



Reducing Chemicals in Water Demineralization Systems

TUR Process Characterization And Options Review

Some practical experience



Berkshire Environmental Consultants, Inc. Maura Hawkins

Water Demineralization Systems:

What we will cover

- Why Demineralize?
- Demineralizer Systems in power plants
- The Basics of Cation/Anion Demineralization Systems
- Chemical use
- Process Characterization
- Options

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Water Contaminants

Water Contaminants

All natural waters contain varying amounts of suspended and dissolved solids and gases

- ✓ Salts and minerals
- ✓ Ca, Mg, Fe, Al, Silica, silt, oil etc.
- ✓ Organics and VOCs
- ✓ Bacteria, minerals, charged ions, pharmaceuticals, caffeine, fertilizers, cleaning agents, debris or
- ✓ Anything else naturally or man-made

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Water Treatment Systems

How is water treated?

To remove the impurities in the water, water needs to be treated. The treatment system can depend on the use of the water.

- ✓ Filtration
- ✓ Coagulation
- ✓ Clarification
- ✓ Neutralization
- ✓ Deaeration
- ✓ Ion removal including distillation, ion exchange, precipitation and separation and membrane separation

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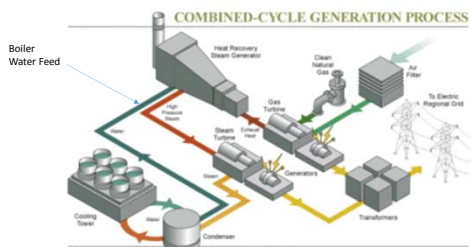
Water Treatment Systems

Who uses demin water?

- Lab applications, testing and hospitals
- Electronics manufacturers
- Manufacturers – rinsing, spraying, washing
- Laser cutting
- Steam applications
- Pharmaceutical manufacturing
- Cosmetics
- High-pressure boiler water feed

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Power Plants - Large Demineralized Water Users



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Demineralization Systems

Impurities and their Treatment			
Impurity	Resulting in	Treatment	
Soluble Gases	H ₂ S	Corrosion of boiler tubes	Aeration, deaeration and chemical treatment
	O ₂		
Suspended solids	CO ₂	Sludge and scale carryover	Clarification, filtration and chemical treatment
	Sediment and turbidity		
Dissolved solid/total solids	Organic matter	Carryover, foaming and corrosion	
	Oil and grease	Foaming, deposition	Coagulation, filtration
Hardness Ca & Mg	Scaling, erodes HT boiler tube	Softening and internal treatment	
	Turn thru		
Na, Alkalinity Na ₂ CO ₃	Foaming, corrosion, embrittlement	Ion exchange, deionization	
	Sulphates	Hard scales if Ca present	Deionization
Chlorides	Pitting, staining	Deionization	
Fe, Mn	Rusting, resistance to HT	Aeration, filtration, ion exchange	
Silica	Scaling	Deionization, lime-soda process	

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Water Treatment Systems

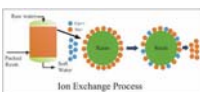
What is demin water?

Water in its purest form consists of Hydrogen (H+) and Hydroxyl (OH-) ions, which combine to create H₂O. When considering a water's purity, anything found in water other than the Hydrogen and Hydroxyl ions, are an impurity.

The process of deionization exchanges all of the charged ions found in water for Hydrogen and Hydroxyl ions. This process helps to form the water molecule, H₂O. The deionization or ion exchange process results in a true water "blank".

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Demineralization Systems



Deionization entails removal of undesirable electrically charged (ionized) dissolved substances by binding them to positively or negatively charged sites on a resin as the water passes through a column or columns packed with this resin in a process called [ion exchange](#).

These systems are often two or three vessels - one containing a cation-exchange resin in the hydrogen (H+) form, the other containing an anion resin in the hydroxyl (OH-) form and a mixed bed containing both. Water flows through the cation column, where all the cations are exchanged for hydrogen ions. The water then flows through the anion column where all the negatively charged ions are exchanged for hydroxide ions which then combine with the hydrogen ions to form water (H₂O). Some systems have a third mixed bed for polishing.

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Demineralization Systems – Regeneration

- Regeneration carried out using a strong acid for the cation (as a source of hydronium ions) and liquid caustic (sodium hydroxide) as a source of hydroxyl ions for the anion.
- Resin is regenerated using **sulfuric acid** and **sodium hydroxide** (caustic) to regenerate the cation and anion respectively.
- First the resin is backwashed with water to fluff the resin and wash out any entrained particles.
- The system draws a set amount of regenerant chemical for a specified period of time and at a specified flowrate.
- Finished by a slow and fast rinse.

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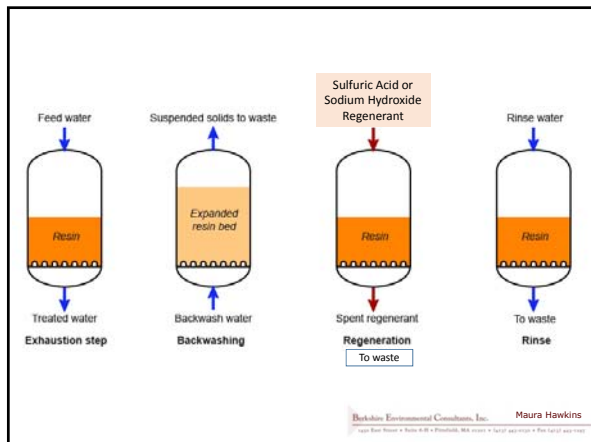
Demineralization Systems

Power plants generally have at least two demineralizer trains. One train is in service while the other is regenerating.

Prior to entering the demineralizer train:

- Raw water is passed through a dual media filter to removed suspended solids and reduce turbidity.
- Filtered water is directed to a large water storage tank.
- Water for steam cycle makeup is drawn from this tank and passed through an activated carbon filter to remove dissolved gases.

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Demineralization Systems and TUR

PFD

Applying
TUR

Unit of Product = MW

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TUR Option ID and Evaluation

For each toxic in the production unit:

Identify

Eliminate Options

- Technically infeasible
- Not TUR

Evaluate

Evaluate Remaining Options

- Technical evaluation
- Hazard evaluation
- Economic evaluation

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Demineralization Systems and TUR

TUR
Options

TUR Options by Category for Ion Exchange Demineralizers

INPUT SUBSTITUTION:

- No good options here
- Chemistry is chemistry – you need the regenerant
- Could use HCl instead of sulfuric for cation regeneration, but this is not common and has issues

PRODUCT REFORMULATION:

- No good options here
- Product is either gallons of water demineralized or MW

IN-PROCESS (INTEGRAL) RECYCLING OR REUSE

- No good options here

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Demineralization Systems and TUR

TUR
Options

TUR Options by Category

PRODUCTION UNIT MODIFICATION:

There are other ways to demineralize water instead of onsite ion exchange systems

- Off-site ion exchange systems – use a trailer on site and send beds offsite for regen.
- Purchase demineralized water – vendor supplied system.
- Reverse osmosis systems - force water through a semi-permeable membrane to filter water.
- Electrodeionization (EDI) - uses an electric field to remove ions and polar species from an aqueous stream. EDI is often used with reverse osmosis to replace ion exchange resin-mixed beds, which require onsite or offsite chemical regeneration.


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Demineralization Systems and TUR


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TUR Options by Category

PRODUCTION UNIT MODIFICATION (CONT.):

Change the water source – use more city/municipal water instead of ground water, surface water, POTW discharge or process wastewater 

Add Equipment to Pretreat Raw Water

- ✓ Soften and/or dealkalize via ion exchange which use a salt solution (NaCl) for regeneration 
- ✓ Filters to remove particulates and other impurities
- ✓ Decarbonator to remove CO2 prior to the anion bed
- ✓ Carbon filter to remove chlorine, organics and particles

- Combine Pre-treatment Systems and Replacement Systems

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Demineralization Systems and TUR

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TUR Options by Category:

PRODUCTION UNIT MODERNIZATION

- Replace resin with newer more efficient resins

IMPROVED OPERATIONS AND MAINTENANCE

- Optimize the operation of the resin beds
- Reduce the amount of makeup water needed by improving condensate return or producing less export steam
- Extensive valve and vent leak repair; install steam traps
- Reduce the frequency and amount of regens
- Install a conductivity probe on the demin inlet to assist in optimizing the performance of the system
- Meter regenerants

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Demineralization Systems and TUR

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Economic Evaluation

- Evaluate Cost based on \$\$/1000 gal demineralized
- Major factors are
 - ✓ Cost of Chemical – can swing up and down yr. to yr.
 - ✓ Source and Cost of Water – city water costs more
 - ✓ Resin Quality and Life – higher quality \$\$
 - ✓ Average Maintenance Costs
 - ✓ Amount of Run Time – If capacity factors are low, less incentive (big issue in power markets)
 - ✓ Ongoing Capital Expenditures – can be high to keep an old system running

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Challenges

- Getting the process down and understanding all the parts of the site specific plant steam cycle
- Getting good numbers and calculations
- Making predictable estimates of ROI
- Aging systems and maintenance costs
- Unpredictable plant run time
- The changing power markets
- The reality that things change

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Demineralization Systems and TUR

Next year is a planning year. I hope you get all your credits!

Thank You

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