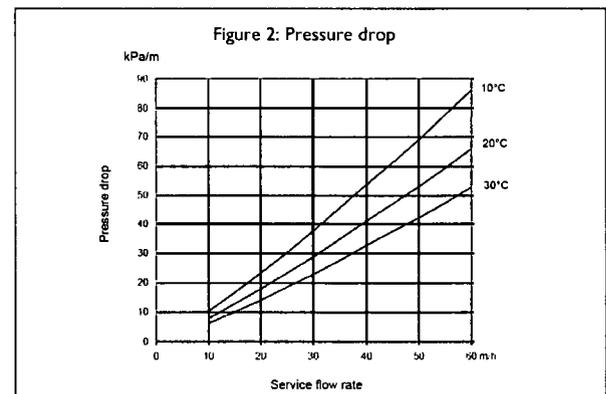


Figure 2 shows the approximate pressure drop for each meter of bed depth of AMBERLITE IRN78 resin in normal downflow operation at various temperatures and flow rates. Pressure drop data are valid at the start of the service run with clear water.



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PRODUCT DATA SHEET

AMBERLITE™ IRN97 H
Nuclear Grade Strong Acid Cation Resin

AMBERLITE IRN97 H resin is a uniform particle size strongly acidic high capacity gelular polystyrene cation exchanger supplied in the hydrogen form. This resin is Nuclear Grade and processed to the highest purity standards to meet the most stringent requirements of the nuclear power industry.

AMBERLITE IRN97 H resin contains a minimum of 99 % of its exchange sites in the hydrogen form.

The uniform particle size and the absence of fine resin beads results in a lower pressure drop compared to conventional resins.

PHYSICAL CHARACTERISTICS

Physical form _____	Dark amber translucent spherical beads
Matrix _____	Polystyrene divinylbenzene copolymer
Functional group _____	Sulfonic acid
Ionic form as shipped _____	H ⁺
Total exchange capacity ¹²¹ _____	≥ 2.15 eq/L (H ⁺ form)
Moisture holding capacity ¹¹¹ _____	45 to 51 % (H ⁺ form)
Shipping weight _____	800 g/L
Particle size	
Uniformity coefficient ¹¹¹ _____	≤ 1.2
< 0.300 mm ¹¹¹ _____	0.1 % max
Whole beads _____	≥ 98 %
Breaking weight (average) _____	≥ 350 g/head
> 200 g/head _____	≥ 95 %
Ionic conversion ¹¹¹ _____	≥ 99 % H ⁺

¹¹¹ Contractual value

¹²¹ Average value calculated from statistical quality control

SUGGESTED OPERATING CONDITIONS

Maximum operating temperature _____	120 °C
Minimum bed depth _____	800 mm
Service flow rate _____	8 to 50 BV*/h
Service velocity _____	60 m/h maximum

* 1 BV (Bed Volume) = 1 m³ solution per m³ resin

PURITY

The manufacturing process for this resin is controlled to keep inorganic impurities at the lowest possible level. Special treatment procedures are also used to remove traces of soluble organic compounds. These high standards of resin purity will help keep nuclear systems free of contaminants and deposits, and prevent increases in radioactivity levels due to activation of impurities in the reactor core.

Purity	mg/kg dry resin
Al	≤ 50
Cu	≤ 10
Fe	≤ 50
Na	≤ 50

APPLICATIONS

AMBERLITE IRN97 H resin has proved highly effective in the following applications:

Primary water treatment:

Removal of fission products, activated corrosion products, and suspended matter. It is also used to control the pH of the reactor coolant stream by removing the excess ⁷Lithium.

Radwaste treatment:

Removal of radioactive cations such as ¹³⁷Cesium from waste streams.

Decontamination:

Removal of cationic radioactive material from spent decontaminating solutions.

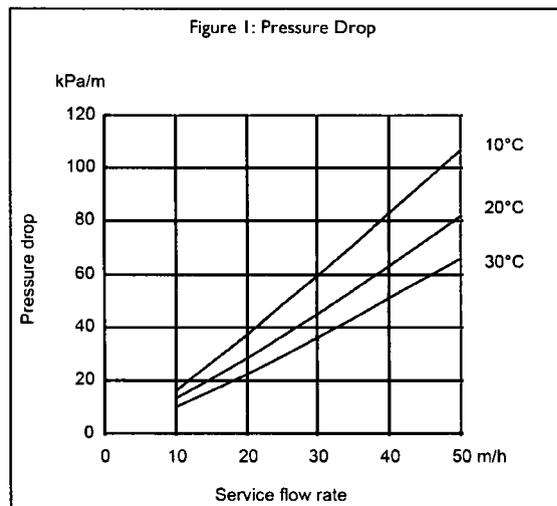
Stream generators blowdown purification:

The high capacity of AMBERLITE IRN97 H resin provides a long service cycle in the removal of cationic impurities in the presence of ammonia.

HYDRAULIC CHARACTERISTICS

Pressure drop

The approximate pressure drop for each meter of bed depth of AMBERLITE IRN97 H resin in normal downflow operation at various temperatures and flow rates is shown in the graph below. Pressure drop data are valid at the start of the service run with a clear water.



LIMITS OF USE

AMBERLITE IRN97 H resin is suitable for industrial uses. For other specific applications such as pharmaceutical, food processing or potable water applications, it is recommended that all potential users seek advice from Rohm and Haas in order to determine the best resin choice and optimum operating conditions.

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PRODUCT DATA SHEET

AMBERLITE™ IRN99

Nuclear Grade High Capacity Strong Acid Cation Resin

AMBERLITE IRN99 resin is a nuclear grade, gel type, strong acid cation exchange resin with a combination of very high capacity and oxidative stability that enables a completely new level of performance in nuclear power applications. It is sold in the fully regenerated Hydrogen form and intended for use in *non-regenerable* single bed or mixed bed nuclear systems which demand the ultimate in effluent purity, operating capacity, and resin life. The particle size of Amberlite IRN99 resin is specifically designed to give an optimized balance of pressure drop, exchange kinetics, and resistance to separation from the anion exchange resin, Amberlite IRN78 resin, when used in a mixed bed.

In BWR condensate polishing, Amberlite IRN99 resin can help to achieve the lowest possible reactor water sulfate levels. The exceptionally high DVB crosslinker level of Amberlite IRN99 resin gives it the best oxidative stability of any gel cation resin available, thus minimizing the release of sulfonic acid leachables. Also Amberlite IRN99 resin is made at a particle size which reduces the chance of creating

a separated cation resin layer at the bottom on the mixed bed service vessel.

The very high total capacity of Amberlite IRN99 resin, typically **2.5 eq/L**, delivers another important benefit, not only in BWR condensate polishing, but also in other nuclear applications such as PWR steam generator blowdown treatment, PWR primary system CVCS resin beds, and even radioactive waste demineralizers. The high total cation exchange capacity can produce a 15 to 30% increase in operating throughput. Since the nuclear grade resins from all these applications are generally disposed of as rad waste, high capacity and long resin bed life are critical to minimizing rad waste disposal cost and volume. For most users, rad waste disposal cost will often exceed resin purchase cost, so high resin capacity directly translates into savings in these non-regenerable nuclear applications. Furthermore, longer bed life means fewer bed change-outs, less work, less resin handling, and less chance for radiation exposure

PHYSICAL CHARACTERISTICS

Physical form _____	Dark amber translucent spherical beads
Matrix _____	Polystyrene divinylbenzene copolymer
Functional group _____	Sulfonic acid
Conversion to H ⁺ form _____	≥ 99 %
Total exchange capacity _____	≥ 2.40 eq/L (H ⁺ form)
Moisture holding capacity _____	37 to 43 % (H ⁺ form)
Shipping weight _____	52.4 lb/ft ³ (840 g/L)
Particle size	
Uniformity coefficient _____	≤ 1.2
Through 50 mesh (0.300 mm) _____	0.1 % max
Friability average _____	≥ 350 g/bead
> 200 g/bead _____	≥ 95 %
Na _____	50 mg/kg dry maximum
Al _____	50 mg/kg dry maximum
Fe _____	50 mg/kg dry maximum
Cu _____	10 mg/kg dry maximum
Heavy Metals as Pb _____	10 mg/kg dry maximum

SUGGESTED OPERATING CONDITIONS

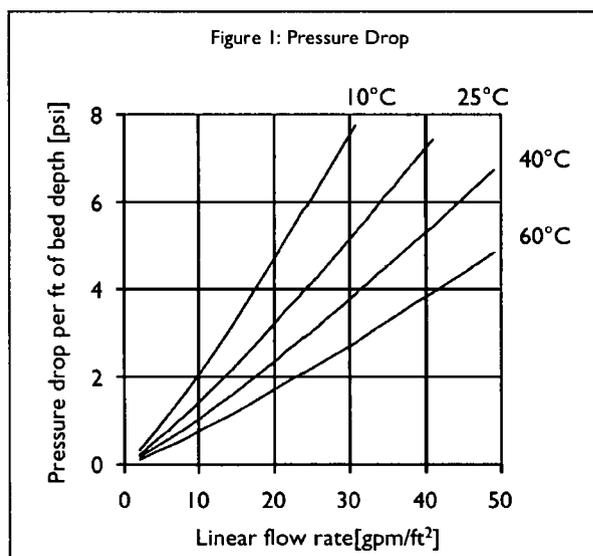
Maximum operating temperature _____	60 to 140 °F (15 to 60°C)
Minimum bed depth _____	36 inches
Service flow rate for condensate polishing (LV) _____	50 gpm/ft ²
Service flow rate for other applications (SV) _____	1 to 6 gpm/ft ³ (8 to 50 BV/h)

HYDRAULIC CHARACTERISTICS

The figure shows the pressure drop data for AMBERLITE IRN99 resin as a single component resin, as a function of service flow rate and water temperature. Pressure drop data are for clean, classified beds which have not accumulated solids during the service run. If the bed accumulates solids, the pressure drop would increase. The pressure drop of a mixed bed can be approximated by summing the component pressure drops.

LIMITS OF USE

AMBERLITE IRN99 resin is suitable for industrial uses. For other specific applications such as pharmaceutical, food processing or potable water applications, it is recommended that all potential users seek advice from Rohm and Haas in order to determine the best resin choice and optimum operating conditions.



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PRODUCT DATA SHEET

AMBERLITE™ IRN150
Nuclear Grade Mixed Bed Resin

AMBERLITE IRN150 resin is a mixture of uniform particle size gel polystyrene cation and anion exchange resins. AMBERLITE IRN150 resin as supplied contains a stoichiometric equivalent of the strongly acidic cation and the strongly basic anion

exchange resins. It is supplied in the fully regenerated H⁺/OH⁻ form. The resin combines the properties of high capacity and excellent physical strength.

PROPERTIES

Physical form _____	Spherical beads	
Matrix _____	Styrene divinylbenzene copolymer	
Shipping weight _____	690 g/L	
Functional group _____	Cation resin	Anion resin
Ionic form as shipped _____	Sulphonic acid	Trimethylammonium
Total exchange capacity ^[2] _____	H ⁺	OH ⁻
Moisture holding capacity ^[1] _____	≥ 1.90 eq/L (H ⁺ form)	≥ 1.20 eq/L (OH ⁻ form)
Particle size	49 to 55 % (H ⁺ form)	54 to 60 % (OH ⁻ form)
Harmonic mean size ^[1] _____	0.600 to 0.700 mm	0.580 to 0.680 mm
Uniformity coefficient ^[1] _____	≤ 1.2 (for each component)	
< 0.300 mm ^[1] _____	0.2 % max	
Whole beads _____	≥ 95 %	
Breaking weight (average) _____	≥ 350 g/bead	
> 200 g/bead _____	≥ 95 %	
Ionic conversion ^[1] _____	≥ 99 % H ⁺	≥ 95 % OH ⁻
CO ₃ ⁼ _____	-	≤ 5 %
Cl ⁻ _____	-	≤ 0.1 %
SO ₄ ⁼ _____	-	≤ 0.1 %

^[1] Contractual value

^[2] Average value calculated from statistical quality control

Test methods and SQC charts are available on request.

SUGGESTED OPERATING CONDITIONS

Maximum operating temperature _____	60 °C
Minimum bed depth _____	800 mm
Service flow rate _____	8 to 50 BV*/h
Maximum Service velocity _____	60 m/h

* 1 BV (Bed Volume) = 1 m³ solution per m³ resin

PURITY

AMBERLITE IRN150 resin is designated as a nuclear grade resin and is manufactured using special processing procedures. These procedures, combined with a Rohm and Haas process to reduce the chloride content of the anion component, produce material of the ultimate purity and yield a product meeting the exacting demands of the nuclear industry.

AMBERLITE IRN150 resin is recommended in any non-regenerable mixed bed application where reliable production of the highest quality water is required and where the "as supplied" resin must have an absolute minimum of ionic and non-ionic contamination.

Purity	Cation mg/kg dry resin	Anion
Al	≤ 50	≤ 50
Ca	≤ 50	≤ 50
Co	≤ 30	≤ 30
Cu	≤ 10	≤ 10
Fe	≤ 50	≤ 50
Hg	≤ 20	≤ 20
K	≤ 40	≤ 40
Mg	≤ 50	≤ 50
Na	≤ 50	≤ 20
Pb	≤ 10	≤ 10
Total Cl		≤ 500
SiO ₂		≤ 100
Total SO ₄		≤ 600

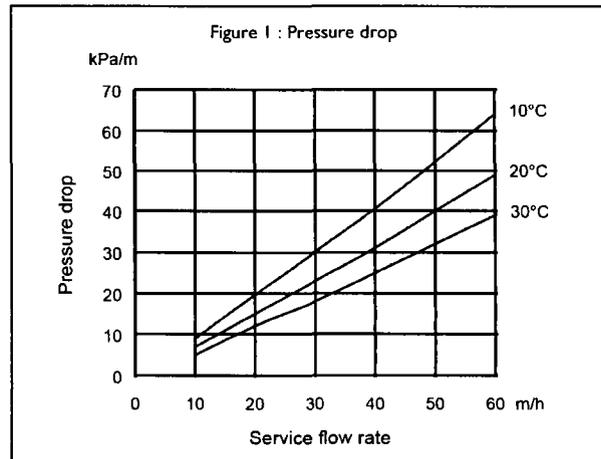
APPLICATIONS

The purity and physical stability of AMBERLITE IRN150 resin provides unsurpassed performance in nuclear applications such as decontamination of primary water. AMBERLITE IRN150 resin can also be used for a variety of radwaste applications.

HYDRAULIC CHARACTERISTICS

Pressure drop

The approximate pressure drop for each meter of bed depth of AMBERLITE IRN150 resin in normal downflow operation at various temperatures and flow rates is shown in the graph below.



RESIN HANDLING

To maintain the high purity of nuclear grade resins, deionized water should be used for all resin handling. Contact of the resin with air should also be minimized to avoid CO₂ pickup and subsequent loss of capacity of the anion resin.

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Independence Mall West
Philadelphia, PA 19105

HEALTH EMERGENCY : 215-592-3000
SPILL EMERGENCY : 215-592-3000
OTHER : 800-424-9300
CHEMTRAC : 800-424-9300

MATERIAL SAFETY DATA SHEET

PRODUCT IDENTIFICATION

AMBERLITE® IRN-150 Resin

Product Code : 69855
Key : 891090-3
MSDS Date : 07/22/91
Supersedes : 11/08/88

Rohm and Haas Hazard Rating		Scale
Toxicity	1	4=EXTREME 3=HIGH
Fire	1	2=MODERATE 1=SLIGHT
Reactivity	0	0=INSIGNIFICANT
Special	-	

Product as supplied is a mixed bed ion exchange resin, strongly acidic cation, hydrogen ion form and strongly basic anion, hydroxide ion form.

COMPONENT INFORMATION

No.	CAS REG NO.	AMT.(%)
1 Sulfonated divinylbenzene/styrene copolymer, H ion form	39389-20-3	35-50
2 Quat amine divinylbenzene/styrene copolymer, OH ion form	9017-79-2	
3 Water	7732-18-5	50-65

EMERGENCY RESPONSE INFORMATION

FIRST AID PROCEDURES

Eye Contact

Flush eyes with a large amount of water for at least 15 minutes. Consult a physician if irritation persists.

Skin Contact

Wash affected skin areas thoroughly with soap and water.

FIRE FIGHTING INFORMATION

Unusual Hazards

Combustion generates toxic fumes of the following:
- sulfur oxides - nitrogen oxides

Extinguishing Agents

Use the following extinguishing media when fighting fires involving this material:
- carbon dioxide - dry chemical - water spray

CONTINUED

CONTINUATION

Personal Protective Equipment

Wear self-contained breathing apparatus (pressure-demand MSHA/NIOSH approved or equivalent) and full protective gear.

SPILL OR LEAK HANDLING INFORMATION

Personal Protection

Wear gloves made of the following material:
- butyl rubber
Additional personal protective equipment should include the following:
- safety glasses (ANSI Z87.1 or approved equivalent)

Procedures

Floor may be slippery; use care to avoid falling. Transfer spilled material to suitable containers for recovery or disposal.

HAZARD INFORMATION

HEALTH EFFECTS FROM OVEREXPOSURE

Eye Contact

Material can cause the following:
- irritation

Skin Contact

Prolonged or repeated skin contact can cause the following:
- slight skin irritation

FIRE AND EXPLOSIVE PROPERTIES

Flash Point	Not Applicable
Auto-ignition Temperature	500°C/932°F Estimate
Lower Explosive Limit	Not Applicable
Upper Explosive Limit	Not Applicable

REACTIVITY INFORMATION

Instability

This material is considered stable under specified conditions of storage, shipment and/or use. See **STORAGE AND HANDLING INFORMATION** Section for specified conditions. However, avoid temperatures above 200C/392F.

CONTINUED



CONTINUATION

Hazardous Decomposition Products

Thermal decomposition may yield the following:
- monomer vapors - sulfur oxides - alkylamines - oxides of nitrogen

Hazardous Polymerization

Product will not undergo polymerization.

Incompatibility

Avoid contact with strong oxidizing agents, particularly concentrated nitric acid.

ACCIDENT PREVENTION INFORMATION

COMPONENT EXPOSURE INFORMATION

Component Information

No.		CAS REG NO.	AMT.(%)
1	Sulfonated divinylbenzene/styrene copolymer, H ion form	39389-20-3	35-50
2	Quat amine divinylbenzene/styrene copolymer, OH ion form	9017-79-2	
3	Water	7732-18-5	50-65

Exposure Limit Information

Component No.	Units	ROHM AND HAAS		OSHA		ACGIH	
		TWA	STEL	TWA	STEL	TLV	STEL
1		None	None	None	None	None	None
2		None	None	None	None	None	None
3		None	None	None	None	None	None

PERSONAL PROTECTION MEASURES

Respiratory Protection

A respiratory protection program meeting OSHA 1910.134 and ANSI Z88.2 requirements must be followed whenever workplace conditions warrant a respirator's use. None required under normal operating conditions.

Eye Protection

Use safety glasses (ANSI Z87.1 or approved equivalent).

CONTINUED

CONTINUATION
Hand Protection

Chemically resistant gloves should be worn whenever this material is handled. Gloves should be removed and replaced immediately if there is any indication of degradation or chemical breakthrough.

FACILITY CONTROL MEASURES

Ventilation

The ventilation system employed is dependent on the user's specific application of this material. Refer to the current edition of Industrial Ventilation: A Manual of Recommended Practice published by the American Conference of Governmental Industrial Hygienists for information on the design, installation, use, and maintenance of exhaust systems.

Other Protective Equipment

Facilities storing or utilizing this material should be equipped with an eyewash facility.

STORAGE AND HANDLING INFORMATION

Storage Conditions

The minimum recommended storage temperature for this material is 0C/32F. The maximum recommended storage temperature for this material is 49C/120F. Avoid repeated freeze-thaw cycles; beads may fracture.

Handling Procedures

The maximum recommended operating temperature for this material is 60C/140F. Properly designed equipment is vital if these ion exchange resins are to be used in conjunction with strong oxidizing agents such as nitric acid to prevent a rapid build-up of pressure and possible explosion. Consult a source knowledgeable in the handling of these materials before proceeding. Do not pack column with dry ion exchange resins. Dry beads expand when wetted; this expansion can cause glass columns to shatter.

SUPPLEMENTAL INFORMATION

TYPICAL PHYSICAL PROPERTIES

State	Beads
pH	5-9 Aqueous slurry
Viscosity	Not Applicable
Specific Gravity (Water = 1)	1.1-1.3
Vapor Density (Air = 1)	< 1
Vapor Pressure	17 mm Hg @20°C/68°F Water
Melting Point	0°C/32°F Water

CONTINUED



CONTINUATION

Boiling Point	100°C/212°F	Water
Solubility in Water	Practically insoluble	
Percent Volatility	50-65 %	Water
Evaporation Rate (BAC = 1)	< 1	Water

TOXICITY INFORMATION

Acute Data

No toxicity data are available for this material.

WASTE DISPOSAL

Procedure

Unused resin may be incinerated or landfilled in facilities meeting local, state, and federal regulations. For contaminated resin, the user must determine the hazard and use an appropriate disposal method.

REGULATORY INFORMATION

WORKPLACE CLASSIFICATIONS

This product is considered non-hazardous under the OSHA Hazard Communication Standard (29CFR 1910.1200).

This product is not a 'controlled product' under the Canadian Workplace Hazardous Materials Information System (WHMIS).

TRANSPORTATION CLASSIFICATIONS

US DOT Hazard Class NONREGULATED

EMERGENCY PLANNING & COMMUNITY RIGHT-TO-KNOW (SARA TITLE 3)

Section 311/312 Categorizations (40CFR 370)

This product is not a hazardous chemical under 29CFR 1910.1200, and therefore is not covered by Title III of SARA.

Section 313 Information (40CFR 372)

This product does not contain a chemical which is listed in Section 313 above de minimis concentrations.

CERCLA INFORMATION (40CFR 302.4)

Releases of this material to air, land, or water are not reportable to the National Response Center under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) or to state and local emergency planning committees under the Superfund Amendments and Reauthorization Act (SARA) Title III Section 304.

RCRA INFORMATION

When a decision is made to discard this material as supplied, it does not meet RCRA's characteristic definition of ignitability, corrosivity, or reactivity, and is not listed in 40 CFR 261.33. The toxicity characteristic (TC), however, has not been evaluated by the Toxicity Characteristic Leaching Procedure (TCLP).

CHEMICAL CONTROL LAW STATUS

All components of this product are listed or are excluded from listing on the U.S. Toxic Substances Control Act (TSCA) Chemical Substance Inventory.

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ABBREVIATIONS:

ACGIH = American Conference of Governmental Industrial Hygienists
OSHA = Occupational Safety and Health Administration
TLV = Threshold Limit Value
PEL = Permissible Exposure Limit
TWA = Time Weighted Average
STEL = Short-Term Exposure Limit
BAc = Butyl acetate

Bar denotes a revision from previous MSDS in this area.

The information contained herein relates only to the specific material identified. Rohm and Haas Company believes that such information is accurate and reliable as of the date of this material safety data sheet, but no representation, guarantee or warranty, express or implied, is made as to the accuracy, reliability, or completeness of the information. Rohm and Haas Company urges persons receiving this information to make their own determination as to the information's suitability and completeness for their particular application.

PRODUCT DATA SHEET

AMBERLITE™ IRN160
Nuclear Grade Mixed Bed Resin

AMBERLITE IRN160 resin is a mixture of uniform particle size gelular polystyrene cation and anion exchange resins. AMBERLITE IRN160 resin as supplied contains a stoichiometric equivalent of the strongly acidic cation and the strongly basic anion exchange resins. It is supplied in the H⁺/OH⁻ form. AMBERLITE IRN160 resin is designed for use in radwaste applications and deep bed

condensate polishing in BWR nuclear power plants. The resin combines the properties of high capacity and excellent resistance to bead fracture from attrition and osmotic shock. The non separating properties of this resin make it easily transferable from one location to another, leaving no cation layer that has separated from anion resin.

PROPERTIES

Physical form _____	Uniform particle size spherical beads	
Matrix _____	Styrene divinylbenzene copolymer	
Shipping weight _____	690 g/L	
Functional group _____	Cation resin	Anion resin
Ionic form as shipped _____	Sulphonic acid	Trimethylammonium
Total exchange capacity ^{III} _____	H ⁺	OH ⁻
Moisture holding capacity ^{III} _____	≥ 2.15 eq/L (H ⁺ form)	≥ 1.2 eq/L (OH ⁻ form)
Particle size	45 to 51 % (H ⁺ form)	54 to 60 % (OH ⁻ form)
Uniformity coefficient ^{III} _____	≤ 1.2 (for each component)	
Harmonic mean size ^{III} _____	0.525 ± 0.05 mm	0.630 ± 0.05 mm
< 0.300 mm ^{III} _____	≤ 0.2 %	
Whole beads _____	≥ 95 %	
Breaking weight (average) _____	≥ 350 g/bead	
> 200 g/bead _____	≥ 95 %	
Ionic conversion _____	≥ 99 % H ⁺	≥ 95 % OH ⁻ ^{III}
CO ₃ ⁻ _____	-	≤ 5 % ^{III}
Cl ⁻ _____	-	≤ 0.1 % ^{III}
SO ₄ ⁼ _____	-	≤ 0.1 % ^{III}

^{III} Contractual value

Test methods and SQC charts are available on request.

SUGGESTED OPERATING CONDITIONS

Maximum operating temperature _____	60 °C
Minimum bed depth _____	800 mm
Service flow rate _____	80 BV*/h
Maximum Service velocity _____	120 m/h at 35-50 °C

* 1 BV (Bed Volume) = 1 m³ solution per m³ resin

PURITY

AMBERLITE IRN160 resin is designated as a nuclear grade resin and is manufactured using special processing procedures. These procedures, combined with a Rohm and Haas process to reduce the chloride content of the anion component, produce material of the ultimate purity and yield a product meeting the exacting demands of the nuclear industry.

AMBERLITE IRN160 resin is recommended in any non regenerable mixed bed application where reliable production of the highest quality water is required and where the "as supplied" resin must have an absolute minimum of ionic and non ionic contamination.

Purity	Cation mg/kg dry resin	Anion
Al	≤ 50	≤ 50
Ca		≤ 50
Co		≤ 30
Cu	≤ 10	≤ 10
Fe	≤ 50	≤ 50
Hg		≤ 20
K		≤ 40
Mg		≤ 50
Na	≤ 50	≤ 20
Pb		≤ 10
Total Cl		≤ 500
SiO ₂		≤ 100
Total SO ₄		≤ 600

APPLICATIONS

The purity and physical stability of AMBERLITE IRN160 resin provides unsurpassed performance in nuclear applications. The non separating feature of

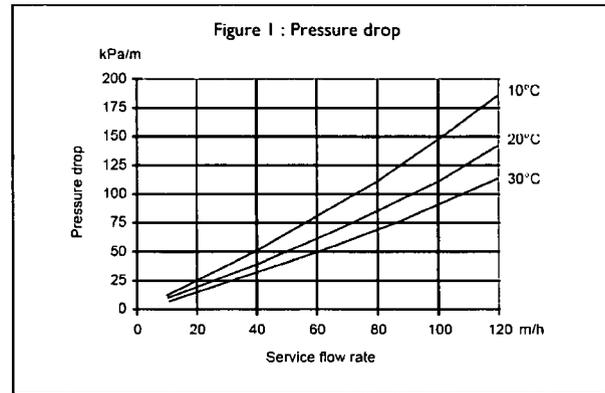
AMBERLITE IRN160 makes it an excellent choice for :

- BWR deep bed condensate polishing
- Radwaste deionisation
- Mixed bed deionisation

HYDRAULIC CHARACTERISTICS

Pressure drop

The approximate pressure drop for each meter of bed depth of AMBERLITE IRN160 resin in normal downflow operation at various temperatures and flow rates is shown in the graph below. Pressure drop data are valid at the start of the service run with a clear water.



LIMITS OF USE

AMBERLITE IRN160 resin is suitable for industrial uses. For other specific applications such as pharmaceutical, food processing or potable water applications, it is recommended that all potential users seek advice from Rohm and Haas in order to determine the best resin choice and optimum operating conditions.

All our products are manufactured in ISO 9001 certified facilities.

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Ion exchange resins and polymeric adsorbents, as produced, contain by-products resulting from the manufacturing process. The user must determine the extent to which organic by-products must be removed for any particular use and establish techniques to assure that the appropriate level of purity is achieved for that use. The user must ensure compliance with all prudent safety standards and regulatory requirements governing the application. Except where specifically otherwise stated, Rohm and Haas Company does not recommend its ion exchange resins or polymeric adsorbents, as supplied, as being suitable or appropriately pure for any particular use. Consult your Rohm and Haas technical representative for further information. Acidic and basic regenerant solutions are corrosive and should be handled in a manner that will prevent eye and skin contact. Nitric acid and other strong oxidising agents can cause explosive type reactions when mixed with Ion Exchange resins. Proper design of process equipment to prevent rapid buildup of pressure is necessary if use of an oxidising agent, such as nitric acid is contemplated. Before using strong oxidising agents in contact with Ion Exchange Resins, consult sources knowledgeable in the handling of these materials.

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PRODUCT DATA SHEET

AMBERLITE™ IRN170

Nuclear Grade Mixed Bed Resin

AMBERLITE IRN170 resin is a fully regenerated nuclear grade mixed bed resin designed for the ultimate performance in non-regenerable nuclear applications. The cation component of this mixed bed product is Amberlite IRN99 resin, which delivers the highest total capacity and the best oxidative stability of any available cation exchange resin. This revolutionary highly cross-linked gel cation resin is combined in a 1 to 1 equivalent ratio with the proven anion exchange resin, Amberlite IRN78 resin, to make Amberlite IRN170 resin. This new mixed bed is now the resin of choice for nuclear applications which demand the highest effluent purity, highest operating capacity, and longest resin life.

Amberlite IRN170 resin was originally developed for use in BWR condensate polishers to help achieve the lowest possible sulfate levels in reactor water. This is accomplished through a combination of the extraordinary oxidative stability of the cation resin, and a particle size balance between the cation and anion resins, which minimizes the

formation of a re-separated cation resin layer on the bottom of the service vessels. The purchase of Amberlite IRN170 resin as a pre-mixed resin also allows for faster initial rinse-up prior to service, which minimizes rinse waste water volume.

The exceptionally high total capacity of Amberlite IRN170 resin delivers an important benefit, for many other nuclear applications including PWR steam generator blowdown treatment, PWR primary system CVCS resin beds, fuel pool demineralizers, and radioactive waste treatment. Since the nuclear grade resins from all these applications are generally disposed of as rad waste, high capacity and long resin bed life are critical to minimizing rad waste disposal cost and volume. For most users, rad waste disposal cost will exceed resin purchase cost, so higher resin capacity directly translates into lower costs in these non-regenerable nuclear applications. Longer bed life also brings significant operational benefits such as fewer bed change-outs, less resin handling, and fewer chances for radiation exposure.

PHYSICAL CHARACTERISTICS

Physical form _____
 Matrix _____
 Chemical form _____
 Shipping weight _____

Mixture of dark and light amber translucent spherical beads
 Styrene divinylbenzene copolymer
 1 to 1 equivalent mixture of H⁺ and OH⁻ form resins
 43 lb/ft³ (690 g/L)

Functional group _____

Cation resin

Anion resin

Total exchange capacity ^[2] _____

Sulphonic acid

Quarternary ammonium

Moisture holding capacity ^[1] _____

≥ 2.40 eq/L (H⁺ form)

≥ 1.2 eq/L (OH⁻ form)

% Regenerated sites _____

37 to 43% (H⁺ form)

54 to 60 % (OH⁻ form)

% Cl form sites _____

≥ 99 % H

≥ 95 % OH

Particle size

-

≤ 0.1 %

Retained on 50 mesh (0.300 mm) _____

0.1 % max

Whole beads _____

≥ 95 %

Breaking weight (average) _____

≥ 350 g/bead

> 200 g/bead _____

≥ 95 %

Na _____

50 mg/kg dry maximum

Al _____

50 mg/kg dry maximum

Fe _____

50 mg/kg dry maximum

Cu _____

10 mg/kg dry maximum

Heavy Metals as Pb _____

10 mg/kg dry maximum

SUGGESTED OPERATING CONDITIONS

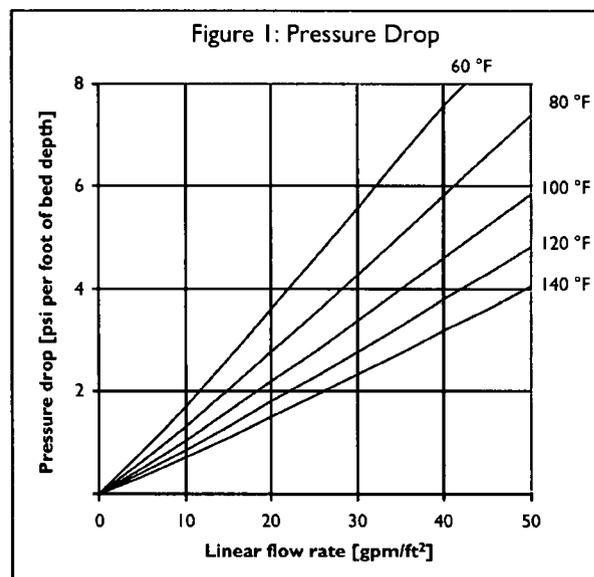
Maximum operating temperature _____	60 to 140 °F (15 to 60°C)
Minimum bed depth _____	36 inches
Service flow rate for condensate polishing (LV) _	50 gpm/ft ²
Service flow rate for other applications (SV) ____	1 to 6 gpm/ft ³ (8 to 50 bv/h)

HYDRAULIC CHARACTERISTICS

The figure shows the pressure drop data for Amberlite IRN170 resin, as a function of service flow rate and water temperature. Pressure drop data are for clean beds which have not accumulated solids during the service run. If the bed accumulates solids, the pressure drop would increase.

LIMITS OF USE

AMBERLITE IRN170 resin is suitable for industrial uses. For other specific applications such as pharmaceutical, food processing or potable water applications, it is recommended that all potential users seek advice from Rohm and Haas in order to determine the best resin choice and optimum operating conditions.



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PRODUCT DATA SHEET

AMBERLITE™ IRN217
Industrial Nuclear Grade Mixed Bed Resin

AMBERLITE IRN217 resin is a mixture of uniform particle size gelular polystyrene cation and anion exchange resins. AMBERLITE IRN217 resin as supplied contains a stoichiometric equivalent of the strongly acidic cation resin, fully converted in the ⁷Li form, and the strongly basic anion exchange resins. It is supplied in the Li⁺/OH⁻ form. AMBERLITE IRN217 resin is designed

for use in primary water chemistry control in PWR nuclear power operations. Only LiOH of certified isotopic purity greater than 99.9 % ⁷Li is used in manufacturing the cation component of AMBERLITE IRN217 resin. The resin combines the properties of high capacity and excellent resistance to bead fracture from attrition and osmotic shock.

PROPERTIES

Physical form _____	Uniform particle size spherical beads	
Matrix _____	Styrene divinylbenzene copolymer	
Shipping weight _____	690 g/L	
	Cation resin	Anion resin
Functional group _____	Sulphonic acid	Trimethylammonium
Ionic form as shipped _____	⁷ Li ⁺	OH ⁻
Total exchange capacity ¹¹ _____	≥ 1.75 eq/L (⁷ Li ⁺ form)	≥ 1.2 eq/L (OH ⁻ form)
Strong base capacity ¹² _____	-	≥ 90 %
Moisture holding capacity ¹² _____	49-55 % (H ⁺ form)	54 - 60 % (OH ⁻ form)
Particle size	≤ 1.2 (for each component)	
Uniformity coefficient _____	0.650 ± 0.05 mm	
Harmonic mean size _____	0.630 ± 0.05 mm	0.630 ± 0.05 mm
< 0.300 mm	0.2 % max	
Whole beads _____	98 % minimum	
Ionic conversion ¹² _____	99 % min ⁷ Li ⁺	95 % min OH ⁻ ¹²
CO ₃ ⁼ _____	-	5 % max
Cl ⁻ _____	-	0.1 % max
SO ₄ ⁼ _____	-	0.1 % max

¹¹ Average value calculated from statistical quality control

¹² Contractual value

Test methods and SQC charts are available on request.

RECOMMENDED OPERATING CONDITIONS

Maximum operating temperature _____	60 °C.
Minimum bed depth _____	800 mm
Service flow rate _____	8 to 50 BV*/h
Service velocity _____	60 m/h maximum

* 1 BV (Bed Volume) = 1 m³ solution per m³ resin

PURITY

AMBERLITE IRN217 resin is designated as a nuclear grade resin and is manufactured using special processing procedures. These procedures, combined with a Rohm and Haas process to reduce the chloride content of the anion component, produce material of the ultimate purity and yield a product meeting the exacting demands of the nuclear industry.

AMBERLITE IRN217 resin is recommended in any non regenerable mixed bed application where reliable production of the highest quality water is required and where the "as supplied" resin must have an absolute minimum of ionic and non ionic contamination.

Purity	Cation mg/kg dry resin	Anion mg/kg dry resin
Al	≤ 50	≤ 50
Ca	≤ 50	≤ 50
Co	≤ 30	≤ 30
Cu	≤ 10	≤ 10
Fe	≤ 50	≤ 50
Hg	≤ 20	≤ 20
K	≤ 40	≤ 40
Mg	≤ 50	≤ 50
Na	≤ 50	≤ 20
Pb	≤ 10	≤ 10
Total Cl		≤ 500
SiO ₂		≤ 100
Total SO ₄		≤ 600

APPLICATIONS

AMBERLITE IRN217 resins specifically designed for mixed beds for purification in the chemical and volumetric control system of pressurised water reactors. This application requires the mixed bed to remove radio-isotopes such as 137 Cesium, 58 Cobalt and 131 Iodine, and also chemical contaminants such as Cl and SO₄. Since the primary reactor coolant contains relatively high background levels of boric acid buffered with 7LiOH, the mixed bed resins will operate in the 7Li/Borate form.

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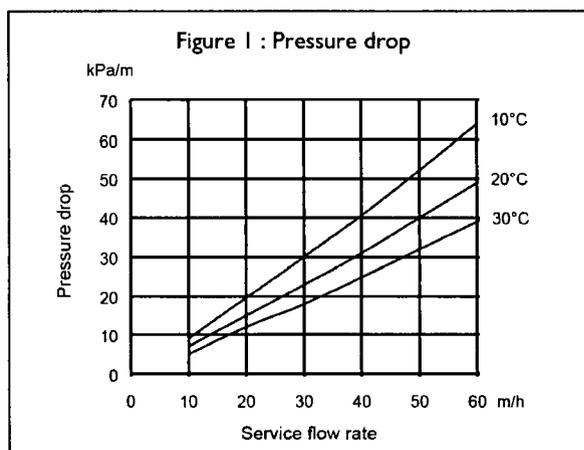
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The cation resin component of AMBERLITE IRN217 resin is supplied in the 7 Lithium form in order to minimise fluctuations in the concentration in 7 Li in the reactor coolant, when a new purification mixed bed is put into service. AMBERLITE IRN217 is made only using certified isotopically pure 7LiOH in order to minimise the undesirable reaction $6Li+n \rightarrow 3H+@$.

The anion resin component of AMBERLITE IRN217 resin is very highly regenerated to the hydroxide form to insure that less than 0.1 equivalent percent of the sites on the resin are in the chloride form and 0.1 percent equivalent in the sulphate form. Therefore, AMBERLITE IRN217 resin can effectively control chloride and sulphate impurities while operating in a 7Li/Borate solution.

HYDRAULIC CHARACTERISTICS

The approximate pressure drop for each meter of bed depth of AMBERLITE IRN217 resin in normal downflow operation at various temperatures and flow rates is shown in the graph below.



RESIN HANDLING

To retain the high purity standards of nuclear grade resins, deionised water should be used for all resin handling. Contact of the resin with air should also be minimised to avoid CO₂ pickup and subsequent loss of capacity of the anion resin.

PRELIMINARY PRODUCT DATA SHEET

AMBERLITE™ IRN317 Li⁷ / OH form Nuclear Grade Mixed Bed

AMBERLITE IRN317 resin is a stoichiometric equivalent mixed bed of gel strong acid cation resin in the Li⁷ form and gel strong base anion resin in the OH form. Amberlite IRN317 resin is specifically designed for enhanced performance and long resin life in the Chemical and Volume Control System (CVCS) of Pressurized Water Reactors (PWR).

The cation resin used for this mixed bed is derived from Amberlite IRN99 resin, which is a uniform particle size, highly cross-linked gel cation exchanger. The anion exchange resin in this mixed bed is Amberlite IRN78 resin, which has a long established record of performance and reliability in nuclear applications.

The new highly crosslinked gel cation resin component of this mixed bed delivers the highest total capacity (typically 2.5 eq/L) and the best chemical and oxidative stability of any available nuclear grade resin. The enhanced oxidative stability significantly lowers the release of organic sulfonates thus reducing sulfate levels in the reactor coolant. The high level of crosslinking also provides substantially increased selectivity for removal of Cs¹³⁷ and other radioactive species.

For additional information on the component resins used in Amberlite IRN317 resin, see the data sheets for Amberlite IRN78 and Amberlite IRN99 resins.

PROPERTIES

Physical Form _____	Mixture of dark and light amber translucent spherical beads	
Matrix _____	Polystyrene divinylbenzene copolymer	
Chemical Form _____	1 to 1 equivalent mixture of Li ⁷ and OH form resins	
Shipping Weight _____	45 lbs/ft ³ (720 g/L)	
	Cation Resin	Anion Resin
Functional Group _____	Sulfonic acid	Quaternary ammonium
Total Exchange Capacity _____	≥ 2.4 meq/ml (Li form)	≥ 1.2 meq/ml (OH form)
Moisture Content _____	33 - 40 % (Li form)	54 - 64 % (OH form)
% Regenerated Sites _____	99% Li ⁷ , minimum	95% OH, minimum
% Cl form sites _____	—	0.1 % maximum
Particle Size		
Retained on 20 mesh (0.850 mm) _____	5 % maximum	
Through 40 mesh (0.425 mm) _____	5 % maximum	
Through 50 mesh (0.300 mm) _____	0.1% maximum	
Na _____	50 mg/kg dry, maximum	
Fe _____	100 mg/kg dry, maximum	
Cu _____	50 mg/kg dry, maximum	
Al _____	50 mg/kg dry, maximum	
Pb _____	50 mg/kg dry, maximum	

SUGGESTED OPERATING CONDITIONS

Maximum Operating Temperature _____	140 °F (60 °C)
Minimum Bed Depth _____	36 inches
Service Flow Rate (Linear Velocity) _____	10 to 30 gpm/ft ²

APPLICATION

AMBERLITE IRN317 resin is specifically designed for the purification of primary reactor coolant in PWR plants. This application requires the removal of Cs¹³⁷, Co⁵⁸, I¹³¹, other radioisotopes, and chemical contaminants such as chloride and sulfate which may appear in the reactor coolant. Since the reactor coolant contains high background levels of boric acid buffered with Li⁷OH, the mixed bed resins will operate in the borate and Li⁷ form.

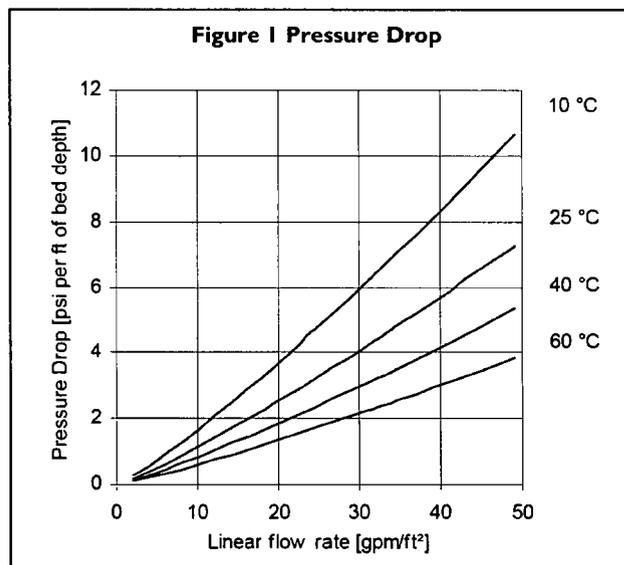
The cation resin component of Amberlite IRN317 resin is supplied in the Li⁷ form in order to minimize fluctuations in the concentration of Li⁷ in the reactor coolant when the mixed bed is first placed into service. Amberlite IRN317 resin is made using only certified isotopically pure Li⁷OH in order to minimize the undesirable reaction:



The anion resin component of Amberlite IRN317 resin is very highly regenerated to the OH form to insure that less than 0.1% of exchange sites are present in the chloride form or the sulfate form. Therefore Amberlite IRN317 resin can effectively control chloride and sulfate impurities even while operating at high background concentrations of lithium and borate.

HYDRAULIC CHARACTERISTICS

The approximate pressure drop of Amberlite IRN317 resin in normal downflow operation is shown in the figure below as a function of service flow rate and water temperature. Pressure drop data are for clean beds which have not accumulated solids during the service run. If the bed accumulates solids, the pressure drop will increase.



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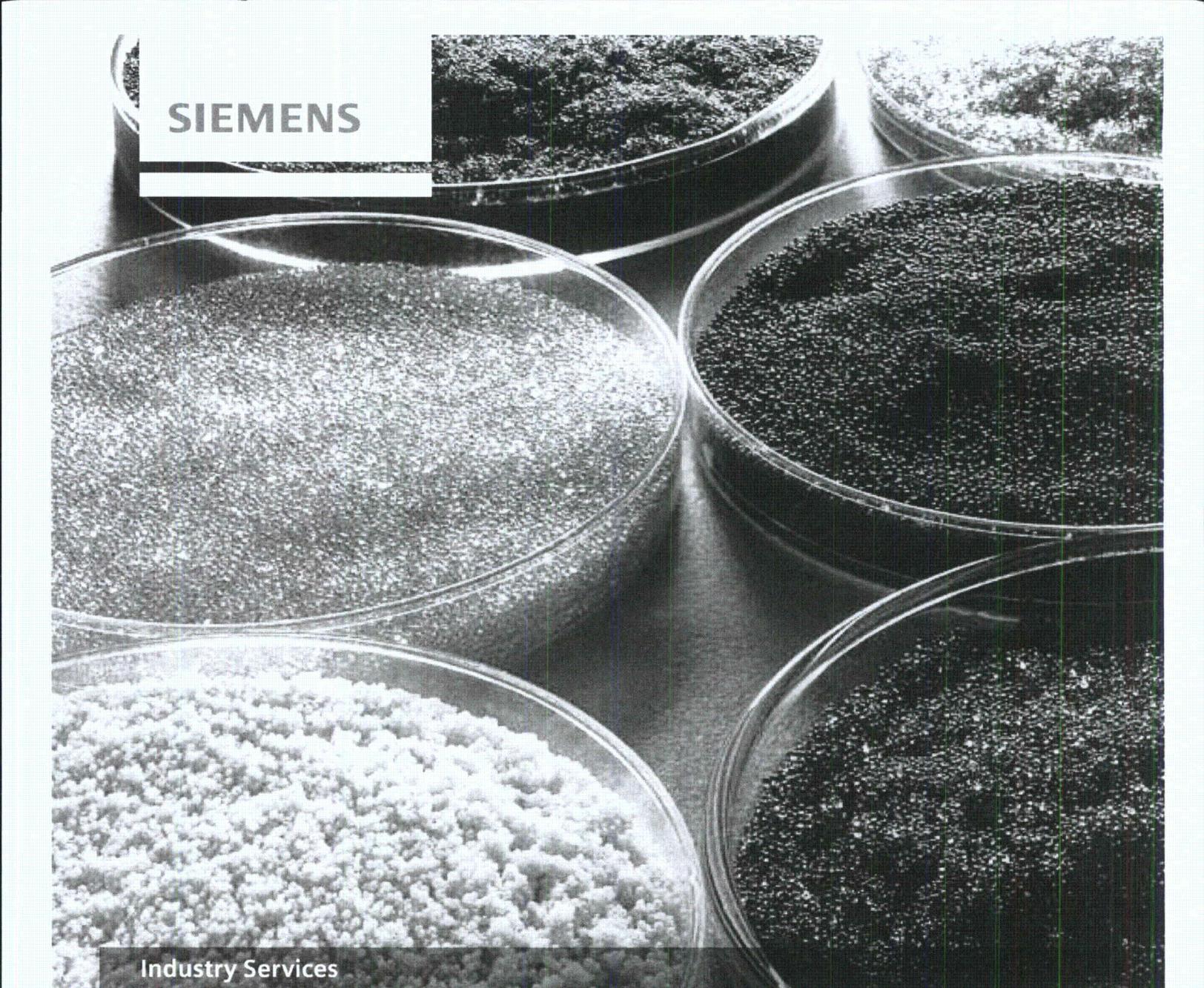
Ion exchange resins and polymeric adsorbents, as produced, contain by-products resulting from the manufacturing process. The user must determine the extent to which organic by-products must be removed for any particular use and establish techniques to assure that the appropriate level of purity is achieved for that use. The user must ensure compliance with all prudent safety standards and regulatory requirements governing the application. Except where specifically otherwise stated, Rohm and Haas Company does not recommend its ion exchange resins or polymeric adsorbents, as supplied, as being suitable or appropriately pure for any particular use. Consult your Rohm and Haas technical representative for further information. Acidic and basic regenerant solutions are corrosive and should be handled in a manner that will prevent eye and skin contact. Nitric acid and other strong oxidising agents can cause explosive type reactions when mixed with Ion Exchange resins. Proper design of process equipment to prevent rapid buildup of pressure is necessary if use of an oxidising agent such as nitric acid is contemplated. Before using strong oxidising agents in contact with Ion Exchange Resins, consult sources knowledgeable in the handling of these materials.

Rohm and Haas Company makes no warranties either expressed or implied as to the accuracy or appropriateness of these data and expressly excludes any liability upon Rohm and Haas arising out of its use. We recommend that the prospective users determine for themselves the suitability of Rohm and Haas materials and suggestions for any use prior to their adoption. Suggestions for uses of our products of the inclusion of descriptive material from patents and the citation of specific patents in this publication should not be understood as recommending the use of our products in violation of any patent or as permission or license to use any patents of the Rohm and Haas Company and its affiliates. Material Safety Data Sheets outlining the hazards and handling methods for our products are available on request.

Siemens

Ion Exchange Resin Products

Information Guide.....	131
USF A-254 PSSG OH	
Product Sheet.....	143
USF A-464 MEG (OH)	
Product Sheet.....	144
USF A-464LC OH	
Product Sheet.....	145
USF A-674PSMBSG OH	
Product Sheet.....	146
USF C-361 MEG (H)	
Product Sheet.....	147
USF C-361C H	
Product Sheet.....	148
USF C-373 PSSG H	
Product Sheet.....	149
USF C-381C H	
Product Sheet.....	150
USF NR-1	
Product Sheet.....	151
USF NR-20LC	
Product Sheet.....	152
USF NR-31LC	
Product Sheet.....	153
USF NR-35LC	
Product Sheet.....	154
USF NR-57LC	
Product Sheet.....	155
USF NR-62	
Product Sheet.....	156
USF NR-63RLS	
Product Sheet.....	157
MSDS.....	158
USF NR-6LC	
Product Sheet.....	164
USF PURCAT C-373 H	
Product Sheet.....	165

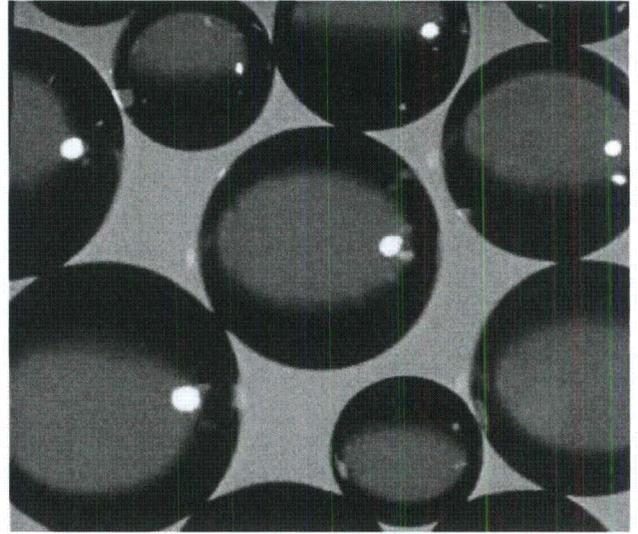
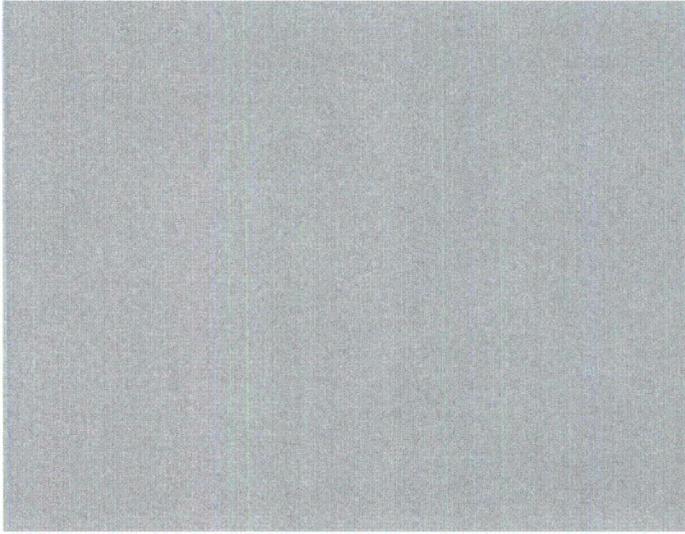


SIEMENS

Industry Services

Ion Exchange Resin Products and Services

Answers for industry.



Resin products and services for peak performance

Siemens is a leader in developing new technologies and applications for resin. We also work closely with the leading resin manufacturers to improve existing product quality and to develop new products to meet changing application needs. Our experience in ion exchange technology spans greater than 80 years and is backed by a rich history of businesses recognized as leaders in the water treatment industry.

Siemens' offers a complete support program to provide our customers with the products and support services necessary to maintain their ion exchange systems for peak performance and long-term operation. In addition to being the largest distributor of ion exchange resin, we also provide a full range of services including analytical testing, resin removal/reinstallation, cleaning and reconditioning. For specialty applications, we offer customized high-purity resin processing and blending to meet FDA requirements for the food and beverage and pharmaceutical markets. And, when it is time to dispose of your spent resin, we can assist in coordinating options for investment recovery or proper disposal. Siemens offers complete support at every phase throughout the life of your system.

Industry-recognized products, experienced technical support and an expertly trained field service team are all available to you as part of the offering from Siemens.

Siemens' ion exchange resin program features

- Large inventory of stocked resins, including Siemens resins and resins from other leading manufacturers
- Same day shipment of stocked resins
- Regional resin distribution/stocking centers
- Extensive analytical and testing laboratory
- Customized packaging and delivery options
- Disposal and investment recovery coordination
- Performance evaluation and optimization
- Service and preventative maintenance contracts
- Personnel training and start-up services
- Temporary/mobile water treatment systems
- 24/7 customer service
- Trained, technical support staff
- 85+ sales and service branches throughout North America and Canada

Regional stocking and distribution centers:

- Los Angeles, CA
- Jacksonville, FL
- Rockford, IL
- Geismar, LA
- Conroe, TX
- Fallsington, PA
- Ancaster, Ontario, Canada



Quality Assured with Siemens Ion Exchange Resin

Siemens ion exchange resin is manufactured by the leading resin companies to meet Siemens' more stringent, performance-based specifications. These standards are higher than those used by the manufacturers in testing their own products.

Siemens ion exchange resin was developed in response to inconsistent performance and quality trends experienced in the resin marketplace. Siemens provides process guarantees on all resins sold and therefore, it became necessary to establish new, more stringent resin performance specifications to ensure our resins met stated expectations.

Siemens ion exchange resins are guaranteed to meet our performance specifications. The resins are tested in our state-of-the-art analytical laboratory to verify compliance to specifications based on the following:

- Capacity
- Percent salt split capacity vs. total capacity
- Percent conversion
- Percent moisture
- Particle size
- Percent whole, cracked, broken
- Organic impurities
- Bead strength
- Metallic and inorganic impurities
- Kinetics

Additional performance testing is also available upon request.

Some of the advantages to choosing Siemens brand resin include:

- Life cycle cost savings when compared with equivalent resin products
- Manufactured and tested to meet higher, more stringent performance specifications
- QA/QC programs ANSI N45.2, 10CFR50 (appendix B) and 10CFR21 compliant to meet nuclear safety requirements
- Process performance guarantees available upon request
- Extensive technical support and resin application knowledge
- Annual resin analysis
- Custom packaging to meet your volume needs
- Certificates of Analysis, Certificate of Conformance, and shelf life statements available upon request

Siemens Ion Exchange Resin and Media Cross Reference Guide

Siemens is the largest distributor of ion exchange resin. We are able to supply you resin from all of the leading manufacturers, and are the largest stocking distributor of Dowex® brand resin.

Siemens Brand	Amberlite® Rohm & Haas	Lewatit® LANXESS	Ionac® Sybron	Diaion® Mitsubishi	Dowex® Dow Chemical	Purolite® Purolite Co.
Weak Acid Cation						
C-271	IRC-76	CNP-80			MAC-3 (Dowex Marathon® MAC-3)	C-106
C-281	IRC-86		CC	WK-40		C-105
Strong Acid Cation						
C-211	IR-120 (Amberjet® 1200)	(Lewatit MonoPlus® S-100)	C-249	SK-1B	HCR-5 (Dowex Marathon® C)	C-100
C-361	IR-122 (Amberjet® 1500)	(Lewatit MonoPlus® S-200)	C-250	SK-110	HGR-W2 (Dowex Marathon® C-10)	C100X10
C-381	IR-200	(Lewatit MonoPlus® SP-112)		PK-228	(Dowex Marathon® MSC)	C-150
Weak Base Anion						
A-399	IRA-96	(Lewatit MonoPlus® MP-64)		WA-30	(Dowex Marathon® WBA-2)	A-100
A-444	IRA-67	VP OC 1072				A-845
Strong Base Anion						
A-244	IRA-410 (Amberjet® 4600)	(Lewatit MonoPlus® M-600)	ASB-2	SA-20A	SAR (Dowex Marathon® A2)	A-300
A-284	IRA-400 (Amberjet® 4200)	(Lewatit MonoPlus® M-500)	ASB-1	SA-10A	SBR-C (Monosphere® 550A)	A-600
A-464	IRA-402 (Amberjet® 4400)		ASB-1P	SA-12A	SBR-P (Dowex Marathon® A)	A-400
A-674	IRA-900	(Lewatit MonoPlus® MP-500)	A-641	PA-312	(Dowex Marathon® MSA)	A-500
A-714	IRA-458	VP OC 1071				A-850
Mixed Bed						
TM-9						NRW-37
EDM						
NR-6	IRN-150	SM94	NM-60		(Dowex Marathon®MR-3)	
NR-14			NM-73			NRW-37
NR-30						EXMB

() indicates Uniform Particle Size Equivalent

Siemens Resins - General Industry Grade

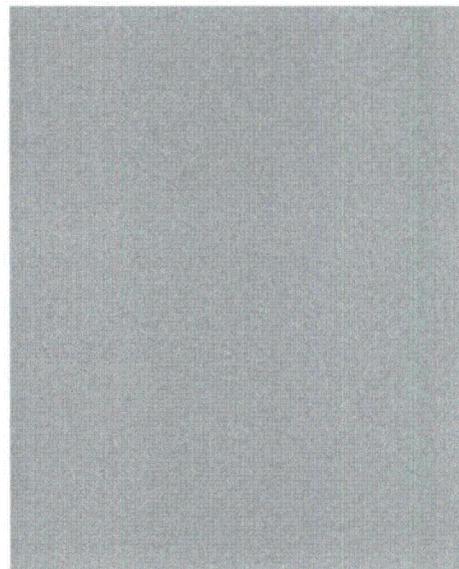
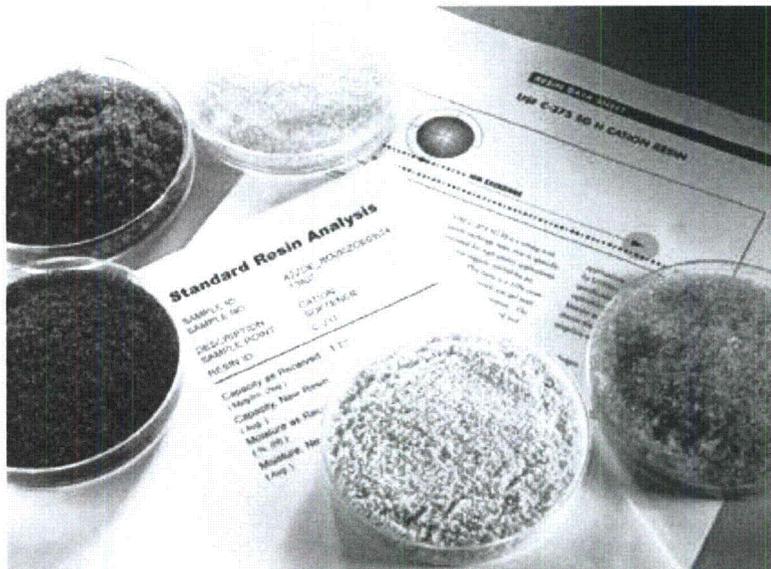
Model	Type	Ionic forms	Description
Cation			
C-211	8% Gel	Na and H	Standard cation resin used for softening and demineralization.
C-361	10% Gel	Na and H	Premium cation resin used in hot condensate polishing, and more resistant to oxidative attack and physical attrition.
C-381	Macroporous	Na and H	High cross-linked macroporous strong acid cation resin used in hot condensate polishing, highly resistant to oxidative attack, and suitable at elevated temperatures.
C-271	Acrylic Weak Acid	H	Acrylic weak acid macroporous cation resin used in dealkazing and softening.
C-281	Acrylic Weak Acid	H	Acrylic weak acid gel cation resin used in dealkazing and softening.
Anion			
A-244	Gel Type II	Cl and OH	Type II strong base gel anion with high regeneration efficiency.
A-284	Gel Type I	Cl and OH	Type I standard strong base gel anion used in demineralization with good silica removal. Recommended in non-regenerable applications.
A-464	Gel Type I Porous	Cl and OH	Type I porous strong base gel anion used in demineralization with good silica removal. Recommended in regenerable applications.
A-674	Type I Macroporous	Cl and OH	Type I macroporous strong base gel anion used in demineralization with good silica removal and better resistance to organic fouling. Recommended in regenerable applications on surface influent waters.
A-714	Acrylic Gel	Cl	Acrylic strong base anion resin used in demineralization and organic traps. Highly resistant to organic fouling.
A-399	Weak Base Macroporous	Free Base	High capacity weak base anion resin used in demineralization and acid removal applications. Excellent regeneration efficiency
A-499	UPS Weak Base	Free Base	Uniform particle size weak base anion resin.
A-444	Acrylic Weak Base	Free Base	High capacity weak base anion resin used in demineralization and acid removal applications. Recommended in applications with high organics. Excellent regeneration efficiency.
Mixed Bed			
TM-8	Mixed Bed	H/OH	1:1 chemical equivalent mix of C-211 (H) and A-244 (OH). High capacity general purpose mixed bed used in demineralization.
TM-9	Mixed Bed	H/OH	1:1 chemical equivalent mix of C-211 (H) and A-464 (OH). General purpose mixed bed used in demineralization when silica reduction is important.
NR-6	Mixed Bed	H/OH	1:1 chemical equivalent mix of C-211 (H) and A-284 (OH). High capacity general purpose mixed bed used in demineralization when silica reduction is important.
NR-30	Mixed Bed	H/OH	1:1 chemical equivalent mix of C-361 (H) and A-464 (OH). General purpose mixed bed used in demineralization when silica reduction is important. Good separation characteristics for regenerable applications.
EDM	Mixed Bed	H/OH	1:1 chemical equivalent mix of C-211 (H) and A-284 (OH). Recommended for EDM and other metal removal applications.

Siemens Resins - Electronics Grade

Model	Type	Ionic forms	Description
Cation			
C-211 SG (H)	8% Gel	H	Specially processed cation resin for demineralization applications in which low TOC leachables are desired.
C-361 SG (H)	10% Gel	H	Specially processed cation resin formixed bed demineralization applications in which low TOC leachables are desired.
C-361MEG (H)	10% Gel	H	Specially processed cation resin formixed bed demineralization applications in which low TOC leachables and extremely low cross contamination are desired.
C-361MEG PPQ (H)	10% Gel	H	Upgraded USF C-361MEG (H) with extremely low sodium content recommended for microelectronics applications.
C-381 SG (H)	Macroporous	H	Specially processed cation resin formixed bed demineralization applications in which low TOC leachables are desired.
C-373 SG (H)	UPS 10% Gel	H	Uniform Particle Size version of USF C-361 SG (H).
Anion			
A-284 SG (OH)	Gel Type I	OH	Specially processed anion resin for demineralization applications in which low TOC leachables are desired.
A-464 SG (OH)	Gel Type I Porous	OH	Specially processed anion resin for regenerable demineralization applications in which low TOC leachables are desired.
A-464MEG (OH)	Gel Type I Porous	OH	Specially processed anion resin formixed bed demineralization applications in which low TOC leachables and extremely low cross contamination are desired.
A-464MEG PPQ (OH)	Gel Type I Porous	OH	Upgraded USF A-464MEG (OH) with extremely low sodium content recommended for microelectronics applications.
A-254 SG (OH)	UPS Gel Type I Porous	OH	Uniform Particle Size version of USF A-464 SG (OH).
Mixed Bed			
NR-6 SG (H/OH)	Mixed Bed	H/OH	1:1 chemical equivalent mix of C-211 SG (H) and A-284 SG (OH). High capacity mixed bed ideal in non regenerable applications requiring low TOC leachables.
NR-30 SG (H/OH)	Mixed Bed	H/OH	1:1 chemical equivalent mix of C-361 SG (H) and A-464 SG (OH). Ideal for regenerable applications requiring low TOC leachables.
NR-30MEG (H/OH)	Mixed Bed	H/OH	1:1 chemical equivalent mix of C-361MEG (H) and A-464MEG (OH). Ideal for regenerable applications requiring low TOC leachables and extremely low cross contamination.
NR-30MEG PPQ (H/OH)	Mixed Bed	H/OH	Upgraded USF NR-30MEG (H/OH) with extremely low sodium content recommended for microelectronics applications.
NR-30MEG NANO	Mixed Bed	H/OH	The ultimate grade in mixed bed purity

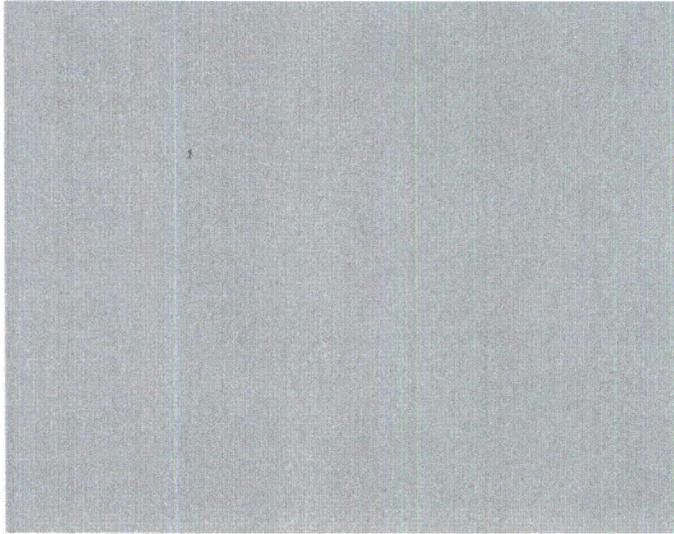
Siemens Resins - Pharmaceutical/Food and Beverage

Model	Type	Ionic forms	Description
Cation			
C-211 XRR	8% Gel	Na and H	Cross regenerated with FDA compliant process for use in food, pharmaceutical and dialysis applications.
C-361 XRR	10% Gel	Na and H	Cross regenerated with FDA compliant process for use in food, pharmaceutical and dialysis applications.
Anion			
A-244 XRR	Gel Type II	Cl and OH	Cross regenerated with FDA compliant process for use in food, pharmaceutical and dialysis applications.
A-464 XRR	Gel Type I Porous	Cl and OH	Cross regenerated with FDA compliant process for use in food, pharmaceutical and dialysis applications with low silica requirements.
Mixed Bed			
TM-8 XRR (H/OH)	Mixed Bed	H/OH	Cross regenerated with FDA compliant process for use in food and pharmaceutical applications.
TM-9 XRR (H/OH)	Mixed Bed	H/OH	Cross regenerated with FDA compliant process for use in food, pharmaceutical and dialysis applications.



SiemensResins - Condensate Polishing and Nuclear

Model	Type	Ionic forms	Description
Cation			
NR-1 (H)	8% Gel	H	Low metals and low leachables cation resin for use in primary, secondary and rad waste applications.
C-361C (H)	10% Gel	H	Low metals and low leachables cation resin for use in condensate polishing and high flow applications.
C-381C (H)	Macroporous	H	Low metals and low leachables macroporous cation resin for use in high flow and high temperature applications.
C-373 PSSG (H)	UPS 10% Gel	H	Low metals and low leachables uniform particle size cation resin processed for superior separation in regenerable mixed bed applications.
C-PURCAT C-373C (H)	UPS 10% Gel	H	Uniform particle size cation resin super cleaned per our patented processing procedure for use in applications requiring the critically low TOC extractables such as condensate polishing applications using alternate amine chemistry.
PURCAT C-471C (H)	UPS 16% Gel	H	Uniform particle size cation resin super cleaned per our patented processing procedure for use in applications requiring the critically low TOC extractables such as condensate polishing applications using alternate amine chemistry.
C-471 RLS (H)	16% Gel	H	Low metals and low leachables high cross linked cation resin for use in condensate polishing applications with extremely low sodium requirements.
TCD-1 (H)	Indicator Dyed 8% Gel	H	Indicator dyed cation resin used in conductivity measurements
Anion			
NR-2 LC (OH)	Gel Type I	OH	Low chloride, low leachable anion resin for primary, secondary and rad waste applications
A-284C (OH)	Gel Type I	OH	Low leachable anion resin processed for high kinetics and superior separation in mixed bed applications.
A-284 LS (OH)	Gel Type I	OH	Less separable anion resin with low leachables for use in BWR condensate polishing and anion underlayment applications.
A-284 RLS (OH)	Gel Type I	OH	Specially processed anion resin for condensate polishing applications with extremely low sodium requirements.
A-464 LC (OH)	Gel Type I Porous	OH	Low chloride, low leachable anion resin for use in primary, secondary and rad waste applications.
A-464MEG (OH)	Gel Type I Porous	OH	Low leachable anion resin processed for superior separation.
A-254 PSSG (OH)	UPS Gel Type I Porous	OH	Uniform particle size anion resin processed for low leachables and superior separation.
A-674 PSMB5G (OH)	Macroporous	OH	Macroporous anion resin processed for low leachables and superior separation.
Mixed Bed			
NR-6 LC (H/OH)	Mixed Bed	H/OH	Low chloride, low leachable mixed bed for use in primary and rad waste applications.
NR-31 LC (H/OH)	Mixed Bed	H/OH	Low chloride, low leachable mixed bed for use in primary, secondary, condensate polishing and rad waste applications
NR-57 LC (H/OH)	Mixed Bed	H/OH	Uniform particle size high cross linked gel cation and uniform particle size gel anion mixed bed processed for low leachables and superior separation in condensate polishing applications.
NR-63 RLS (H/OH)	Mixed Bed	H/OH	High cross linked gel cation and gel anion mixed bed designed for steam generator blow down demineralization applications with extremely low sodium requirements.
NR-62 Stator Cooling (H/OH)	Mixed Bed	H/OH	High capacity mixed bed designed for stator cooling applications.
NR-35 LC (H/OH)	Mixed Bed	H/OH	Macroporous cation, gel anion mixed bed with low leachables and low chlorides designed for blow down demineralization applications and suppression pool for cobalt and cesium control.
NR-20 LC (Li7/OH)	Mixed Bed	Li7/OH	Lithium 7 hydroxide for mixed bed with low leachables and low chlorides for use in primary systems.



Specialized services for system efficiency and cost effective operation

Siemens offers a wide range of support services to help maintain ion exchange systems and eliminate the liabilities associated with spent resin handling and disposal. Our trained service technicians are available to provide services from over 85 branch locations throughout North America.

Resin removal and replacement

Siemens' team of trained professionals will provide complete project coordination, from predisposal testing to new resin installation to used resin landfill disposal or investment recovery (used resin brokers). With complete responsibility in Siemens' hands, you can be assured that your project will be completed professionally, on schedule, within budget and most importantly, in full compliance with all local and governmental regulations.

Removal and Replacement Service includes:

1. Pre-disposal Toxicity Characteristic Leachable Procedure (TCLP) testing for hazardous chemicals and metals.
2. Pre and post disposal documentation.
3. Removal of existing resin.
4. Visual inspection of the service vessel.
5. Installation of the new resin.
6. Pre-arranged disposal at a licensed land fill or investigate potential investment recovery through used resin brokers.

Laboratory testing and process evaluation

To ensure optimum performance, Siemens recommends periodic laboratory analysis of your ion exchange resin. Siemens owns and operates a state-of-the-art laboratory and is capable of determining resin quality, as well as diagnosing operating problems and evaluating new ion exchange products.

Standard laboratory resin testing

- Capacity before/after clean up steps
- Percent moisture
- Particles size
- Iron Fouling
- Microscopic visual examination

Additional testing available

- Percent conversion
- Bead strength
- Metallic impurities
- Cross contamination
- Kinetics (Mix Bed Test)
- Kinetics (MTOC Extractables)
- 16 hour soak Dynamic Mass Transfer)
- Organic Cl, SO4 TOC Extractables
- 16 hour soak (UV)
- Dynamic (UV)
- X-Ray Fluorescence
- Terminal Settling Velocity (TSV)
- Super Fines (-60 mesh)



Resin Processing Facilities

- Columbus, OH
- Conroe, TX
- Fallsington, PA
- Jacksonville, FL
- Los Angeles, CA
- Richmond, VA
- Rockford, IL
- SouthWindsor, CT

Processing/blending

Siemens provides resin processing services to meet customers high purity needs. Our specially designed facility uses microelectronics grade water (typically <3 ppb TOC, 18+Megohm and <50 ppt Na) to ensure the integrity of the processes.

Special customer requirements may include:

- Extremely low organic leachable impurities (TOC, UV Cl, UV SO₄, etc.)
- Conversion to specific ionic forms (Li-7, K, Ca, various amines, etc.)
- Terminal Settling Velocity Modified (for improved separability)
- Custom mixing and blending of resins
- Custom packaging of resins (Mylar®, Heat sealed, 0.5-7 CF drums, 20-35 CF supersacks)
- FDA cycling for food and pharmaceutical applications (taste and odor free)

Resin cleaning and reconditioning

Resin cleaning and reconditioning services provide an option for salvaging fouled, cross-contaminated and/or exhausted resin. Siemens can remove resins, transport them to our local processing plant, convert the resins and return them to your facility. Resin cleaning extends the resin's useful life, minimizes operating costs and reduces system downtime. The resin can be transported to and from the job site via tanker truck, 55 gallon drum, lined fiber drum, or super sack.

Bulk transportation

Siemens offers bulk delivery of new resin and disposal of spent resins. We eliminate drum handling by slurring the resin directly from your water treatment service vessels to one of our company-owned tanker trucks. Bulk transportation greatly reduces the labor and steps involved with the documentation and administrative controls associated with temporary on-site and off-site disposal of resin.

Performance evaluation program

An important part of the Siemens service offering is to assist customers achieve maximum performance from their ion exchange system. Our proprietary, Performance Evaluation Program is a computer-based tool which evaluates current operating conditions and economic factors versus theoretical data. This allows us to evaluate the current resins, system operating parameters and replacement times, and make appropriate recommendations

Siemens Industry, Inc.
3333 Old Milton Parkway
Alpharetta, GA 30005

Customer service: 800.466.7873
Technical support: 800.875.7873 ext. 5000

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The information provided in this brochure contains merely general descriptions or characteristics of performance which in actual case of use do not always apply as described or which may change as a result of further development of the products. An obligation to provide the respective characteristics shall only exist if expressly agreed in the terms of contract.

USF A-254 PSSG OH ANION RESIN

Description:

USF A-254 PSSG OH anion resin is a specially processed resin for nuclear applications. The starting material, USF A-254, is a Type I uniform particle size strong base gel anion resin that has been specially processed by Siemens for low TOC and enhanced separability.

Chemical Properties

Functional Group	Trimethylamine
Ionic Form (as Shipped)	Hydroxide
Moisture Content	42 – 50% (Cl form)
Exchange Capacity	1.0 meq / ml minimum (OH form)
Kinetics	18 megohm (Siemens Kinetics Test)
Conversion to Hydroxide Form	94% minimum
Impurities	
Chloride (Cl)	0.2% maximum
Sulfate (SO ₄)	0.2% maximum
Carbonate (CO ₃)	5% maximum

Physical Properties

Particle Size	
+ 20 Mesh	2% maximum
- 50 Mesh	0.2% maximum
Effective Size	590 ±50 µm
Whole Beads (%)	95 minimum
Friability	350 g / bead average 90% > 200 g / bead

Operating Conditions

Operating pH Range	0 to 14
Service Flow Rate	
Demineralization	1-6 GPM/ft ²
Condensate Polishing	1-65 GPM/ft ² (dependent on operating conditions and performance expectations)
Regenerant Flow Rate	0.25 - 0.5 GPM/ft ³
Rinse Flow Rate	0.25 - 0.5 GPM/ft ³ initially, then 1.5 GPM/ft ³
Rinse Volume	60 - 75 gal/ft ³
Maximum Operating Temperature	140°F
Shipping Weight	40 lbs. / cu. ft.

USF A-464 MEG (OH) ANION RESIN

Description:

USF A-464 MEG (OH) is a Type I porous strong base gel anion resin consisting of a styrene divinylbenzene polymer matrix functionalized with a quaternary amine supplied in the hydroxide form. This resin has the ability to remove anions and weak acids from aqueous solutions, such as carbonic and silicic acids. This resin product is specially processed to provide excellent mixed bed separation, low TOC leachables, and is analyzed kinetically to ensure it is capable of producing 18 megohm mixed bed deionized water.

Chemical Properties

Functional Group	Trimethylamine
Ionic Form (as shipped)	Hydroxide
Moisture Content	52 - 59% (Cl form)
Exchange Capacity	1.0 meq / ml minimum (OH form)
Conversion to Hydroxide Form	94% minimum
Impurities	
Sulfate (SO ₄)	0.2% maximum
Chloride (Cl)	0.1% maximum
Carbonate (CO ₃)	5% maximum
TOC Leachables at 15 Bed Volumes	≤ 10 ppb maximum as a mixed bed with low TOC cation
Metals at 15 Bed Volumes	Low ppt levels (feed water dependent)
Kinetics	18 megohm (Siemens Kinetics Test)

Physical Properties

Particle Screen Sizing	
+ 16 Mesh	3% maximum
- 50 Mesh	0.5% maximum
Uniformity Coefficient	1.5 maximum
Whole Beads (%)	95 minimum
Shipping Weight	40 lbs. / cu. ft.
Friability	350 gm / bead
	90% minimum > 200 g/bead

Operating Conditions

Operating pH Range	0 to 14
Service Flow Rate	2 - 4 gpm / cu. ft.
Regenerant Flow Rate	0.25 - 0.5 gpm / cu. ft.
Rinse Flow Rate	0.25 - 0.5 gpm / cu. ft. initially, then 1.5 gpm / cu. ft.
Rinse Volume	60 - 75 gallons / cu. ft.
Maximum Operating Temperature	140°F

USF A-464LC OH ANION RESIN

Description:

USF A-464LC OH is a Type I porous strong base gel anion resin consisting of a styrene divinylbenzene matrix supplied in the hydroxide form. This resin product is specially processed to provide excellent mixed bed separation, low TOC leachables and very low chloride content. It is analyzed kinetically to ensure it is capable of producing high-quality mixed bed deionized water.

Chemical Properties

Functional Group	Trimethylamine
Ionic Form (as shipped)	Hydroxide
Moisture Content	52 - 59% (Cl form)
Exchange Capacity	1.0 meq / ml minimum (OH form)
Conversion to Hydroxide Form	94% minimum
Impurities	
Sulfate (SO ₄)	0.5% maximum
Chloride (Cl)	0.1% maximum
Carbonate (CO ₃)	5% maximum
Kinetics	> 17 megohm (Siemens Kinetics Test)

Physical Properties

Particle Screen Sizing	
+16 Mesh	5% maximum
-50 Mesh	0.5% maximum
Whole Beads (%)	90 minimum
Shipping Weight	40 lbs. / cu. ft.

Operating Conditions

Operating pH Range	0 to 14
Service Flow Rate	2 - 4 gpm / cu. ft.
Regenerant Flow Rate	0.25 - 0.5 gpm/cu. ft.
Rinse Flow Rate	0.25 - 0.5 gpm / cu. ft. initially, then 1.5 gpm / cu. ft.
Rinse Volume	60 - 75 gallons / cu. ft.
Maximum Operating Temperature	140°F

USF A-674PSMBSG OH ANION RESIN

Description:

USF A-674PSMBSG OH is a Type I strong base macroporous anion resin consisting of a styrene divinylbenzene matrix supplied in the hydroxide form. The general appearance is an opaque hard spherical bead. This resin is resistant to organic fouling from waters containing dissolved organics and is used in condensate polishing or other applications requiring excellent physical stability.

Chemical Properties

Functional Group	Trimethylamine
Ionic Form (as shipped)	Hydroxide
Moisture Content	54 - 64% (Cl form)
Exchange Capacity	0.9 meq / ml minimum (OH form)
Kinetics	> 17 megohm (Siemens Kinetics Test)

Physical Properties

Particle Screen Sizing	
+16 Mesh	3% maximum
-50 Mesh	0.5% maximum
Whole Beads (%)	95 minimum
Shipping Weight	40 lbs. / cu. ft.

Operating Conditions

Operating pH Range	0 to 14
Service Flow Rate	
Demineralization	1-6 GPM/ft ²
Condensate Polishing	1-65 GPM/ft ² (dependent on operating conditions and performance expectations)
Regenerant Flow Rate	0.25 - 0.5 gpm / cu ft
Rinse Flow Rate	0.25 - 0.5 gpm / cu ft initially, then 1.5 gpm / cu ft
Rinse Volume	60 - 75 gallons / cu ft
Maximum Operating Temperature	140°F

USF C-361 MEG (H) CATION RESIN

Description:

USF C-361 MEG (H) is a 10% cross-linked gel strong acid cation exchange resin consisting of a sulfonated polymer matrix of styrene and divinylbenzene supplied in the hydrogen form. The resin has a high exchange capacity, excellent stability at elevated temperatures, and superior resistance to oxidizing agents. It has been specially processed to provide high quality mixed bed separation and analyzed kinetically to ensure the capability of producing 18 megohm mixed bed deionized water. This resin is specially processed to be low in TOC leachables.

Chemical Properties

Functional Group	Sulfonic Acid
Ionic Form (as shipped)	Hydrogen
Moisture Content	46 - 51% (H form)
Exchange Capacity	2.0 meq / ml minimum (H form)
Conversion to Hydrogen Form	99% minimum
TOC Leachables at 15 Bed Volumes	≤ 10 ppb maximum as a mixed bed with low TOC anion
Metals at 15 Bed Volumes	Low ppt levels (feed water dependent)
Kinetics	18 megohm (Siemens Kinetic Test)

Physical Properties

Particle Screen Sizing	
+ 16 Mesh	2% maximum
- 50 Mesh	0.2% maximum
Uniformity Coefficient	1.5 maximum
Whole Beads (%)	95 minimum
Shipping Weight	51 lbs. / cu. ft.
Friability	500 gm / bead (average) 95% > 200 g / bead

Operating Conditions

Operating pH Range	1 to 14
Service Flow Rate	1 to 50 gpm / ft ²
Regenerant Flow Rate	
HCl	0.5 to 1.0 gpm / cu. ft.
H ₂ SO ₄	0.5 to 2.0 gpm / cu. ft.
Rinse Flow Rate	0.5 to 1.5 gpm / cu. ft.
Rinse Volume	40 to 75 gallons / cu. ft.
Maximum Operating Temperature	250°F

USF C-361C H CATION RESIN

Description:

USF C-361C H is a 10% cross-linked gel strong acid cation resin in bead form. The resin has a high exchange capacity, excellent stability at elevated temperatures, and superior resistance to oxidizing agents. It has been specially processed to provide high-quality mixed bed separation and analyzed kinetically to ensure the capability of producing high-quality mixed bed deionized water. This resin is used in condensate polishing or other applications requiring excellent physical stability.

Chemical Properties

Ionic Form (as shipped)	Hydrogen
Moisture Content	46 - 51% (H form)
Exchange Capacity	2.0 meq / ml minimum (H form)
Conversion to Hydrogen Form	99% minimum
Kinetics	> 17 megohm (Siemens Kinetics Test)

Physical Properties

Particle Screen Sizing	
+ 16 Mesh	2% maximum
- 50 Mesh	0.5% maximum
Friability	
Average	350 grams / bead minimum
% > 200 gm / bd	95%
Whole Beads (%)	95 minimum
Shipping Weight	51 lbs. / cu. ft.

Operating Conditions

Operating pH Range	1 to 14
Service Flow Rate	
Demineralization	1-6 GPM/ft ²
Condensate Polishing	1-65 GPM/ft ² (dependent on operating conditions and performance expectations)
Regenerant Flow Rate	0.5 to 2.0 gpm / cu. ft.
Rinse Flow Rate	0.5 to 1.5 gpm / cu. ft.
Rinse Volume	40 to 75 gallons / cu. ft.
Maximum Operating Temperature	250°F

USF C-373 PSSG H CATION RESIN

Description:

USF C-361C H is a uniform particle size 10% cross-linked gel strong acid cation resin in bead form. The resin has a high exchange capacity, excellent stability at elevated temperatures, and superior resistance to oxidizing agents. The resin is processed by Siemens for enhanced separability, low TOC and high kinetics and is analyzed kinetically to ensure the capability of producing 18 megohm mixed bed deionized water.

Chemical Properties

Ionic Form (as shipped)	Hydrogen
Moisture Content	46 to 51% (H form)
Exchange Capacity	1.9 meq / ml minimum (H form)
Kinetics	18 megohm (Siemens Kinetics Test)
Conversion to Hydrogen Form	99% minimum

Physical Properties

Particle Screen Sizing	
+ 16 Mesh	2% maximum
- 50 Mesh	0.2% maximum
Mean Size	600 to 700 microns
Whole Beads (%)	95 minimum
Friability	
Average (gm / bd)	350
% > 200 gm / bd	95
Swelling	6% sodium to hydrogen form
Shipping Weight	50 lbs. / cu. ft.

Operating Conditions

Operating pH Range	1 to 14
Regenerant Flow Rate	0.5 to 1.0 gpm / cu. ft.
Rinse Flow Rate	0.5 to 1.0 gpm / cu. ft.
Maximum Operating Temperature	250°F

USF C-381C H CATION RESIN

Description:

USF C-381C H is a strong acid cation exchange resin that is manufactured from polystyrene and is cross-linked with divinylbenzene. This resin is a macroporous cation with an opaque bead appearance and is supplied in the hydrogen form. This type of resin is more resistant to chemical attack and has been processed by USFilter to meet the following specifications for low TOC and high kinetic requirements.

Chemical Properties

Ionic Form (as shipped)	Hydrogen
Moisture Content	49 to 56% (H form)
Exchange Capacity	1.7 meq / ml minimum (H form)
Kinetics	> 17 megohm (Siemens Kinetics Test)

Physical Properties

Particle Screen Sizing	
+ 16 Mesh	5% maximum
- 50 Mesh	1% maximum
Effective Size (Approximate)	0.47 - 0.63 mm
Swelling	5% sodium to hydrogen form
Whole Beads (%)	95 minimum
Shipping Weight	48 lbs. / cu. ft.

Operating Conditions

Operating pH Range	1 to 14
Service Flow Rate	
Demineralization	1-6 GPM/ft ²
Condensate Polishing	1-65 GPM/ft ² (dependent on operating conditions and performance expectations)
Regenerant Flow Rate	0.5 to 2.0 gpm / cu. ft.
Rinse Flow Rate	0.5 to 2.0 gpm / cu. ft.
Rinse Volume	25 to 50 gallons / cu. ft.
Maximum Operating Temperature	250°F

USF NR-1 CATION RESIN

Description:

USF NR-1 is a premium grade, 8% cross-linked gel, strong acid cation resin in bead form. The resin has a high exchange capacity, excellent stability at elevated temperatures, and good chemical resistance over a wide pH range. This resin is typically used in deionization and chemical processing applications.

Chemical Properties

Ionic Form (as shipped)	Hydrogen
Moisture Content	50 - 55% (H form)
Exchange Capacity	1.8 meq / ml minimum (H form)
Conversion to Hydrogen Form	99% minimum
Kinetics	> 17 megohm (Siemens Kinetics Test)

Physical Properties

Particle Screen Sizing	
+ 16 Mesh	5% maximum
- 50 Mesh	0.5% maximum
Friability Average	200 grams/bead minimum
Whole Beads (%)	90 minimum
Shipping Weight	50 lbs. / cu. ft.

Operating Conditions

Operating pH Range	1 to 14
Demineralization	1-6 GPM/ft ²
Condensate Polishing	1-65 GPM/ft ² (dependent on operating conditions and performance expectations)
Regenerant Flow Rate	
HCl	0.5 to 1.0 gpm / cu. ft.
H ₂ SO ₄	0.5 to 2.0 gpm / cu. ft.
Rinse Flow Rate	0.5 to 1.5 gpm / cu. ft.
Rinse Volume	40 to 75 gallons / cu. ft.
Maximum Operating Temperature	250°F

USF NR-20LC NUCLEAR GRADE MIXED BED RESIN

Description:

USF NR-20LC is a 1:1 chemical equivalent of USF NR-26 and NR-2LC. USF NR-26 is a strong acid cation exchange resin that is manufactured from polystyrene, is crosslinked with divinylbenzene, and is in the lithium⁷ form. This resin is a gel cation with an amber to dark bead appearance. USF NR-2LC is a strong base Type I gel anion resin consisting of a styrene divinylbenzene matrix with an amber color processed to have extremely low chloride content. USF NR-20LC is designed for use in the primary systems of nuclear applications.

Chemical Properties

Functional Groups	Sulfonic Acid, Trimethylamine
Ionic Form (as shipped)	Lithium ⁷ / Hydroxide mix
Moisture Content	55% maximum (H form cation) / 48% maximum (Cl form anion)
Exchange Capacity	1.8 meq / ml minimum (H form cation) / 1.1 meq / ml minimum (OH form anion)
Impurities	
Hydrogen (H)	1% maximum (cation)
Chloride (Cl)	0.1% maximum (anion)
Carbonates (CO ₃)	5% maximum (anion)

Physical Properties

Particle Screen Sizing	
+ 16 Mesh	3% maximum
- 50 Mesh	0.5% maximum
Whole Beads (%)	90 minimum
Shipping Weight	43 lbs. / cu. ft.

Operating Conditions

Operating pH Range	1 to 14
Service Flow Rate	1 to 4 gpm / ft ³
Maximum Operating Temperature	140°F

USF NR-31LC MIXED BED RESIN

Description:

USF NR-31LC is a 1:1 chemical equivalent of a 10% cross-linked cation and a Type I gel anion. The cation and anion components are specially selected to provide a high quality mixed bed resin. Both resins are styrene divinylbenzene based. The individual components are specially processed to have low TOC leachables and be highly converted with low impurities. This mixed bed resin is specially processed to have very low chloride content.

Chemical Properties

Functional Groups	Sulfonic Acid, Trimethylamine
Ionic Form (as shipped)	Hydrogen / Hydroxide mix
Moisture Content	51% max. (H form cation)/48% max. (Cl form anion)
Exchange Capacity	2.0 meq / ml minimum (H form cation) / 1.2 meq / ml minimum (OH form anion)
Kinetics	> 17 megohm (Siemens Kinetics Test)
% Conversion	
Cation	99% minimum (H form)
Anion	94% minimum (OH form)
Impurities	
Chloride (Cl)	0.1% Cl maximum
Sulfate (SO ₄)	0.2% SO ₄ maximum

Physical Properties

Particle Screen Sizing	
+ 16 Mesh	5% maximum
- 50 Mesh	0.5% maximum
Whole Beads (%)	95 minimum
Shipping Weight	45 lbs. / cu. ft.

Operating Conditions

Operating pH Range	1 to 14
Maximum Operating Temperature	140°F

USF NR-35LC NUCLEAR GRADE MIXED BED RESIN

Description:

USF NR-35LC is a 2:1 equivalent mix of USF C-381 H and NR-2LC. USF C-381 H is a macroporous hydrogen form strong acid cation exchange resin that is manufactured from polystyrene and is cross-linked with divinylbenzene. USF NR-2LC OH is a Type I strong base gel anion resin consisting of a styrene divinylbenzene matrix with an amber color.

Chemical Properties

Functional Groups	Sulfonic Acid, Trimethylamine
Ionic Form (as shipped)	Hydrogen / Hydroxide mix
Moisture Content	56% max. (H form cation) / 60% max. (OH form anion)
Exchange Capacity	1.65 meq / ml min. (H form cation) / 1.1 meq / ml min. (OH form anion)
Kinetics	> 17 megohm (Siemens Kinetics Test)
Conversion:	
Cation	99% minimum (H form)
Anion	94% minimum (OH form)
Impurities:	
Chloride (Cl)	≤ 0.1%
Sulfate (SO ₄)	≤ 0.5%
Friability	
Average	≥ 350 gm / bead
% > 200	95%

Physical Properties

Particle Screen Sizing	
+ 16 Mesh	5% maximum
- 50 Mesh	0.5% maximum
Effective Size (Approximate)	0.40 - 0.60 mm
Whole Beads (%)	95 minimum
Shipping Weight	47 lbs. / cu. ft.

Operating Conditions

Operating pH Range	1 to 14
Service Flow Rate	1 to 4 gpm / cu. ft.
Regenerant Flow Rate	0.5 gpm / cu. ft.
Rinse Flow Rate	0.5 to 2.0 gpm / cu. ft.
Rinse Volume	50 gallons / cu. ft. (approximate)
Maximum Operating Temperature	140°F

USF NR-57LC NUCLEAR GRADE MIXED BED RESIN

Description:

USF NR-57LC is a 1:1 equivalent mix of USF C-471SG H and USF A-254PSSG OH. USF C-471SG H is a 16% cross linked uniform particle size strong acid gel cation exchange resin consisting of a sulfonated polymer matrix of styrene and divinylbenzene. USF A-254PSSG OH is a uniform particle size Type I porous strong base gel anion resin consisting of a styrene divinylbenzene polymer matrix functionalized with a quaternary amine.

Chemical Properties

Functional Groups	Sulfonic Acid, Trimethylamine
Ionic Form (as shipped)	Hydrogen / Hydroxide mix
Moisture Content	42% max. (H form cation) / 60% max. (OH form anion)
Exchange Capacity	2.4 meq / ml min. (H form cation) / 1.0 meq / ml min. (OH form anion)
Kinetics	> 17 megohm (Siemens Kinetics Test)
Conversion	
Cation	99% minimum (H form)
Anion	94% minimum (OH form)
Impurities:	
Chloride (Cl)	≤ 0.2%
Sulfate (SO ₄)	≤ 0.2%
Friability	
Mean	≥ 350 gm / bead
% > 200	95% minimum

Physical Properties

Particle Screen Sizing	
+ 16 Mesh	2% maximum
- 50 Mesh	0.2% maximum
Particle Size	525 ±50 um (Cation), 590 ±50 um (Anion)
Whole Beads (%)	95 minimum
Shipping Weight	44 lbs. / ft ²

Operating Conditions

Operating pH Range	1 to 14
Service Flow Rate	
Demineralization	1-6 GPM/ft ²
Condensate Polishing	1-65 GPM/ft ² (dependent on operating conditions and performance expectations)
Maximum Operating Temperature	140°F

USF NR-62 STATOR COOLING MIXED BED RESIN

Description:

USF NR-62 STATOR COOLING MIXED BED is a 60:40 volumetric mix of USF A-284C OH and C-361C H. USF C-361C H is a 10% cross-linked gel strong acid cation exchange resin that is manufactured from polystyrene and is cross-linked with divinylbenzene. USF A-284C OH is a strong base, Type I, gel anion resin consisting of a styrene divinylbenzene matrix. This resin is designed for use in Stator Cooling applications and satisfies GE Spec A50A306-S8.

Chemical Properties

Functional Groups	Sulfonic Acid, Trimethylamine
Ionic Form (as shipped)	Hydrogen / Hydroxide mix
Moisture Content	51% max. (H form cation) / 48% max. (Cl form anion)
Exchange Capacity	2.0 meq / m l min. (H form cation) / 1.2 meq / ml min. (OH form anion)
Kinetics	> 15 megohm (Siemens Kinetics Test)

Physical Properties

Particle Screen Sizing	
+ 16 Mesh	5% maximum
- 50 Mesh	0.5% maximum
Effective Size (Approximate)	0.40 - 0.60 mm
Whole Beads (%)	90 minimum
Shipping Weight	45 lbs. / cu. ft.

Operating Conditions

Operating pH Range	1 to 14
Service Flow Rate	1 to 4 gpm / cu. ft.
Maximum Operating Temperature	140°F

USF NR-63RLS MIXED BED RESIN

Description:

USF NR-63RLS is a 1:1 chemical equivalent mix of USF C-471RLS H and A-284RLS OH. USF C-471RLS H is a 16% cross-linked strong acid cation exchange resin that is manufactured from polystyrene and is cross-linked with divinylbenzene. C-471 RLS H is a gel cation with a dark color which is easily distinguished from USF A-284 RLS OH in the mix. A-284RLS OH is a strong base Type I gel anion resin consisting of a styrene divinylbenzene matrix with an amber color. C-471RLS H and A-284RLS OH are produced using selected starting resins meeting USFilter specifications and are processed to have very low TOC leachables and dynamic sodium levels for use in the nuclear industry.

Chemical Properties

Functional Groups	Sulfonic Acid, Trimethylamine
Ionic Form (as shipped)	Hydrogen / Hydroxide mix
Moisture Content	42% max. (H form cation) / 48% max. (Cl form anion)
Exchange Capacity	2.4 meq / ml min. (H form cation) / 1.2 meq / ml min. (OH form anion)
Kinetics	18 megohm (Siemens Kinetics Test)
Conversion:	
Cation	99% minimum (H form)
Anion	94% minimum (OH form)
Impurities	
TOC (15 bed volumes of rinse)	≤10 ppb maximum above the influent
Sodium (15 bed volumes)	≤20 ppt maximum above the influent
Metals (15 bed volumes of rinse)	Low ppt levels (feedwater dependent)

Physical Properties

Particle Screen Sizing	
+ 16 Mesh	5.0% maximum
- 50 Mesh	0.5% maximum
Whole Beads (%)	95 minimum
Shipping Weight	48 lbs. / cu. ft.
Bead Strength (friability)	350 gm / bead (minimum)

Operating Conditions

Operating pH Range	1 to 14
Service Flow Rate	1 to 4 gpm / cu. ft.
Maximum Operating Temperature	140°F

Material Safety Data Sheet

SECTION 1 – CHEMICAL PRODUCT AND COMPANY INFORMATION

Product Name: NR-63RLS Ion Exchange Resin

Part Number: multiple

Chemical Family: cation and anion exchange polymers

Manufacturer's Name: Siemens Industry, Inc. - Water Technologies Business Unit

Address: 4669 Shepherd Trail, Rockford, IL 61103

Product/Technical Information Phone Number: (815) 877-3041

Medical/Handling Emergency Phone Number: Call CHEMTREC at 800/424-9300
24 hours a day

Transportation Emergency Phone Number: Call CHEMTREC at 800/424-9300
24 hours a day

Issue Date: July 2007

Revision Date/Revision Number: April 2011/ Rev 1

SECTION 2 – COMPOSITION INFORMATION

<u>Chemical Name</u>	<u>% By Weight</u>	<u>CAS #</u>
Sulfonated copolymer of styrene and divinylbenzene in hydrogen form	20 – 30	069011-20-7
Trimethylamine functionalized, chloromethylated copolymer of styrene and divinylbenzene in hydroxide form	15 – 30	069011-18-3
Water	30 - 60	007732-18-5

SECTION 3 – HAZARDS IDENTIFICATION

Appearance & Odor: Spherical beads/Odorless to slight amine odor

Emergency Overview:

- ◆ Corrosive to the eyes (may cause severe eye burns)
- ◆ Spills make the floor slippery

Fire & Explosion Hazards: This material will not burn until moisture is removed, then resin starts to burn in flame at 230⁰ C. Under fire conditions some components of this product may decompose. The smoke may contain unidentified toxic and/or irritating compounds. Nitric acid and other strong oxidizing agents can cause explosive-type reactions when mixed with ion exchange resins. Proper design of equipment to prevent build up of pressure is necessary if use of an oxidizing agent such as nitric acid is contemplated.

Primary Route(s) of Exposure: skin and eye contact

Inhalation – Acute Effects: Vapors are unlikely due to physical properties.

Skin Contact – Acute Effects: No adverse effects are expected from brief skin contact. Extended skin contact may cause skin rash.

Eye Contact – Acute Effects: The spherical beads may cause severe damage to eyes, eye irritation, redness, and moderate corneal injury.

Material Safety Data Sheet

Ingestion – Acute Effects: Single dose oral toxicity is considered to be low. No hazards anticipated from swallowing small amounts incidental to normal handling operation. Swallowing large amounts may cause irritation to the gastrointestinal tract.

SECTION 4 – FIRST AID MEASURES

Inhalation First Aid: Remove affected person from area to fresh air and provide oxygen if breathing is difficult. Give artificial respiration ONLY if breathing has stopped and give CPR ONLY if there is no breathing and no pulse. Obtain medical attention. No adverse effects anticipated by this route of exposure.

Skin Contact First Aid: Immediately remove clothing from affected area and wash skin vigorously with flowing water. Clothing should be washed before reuse. Seek medical attention if irritation occurs. DO NOT instruct person to neutralize affected skin area.

Eye Contact First Aid: Immediately irrigate eyes with flowing water continuously for 15 minutes while holding eyes open. Contacts should be removed before or during flushing. Obtain medical attention. DO NOT instruct person to neutralize.

Ingestion First Aid: No adverse effects anticipated by this route of exposure incidental to proper industrial handling. If ingestion does occur, if victim is alert and not convulsing rinse mouth with water and give plenty of water to drink. If spontaneous vomiting occurs, have affected person lean forward with head down to avoid breathing in of vomitus. Rinse mouth again and give more water to drink. Obtain medical attention.

Medical Conditions Aggravated: There are no known conditions aggravated by exposure.

Note to Physician: No specific antidote. Supportive care. Treatment based on judgment of the physician in response to reactions of the patient.

SECTION 5 – FIRE FIGHTING MEASURES

Flash Point/Method: N/A

Auto Ignition Temperature: Above 500⁰ C (900⁰ F)

Upper/Lower Explosion Limits: N/A

Extinguishing Media: Water, carbon dioxide, dry chemical

Fire Fighting Procedures: Keep people away. Isolate fire area and deny unnecessary entry. Cool surrounding area with water to localize fire zone. Soak thoroughly with water to cool and prevent reignition.

Fire-Fighting Equipment: NIOSH approved positive-pressure self-contained breathing apparatus (SCBA) and protective fire fighting clothing (includes fire fighting helmet, coat, pants, boots and gloves). If protective equipment is not available or not used, fight fire from a protected location or a safe distance.

Material Safety Data Sheet

Fire & Explosion Hazards: This material will not burn until moisture is removed, then resin starts to burn in flame at 230⁰ C. Under fire conditions some components of this product may decompose. The smoke may contain unidentified toxic and/or irritating compounds. Nitric acid and other strong oxidizing agents can cause explosive-type reactions when mixed with ion exchange resins. Proper design of equipment to prevent build up of pressure is necessary if use of an oxidizing agent such as nitric acid is contemplated.

Hazardous Products of Decomposition and/or Combustion: May include but not limited to hydrocarbons, sulfur oxides, organic sulfonates, carbon monoxide, carbon dioxide and benzene compounds.

NFPA Ratings:

HEALTH- 1 FLAMMABILITY- 1 REACTIVITY- 1 OTHER- none

SECTION 6 – ACCIDENTAL RELEASE MEASURES

Spill/Leak Procedures: Isolate spill area to prevent falls as material can be a slipping hazard. Avoid contact with eyes and skin. Material is heavier than water and has limited water solubility. It will collect on the lowest surface.

Cleanup: Clean up floor area. Sweep up. Avoid generation of dust.

Regulatory Requirements: Follow all applicable Federal, State, Local, or Provincial regulations.

Disposal: DO NOT DUMP INTO ANY SEWERS, ON THE GROUND, OR INTO ANY BODY OF WATER. All disposal methods must be in compliance with all Federal, State, Local and Provincial laws and regulations. Regulations may vary in different locations. Waste characterizations and compliance with applicable laws are the responsibility solely of the waste generator.

SECTION 7 – HANDLING AND STORAGE

Handling: Practice reasonable care and caution. Metal equipment should be compatible with feed, regenerant, resin form and effluent of that process.

Storage: Keep containers tightly closed when not in use. Store between 2⁰ - 38⁰ C (35⁰ - 100⁰F).

General Comments: Containers of this material may be hazardous when empty since they retain product residues (dust, solids); observe all warnings and precautions listed for the product.

SECTION 8 –PERSONAL PROTECTION/ EXPOSURE CONTROL

Respiratory Protection: No respiratory protection should be needed.

Skin Protection: Wear gloves impervious to this material to prevent skin contact.

Material Safety Data Sheet

Eye Protection: Wear protective eyeglasses or chemical safety goggles. Contact lenses are not eye protective devices. Appropriate eye protecting must be worn instead of, or in conjunction with contact lenses.

Ventilation Protection: Good general ventilation should be sufficient.

Other Protection: Never eat, drink, or smoke in work areas. Practice good personal hygiene after using this material, especially before eating, drinking, smoking, using the toilet, or applying cosmetics. Safety showers, with quick opening valves which stay open, and eye wash fountains, or other means of washing the eyes with a gently flow of cool to tepid tap water, should be readily available in all areas where this material is handled or stored. Water should be supplied through insulated and heat-traced lines to prevent freeze-ups in cold weather.

Exposure Limits:

Exposure limits have not been developed.

SECTION 9 – PHYSICAL AND CHEMICAL PROPERTIES

Appearance & Odor: Spherical beads/Odorless to slight amine odor

Vapor Pressure: N/A*

Vapor Density (Air=1): N/A

Boiling Point: N/A

Melting Point: N/A

Specific Gravity: N/D**

Solubility in Water: Insoluble

Volatile Percentage: N/A

pH: N/A

Flash Point/method: N/A

Auto Ignition Temperature: Above 500⁰ C (900⁰ F)

Upper/Lower Explosion Limits: N/A **Other:** N/D

*N/A=Not applicable

**N/D=Not determined

SECTION 10 – STABILITY AND REACTIVITY

Stability: Stable under normal handling and storage conditions.

Incompatibilities: Oxidizing agents such as nitric acid attack organic ion exchange under certain conditions and could result is slightly degraded resin up to an explosive reaction. Before using strong oxidizing agents, consult sources knowledgeable in handling such materials.

Polymerization: Hazardous polymerization cannot occur.

Decomposition: Hazardous decomposition products depend upon temperature, air supply, and the presence of other materials. Hazardous decomposition products may include and are not limited to: aromatic compounds, hydrocarbons, organic sulfonates, sulfur oxides.

Material Safety Data Sheet

Conditions to Avoid: Resin can decompose at temperatures greater than 90⁰ C (194⁰ F). Do not pack column with dry ion exchange resins. Dry beads expand when wet. This expansion can cause a glass column to shatter.

SECTION 11 – TOXICOLOGICAL INFORMATION

Inhalation – Acute: Vapors are unlikely due to physical properties.

Inhalation – Chronic: There are no known chronic inhalation effects.

Skin Contact – Acute: Skin contact may cause mild irritation and redness.

Skin Contact – Chronic: There are no known chronic dermal effects.

Eye Contact – Acute: May cause severe eye irritation and redness. May cause moderate corneal injury. Effects are likely to heal.

Ingestion – Acute: Single dose oral toxicity is considered to be low. No hazards anticipated from swallowing small amounts incidental to normal handling operation. Swallowing large amounts may cause irritation to the gastrointestinal tract. Swallowing extremely large amounts may produce gastrointestinal disturbances.

Ingestion – Chronic: There are no known chronic ingestion effects.

Carcinogenicity/Mutagenicity: There are no known carcinogenic/mutagenic effects.

Reproductive Effects: There are no known reproductive effects.

Neurotoxicity: There are no known neurotoxic effects.

Other Effects: There are no other known toxic effects.

Target Organs: Target organs include the eyes and skin.

SECTION 12 – ECOLOGICAL INFORMATION

The environmental fate and ecological toxicity are not known.

SECTION 13 – DISPOSAL CONSIDERATIONS

Spill/Leak Procedures: Isolate spill area to prevent falls as material can be a slipping hazard. Avoid contact with eyes and skin. Material is heavier than water and has limited water solubility. It will collect on the lowest surface.

Cleanup: Clean up floor area. Sweep up. Avoid generation of dust.

Regulatory Requirements: Follow all applicable Federal, State, Local, or Provincial regulations.

Material Safety Data Sheet

Disposal: DO NOT DUMP INTO ANY SEWERS, ON THE GROUND, OR INTO ANY BODY OF WATER. All disposal methods must be in compliance with all Federal, State Local and Provincial laws and regulations. Regulations may vary in different locations. Waste characterizations and compliance with applicable laws are the responsibility solely of the waste generator.

SECTION 14 – TRANSPORTATION INFORMATION

DOT Shipping Description: This product is not regulated by DOT when shipped domestically by land.

Canadian TDG Information: For TDG regulatory information, if required, consult transportation regulations, or product shipping.

SECTION 15 – REGULATORY INFORMATION

US Regulations:

SARA HAZARD CATEGORY: This product has been reviewed according to the EPA "Hazard Categories" promulgated under Sections 311 and 312 of the Superfund Amendment and Reauthorization Act of 1986 (SRA Title III) and is considered, under applicable definitions, to meet the following categories: An immediate health hazard

TSCA Considerations: Every different salt or ionic form of an ion exchange resin is a separate chemical. If you use an ion exchange resin for ion exchange purposes and then remove the by-product resin from its vessel or container prior to recovery of the original or another form of the resin or of another chemical, the by-product resin must be listed on the TSCA Inventory (Unless an exemption is applicable). It is the responsibility of the customer to ensure that such isolated, recycled by-product resins are in compliance with TSCA. Failure to comply could result in substantial civil or criminal penalties being assessed by the EPA.

State Regulations: Consult individual state agency for further information.

Canadian Regulations:

WHMIS INFORMATION: The Canadian Workplace Hazardous Materials Information System (WHMIS) Classification for this product is: D2B - eye or skin irritant. Refer elsewhere in the MSDS for specific warnings and safe handling information.

CPR Statement: This product has been classified in accordance with the hazard criteria of the Canadian Controlled Products Regulations (CPR) and the MSDS contains all the information required by the CPR.

SECTION 16 – OTHER INFORMATION

Disclaimer: The information contained herein is based on data considered accurate. However, no warranty is expressed or implied regarding the accuracy of these data or the results to be obtained from the user thereof. It is the buyer's responsibility to ensure that its activities comply with federal, state, provincial and local laws.

Revision Indicator: April 2011, Revised Section 1 (Updated manufacturer's name)

USF NR-6LC MIXED BED RESIN

Description:

USF NR-6LC is a 1:1 chemical equivalent of USF NR-1 and NR-2LC. USF NR-1 is a strong acid cation exchange resin that is manufactured from polystyrene and is cross-linked with divinylbenzene. This resin is a gel cation with an amber to dark bead appearance. USF NR-2LC is a strong base Type I gel anion resin consisting of a styrene divinylbenzene matrix with an amber color. NR-1 and NR-2LC are specially processed to have low TOC leachables.

Chemical Properties

Functional Groups	Sulfonic Acid, Trimethylamine
Ionic Form (as shipped)	Hydrogen / Hydroxide mix
Moisture Content	55% max. (H form cation) / 48% max. (Cl form anion)
Exchange Capacity	1.8 meq / ml min. (H form cation) / 1.2 meq / ml min. (OH form anion)
Kinetics	> 17 megohm (Siemens Kinetics Test)
Conversion:	
Cation	99% minimum (H form)
Anion	94% minimum (OH form)
Impurities	
Chloride (Cl)	0.1% maximum
Sulfate (SO ₄)	0.5% maximum

Physical Properties

Particle Screen Sizing	
+ 16 Mesh	5% maximum
- 50 Mesh	0.5% maximum
Effective Size (Approximate)	0.40 - 0.60 mm
Whole Beads (%)	90 minimum
Shipping Weight	45 lbs. / cu. ft.

Operating Conditions

Operating pH Range	1 to 14
Service Flow Rate	1 to 4 gpm / cu. ft.
Maximum Operating Temperature	140°F

USF PURCAT C-373 H CATION RESIN

Description:

USF PURCAT C-373 H is a strong acid cation exchange resin that is specially processed using a patented cleaning procedure for high-purity condensate polishing applications where extremely low organic leachables are important and amines, such as ETA, are being added for pH control. This resin is a 10% cross-linked uniform particle size gel resin and is typically used in mixed bed applications. The resin is processed by USFilter to meet the following specifications for enhanced separability, low TOC and high kinetics and is analyzed kinetically to ensure the capability of producing 18 megohm mixed bed deionized water.

Chemical Properties

Ionic Form (as shipped)	Hydrogen
Moisture Content	46 to 51% (H form)
Exchange Capacity	1.9 meq / ml minimum (H form)
Kinetics	18 megohm (Siemens Kinetics Test)
Conversion to Hydrogen Form	99% minimum
16 Hr. Soak TOC	< 5 ppm

Physical Properties

Particle Screen Sizing	
+ 16 Mesh	2% maximum
- 50 Mesh	0.2% maximum
Mean Size	600 to 700 microns
Whole Beads (%)	95 minimum
Friability	
Average (gm / bd)	500
% > 200 gm / bd	95
Swelling	6% sodium to hydrogen form
Shipping Weight	50 lbs. / cu. ft.

Operating Conditions

Operating pH Range	0 to 14
Service Flow Rate	
Demineralization	1-6 GPM/ft ²
Condensate Polishing	1-65 GPM/ft ² (dependent on operating conditions and performance expectations)
Regenerant Flow Rate	0.5 to 1.0 gpm / cu. ft.
Rinse Flow Rate	0.5 to 1.0 gpm / cu. ft.
Maximum Operating Temperature	250°F