Tech Fact

Ion Exchange Resins

Recommended operating conditions for separate beds in water treatment

Introduction

For optimum performance in water treatment, ion exchange resins should be used within a certain range of operating conditions. Although operating outside the suggested range is possible or even required in specific cases, resin performance data shown in the Product Data Sheets supplied by The Dow Chemical Company are valid within the recommended range only. Contact Dow Technical Service for assistance when operating outside the suggested ranges to ensure smooth operation. This document presents typical conditions of use for single beds. Other conditions apply to mixed bed units (please refer to Tech Fact 177-03705).

The Ion Exchange Cycle

A complete ion exchange cycle consists of the following steps:

- Production (service run)
- Backwash
- Regeneration
- Displacement rinse (slow rinse)
- Fast final rinse

Abbreviations

- CFR: co-flow regeneration
- RFR: reverse-flow regeneration (counter-flow) with air or water hold-down
- BV: bed volume (1 m^3 water per m^3 resin or 7.5 gallons per ft^3 resin)
- SAC: strong acid cation exchange resin
- WAC: weak acid cation exchange resin
- SBA: strong base anion exchange resin
- WBA: weak base anion exchange resin

Packed Beds

All packed beds are regenerated in reverse flow. There are two types of packed bed systems:

1. AMBERPACK™ Packed Bed System and floating beds: upflow loading, downflow regeneration

2. UPCORE™ Packed Bed System and others: downflow loading, upflow regeneration

Operating conditions for these two types are partially different. Those valid for upflow loading will be indicated by (1), those for downflow loading by (2).

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Operational Conditions – Production**

Bed Depth	CFR	RFR[a]	Packed Beds
Single beds	700 – 2500 mm	1400 – 3000 mm	1400 – 4000 mm
Layered bed (weak component)		> 600 mm	> 600 mm
Layered bed (strong component)		> 800 mm	> 1000 mm
Specific flowrate (also called Space Velocity)	6 – 60 BV/h (0.7-7gpm/ft³)		
Linear flowrate (also called Linear Velocity)	limit is ΔP* < 150 kPa LV > 12 m/h / SAC ≥ 25 m/h (1)		
Temperature	Ambient water temperature, except for condensate polishing. See individual resin data sheets for acceptable operational range. Note: operational temperature may impact resin lifetime and/or removal of specific ions, e.g., silica.		

(1) Upflow loading, downflow regeneration such as AMBERPACK™ System

* For design purposes a target ΔP of 100kPa for anion should be used. During service, max ΔP for cation resins is 300 kPa and 200 kPa for anion resins.

[a] With RFR, including packed beds, a higher bed depth produces a higher operating capacity. The limiting parameter for bed depth and linear flowrate is pressure drop.

Operational Conditions – Backwash**

CFR
Backwash is recommended at the end of each service run before regeneration to loosen the resin bed and remove suspended solids that may have accumulated on the resin surface.

RFR Hold down systems
Backwash is required only when pressure drop increases due to accumulation of suspended solids or resin particles. Typically it should be performed every 15 – 20 cycles or when pressure drop exceeds the normal value by more than 50%. It is not recommended to perform backwashes routinely because it could disturb the resin layers. After backwash, a double regeneration must be performed.

RFR Packed bed systems
Backwashing AMBERPACK™ and Floating beds is not required unless pressure drop exceeds 1.5 times the normal value. When required, backwash is carried out in a separate column after resin transfer. The UPCORE™ system has a self-cleaning ability that can be used to migrate suspended solids out.

Layered beds
Backwash frequency for layered beds is the same as for RFR systems. However, backwash for layered beds should be performed ***after regeneration***. Resin densities are more favorable to achieve a clean separation between the weak and the strong component after regeneration than before. Instead of a double regeneration, perform a regeneration before backwashing, and another after backwashing.

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Velocity

The backwash flowrate must be adjusted to achieve a percentage of bed expansion close to the maximum value compatible with the vessel geometry, without losing resin by overflow. The flowrate depends on resin type and on temperature.

Time

A backwash for 15 – 30 minutes is typically sufficient for CFR systems, unless the resin bed is contaminated with foreign matter. For ***initial resin loading***, each new resin charge should be backwashed for at least one hour to make sure that foreign particles and resin fines are washed away.

Operational Conditions for Strong Acid Cation and Strong Base Anions – Regeneration**

Quantity	CFR	RFR	Packed beds
NaCl	90 – 240 g/L	70 – 120 g/L	60 – 100 g/L
HCl	75 – 150 g/L	40 – 80 g/L	40 – 70 g/L
H_2SO4	90 – 240 g/L	60 – 100 g/L	55 – 90 g/L
NaOH	75 – 160 g/L	40 – 80 g/L	40 – 70 g/L
Concentration			
NaCl	10%	10%	10% (1) / 2 – 10% (2)
HCl	5%	5%	5% (1) / 1.5 – 5% (2)
H_2SO4	0.8 – 6% depending on Ca content of feed;		
	0.7% only for any WAC resin, in single column or combined with SAC		
NaOH	4%	2 – 4%	2 – 4%
Regenerant flowrate	The flowrate derives from regenerant volume and contact time. For UPCORE, the flowrate (linear velocity) should be enough to guarantee that the resin remains compacted.		
Contact time	> 20 minutes for all systems (< 60 minutes for H_2SO_4)		

(1) Upflow loading, downflow regeneration such as AMBERPACK™ System

(2) Downflow loading, upflow regeneration such as UPCORE™ System

For efficient hydraulic distribution, the volume of regenerant solution should preferably amount to one bed volume or more, and the flowrate should not be too low (≥ 2 BV/h). Lower concentrations may be required for upflow regenerated packed beds marked (2) above to achieve sufficient contact time.

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Operational Conditions – Rinse**

Displacement rinse

Volume	CFR	RFR	Packed beds
Cation	2 BV	1.5 BV	1.5 BV
Anion	3 BV	3 BV	2.5 BV
Rinse flowrate	Same as regeneration flowrate		

Final rinse

Volume	CFR	RFR	Packed beds
Cation	2 – 4 BV	0 (recycling) or 2 – 4 BV	0 BV (recycling)
Anion	3 – 8 BV	0 (recycling) or 3 – 8 BV	0 BV (recycling)
Rinse flowrate	Same as service flowrate or 10 – 30 BV/h		

Operational Conditions for Weak Acid Cation Resins – Regeneration

Quantity	**Dealkalization (% operating capacity)**	**Softening (% total capacity)**	
HCl	105-110%	110-160%	-
H_2SO4	105-110%	110-160%	-
NaOH	75 – 160 g/L	-	110-160%
Concentration			
HCl	2 - 5%	2 - 5%	
H_2SO4	0.5-0.7%	0.5-0.7%	
NaOH	-	-	2 – 4%
Regenerant flowrate			
HCl	2-4 BV/h		
H_2SO4	6-40 BV/h	6-40 BV/h	
NaOH			2-4 BV/h
Displacement rinse	2 BV at regeneration flow rate		
Fast rinse	4-8 BV at service flow rate		
Contact time	> 20 minutes for all systems (< 60 minutes for H_2SO_4)		

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Operational Conditions for Weak Base Anion Resins – Regeneration

Quantity	**Demineralization (% ionic load)**
NaOH	115%*
NH_3	150 %
Na_2CO_3	200%
Concentration	
NaOH	2-4%
NH_3	2-6%
Na_2CO_3	5-8%
Regenerant flowrate	The flowrate derives from regenerant volume and contact time.
Displacement rinse	2 BV at regeneration flow rate
Fast rinse	4-8 BV at service flow rate
Contact time	> 30 minutes for all regenerants

* Increasing NaOH dose to a minimum of 130% stoichiometry is critical for protecting the WBA resin from organic matter fouling when overrunning the resin or for achieving lower total organic carbon (TOC) values in the treated water.

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