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Monitoring, Operation and Control of Ion Exchange Plant

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ABB

Introduction

Successful operation of ion exchange plant follows on from the areas that you have already heard about:

- Good specification and design:
  - Well defined raw water quality
  - Well designed ion exchange plant to produce water of the required quality

Now we will look at practical aspects of monitoring, operation and control to ensure continued good operation of an ion exchange plant

- Good operation:
  - Key performance monitoring parameters
  - Understanding of troubleshooting techniques
  - Identifying early warning signs during operation of the plant cycle

- It would be nice to think that ion exchange plants, once installed, would run reliably and efficiently without intervention or maintenance
  - This is the way many plant are operated!
- Unfortunately it is not true...

- A basic level of monitoring is required just to keep them operating
- A good level of monitoring and understanding is required to keep them operating well

- Content of this module is aimed at high level plants

Monitoring, operation and control

Three areas to consider when monitoring the operation of an ion exchange plant

- Is it producing the correct / expected water quality?
- Is it producing the correct water volume between regenerations?
- Is the regeneration sequence performing as designed?

This can be achieved by:

- Taking grab samples for off line analysis
- On-line instrumentation
- Flow monitoring
- Pressure measurement

Common issues

Some issues are common to all designs of ion exchange plant:

- Sight glasses
- Valve position indicators
- Sampling/monitoring points
- Analysis of purified water
- Regeneration
- Raw water quality

Common issues
Sight glasses

- Mainly a design issue, but
- If you don't have sight glasses, how are you going to tell how much resin you have in the vessel – if any?
  - Required at "normal" level for single beds and
  - Interface for mixed beds and stratabeds

- Easy to lose resin through failed laterals or distributor plate nozzles or top hat during backwashing
- Resin traps after vessels can help, but not foolproof

- BUT sight glasses largely limited to steel vessels
  - Rarely fitted to FRP vessels due to risk of leaks...

- Surprisingly, if the resin isn't there, it won't work!

Common issues
Valve position indicators

- Again, a design issue. But:
- Valve position indicators are extremely useful in helping to identify what has failed, e.g.
  - Poor treated water quality
  - Failed regenerations
- Not available on “cheaper” plants, but invaluable on more critical plants...

Common issues
Sampling/monitoring (1)

To aid management of an ion exchange plant it should have:

- Sample Points located on
  - Feed water
  - Before and after each vessel
  - Final water quality
  - Regenerant flow
- Pressure Measurement
  - Before and after each vessel
- Flow Measurement
  - Through each vessel
    - During normal operation and regeneration

Common issues
Sampling/monitoring (2)

- Sample points may just be simple on/off valves, but for high purity waters will need continuous flow to On-line analysers
- Sample points that do not flow continuously should be left running for a few minutes to ensure a representative sample is taken

- For off line samples, **clean**, plastic screw-capped bottles are required
  - Glass bottles are not acceptable
- Sample bottles should be filled to the top to avoid CO_2 pick-up

- Samples should be analysed promptly – otherwise the quality will change in the bottle...

Common issues
Analysis

- Deionised water can be 500 times purer than potable water for a simple demineralisation plant - and up to 10000 times purer than potable water for a polishing demineralisation plant.
- Correct collection of samples is therefore important to ensure they are representative of the water being produced

- It is extremely difficult to carry out off-line analysis of critical parameters such as pH and conductivity in high purity water

- The levels of impurities can be as low as a few µg/kg, therefore analysis must be carried out in a **clean environment** using **skilled personnel** using the required level of **instrumentation** costing many thousands of pounds

Common issues
Regeneration (1)

- Poor regeneration is the most common problem when ion exchange plants fail to produce either
  - The required water quality or
  - The required volume of treated water
- Regeneration may be initiated by:
  - Time
  - Throughput
  - Quality
  - Or a combination of two or more of these parameters
- For the most demanding duties it is most common to use a combination of throughput limit with a quality (conductivity or silica) over-ride
  - However, this may mask underlying problems of reducing capacity

Common issues
Regeneration (2)

- Once initiated it is vital:
  - Regenerant is the right strength
  - Regenerant is injected at the correct flow rate and over correct time to provide sufficient contact time of regenerant
  - Slow (displacement) rinse is at the correct flow rate and time
  - Fast rinse is at the correct flow rate and time
- It is important that you have the ability to monitor this
  - Not every regeneration, but often enough to confirm that it is working successfully.

Common issues
Regenerant quality

- Important to use best quality regenerant to protect resin life
  - Problem with long term degradation and/or fouling
- Normal regenerant strength for acid or caustic is around 4%
- Sulphuric acid tend to use stepwise regeneration to avoid calcium sulphate precipitation
  - Two steps – at 0.75 to 1.5% then at 2 to 2.5%
  - Determined by % Ca in raw water
- Too high a regenerant strength (>8%) will irreversibly damage the resin through osmotic shock
  - Slow at 8%, but much faster at higher strength
  - Often caused by low dilution flowrate – but how will you know?

- Standards available for the quality of concentrated regenerant from resin supplier

Common issues
Regenerant quality

Parameter	Hydrochloric Acid	Sulphuric Acid	Sodium Hydroxide (rayon grade)	Sodium Hydroxide (diaphragm grade)
Colour	White to light yellow	White to light brown	-	-
Iron	100 mg/l max	50 mg/l max	10 mg/l max	2000 mg/l max
Nitrogen compounds	-	20 mg/l max	-	-
Arsenic	-	0.2 mg/l max	0.01 mg/l max	-
Organic compounds	100 mg/l max	100 mg/l max	-	-
Sulphuric acid as SO_3	0.4% max	-	-	-
Salt (NaCl)	-	-	1200 mg/l max	1200 mg/l max
Na_2CO_3	-	-	0.75% max	3000 mg/l max
$NaClO_3$	-	-	<2 mg/l max	30 mg/l max

Ref: Purolite International Ltd

Common issues
Raw water quality

- Changes in raw water quality have a major impact or plant performance – both capacity and treated water quality
  - May be day to day or seasonal
  - May be due to rainfall patterns or supply management

- It is common practice to analyse raw water quality routinely off-line for multiple parameters, but
- The most valuable parameter to support day-to-day operation is continuous on-line conductivity measurement on a flowing sample
  - Forewarned is forearmed!

Monitoring

- Aim is to show the different monitoring approaches based on plant configuration and criticality of treated water quality
  - On-line via instrumentation
  - Off line routines
  - Regeneration schedules
  - Physical operations (pressure drop, flow rates and volume)

- Presentation considers the following configurations of plant
  - Softening
  - Dealkalisation
  - Simple demineralisation plant: SAC - (DG) - SBA
  - Enhanced demineralisation plant (WAC and/or WBA added)
  - Polishing (cation polishing or MB)

Structure

- Developing reference table for monitoring requirements, covering all configurations
  - Aim to demonstrate the progressive but predictable need for monitoring as duty becomes more demanding

Configuration	**On-line instrumentation**	**Off line routines**	**Regeneration**	**Physical parameters**
Softening				
Dealkalisation				
Simple Demineralisation				
Enhanced Demineralisation				
Polishing				

Structure - definitions

Basic plant

- Simple off the shelf plant for non critical duties

Standard plant

- Pre engineered plant bought off the shelf as a standard design

Bespoke plant

- Purpose designed, highly engineered plant for critical or challenging duties

↓

Greater reliability

Better instrumentation

Better treated water quality

Better diagnostics

Better control panel

More expensive

Purpose of monitoring

- Monitoring is not only about day to day, regeneration to regeneration operation
- It is important to analyse the data regularly (3 monthly?) to look at medium and long term performance trends
  - Shows resin deterioration due to ageing or fouling
  - Shows increasing pressure drop due to resin fouling or resin bead breakage
  - Helps to identify optimum time for resin replacement
    - Economic
    - Reliability
  - Important to “normalise” the data to allow for changes in raw water quality
- Aim is to identify problems early – before the plant fails

Softening
General description

- Probably the simplest form of ion exchange
  - Replaces calcium and magnesium ions with sodium
  - Reliable and robust
  - Uses sodium chloride as regenerant
  - But can have a critical impact on downstream processes if not managed correctly

- Main uses
  - Prevent scale formation in steam raising boilers
  - Pre treatment to reverse osmosis plant
  - Process duties

Softening
Key performance/monitoring parameters

- Good quality operation will produce water <2 mg/l total hardness
- Can get hardness leakage from ion exchange bed
  - Typically occurs towards the end of the run
  - Normally tested for by taking a grab sample
    - Use Yes/No tablets, fast test
    - Green - water soft, red – water hard
- Sample bottle materials not critical
- Can automate using on-line hardness monitors
  - Can set differing alarm levels
  - Low maintenance
  - Can afford to run to low level hardness break through

Softening
Regeneration

- Uses sodium chloride brine as a regenerant – 10% strength
- One of the most common faults is lack of available regenerant
- Saturated brine made up in salt saturator
  - May be combined with measure tank
- Important to schedule check on salt saturator
  - Daily check on salt levels in saturator
  - If manual fill, top up as required to ensure salt granules can be seen in the saturator tank

Softening
Basic plant

- Example duty – low pressure steam raising

- Simplest of plants with the least amount of monitoring
  - Regenerated on time or throughput
  - May, if you are lucky, have a totalising flowmeter

- Difficult to troubleshoot as single “tree” valve arrangement on top of vessel
  - At best grab samples of treated water towards the end of the service run for hardness determination

- Good practice to monitor raw water quality for changes which will affect service runs

Softening
Standard plant

- Example duty – low/medium pressure steam raising boilers
- On this plant you might start to see some on-line analysis installed or still carry out once a shift off line grab analyses
- On-line analysers are colorimetric
  - Can be set for differing levels of alarm, dependent of quality required
- May also start to see physical measurements taken, e.g.
  - Pressure drop gives an indication of fouling with suspended solids or resin breakdown
- Will have totalising flowmeter

Softening
Bespoke plant

- Example duty – upstream of reverse osmosis plants
  - Important to protect membranes from scaling

- Engineered designed plant will come with:
  - On-line hardness analysis
  - Individual distribution/collection systems
  - Pressure gauges
  - Totalising flowmeter

- Salt delivered in bulk into a salt saturator

Softening
Common faults

Problem	Cause	Action
Short runs	Change in raw water quality.	Analyse raw water compared to design.
	Regeneration problems	Check salt levels and/or watch regeneration sequence
	Loss of resin	Check resin inventory
Limited throughput/flow rate	Fouled resin bed	Measure pressure drop Sample resin for analysis
	Broken resin beads	Check brine strength, resin age, free chlorine
Poor quality service water	Poor regeneration - brine not rinsing off resin - lack of regenerant	Monitor regeneration
	Damaged or fouled resin resin	Sample resin for analysis

Softening
Day to day monitoring

- Under normal operation problems only seen at the end of the service run as the bed moves towards exhaustion

- However, poor quality water can be seen at start of the service run caused by insufficient rinsing of brine solution
  - May be due to rinse flow or duration

- Remember: Softening will not reduce the TDS of the raw water, in fact it will increase. This is not a problem with the operation of the plant

Softening
What to monitor

- If you do not have the following information, you cannot trouble shoot the plant
  - Ensure totalising water meter installed to monitor volume of treated water produced between regenerations
  - Carry out routine raw water analysis
    - Match raw water analysis vs. treated water produced
  - Ensure regenerant always available
  - Monitor quality of water first produced to service
    - Look for increased conductivity and levels of chloride
  - Monitor quality of water towards the end of the service run to ensure no premature hardness breakthrough
  - Monitor pressure drop across resin beds
  - Sample resin on an annual basis for condition testing

Softening Summary

Configuration		On-line instrumentation	Off line routines	Regeneration	Physical parameters
Softening	Basic	None	Sample at end of run	Check salt daily Fill salt weekly	Flow measurement on request
	Standard	Hardness monitor	Shift sample	Check salt daily Fill salt saturator	Pressure drop plus flow measurement
	Bespoke			Bulk salt saturator	Pressure drop plus flow measurement
Dealkalisation					
Simple Demineralisation					
Enhanced Demineralisation					
Polishing Demineralisation					

Dealkalisation
General description

- Uses WAC to remove calcium and magnesium ions associated with carbonate and bicarbonate alkalinity (temporary hardness)
  - More efficient regeneration than SAC
- Followed by degasser tower to air strip carbon dioxide
- Unlike softening, dealkalisation does reduce the TDS of the water
- Regenerant on exhaustion of the bed is normally with hydrochloric acid
- Regeneration initiated by pH measurement

Dealkalisation
Key performance/monitoring parameters

- Good quality operation will produce water with a pH value <5.5
- On-line instrumentation will include a pH analyser
  - Used to monitor bed performance to determine end of service run
  - Typically bed taken out when the pH value rises to 5.5
- pH change towards end point is rapid and therefore need reliable pH measurement
  - Can't rely on manual pH determination
  - But can regenerate on time or throughput - inefficient
- Over-running dealkalisation unit puts extra load on SAC

Dealkalisation
Regeneration

- Normally uses hydrochloric acid as a regenerant – 2-3% strength
  - Can use sulphuric acid but be aware of risk of calcium sulphate deposition

- Dilute acid can be made up as bulk solution or as required
  - Dilution of concentrated acid via eductor into motive water
  - Uses rotameters to measure flows
  - Or can use pumps to inject acid into motive water with conductivity meter to monitor dilute acid strength

- If not using conductivity to monitor regenerant strength, good practice to have measure tank to deliver known amount of acid

Dealkalisation
Basic plant

- Example duty – pre treatment to SAC to increase efficiency or pre-treatment to softening plant

- Basic (uninstrumented) plant inherently unreliable
  - Lack of on-line monitoring likely to result in inefficient operation
  - Regenerate on time or throughput (if flowmeter installed)
    - Only acceptable with very stable raw water quality, e.g. Boreholes
    - Unreliable if raw water quality variable

Dealkalisation
Standard plant

- Example duty – pre treatment to SAC to increase efficiency or pre-treatment to softening plant

- On-line instrumentation as previously discussed
  - pH analyser to monitor performance and initiate regeneration

- Totalising flowmeter should be installed

- May also see pressure gauges installed to measure pressure drop across the resin bed

Dealkalisation
Bespoke plant

- Example duty – pre treatment to SAC to increase efficiency or pre-treatment to softening plant
- Similar on-line instrumentation to standard plant, i.e. pH analyser
- Will have totalising flowmeter to show how much water is being treated between regenerations
- Pressure gauges to measure pressure drop across the resin bed
- May see sight glass windows installed on (lined, steel) vessels

Dealkalisation
Common faults

Problem	Cause	Action
Short runs	Change in raw water quality.	Analyse raw water compared to design.
	Regeneration problems	Check regenerant strength and/or watch regeneration sequence
	Loss of resin	Check resin inventory
	Distribution problems	Inspect collection and distribution system
Limited throughput/flow rate	Fouled or broken resin bed	Measure pressure drop Sample resin for analysis
Over-run	Instrument problems	Calibrate instruments

Dealkalisation
Day to day monitoring

- Should have an installed flow meter to check flow does not exceed 30 BV/hr
- Should have totalising flow meter for diagnostics
- Should have pressure gauges on to monitor for increased pressure drop due to:
  - Fouling of bed with suspended solids
  - Damage to resin beads
  - Precipitation during regeneration

Dealkalisation
What to monitor

- If you do not have this information you cannot troubleshoot the plant
  - Ensure totalising water meter installed to monitor volume of treated water produced between regenerations
  - Carry out routine raw water analysis
  - Match raw water analysis v treated water produced
  - Regenerant strength
  - Flow rates and times during regeneration rinses
  - Pressure drop across resin beds
  - Sample resin on an annual basis for condition testing

Dealkalisation Summary

Configuration		On-line instrumentation	Off line routines	Regeneration	Physical parameters
Softening	Basic	None	Sample at end of run	Check salt daily Fill salt weekly	Flow measurement on request
	Standard	Hardness monitor	Shift sample	Check salt daily Fill salt saturator	Pressure drop plus flow measurement
	Bespoke			Bulk salt saturator	Pressure drop plus flow measurement
Dealkalisation	Standard	pH monitor	pH check	Acid strength	Pressure drop plus flow measurement
	Bespoke				
Simple Demineralisation					
Enhanced Demineralisation					
Polishing Demineralisation					

Simple demineralisation
General description

- Demineralisation using SAC followed by SBA
  - May have a degasser installed after SAC unit

- SAC resin removes cations from feed water
- SBA resin removes anions from feed water

- When bed is exhausted:
  - SAC uses hydrochloric acid or sulphuric acid for regeneration
  - SBA uses sodium hydroxide for regeneration

- Regeneration initiated by:
  - Time
  - Volume
  - Quality

Simple demineralisation
Key performance/monitoring parameters

- Good quality operation will produce water with a conductivity:
  - Co-current plant 5 – 10 μS/cm – typically 2 – 3 μS/cm
  - Counter current plant <5 μS/cm – typically 1 to 2 μS/cm

- Depending on design of plant, On-line monitoring to initiate regeneration could be:
  - Timer – if time controlled
  - Totalising flow meter – if volume controlled
  - Conductivity
  - Silica
  - Sodium
  - Manual

Simple demineralisation
Regeneration (1)

- For all demineralisation plants the ability to monitor the regeneration is critical

- Parameters to monitor include:
  - Regenerant strength
  - Time to inject regenerant
  - Time and volume of water for slow rinse
  - Time and volume of water for fast rinse

Simple demineralisation
Regeneration (2)

- Regenerant strength is important for the following reasons:
  - Using sulphuric acid too high in concentration can lead to calcium sulphate precipitation on the resin beads
    - Reduces capacity of bed due to bead fouling
    - Increased pressure drop across the bed
  - Using too low strength hydrochloric acid or sodium hydroxide will not efficiently regenerate the resin and reduce throughput between regenerations

- Regenerant strength can be measured off line or by on-line conductivity measurement

Simple demineralisation
Basic plant

- Example duty – low capital cost process water purification plant

- Consists of SAC followed by SBA unit
  - Instrumentation and sampling points will be limited
  - Plant may be PLC controlled with simple mimic screen
  - Regeneration initiated by time or volume of water treated
  - Grab samples taken to demonstrate water quality
  - No valve position indicators

- Totalising flowmeter highly desirable – but you may have to ask

Simple demineralisation
Standard plant

- Example duty – producing good quality water for process or MP steam raising duties

- Consists of SAC followed by SBA unit
- May have a degasser installed between SAC and SBA to reduce load on SBA

- Will probably be designed to be cation limiting and will have limited on-line instrumentation
  - Conductivity analyser exit SBA
  - Designed to operate without on-line silica analyser

- Conductivity meter should be temperature compensated to allow for change in water temperature

- Totalising flowmeter essential for performance monitoring

Simple demineralisation
Standard plant

Cation-limiting operation:

- If the SAC exhausts before the SBA then there will be a rise in conductivity
  - Sodium slips from SAC unit before silica slips from SBA unit
  - Can safely use conductivity as indication of exhaustion to initiate regeneration
- But what happens as the anion resin ages or becomes fouled?
  - Plant is no longer cation limited
  - The SBA exhausts before the SAC and there will be a slight fall in conductivity followed by a sharp rise in conductivity
    - By which time silica will already be slipping...
- How will you be able to detect when the plant is no longer cation limited?

Simple demineralisation
Standard plant

Pressure drop

- Monitoring pressure drop across vessels can be useful
  - Cation
    - Suspended solids in feed water
    - Breakdown of resin beads
    - Calcium sulphate precipitation
    - Problem with distribution/collection system
  - Anion
    - Breakdown of resin beads
    - Precipitation of hydroxides on resin if raw water used for regeneration
    - Problem with distribution/collection system

Degassing tower

- It is not normal to monitor the performance of a degassing tower except for :
  - Level in the sump
  - Operation of the fan

- Any deterioration in performance will be shown by a short service run of the ion exchange plant as the SBA will have extra load on it

Simple demineralisation
Bespoke plant (1)

- Typical duty – process and steam raising applications where the quality of demineralised water is critical

- Similar to the standard plant but with enhanced monitoring:
  - On-line conductivity monitoring exit anion unit
    - Conductivity probe can be placed up to 25% above the bottom distributor to identify imminent breakthrough of the SAC or SBA bed
  - On-line sodium monitoring on exit to SAC bed
    - Uses ion selective electrode, LOD ≤ 0.10 µg/kg
    - Regeneration set dependent on final water quality required

Simple demineralisation
Bespoke plant (2)

- On-line silica monitoring
  - Colorimetric method for low levels of silica down to 1 µg/kg
  - Not an instantaneous result, takes several minutes to get a reading
  - Regeneration set dependent on final water quality required
  - Manifold arrangement can be used for multiple streams
- On-line pH monitoring
  - Ex SAC Low pH values will indicate good removal of calcium, magnesium and sodium.
    - pH will rise as the bed becomes exhausted
  - Ex SBA the pH will be neutral.
    - pH rising indicates slippage of sodium from the SAC bed
    - pH falling indicates slippage of alkalinity - silica probably already slipping
  - pH electrodes are temperature sensitive, so should be temperature compensated
  - In line pH electrodes are required due to the rapid pick up of carbon dioxide from the atmosphere on exposure

Simple demineralisation
Common faults

Problem	Cause	Action
Short runs	Change in raw water quality.	Analyse raw water compared to design
	Regeneration problems	Check regenerant strength and/or watch regeneration sequence (both units)
	Loss of resin	Check resin inventory
	Distribution problems	Inspect collection and distribution system
Limited throughput/flow rate	Fouled or broken resin beds	Measure pressure drop Sample resin for analysis
Poor quality water	Organic fouled anion resin	Sample resin for analysis
	Instrument problems	Calibrate instruments

Simple demineralisation
Monitoring

- The service flow rate through the bed should be designed to 8 – 40 BV/hr

- It is difficult to accurately measure pH and conductivity measurements off-line
  - Water will absorb carbon dioxide readily from the atmosphere

- Feed water should be monitored for free chlorine
  - Free chlorine > 0.3 mg/l will progressively and irreversibly damage SAC & SBA resins

Simple demineralisation
What to monitor

- Sample points should be installed before and after each vessel
  - Off line analysis for sodium or silica
  - Samples should be collected in screwed capped polyethylene bottles
  - Analysis via atomic absorption, colourimetric or ion chromatography
- Sample points for regenerant strength to ensure correct regeneration
- Ensure totalising water meter installed to monitor volume of treated water produced
- Carry out routine raw water analysis
- Match raw water analysis vs.. treated water produced
- Monitor conductivity of purified water
- Monitor pressure drop across beds
- Monitor pH of purified water
- Sample resin on an annual basis for condition

Simple demineralisation
Summary

Configuration		On-line instrumentation	Off line routines	Regeneration	Physical parameters
Softening	Basic	None	Sample at end of run	Check salt daily Fill salt weekly	Flow measurement on request
	Standard	Hardness monitor	Shift sample	Check salt daily Fill salt saturator	Pressure drop plus flow measurement
	Bespoke			Bulk salt saturator	Pressure drop plus flow measurement
Dealkalisation	Standard	pH monitor	pH check	Acid strength	Pressure drop plus flow measurement
	Bespoke				
Simple Demineralisation	Basic	Conductivity	Silica, sodium	Acid and caustic strength	Flow measurement on request
	Standard	Conductivity, Silica		Acid and caustic strength Rinse times	Pressure drop plus flow measurement
	Bespoke	Conductivity, silica, sodium, pH		Acid and caustic strength Rinse times Regenerant quality	
Enhanced Demineralisation					
Polishing Demineralisation					

Enhanced demineralisation
General description

- Enhanced demineralisation would be similar plants to SAC – Degasser – SBA but with either a WAC or WBA bed added
  - Generally installed to improve regeneration efficiency
  - WBA will also protect SBA from organic fouling
- These may be installed as separate beds or as stratified beds inside the same vessels.
- If installed in same vessels same monitoring procedures as for standard demineralisation plants

Enhanced demineralisation
Separate WAC bed

- This has already been covered under dealkalisation
  - On-line monitoring
  - Regenerant strength
  - Totalising flow meter

- The resin should be sampled on an annual basis to check its condition

Enhanced demineralisation
Separate WBA bed

- It is not normal to provide additional monitoring of the performance of a separate WBA unit.
- The resin should be sampled on an annual basis to check its condition

Enhanced demineralisation Summary

Configuration		On-line instrumentation	Off line routines	Regeneration	Physical parameters
Softening	Basic	None	Sample at end of run	Check salt daily Fill salt weekly	Flow measurement on request
	Standard	Hardness monitor	Shift sample	Check salt daily Fill salt saturator	Pressure drop plus flow measurement
	Bespoke			Bulk salt saturator	Pressure drop plus flow measurement
Dealkalisation	Standard	pH monitor	pH check	Acid strength	Pressure drop plus flow measurement
	Bespoke				
Simple Demineralisation	Basic	Conductivity	Silica, sodium	Acid and caustic strength	Flow measurement on request
	Standard	Conductivity, Silica		Acid and caustic strength Rinse times	Pressure drop plus flow measurement
	Bespoke	Conductivity, silica, sodium, pH		Acid and caustic strength Rinse times Regenerant quality	
Enhanced Demineralisation	Standard	pH monitor	pH check	Acid and caustic strength	Pressure drop
	Bespoke				
Polishing Demineralisation					

Polishing demineralisation
General description

Polishing demineralisation can be achieved in two ways:

Cation polishing

- Contains only SAC resin to improves the quality of a twin bed unit without the capital expense of a MB unit
  - Useful if you want to polish out trace amounts of sodium

MB units

- Contains SAC and SBA resin to improve the quality of a twin bed plant
  - Removes sodium and silica ions that have slipped from the twin bed plant
  - Regenerated after a set number of regeneration of a twin bed unit
    - Maximum of every 4 weeks to prevent bed compaction

Polishing demineralisation plant
Key performance/monitoring parameters

- Monitoring of cation polishing is normally limited to:
  - Conductivity
  - Sodium (on-line or off-line)

- Monitoring of MB unit would normally include:
  - Separation of resins during regeneration
  - Silica
  - pH
  - Sodium
  - Conductivity
  - Regenerant strength
  - Flow monitoring
  - Pressure drop

Polishing demineralisation
Regeneration

Cation polishing

- Typically thoroughfare regeneration
  - Polishing vessel is regenerated at the same time as the SAC bed. Acid passes through the polisher before the SAC unit
- For bespoke designs can be regenerated separately

MB units

- Separation of resins during regeneration is critical to the good operation of a MB plant
- Poor separation will affect final water quality

- Sight glasses should be installed at:
  - the top of the resin bed - to watch level of water in vessel prior to air mixing
  - the centre lateral to enable resin separation to be observed

Polishing demineralisation
Basic plant

By definition polishing demineralisation plants will be either standard or bespoke designs

Polishing demineralisation
Standard plant

- Cation polishing units do not normally run to exhaustion and therefore rely on on-line instrumentation to monitor their performance.
  - Conductivity analysers

- Polishing MB units should not be run to exhaustion and therefore rely on on-line instrumentation to monitor their performance.
  - Silica analysers
  - Conductivity analysers

- Regenerant strength and flows will be similar to those of simple demineralisation design – already covered

Polishing demineralisation
Bespoke plant

- Bespoke cation polishing units will be similar to standard units
  - May have extra on-line instrumentation such as sodium and/or pH analysers
- Bespoke design MB units follow the same principles as standard design, the major differences being resin volumes being matched to feed water and produced water requirements
  - Likely to have on-line pH and sodium analysers for critical duties

Polishing demineralisation
Common faults

Problem	Cause	Action
Short runs	Change in feed water quality	Analyse feed water compared to design
	Regeneration problems	Check regenerant strength and/or watch regeneration sequence (both units)
	Loss of resin	Check resin inventory
	Distribution problems	Inspect collection and distribution system
Limited throughput/flow rate	Fouled or broken resin beds	Measure pressure drop Sample resin for analysis
Poor quality water	Organic fouled anion resin	Sample resin for analysis
	Regeneration problems	Check separation of resins
	Instrument problems	Calibrate instruments

Polishing demineralisation
Monitoring

- Cation polishing units can have much higher service flow rates
  - Up to 200 BV/hr
- The service flow rate through a MB unit should be limited to 60 – 100 BV/hr
- It is difficult to accurately measure pH and conductivity measurements off line, due to carbon dioxide absorption, therefore on line instrumentation with flow through cells is required

Polishing demineralisation
Troubleshooting

- Sample points should be installed before and after each vessel
  - Off line analysis for sodium or silica
  - Samples should be collected in screwed capped polyethylene bottles
  - Analysis via atomic absorption, colourimetric or ion chromatography
- Sample points for regenerant strength to ensure correct regeneration
- Monitor conductivity of purified water
- Monitor pressure drop across beds
- Monitor pH of purified water
- Sample resin on an annual basis for condition

Polishing demineralisation Summary

Configuration		On-line instrumentation	Off line routines	Regeneration	Physical parameters
Softening	Basic	None	Sample at end of run	Check salt daily Fill salt weekly	Flow measurement on request
	Standard	Hardness monitor	Shift sample	Check salt daily Fill salt tank twice weekly	Pressure drop plus flow measurement
	Bespoke			Bulk salt saturator	Pressure drop plus flow measurement
Dealkalisation	Standard	pH monitor	pH check	Acid strength	Pressure drop plus flow measurement
	Bespoke				
Simple Demineralisation	Basic	Conductivity	Silica, sodium	Acid and caustic strength	None
	Standard	Conductivity, Silica		Acid and caustic strength Rinse times	Pressure drop
	Bespoke	Conductivity, silica, sodium, pH		Acid and caustic strength Rinse times Regenerant quality	Pressure drop Flow rates
Enhanced Demineralisation	Standard	pH monitor	pH check	Acid and caustic strength	Pressure drop Flow rates
	Bespoke				
Polishing Demineralisation	Standard and Bespoke	Conductivity. Silica, sodium and pH	Silica and sodium	Acid and caustic strength	Flow rates, pressure drop

Resin sampling

- As you will already have seen in John Greene's presentation:

- Regular resin testing is a key factor (though under-utilised) in monitoring the medium and long term performance of an ion exchange plant
- Can assist in trouble shooting problems
- Will assist in budgeting for replacement resins
  - Predicts when it is economic to change the resin vs. regenerant usage.

Controller

- It is important that the controller and the provided software is capable of handling and storing all the data available
  - For a Basic plant, with limited instrumentation, it may be sufficient to use a PLC and simple text screen
  - For Standard and Bespoke plants, a more sophisticated control system may be required, with a DCS or SCADA system, especially if the plant is to be monitored and controlled from a central control room
- More sophisticated plants also benefit from having full mimic screens local to the plant to allow local operation, e.g.
  - step-through regeneration capability,
  - the ability to interrogate the recent operation for fault tracing, etc.
- The ability to modify the control algorithm, e.g. to fine-tune the regeneration sequence is also important for Standard and Bespoke plants
- Data generated should be stored for a period of 12 months or longer to allow periodic assessment of the performance of the plant

Conclusions

- In the most simple terms, the more you want from your ion exchange plant in terms of water quality and reliability, the more monitoring you must do
  - As the duty becomes more critical, so the need for on-line monitoring increases
  - Data generated needs to be collected and used for periodic assessment
- Failed regeneration is one of the most common faults seen on ion exchange plants
  - Ability to investigate the cause of regeneration failure is essential
- On line analysis is essential control if you want high purity waters
- Off line analysis can be carried out where appropriate, especially for fault finding, but understand its limitations
- Resin sampling should be built into a monitoring plan

Summary

- Typical parameters and locations for monitoring of demineralisation plants

Sample Location	Parameters
Feed water	Conductivity, TOC, chlorine, temperature
WAC	pH
SAC water	Sodium, conductivity, pH, flow rate, pressure drop, throughput,
Ex Degasser	No analysis normal
SBA water	Silica, conductivity, pH, flow rate, pressure drop, throughput
MB water	Silica, sodium, conductivity, pH, flow rate, pressure drop, throughput
Cation polished water	Sodium

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