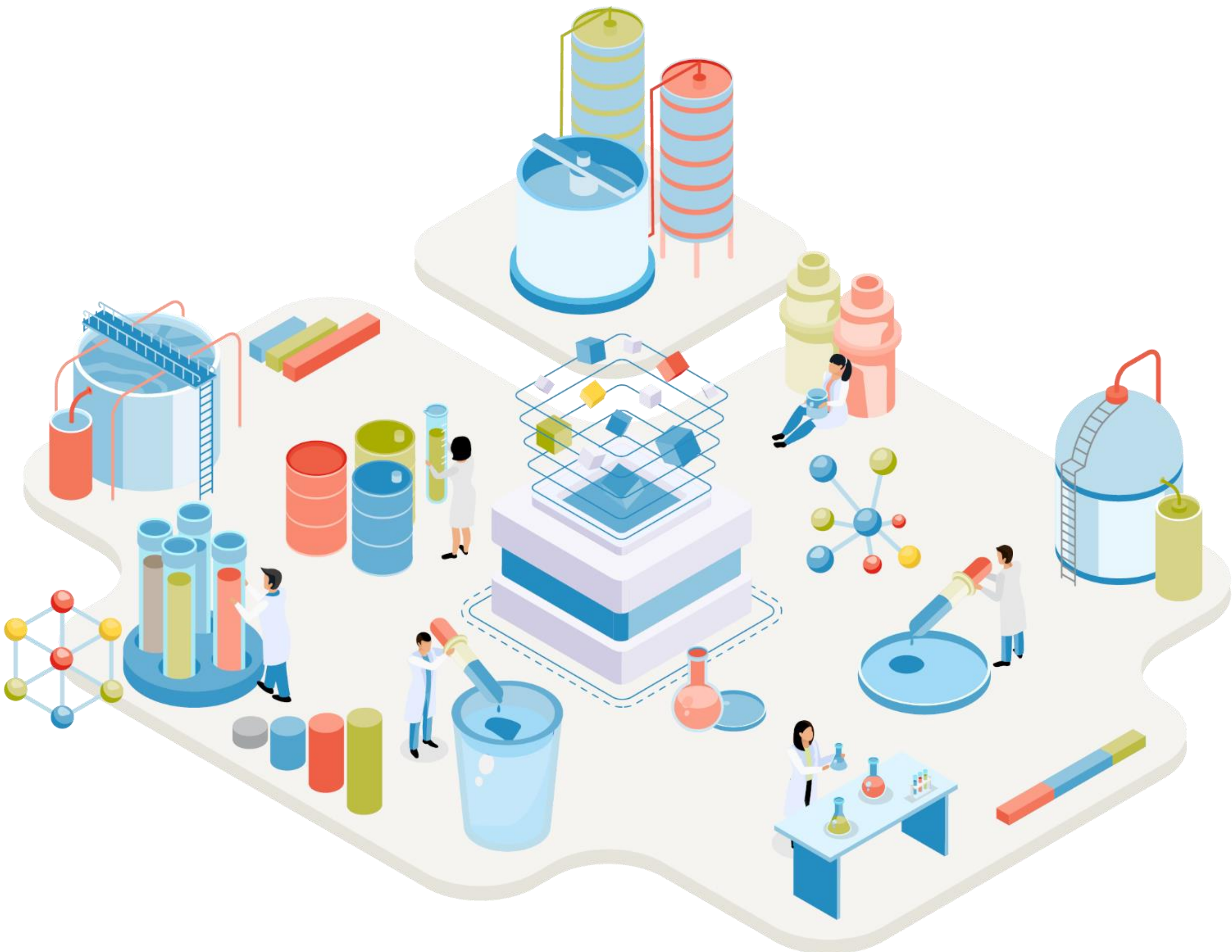
TRILITE Ion Exchange Resin for Condensate Polishing Plant (CPP)

Technical Report



Samyang Corporation Ion exchange resin
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TRILITE in numbers

1 First & Only

TRILITE 삼양 트리라이트 Ion Exchange Resin — Korea's only ion exchange resin maker

+2 Factories

Our factories in Ulsan and Gunsan, OEM factory abroad

+200 Products

Over 200 types of products for power plants, ultrapure water, food, pharmaceuticals, and catalysts

+400 Partners

Collaborate with 400 partners worldwide

+50 Sales networks

Sell in 50 countries worldwide

1.1↓ Uniformity coefficient

High-quality UPS IER with a uniformity coefficient of 1.1 or lower

Locations (Headquarter, Plant, Tech center)

Seoul (Headquarter)

- **Possession of specialized technical sales personnel in three fields**
  - Water treatment/Ultrapure water/ Condensate polishing/ (Condensate polishing) Catalysts
  - Starch / Nucleic acids / Amino acids / Pharmaceuticals
  - Wastewater treatment / Chelates / Specialty purification

- **Providing one-stop total solutions**
  - Ion exchange resin analysis
  - Equipment diagnosis
  - Design support
  - Technical seminars
  - Trouble shooting

Gusan (UPS Resin Plant)

- Uniform particle sized resins

- **Samyang Fine Technology (Since 2016)**
- **Joint venture with Mitsubishi Chemical Corporation, Japan**
- **Asia's largest dedicated factory for uniform particle sized ion exchange resins**
- **Product line**
  - Uniform particle sized ion exchange resins
  - Ultrapure water resins (OLED, LCD)
  - Chromatography resins

Daejeon (Technical Center)

- **Analysis of ion exchange resins**
- **Improvement of ion exchange resin production recipe**
- **Development of new products**
  - Customization / Specialty products
- **Development of application technology**
  - Pilot test
  - Engineering data gathering
  - Process proposal

Ulsan (UPW/ Tailored/ Specialty Resin Plant)

- **Samyang Corporation Ulsan Plant (Since 1976)**
- **Production of various customer-tailored ion exchange resins**
- **Product line**
  - Ultrapure water resins (semiconductor)
  - Customization resins (starch, nucleic acids, catalysts, etc.)
  - Specialty resins (chelate, synthetic adsorbents, etc.)

1. Overview

Ion exchange resin is used not only for producing pure boiler feedwater but also for the condensate polishing plant (CPP), which removes various impurities accumulated in boilers that use condensate water. The high-purity condensate water that directly passes through the turbine of the power generator has a high temperature (60~80℃) and high-pressure characteristics. The reason why a condensate polishing system (or multiple demineralizers) is necessary is as follows.

1) Even trace amounts of elements and impurities are concentrated within the boiler system.
2) Due to the high solubility of ions in hot condensate, the corrosion of pipes is accelerated, resulting in relatively high concentrations of Ca^{2+}, Mg^{2+}, and Fe^{3+} ions.
3) The hardness components are critical to the equipment as they directly affect the power generation of the boiler turbine.

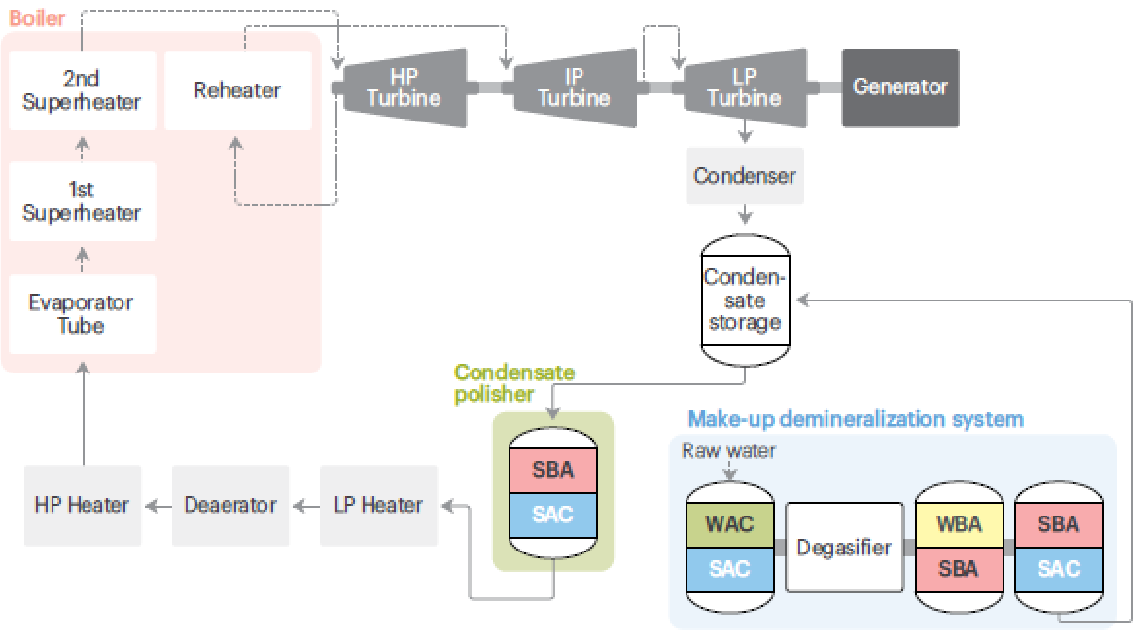


Figure 1. Demi water circulation diagram of a thermal power plant

Steam passing through the turbine is cooled and exits as condensate. Condensate is produced using a similar principle to distilled water. Condensate is essentially highly purified water, but it becomes contaminated by various impurities as it passes through the piping. Common impurities typically found in condensate include sediments of iron and copper, as well as soluble ions and other minor impurities may also be introduced in trace amounts. CPP filters out sediments and removes soluble impurities through ion exchange.

2. Characteristics of the Condensate Polishing Plant (CPP) System

Typically, a Condensate Polishing Plant (CPP) has the characteristics of high-purity treatment capacity, a high flow rate, and efficient removal of colloidal substances. Also, due to the system's characteristics, there are often heavy loads of cationic substances. Depending on the composition of the raw water and the system configuration, it is essential to consider the mixing ratio of cation exchange resin and anion exchange resin. The optimized ratios can appear in various combinations, such as 1:1, 3:2, 2:1, 1:2, and others. Using a mixed bed containing strong acid cation exchange resin and strong base anion exchange resin is desirable for the treatment process.

When regenerating the ion exchange resins charged in the mixed bed, it is performed after the cation exchange resin and anion exchange resin are separated by the difference in specific gravity through backwashing. In this case, using products with a significant difference in specific gravity between the cation and anion exchange resins is relatively advantageous. If the cation and anion exchange resins are not completely separated, there may be a slight mixing at the interface. Typically, most resin beds for CPP use separate regeneration tanks to regenerate cation and anion resins, employing the regeneration method using HCl/H_2SO_4 and NaOH.

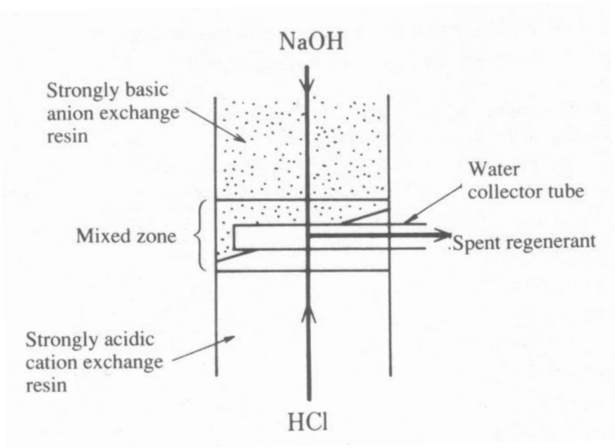


Figure 2. Cation/Anion interface in the mixed bed

In the case of a system without separate regeneration tanks, at the interface, there is a partial mixture of cation and anion exchange resins. The cation exchange resin mixed with the anion exchange resin on top of the collector is converted to Na-form by contacting NaOH, while the anion exchange resin mixed with the cation exchange resin below the collector is converted to Cl-form by contacting HCl. (When using H_2SO_4 as the regenerant for cation exchange resin, it is converted to the SO_4 form) When operating the mixed bed, as the loaded form of the ion exchange resin increases, the leakage of Na^+ and Cl^- ions also increases.

Various systems have been proposed to reduce the leakage of Na^+ and Cl^- ions in the existing mixed bed structure. However, in this case, we will introduce a method using inert resins. In other words, three types of ion exchange resins are used, and this method is called the Triobed Method. To address the issues arising at the interface between cation exchange resin and anion exchange resin, an inert resin with a specific gravity between that of cation and anion exchange resins is introduced to exist between them when separated after backwashing. Refer to Figure 3) The inert resin is a resin without chemical functional groups which exists between the cation and anion exchange resins and prevents the reverse regeneration caused by the regenerant.

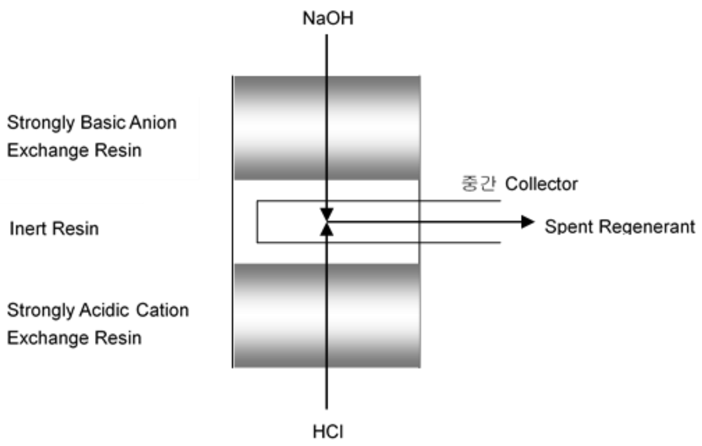


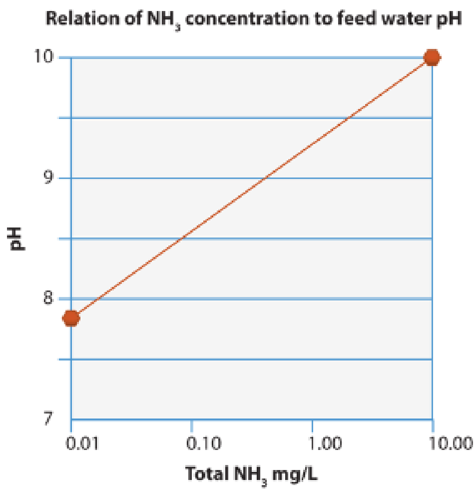
Figure 3. Triobed Method

As shown in Table 1), the allowable limit for Na leakage in the condensate polishing plant is 5 ppb or less. When the separation is carried out after the backwash, if the middle collector is positioned below the interface of cation and anion exchange resins, the presence of Na^+ form in the cation exchange resin and Cl^- form in the anion exchange resin to some extent does not cause a significant problem in terms of ion leakage in the treated water. Therefore, it is desirable to consider these advantages when designing the mixed bed or replacing the ion exchange resins.

Parameter \ Operating conditions \ Water quality	Water quality at inlet		Water quality at outlet
	At ordinary times	During seawater leakage	At ordinary times
pH (25°C)	9.3 ~ 9.5	9.3 ~ 9.5	—
Total dissolved solids (μg $CaCO_3$/l)	50	2,000	25
Ammonia (μg NH_3/l)	760 ~ 1,600	760 ~ 1,600	—
Silica (μg SiO_2/l)	20	100	10
Suspended solids (μg $CaCO_3$/l)	10 ~ 60	100	—
Conductivity (μS/cm, 25°C)	—	—	0.1
Total iron (μg Fe/l)	—	—	5
Total copper (μg Cu/l)	—	—	2
Sodium (μg Na/l)	—	—	5

Table 1. Inlet/Outlet conditions of the condensate polishing plant (CPP)

One of the features of the CPP (Condensate Polishing Plant) system is the removal of ionic substances through ion exchange resins, followed by the dissolution of ammonia (NH_3). The reason for this can be explained as follows.



$$H^+ + OH^- \leftrightarrow H_2O + Heat$$

$$NH_3 + H_2O \leftrightarrow NH_4+ + OH^-$$

1) The higher the temperature, the more the reverse reaction of neutralization is promoted, leading to an increase in the concentration of H^+ ions. Therefore, at high temperatures, corrosion is relatively more likely to occur.

2) When NH_3 is dissolved, less corrosive NH_4^+ ions increase, and the pH rises due to the presence of OH^- ions.

For this reason, ammonia is introduced to suppress piping corrosion. However, a disadvantage of this is that it increases the load on cation exchange resin.

3. Selection of Ion Exchange Resin for CPP

The ion exchange resin suitable for the characteristics of the CPP (Condensate Polishing Plant) system mentioned above should have the following features.

1) The ion exchange resin should have excellent physical and chemical durability. Since it needs to handle high-temperature (60~80℃) and high-pressure condensate, having superior physical and chemical strength is crucial. In particular, SO_4^{2-} and Cl^- ions can corrode ion exchange resins and boiler surfaces under high-pressure conditions, and their oxidation resistance can increase due to iron content. Therefore, the ability to remove these ions even under harsh conditions is essential.

2) To achieve a fast flow rate, small particles are excluded, or uniform ion exchange resins are used.

   Typically, the flow rate of condensate is very fast, exceeding 100m/hr. Therefore, if there are small particles or non-uniform particles, there is a high possibility of pressure loss. This pressure loss increases the crack rate of the ion exchange resin and promotes the generation of crushed resin, leading to higher pressure loss and causing regeneration defects due to channeling phenomena. Therefore, using uniform particle size ion exchange resin is desirable.

3) It should facilitate layer separation through backwashing, so there should be a significant difference in specific gravity between the cation exchange resin and the anion exchange resin. In condensate polishing, where regeneration plays a crucial role, the layer separation of cation exchange resin and anion exchange resin through backwashing is a critical factor in ion resin selection. Therefore, it is essential to choose products with significant differences in particle size distribution and density.

Figure 4. Boundary between cation and anion in the mixing tower

4) The exchange capacity should be high.

Most thermal power plants show an inlet feed water pH of 8.8 to 9.6 before passing through the ion exchange resin. This is a phenomenon caused by ammonia. The concentration of ammonia is approximately 1ppm to 2ppm, and the cation exchange resin that removes such ammonia experiences a significant exchange capacity load. Therefore, it is necessary to consider using a cation exchange resin with a high exchange capacity and increasing the ratio of ion resin charging amount.

4. Overall Summary - Recommended TRILITE® Ion Exchange Resin for CPP

To meet the aforementioned conditions, TRILITE MC-10H and TRILITE MA-10OH are recommended as the most suitable ion exchange resins for the Condensate Polishing Plant (CPP). TRILITE MC-10H and TRILITE MA-10OH are gel-type ion exchange resins that exhibit excellent durability and low-pressure drop even at high flow rates. They also offer superior layer separation, which contributes to increased regeneration efficiency, reduced chemical usage, and improved water collection volume.

1) TRILITE® MC-10H

TRILITE® MC-10H is a UPS, SAC gel-type exchange resin with excellent ion removal capacity, which allows for the economical production of high-purity water. TRILITE® MC-10H is a highly cross-linked product with excellent physical and chemical strength, resulting in low resin degradation over long-term use. TRILITE® MC-10H is supplied in H^+ form.

Product characteristics			
Matrix	Polystyrene+DVB, Gel	Functional group	Sulfonic acid
Ion form	H^+	Exchange capacity(eq/ℓ)	2.00↑
Apparent density (g/ℓ)	805	Moisture retention (%)	45~51
True specific gravity	1.22	Uniformity coefficient	1.1↓
Particle size range (㎛)	660±50	Volume change (Na^+H^+, %)	8
Whole beads rate (%)	95↑		

Table 2. Product characteristics of MC-10H

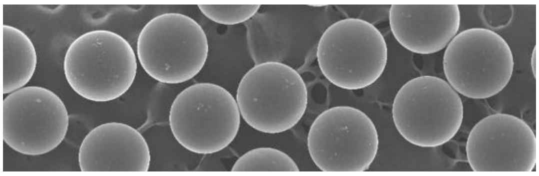


Figure 5. Electron microscope picture of MC-10H

Operating conditions			
Max. temperature (℃)	120↓	pH Range	0~14
Min. resin bed depth (mm)	800	Operating flow rate (m/h)	5~120
Regeneration			
regenerant	HCl / H_2SO_4	Concentration (%)	HCl (4~10) / H_2SO_4 (1~4))
Level (g/ℓ)	50~200	Flow rate (m/h)	2~10
Rinsing volume (BV)	2~6		

Table 3. Operating conditions of MC-10H

2) TRILITE® MA-10OH

TRILITE® MA-10OH is a high cross-linked UPS SBA gel-type type 1 exchange resin with excellent ion removal capacity, allowing for the economical production of high-purity water. TRILITE® MA-10OH has excellent physical and chemical strength, resulting in low resin degradation over long-term use. TRILITE® MA-10OH is supplied in the OH^- form.

Product characteristics			
Matrix	Polystyrene+DVB, Gel	Functional group	Type1 (Trimethylammonium)
Ion form	OH^-	Exchange capacity(eq/ℓ)	1.10↑
Apparent density (g/ℓ)	665	Moisture retention (%)	59~65
True specific gravity	1.07	Uniformity	1.1↓

		coefficient	
Particle size range (㎛)	590±50	Volume change (Cl^- OH^-, %)	23
Whole beads rate (%)	95↑		

Table 4. product characteristics of MA-10OH

Operating conditions			
Max. temperature (℃)	60↓(OH-form) 80↓(Cl-form)	pH Range	0~14
Min. resin bed depth (mm)	800	Operating flow rate (m/h)	5~120
Regeneration			
Regenerant	NaOH	Concentration (%)	2~8
Level (g/ℓ)	50~150	Flow rate (m/h)	2~8
Rinsing volume (BV)	2~8		

Table 5. Operating conditions of MA-10OH

5. The Hydraulic Properties of TRILITE® CPP Ion Exchange Resin

1) TRILITE® MC-10H

The backwash velocity of TRILITE® MC-10H and backwash bed expansion rate according to water temperature changes are as follows.

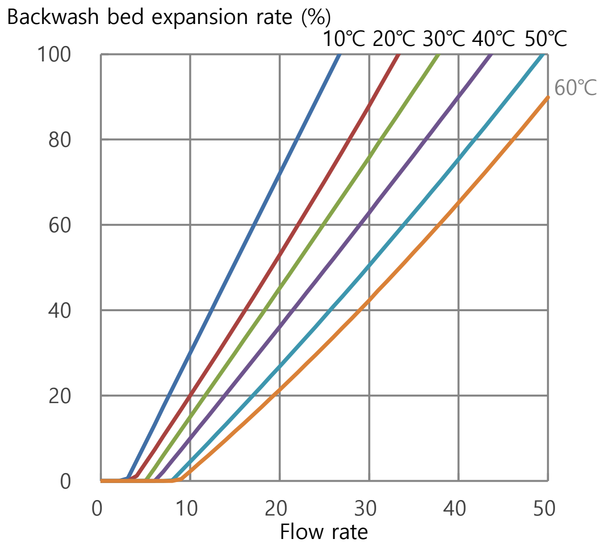


Figure 6. Backwash bed expansion rate of TRILITE® MC-10 Na^+ form

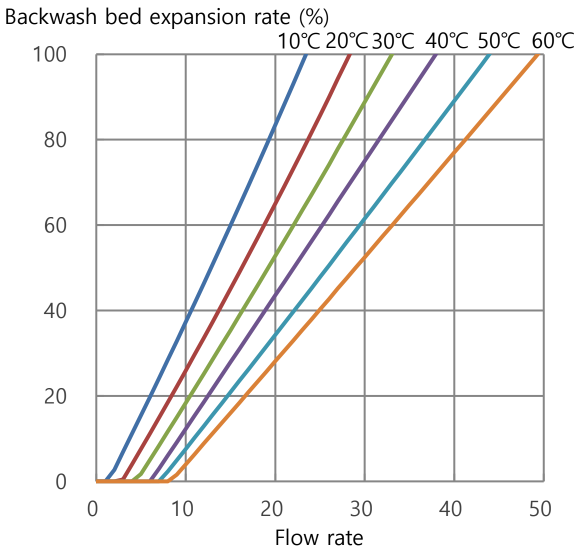


Figure 7. Backwash bed expansion rate of TRILITE® MC-10 H^+ form

The operating flow rate of TRILITE® MC-10H and the headloss according to water temperature changes are as follows.

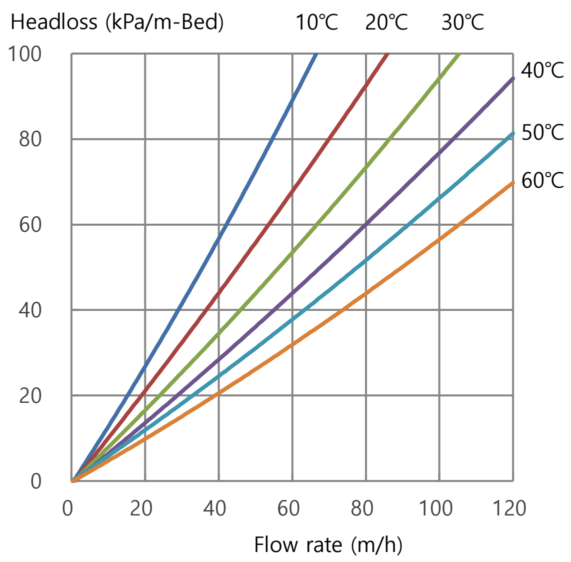


Figure 8. Headloss of TRILITE® MC-10

Na^+ form

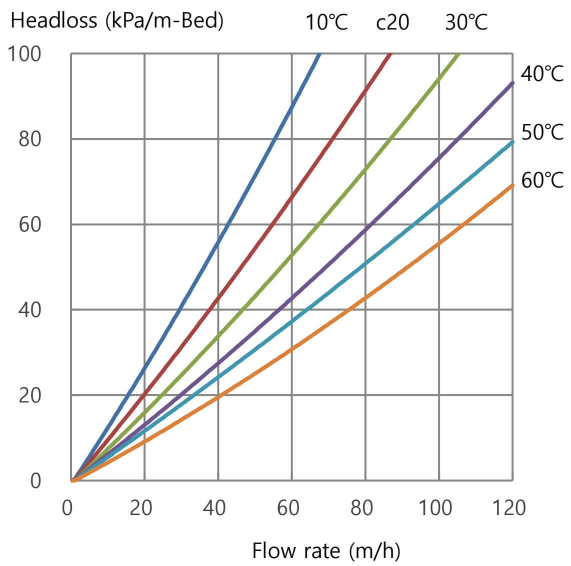


Figure 9. Headloss of TRILITE® MC-10

H^+ form

2) TRILITE® MA-10OH

The backwash velocity of TRILITE® MA-10OH and backwash bed expansion rate according to water temperature changes are as follows.

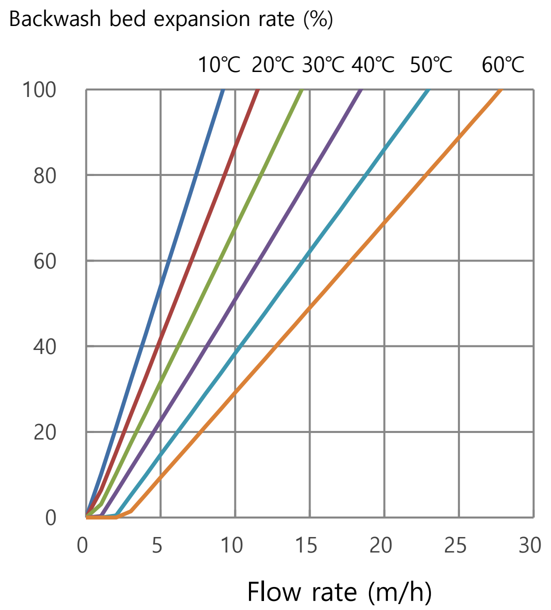


Figure 10. TRILITE® MA-10 Cl^- Type

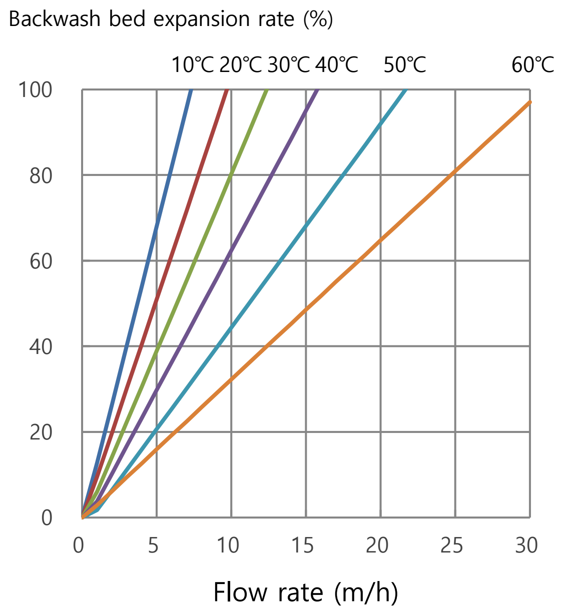


Figure 11. TRILITE® MA-10 OH^- Type

The operating flow rate of TRILITE® MA-10OH and the headloss according to water temperature changes are as follows.

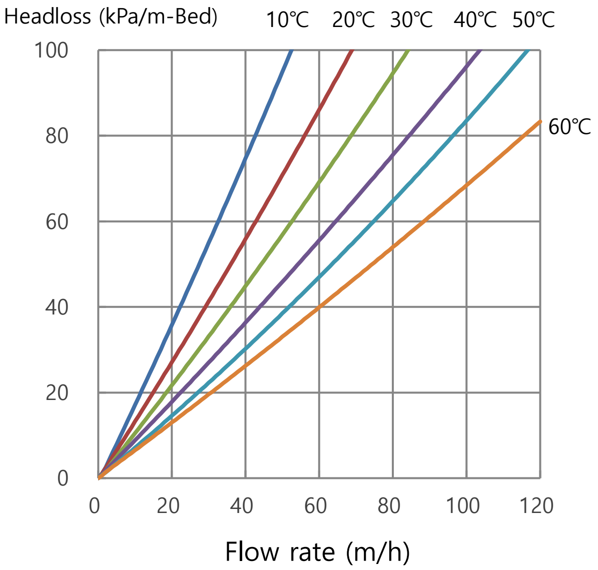


Figure 12. TRILITE® MA-10 Cl^- Type

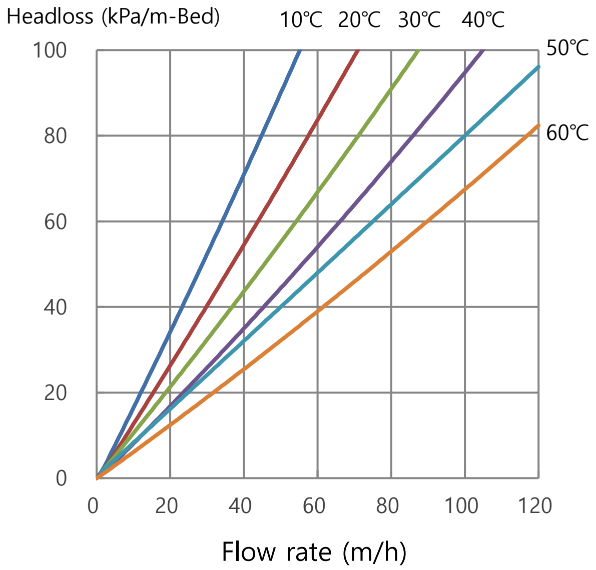


Figure 13. TRILITE® MA-10 OH^- Type

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