LG Water Solutions

Technical Service Bulletin

QuantumPure™

Ion Exchange Resins

Technical Service Bulletin

Contents

LG QuantumPure™ IX Resins

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Ion Exchange Resins Handling, Storage and Disposal

1. Handling

To prevent contact with the eyes and skin, appropriate Personal protective equipment (PPE) should be used/worn, and work should be done in a well-ventilated area. An eye-wash facility must be installed. Beware of slippery floor there is ion exchange resins spillage.

Avoid contact with hot substances, sparks etc. as the Resin may get damaged. Similarly contact or mixing with oxidizing agents or nitric acid shall be avoided.

2. Storage

Store in a dry place with good ventilation and avoiding avoid direct sunlight. The packaging container should be sealed to prevent contamination and drying of Resins. The resin drums or bags should not be stored along with oxidizing agents.

Storage at high temperatures can cause rapid degradation of ion exchange resins. Storage at 0°C or below may cause can frequent freezing and thawing resulting into cracked beads of the Ion Exchange resins, so caution should be taken in extreme cold weathers.

3. Disposal

Disposal of ion exchange resins shall be done by landfill or incineration in accordance with Local, State and Federal Statutory requirements. Incineration should be done using a suitable incinerator equipped complying with regulatory norms.

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Ion Exchange Resins Long-term Storage

When ion exchange resins are stored for a long period of time, their physical and chemical performance may deteriorate if proper storage precautions are not taken. The factors that can affect the storage conditions of ion exchange resins and ways to minimize performance degradation are as follows.

1. Long-term Storage in Original Packaging

Refer to TSB 901 for handling and short-term storage of ion exchange resins in their original packaging.

Ion exchange resins are supplied in polyethylene bags with some moisture and fully hydrated. However, due to damaged sealing during storage, there is a possibility of drying of beads during long-term storage. Ion exchange resins should not be stored at temperatures above 50 °Celsius (122 °F) as there is a risk of drying of resin beads, and for anion exchange resins, performance deterioration may occur, so caution is required. When stored in a hot climate, ion exchange resins should be protected from direct sunlight and moisture should be checked manually every 2 weeks. Ion exchange resins should be protected from sudden freezing and thawing, but gradual temperature changes do not affect them. They should also be protected from physical shock and not stacked more than 12 bags on a pallet to prevent physical shock during transportation.

2. Storage After System Startup

When the equipment is shut down during normal operation, there is a need to store new or used ion exchange resins in the resin column to prevent performance deterioration. It is important to maintain moisture during storage. To prevent freezing of the resin and damage to the resin column during winter storage, it is desirable to store the resin in a NaCl solution. Failure to adhere to proper preservation techniques can lead to several issues that may compromise system performance and resin longevity.

Intermittent usage or long-term equipment shutdown may result in resin contamination due to microbial growth. This contamination can be prevented by storing in a NaCl solution. However, caution should be taken as the combination of NaCl and H ions in cation exchange resins can produce HCl, which may cause problems with the equipment.

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Ion Exchange Resins Long-term Storage

During the long-term storage for ion exchange resins without operation, as H, OH form, performance degradation may occur. Therefore, it should be stored as Na, Cl form after ion exchange. In order to convert anion exchange resins to Cl form, there are two methods: soaking in a 10% NaCl solution and converting to exhausted form after service cycle. Even if both cation and anion exchange resins are stored as Na, Cl form, there is a possibility of contamination due to microbial growth during long-term storage. Therefore, measures to prevent microbial growth should be taken during storage using the following methods:

1) The resin should be flushed with water of twice bed volume at a low flow rate at a frequency of once per day, and the water in the column should then be replaced with fresh feed water.
2) If it is not possible to flush, the resin column, it should be stored in a 10% NaCl solution.
3) If NaCl solution cannot be added, HCl should be added to prevent microbial growth, and the pH in the column should be maintained in an acidic pH during storage (Refer individual Resin Data Sheet for Allowable pH range).

DO NOT store resin, in the preserved state at freezing conditions or at temperatures in excess of 50ºC (122ºF).

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Loading of Resin

There are variety of ways for the loading/unloading resins depending on the equipment design and procedures developed at the site for its own suitable ways. Before loading the resins, it is recommended to make a detailed inspection of the empty column.

1. Equipment and Materials

- Ion exchange column(s)
- Ion exchange resin
- Feed water
- Personal Protective Equipment (PPE)

2. Pre-loading Procedures

2.1 Safety Precautions

- Wear appropriate PPE, including safety goggles and gloves
- Check PPE before use.
- Ensure fall distance before selecting PPE.
- Lockout–tagout (LOTO) all the drives to ensure water will not enter column while working.
- Ensure people are not working near column when hardware/tools are used to open the Manholes.
- Ensure proper ventilation in work area.
- Familiarize yourself with the Material Safety Data sheet (MSDS) for each resin

2.2 Column Preparation

1) Ensure that all debris from used resins or foreign materials is removed from the column(s).
2) Clean the distributors and inspect all laterals, splash-plates, and nozzles for any damage or blockages.
3) Check the integrity of the rubber lining, if present, and perform a spark test if possible.
4) Whenever possible, check the pressure loss of the empty column at nominal flow rate and observe the flow patterns for uniformity.

3. Loading Procedure for Single Bed

A single bed is a resin column in which only one type of ion exchange resin is charged.

1) Fill column with sufficient feed water to allow settling to avoid resin damage.
2) Load the ion exchange resin about one-third of the total resin capacity to be charged by pouring it from the top or by the use of a vacuum eductor.
3) Drain excess water as necessary.
4) Let the bed settle for 10 minutes.
5) Wait for 10 minutes for the resin bed to settle.
6) Drain the water until further resin quantity can be added.
7) Repeat the procedure from step 2 to step 7 till complete quantity is loaded.

8) Backwash the resins for 30 mins.
9) Drain the water until the water level is 0.1 meter higher than resin bed height.
10) Take ion exchange resin sample if needed.
11) Close Column and carry out double regeneration.
12) For Small Columns resin can be filled in a single step.

4. Loading Procedure for Mixed Bed Resins

A mixed bed produces high-purity water by mixing cation and anion exchange resins. It separates two types of ion exchange resins around a middle collector, and it is important to separate each part of ion exchange resins including its level. Therefore, caution should be taken during the charging process.

4.1 Cation Resin

1) Fill the column with sufficient feed water to allow settling to avoid resin damage.
2) Load the cation exchange resin by pouring it from the top or by the use of a vacuum eductor. Drain excess water from bottom as necessary.

Note

Top level of cation exchange resin (H form) layer should approximately align with center of the middle collector. The Middle Collector position shall be carefully designed to match the volume of resin. This condition will not apply when Inert resin is used. In such case the Middle Collector position shall be as per the Inert resin volume.

4.2 Anion Resin

1) Check if the top layer of the charged cation exchange resin is flat, and if not, apply a reverse flow that moves the top layer of the resin slightly to make it flat.
2) Load the anion exchange resin from the top manhole of the resin column, and if drainage is necessary, drain it through the middle collector.
3) After loading the resin, add water from the top of the resin column and flush with twice the resin Bed Volume using feed water, for about 10 minutes, by draining through the middle collector.

Note

If water should be added after completing the loading of the anion exchange resin, it should be added up to the top or the top of collector of the resin column, and drainage should be done through the middle collector. It is not recommended to apply a reverse flow or add water through the middle collector, as this can cause disturbance in the resin bed.

5. Precautions

- Avoid dropping resin beads from a height to prevent breakage.
- Do not overfill the column; leave adequate space for resin.
- Prevent the resin from drying out during the loading process.
- Avoid contamination of the resin with oils, metals, or other impurities.
- Handle the resin gently to prevent physical damage to the beads.

6. Quality Control

- Verify the final bed height meets specifications.
- Check for uniform distribution and absence of channels or cracks in the resin bed.
- Confirm proper sealing of all column fittings.

7. Documentation

- Record the type and quantity of resin used.
- Document any observations or deviations from standard procedures.
- Update relevant logs and maintenance records.

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Conditioning of Ion Exchange Resin

Ion exchange resins are essentially insoluble polymers and usually do not require any pretreatment before use. However, the ion exchange resins supplied contain a small amount of soluble impurities, which may need to be removed before use depending on the application. This is done to obtain high purity for the initial treated water or solution.

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Cautions

1. Familiarize yourself with the Material Safety Data Sheets (SDS) for all chemicals used.

2. Always work in well-ventilated area.

3. Wear proper PPE like tight goggles, nitrile gloves, acid/alkali proof clothing as may be required.

4. Always add acid to water.

Warnings

1. Do not inhale vapours/fumes.

2. Avoid substance contact.

3. Do not empty acidic/alkaline contents to unspecified drains.

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Conditioning of Ion Exchange Resin

1. Preparation for Conditioning

1) Load the ion exchange resin and water into the ion exchange column.
2) Perform a backwash to expand the resin bed by about 50%, remove the air, and arrange the ion exchange resin by particle size.
3) Stop the backwash and allow the resin bed to settle without disturbance.
4) Drain water until the water level reaches 3cm (slightly more than 1”) above the top of the ion exchange resin bed.

2. Anion Exchange Resin Conditioning

No.	Conditioning	Remarks
1	Pass 1.5N (N, normality) sodium hydroxide (NaOH) through at twice the volume of the resin.	20min
2	Rinse with Feed water at five times the volume of the resin to remove residual sodium hydroxide. Maintain the water level at 3cm above the top of the resin bed.	30min
3	Pass 2.0N hydrochloric acid (HCl) through at twice the volume of the resin.	20min
4	Rinse with Feed water at five times the volume of the resin to remove residual hydrochloric acid. Maintain the water level at 3cm above the top of the resin bed.	30min
5	Repeat the steps of sodium hydroxide injection → wash → hydrochloric acid injection → wash from 1) to 4).	
6	If a high purity resin bed is required, pass a polar solvent such as acetone or ethanol through at twice the volume of the resin, followed by rinsing.	
7	Once conditioning is complete, the ion exchange resin is in the Cl form. To change it to the OH form, regeneration is performed through steps 1) → 2), followed by rinsing with DM/Ultrapure water until the rinse water pH reaches 9.0.	

3. Cation Exchange Resin Conditioning

No.	Conditioning	Remarks
1	Pass 2.0N hydrochloric acid (HCl) through at twice the volume of the resin.	20min
2	Rinse with water at five times the volume of the resin to remove residual hydrochloric acid. Maintain the water level at 3cm above the top of the resin bed.	30min
3	Pass 1.5N sodium hydroxide (NaOH) through at twice the volume of the resin. (For weakly acidic cation exchange resins that swell when converted to the Na form, this can cause compaction of the resin bed and risk of damage to the ion exchange column. Therefore, it is advisable to pass the sodium hydroxide up-flow and special care is needed depending on the size of the ion exchange column.)	20min
4	Rinse with water at five times the volume of the resin to remove residual sodium hydroxide. Maintain the water level at 3cm above the top of the resin bed.	30min
5	Repeat the steps of hydrochloric acid injection → wash → sodium hydroxide injection → wash from ① to ④.	
6	If a high purity resin bed is required, pass boiling water through for about 30 minutes, allow to cool, then pass a polar solvent such as methanol, acetone, or ethanol through at twice the volume of the resin, followed by rinsing with DM/ultrapure water.	
7	Once conditioning is complete, the ion exchange resin is in the Na form. To change it to the H form, regeneration is performed through steps ① → ②, followed by rinsing with DM/ultrapure water until the rinse water pH reaches 4.0.	

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Clumping of Ion Exchange Resins

1. What Is the Clumping of Ion Exchange Resins?

The clumping of ion exchange resins is an issue sometimes encountered when mixing cation and anion exchange resins in a mixed bed, particularly when new resins are in regenerated forms (H form for cations, OH form for anions), clumping occurs more frequently.

When clumping occurs, the cation and anion exchange resins intertwine and form clumps, and even after backwashing, due to the difference in densities, the separation of the cation and anion exchange resins is not effectively achieved, leading to poor regeneration. Additionally, parts of the resin layer clump together, causing channeling, and the increase in void spaces leads to an increase in the volume of the resin layer.

2. Why Does Clumping of Ion Exchange Resins Occur?

The clumping of ion exchange resins is known to occur due to the strong electrostatic attraction between the surfaces of the regenerated cation exchange resin (H form) and anion exchange resin (OH form). This phenomenon is especially pronounced in pure or ultrapure waters, where the electrolyte concentration is very low.

3. What Are the Solutions When Clumping Occurs?

3.1 Air-scrubbing and NaOH Injection

Typically, the clumping resolves naturally after 3-4 cycles of service and regeneration as the surface charge of the anion exchange resin decreases, but it can persist in processes using ultrapure water with very little electrolyte. The best environment for clumping to occur is, as mentioned above, when cation/anion exchange resins in ultrapure or pure waters with minimal electrolyte are in their regenerated form. Therefore, methods involve converting the cation/anion exchange resins, artificially, to the exhausted form or injecting electrolytes, with the most widely used methods being air-scrubbing and using NaOH.

The detailed operating methods are as follows:

1) Air-scrubbing: Air is blown into the bottom of the resin column to mix the cation/anion exchange resins and partially loosen the entangled resin layer. (N^2 may also be used depending on the process)
2) After air-scrubbing, a NaOH solution (typically around 5%) is injected from the top of the resin column and discharged from the bottom. The cation exchange resin becomes the Na form, increasing its density (increasing the cation/anion density difference), reducing the interaction with the OH form anion exchange resin, and decreasing electrostatic interactions due to the injected electrolyte (NaOH).
3) Backwashing is performed to separate the cation/anion exchange resins.
4) After separation, the Na form cation exchange resin is regenerated with HCl. The anion exchange resin, already in the OH form, does not require regeneration.
5) Start service after mixing of resins and check water quality.

3.2 Air-scrubbing and PSA (Polystyrene Sulfonic Acid) Injection

If the clumping does not improve even after air-scrubbing or NaOH injection, a linear polymer electrolyte, typically PSA (Polystyrene Sulfonic Acid), is used as an anti-clumping agent.

1) Typically, about 200-300 mL of PSA original solution is used per 1m3 of anion exchange resin, and it is prepared to be injected by diluting 200-300 mL of the original solution with 10L of pure water.
2) During air-scrubbing with the mixed cation/anion exchange resins, about 10L of the prepared PSA solution is injected from the top of the resin column over 20-30 minutes, and after injection completion, air-scrubbing is continued for another 20-30 minutes.
3) Backwashing is performed to separate the cation/anion exchange resins.
4) The regeneration process is conducted after separation, and water Service is started to verify water quality.

4. Why Does the Volume of the IER Bed Increase When Clumping Occurs?

When clumping of ion exchange resins occurs, the cation/anion exchange resins tangle, increasing the void spaces between the resin layers, which in turn increases the volume.

4.1 Precautions During Commissioning After Regeneration

If the required water quality is not achieved during commissioning after regeneration, separating the ion exchange resins through backwashing and re-conducting regeneration immediately can lead to clumping as the cation/anion exchange resins are in the regenerated form. Therefore, to prevent ongoing trouble, it is necessary to continue the service process for at least 5 hours to partially convert to the exhausted form before performing air-scrubbing for 10-20 minutes and then separating through the backwash process.

Be cautious when attempting to separate and regenerate the regenerated ion exchange resins (H form for cation, OH form for anion) after charging, as there is a high likelihood of clumping.

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Exchange Process for Silica Removal

1. What is the Silica?

In a state of nature, Si ion exists as silicates with metal ions, in the form of crystals, or sand as silica (SiO_2). When surface water flows over the ground and comes into contact with silicate minerals, a small amount of silica dissolves, and the concentration varies depending on the region. In natural water, silicate ions exist in various forms, most typical form is SiO_3^{2-}, with some resembling phosphate ions, and when they aggregate, they can be classified as colloid particles. In this state, they are no longer ions and exist in a suspended solid state in the solution. These characteristics can lead to difficulties in operation or analysis.

In water, silica can be classified into three major types.

1) Ionic Silica: Also known as reactive silica or monomeric silica, is readily removed by ion exchange resins. Although silica has a very low solubility in water, its solubility increases when the pH is high.
   Ionic Silica
   $SiO_2 + H_2O \rightarrow H_2SiO_3$
   Silica removed by anion exchange resin
   $R\text{-}N{\cdot}OH + H_2SiO_3 \leftrightarrow R\text{-}N{\cdot}HSiO_3 + H_2O$
2) Colloidal Silica: It is impossible to remove it by ion exchange resin, and when dried, it is deprived of moisture and precipitates as SiO_2. If it is deposited on anion exchange resins, it can cause a decrease in the performance of the resin.
3) Non-ionic Silica: Silica component that does not have an ion charge and does not form a polymer with other ions or substances. It exists in trace amounts and cannot be removed by ion exchange resins.

2. Silica Leakage

When dissolved silica leaks, it does not affect the conductivity (in fact there is slight dip in conductivity initially), but it can cause critical problems in equipment such as Steam Turbines & high-pressure boilers. The leakage of silica is related to the amount of residual silica in the ion exchange resin after the regeneration process. When silica is adsorbed onto an anion exchange resin, it can be adsorbed as a simple ion such as H_2SiO_3 or as a relatively small molecular weight soluble polymer. Larger molecular weight polymers are classified as colloidal silica and cannot be removed by ion exchange resin. The formation of silica polymers can occur during the process of surface water treatment, but it can also be accelerated when it comes into contact with acid at the cation exchange resin column. Acidic media catalyze the formation of silica polymers, while alkaline media catalyze their decomposition. If silica is not completely removed during the regeneration process, the small amount of Na leaked from the cation exchange column can generate an alkaline medium, which catalyzes the decomposition of adsorbed silica. Therefore, to reduce silica leakage, the following should be noted

1) Silica can be removed by strong base anion exchange resin. During multiple usage cycle of the strong base exchange resin, the exchange capacity tends to deteriorate and become weakly base exchange functional group. Therefore, it is necessary to replace the portion of exchange resin with new resin.

2) It is recommended to use excess amount of anion exchange resin than calculated at the design stage and manage the silica through total conductivity measurement.

For the 2B3T+MBP system, it is recommended to manage the regeneration process of MBP to prevent regeneration failure and maintain the appropriate temperature during the regeneration process. At the high temperature, it is easier to remove silica deposited on the anion exchange resin. Therefore, the temperature should be controlled within the limit of the heat resistance limits of the ion exchange resin.

3. Cause of Silica Leakage

3.1 Alkalization and Performance Degradation of Strong Base Anion Exchange Resin

The exchange group of strong base anion exchange resin is tertiary or quaternary amines, which can be easily oxidized by dissolved oxygen in water. After oxidization, the exchange capacity decreases because the exchange group is transformed from strong base to weak base. The oxidation of strong acid cation exchange resin only affects the resin support structure, but the oxidation of strong base anion exchange resin affects both the resin support structure and the exchange functional group. This means the exchange group of anion exchange resin is chemically unstable. When strong base anion exchange resin is changed to weak base, the efficiency of silica removal decreases, which can cause leakage.

3.2 An Increase in Silica Concentration in Raw Water

When the TDS or silica concentration in the influent water increases rapidly, silica leakage may occur in the treated water. If the silica concentration in the influent water is high, increasing the regeneration level during operation can reduce silica leakage.

3.3 Accumulation of Silica in Ion Exchange Resin

When silica adsorbed on the strong base cation resin is not completely removed during regeneration, silica will accumulate in the ion exchange resin. This can cause continuous leakage during operation, leading to a decrease in water production. Silica adsorbed on strong base anion exchange resin can be removed more efficiently during regeneration at higher temperatures of the regenerant. Therefore, regenerating at the highest temperature allowed by the strong base anion exchange resin can reduce silica leakage in the next cycle.

3.4 Feed Water Temperature Increase

Silica is more easily removed from ion exchange resin at higher temperatures. Conversely, if the temperature of the influent water is high, the ion exchange resin will have a stronger tendency to remove silica rather than retain it. Therefore, during the summer when the amount of silica in the feed water increases and the temperature of the raw water is high, it is desirable to increase the regeneration level during operation.

3.5 Alkalization and Performance Degradation of Strong Base Anion Exchange Resin

During the ion exchange process, strong base anion exchange resins undergo not only ion exchange reactions with inorganic ions but also adsorption and exchange reactions with organic matter. Organic matter adsorbed during the ion exchange process is removed from the resin during regeneration using NaOH, but the process is slow and generally less efficient than the ion exchange process. As a result, organic matter accumulates inside the resin. The characteristics of organic contamination include prolonged rinse time, decreased exchange capacity, and especially in the case of strong base anion exchange resin, silica leakage.

The cleaning of ion exchange resin is typically performed with brine cleaning, and the procedure is as follows:

1) The removal of organic contamination from ion exchange resin is carried out at the end of the service cycle.
2) Prepare a 10% w/v brine solution including 2% w/v NaOH at a volume as three times of BV (Bed Volumes) of resin.
3) First, pass through 1 BV of the brine solution through the fouled ion exchange resin at a flow rate of less than or equal to SV (Spatial Velocity, BV/h). Drain the first BV.
4) After step 3), introduce 1 BV of the brine solution and let the resin soak for at least 2 hours in the resin tank. Stirring the solution will enhance the effect. Drain the solution (second BV) to drain.
5) Pass though the last 1 BV of the brine solution through the ion exchange resin at a flow rate of SV.
6) Rinse the resin bed with pure water and perform double regeneration before returning to service.

Note

To maximize the effectiveness of organic fouling removal, brine solution temperature is recommended to be between 35℃ (95°F) and 60℃ (140°F).

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Regeneration Process

Ion Exchange Column is regenerated when design output between regeneration (OBR) is achieved or designed run hours are completed or outlet water quality deteriorates. It is not correct practice to exhaust bed completely as the regenerant quantity is never sufficient to fully regenerate resin. The typical regeneration process of an ion exchange resin column is as follows:

Backwash	Backwashing discharges accumulated particulates from the ion exchange resin and serves to loosen the compaction and entanglement of the ion exchange resin layer that has been compressed from the top. Since backwash bed expansion varies with temperature and flow rate, it is necessary to adjust the optimal conditions according to the equipment and season. In counter-current regeneration (CCR) units, backwash shall be done only after 7-8 service cycles, followed by double regeneration, as a minimum.
Settling	After backwashing, wait until the expanded ion exchange resin layer naturally settles.
Injection	The process involves passing the regenerant uniformly through the ion exchange resin layer to restore its exchange capacity. The amount of regenerant, concentration, and flow rate vary depending on the type of equipment and its purpose.
Slow rinse	After the injection process, unreacted regenerant remains within the resin layer. To make full use of it, water is used to push it through at the same flow rate & same direction as the injection. This is also referred to as a slow rinse.
Rinse	Following the slow rinse process, the procedure to wash out the remaining regenerant waste liquid in the resin layer involves increasing the water flow rate to the same as the service flow rate and same direction. Rinsing is carried out until the regenerant is completely washed out, and the target water quality is achieved. This is also referred to as a fast rinse
Service	Once the target water quality is secured, the service is initiated to produce the desired treated water and supply to the process. If the water quality deteriorates during service, or after a set amount of target water has been produced, the regeneration process is repeated starting from the backwash step.

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Regeneration Process

1. Example of Co-current Regeneration

The table below is for reference only and may vary depending on site conditions.

1.1 Cation Exchange Column

Process	Backwash	Settling	Water filling	HCl Injection	Slow Rinse	Rinse	Service
Time (min)	15	5	5	30	30	10	-

1.2 Anion Exchange Column

Process	Backwash	Settling	Water filling	NaOH Injection	Slow Rinse	Rinse	Service
Time (min)	15	5	5	30	30	10	-

Note

As the Anion Resin ages it requires more time to rinse. At the same time the rinse time can be cut short if expected conductivity is achieved.

1.3 Weak Acid Cation Column

Process	Backwash	Settling	Water filling	HCl Injection	Slow Rinse	Rinse	Service
Time (min)	15	5	5	30	30	10	-

1.4. Weak Base Anion Column

Process	Backwash	Settling	Water filling	NaOH Injection	Slow Rinse	Rinse	Service
Time (min)	15	5	5	30	30	10	-

2. Example of Counter-current Regeneration

2.1 Cation Exchange Column

Process	Backwash (Optional)	Middle Collector Wash	Settling	Water Filling	HCl Injection	Slow Rinse	Rinse	Service
Time (min)	15	5	3	2	30	30	10	-

Note

In Counter-current type regeneration, backwash should be carried out only after 7- 8 service cycles. After Backwash the Resin needs to be regenerated at least twice.

2.2 Anion exchange column

Process	Backwash (Optional)	Middle Collector Wash	Settling	Water Filling	NaOH Injection	Slow Rinse	Rinse	Service
Time (min)	15	5	3	2	30	30	10	-

Note 1

In Counter-current type regeneration, Backwash should be carried out only after 7- 8 service cycles. After Backwash the Resin needs to be regenerated at least twice.

Note 2

Thoroughfare & Layered Bed Regeneration has not been discussed here as it involves lot of steps which are difficult to tabulate in a simple table.

3. Example of Mixed Bed Regeneration Time Schedule

The timers in the table below are for reference only and may vary depending on site conditions.

Both Beds			**Cation Bed**			**Both Beds**				
Process	**Backwash**	**Settling**	**Process**	**HCl Injection**	**Slow rinse**	**Drain**	**Mixing**	**Water Filling**	**Rinse**	**Service**
Time (min)	15	3	**Time (min)**	30	30	5	15	5	10	-
			Anion Bed							
			Process	**NaOH Injection**	**Slow rinse**					
			Time (min)	30	30					

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Performance Deterioration

Ion exchange resins can theoretically last for several years, but in practice their performance can degrade due to various factors, leading to a decrease in yield and deterioration in treated water quality. The performance degradation of ion exchange resins can be caused by chemical changes such as oxidation of the ion exchange resin, decomposition of the functional group, physical issues like contamination or fracturing of the ion exchange resin with foreign substance accumulation, fines formation due to cyclical swelling & reversible swelling from repeated Service-Regeneration cycles, and compaction during the service cycle.

1. Oxidative degradation of Strong Acid Cation Exchange Resins

Styrene-based strong acid cation exchange resins are chemically very stable and have strong heat resistance. However, they are prone to oxidation. When strong acid cation exchange resins are oxidized, the cross-linked structure of the ion exchange resin is destroyed, causing the resin to swell in volume, which is irreversible. The portion where the crosslink is cut has a weak acid functional group containing carboxyl groups.

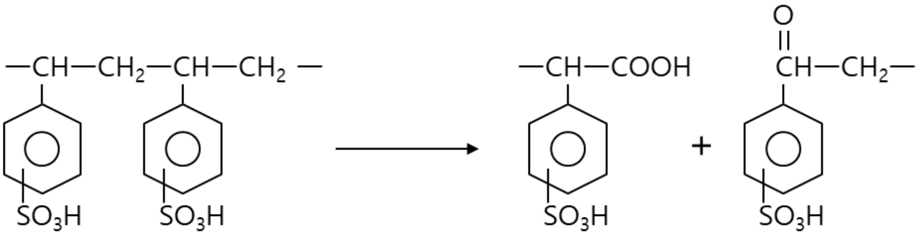


Figure 1) Irreversible swelling of functional group in strong acid cation exchange resin

Low cross-linked ion exchange resins are easily oxidized and are more likely to undergo irreversible swelling. Irreversible swelling reduces the exchange capacity per unit volume, but the overall exchange capacity does not decrease (as the functional group is not decomposed or transformed). As oxidation progresses, the resin becomes a low cross-linked resin, which may lead to an increase in yield due to improved regeneration efficiency.

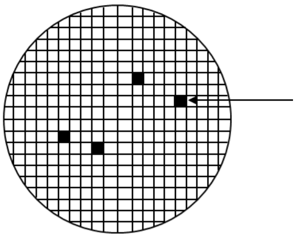
In general water treatment processes, oxidizing agents like free chlorine are often present in the raw water. Even trace amounts of these can oxidize the ion exchange resin over prolonged use. Ions like Fe and Cu can act as catalysts for oxidation. Extensive oxidation of ion exchange resins can weaken the strength of the resin, making it impossible to service. Therefore, the feed free chlorine and Fe should be restricted. Preferably, Activated Carbon Filter for removal of oxidizing agents & Iron/Mn removal filters should be considered as pre-treatment in case presence is detected or anticipated.

Please refer the resin data sheet for allowable free Chlorine and Iron in feed water.

2. Fouling of Strong Acid Cation Exchange Resins

Ion exchange resins, during service cycle, tend to accumulate Suspended Solids (SS) from the raw water. Regular backwash will help in removing the accumulated suspended solids from the Resin Bed.

In water softening units, Fe and Mn readily accumulate on cation exchange resins and cause contamination. Iron exists as divalent or trivalent inorganic salts or a s part of separated organic complexes. Divalent iron is exchanged on the ion exchange resin, but trivalent iron cannot be exchanged and is insoluble. Trivalent iron deposits on the cation exchange resin, causing performance degradation. To remove deposited iron, acid cleaning or strong reducing agents should be used. The contamination mechanism for manganese is similar to that of iron.



It is deposited in micropores of the ion exchange resin and prevents diffusion of ions.

Figure 2) Cation exchange resin contaminated with iron

In addition to SS, attention should be paid to substances that precipitate and accumulate on the ion exchange resin. When regenerating with sulfuric acid at a high concentration, the hardness components such as Ca, Mg, Ba bound to the ion exchange resin react with the sulfate ions, forming precipitates like $CaSO_4$.

$$\mathbf{(R\text{-}SO_3)_2Ca + H_2SO_4 \leftrightarrow 2R\text{-}SO_3H + CaSO_4 \downarrow}$$

These precipitates accumulate in the resin bed, gradually dissolving during operation, affecting the treated water hardness and hindering ion diffusion. To prevent precipitation of calcium sulfate, the concentration of sulfuric acid is typically controlled at 1~4%, and a stepwise regeneration (injection divided into 3 stages) is adopted. If the resin bed is contaminated with $CaSO_4$, it is necessary to clean with HCl.

3. Thermal Degradation of Strong Acid Cation Exchange Resins

Strong acid cation exchange resins are chemically very stable. They are also very heat-resistant, but when heated above a certain temperature, the functional group starts to decompose slowly. The following figures illustrate the thermal decomposition mechanism of functional group in strong acid cation exchange resins.

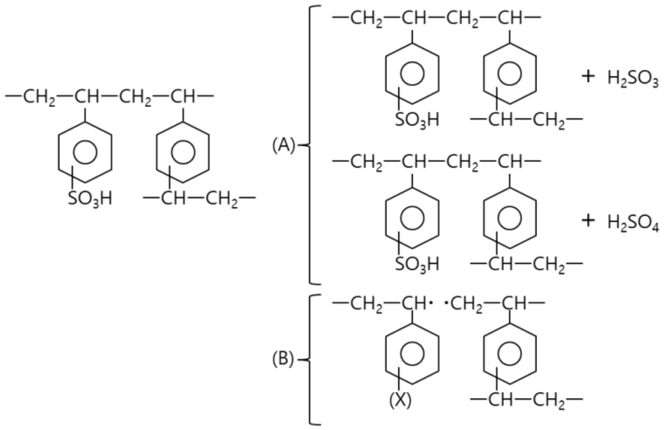


Figure 3) Thermal decomposition of functional group in strong acid cation exchange resin

3.1 H-Form

Standard cross-linked ion exchange resins can be used at temperatures of 120℃ or higher for a significant period. However, they become somewhat unstable above 150℃, which may lead to a reduction in exchange capacity during use.

3.2 Na-Form

More stable than the H form, it can be used not only at 120℃ but also at 150℃ for a significant period. However, above 180℃, it becomes unstable, which may lead to a reduction in exchange capacity during use.

4. Thermal Degradation of Strong Base Anion Exchange Resins

Strong base anion exchange resins use tertiary or quaternary amines as functional groups, which can easily decompose with heat.

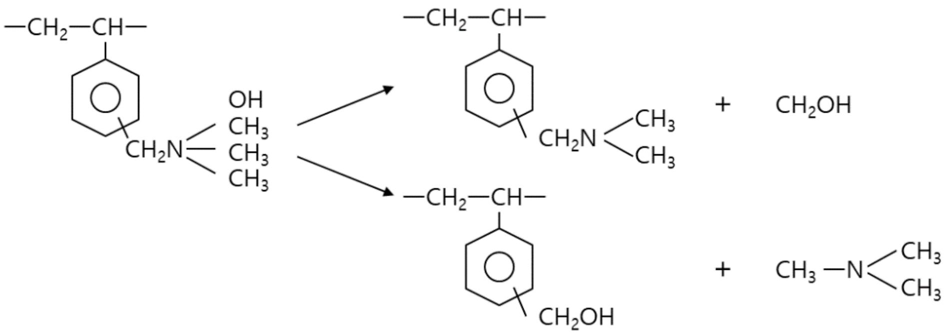


Figure 4) Thermal decomposition of functional group in strong base anion exchange resin

The thermal decomposition mentioned above is due to the self-decomposition of amine groups caused by heat. Especially in the OH-Form, the OH ion, being highly nucleophilic, attacks the C-N bond, making the functional group decomposition easier. Functional group decomposition leads to a decrease in exchange capacity and causes partial weak-base formation.

Type II resins decompose more easily than Type I, which is due to their instability. Typically, the limits are as follows: Type I resin (OH-Form): 60℃, Type I resin (Cl-Form): 80℃, Type II resin (OH-Form): 40℃, Type II resin (Cl-Form): 60℃. These limits are inferred from experimental results, and it does not mean that using the resin below these temperatures will prevent any performance deterioration.

The OH-Form decomposes quickly, so long-term storage in this form leads to rapid decomposition. Therefore, for long-term storage of strong base anion exchange resins, it is advantageous to convert them to the Cl-Form, and the general commercial form is the Cl-Form.

5. Oxidative Degradation of Strong Base Anion Exchange Resins

The functional groups of strong base anion exchange resins are tertiary or quaternary amines, which are easily oxidized by dissolved oxygen in water. Oxidation leads to a reduction in exchange capacity since the functional group transforms from a strong base to a weak base.

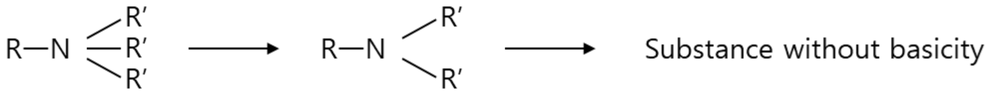


Figure 5) Weakening of base due to oxidation of strong base anion exchange resin

While oxidation affects only the resin matrix of strong acid cation exchange resins, it affects both the matrix and the functional group of strong base anion exchange resins. This indicates the chemical instability of the exchangers in anion exchange resins.

6. Organic Contamination of Anion Exchange Resins

When using strong base anion exchange resins for water treatment, after many cycles, the purity of the treated water may decrease. This may be due to organic matter being absorbed on to the resin, blocking the micropores and hindering ion diffusion. This phenomenon is called organic contamination. Organic contaminants change into polymers at a certain pH and become fixed within the anion exchange resin. Generally, low cross-linked resins are more resistant to organic contamination than standard cross-linked resins.

Organic matter in raw water can be categorized into two types:

1) Insoluble organic matter - Particulates of plant and animal origin, microorganisms, plant and mineral oils
2) Soluble organic matter - Humic and fulvic acids, sugars, amino acids, proteins

Insoluble organic matter in raw water can be removed by methods such as sedimentation and filtration, leaving soluble organic matter. Among soluble organic matter, the key substances affecting ion exchange resins are humic and fulvic acids. Humic and fulvic acids exist in raw water as acids or salts, and their structures are known to be very complex.

Humic and fulvic acids can adsorb onto anion exchange resins, acting as potential sources of organic contamination. They can also bind with heavy metal ions, forming even more complex structures that contaminate anion exchange resins.

The process of anion exchange resin contamination involves both ion exchange and physical adsorption via Van der Waals forces. Anion exchange resins not only undergo ion exchange reactions with inorganic ions during the service process but also adsorption and exchange reactions with organic matter. Organic matter adsorbed during the service process is desorbed outside the resin during the regeneration process using caustic soda, but the rate is slow. Since the regeneration process is generally shorter than the service process, organic matter continues to accumulate inside the resin.

The typical discharge rate of contaminants during regeneration is as follows:

(1) Strong base anion exchange resin (Gel type, Type I): 30~70%
(2) Strong base anion exchange resin (Gel type, Type II): 60~95%

When organic matter deposits on the ion exchange resin, the following phenomena are observed:

(1) Reduction in the purity of the treated water
(2) Decrease in yield (reduction in the operational exchange capacity of the ion exchange resin)
(3) Increase in the amount of rinsing water

LG QuantumPure™ IX Resins

Technical Service Bulletin 909

Cleaning of Fouled Resins

Ion exchange resins can become contaminated by various substances during use, leading to a loss of ion exchange capacity. The mechanisms by which contamination occurs and the methods for cleaning the contaminated substances can vary. The purpose of this technical document is to understand the treatment methods for each case to ensure stable operation. If the ion exchange resin is contaminated over a long period, the actual treatment described below may be ineffective, so it is best to reduce contamination of the ion exchange resin through appropriate pretreatment.

⚠

Cautions

1. Familiarize yourself with the Material Safety Data Sheets (SDS) for all chemicals used.

2. Always work in well-ventilated area.

3. Wear proper PPE like tight goggles, nitrile gloves, acid/alkali proof clothing as may be required.

4. Always add acid to water.

Warnings

1. Do not inhale vapours/fumes.

2. Avoid substance contact.

3. Do not empty acidic/alkaline contents to unspecified drains.

Please refer the MSDS for First Aid information.

Version.1.0.0

Technical Service Bulletin 909

Cleaning of Fouled Resins

Equipment and Tools Required

Chemical-resistant pumps and hoses for solution circulation

Temperature-controlled heating equipment (for heated cleaning solutions)

pH meter for monitoring solution acidity/alkalinity – portable Hand held

Conductivity meter for assessing rinse effectiveness – portable hand held

Chemical storage containers for cleaning solutions – regeneration tanks can be used too.

Proper waste containment and disposal equipment

Sampling equipment for resin and solution analysis

Calibrated measuring devices for chemical preparation

Emergency eyewash station and safety shower nearby

Resin transfer equipment (e.g., eductor or vacuum system)

Personal protective equipment (PPE) storage and disposal area

Spill containment materials (e.g., absorbent pads, neutralizing agents)

Portable air monitoring equipment for confined space entry

Pressure gauges to monitor system pressure during cleaning

Flow meters to ensure proper circulation rates

Temporary storage tanks for spent cleaning solutions

Labeling materials for identifying chemicals and solutions

LG QuantumPure™ IX Resins

Technical Service Bulletin 909

Cleaning of Fouled Resins

1. Contamination of Cation Exchange Resin Column

1.1 Contamination by Iron

1.1.1 Iron Contamination Mechanism

Iron exists as divalent and trivalent inorganic salts or as organic complexes. Divalent iron can be exchanged in the ion exchange resin, but trivalent iron cannot be exchanged as it is insoluble. Trivalent iron deposits in the cation exchange resin, causing performance degradation. To remove deposited iron, acid cleaning or a strong reducing agent should be used. Iron bound to organic matter passes through the cation exchange column and becomes a contaminant in the anion exchange resin. This should be removed along with the organic matter. Manganese has a similar contamination mechanism to iron.

1.1.2 Regeneration Method for Iron-Contaminated Ion Exchange Resin

1) Air Injection and Backwash

When iron with inorganic and organic substances combine to form insoluble precipitates, the following methods are used to remove them:

(1) Blow compressed air from the bottom of the ion exchange resin column to sufficiently shake the resin layer and loosen any blocked resin layers.
(2) Perform backwash for 30 minutes to discharge insoluble precipitates.
(3) Conduct the regeneration process.

2) $Na_2S_2O_4$ Treatment

$Na_2S_2O_4$ is a reducing agent that reduces the trivalent iron deposited in the ion exchange resin to soluble divalent iron. The reduced and soluble iron can be removed during the backwash or regeneration process.

(1) The pore volume (space between resin particles) is roughly estimated to be half the amount of resin filled. Adjust the water level in the resin column by draining (to be slightly more than the pore volume + the resin layer height).
(2) Prepare $Na_2S_2O_4$ so that a 4% solution is formed when mixed with the water above the resin layer. (Do not add water to $Na_2S_2O_4$; add $Na_2S_2O_4$ to water) During this process, strong odors are emitted, so ventilation is required. Na2S2O4 is dangerous when it comes into contact with eyes and skin, so caution is needed.
(3) Introduce the concentrated $Na_2S_2O_4$ solution into the resin column.
(4) Drain water from the bottom of the resin column equal to the pore volume which is roughly 50% of resin volume.
(5) Mix the aqueous solution inside the resin column, with a paddle, to spread the $Na_2S_2O_4$ throughout the resin layer. Note that if air is used for stirring, $Na_2S_2O_4$ may oxidize and lose its reducing power.
(6) Mix the aqueous solution inside the resin column, with a paddle, to spread the $Na_2S_2O_4$ throughout the resin layer. Note that if air is used for stirring, $Na_2S_2O_4$ may oxidize and lose its reducing power.
(7) Leave the $Na_2S_2O_4$ in contact with the resin layer for 12 hours. If this is not feasible, a minimum contact time of 4 hours is recommended.
(8) Drain the reduced iron and other impurities, rinse with feed water, and perform backwash for 30 minutes.
(9) Perform regeneration prior to initiating service operation.

3) Hydrochloric Acid Treatment

When the ion exchange resin is severely contaminated, hydrochloric acid (HCl) washing is the only method to restore the exchange capacity of the ion exchange resin. Acid washing is risky due to its potential to damage the piping line, so it should be performed with caution. The resin column and its piping equipment may be damaged by contact with hydrochloric acid. Therefore, hydrochloric acid washing should only be performed after inspecting the equipment and ensuring that it is durable enough to withstand the acid; otherwise, use corrosion-resistant hydrochloric acid. Corrosion-resistant hydrochloric acid is hydrochloric acid mixed with a corrosion inhibitor. The corrosion inhibitor is typically a nitrogen compound that forms a metallic film on the resin column or piping to prevent corrosion. Cleaning procedure is the same as when using $Na_2S_2O_4$.

1.2 Contamination by Sulfates ($CaSO_4$ or $MgSO_4$)

1.2.1 Sulfate Contamination Mechanism

When sulfuric acid is used as a regenerant in a cation exchange resin column, insoluble salts (sulfates, $CaSO_4$ or $MgSO_4$) may form due to a reaction between the hardness components of the raw water and the regenerant. When sulfates accumulate in the resin layer, they will slowly dissolve during service, degrading water quality and clogging the micropores of the ion exchange resin, thus inhibiting ion diffusion and reducing exchange capacity.

1.2.2 Regeneration Method for Sulfate-Contaminated Ion Exchange Resin

1) Perform a normal cation exchange resin regeneration.
2) Charge the column with a 10% sodium citrate solution at 1BV (Bed Volume) in an up-flow direction for 20-30 minutes.
3) Allow enough time for the citrate to react with the ion exchange resin by blowing air and soaking for about 12 hours.
4) Rinse with 5BV of pure water in a downflow direction.
5) Perform backwash and a double regeneration before returning to service operation.

1.3 Contamination by Polyelectrolyte

1.3.1 Polyelectrolyte Contamination Mechanism

Contamination by polyelectrolytes can occur when raw water quality deteriorates in winter or when there are problems with pretreatment. When contamination becomes severe, the resin layer becomes blocked and sticky, leading to poor flow.

1.3.2 Regeneration Method for Polyelectrolyte-Contaminated Ion Exchange Resin

1) After the cation exchange resin column service ends, perform backwash for 15 minutes. If necessary, inject air to loosen the blocked resin layer.
2) Flow 2% NaOH solution at 1BV up-flow through the column for 30 minutes.

2. Contamination of Anion Exchange Resin Columns

2.1 Contamination by Organic Matter

2.1.1 Organic Contamination Mechanism

The process of anion exchange resin becoming organically contaminated involves ion exchange and physical adsorption due to Van der Waals forces. Anion exchange resin not only undergoes ion exchange reactions with inorganic ions during the flow process but also adsorption and exchange reactions with organic matter. Organic matter adsorbed during the service process is desorbed from the resin during the regeneration process using caustic soda, but the desorption rate is slow, and the regeneration process is typically shorter than the service process, leading to accumulation within the resin. The characteristics of organic contamination include long water rinse times, decreased exchange capacity, and particularly for strong base anions, silica leakage.

2.1.2 Regeneration Method for Organic Contaminated Ion Exchange Resin

1) Brine cleaning

(1) Organic contaminant removal from the resin is conducted at the end of the service process.
(2) Prepare 3BV of a 10% NaCl brine solution containing 2% NaOH.
(3) Flow 1BV through the contaminated resin at a speed lower than Specific flowrate 2 BV/h to drain.
(4) Introduce second 1BV into the resin column and soak for at least 2 hours.
(5) If possible, stirring the volume by low pressure Air if available. (0.3 Bar or so) during the 4) operation can enhance the effect. Drain the second BV.
(6) Flow the final 1BV through the resin at Specific flowrate 1 BV/h and drain.
(7) Rinse with pure water.
(8) Perform double regeneration before returning to service operation.

Note

For maximum effectiveness in removing organic contamination, the operational temperature of the brine should be selected as high as possible between a minimum of 35℃ and a maximum of 60℃ (95 - 140ºF).

2.2 Contamination by Silica

2.2.1 Silica Contamination Mechanism

Natural silicon (Si) mainly exists as various metal silicates or as silica (SiO_2) in quartz or sand. When surface water comes into contact with silicate minerals, small amounts of silica dissolve, with concentrations varying by region.In water, silica exists in various forms, with the most common being silicate (SiO_3^{2-}). In natural water, silicate ions can take many forms, sometimes resembling phosphates, and can agglomerate into colloidal particles large enough to be classified as suspended in solution. At this stage, they are no longer ions and exist in a suspended state in the aqueous solution. This characteristic can pose difficult problems in operation or analysis.

Silica in water can be classified into three categories:

1) Ionic silica

Ionic silica is the part that can be removed by ion exchange resins. Although silica has a very low solubility in water, its solubility increases at higher pH levels.
$SiO_2 + H2O \rightarrow H_2SiO_3$ (ionic silica)
$R\text{-}N\cdot OH + H_2SiO_3 \leftrightarrow R\text{-}N\cdot HSiO_3 + H_2O$ (silica removed by anion exchange resin)

2) Colloidal silica

It cannot be removed by ion exchange resin. When dried, it loses water and precipitates as SiO_2. When deposited on an anion exchange resin, it causes performance degradation.

3) Non-ionic silica

It is not ionic and does not form polymers with other ions or substances. It cannot be removed by ion exchange resin and exists in trace amounts.

When regenerating an anion exchange resin, if the temperature is lower than recommended, desorption of silica deposited on the resin is poor, eventually leading to silica contamination. Silica deposited on the anion exchange resin polymerizes and coats the resin surface.

2.2.2 Regeneration Method for Silica-Contaminated Ion Exchange Resin

The silica desorption rate is proportional to the regenerant temperature during regeneration, so it is desirable to heat the regenerant to the highest temperature possible (see table below) without causing performance degradation of the anion exchange resin.

Additionally, brine cleaning may be necessary to remove colloidal silica that is bound to organic matter.

	Ion Exchange Resin	Regenerant Temperature	Remarks
1	Type I Resin	45~50℃	
2	Type II Resin	35~40℃	

3. Others

3.1 Inhibition of Microbial Growth

Normally, when an ion exchange resin demineralization system is used, microbial growth is unlikely due to the significant pH changes during regeneration. However, if the equipment is not operated for a long time, microorganisms can proliferate and contaminate the ion exchange resin. Therefore, in such cases, it is advisable to use a high concentration of NaCl solution to inhibit microbial growth. The procedure is as follows:

1) Perform backwash.
2) Introduce a 15-20% NaCl solution into the resin column (fill up to the top of the column to minimize the presence of air).
3) Perform double regeneration before returning to service operation.

3.2 Contamination by Oil

If the ion exchange resin is contaminated by oil, the anion exchange resin typically has a higher affinity for organic matter, so often only the anion exchange resin is contaminated. Therefore, for mixed bed columns contaminated with oil, it is effective to separate the cation and anion exchange resins and clean only the anion exchange resin. The cleaning procedure for ion exchange resin contaminated by oil is as follows:

1) Perform backwash.
2) Flow 5BV of 1% H_2SO_4 or HCl through the resin to convert the anion exchange resin to SO_4 or Cl form. This is done because the anion exchange resin can fracture due to sudden osmotic shock.
3) Introduce 1BV of 15% H_2SO_4 or HCl mixed with 0.2-1.0% non-ionic detergent (which produces less foam) into the resin column.
4) Soak for about 4 hours (maintaining a temperature between 40℃ and 50ºC (104 - 122ºF) during this time. Injecting air for about 10 minutes every 2 hours can double the effectiveness).
5) Perform backwash for about an hour, soak for another 2 hours, then perform another 30 minutes of backwash.
6) Perform double regeneration before returning to service operation.

Note

It is advisable to conduct a test in a 500ml beaker before implementing the above procedure on-site. If excessive foam is produced when the detergent is added, it may cause difficulties during on-site implementation

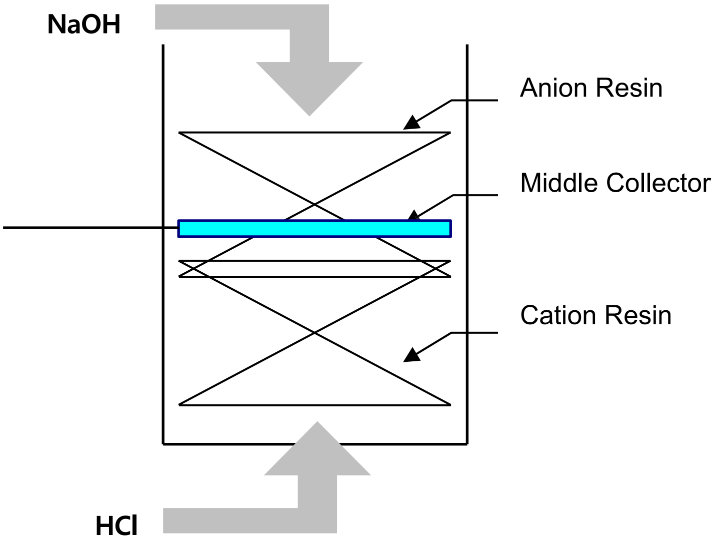
LG QuantumPure™ IX Resins

Technical Service Bulletin 910

Improper Level of Mixed Bed Column

During service operation, the mixed-bed column uses air-mixing to mix the cation and anion exchange resins, but during regeneration, the resins are separated after backwashing, due to the apparent density differences, and then regenerated. Separation of the cation and anion exchange resins above and below the middle collector during regeneration of the mixed-bed column is very important for proper operation. Accurately matching the levels of the cation and anion exchange resins at the initial charge is a shortcut to improving the purity of the treated water from the mixed-bed column. The main cause of the decline in purity of the treated water from the mixed-bed column is the imbalance of the cation and anion exchange resins above and below the middle collector, with the next cause being the failure of the resins to mix properly. Before use, the cation and anion exchange resins can be distinguished by color (the cation resin is a light brown transparent sphere, and the anion resin is a light-yellow transparent sphere), making it easy to check the separation state and level. However, as time passes with usage, the colors gradually become similar (brown transparent spheres), making it difficult to distinguish with the naked eye.

1. Problems When the Cation Exchange Resin Is Undercharged in the Mixed-bed Column

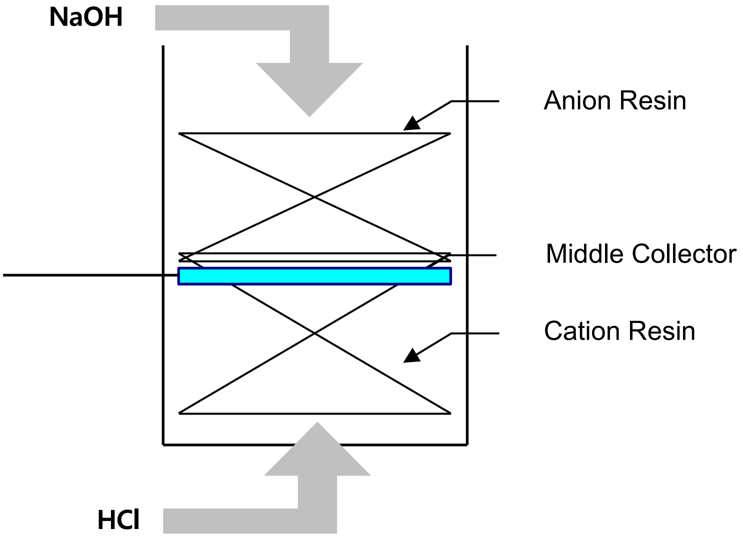


If cation resin is under-charged, there will likely be some anion resin below the middle collector level. During the regeneration process, the anion exchange resin below the middle collector comes into contact with HCl and converts to the Cl^- form (ⓐ), which leads to a deterioration in water quality, during the service operation, due to the leakage of Cl^- ions (ⓑ).

$R\text{-}NOH + HCl \leftrightarrow R\text{-}NCl + H_2O$ (ⓐ)

$2R\text{-}NCl + SO_4^{2-} \leftrightarrow (R\text{-}N)_2 SO_4 + 2Cl^-$ (ⓑ)

2. Problems When the Cation Exchange Resin Is Overcharged in the Mixed-bed Column



If cation resin is over-charged, there will likely be some cation resin above the middle collector level. During the regeneration process, the cation exchange resin above the middle collector comes into contact with NaOH and converts to the Na-form (ⓐ), which leads to a deterioration in water quality during the service operation due to the leakage of Na^+ ions (ⓑ).

$R\text{-}SO_3H + NaOH \leftrightarrow R\text{-}SO_3Na + H_2O$ (ⓐ)
$R\text{-}SO_3Na + Ca^{2+} \leftrightarrow (R\text{-}SO_3)_2Ca + 2Na^+$ (ⓑ)

Due to the risks mentioned above, it is advisable not to perform partial replacement of the mixed-bed column but to do a full replacement or continue using it as is.

LG QuantumPure™ IX Resins

Technical Service Bulletin 911

Troubleshooting of Cation Column

Performance problems in ion exchange systems are usually characterized by shortened useful operating cycles and/or a significant drop in water quality produced by the unit. These conditions usually show up when conductivity or analytical tests indicate the system is failing to meet effluent purity standards or is exhausting before the normal water throughput is reached. Some of the more common reasons for cation ion exchange performance issues are listed below.

1. Reduced Production Capacity

No.	Possible Cause	Corrective Measure
1	Leaking Valves	Leaking backwash inlet valve can affect the outlet quality, misleading one to believe that bed has exhausted. Check all valves for tightness, replace/repair as the case may be.
2	Instrumentation	Check if flow meter & totalizer is working properly. Rectify/Calibrate if found faulty.
3	Regenerant	Check if Acid quantity, concentration and quality is as specified. In case of H_2SO_4 regeneration ensure two step regeneration is done.
4	Regenerant	Check regenerant flow and timing is maintained during the regeneration cycle. Slow rinse cycle should not be cut short to save time, slow rinse time should be as long as injection time as a minimum.
5	Change in Feed Analysis	Simultaneously check the feed water quality if there is increase in TDS, Hardness or Sodium levels. In such case increase the regeneration level.

2. Hardness Leakage (Decreased Purity of Produced water)

No.	Possible Cause	Corrective Measure
1	Leaking Valves	Leaking backwash inlet valve can affect the outlet quality, resulting in poor outlet quality. Check all valves for tightness, replace/repair as the case may be.
2	Regenerant	Check if Acid quantity, concentration and quality is as specified. In case of H_2SO_4 regeneration ensure two step regeneration is done.
3	Regenerant	Check regenerant flow and timing is maintained during the regeneration cycle Slow rinse cycle should not be cut short to save time, slow rinse time should be as long as injection time as a minimum.
4	Change in Feed Analysis	Simultaneously check the feed water quality if there is increase in TDS, Hardness or Sodium levels. In such case increase the regeneration level.
5	Resin Fouling	Take sample of the Resin for testing. Check for any fouling & carry our de-fouling as per TSB 909
6	Resin Quantity	Please check the resin quantity is as per design or not. The resin level should be visible at the lower glass of the resin column. If level is less, top up with new resin.

3. Pressure Drop Increase

No.	Possible Cause	Corrective Measure
1	Faulty Valves	Check if Valves are not stuck in the partially open position. In Acidic corrosive environment valves may get stuck.
2	High Flow Rate	Check the flow in flow meter, correct flow to design value.
3	Bottom Collector Choked	Strainer buttons get choked due to resin fines. An extended backwash might help in removing the fines stuck in the strainer button slits. In case it doesn't work, open top manhole & observe the Backwash distribution pattern. It should reveal if bed is choked. If bed is choked, remove the resin, clean strainer buttons/bottom collector screens & reload resin.
4	Increased Suspended Solids	Improve pretreatment/Filter operations. Increase backwash period to properly loosen the resin bed.
5	Fouling by Iron or Calcium Sulphate.	Analyze feed water for Fe. In case Fe is present, carry out Iron de-fouling as per TSB 909. Check the H_2SO_4 concentration in case of $CaSO_4$ fouling. In step wise regeneration do not exceed 2% in first step & 4 % in second step.
6	Bio growth in Resin Bed.	Check pre-treatment for presence of Organic matter. Improve pre-chlorination. Carry out de-fouling as per TSB 909
7	Compacted Bed	If in previous cycles backwash is not properly carried out in case of co-current vessels or more than 7-8 cycles are run without backwash in case of counter current regeneration, bed would get compacted, especially in second scenario. Carry out extended backwash to de-compact the resin bed.
8	Resin Fines	Excessive resin fines will lead to increased pressure drop. Carryout extended backwash & scrape off the top layer of fines & replace with fresh resin.
9	Excessive Resin	Ensure only required volume is filled in the column. Remove excess resin.

LG QuantumPure™ IX Resins

Technical Service Bulletin 912

Troubleshooting of Anion Column

Performance problems in ion exchange systems are usually characterized by shortened useful operating cycles and/or a significant drop in water quality produced by the unit. These conditions usually show up when conductivity or analytical tests indicate the system is failing to meet effluent purity standards or is exhausting before the normal water throughput is reached. Some of the more common reasons for anion ion exchange performance issues are listed below.

1. Reduced Production Capacity

No.	Possible Cause	Corrective Measure
1	Leaking Valves	Leaking backwash inlet valve can affect the outlet quality, misleading one to believe that bed has exhausted. Check all valves for tightness, replace/repair as the case may be.
2	Instrumentation	Check if flow meter & totalizer is working properly. Rectify/Calibrate if found faulty.
3	Regenerant	Check if Alkali quantity, concentration and quality is as specified.
4	Regenerant	Check regenerant flow and timing is maintained during the regeneration cycle. Slow rinse cycle should not be cut short to save time, slow rinse time should be as long as injection time as a minimum.
5	Change in Feed Analysis	Simultaneously check the feed water quality if there is increase in TDS, Chloride or Silica levels. In such case increase the regeneration level.
6	Resin Fouling	Take sample of the Resin for testing. Check for any fouling & carry our de-fouling as per TSB 909
7	Resin Quantity	Please check the resin quantity is as per design or not. The resin level should be visible at the lower glass of the resin column. If level is less, top up with new resin.

LG QuantumPure™ IX Resins

Technical Service Bulletin 912

Troubleshooting of Anion Column

2. High Silica Leakage (Decreased Purity of Produced Water)

No.	Possible Cause	Corrective Measure
1	Leaking Valves	Leaking backwash inlet valve can affect the outlet quality, resulting in Increased silica leakage. Check all valves for tightness, replace/repair as the case may be.
2	Regenerant	Check if caustic quantity, concentration and quality is as specified. Check regenerant flow and timing is maintained during the regeneration cycle. Slow rinse cycle should not be cut short to save time, slow rinse time should be as long as injection time as a minimum.
3	Change in Feed Analysis	Simultaneously check the feed water quality if there is increase in TDS, Chloride or Silica levels. In such case increase the regeneration level.
4	Resin Fouling	Take sample of the Resin for testing. Check for any fouling & carry our de-fouling as per TSB 909
5	Resin Quantity	Please check the resin quantity is as per design or not. The resin level should be visible at the lower glass of the resin column. If level is less, top up with new resin.
6	Na Leakage	Na leakage from SAC column will result in Silica slippage. Double regenerate the SAC column immediately.
7	WBA Underperformance	When WBA -SBA combination is used, it is expected that main load on the SBA column will be CO_2 and Silica. But if there is SO_4 or Cl slippage the SBA will be additionally loaded resulting in Silica slippage. Care must be taken while regenerating the WBA resin either in layered bed or separate column.

3. High Conductivity (Decreased purity of produced water)

No.	Possible Cause	Corrective Measure
1	Inadequate Regeneration	Check if caustic quantity, concentration and quality is as specified. Check regenerant flow and timing is maintained during the regeneration cycle. Slow rinse cycle should not be cut short to save time, slow rinse time should be as much as injection time as minimum.
2	Internals Blocked	Check in all the internals like Inlet distributor, Caustic distributor & bottom collector are distributing/collecting in uniform fashion. Many a times resin fines tend to block the slits.
3	Low Service Flow Rate	Lower than design flow may cause channeling in the resin bed resulting in poor exchange.
4	CO_2 Leakage from Degasser Tower	Check the degasser blowers are working properly. A well designed/good working Degasser will have only 6 – 10 ppm of CO_2. Check free CO_2 in degassed water. If it is greater than 10 ppm Degasser Tower operations need to be investigated. Normally the PG should show 100mm wc which is indicative of good resistance to Air flow. If pressure is not being maintained, check Degasser tower Raschig/Pall ring column is not disturbed.

4. High pH (Decreased purity of produced water)

No.	Possible Cause	Corrective Measure
1	Short Rinse Time/Caustic Over-injection	Check the slow rinse timing. Correct if less than design. Caustic solution is sticky and it takes time to wash off the excess Caustic from resin beads.
2	Possible Na Leakage from SAC	In case of leakage, double regenerate Cation Bed.

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Troubleshooting of Anion Column

5. Pressure Drop Increase

No.	Possible Cause	Corrective Measure
1	Faulty Valves	Check if Valves are stuck in the partially closed position. In corrosive environment valves may get stuck.
2	High Flow Rate	Check the flow in flow meter, correct flow to design value.
3	Bottom Collector Choked	Strainer buttons get choked due to resin fines. An extended backwash might help in removing the fines stuck in the strainer button slits. In case it doesn't work, open top manhole & observe the Backwash distribution pattern. It should reveal if bed is choked. If bed is choked, remove the resin, clean strainer buttons/bottom collector screens & reload resin.
4	Organic Fouling	Analyze feed water for Organic matter (OM). In case Organic Matter is present, carry out Caustic Brine wash as per TSB 909.
5	Compacted Bed	If in previous cycles backwash is not properly carried out in case of co-current vessels or more than 7-8 cycles are run without backwash in case of counter current regeneration, bed would get compacted, especially in second scenario. Carry out extended backwash to de-compact the resin bed.
6	Resin Fines	Excessive resin fines will lead to increased pressure drop. Carryout extended backwash & scrape off the top layer of fines & replace with fresh resin.
7	Excessive Resin	Ensure only required volume is filled in the column. Remove excess resin.

6. High Wastewater Generation

No.	Possible Cause	Corrective Measure
1	Organic Matter Influx	Check for Organic Matter (OM) in feed water. Organic fouling leads to longer rinse time. Do alkaline – brine treatment of SBA resin as detailed in TSB 909.
		Caustic-brine (Alkaline brine) treatment is temporary remedy is not to be repeatedly carried out. The resin bead is subjected to physical shock due to continuous and sudden shrinking & expansion leading to premature fines formation. User is advised to address the presence of OM in feed water.

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Troubleshooting Mixed Bed Column

Performance problems in ion exchange systems are usually characterized by shortened useful operating cycles and/or a significant drop in water quality produced by the unit. These conditions usually show up when conductivity or analytical tests indicate the system is failing to meet effluent purity standards or is exhausting before the normal water throughput is reached. Some of the more common reasons for ion exchange performance issues are listed below.

1. Reduced Production Capacity

No.	Possible Cause	Corrective Measure
1	Increase in Raw Water TDS	For short-term increases, increase the regeneration level to boost operating exchange capacity; for long-term increases, consider equipment re-design.
2	Poor Separation of Cation and Anion Exchange Resins	Check the backwash flow rate and temperature. Clumping due to high molecular weight electrolytes in cation and anion exchange resins can be separated by NaOH injection.
3	Poor Mixing After Regeneration	Adjust mixing conditions (mixing time, Air flow rate and pressure) appropriately and check the equipment.
4	Improper Level of Cation and Anion Exchange Resins	Maintain the appropriate resin level with reference to the middle collector.
5	Increase in Rinse Time	Conduct analysis as contamination of the ion exchange resin is suspected.
6	Poor Regeneration	1) Check for equipment failure - Check for leaks in the chemical injection valve- Inspect the inside of the resin column (lower strainer plate, middle collector, etc. 2) Check the quantity and flow rate of the regenerant - Operate with the appropriate regeneration level and flow rate 3) Check regenerant concentration & injection/displacement time.
7	Degradation of Ion Exchange Resin Performance	Analyze the ion exchange resin and consider replacement.
8	Increase in pH (above pH 8) with Cation Leakage	This may result from NaOH contaminating the cation exchange resin during regeneration Increase the flow rate of Blocking Water during anion exchange resin regeneration.
9	Decrease in pH (below pH 6) with Anion Leakage	This may result from HCl or H_2SO_4 contaminating the anion exchange resin during regeneration. Increase the flow rate of Blocking Water during cation exchange resin regeneration, or supplementation of the cation exchange resin level may be necessary.
10	Increase in Silica Leakage	Increase the amount of NaOH injected and check the regeneration temperature.
11	Change in Water Temperature	Ion exchange reactions generally proceed better at higher temperatures, so a decrease in water production can occur with cold feed water temperature.
12	Performance Degradation of Ion Exchange Resins Due to the Influx of Contaminants	If contamination is related to particulate matter, clean the ion exchange resins by extended Backwash & Air scour. For other types of contamination, refer to TSB 909.

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Troubleshooting Mixed Bed Column

2. Decreased Purity of Produced Water

No.	Possible Cause	Corrective Measure
1	Equipment Failure	Check for faults in conductivity, silica, pH meters, leaks in the chemical injection valves, and inspect inside the resin column (lower strainer, middle collector, etc.) for damage.
2	Poor Mixing After Regeneration	Adjust mixing conditions (mixing time and pressure) appropriately and check the equipment.
3	Improper Level of Cation and Anion Exchange Resins.	Maintain the appropriate resin level with reference to the middle collector.
4	Increase in Rinse Time	Conduct Resin analysis as contamination of the ion exchange resin is suspected.
5	Poor Regeneration	1) Check equipment failure - Inspect the inside of the resin column (lower strainer, middle collector, etc.) for damage. 2) Check the quantity and flow rate of the regenerant - Operate with the appropriate regeneration level and flow rate 3) Check concentration & timing of the regenerant Injection & displacement
6	Degradation of Ion Exchange Resin Performance	Analyze the ion exchange resin and consider replacement. • Perform visual inspection for color changes or broken beads. • Conduct laboratory analysis for exchange capacity and fouling.
7	Increase in pH (above pH 8)	This may result from NaOH contaminating the cation exchange resin during regeneration, increase the flow rate of Blocking Water during anion exchange resin regeneration.
8	Decrease in pH (below pH 6)	1) his may result from HCl or H_2SO_4 contaminating the anion exchange resin during regeneration, increase the flow rate of Blocking Water during cation exchange resin regeneration. 2) Insufficient amount of cation exchange resin - If there is a structural issue due to insufficient design quantity of cation exchange resin, raise the middle collector to increase the amount of cation exchange resin.
9	Increase in Silica Leakage	Increase the amount of NaOH injected and check the regeneration temperature.

3. Pressure Drop Increase

No.	Possible Cause	Corrective Measure
1	Particle Accumulation in the Resin Bed	Perform extended backwash, typically 30 to 60 minutes.
2	Resin Degradation	Check for resin breakage and replace if necessary. If the resins are soft and mushy like used coffee grounds, the resin may require changing
3	Improper Backwash	Verify and adjust backwash flow rates

Technical Service Bulletin 914

Resin Sample Collection Procedure from Ion Exchange Column

1. Purpose

This Procedure explains the procedure to collect a representative resin sample from an ion exchange column

2. Scope

This procedure applies to all operations involving collection of resin samples from an ion exchange column. It must be followed by all authorized personnel performing this operation.

3. Safety Precautions

Personnel must wear appropriate personal protective equipment (PPE) including chemical-resistant gloves, face shield, chemical splash goggles, rubber boots, and chemical-resistant clothing. An emergency eyewash station and safety shower must be readily accessible in the work area.

Note

This procedure is not intended to act in confined space entry procedure and all local/site precautions should be followed.

4. Equipment and Materials Required

It's assumed that ion exchange column, with resin, with proper drain system and anti-corrosive coating is available.

- A small (10 liter or 2 to 3 gallon) clean plastic bucket
- Plastic sample jars (1 liter or 1 US quart)
- Plastic storage bags for secondary leak containment
- Sampling rod/pipe
- Marker pen or Labels
- Process water supply
- Waste collection system
- PPE as specified above

5. Sampling Procedure

1) Backwash resin bed for 15-20 minutes to loosen bed.
2) This is a good opportunity to check bed depth. Check free board so bed depth can be calculated.
3) Open the drain valve of the unit with air release valve and drain excess water.
4) Open manhole of the unit.
5) Enter the unit, using proper PPE & safety harness.
6) Fit wooden planks over the surface of the resin bed.
7) For small diameter columns (less than 1 m or 3 feet) take a sample from the center.

8) For large diameters, a sample should be taken from the center, plus two-three additional points evenly spaced around the center of the bed.
9) Plunge sampling pipe vertically into the resin bed.
10) Pipe should reach to approximately the center of the bed. Top of the bed will have fines & lower most layer beads will be as supplied, due to bed stratification after backwash. Take care not to hit the bottom of the bed as plastic parts of the collection system, if any, may get damaged.
11) Open the sampling rod, rotate it, close it again and withdraw it from the bed. In case sampling rod is not available use a PVC pipe.
12) Collect the resin sample(s).
13) Remove the planks, close the manhole and fill the column again. Care should be taken that no foreign material is dropped or left in the resin bed as the resin itself, column lining or internals may get damaged.
14) Ideally, 2 – 3 liters of the sample should be withdrawn. Repeat the procedure till enough quantity is collected.
15) Label the resin samples carefully, noting the column details, date of resin loading, whether it was top up or complete replacement, resin grade and suspected problem.

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Technical Service Bulletin 915

Ion Exchange Resin Analysis Service Request Form

General Conditions

Customers may request analysis of product that has deteriorated in performance due to fouling, contamination, damage, etc. during operation. The customer is responsible for prepaying the shipping charges of the product for analysis. The Manufacturer will not accept any product unless it is prepaid. The Manufacturer may request that the customer issue a valid purchase order covering all work related to analytical work. Please discuss the detailed costs related to the resin analysis with LG Chem sales representative.

The resin sample should be taken as prescribed in TSB 914.

Section 1			
TO BE FILLED OUT BY REQUESTOR			
Name of Requestor		Date of Request	
CUSTOMER INFORMATION			
Company Name			
Address/ Region			
Contact Person			
Phone/ Mobile		Email	
REPORTED PROBLEM			
☐ Low Output Between Regeneration		☐ Poor Outlet Quality	
☐ High Rinse Volume		☐ Suspected Iron/Particulate Fouling	
☐ Suspected Organic fouling		☐ Other	
TIME WHEN PROBLEM FIRST OCCURRED			
☐ Before Resin Loading (In case of replacement)			
☐ After Commissioning/Start-up (Less than 24 hours of continuous operation)			
☐ After Startup (within 30 days)			
☐ Other:	Months After Startup		
RESIN INFORMATION			
Resin Grade:		Resin Volume	
No. of Trains		No. of Trains affected	
Resin Batch no.:			
NOTES			
Has the resin(s) to be sent been exposed to Hazardous Materials? ☐ Yes ☐ No			
If **Yes**, please provide details below (or attach to this document) and ensure that MSDS sheets for all hazardous materials are submitted along with this Resin Analysis request. If approved, the same MSDS sheets are to be included with the resin shipment.			

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Ion Exchange Resin Analysis Service Request Form

Section 2				
TO BE FILLED OUT BY REQUESTOR				
SYSTEM INFORMATION				
Plant Location:				
☐ New		☐ Replacement		
Plant Configuration				
Inlet Quality				
Expected Outlet Quality				
Start-Up Date				
Plant Capacity				
Total Quantity of Resin				
Application				
Output Between Regeneration (OBR) & Regeneration Frequency				
Pretreatment				
Feed Water Source:	☐ Well	☐ Surface Intake	☐ RO Permeate	☐ Distillate
	☐ Municipal Supply	☐ Industrial Waste	☐ Other	
Intended Use:	☐ Boiler Feed	☐ Condensate Recirculation	☐ Process Water	
	☐ EDM/OLED Semiconductor	☐ Other		
OPERATING DATA INFORMATION				
Data Collection Frequency	☐ Daily	☐ Per Shift	☐ Other	
Data Format	☐ Handwritten	☐ Excel Spreadsheet	☐ SCADA	☐ Other

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Ion Exchange Resin Analysis Service Request Form

Section 3
TO BE FILLED OUT BY REQUESTOR
REQUIRED TEST (BASIC PERFORMANCE ANALYSIS)
☐ Water Retention, %
☐ Total Exchange Capacity, eq/l
☐ Apparent Density, g/l
☐ Whole Bead Count, %
REQUIRED TEST (OPTIONAL PERFORMANCE ANALYSIS)
☐ Organic Contamination
☐ Iron Contamination
☐ Particle Distribution
☐ Friability
☐ Osmotic Stability

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Ion Exchange Resin Analysis Service Request Form

Commercial Invoice

Sender: Email Address: Phone Number:			Recipient: *Contact LG Chem Technical Service representative for shipping information*			
Invoice Date:			Invoice Number:			
Waybill Number:			Sender's Reference:			
Carrier:			Recipient's Reference:			
Quantity	Country of Origin	Description of Contents	Harmonized Code	Unit Weight	Unit Value	Sub Total
Total Net Weight			Total Declared Value: (USD)			
Total Gross Weight			Freight & Insurance Charges (USD):			
Total Shipment Pieces			Other Charges (USD):			
Currency Code			Total Invoice Amount (USD):			
Type of Export			Terms of Trade:			
Reason for Export						
General Notes						

The exporter of the products covered by this document declares that, except where otherwise clearly indicated, these products are of Republic of Korea, preferential origin.

I/We hereby certify that the information on this invoice is true and correct and that the contents of this shipment are as stated above.

Name: Position in Company: Signature: ____.	Company Stamp