The Effects of Water Quality on Metalworking Fluids and Manufacturing Processes

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Overview

1. Understanding Metalworking Fluid Failure and Water Interaction

2. Corrective Actions

3. Summary

What Causes a Fluid to Fail?

Why Does This

Turn Into This Over Time ?

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What Causes a Fluid to Fail?

Five Key Failure Mechanisms Acting On The Fluid

Basic Failure Mechanisms

- FM 1 Cation Loading
  - » Metals being machined
  - » Metals from “hard water” ←
- FM 2 Anion Loading ←
- FM 3 Bacteria Deterioration
- FM 4 Tramp Oil Infiltration
- FM5 Lack of pH Control

Can the Rate of Failure of Metalworking Fluids be Modified?

1 Week

Can the Rate of Failure of Metalworking Fluids be Modified?

15 weeks

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After 15 Weeks

No Control

Some Control

Biocide + Filter

Best Control

Biocide + Filter + pH + RO water

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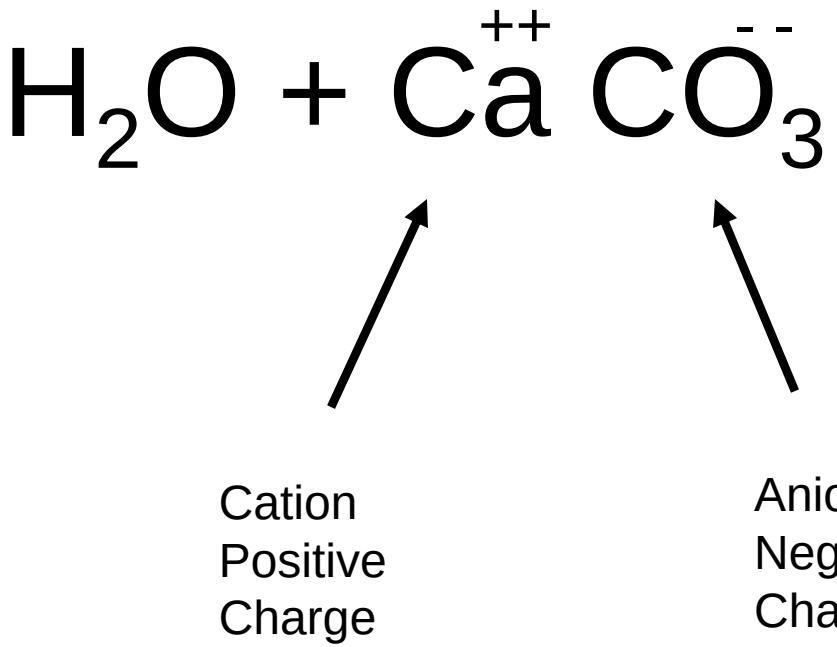
Low water Quality Effects on Parts and Production

- Emulsion Failure – Tool Life - **$$$**
- Residues – Sticky / Gummy/ Substrate for Biofilms
- Odors – Biological
- Water Spots – Appearance – Scrap - **$$$**
- Corrosion – Parts and Machinery
- Poor Mixing - **$$$ -** Increase Filter Media Use - **$$$**
- Increase Consumption of MWF - **$$$**
- Increased Mist **– Potential OSHA Issue**

Water Basics

- Hard Water



Failure Mechanism #1 Cation Loading- Water

The Battle of the Cations

Potassium	K^{+}	
Sodium	Na^{+}	
Calcium	Ca^{++}	
Magnesium	Mg^{++}	
Iron Ferrous	Fe^{++}	
Iron Ferric	Fe^{+++}	

Why Fluids Fail

Three Basic Water Reducible MRF Formulations

Emulsifiable Oil (Soluble Oil)	**Oil + Anionic Soap + Rust Preventative + Coupling Agent + Biocide + Buffer**
Semi-Synthetic	**Oil + Synthetic Component + Anionic Soap + Coupling Agent + Rust Preventative + Buffer + Biocide**
Synthetic	**Synthetic Component + Fatty Acid + Anionic Wetting Agent + Rust Preventative + Buffer + Biocide**

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Why Fluids Fail

Highlighted areas
Are negatively charged

Three Basic Water Reducible MRF Formulations

Emulsifiable Oil (Soluble Oil)	***Oil* + Anionic Soap + Rust Preventative + *Coupling Agent* + *Biocide* + *Buffer***
Semi-Synthetic	***Oil* + *Synthetic Component* + Anionic Soap + *Coupling Agent* + Rust Preventative + *Buffer* + *Biocide***
Synthetic	***Synthetic Component* + Fatty Acid + Anionic Wetting Agent + Rust Preventative + *Buffer* + *Biocide***

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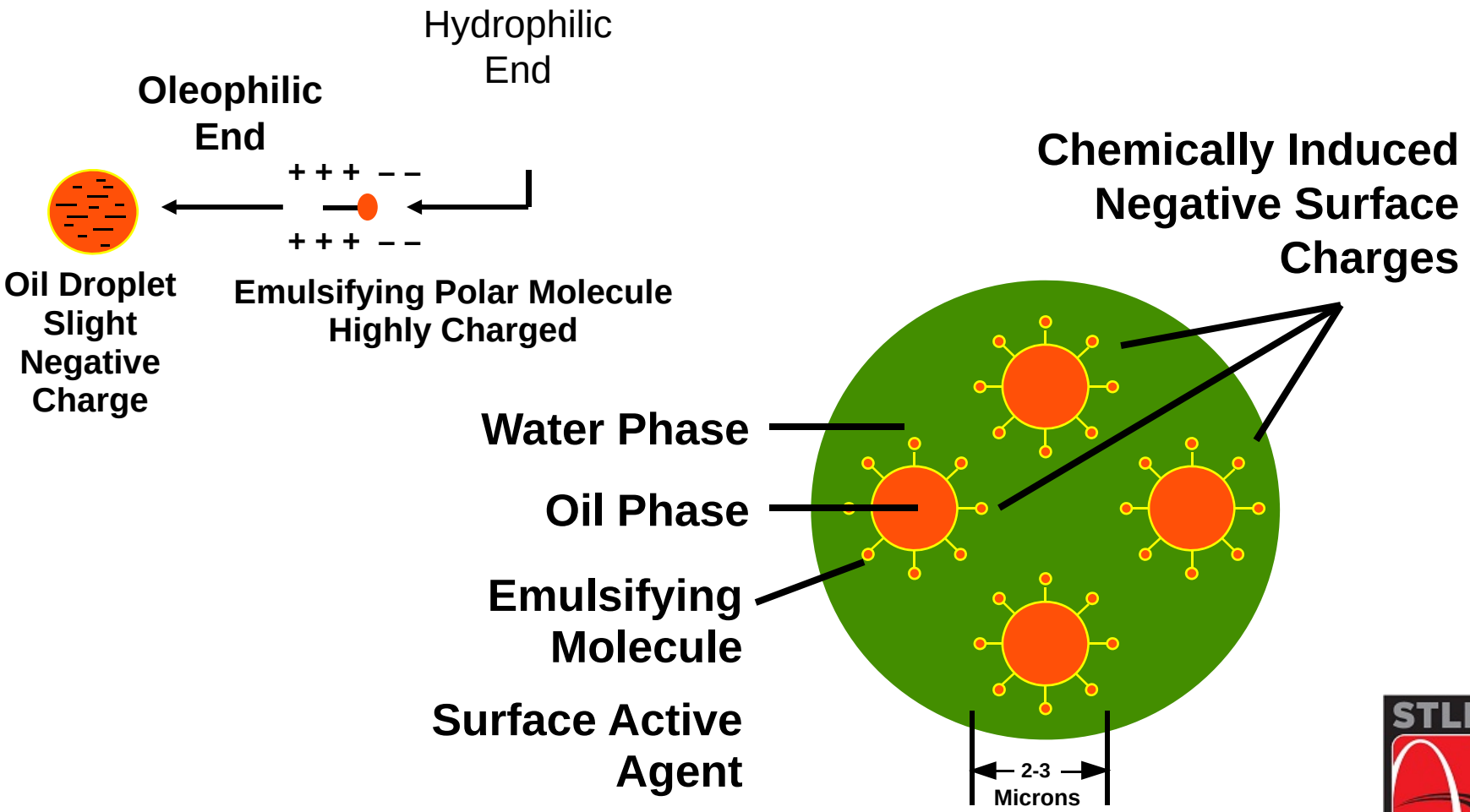
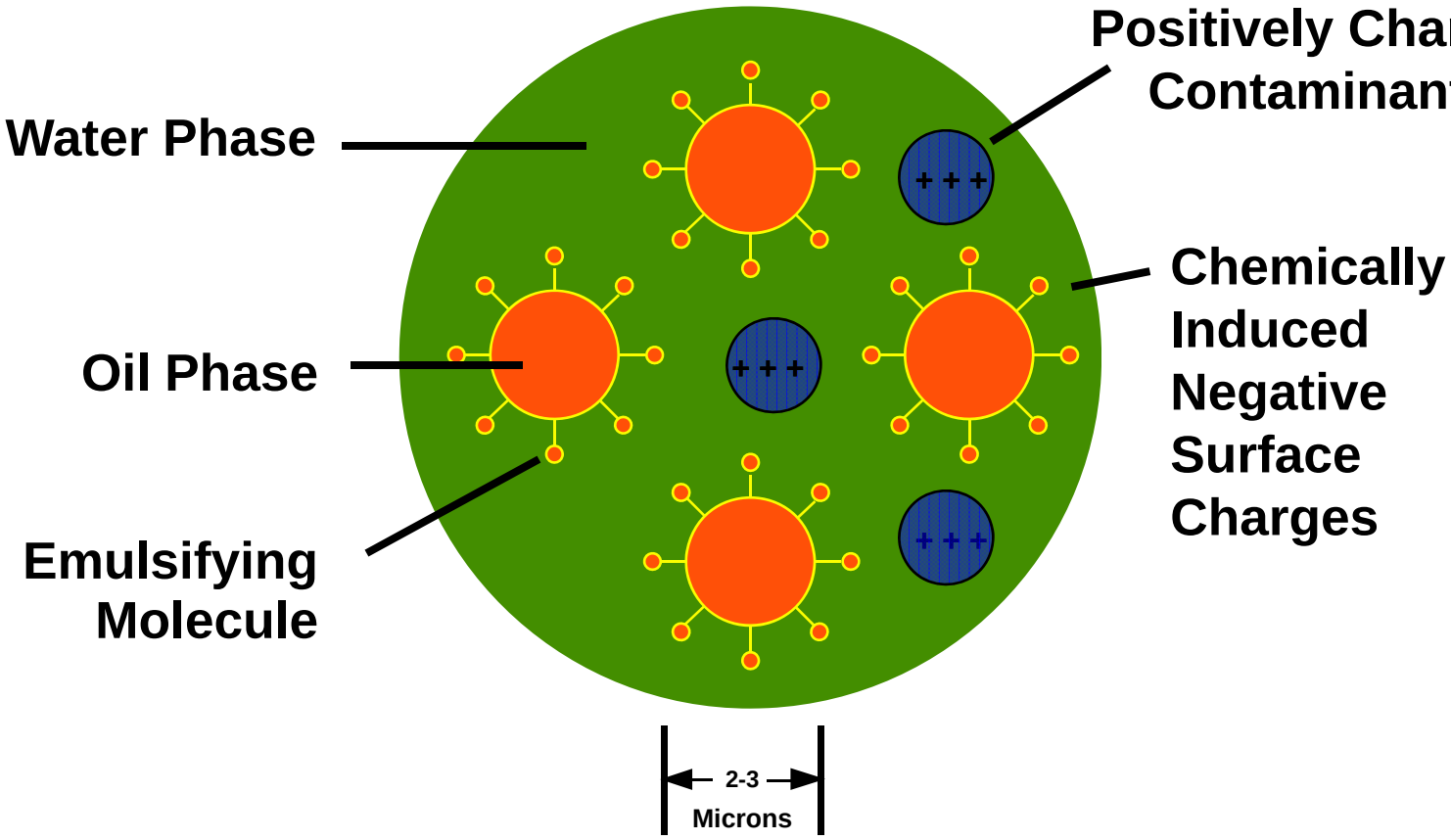
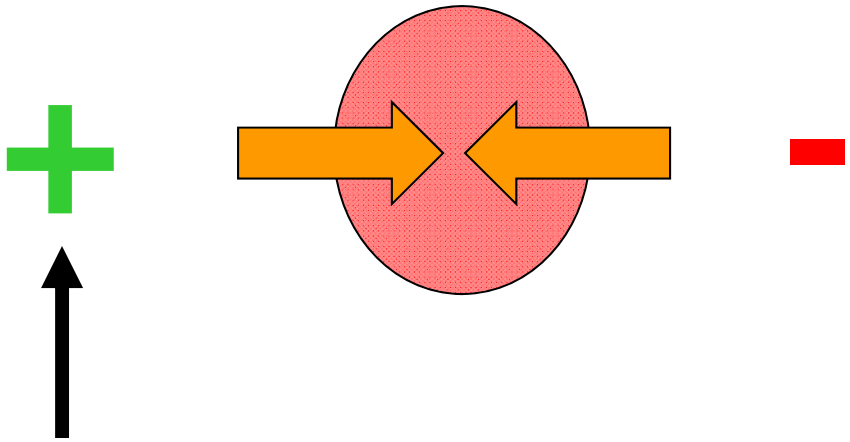
Typical Emulsified Oil MWF Schematic



Typical Emulsified Oil MRF Schematic
On the Road to Failure

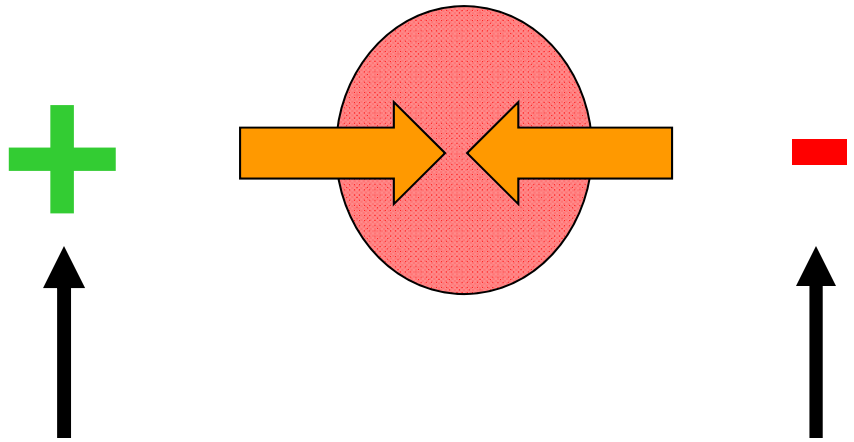


It’s Mainly About Plusses and Minuses



One Group of
Failure Mechanisms Is
Positively Charged

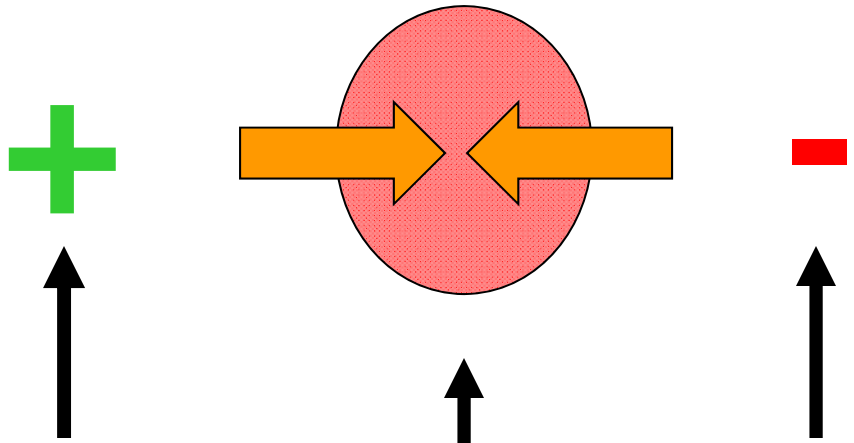
It’s Mainly About Plusses and Minuses



One Group of
Failure Mechanisms is
Positively Charged

Key Components of
A MRF Are
Negatively Charged

Its is Mainly About Plusses and Minuses



One group of
Failures Mechanisms are
Positively Charged

Key Components of
A MRF are
Negatively Charged

When the two groups come together,
MRF failure begins

The Effects of Hard Water

Key Point:

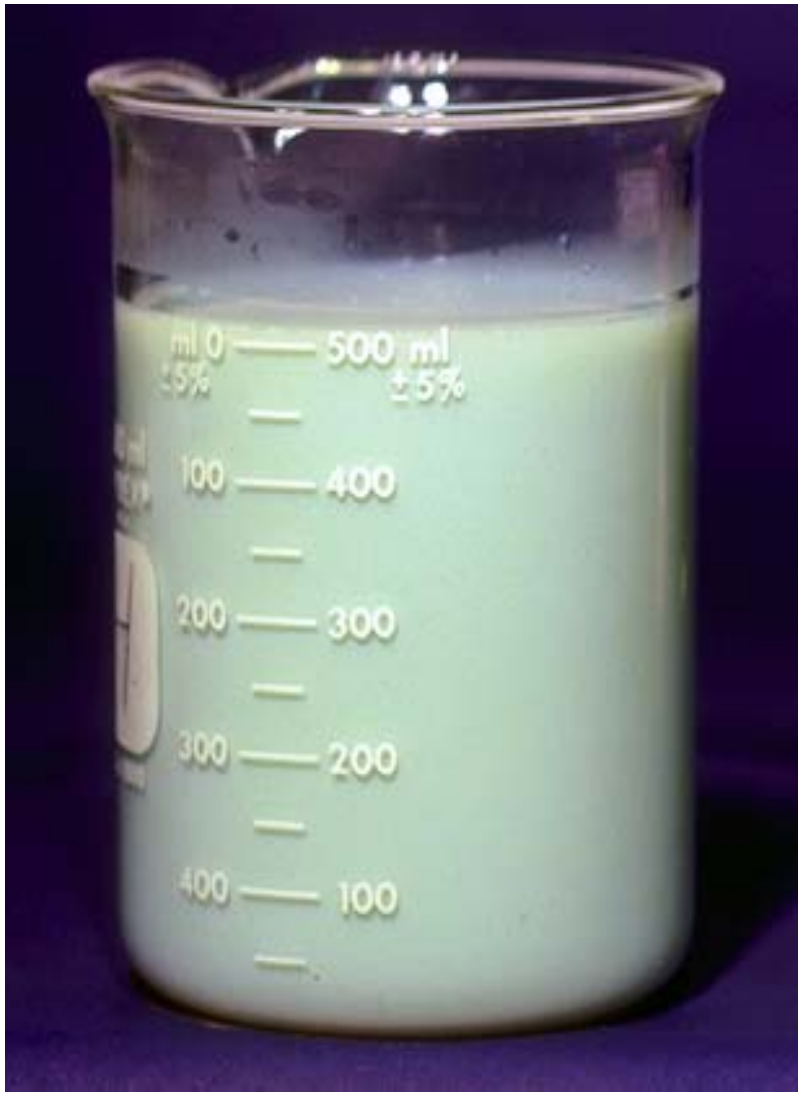
- **The reaction of hard water to de-stabilize a MRF occurs very rapidly**
- **Usually in seconds**

Failure Mechanism - Water

Amount of water entering the system per day

- **It not just about how hard the water is**
- **It is also about how much you use**

Failure Mechanism - Water



- Premium emulsified oil
- 5 % V/V
- Cleveland tap
- 1 concentration cycle

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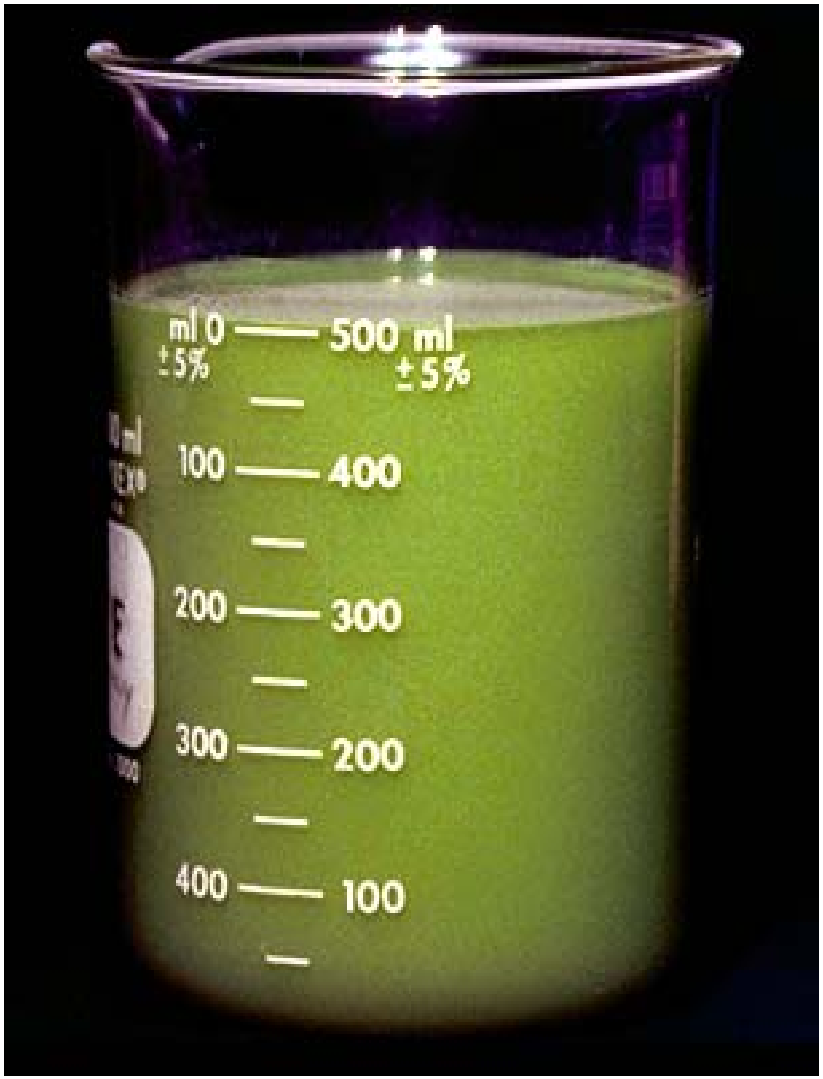
Failure Mechanism - Water



- Premium emulsified oil
- 5 % V/V
- Cleveland tap
- 5 concentration cycles

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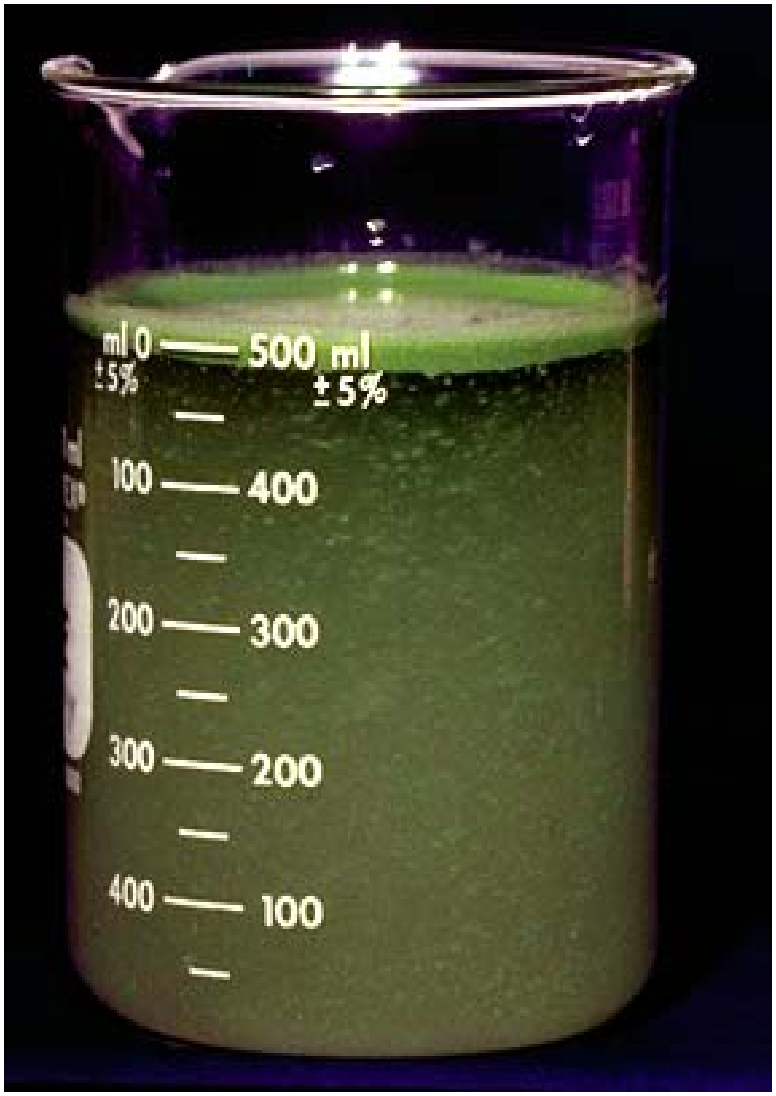
Failure Mechanism - Water



- Premium emulsified oil
- 5 % V/V
- Cleveland tap
- 10 concentration cycles

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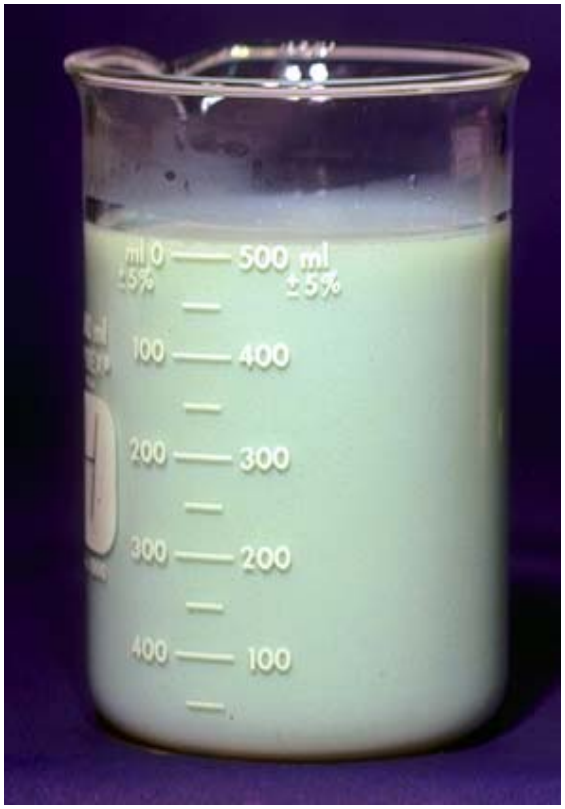
Failure Mechanism - Water

Premium Emulsified Oil
Effects of Evaporation and Hard Water (Cleveland Tap)



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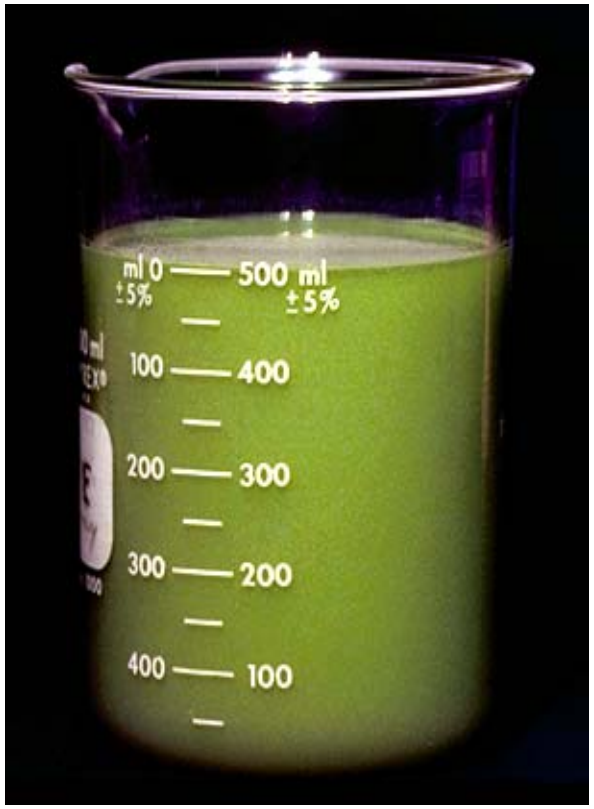

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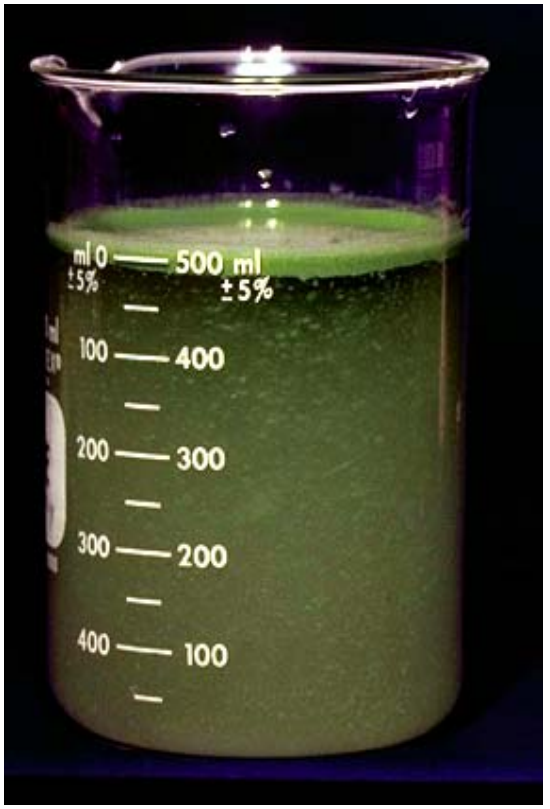

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What are Areas of Concern When Using This Water ?

CANTON WATER DEPARTMENT, WATER ANALYSIS - 2003

INORGANIC CONTAMINANTS	DATE SAMPLED	SAMPLING FREQUENCY	NORTHEAST WATER PLANT	NORTHWEST WATER PLANT	SUGARCREEK WATER PLANT
ALKALINITY, mg/l AS CaCO3	Avg. 02	MONTHLY	238	288	201
ALKALINITY STABILITY, mg/l AS CaCO3	Avg. 02	MONTHLY	236	276	186
ASBESTOS, fibers >10um length/l	9-1-95	NA	<200,000	<200,000	<200,000
CALCIUM TOTAL, mg/l as CaCO3	2-25-98	NA	358	369	270
CHLORIDE, mg/l	Avg. 96	MONTHLY	90	90	32
CHLORINE, FREE, mg/l, Daily Min.	Avg. 02	DAILY	0.9	0.9	0.9
CYANIDE TOTAL, as (CN) mg/l	9-18-95	NA	<0.005	<0.005	<0.005
FLUORIDE, mg/l	Avg. 02	DAILY	1.1	1.0	1.1
TOTAL HARDNESS, mg/l as CaCO3	Avg. 02	MONTHLY	406	475	369
TOTAL HARDNESS, grains per gal.	Avg. 02	MONTHLY	24	28	22
MAGNESIUM TOTAL, mg/l as CaCO3	2-25-98	NA	116	119	91
NITRATE, mg/l NO3 as N	9-16-02	NA	<0.1	<0.1	<0.1
NITRITE, mg/l NO2 as N	7-28-98	NA	<0.1	<0.1	<0.1
pH	Avg. 02	WEEKLY	7.1	7.1	7.6
TURBIDITY, NTU	Avg. 02	WEEKLY	0.06	0.18	0.14
ANTIMONY ug/l	9-12-01	EVERY 3 YRS	<3.0	<3.0	<3.0
ARSENIC ug/l	9-12-01	EVERY 3 YRS	<3.0	<3.0	<3.0
BARIUM ug/l	12-9-96	NA	<300	<300	<300
BERYLLIUM ug/l	9-12-01	EVERY 3 YRS	<.5	<.5	<.5
CADMIUM ug/l	12-9-96	NA	<1.0	<1.0	<1.0
CHROMIUM ug/l	12-9-96	NA	<10.0	<10.0	<10.0
COPPER ug/l	12-9-96	NA	<50	<50	<50
IRON mg/l	Avg. 02	WEEKLY	0.032	0.070	0.035
LEAD ug/l	12-9-96	NA	<1	<1	<1
MANGANESE mg/l	Avg. 02	WEEKLY	0.030	0.031	0.030
MERCURY ug/l	12-9-96	NA	<0.5	<0.5	<0.5
NICKEL ug/l	9-12-01	EVERY 3 YRS	<10.0	<10.0	<10.0
SELENIUM ug/l	12-9-96	NA	<5	<5	<5
SILVER ug/l	9-18-95	NA	<0.8	<0.8	<0.8
SODIUM mg/l	Avg. 99	NA	44	55	15
THALLIUM ug/l	9-12-01	EVERY 3 YRS	<1.0	<1.0	<1.0
TOTAL TRIHALOMETHANES ug/l	Avg. 02	Qrtly	16.7	13.2	22.6
ZINC mg/l	12-9-98	NA	<0.02	<0.02	<0.02

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Water Quality Report Canton Ohio

Inorganic Contaminant	Date Sampled	Sampling Frequency	North Well Field	West Well Field	South Well Field
Calcium	January 2006	Monthly	358	369	270
Hardness	January 2006	Quarterly	408	475	369
Magnesium	January 2006	Quarterly	115	119	91
Sodium	January 2006	Monthly	44	55	15
Chloride	January 2006	Monthly	90	90	32

Water Quality Report Canton Ohio

Three Water Sources

Inorganic Contaminant	Date Sampled	Sampling Frequency	North Well Field	West Well Field	South Well Field
Calcium	January 2006	Monthly	358	369	270
Hardness	January 2006	Quarterly	408	475	369
Magnesium	January 2006	Quarterly	115	119	91
Sodium	January 2006	Monthly	44	55	15
Chloride	January 2006	Monthly	90	90	32

Water Quality Report Canton Ohio

Significant Variation Between Water Sources

Inorganic Contaminant	Date Sampled	Sampling Frequency	North Well Field	West Well Field	South Well Field
Calcium	January 2006	Monthly	358	369	270
Hardness	January 2006	Quarterly	408	475	369
Magnesium	January 2006	Quarterly	115	119	91
Sodium	January 2006	Monthly	44	55	15
Chloride	January 2006	Monthly	90	90	32

Significant Cation Load

Water Quality Report Canton Ohio

Inorganic Contaminant	Date Sampled	Sampling Frequency	North Well Field	West Well Field	South Well Field
Calcium	January 2006	Monthly	358	369	270
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Failure Mechanism - Water

- Is one water analysis all I need to make further decisions about my water concerns?

No:

Most water sources vary considerably

Seasonally

Sometimes even hourly

Exception:

Water from the Great Lakes does not vary considerably

Failure Mechanism #2 – Anion Loading

Those Nasty Anions

Enemy # 1	**Chloride**	**Cl^-**	**=**	**Corrosion**
	Sulfate	**SO_4**	**=**	**Food**
	Phosphate	**PO_4**	**=**	**Food**
	Nitrate, Nitrite	**NO_3, NO_2**	**=**	**Food, Nitrosamines**
	Carbonate	**CO_3**	**=**	**Nil Effect**

Remember: For every cation there is a corresponding anion

Ca is usually expressed as hardness as $CaCO_3$
(can be misleading depending on test method)

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Nasty Anion

Water Quality Report Canton Ohio

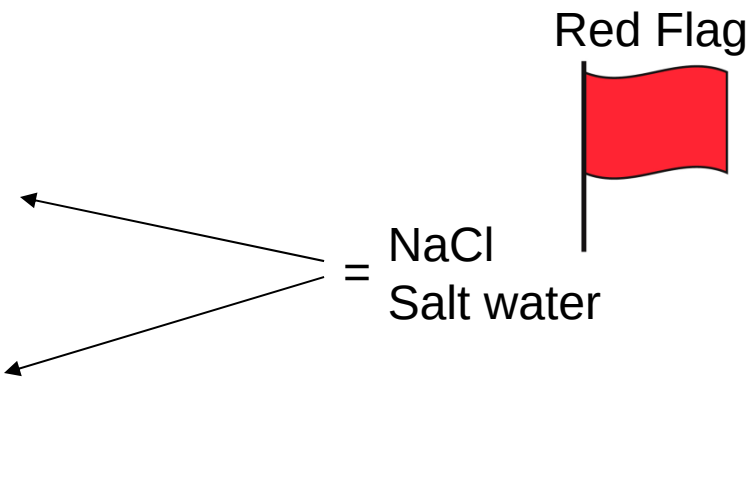
Salt Water

Inorganic Contaminant	Date Sampled	Sampling Frequency	North Well Field	West Well Field	South Well Field
Calcium	January 2006	Monthly	358	369	270
Hardness	January 2006	Quarterly	408	475	369
Magnesium	January 2006	Quarterly	115	119	91
Sodium	January 2006	Monthly	44	55	15
Chloride	January 2006	Monthly	90	90	32

RESULTS OF ANALYSIS:
Stafford TX

All results are in milligrams per liter

Element	Amount
Calcium	17
Magnesium	4
Iron	ND
Sodium	100
Potassium	1
Sulfur	5
Chlorine	55
Phosphorus	ND



Failure Mechanism - Water

Soft water is **NOT** OK for use in MWF

Hard Water $H_2O + CaCO_3$ ⟶

True Sodium “Softened” Water $H_2O + Na_2CO_3 + Cl$

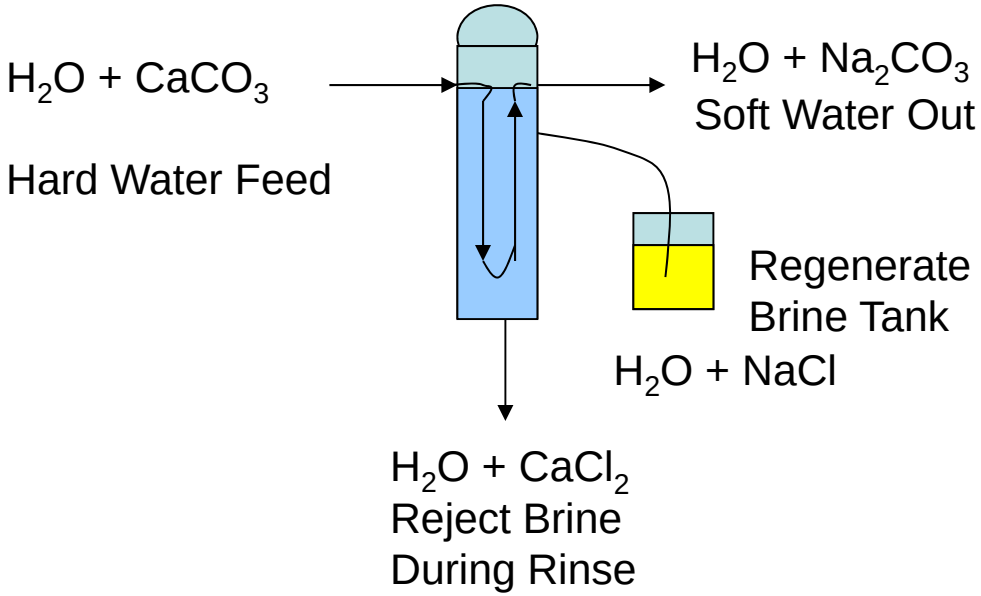
Two Potential Issues with Sodium Softened Water

1. Increase in TDS
2. Potential for chloride corrosion

Hey, Where did the chloride ion come from???

Failure Mechanism - Water

Traditional Water Softener



Before and After Water Softening

Tap Water with
0.25 mg/L Fe
220 as Ca
One liter evaporated

Tap Water after Softening
0.02 mg/L Fe
3 mg/L as Ca
One liter evaporated

Failure Mechanism – Water

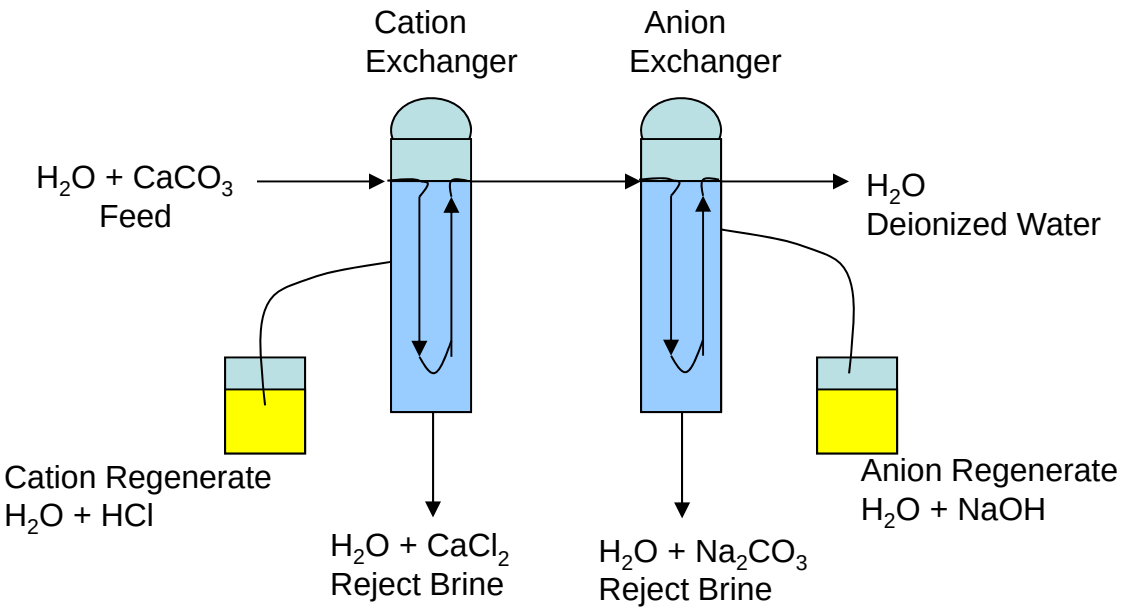
Chloride corrosion = RUST

Failure Mechanism - Water

Rain Water or Air Conditioning Condensate is **NOT** OK for MWF?

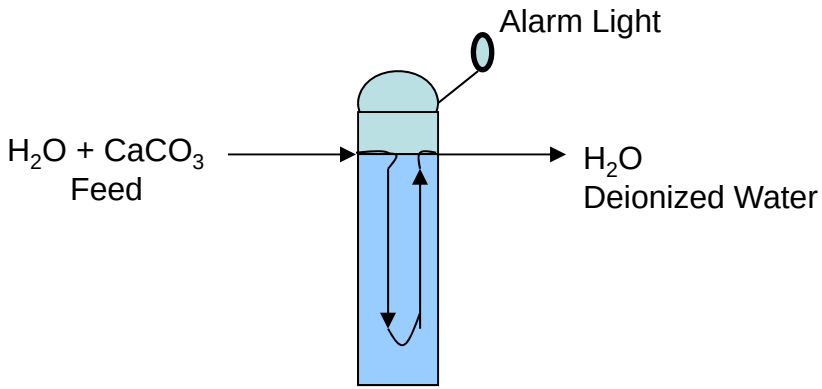
While the rain water may be low in hardness, when it hits the roof or air conditioning coils, it is full of dirt and bacteria

Traditional Dual Bed DI System

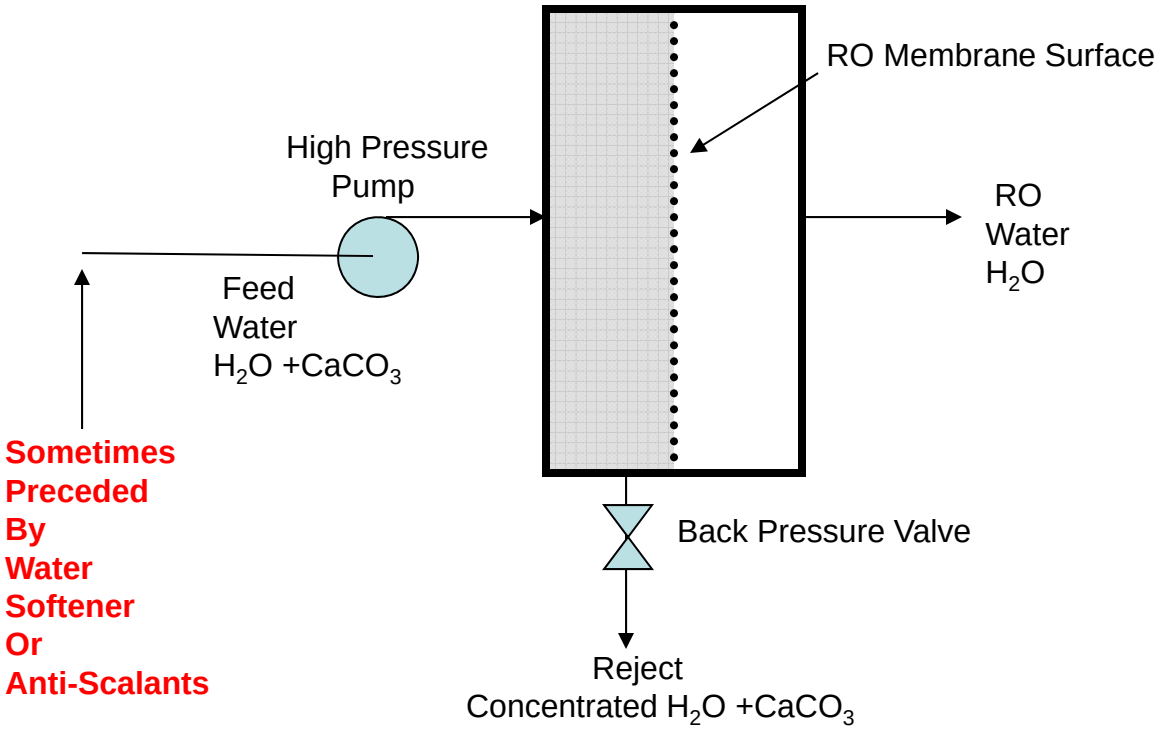


Mixed Bed – Service Exchange - DI

An economical method to make pure water for small shops



RO Water System



All Water Conditioning Systems Can Fail

1. They can actually produce worse water than what you started with.

2. They can confuse you thinking you have treated water when you do not.

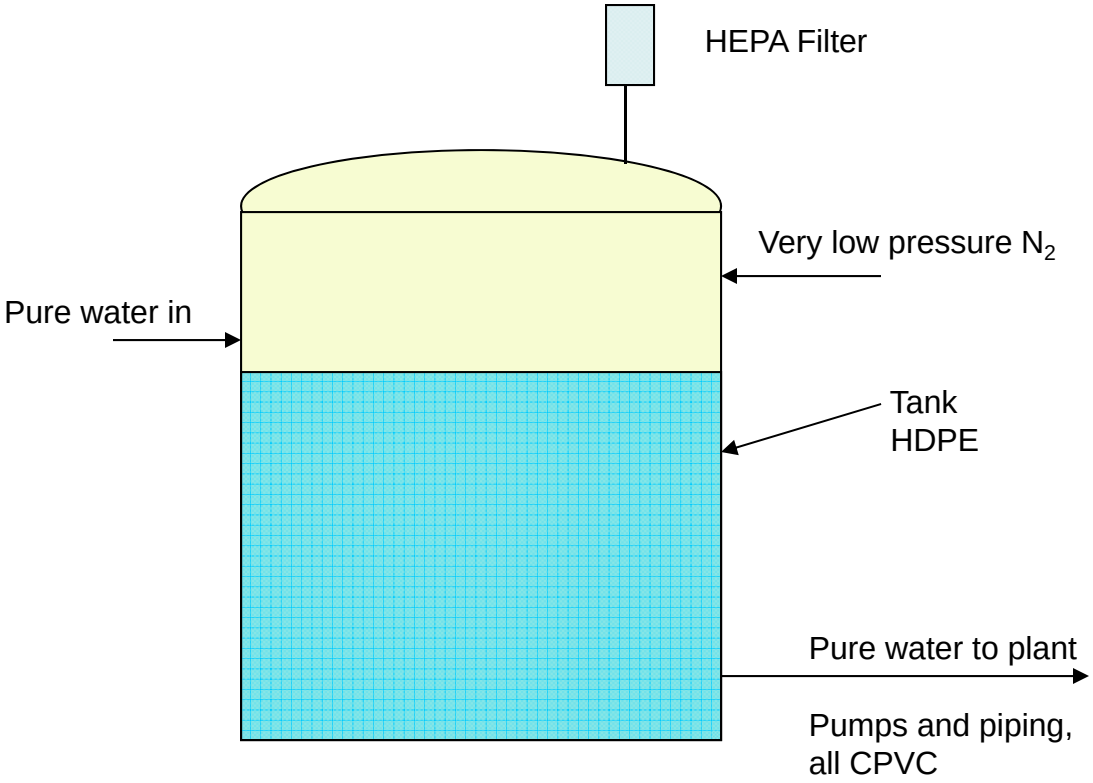
3. They can fail intermittently, and / or without warning

4. A word to the wise:

    a. Never totally trust a water purification device

5. When using a water treatment device, monitor output water quality **DAILY**

Pure Water Storage Is Critical



Hardness Reversal

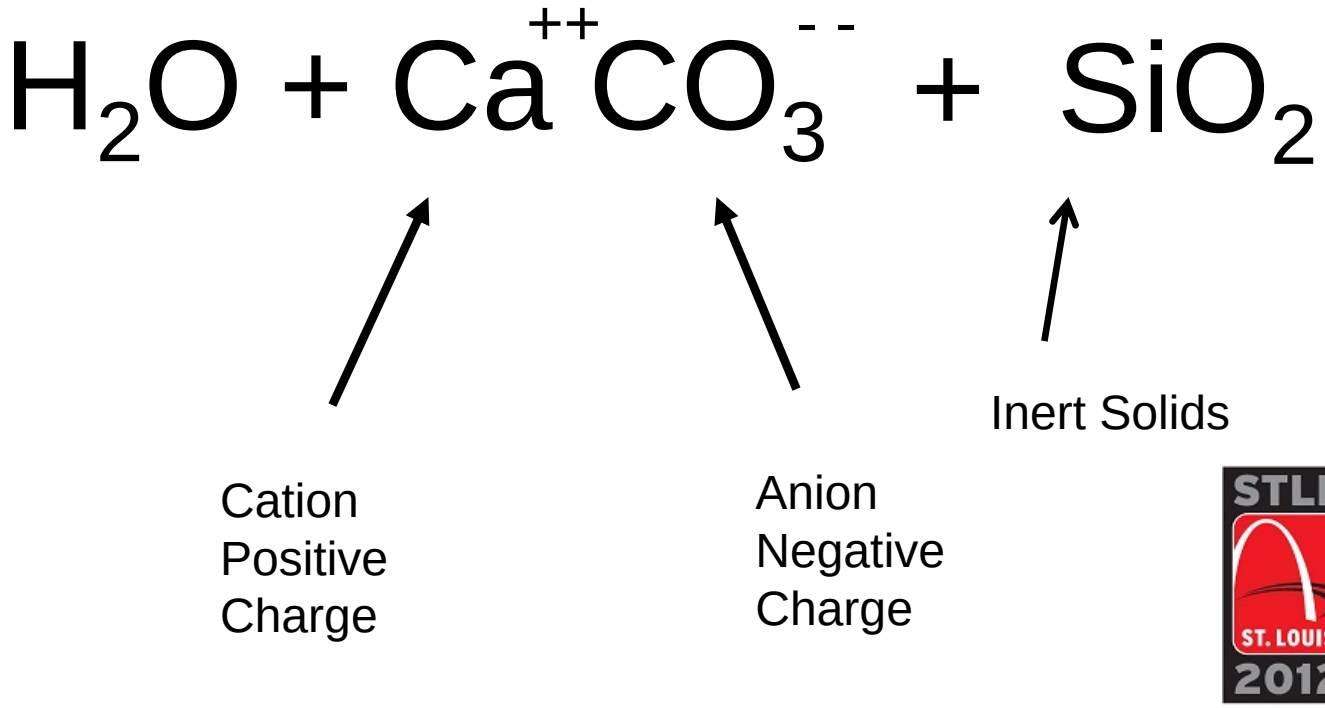
- Addition of chelates or sequestering compounds can help
- Can lead to flash rust
- Does not address total dissolved solids (TDS)

Chloride Reversal

- 400 mg/L or above can lead to corrosion
  - Red rust, White rust, pitting,
- No sump side “fix” is available

Water Basics

- Hard Water + Other Dissolved Solids



Other Water Variables

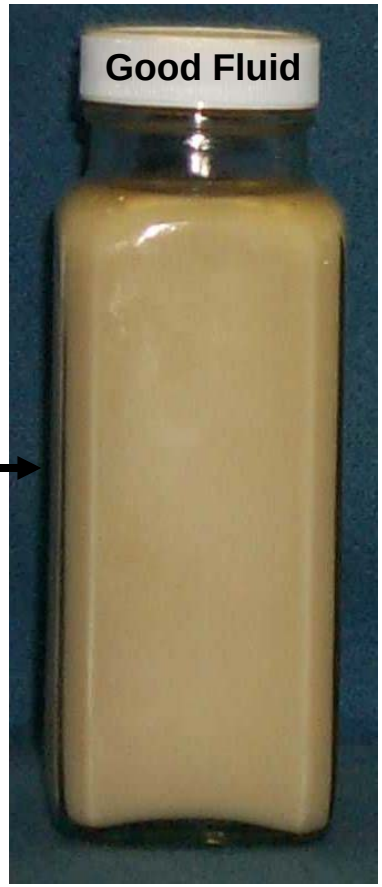
- SiO_2 and other inert compounds
- Silt as silt density index
- BOD, COD
- Biological loading, algae, bacteria (water is not sterile)
- Turbidity
- Color
- Solids – metals not dissolved
- Taste
- Odor
- Specific conductivity, resistivity
- Alkalinity, acidity, pH
- Temperature, summer, winter

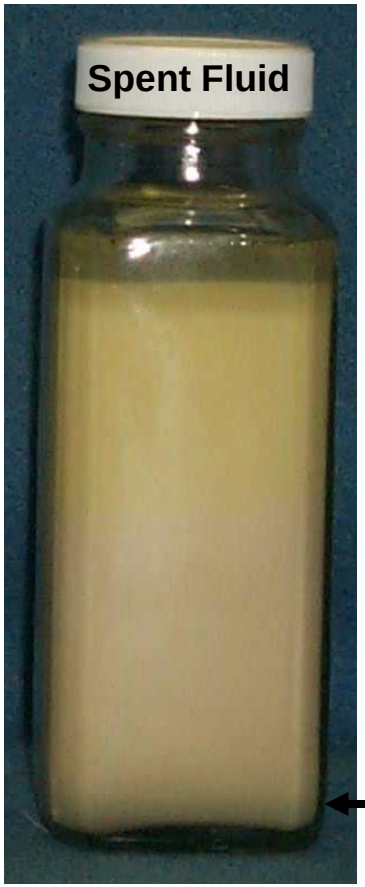
When to treat?

- **Hardness below 100 PPM - Not Likely Cost Effective**
- **Hardness above 275 PPM - YES**
- **Chloride above 60 PPM - YES**

Failure Mechanism – Water

Not always obvious





Continuous Emulsion

Separated Phase

Start

After 24 hours

Advantages of Using Pure Water

- Easier mixing
- Improved wetting
- Minimizes gummy residues
- Improved filtration
- Less part carry-off
- Greater bacterial resistance
- Reduced corrosion – Cl^-
- Less concentrate use
- Less mist

Disadvantages of Using Pure Water

- May lessen tool life on some operations
- Increases risk of generating foam

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Summary

1. Low quality water can be devastating on MWF
2. Using “treated” water can have positive effects
3. Foam can be an issue
4. Initial loss of tool life can happen
5. All water treatment system can fail
6. Get more than one water analysis

References

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