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Water and Energy Conservation in HVAC Systems

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Industrial Water Engineering

- Headquarters-Albuquerque, New Mexico
- GSA Contractor
- ISO 9001:2008 Certified
- **www.industrialwaterengineering.com**

Why Conserve?

- Diminishing supply
- Increasing demand
- Increasing costs
- Tightening of discharge limits
- Waste Water Treatment Plants are being overwhelmed
- Regulatory mandates to conserve

How to Save Water and Energy

- Identify Major water users at the facility
- Characterize water streams over time.
- Use computer models to mix and reuse water.
- Understand costs associated with reuse.

Know Water Cost

- Any investment to save water should be offset by cost of water saved.
- Equipment to process water is reflected in three components:
  - Capital Equipment
  - Operations and Maintenance
  - Energy
    - Electrical-$ per KW/hr
    - Gas-$ per therm.

Water and Sewer Cost

LOCATION	COST PER 1,000 GALLONS, $
Albuquerque, NM	$3.11
Arizona (typical)	$7.00
Bellevue, Washington	$16.11
Dallas, Texas	$6.00
Denver, Colorado	$4.15
Kitchener, ON, Canada	$14.98
Portland, Oregon	$13.07
Santa Fe, NM	$17.35
Vancouver, Washingon	$7.86
Yakima, WA	$5.39

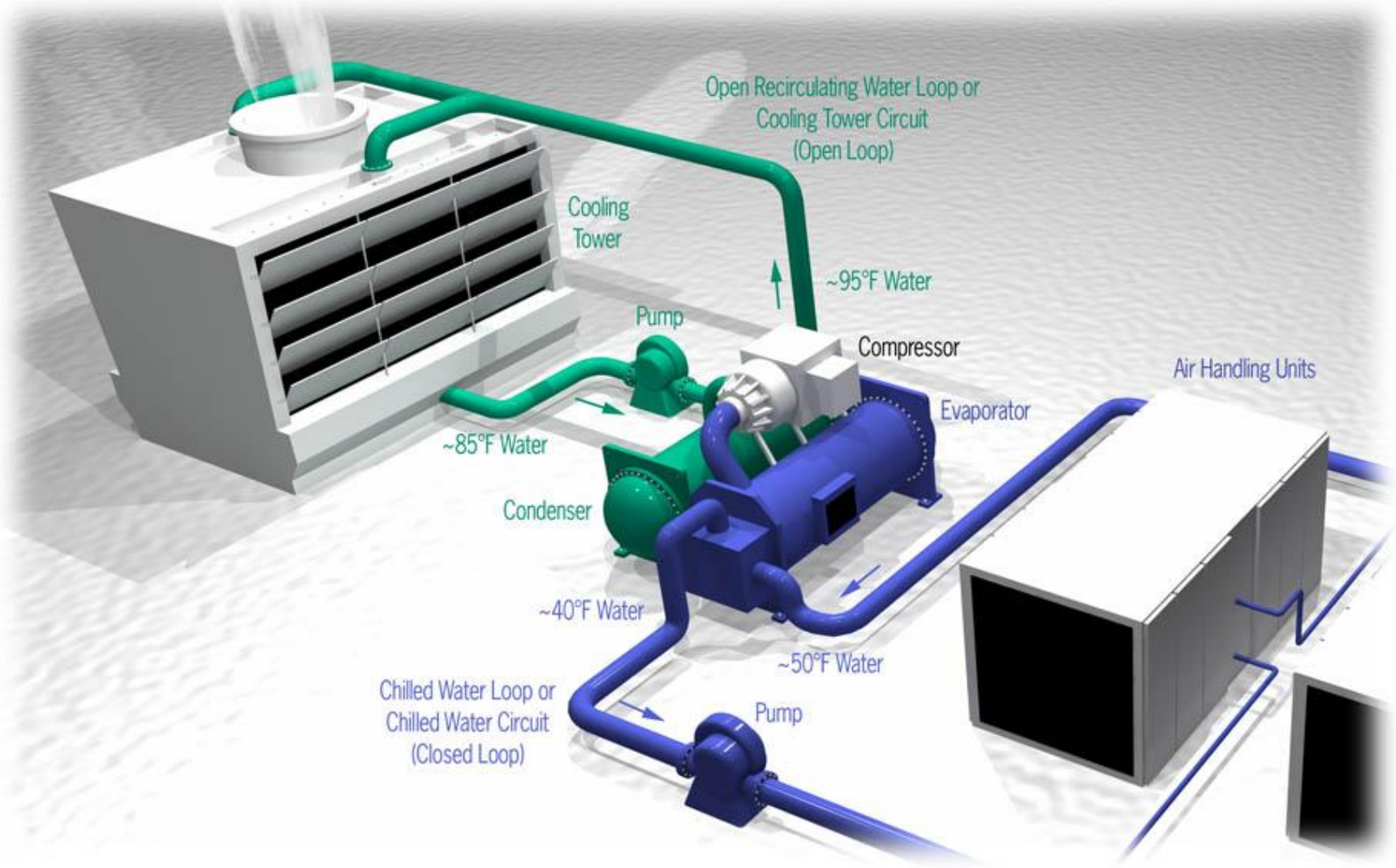
Cooling Towers

Purpose of Cooling Towers

- Once through cooling uses massive amounts of water. Practical on ships and locations near large bodies of water.
- Cooling towers were originally designed to be water conservation devices.
- Cooling towers cool return process water 10 to 15°F through evaporative cooling.

Understanding Water Use in Cooling Towers

- **Evaporation**-water lost to atmosphere by evaporation. Each pound of water evaporated removes about 1,000 BTUs.
- **Drift**-water carried out of the tower by air flow
- **Bleed or Blow-Down** - water drained out of the tower to prevent solids from rising to a critical level and damaging the system
- **Makeup**-water introduced into the tower to replace water loss from Evaporation, Drift, and Bleed



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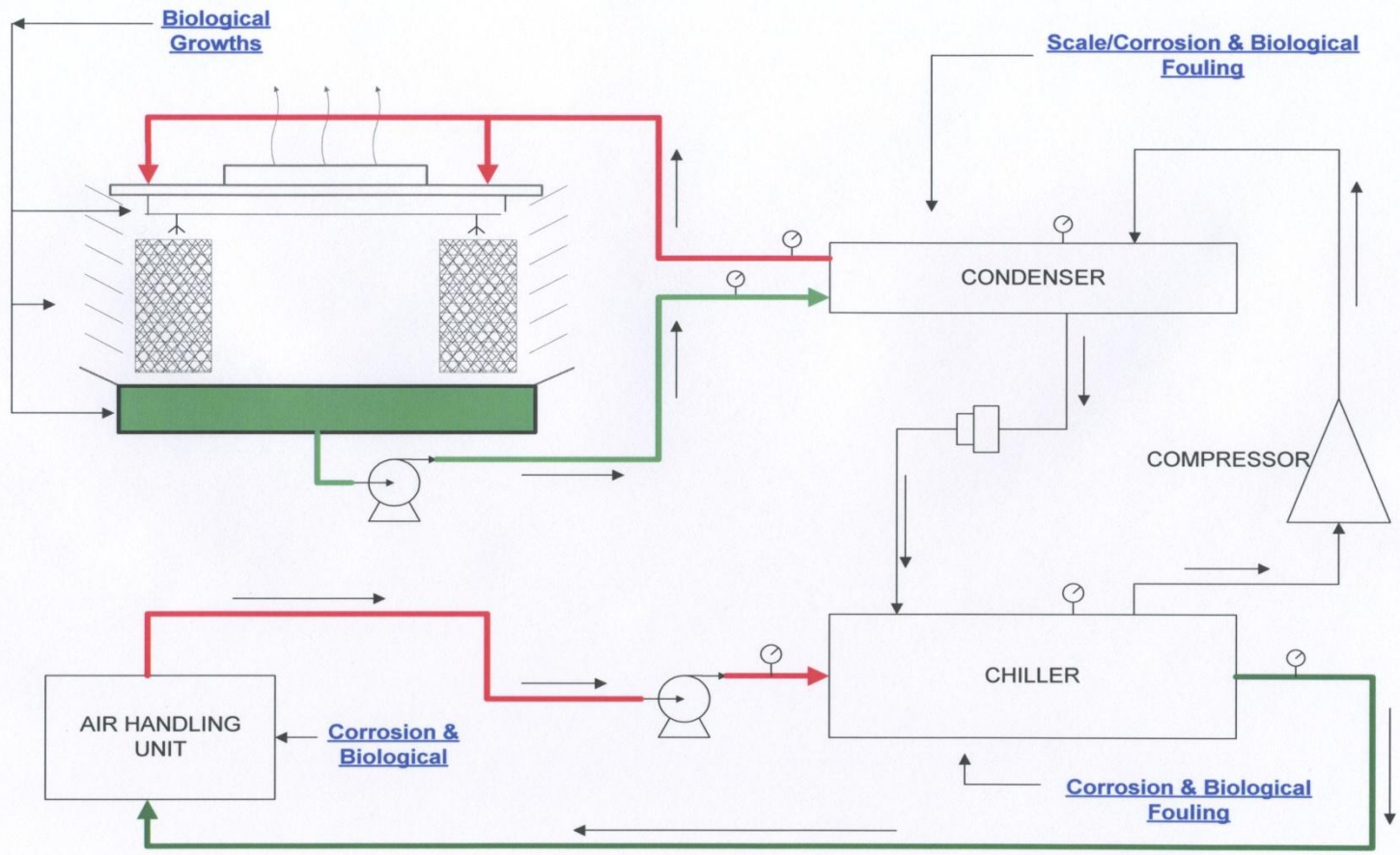

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Typical Problem Areas Cooling Tower System with Closed Loop

Evaporation

- Evaporation is the mechanism used for heat removal.
- Water lost through evaporation cannot be reduced unless load on the tower is reduced
- Facilities incorporate “Free Cooling” to avoid the need to run the towers in the winter
  - Plate and Frame
  - Strainer cycles
  - Refrigeration migration

Bleed or Blow-Down

- The amount of bleed water required can be reduced by allowing the tower water to concentrate to a higher level through evaporation
- The concentration of dissolved solids from higher cycles of concentration in tower water is referred to as ‘Cycles of Concentration’
- Reducing bleed should only be done after a thorough analysis of several issues

Makeup

- Water lost from Evaporation, Drift, and Bleed is replaced by Makeup
- Reducing the amount of makeup water required is the focus of water conservation efforts in cooling towers

Cycles of Concentration (COC)

- Typically measured by conductivity
  - Micromhos
  - Microsiemens
- Can be measured by chlorides, sodium, etc.
- At high conductivity, measurements become inaccurate

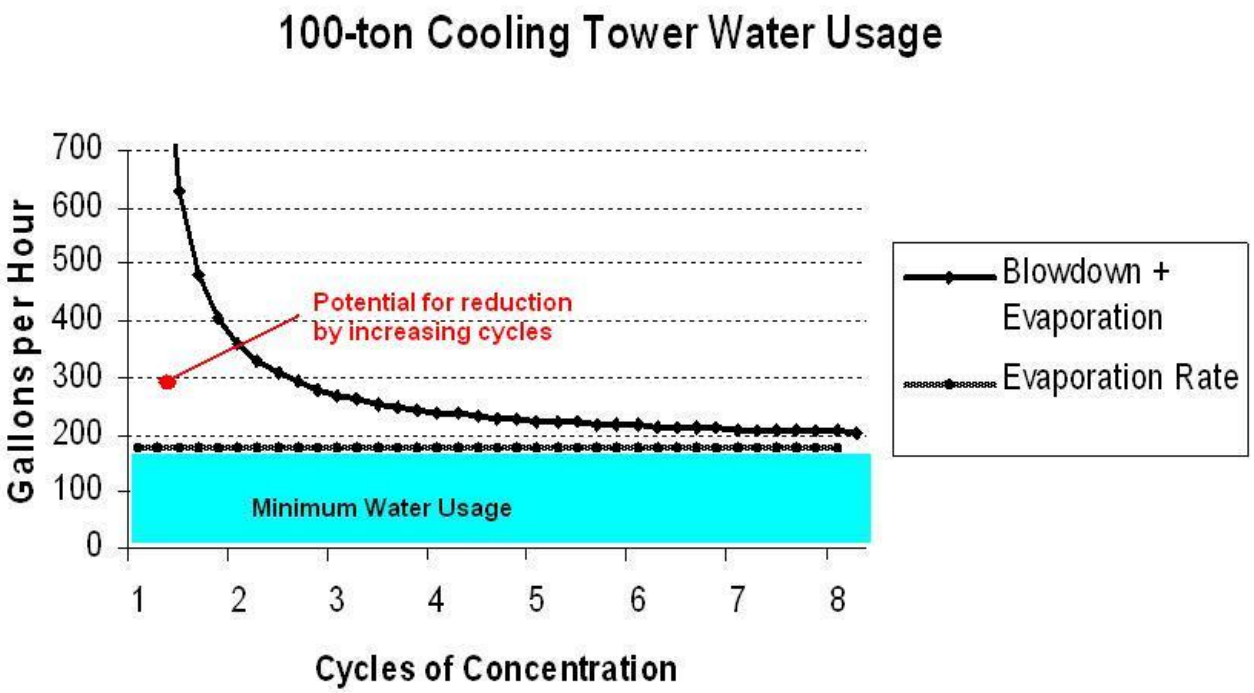
Effects of COC Increases

Cycles (CR)	Conductivity, microsiemens	Sodium, mg/L	Chloride, mg/L
Makeup water (1.0 CR)	500	50	30
2.0	1000	100	60
3.0	1500	150	90
4.0	2000	200	120

When COC increases

- Water use decreases as COC increases.
- Scaling potential increases as COC increases.
- As C0C increases, suspended solids increase.

Water Savings must be balanced with risks.



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Annual Savings Due to Cooling Tower Water Conservation Measures

- 1,000,000 gallons of water saved
- $ saved:
  - Albuquerque $3,110
  - Santa Fe $17,350

KNOW YOUR WATER COSTS

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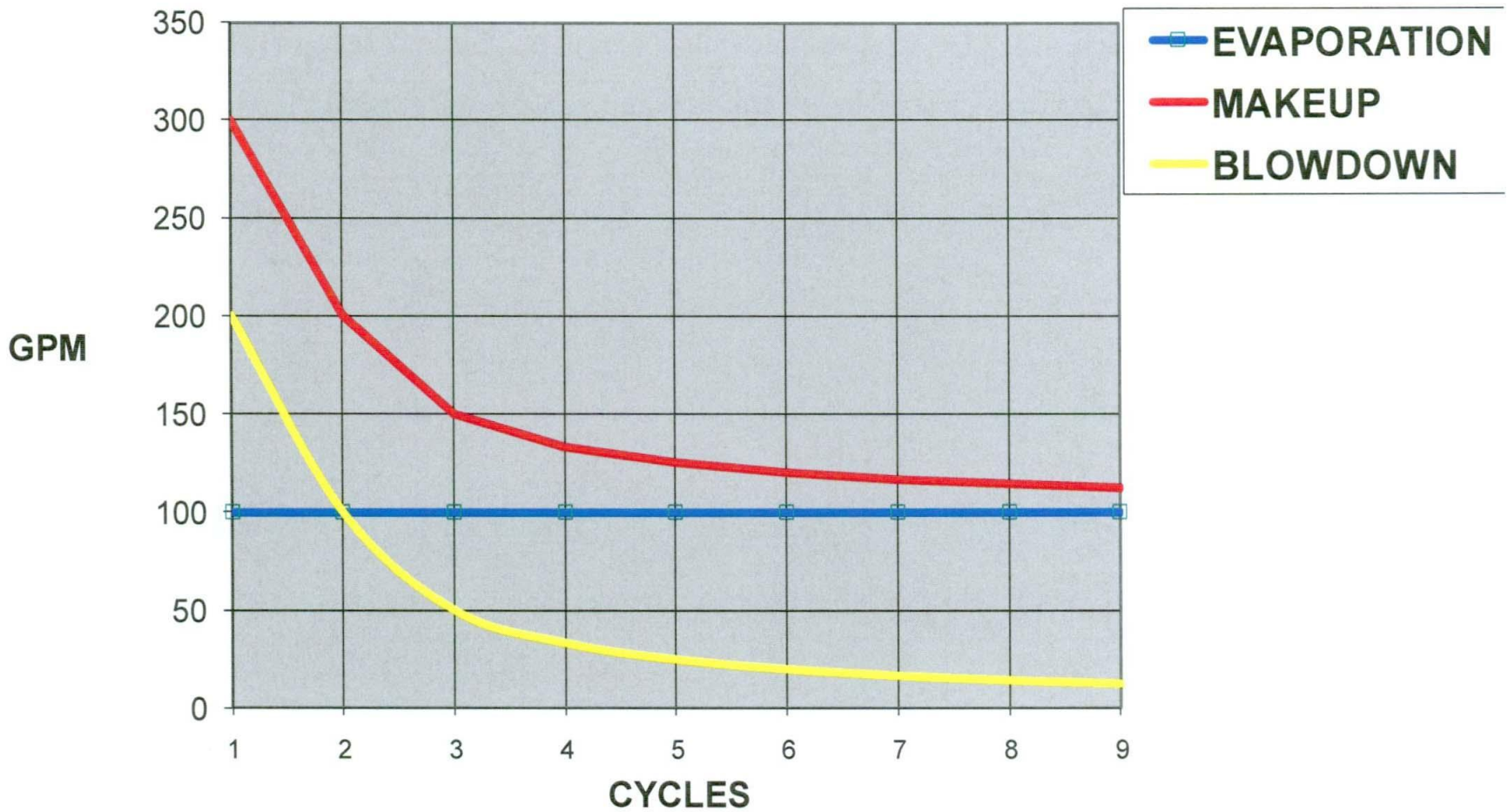
Basic Calculations

- Makeup = Bleed + Evaporation
- Bleed = Evaporation / (COC –1)
- Evaporation = Makeup – Bleed

COOLING TOWER WATER USE



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500 Ton Tower, 25% load

	2.0 Cycles of Concentration	5.0 Cycles of Concentration
Evaporation, gallons per year	1,971,000	1,971,000
Bleed, gallons per year	1,971,000	492,750
Makeup, gallons per year	3,947,404	2,469,154
Water Saved, gallons per year		1,478,250
Water Savings $, Albuquerque		$4,597
Water Savings $, Santa Fe		$25,647

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Equipment Protection and Water Conservation- Finding the Balance

Evaporation Savings

- Evaporation is solely a reflection of load on a system.
- For each 1 pound of water evaporated, approximately 1,000 BTUs of heat are removed.
- Heat is picked up in condenser circuit as freon is cooled in the chiller.

Free Cooling-Strainer Cycle

- Tower water linked directly to chilled water circuit.

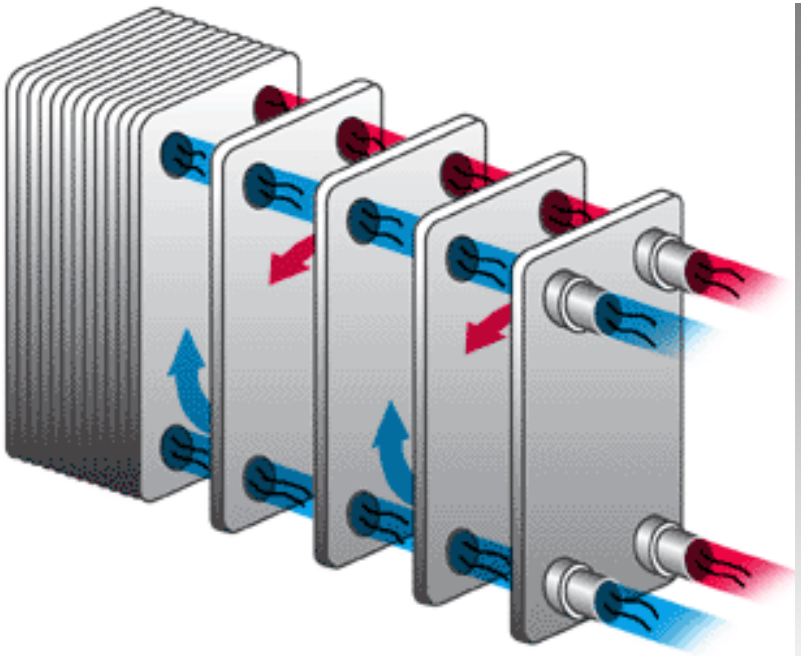
Strainer is to remove debris from tower system prior to chiller. Not recommended as chilled water loops are normally closed and treated. Result will be contaminated chilled loops and high corrosion rates.

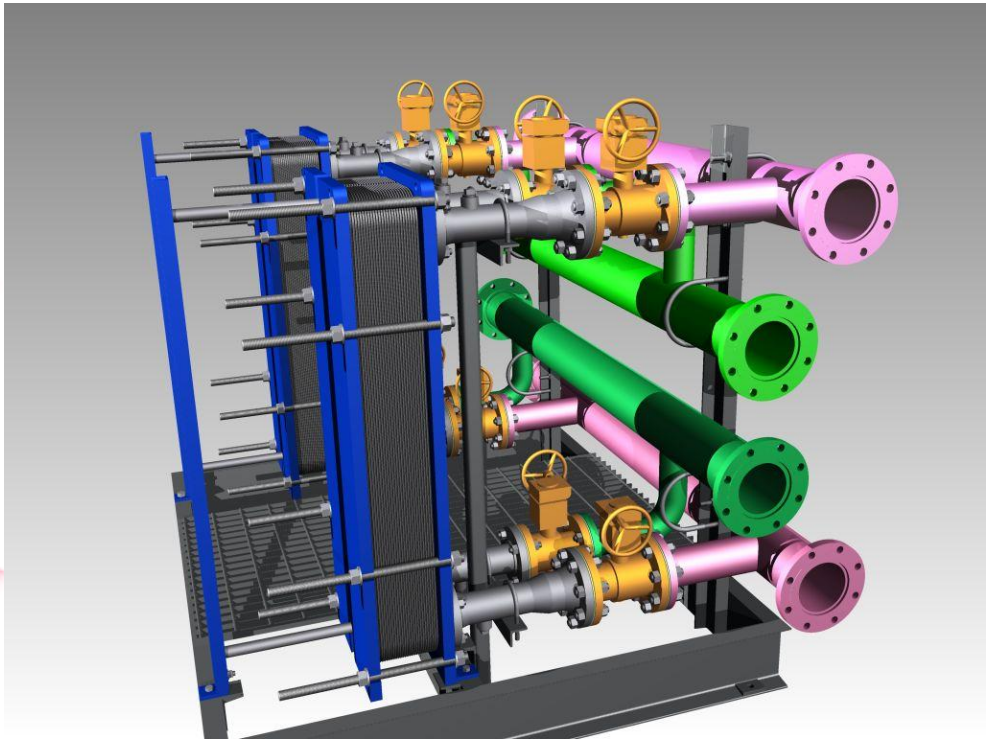
NOT RECOMMENED

Free Cooling-Plate and Frame Heat Exchanger

- Heat exchanger will transfer heat from chilled water loop directly to cooling tower loop. Chiller is bypassed.
- Works very well in cold winter months.
- Chilled loop remains treated and isolated.

Plate and Frame





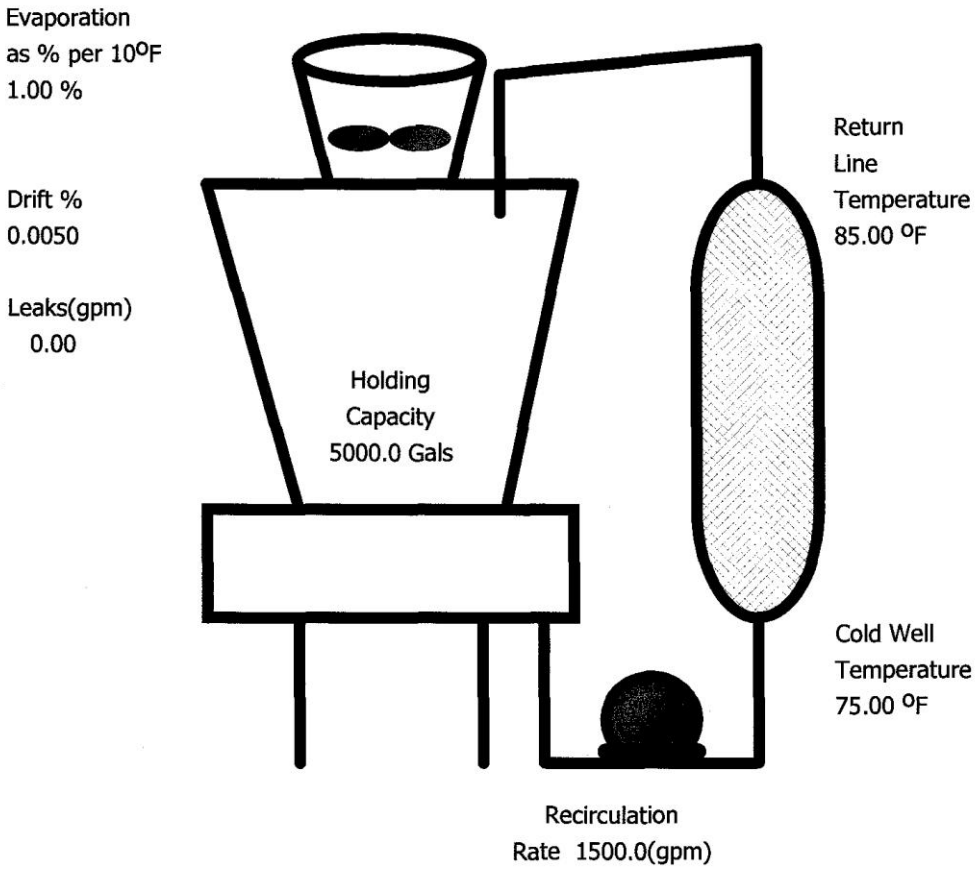
- High Efficiency
- Prone to fouling with debris
- Recommend filter on tower water side.

Free Cooling-Refrigeration Migration

- A valve arrangement within the chiller opens a direct path between the condenser and evaporator. The warm fluid in the chiller loop vaporizes the refrigerant and the energy is carried directly to the condenser where it is cooled and condensed by the tower water. Cost savings are due to compressor inactivity.

Blowdown Savings

- As cycles Increase, blow down decreases
- Majority of water saved after 5 cycles
- Usually not economical to go beyond 5 cycles for small systems.
- Exceptions are discharge limitations and water supply problems.



Calculated Parameters at 5.00 cycles

Makeup (gpm)	18.75
Blowdown (gpm)	3.67
Evaporation (gpm)	15.00
Drift (gpm)	0.0750
Half life(Hrs)	15.40

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Makeup Water Quality

- Calculations can be performed from the makeup water analysis to determine the point at which scale and corrosion will be unacceptable
- The result of the water analysis is compared to what pretreatments and chemical treatments can be used
- By comparing makeup water quality to available treatment options, the maximum potential cycles of concentration can be determined

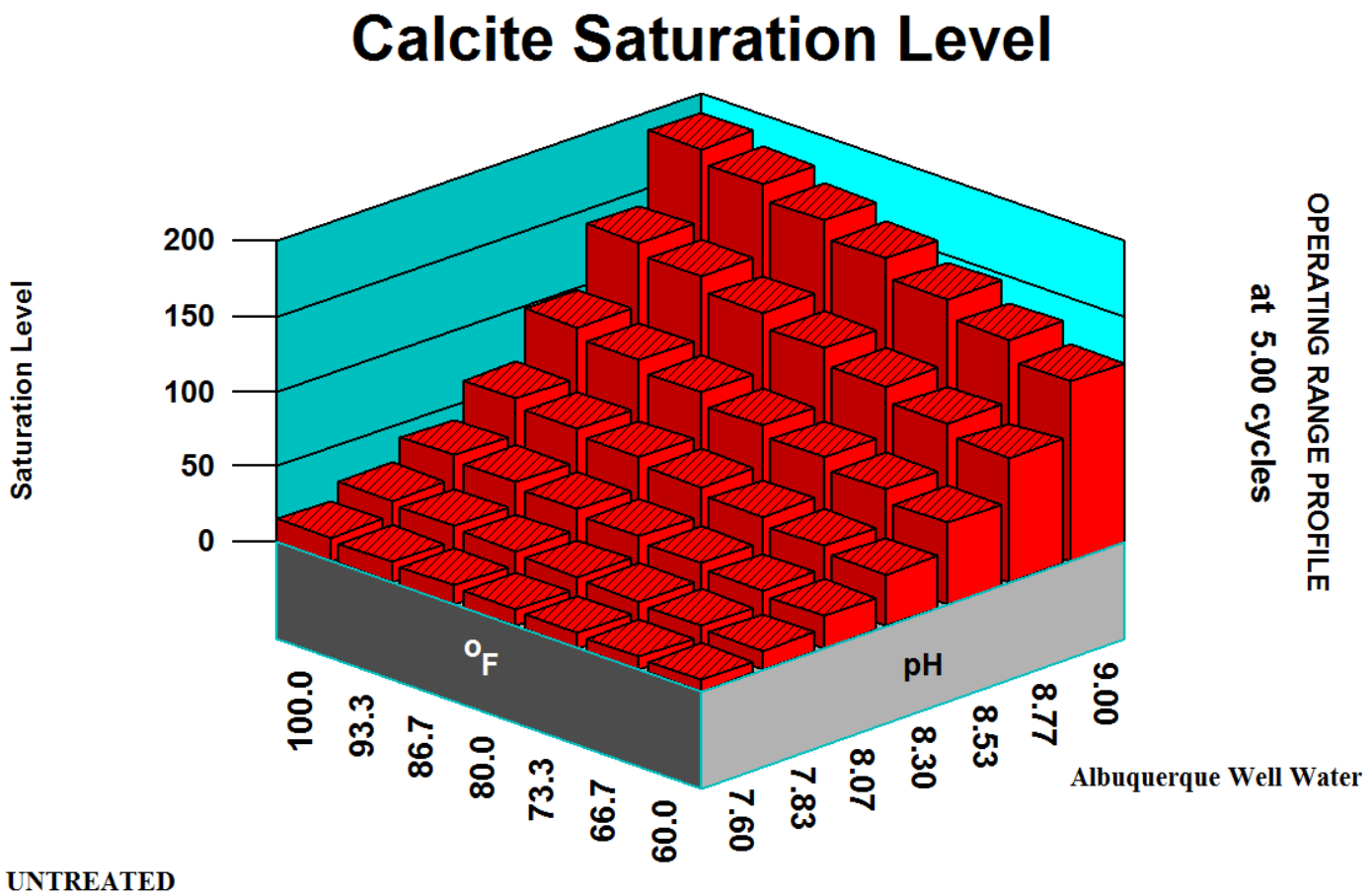
Water Chemistry For Each Source

- Water supplies vary
- Complete analysis should be done at least quarterly
- Computer Model is used to help determine chemistry problems

Computer Models Color Scheme

- RED-Indicates a definite problem.
- MAGENTA-Indicated a problem is highly likely.
- YELLOW-Indicates a problem will occur with minimum change. Slight changes in Temperature and pH.
- GREEN-Problems not likely.
- BLUE-Safe Operating range.

Calcite-Untreated



UNTREATED

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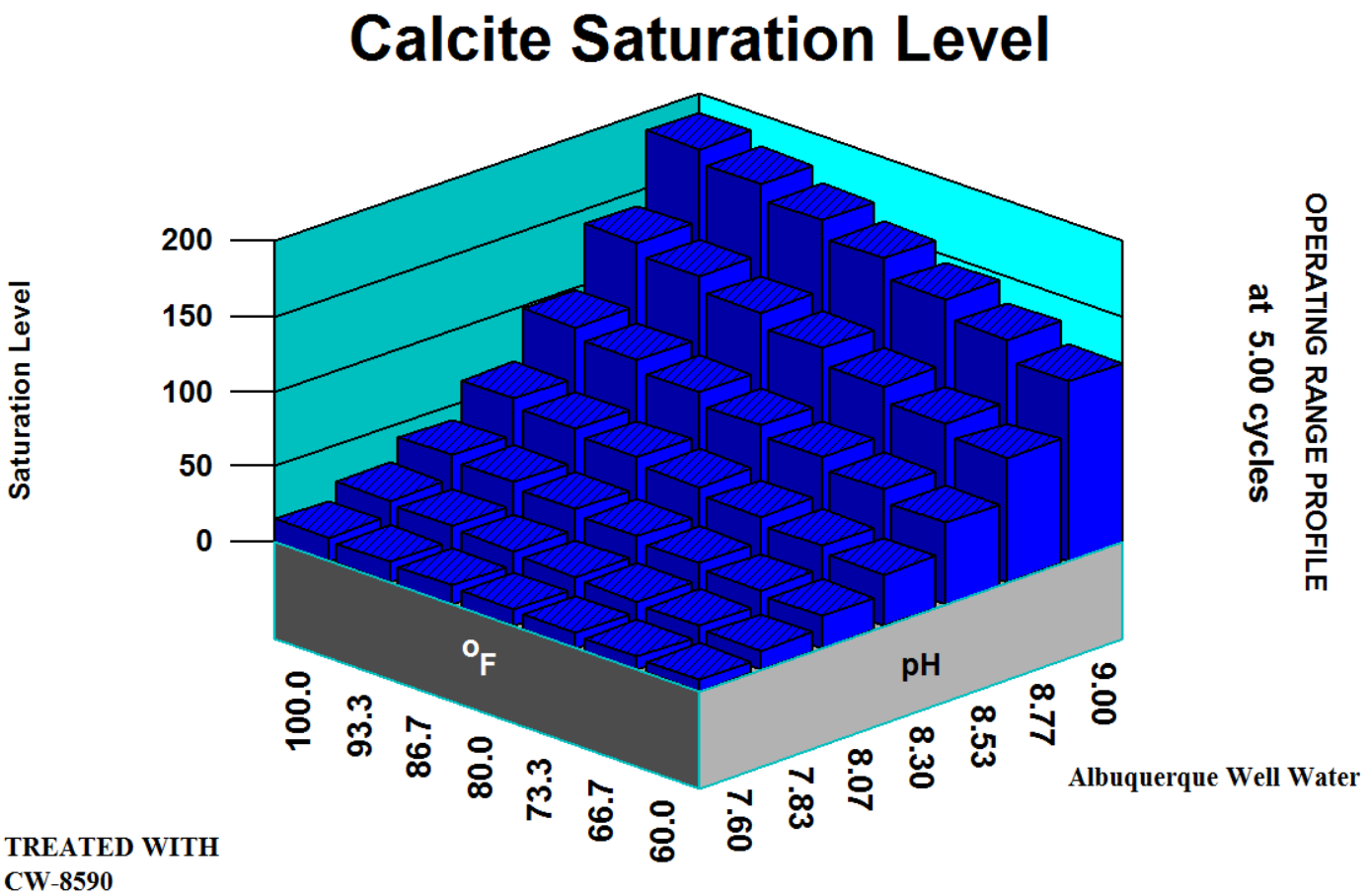
Calcite Treated



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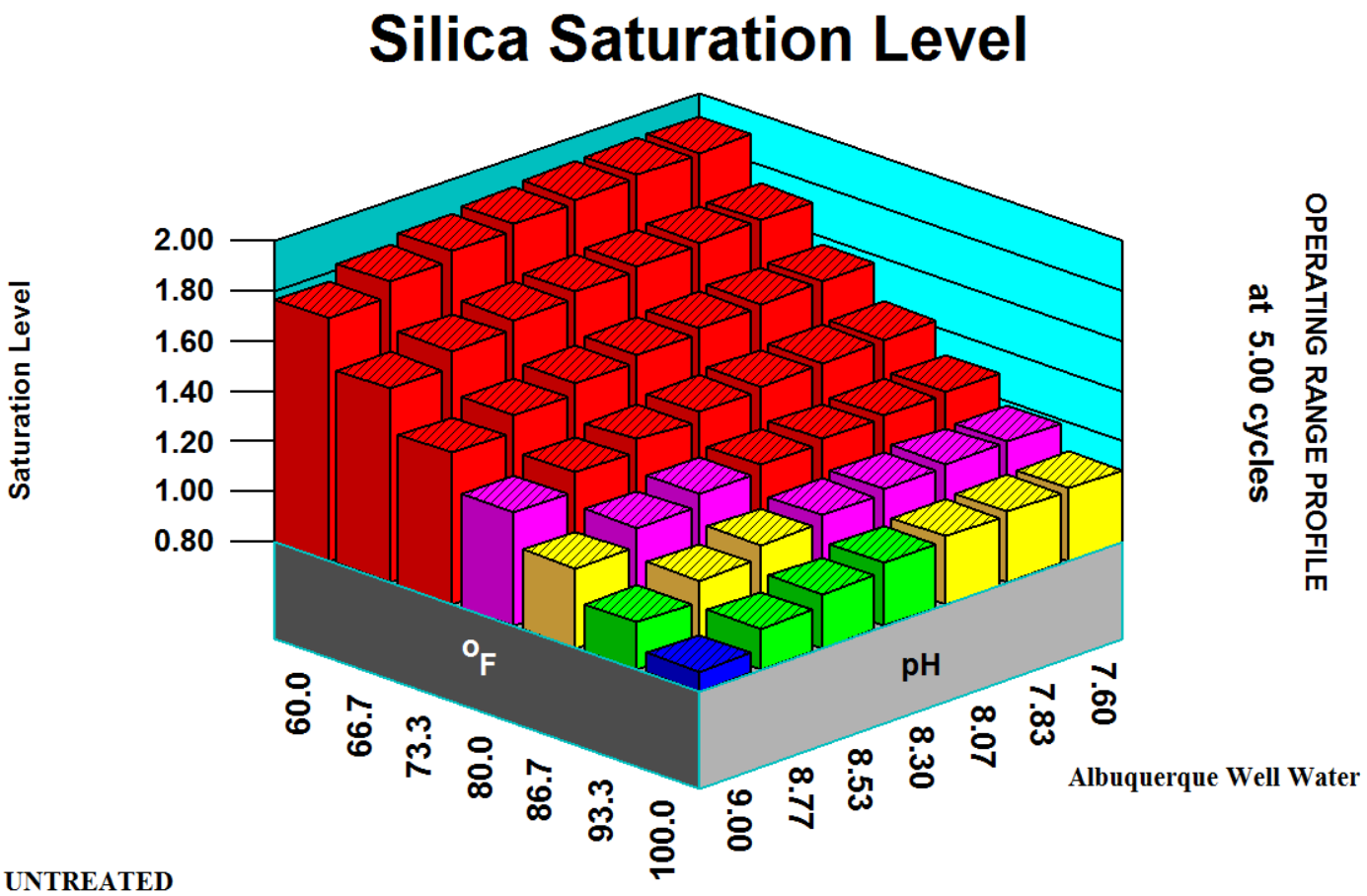
Silica Untreated



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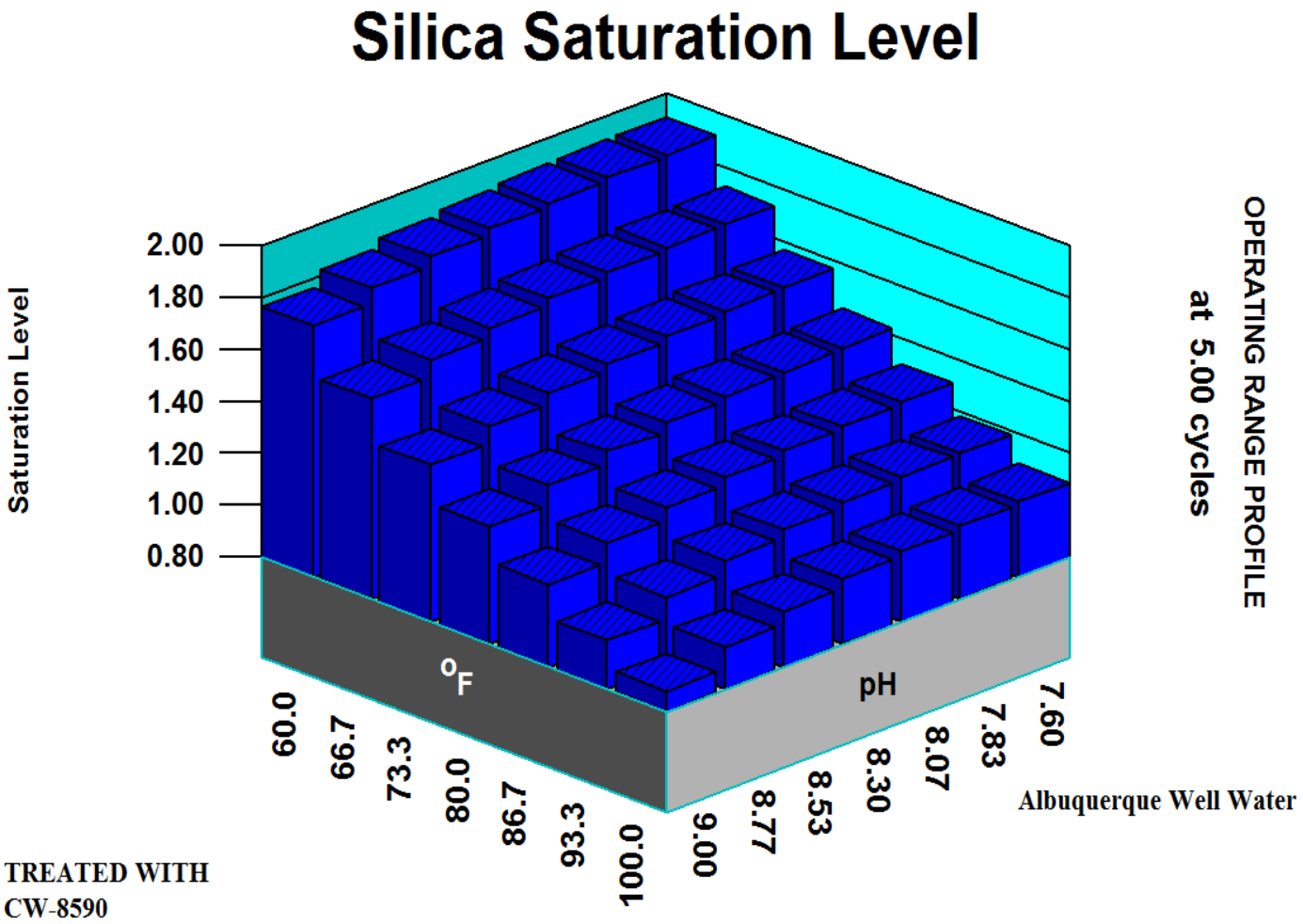
Silica Treated



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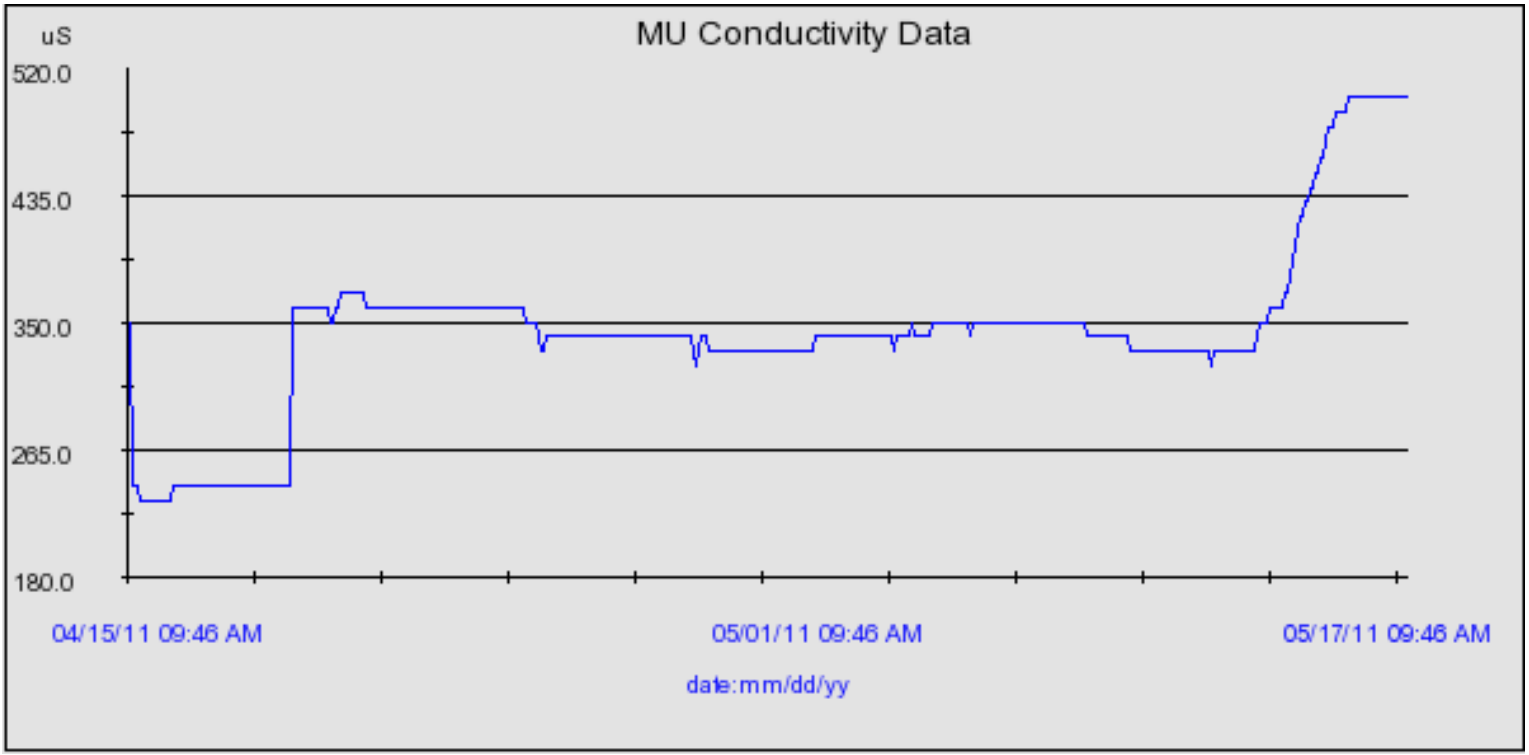
Multiple Water Sources

City of Santa Fe uses 4 separate water sources

1. Buckman well field-high hardness and sulfate
2. City Wells-Moderate Hardness and high silica
3. Buckman Diversion-river water, varies by season
4. Surface water-snow melt lakes, low hardness and silica.

Santa Fe Conductivity



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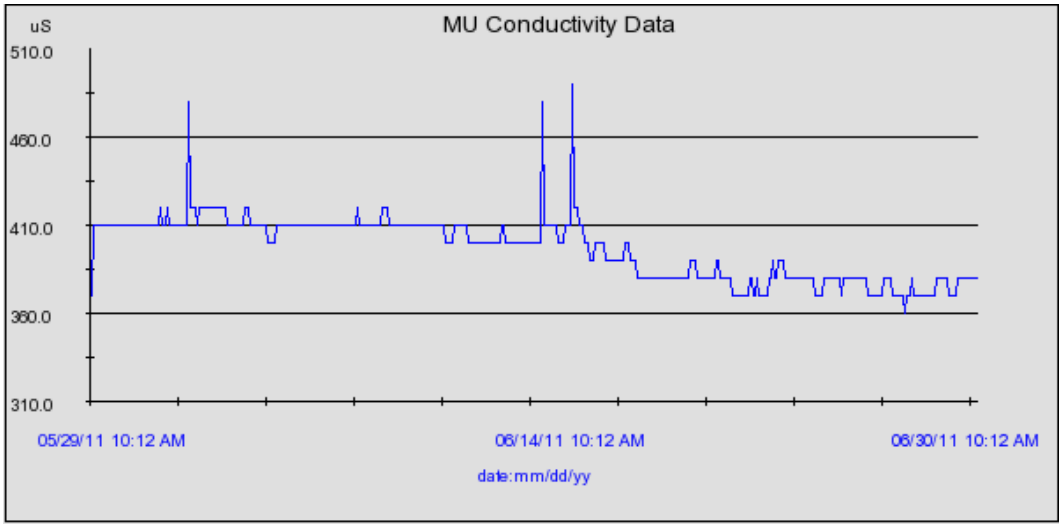
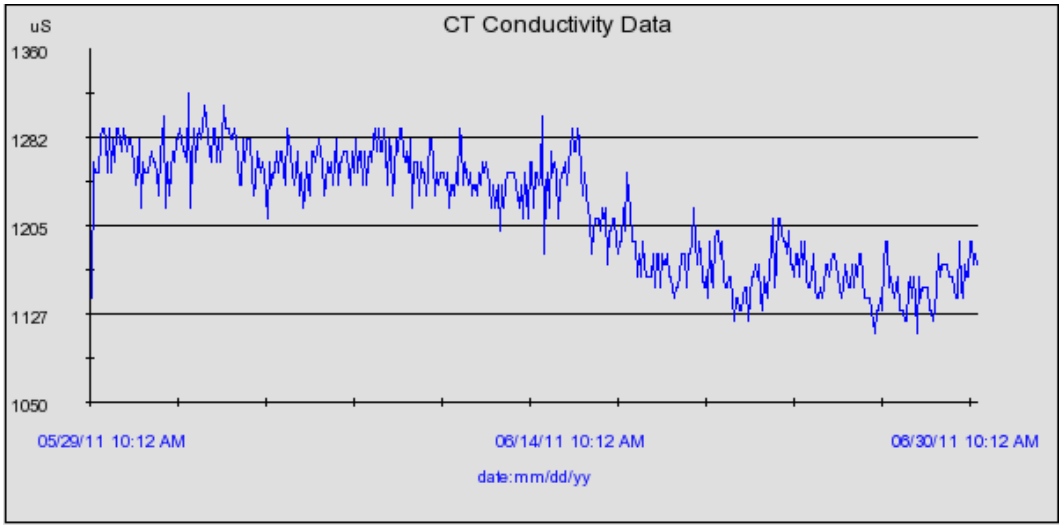
Automated Controllers

- Allow adjustments on bleed set point as makeup quality changes.
- Controllers can alarm and be controlled via our data logging and control system.
- ***<u>Do Not Use "Low End" controllers!!</u>***

Cooling Tower Conductivity-Real Time Auto Cycle Control





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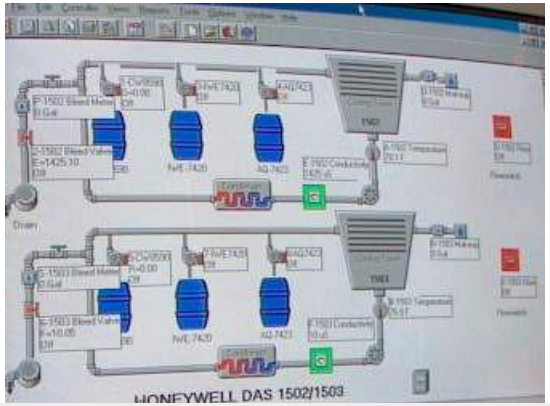
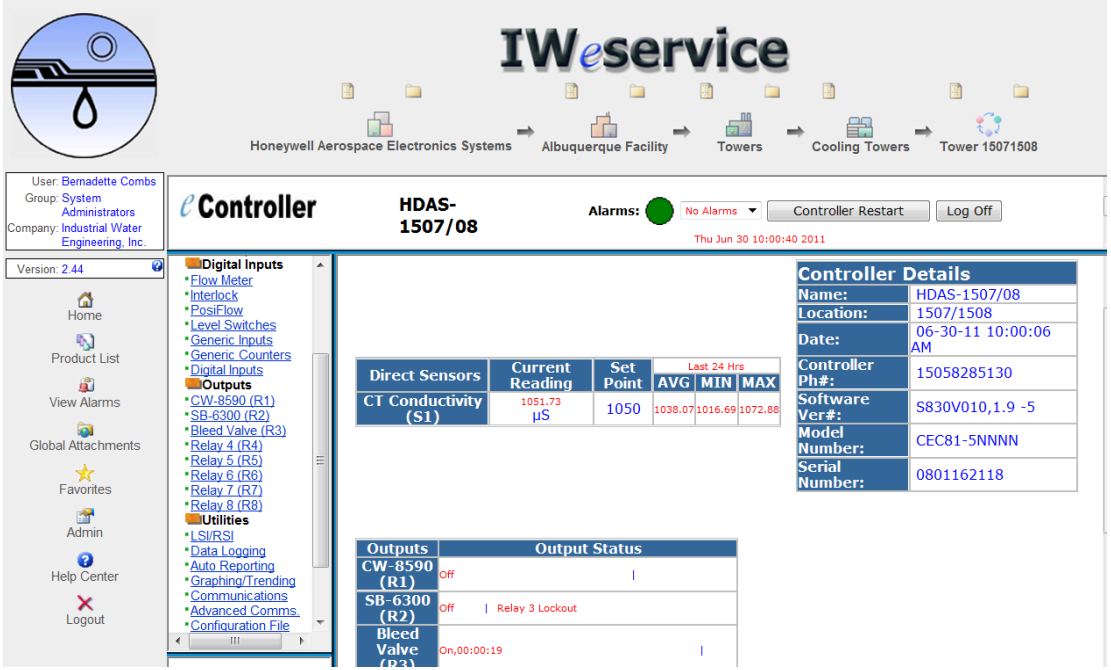
Remote Monitoring and Reporting

- Real Time monitoring
- Alarming Capabilities to email and cell phones
- Remote Login to Controllers 24/7
- 1 location for all records
- Trend parameters over time





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System Monitoring

- All systems will require “hands-on” monitoring
  - Calibration
  - Analytical Tests
  - Maintenance
  - Adjustment
- Do not depend solely on remote monitoring. You will fail!!

Traditional Deposit Control Schemes

- Remove Calcium by Make up Water Pre-treatment
  - Reverse Osmosis/Ultra Filtration
  - Cold Lime Process
- Transport Make-up Calcium to Bleed-off via Chemical Treatment
  - Acid/pH Control
  - Deposit Inhibition – Phosphonates & Polymers

Electro Chemical Device (ECD)

Two Old Technologies Yield A New Treatment Strategy

- "Cold Lime" Softening
- Electrolysis of Water

"COMBINED" IN ONE PROCESS

Electrolysis of Hard Water Containing Calcium Bicarbonate & Dissolved Solids

(Electrical Conductance)

1. <u>Primary Cathodic Reaction (Reduction of Water)</u>

$$4H_2O + 4e^- \rightarrow 2H_2 \uparrow \text{ (Hydrogen Gas)} + 4OH^- \text{ (Caustic)}$$

2. *Secondary Cathodic Reaction (Bicarbonate Ion & Caustic)*

$$4OH^- + 4HCO_3^- \rightarrow 4CO_3^= + 4H_2O$$

3. *Secondary Cathodic Reaction (Carbonate Ion with Calcium Ion)*

$$4CO_3^= + 4Ca^{++} \rightarrow 4CaCO_3 \downarrow \text{ (Solid adherent to cathodic surface)}$$

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8” Cylinder with 2 to 2½ inch accumulation of calcium carbonate

Carbonate ion in water layer at cathodic surface approaches 10,000 ppm

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How to Save Water and Energy

- Identify Major water users at the facility
- Characterize water streams over time.
- Use computer models to mix and reuse water.
- Understand costs associated with reuse.

Successful Applications

- Tower Bleed water used for Irrigation
- Reclaim water from Semi-Conductor Fab used as tower makeup.
- Electrochemical Device to remove Calcium Carbonate raise cycles without acid or chemicals.

Recommendations

- Magic Does Not exist. Do laws of chemistry apply? This is especially true with non-chemical devices.
- Check references of other users.