Cooling Systems: Best Practices and Back to Basics

Ben Hinojosa, Account Manager

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Topics for Cooling Discussion:

- Cooling Water System: Overview
- Cooling System Scale Prevention
- Cooling System Corrosion Prevention
- Cooling System Bacteria and Fouling Control
- Total Cooling System Management

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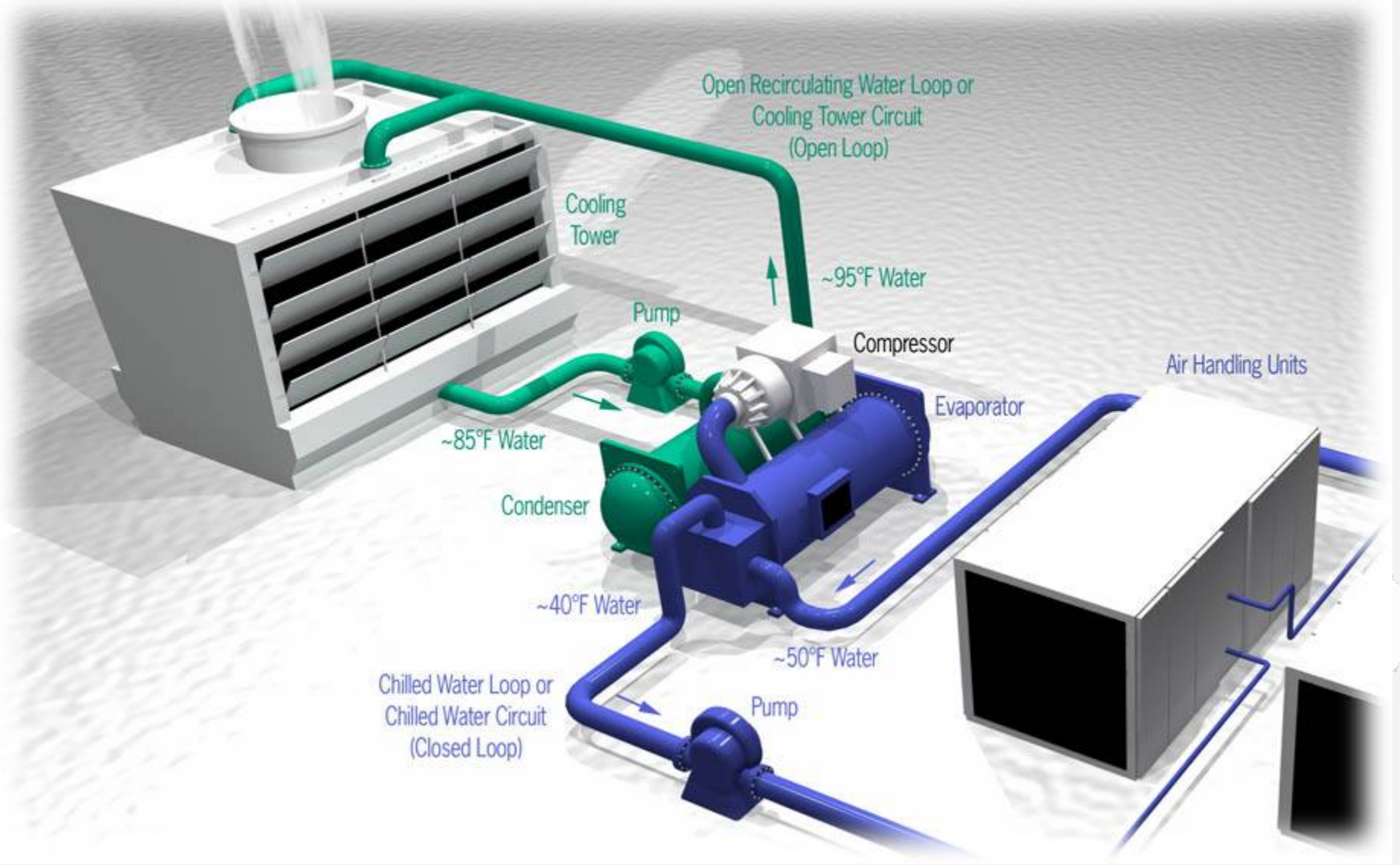
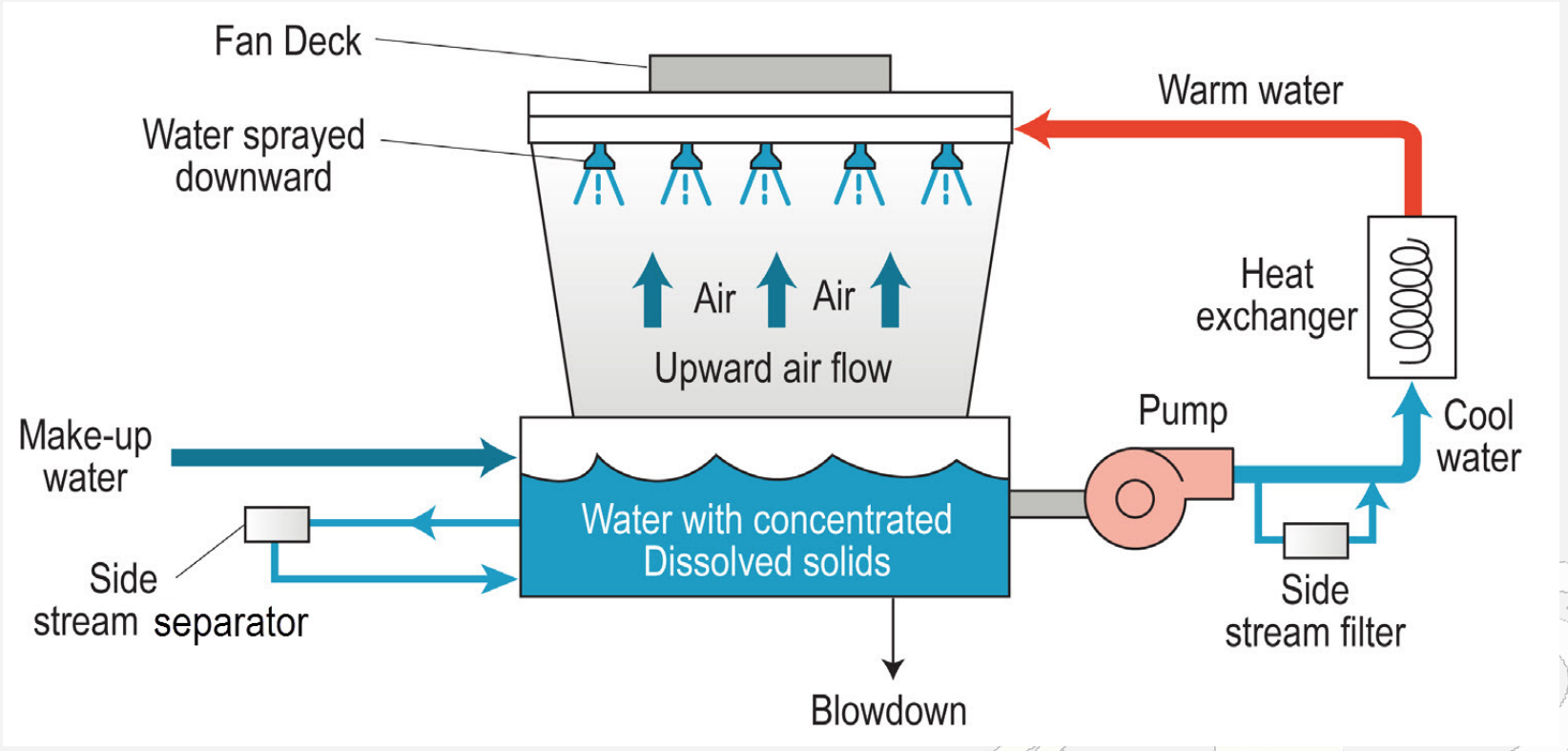


Cooling Tower Process



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- Abundant
- Holds a large amount of heat
- Relatively cheap
- High heat of Vaporization
- High boiling point
- Easily Handled

Two Types of Water

Surface Water

- Low Mineral Content
- High Suspended Solids
- Can Vary Seasonally

Well/Ground Water

- Low Suspended Solids
- High Dissolved Solids
- Content characterized by minerals in surrounding rock formations

Important Properties of Water

1. Conductivity
2. Hardness
3. Alkalinity
4. pH
5. Silica
6. Other impurities: Iron, Chlorides, Phosphate, Chlorides, Sulfate, etc.

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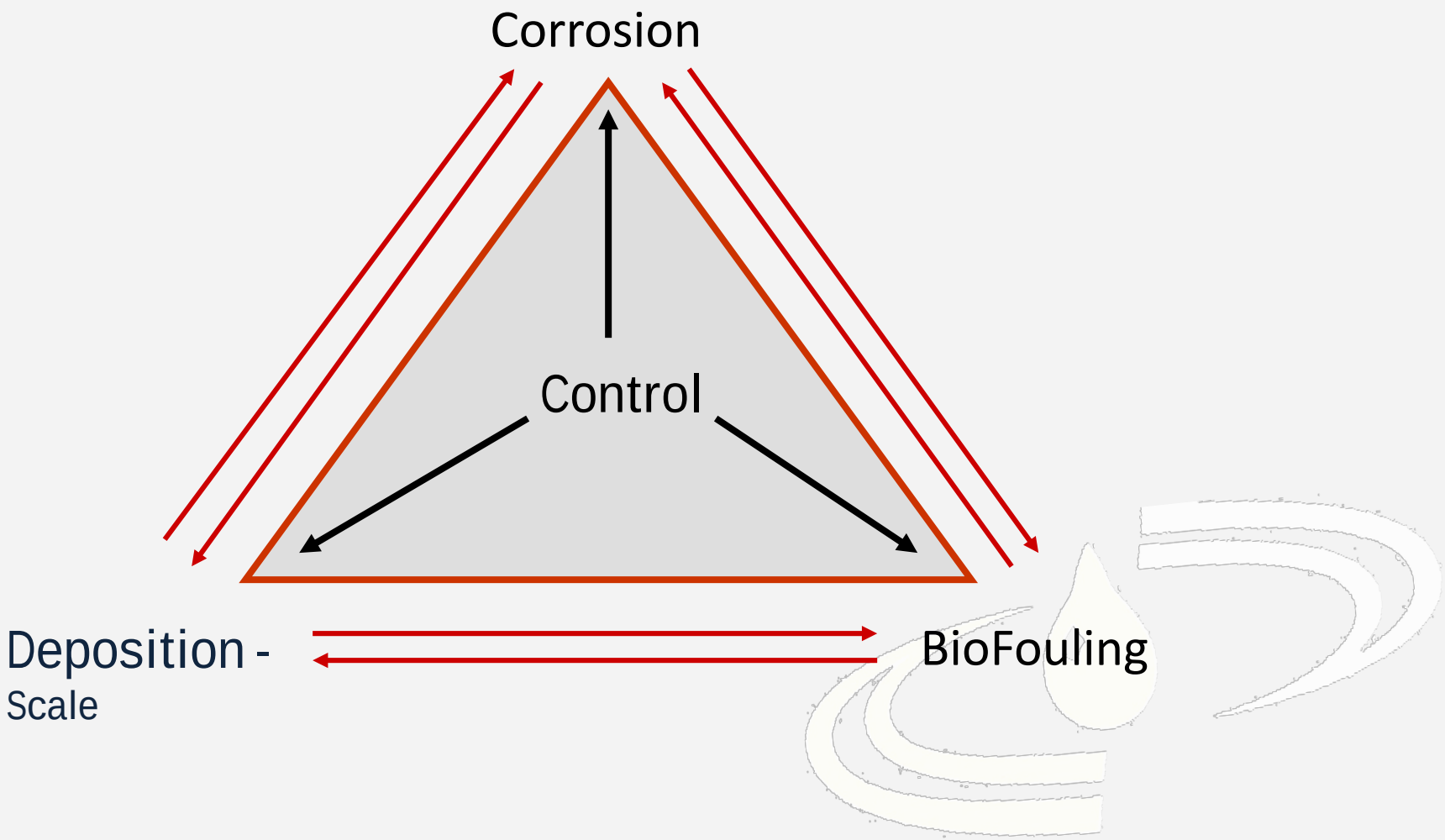
- ✓ Scale
- ✓ Corrosion
- ✓ Fouling
  - Microbiological
  - Other

These issues are all part of the **Fundamental Cooling Triangle**

Left unchecked these problems cause

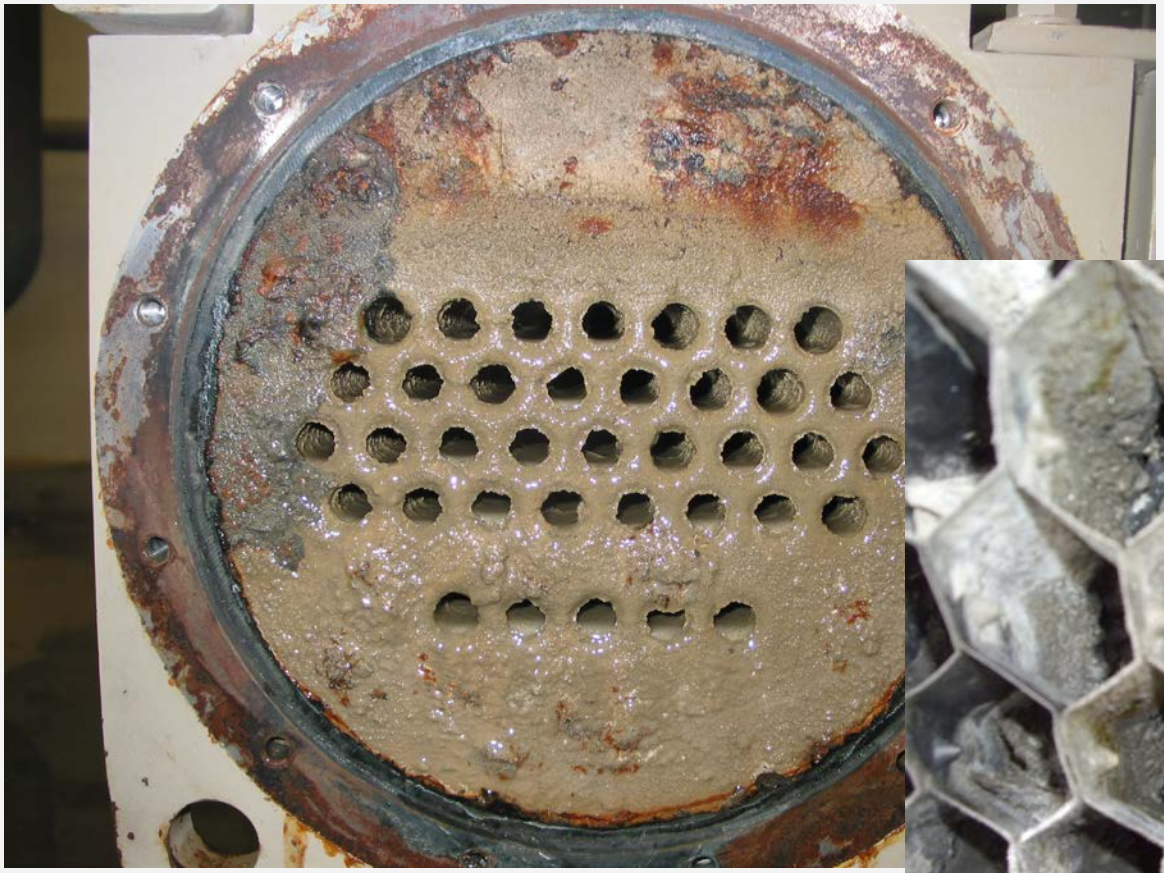
- Loss of heat transfer
- Reduced equipment life
- Equipment failures
- Lost production
- Lost profits
- Increased maintenance costs
- Plant shutdown

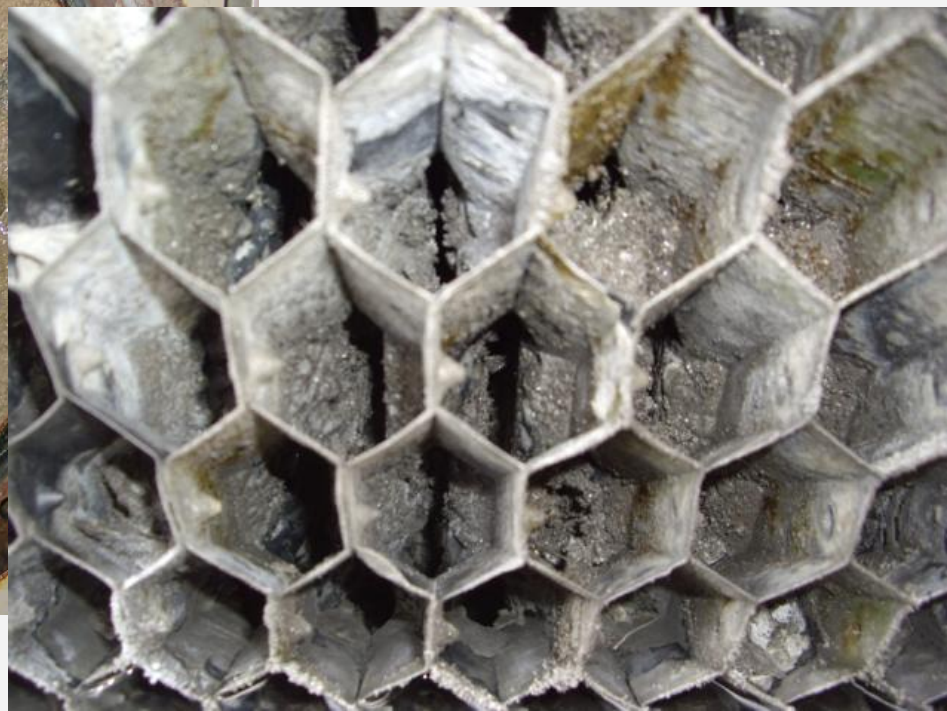
Fundamental Cooling Triangle



Problems in Open Cooling Systems

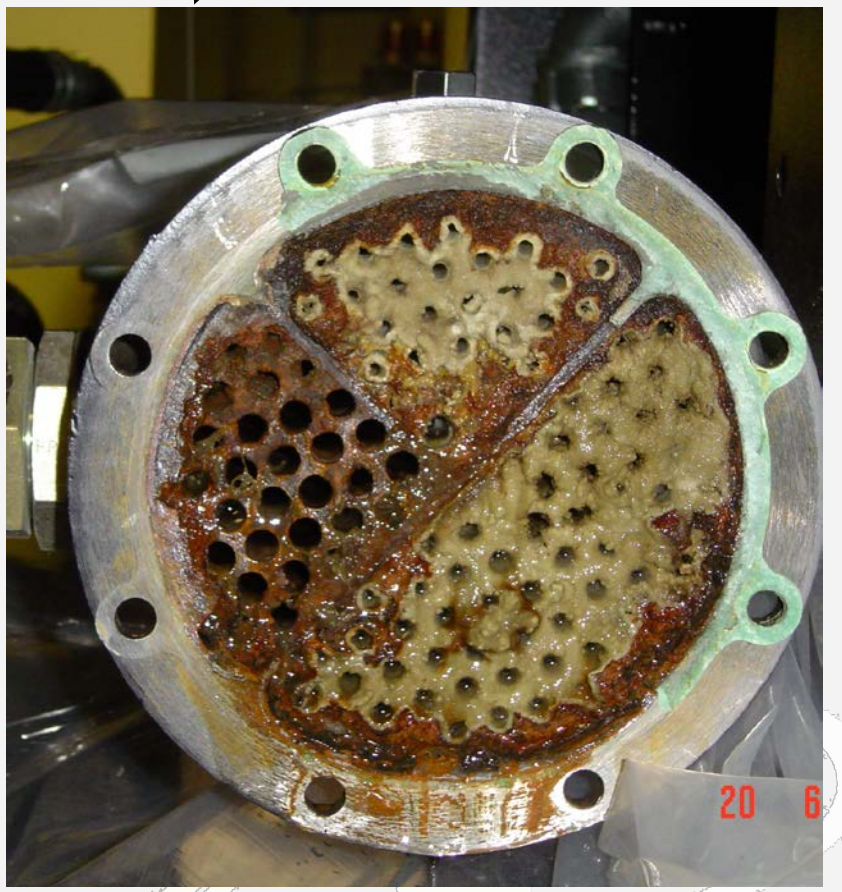
Scale





Loss of Efficiency

- Overheating of Equipment (High Head Pressure)
- Low Flow Problems (Distribution Deck on Towers)
- Premature Equipment Replacement
- Down time
- Mineral content of the water cycled too high
- Microbiological Fouling



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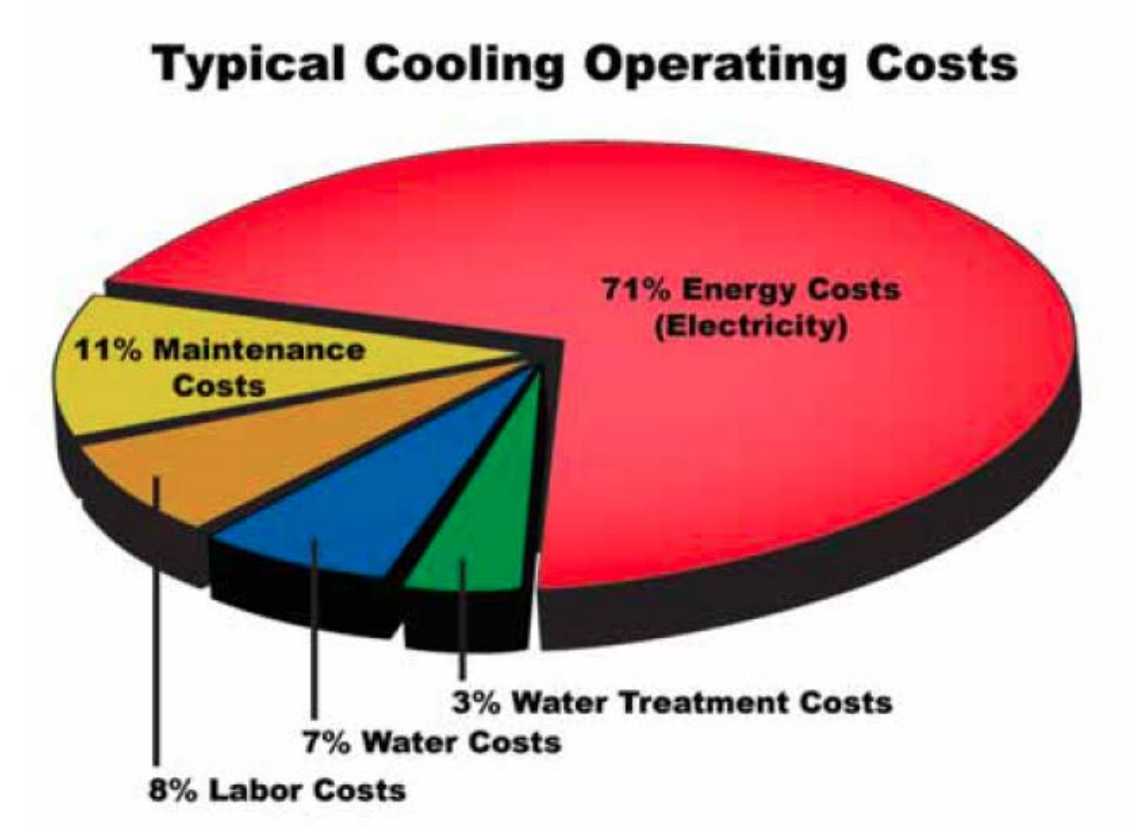
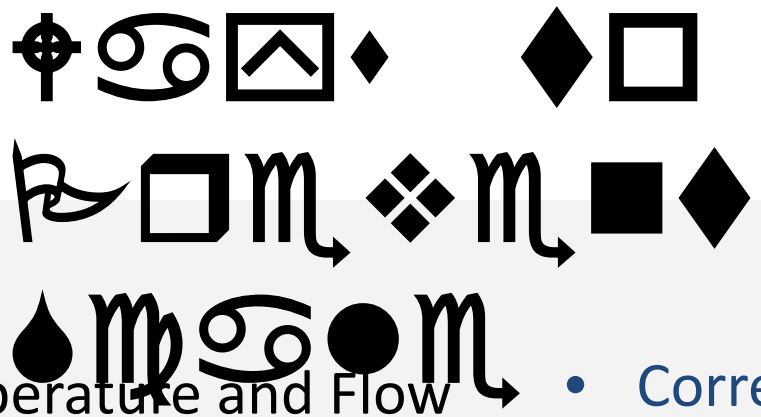
1/64” decreases the efficiency by as much as 17% and increases energy costs

COOLING SYSTEMS*	DEPOSIT COMPOSITION	% LOST EFFICIENCY	INCREASED ENERGY USAGE (KWH/YR)	INCREASED ENERGY COSTS (PER YEAR)
500-Ton Chiller System Operating 24/7, 365 days/yr at 50% Load	.015” Calcium based scale	9.7%	196,396	$19,640
	.015” Silica based scale	16.9%	373,705	$37,371
	0.005” Biofilm	11.3%	233,292	$23,329

*Chiller efficiency of 0.65 kW/Ton and electric costs of $0.10/kwh

Typical Cooling Operating Cost Graph





- Temperature and Flow
- Water pH
- Mineral Concentration
- Bacterial Fouling

- Correct Heat Exchange Valve Settings
- Proper Acid Feed and pH Control
- ***Proper*** Tower Bleed and Chemical Feed
- Maintain System Cleanliness with Biocides and Maintenance

Questions on Cooling System
Scale Prevention?

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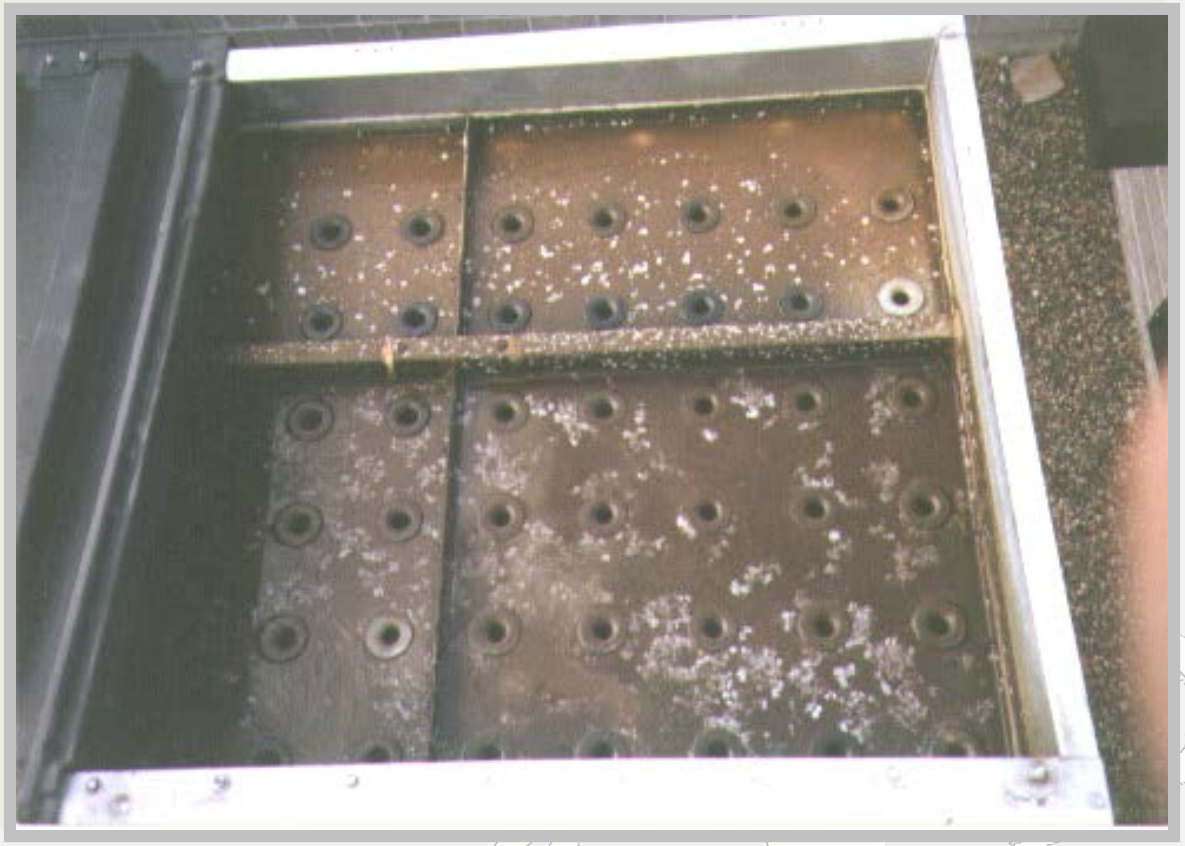
- Scale
- Corrosion



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Natures Electrochemical Process That Allows a Metal to Return to its Lowest Energy State. (Natural State)

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- General Corrosion: Metal loss occurs uniformly over the entire surface.

- Localized or Pitting Corrosion: Extremely localized type of corrosion resulting in pits or holes in the metal.

- Galvanic Corrosion: Different metals in contact in a system creating a difference in potential

Affects of Corrosion

- Destroys cooling system metal
- Corrosion product deposits in heat exchangers
- Heat transfer efficiency is reduced by deposits
- Leaks in equipment develop
- Process side and water side contamination occurs
- Water usage increases
- Maintenance and cleaning frequency increases
- Equipment must be repaired and/or repaired
- Unscheduled shutdown of plant

Methods to Improve Corrosion Inhibition

- Build with Corrosion Resistant Materials
  - *Stainless Steel, Carpenter 20, Titanium, Hastelloy, Plastics*
- Apply Coatings
  - *Epoxy*
- Use Cathodic Protection such as Sacrificial Anodes or Applied Current
- Properly Pre-Clean before Operation
- Minimize Oxidant Concentration
- Optimize pH and Conductivity
- Feed Chemical Corrosion Inhibitors

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- Zinc blocks or donuts used to provide a sacrificial corrosion site where the majority of the corrosion occurs.
- Corrodes sacrificially to the metal of lower electronic potential.

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During idle periods, due to:

- Moisture exposure
- Oxygen exposure
- General fouling-debris, silt, particles, etc...

90% of the *corrosion* happens in the Idle periods!

Questions on Cooling System Corrosion Prevention?

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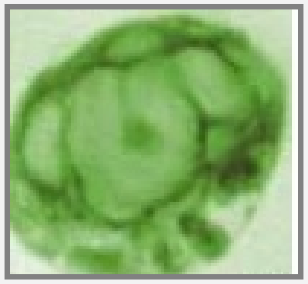
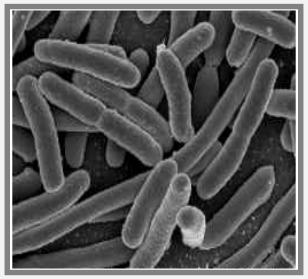
- Scale
- Corrosion
- **Fouling**

Examples of Microbiological Foulants

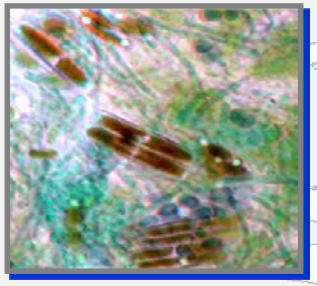
- Algae
  - Plugs Equipment
  - Promotes Legionella



- Bacteria
  - Forms Biofilm
  - Promotes Corrosion
  - Increases Scale Formation



- Fungi
  - Tower Structure Damage



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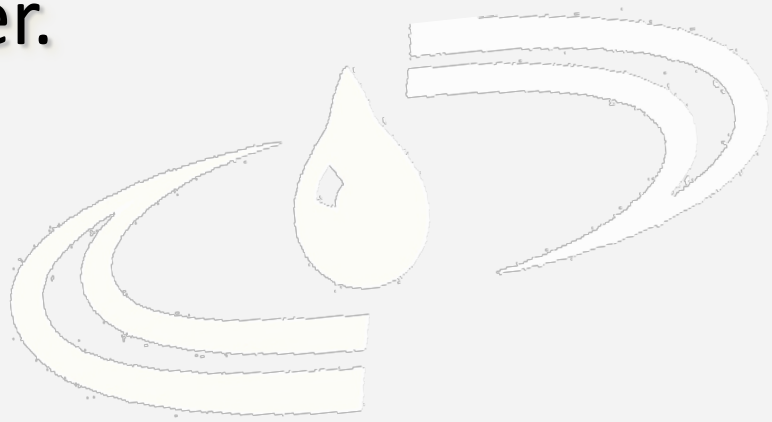
Organic and inorganic materials, other than scale, that coat heat transfer surfaces and block flow through piping.

There are two types of foulants: Microbiological and Other.



Affects of Fouling

- Foulants form deposits in hot and/or low flow areas of cooling systems
- Shell-side heat exchangers are the most vulnerable to fouling
- Deposits ideal for localized pitting corrosion
- Corrosive bacteria thrive under deposits
- Metal failure results

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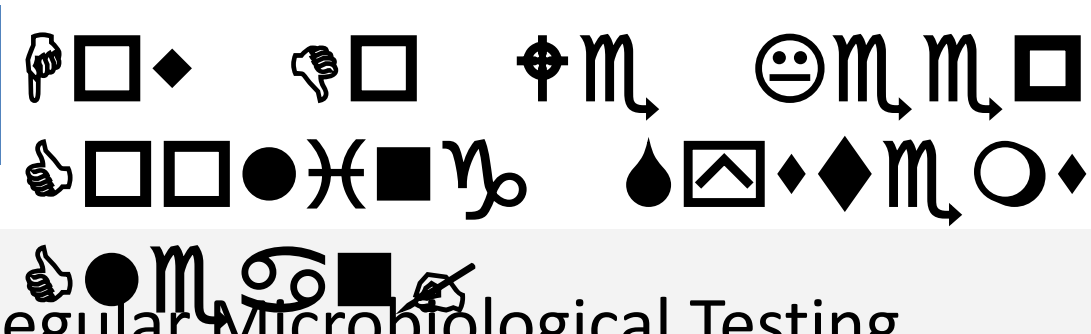
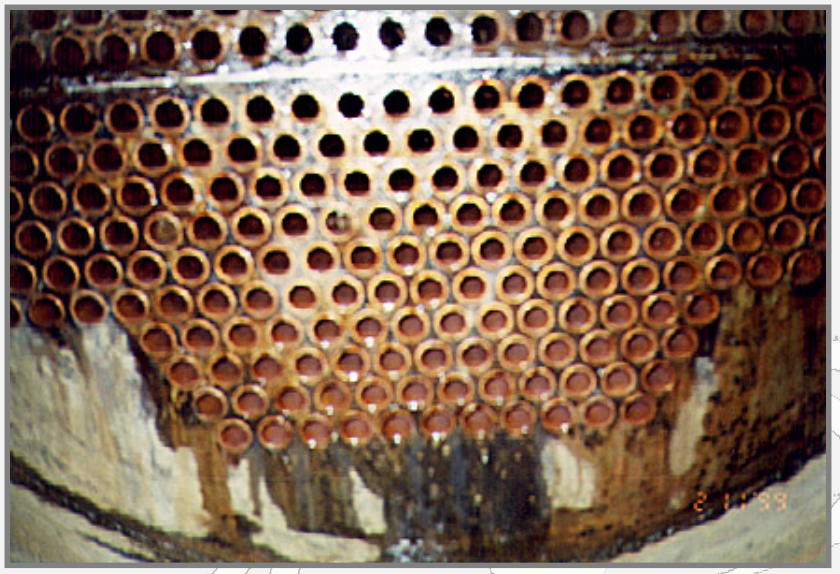
- Towers operate at elevated temperature (usually 85º - 95º)
- Plenty of oxygen is available
- Food and nutrient sources are plentiful from outside air or from process leaks
- Sunlight is available
- Remote/stagnant locations available
- Physical cleaning is difficult



- Regular Microbiological Testing
- Physical Cleaning of the System; Quarterly or Annually
- Bio-dispersant Program if indicated
- Record Keeping of Test Results and Biocide Additions
- Complete Biocide Program: ***Oxidizing & Non Oxidizing Biocides***

Microbiological Organism Control Chemistry

- Oxidizing Biocides
- Non-Oxidizing Biocides
- Biosurfactants



Oxidizing Biocides

- **Chlorine Gas**
- **Sodium Hypochlorite (chlorine bleach)**
- **Sodium Bromide (with bleach or chlorine)**
- Bromine Pellets (chlorine is already added)
- Liquid Stabilized Bromine
- **Chlorine Dioxide**
- Peroxide
- Peracetic Acid
- Ozone
- Iodine

Most common in power plants

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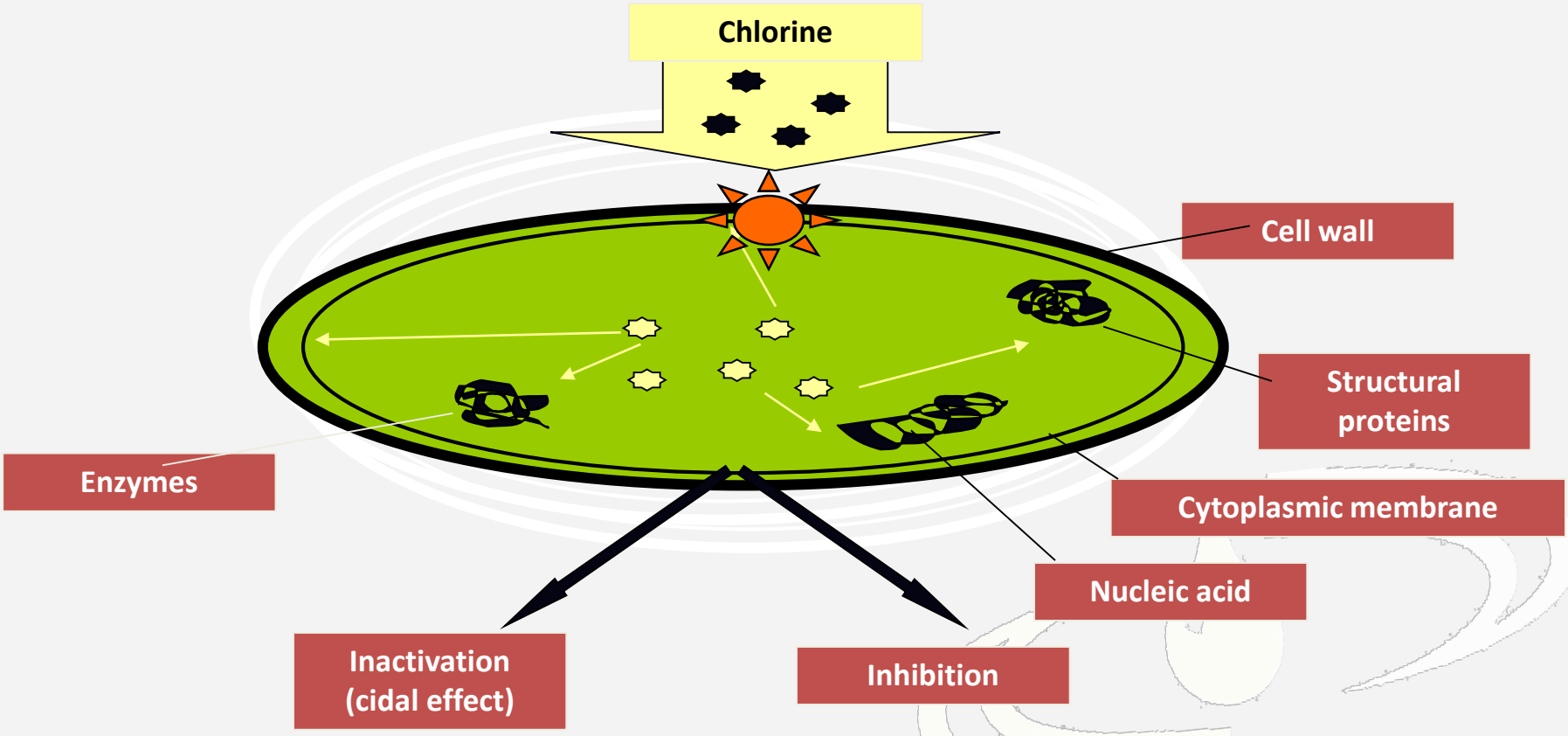
- They Are Inexpensive
- Very Fast Acting (Kill Quickly)
- They Kill by Burning the Cell (Resistance Can Not be Improved)
- Very Broad Spectrum
- Many Sources and Types



Source: C. Chauret. Controlling Encysted Parasites with Disinfection Processes. OWWA Seminar on Disinfection in Drinking Water Treatment. Toronto. April 2000.

Ways to Reduce Fouling

Mechanically

- Screens
- Cyclone Separators
- Sand Filters
- Bag Filters
- ***Use Your Filter Systems***

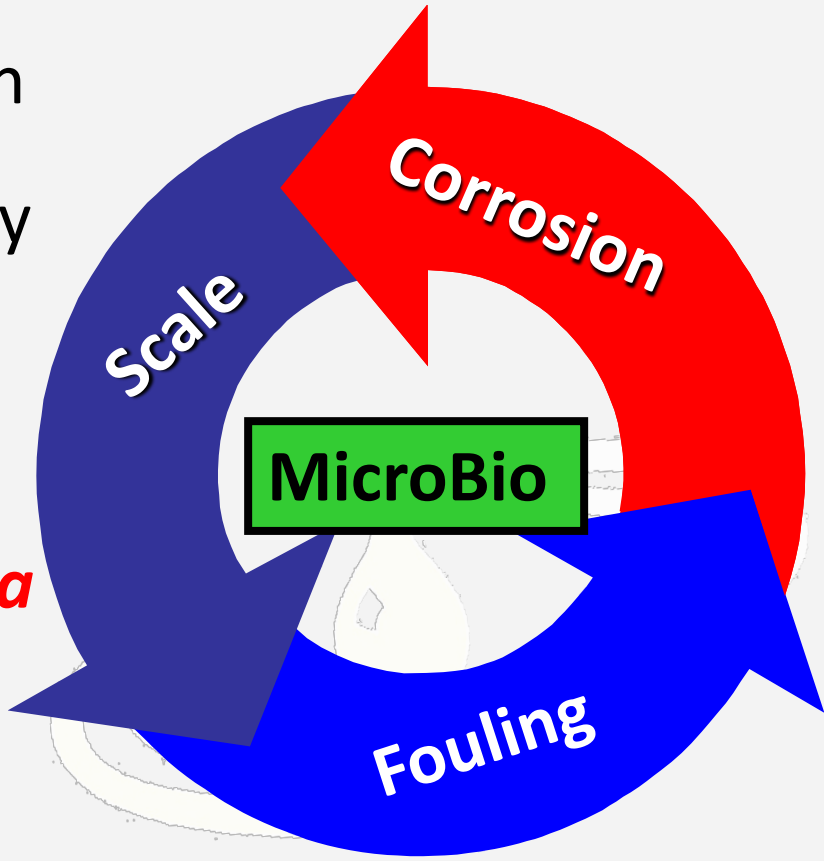
Ways to Reduce Fouling

- Mechanically
  - **Broom and Shovel!**

One of the best ways to keep a cooling system working efficiently is to clean out the basin and sumps regularly.

Controlling Microbiological Growth Will:

- Reduce Corrosion, Scaling & Fouling
- Reduce Chemical Consumption
- Maximize Equipment Efficiency
- Maximize Equipment Life (Reduce Wood Rot)
- ***Reduce Liabilities of Legionella*** and Other Related Risks



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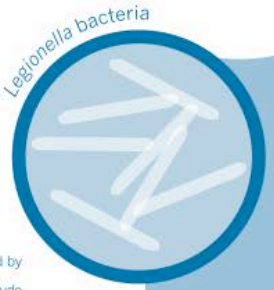
Legionnaires Synopsis

Alliance to Prevent Legionnaires' Disease

LEGIONNAIRES' DISEASE
HELPFUL INFORMATION



THE DISEASE **A severe form of pneumonia** caused by *Legionella* bacteria. Symptoms of this type of respiratory infection include high fever, chills, cough, muscle aches, headaches, and diarrhea.

MOST PEOPLE EXPOSED TO THE BACTERIA DO NOT BECOME ILL.

TRANSMISSION *Legionella* bacteria reach people **when a water supply is contaminated.** Hospitals, hotels, and large buildings are common locations for outbreaks. The **drinking** water supply is the primary source. Once the bacteria enters a water supply, it can multiply and be distributed throughout the building, coming into contact with people through fountains, mist machines, humidifiers, cooling towers, showers and sinks.

WHO'S SUSCEPTIBLE? The bacteria may enter the lungs through aspirated water droplets. While **smokers, the elderly, and those with asthma, chronic lung disease or suppressed immune systems are more likely to become infected,** healthy people may also be at risk.

PREVENTION, MAINTENANCE & MONITORING To prevent Legionnaires', the **drinking** water supply must be kept free of *Legionella* bacteria. The American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) and the Centers for Disease Control and Prevention (CDC) have developed a standard for risk management to support proper **maintenance and monitoring** of building **drinking** water systems.

FALSE	THE FACTS
Legionnaires' disease most often occurs in large outbreaks.	Only 4% of Legionnaires' disease cases are part of known outbreaks. There are approximately 5,000 cases per year in the United States.
The primary cause of Legionnaires' is cooling towers.	Peer-reviewed studies published in the New England Journal of Medicine, The Lancet: Infectious Diseases, and many other publications have found the drinking water supply to be the primary source of the bacteria.
You can't get Legionnaires' from a shower head.	Bacteria can grow in the plumbing and in the shower head, which breaks up the water into a fine mist which can easily be inhaled allowing bacteria to travel directly to the lungs.

optimal temperature for bacteria growth

Questions on Cooling System Bacteria and Fouling?

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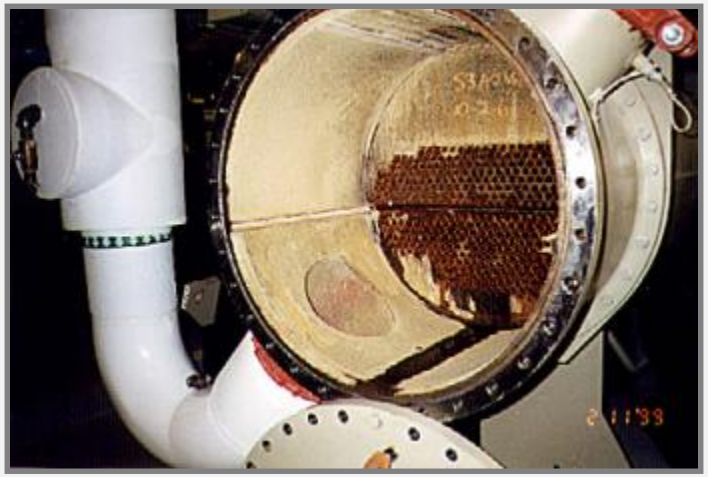
- Should be done yearly on the condenser and every few years on the evaporator.



- A boroscope may be used to get a closer look inside the chiller tube bundle.

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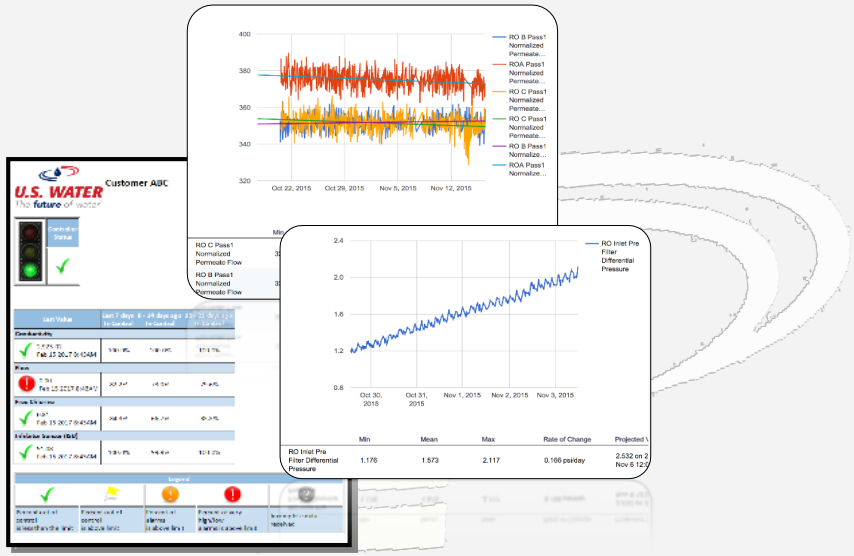
- Scale Control
- Corrosion Inhibitors
- Biocide Feed

- Tower Bleed Control
- Water pH Control
- ***Monitors and Alarms***
- Automatic Data Logging

Why Use Automation?

- Reliability of Program Application is Critical
- Quickly Adjusts to Varying System Demands
- Troubleshooting is Much Easier
- Energy Savings Due to Tighter Control
- Automatic Data Logging for Permit Reports



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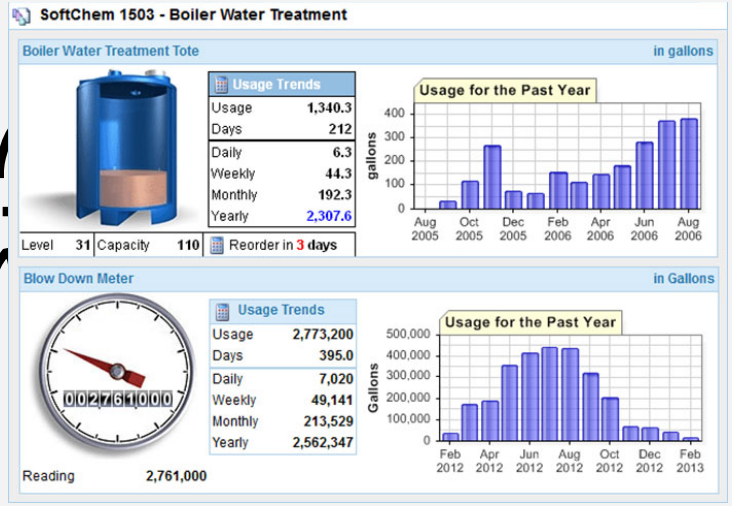
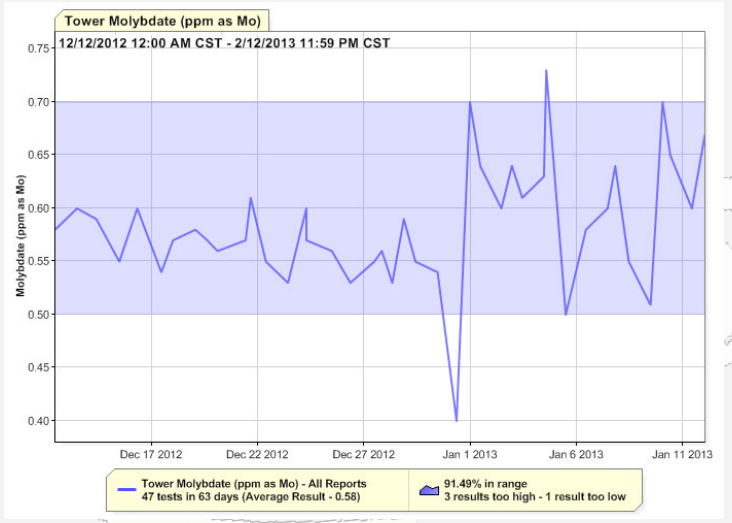
U.S. WATER REPORTS™

- Web Based
- Electronic Log Book
- Inventory Tracking
- Trending
- Troubleshooting Tool
- Storage for Reports





Thank you for your attention.

Any questions?

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