Trouble Shooting Ion Exchange Plant Problems

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Introduction

This presentation is centred on 7 flow diagrams which can be used to track down the cause of Ion exchange plant problems:

The diagrams cover:

CATION – ANION – MIXED BED PLANT

(With or without an intermediate degasser between cation/anion)

However, to use these guides you need to have an understanding of how the plant should perform at each stage, and how ion exchange resins work and what is the sequencing involved in each regeneration of the beds.

Introduction

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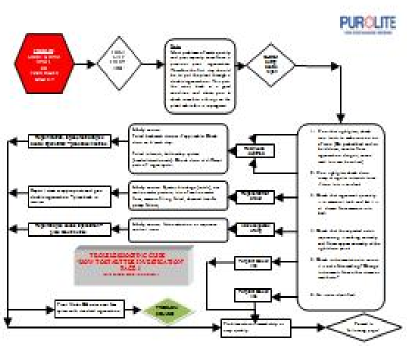
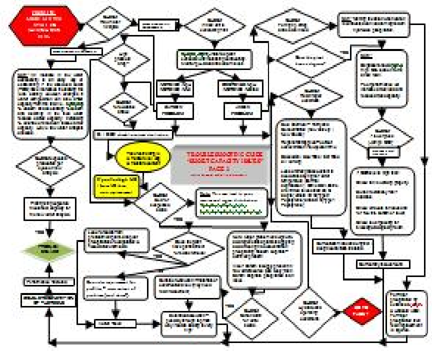
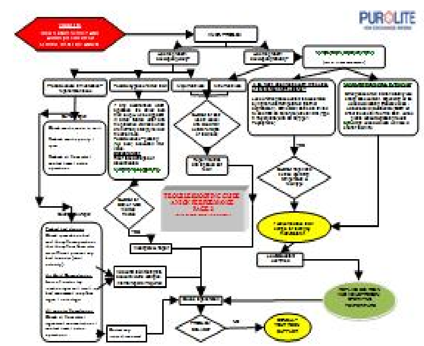
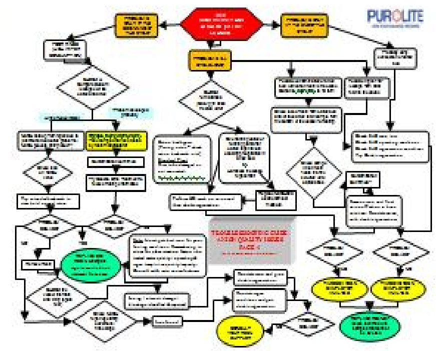
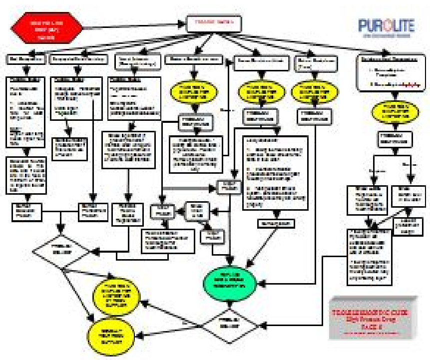
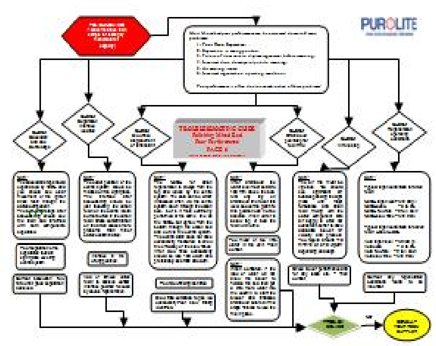
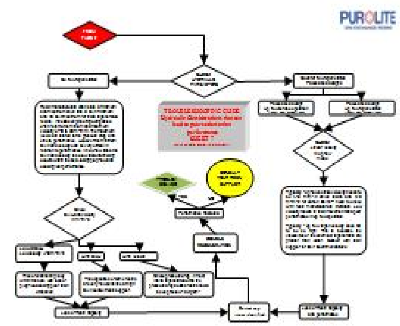

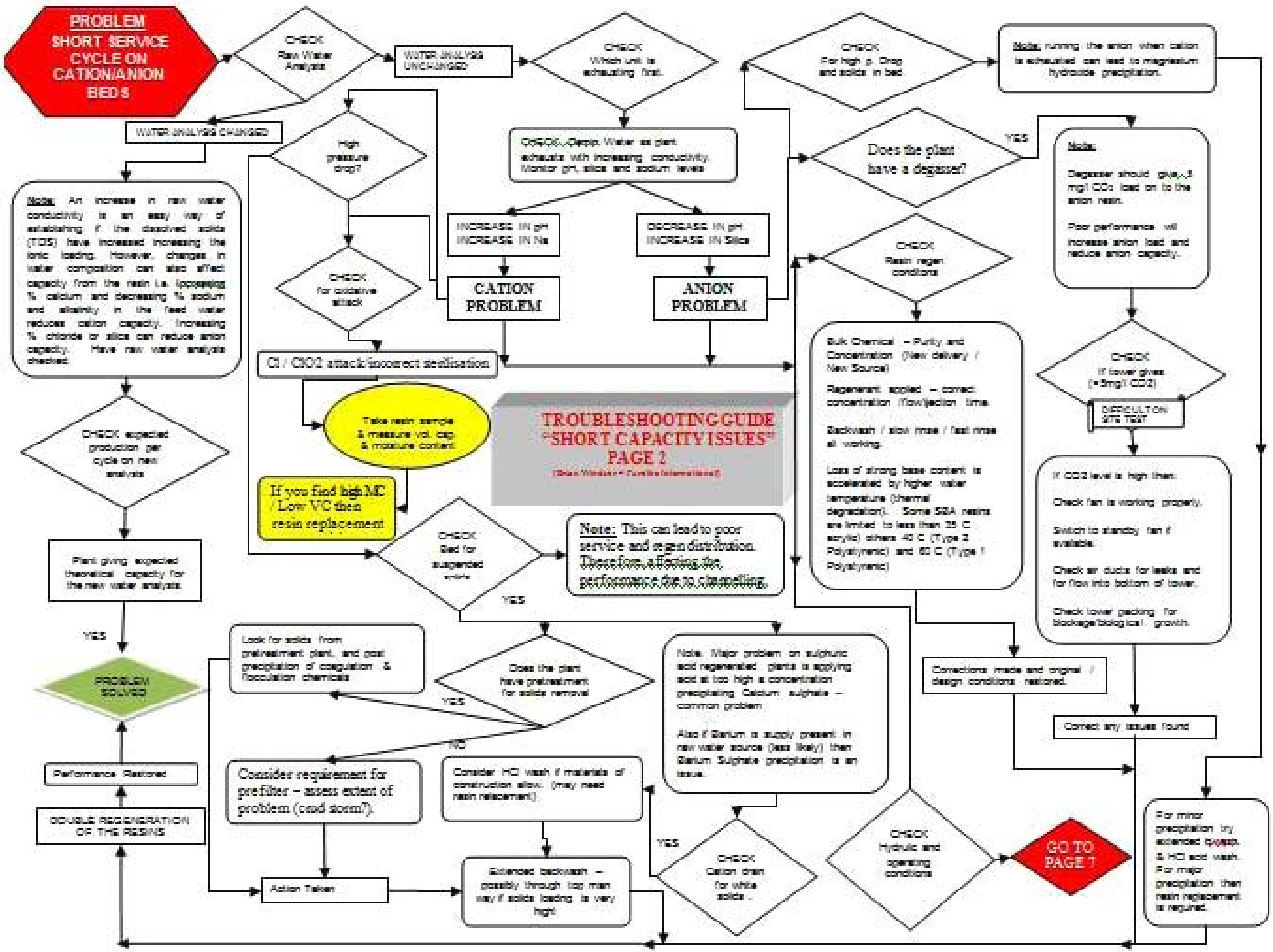

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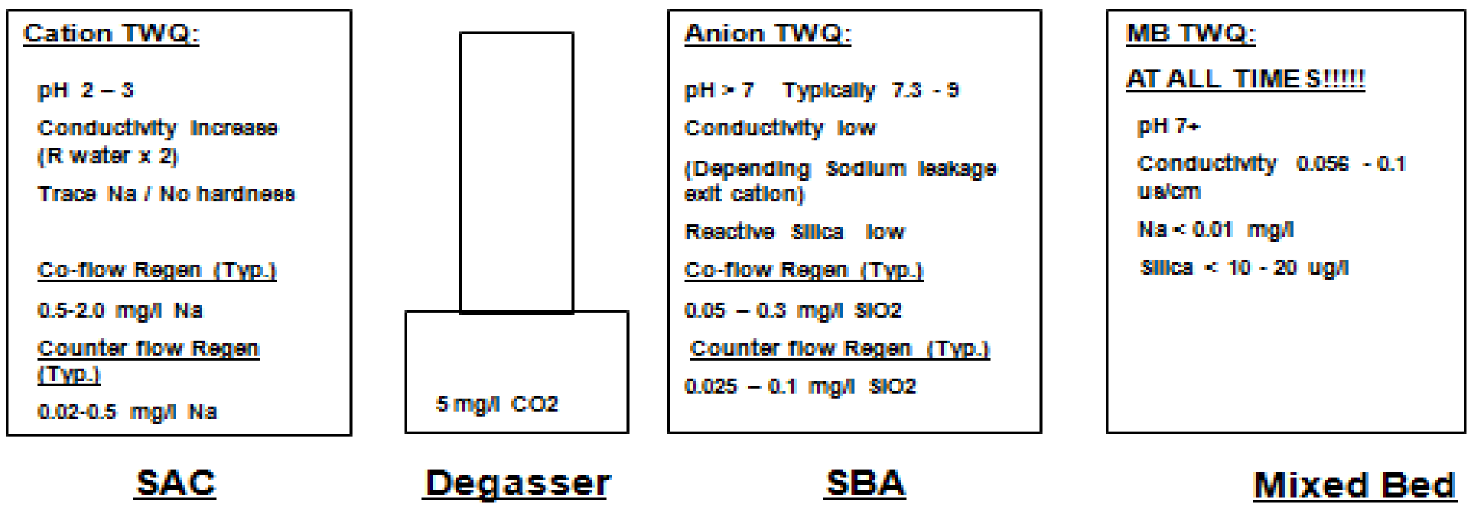
For your plant when it is working well you need to have a chart like this showing the performance at every stage. Below we have given typical performance for co-flow and counter flow regenerated cation – anion systems with polishing mixed bed:



Raw Water Conductivity and pH (and temp variations if heated)
Intermediate Stage Quality with regard to pH / Conductivity / Na / Silica

Remember (Covered in Introductory Course)

Silica performance from demin plants only refers to Reactive Silica, non reactive silica (colloidal silica) is not totally moved by conventional anion resins!

Silica leakage from anion resins does not contribute to conductivity. In fact as silica breaks through the bed there is a very slight conductivity depression seen.

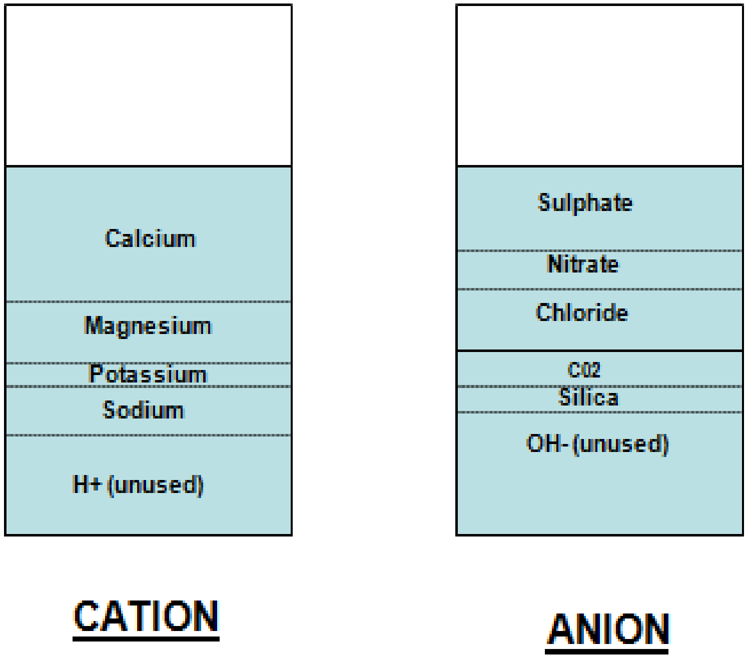
Cation resins exchange H+ - acidity

Anion resins exchange OH- ions – alkaline

Leakage from beds (hence treated water quality) is determined by the efficiency of the last regeneration

Remember (Covered in Introductory Course)

How ion exchange resins work: Order of selectivity



CASE STUDIES

The best way to demonstrate how these diagrams can be used, is to use examples of plant troubleshooting from my 33 years working in ion exchange:

CASE STUDY – NO.1 Chemical Works in North Lincolnshire.

(Example where it was clear client did not understand how the plant worked!)

Plant:	2 stream co flow regenerated cation – anion.
Problem:	Short capacity with service cycle terminated with high conductivity on one stream. Silica ok. – other stream performing well.
Client Actions:	Replaced anion resin and then removed new anion resin to inspect internals but problem persisted

They now approached Purolite for help.

CASE STUDY – NO.1

Purolite involvement:

2nd stream working well so not a raw water issue.

Asked client why he thought it was an anion issue? They based their assumption on the fact that the conductivity monitor was located exit the anion so it was measuring anion performance!

Purolite Recommendation

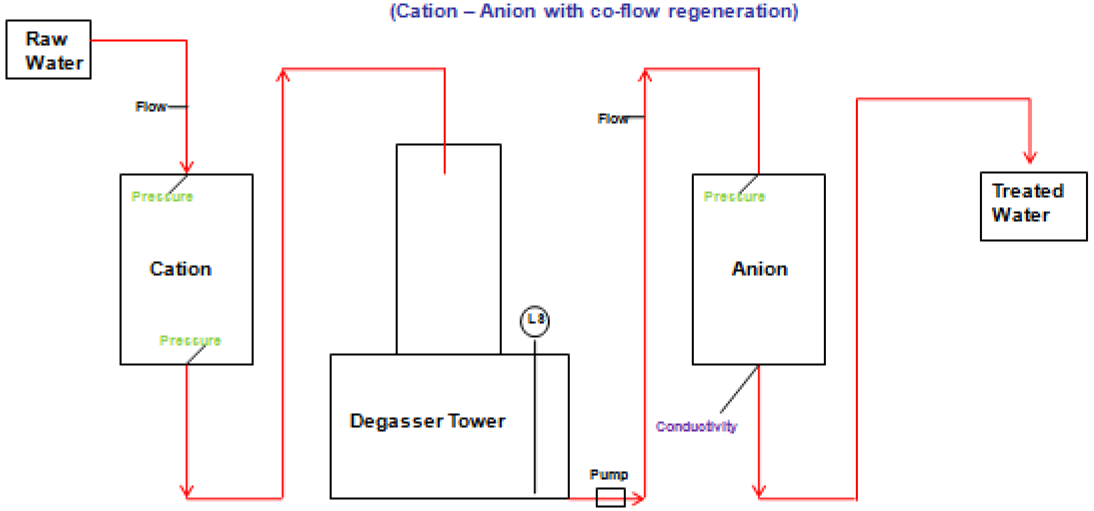
My views was that this was likely to be a cation issue with high sodium leakage resulting in sodium hydroxide leakage from anion. They would have seen high pH if checked through the run. Recommendation – double regeneration of cation before we investigated the problem. Double regen on cation immediately restored performance, there had been a previous faulty cation regeneration.

No need to replace anion resin and no need to strip vessel down!

Client had no silica measurement on plant so thought anion outlet conductivity measured anion performance.

Level of Instrumentation for Cation – Anion

(Cation – Anion with co-flow regeneration)



CASE STUDY – NO.2 Chemical Works in North East

(Example where client had not been thorough in his investigation)

Plant:	Multi-stream co flow regenerated cation – anion.
Problem:	Short capacity on one stream – deteriorating quite quickly but no significant increase in regen rinse times. Service run terminated on silica leakage which was higher than normal during service run. – other stream performing well.
Client Actions:	Client understood it was anion issue and not related to raw water change or chemical purity etc. as other streams were ok. Had given plant double regen but had seen only minor improvement.

They now approached Purolite for help.

CASE STUDY – NO.2

Purolite involvement:

This seemed to be a regeneration issue. Arranged site visit. Client rechecked and assured me the plant drew the chemical every time.

Purolite site visit

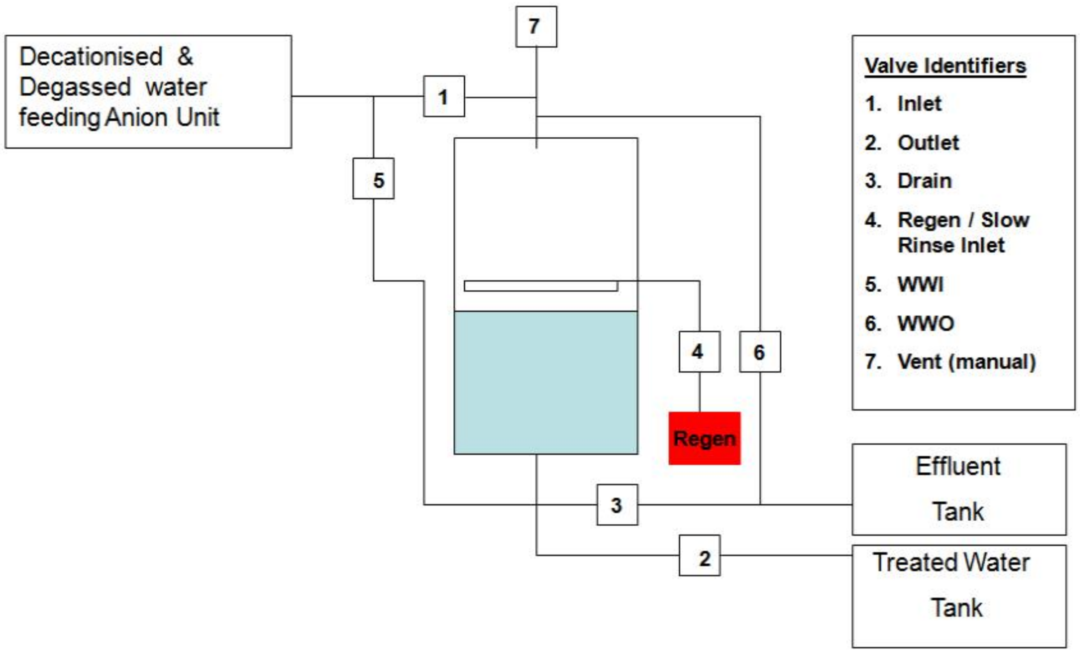
We arranged for a double regeneration comprising:

1. Backwash 2. Bed settle 3. Caustic injection (refill measure).
4. 2nd Caustic injection 5. Slow rinse 6. Fast rinse.

The 3 m diameter vessel only had one site glass at the top of the bed. Backwash stage started, we heard the pump start, we heard the air for valve actuation, but during the whole regeneration there was no resin movement in top site glass! For several weeks that this problem had been getting worse, the bed had never backwashed due to closed WWI valve. The bed was so compacted that the caustic did not flow uniformly through the bed = poor regen = poor capacity / high silica leakage.

Purolite Recommendation: Slow extended backwash followed by double regeneration which then restored performance.

Anion - Co-Flow Regeneration



CASE STUDY – NO.3 Steel Works in North East

(Not an obvious problem)

Plant: 2 stream co flow regenerated cation – anion - PMB.

Problem: Poor quality from anion for whole cycle with high conductivity.

– other stream performing well.

Client Actions: Had given plant double regen but no improvement.

They now approached Purolite for help.

CASE STUDY – NO.3

Purolite involvement:

This again at first glance appeared to be an anion regeneration issue but as client had claimed that the regeneration was working perfectly I asked for a demin water analysis after the anion to be obtained for my site visit and pH measurement.

Purolite site visit:

The client presented all the data he had on the regeneration cycle with chemical quantities, flow rates and a core resin sample from the bed for me to inspect in their lab and to take away for testing. They presented to me the demin water analysis obtained and pH which acidic through the almost all the service cycle.

The demin analysis of the anion treated water showed sulphate and chloride present, nitrate was not measured,

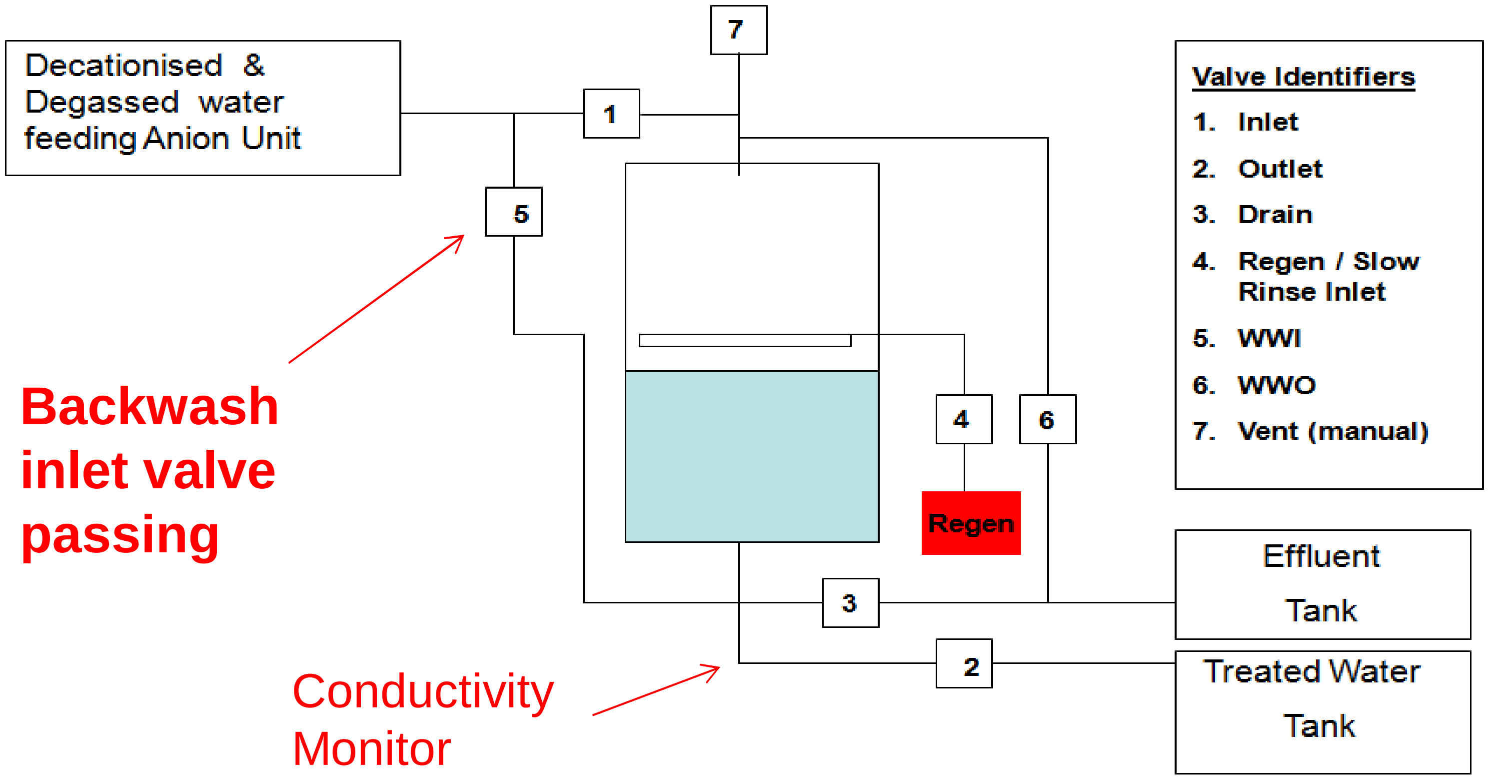
CASE STUDY – NO.3 Purolite Recommendation:

The significant **acid pH through the service cycle** suggested cation was working and this was an **anion issue**, the **presence of sulphate and chloride** which should be held by the resin suggested possible **bypass of anion bed** (Remember **earlier slide of ion selectivity**).

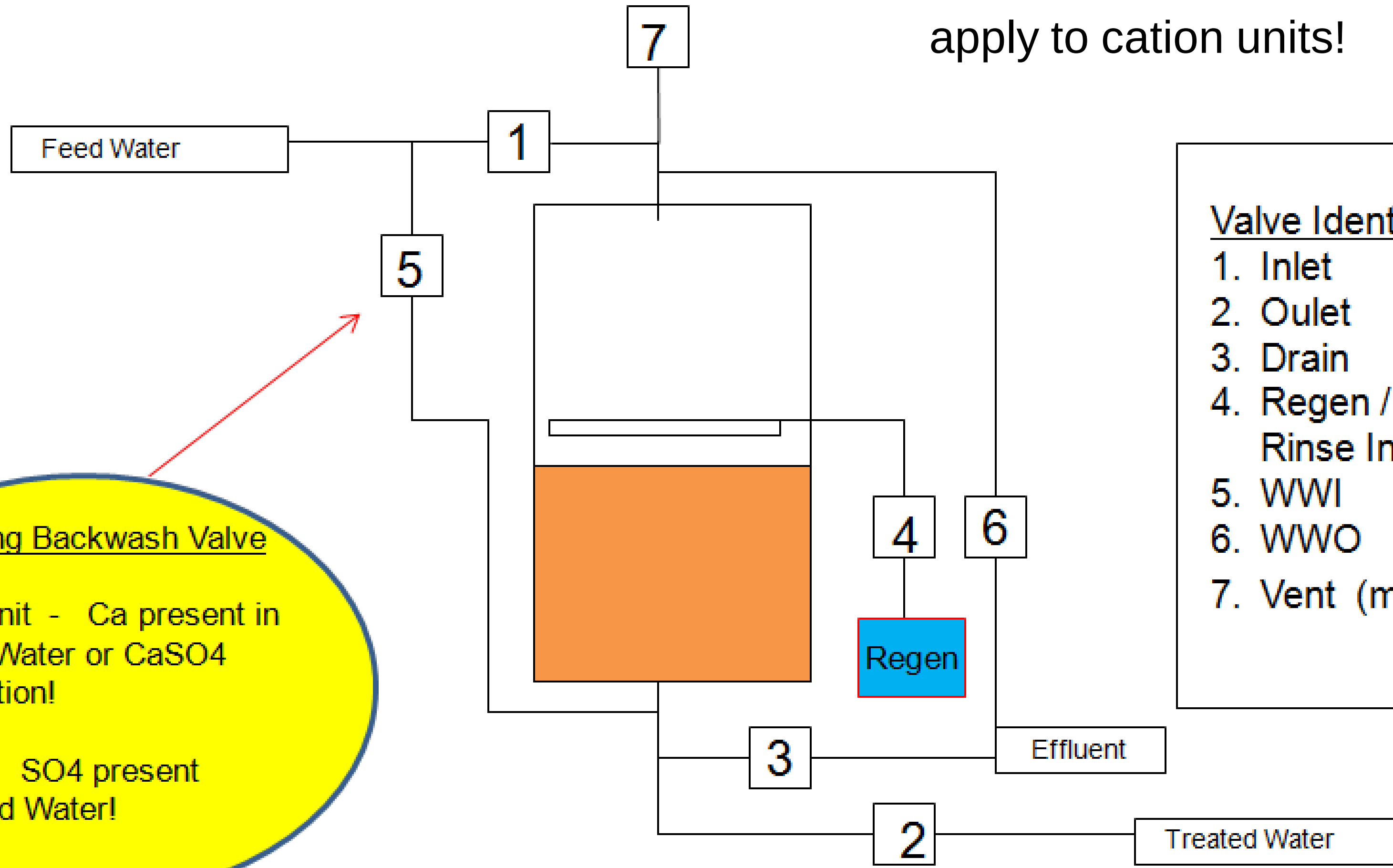
We went down to the plant and by just tapping the **backwash water inlet valve** you could cause the **conductivity to jump** on the monitor measuring anion outlet quality. - Clearly showing passing valve while in service. Small leak across valve was putting decationised water direct to anion outlet.

Valve replaced – problem solved.

Anion - Co-Flow Regeneration



This issue can also apply to cation units!



<u>Passing Backwash Valve</u>

Cation Unit - Ca present in Treated Water or $CaSO_4$ precipitation!

Anion - SO_4 present in Treated Water!

<u>Valve Identifiers</u>

1. Inlet
2. Oulet
3. Drain
4. Regen / Slow Rinse Inlet
5. WWI
6. WWO
7. Vent (manual)

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CASE STUDY – NO.4 Northern Power Station

(This one took some time to resolve)

Plant: Single stream and separate twin stream co flow regenerated cation – anion – PMB. (Single stream different size).

Problem: Poor capacity from cation – anion on single stream with premature silica breakthrough.

– twin stream plant performing as expected

Client Actions: Anion resin was quite old, it had been tested less than 12 months previously and reported as satisfactory. Client decided it a resin age issue and replaced the anion bed. No major improvement in capacity. Client suggested new resin was faulty! Purolite requested to investigate.

CASE STUDY – NO.4 Northern Power Station

During the next week we had the following checked:

1. Retained sample of batch and resin sample from site tested. No issues found.
2. Expected performance against current site water analysis. This showed site were correct, significantly low capacity on anion.
3. Site visit to check regeneration cycle in detail, amount of caustic applied, concentration of caustic correct etc. All were as per normal resin manufacturers recommendation for this raw water. Caustic regen level above 64 g/l and applied as a 4% concentration at less than 4 BV/h.
4. Checked that degasser tower fans were working and slide isolator was not closed in air ducting – all seemed OK

No problem could be found.

CASE STUDY – NO.4 Northern Power Station

More detailed analysis of exhausted resin sample suggested higher than expected CO_2 loading: **Could have been sampling issue.**

Out of Desperation we asked if we could revisit site to check the degasser performance.

Difficult site test inconsistent results – performed by one of lab managers: suggested CO_2 out of degasser was somewhere between 30 and 60 mg/l instead of the normal 5 mg/l.

Purolite Recommendation:

We asked site to change over degasser fans to the standby unit, if this did not work to inspect tower for blockage / broken internals.

CASE STUDY – NO.4 Northern Power Station

Capacity of stream immediately recovered.

Site inspection carried out by power station staff found that the air ducting that feeds the tower (in an area that could not be seen from the walkway) had a damaged flange – air was escaping from the fan they had in service and not entering the degasser tower.

No need to replace anion resin!

Clients first assumption was the new resin was faulty!

CASE STUDY – NO.5 Northern Power Station

Plant: 3 stream co flow regenerated cation – anion - PMB.

Problem: Poor quality from mixed bed for the whole cycle with high conductivity.

– other streams performing much better.

Client Actions: Had given plant double regen but no improvement.

They now approached Purolite for help and we arranged a site visit to see what we could establish as being the likely cause.

I spend more time watching Polishing Mixed Bed regenerations than anything else!

There are five main issues that result in poor mixed bed performance.

1. Inadequate backwash flow rate or time – leading to poor expansion of the bed and poor separation – cross contamination results on regeneration with acid on anion resin and sodium hydroxide on cation resin.
2. Interface located in the wrong position – cross contamination on regeneration.
3. Failure of slow rinse to clear resin components of regenerant before remixing – cross contamination when remixed.
4. Poor resin mixing due to incorrect drain down water level prior to remixing. Too little water and it will not mix. Too much water and a cation layer forms at bottom of the bed.

This is a very common fault!

5. Poor air mixing – blower / site air issue.

Occasionally we find:

6. Incorrect regen conditions – regeneration problem

CASE STUDY – NO.5 Northern Power Station

Plant Visit: By witnessing the regeneration and arranging for the chemist to take samples and test we established two three main problems.

Problem:

a. Inadequate backwash rate – cation resin not expended enough to release anion.

b. Conductivity at centre drain at the end of the slow rinse was over 3000 us/cm. **Why try to separate resins well if we are going to leave the resin full of regenerants.**

c. Too much water in column at end of air mix resulting in cation layer formed at base of the unit, leading to poor rinse / quality.

Proved by high sulphate & acid pH in rinse.

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CASE STUDY – NO.5 Northern Power Station

Actions Taken:

Backwash rates adjusted
Slow rinses extended
Drain down time extended

Good performance restored

CASE STUDY – NO.6 Southern Power Station

Plant problem: Another Polishing Mixed Bed Problem. New resin charge supplied which client could not achieve good water quality. Site had identified backwash separation problem.

Client Reported Faulty Resin! Site visit arranged.

Lab test on retained batches were OK.

Site Visit: Calculation of the backwash rate showed the right flow rate was being used for the vessel diameter and freeboard space available.

Backwash not only did not separate the resins, there was hardly any movement at all in the sight glass!

CASE STUDY – NO.6 Southern Power Station

Further questioning established they had replaced laterals with similar system when resin change was carried out

– **Problem suddenly seemed more obvious!**

We asked client to remove bulk of the resin from unit leaving the bottom laterals only slightly covered so we could watch the bottom system during backwash via the centre sight glass (torch placed at top sight glass to allow good visibility.

Header / laterals / holes were oversized. The total flow was only coming out the first third of the system opposite the sight glass. Poor distribution identified.

Client had engineering company replace bottom internals with correctly sized system – problem resolved.

CASE STUDY – NO.7 North West Site

Plant problem: Large demin plant where capacity of plant was falling very quickly between regenerations on all streams. Surface water of variable quality from local river. Plant also suffering from slowly increasing rinse times on anion.

Purolite assistance requested.

Purolite information requested.

1. pH exit anion towards end of service run.
2. Sodium level measured during extended rinse on anion.
3. Resin samples for analysis

CASE STUDY – NO.7 North West Site

Purolite Knowledge: Local sites treating river water with high TOC levels. (likely cause of rinse issue)

Local river has periods of high suspended solids.

Resin Tests: Confirmed anion resin suffering from organic fouling. Cation resin appeared to have polymer / solids adhered to resin sample taken from bottom resin sample point.

pH rose at exhaustion suggesting cation issue.

Site Inspection of worst performing stream showed:

Complete Failure of Pretreatment System.

Surface of cation covered with a mat made up coagulation chemicals/ polyelectrolyte and suspended solids. – Bed channeling!

CASE STUDY – NO.7 North West Site

Remedy:

1. Improve pretreatment
2. Bed drained completely
3. Chemical/solids mat cut up and removed by hand.
4. Top 600 mm of resin removed and thrown away.
5. Extensive prolonged backwash and air scour of remaining bed. Once cleaned to acceptable level.
6. Replacement of top 600 mm with new cation resin.
7. Caustic brine wash treatment on anion.
8. Double regeneration of plant

PERFORMANCE IMPROVED

Client continued to have pretreatment problems, but later they developed a **chemical treatment** when polymer fouled the bed

CASE STUDY – NO.8 Not site specific – so many examples!

Biggest problem encountered on UK plants are:

1. Oxidative attack by chlorine and the increasing use of Chlorine Dioxide which most companies do not realise is a stronger oxidising agent.
2. Organic fouling
3. Modern Packed Bed Designs with Counter Flow Regeneration

    1. Failure to understand the velocities (flow rates) required to keep the bulk of the bed stationary in up flow operation.
    2. The importance of understanding how resin volumes change between regenerated and exhausted forms & understanding how a small loss of resin can be critical.
    3. Failure to include external backwash facilities and to include adequate pretreatment.

I am from the old school that believes suspended solids on to packed beds should be avoided but not everyone agrees!

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