Green Technology for Water Treatment
MSAPPA 2020

The Increasing Demand for Water

- Fresh Water Uses
  - 43% Power Production
  - 31% Irrigation
  - 15% Public Supply
  - 8% Industrial/Commercial
  - 3% Agriculture
- Average US Household Uses
  - 300 gallons/day
    - 24% Toilet
    - 20% Bathing

- Water Managers in 40 of our 50 United States expect some type of water shortages within the next 10 years
  - (Causes: Population increases, Energy generation, Changes in land uses, & Climate changes)

Commercial & Industrial Water Uses

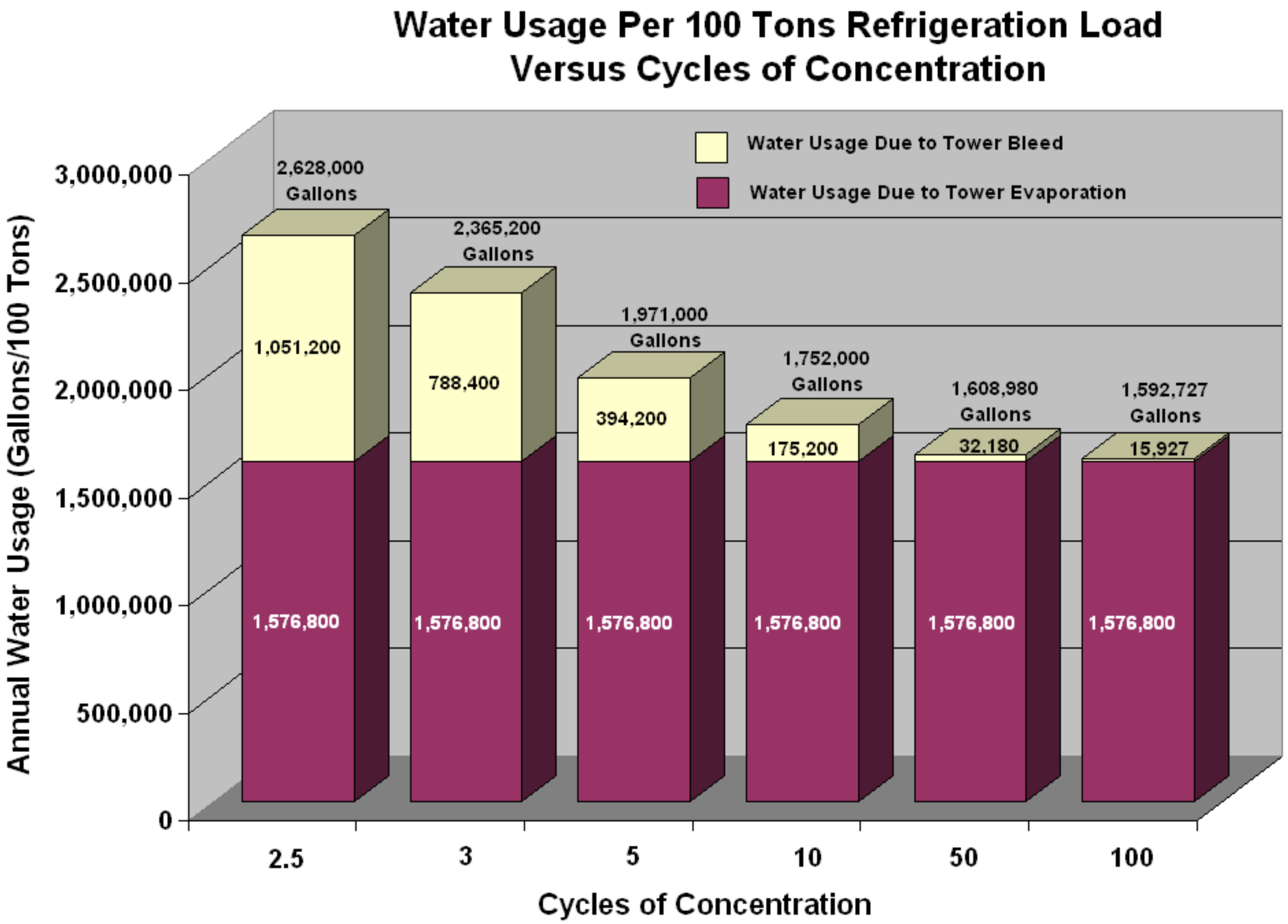
Air Conditioning
Process Cooling

Heating
Process Steam
Power Production

Green Technologies for Utility Reduction

- Pretreatment
- Air handler condensate recovery
- Zero blowdown
- Reclaim water
- Rain water recovery
- Blowdown heat recovery
- Solids water chemistries
- Advanced system controls

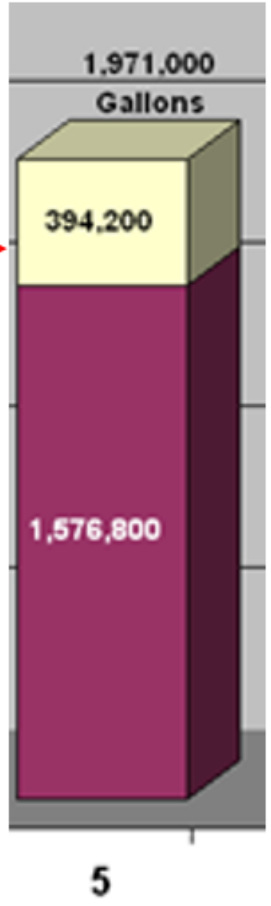
Understanding Where Water Goes



Where We Are

Running at 5.0 cycles

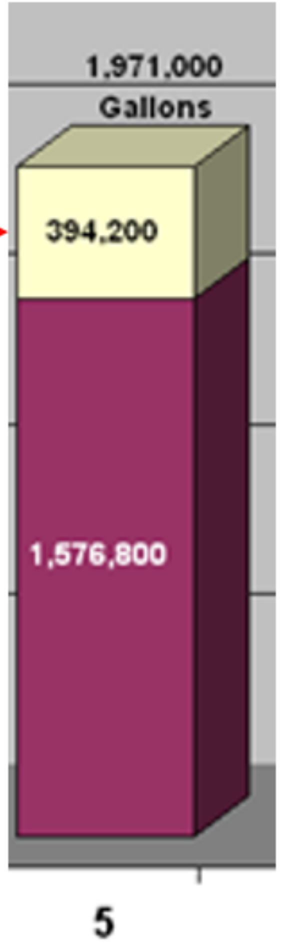
20% of your water
is bleed or blowdown.
This is the only real
“waste” in the system.



80% of your water is
evaporated to provide
the cooling you need.
This cannot be reduced
without reducing the
real cooling load.

Where To Attack

Usage reduction strategies attack here



Alternate water source strategies attack here

Pretreatment

Pretreatment Programs

Ion Exchange

Reverse Osmosis

- Improves water quality reducing the required blowdown or bleed off saving water and energy

Cooling Tower: ROI for Ion Exchange System

COOLSAVE Cooling Savings Opportunities

Calculation Worksheet Version 2014.10 US

Creation Date:	1/1/2020
Company Name	**XYZ Corporation**
Location	**Dallas, Texas**
System ID	Main Chiller Plant
Improvement Project	Ion Exchange on Makeup

Cooling System Data	
Max Cooling Capacity (Tons)	1,500
% Load (Enter in 5% increments)	90
Avg Cooling Load (Tons)	1,350
System Volume (Gal)	10,000
Hours per Day Operation	24
Days per Year Operation	300
Current Cycles	3.0

Utilities & Costs	
Avg Electricity Cost ($/kW-hr)	$0.75
Peak Chiller Efficiency (kW/Ton)	0.62
Current Annual Treatment Cost	$10,000
Makeup Cost ($/1,000 Gal)	$3.00
Sewer Cost ($/1,000 Gal)	$4.00
Total Water Cost ($/1,000 Gal)	$7.00

Typical Peak Chiller Efficiency	KW/Ton
New High Efficiency Chiller	0.50 - 0.62
New Moderate Efficiency Chiller	0.62 - 0.70
Older High Efficiency Chiller	0.70 - 0.85
Older Chiller	0.85 - 1.00

Peak Efficiency Tends to Decrease with Age

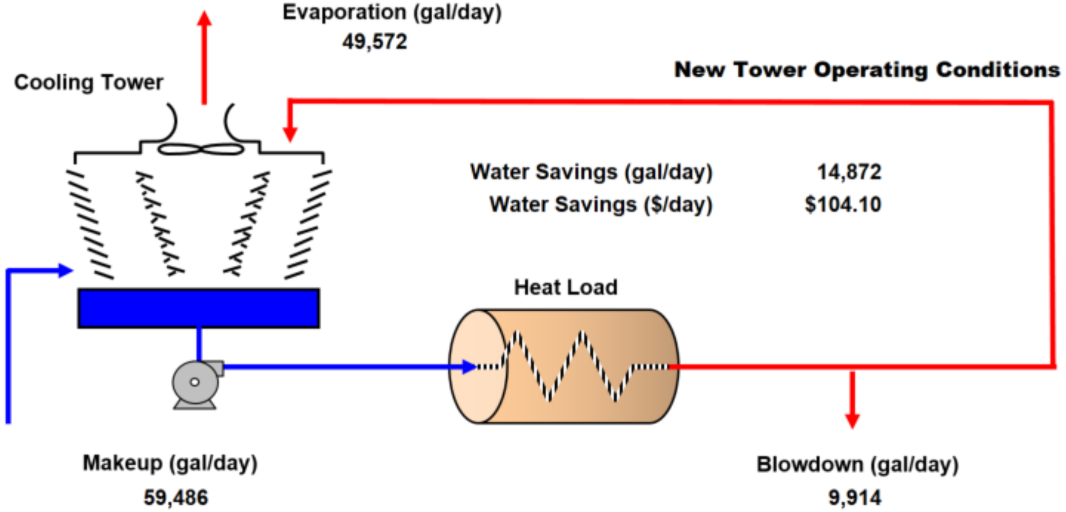
Closed System Data	
Closed System Volume (Gal)	15,000
Water Loss (GPD)	5

Tower LSI & Max Cycles Calculator	
Max. Skin Temp (F) *	110
Makeup Conductivity (µS/cm) *	300
Makeup pH	7.6
Makeup M-Alkalinity (ppm) *	120
Makeup Calcium Hardness (ppm) *	90
Makeup Total Hardness (ppm)	130
Makeup Silica (ppm) *	3.0

* Mandatory Input to Calculate LSI

Current Tower Cycles	3.0
Calculated Tower pH	8.70
LSI @ Calculated pH	2.08
Current Tower pH	8.6
LSI @ Actual pH	1.98
Max Cycles @ 150 ppm Silica	50.0
Silica @ Current Cycles (ppm)	9

Cooling Tower: Savings Through Reduced Blowdown



Cooling System Data			
Cooling Capacity (Tons)	1,500	System Volume (gal)	10,000
Hours per Day Operation	24	Makeup Cost ($/1000 gal)	$3.00
Days per Year Operation	300	Sewage Cost ($/1000 gal)	$4.00
Average % Load	90	Total Water Cost ($/1000 gal)	$7.00

Current Operating Conditions	
Current Tower Cycles	3.0
Evaporation (GPD)	49,572
Bleed (GPD)	24,786
Makeup (GPD)	74,358
Half Life (Hours)	6.8
Bleed (Gallons Per Year)	7,435,800
Makeup (Gallons Per Year)	22,307,400

New Operating Conditions	
New Tower Cycles	6.0
Evaporation (GPD)	49,572
Bleed (GPD)	9,914
Makeup (GPD)	59,486
Half Life (Hours)	16.9
Bleed (Gallons Per Year)	2,974,320
Makeup (Gallons Per Year)	17,845,920

Annual Water Savings From Reduced Blowdown (million gallons/year)	**4.461**
Annual Cost Savings From Reduced Blowdown ($/year)	**$31,230**

Cooling Tower: 10.2 Months ROI

Date:	1/1/2020
Company:	XYZ Corporation
Location:	Dallas, Texas
System:	Main Chiller Plant

Payback & ROI Analysis

Projects	Savings (Annual)	Initial Cost	Ongoing Cost (Annual)	Payback (Years)
Ion Exchange for Cooling Towers	$31,230	$20,000	$2,000	0.70

Steam Boilers: ROI for Reverse Osmosis

BOILERSAVE Boiler Savings Opportunities - US

Calculation Worksheet

Version 2014.11 US

Creation Date:	1/1/2020
Company Name	XYZ Corporation
Location	Dallas, Texas
System ID	Central Plant
Improvement Project	RO Pretreatment Steam Plant

Boiler System Data

Max Boiler Capacity (HP)	1,500
Average % Load	66
Max Boiler Capacity (Lb/Hr)	51,750
Actual Steam Output (Lb/Hr)	34,155
Operating Hours per Day	24
Operating Days per Year	300
% Condensate Return	50.0
% Makeup	50.0
Boiler % Efficiency (Clean Tubes)	80.0
Current % Boiler Efficiency	80.00
Operating Pressure (Psig)	100.0
Feedwater Temp (ºF)	228.0
Makeup Temp (ºF)	60.0
Condensate Temp (ºF)	160.0

Utilities & Costs

Fuel Type	Natural Gas
Fuel Purchase Unit	decatherm
BTU Value per Purchase Unit	1,000,000.0
Fuel Cost per Purchase Unit ($)	$6.00
Carbon Emissions (lb/MMBtu)	116.38
Makeup Cost per 1,000 Gal	$3.00
Sewer Cost per 1,000 Gal	$4.00
Total Water Cost per 1,000 Gal	$7.00
Current Annual Treatment Cost ($)	$12,000.00
Current Daily Treatment Cost ($)	$40.00

Blowdown Data

Current Makeup Cycles	9.0
Current Feedwater Cycles	18.0
Current % Blowdown	5.6%

Calculate Makeup Cycles from Feedwater Cycles

Enter Current Feedwater Cycles	18.0
Current Makeup Cycles	9.0

Calculate Max Makeup Cycles

Makeup Conductivity (µS) *	300
Makeup M-Alkalinity (ppm) *	110
Makeup Total Hardness (ppm) *	0.5
Makeup Silica (ppm) *	3.0

* All Makeup Levels Are After Pretreatment

Boiler Rating Conversions	
lb Steam/hr to Boiler HP	
Enter lb Steam/hr	
Calculated Boiler HP	0.0000
Input BTU Rating to HP Conversion	
Enter BTU Rating, MBH	
Calculated Boiler HP	0.0000
Output BTU Rating to HP Conversion	
Enter BTU Rating, MBH	
Calculated Boiler HP	0.0000

ESTIMATE BOILER EFFICIENCY

Insert Rated Efficiency with Clean Tubes:

Select Scale Thickness from Drop Menu:

None

Select Type of Scale Deposit from Drop Menu:

None

Estimated Present % Efficiency:

MUST CLICK to Enter Scale & Fuel Data

CHOOSE FUEL & UNIT OF MEASUREMENT

Natural Gas (decatherm = 1,000,000 Btu)

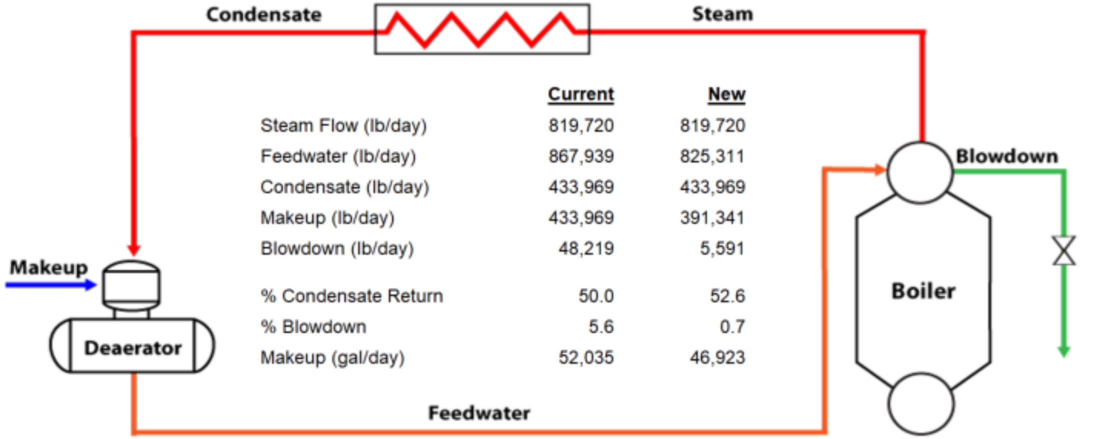
Notes:

TMJ = Thousand Megajoules

Carbon = Carbon Dioxide (CO_2)

Max Makeup Cycles By Parameter		
< 300 psig Firetube Boiler	**< 300 psig Water Tube Boiler**	**301 - 450 psig Water Tube Boiler**
23.3	23.3	11.7
9.1	9.1	6.4
500.0	100.0	50.0
60.0	60.0	33.3

Steam Boilers: Savings Through Reduced Blowdown



	Current	New
Steam Flow (lb/day)	819,720	819,720
Feedwater (lb/day)	867,939	825,311
Condensate (lb/day)	433,969	433,969
Makeup (lb/day)	433,969	391,341
Blowdown (lb/day)	48,219	5,591
% Condensate Return	50.0	52.6
% Blowdown	5.6	0.7
Makeup (gal/day)	52,035	46,923

Boiler System Data

Maximum Boiler Capacity (HP)	1,500	Feedwater Temperature (°F)	228
Average Load (%)	66	Makeup Temperature (°F)	60
Average Steam Flow(lb/hr)	34,155	Condensate Temperature (°F)	160
Hours per Day Operation	24	Fuel Type	Natural Gas
Days Per Year Operation	300	Fuel Unit Of Measure	decatherm
Operating Pressure (psig)	100	Heat Content Per Unit (BTU)	1,000,000
Current Boiler Efficiency (%)	80.0	Carbon Emissions (lb/MMBtu)	116.4
Boiler Water Temperature (°F)	337.8	Fuel Cost Per Unit Measure ($)	$6.00
		Total Water Cost ($/1000 gal)	$7.00

Current Operating Conditions

Current Makeup Cycles	9.0
Current Feedwater Cycles	18.0

New Operating Conditions

New Makeup Cycles	70.0
New Feedwater Cycles	147.6

Savings Summary

Blowdown Savings (lb/hr)	1776		
Energy Savings (MMBtu/day)	14.80	Water Savings (gal/day)	5,111
Energy Savings (MMBtu/year)	4,440.8	Water Savings (gal/year)	1,533,390
Energy Savings ($/year)	$26,645	**Water Savings ($/year)**	$10,734

Annual Cost Savings From Reduced Blowdown ($/year)	**$37,379**
Annual Reduction in Carbon Emissions (lb/year)	**516,820**

Steam Boilers: 24 Month ROI

Date:	1/1/2020
Company:	XYZ Corporation
Location:	Dallas, Texas
System:	Central Plant

Payback & ROI Analysis

Projects	Savings (Annual)	Initial Cost	Ongoing Cost (Annual)	Payback (Years)
RO Makeup Steam Plant	$37,379	$80,000	$2,000	2.19

Air Handler Condensate (AHC) Recovery

Capturing and Reusing Air Handler Condensate (AHC)

- Concept is not new
- Will discuss some of the easiest ways to reuse AHC with significant savings
- **Possible Uses:**
  - Internal gray water (flushing commodes, utility wash water, etc.)
  - Decorative fountain makeup water
  - Irrigation
  - Cooling tower makeup water
  - Chilled water makeup water
  - Chilled water makeup, then tower water makeup

How Much AHC is Available

An article in the May 2012 ASHRAE Journal did a very comprehensive study of the amount of AHC available in different cities around the U.S.

10 Cities With the Most*	10 Cities With the Least*
1. Miami, FL	1. Spokane, WA
2. Honolulu, HI	2. Salt Lake City, UT
3. Orlando, FL	3. Billings, MT
4. New Orleans, LA	4. Las Vegas, NV
5. San Antonio, TX	5. Des Moines, IA
6. Denver, CO	6. Albuquerque, NM
7. Memphis, TN	7. Redmond, WA
8. Athens, GA	8. Seattle, WA
9. Chicago, IL	9. San Francisco, CA
10. Topeka, KS	10. San Luis Obispo, CA

*For a complete list, please see “The Economics of AHU Condensate Collection,” Lawerence, Perry, Alsen; ASHRAE Journal, May 2012.

How Much AHC is Available

- You can calculate how much is available to you by one of two methods:

Use the formula:

AHC (gal/cfm) = 0.4777 x Average Dew Point

\+

0.00204 Cooling Degree Days + 0.32596

x

(Average Rainfall April through Oct) - 22.50

Or…

Examples of Available AHC

Facility Size	Type	Location	Condensate Recovery
165,000 sq ft	Office Building	Dallas, TX	650,000 gal/year
280,000 sq ft	Office Building	Miami, FL	1,420,000 gal/year
420,000 sq ft	Office Building	New York, NY	2,400,000 gal/year
300 Bed	Hospital	Atlanta, GA	3,400,000 gal/year
11,000 Students	University[1]	Dallas, TX	11,000,000 gal/year
18,000 Students	University[2]	Birmingham, AL	35,000,000 gal/year

[1] Approximately six buildings out of 50 are used to generate this amount of condensate water.
[2] Only twenty buildings out of over 160 are used to generate this amount of condensate water.

AHC Re-use

- Now that you have a rough idea of how much AHC you have available, let’s consider the relative ROI’s for the various uses.

AHC ROI

AHC: Decorative Fountain Makeup Water

- Available Savings
  - Reduction in potable water ($3.00/1,000 gal)
  - Possible reduction in sewer charges, if not metered separately ($4.00/1,000 gal)

AHC: Irrigation

- Available Savings
  - Reduction in potable water ($3.00/1,000 gal)
  - Possible reduction in sewer charges, ($4.00/1,000 gal)

AHC or Internal Grey Water

- Possible uses include flushing commodes and utility wash water.
- Available Savings
    - Reduction in potable water ($3.00/1,000 gal)
    - Possible reduction in sewer charges, if not metered separately ($4.00/1,000 gal)

AHC: Cooling Tower Makeup Water

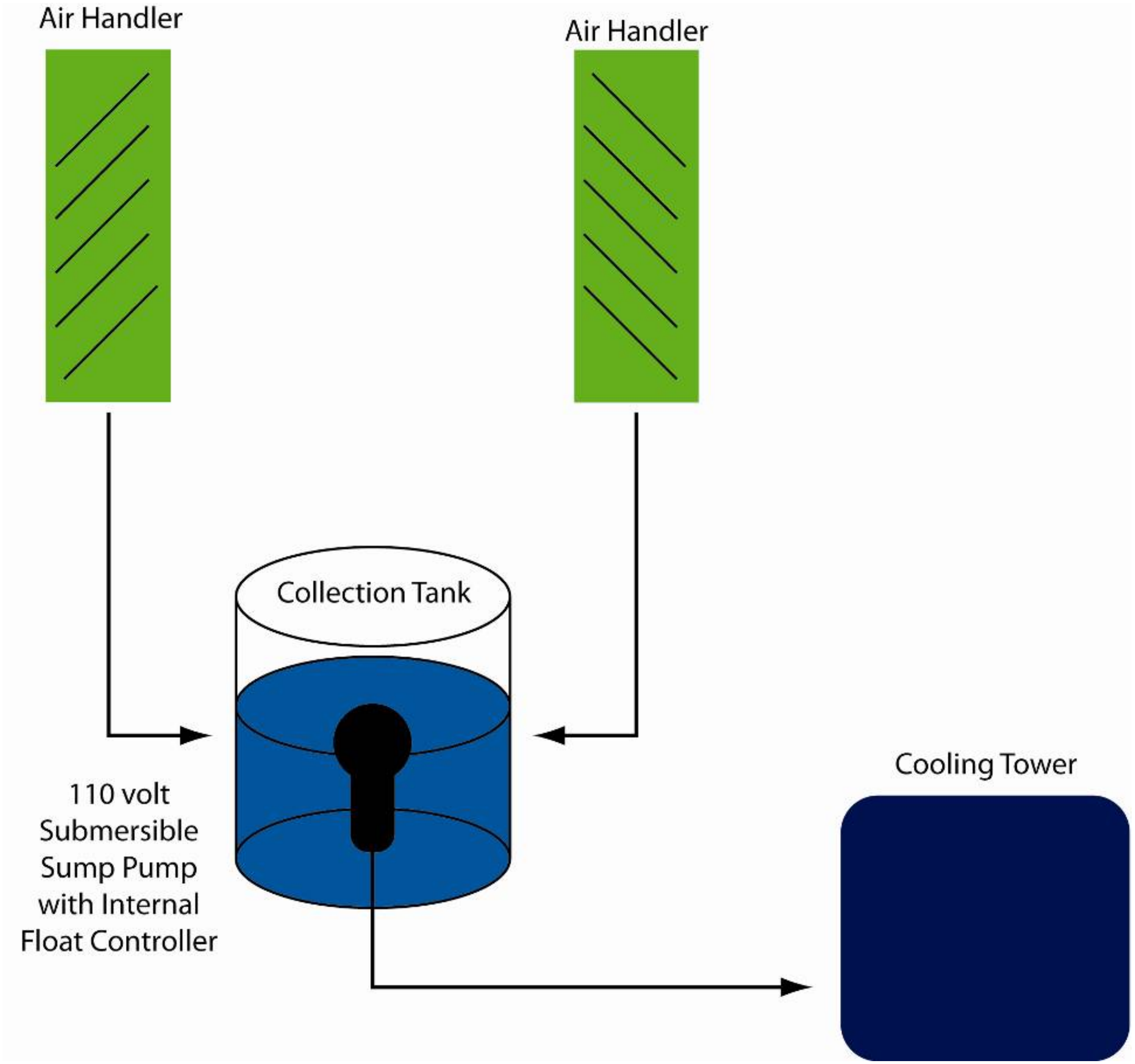
- Available Savings
  - Reduction in potable water ($3.00/1,000 gal)
  - Possible reduction in sewer charges ($4.00/1,000 gal)
  - Further reduction in both potable water and sewer by allowing higher cycles from existing potable water ($7.00/1,000 gal)
  - Energy savings by reducing approach temperature on hottest days (up to 10% of electrical cost)

AHC: Chilled Water then Tower Makeup

- Available Savings
  - Reduction in potable water ($3.00/1,000 gal)
  - Possible reduction in sewer charges, if not metered separately ($4.00/1,000 gal)
  - Direct energy savings by making up with 45°F water instead of 65°F water (210 Btu's/gal at 80% efficient chiller)
  - Further reduction in both potable water and sewer by allowing higher cycles from existing potable water ($7.00/1,000 gal)
  - Energy savings by reducing approach temperature on hottest days (up to 10% of electrical cost)

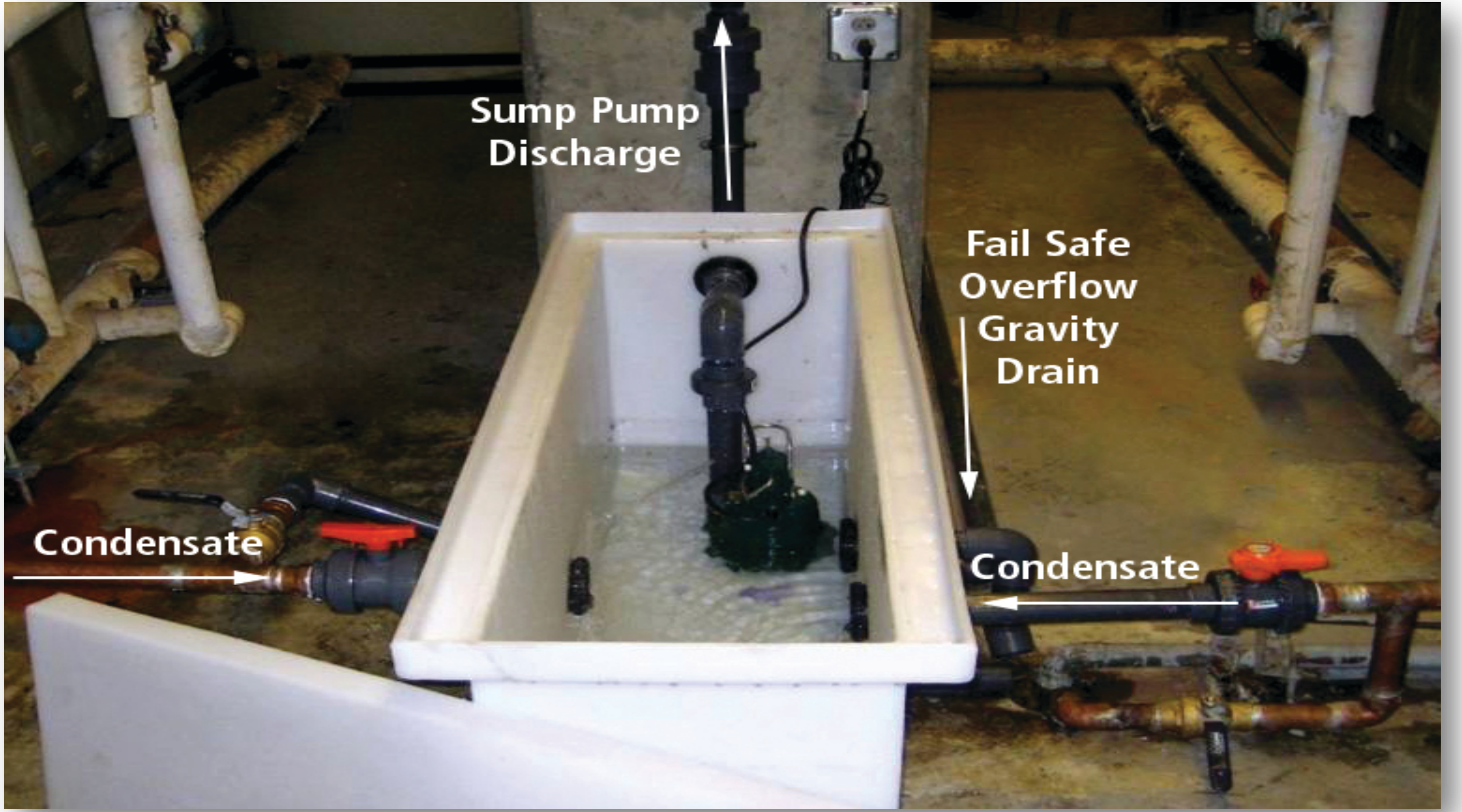
AHC Example

Collecting AHC From Two Air Handlers Using a Single Tank



In most facilities, the air handlers are in close proximity to either the tower water return line or the condenser water supply line. In those instances it is simple to collect the AHC water from the air handlers (usually by gravity) into a small collection tank, then pump it directly into the tower water or condenser water line. It can also be pumped directly into the tower basin.

Collecting AHC From Two Air Handlers Using a Single Tank



AHC as Cooling Tower Makeup Water

- This is an easy, straightforward project
- Typically can be done in-house with commonly available parts and fittings
- Payback, just based on water and sewer savings, is generally between 8 and 18 months, depending on the amount of AHC available and local water and sewer rates

AHC as Cooling Tower Makeup Water

Where do those energy savings come from?

- Most AHC is captured at a temperature of around 45°F
- On the hottest, most humid days you have the most AHC available
- If you can add enough cold water directly to the chiller supply, you can improve the chiller approach temperature
- A 2°F improvement over design typically reduces electrical consumption by 10%

Reclaim Water

Using Municipal Waste Discharge Reclaim Water for Cooling Tower Makeup at Large International Airport

Reclaim Water: Project Background

- The Airport supplies air conditioning to the terminals and planes
  - 39,000 tons of refrigeration capacity
  - 500,000 gallon cooling tower system
  - 8.5 million gal thermal storage system (helps shift chillers load to off peak hours)

Reclaim Water: Project Background

- 2013 Water use
    - 140,000,000 gallons potable water used for cooling tower make up
    - Annual Cost $500,000
- Replacing the potable water with reclaimed water
    - Reduced water costs by $300,000 annually
- Project Challenges
    - Variable makeup water quality makes treatment more difficult and costly
    - Increased potential for scale deposits, especially calcium phosphate deposits
    - Increased potential for corrosion problems
    - Increased potential for microbiological problems (slime, algae, microbial fouling)

Reclaim Water: Water Quality Challenges

The reclaimed water analysis shows significantly higher levels of 4 key impurities than the city water currently used for tower makeup.

- Orthophosphate
- Calcium Hardness
- Alkalinity
- Nitrogen – Nitrate

	City Water	Reclaimed
Conductivity (µmhos/cm)	327	952
pH	7.7	8.4
Calcium Hardness (ppm $CaCO_3$)	66	155
Magnesium (ppm $CaCO_3$)	13	28
M-Alkalinity (ppm $CaCO_3$)	88	172
Chloride (ppm Cl)	25	105
Silica (ppm SiO_2)	2.3	8.5
OrthoPhosphate (ppm PO_4)	0.2	4.2
Nitrate (ppms NO_3-N)	0.6	17.3
Iron, Total (ppm Fe)	0.15	0.19
Copper, Total (ppm Cu)	0.03	0.00

Reclaim Water: Dollars Invested

Significant financial investments and commitments have been made to deliver reclaimed water from the municipal facility to the Airport property

The economic, social, and environmental payback associated with these investments is a direct function of how much reclaimed water can be used to replace potable water

Reclaimed Water Storage Tank

Reclaim Water: Project Scope of work

- PHASE 1 - Initial Feasibility Study
  - Identify key technical issues and requirements
  - Identify key economic issues and requirements
  - Generate Project Plan and Costing Proposal
- PHASE 2 - Benchmarking and Program Development (3 – 6 months, Apr 2014 –Sept 2014)
  - Begin weekly laboratory mineral / microbiological analysis of reclaimed water, city, and tower water samples.
  - Begin in-plant testing program for reclaimed water
  - Develop treatment program for PHASE 3
  - Provide Direct Analysis Response Technology Control System to monitor 24/7 and document water chemistry (pH, ORP, Inhibitor) and program results including corrosion rates
- PHASE 3 – Operate Cooling Tower System With 50% Reclaimed Makeup (6 – 12 months , Sept 2014 – Feb 2015)
  - Monitor Program for 6 – 12 months and refine treatment approach and service program based on additional data
  - Quarterly Technical / Business Review with a formal Presentation PHASE 4 (Recommendations and Cost Proposal)
- PHASE 4– Migrate Cooling Tower System To 100% Reclaimed Makeup (On-Going)
  - Continue to refine treatment approach and service program
  - Quarterly Technical / Business Reviews

Reclaim Water: Project to Date

- Due to the wide swing of reclaim quality limited to 50% blend (city with reclaim)
    - Phosphate impurities vary significantly
    - High microbiological counts
- Chiller inspections show acceptable results
- On going effort to increase reclaim % blend
- Continue to refine treatment approach
- Social and environmental payback meeting expectations
- Average annual savings ≈ $85,000 (15% reduction)

Reclaimed Water: Reclaimed Water Analysis

Location	Dallas TX	Dallas TX	San Antonio, TX	Lubbock, TX	Orlando, FL	Ashburn, VA
Sample Type	City	Reclaimed	Reclaimed	Well	Reclaimed	Reclaimed
Test						
Conductivity	327	944	1100	2133	661	1248
pH	7.7	8.4	7.5	7.8	7.6	7.7
M-Alkalinity as $CaCO_3$	88	169	250	261	134	125
Calcium Hardness as $CaCO_3$	66	162	235	249	114	116
Magnesium as $CaCO_3$	0	33	37	493	38	48
Chloride as Cl	25	98	190	276	81	129
Sulfate as SO_4	28	51	61	324	33	89
Silica as SiO_2	2.3	10.3	16.1	64.8	13.4	8.5
Ortho Phosphate as PO_4	0.2	4.9	7.0	0.3	5.3	0.2
Iron - Total as Fe	0.15	0.22	0.08	0.06	0.07	0.223
Ammonia (N-NH_3)	0	0.6	1.5	NA	NA	9.4
Turbidity		<1	1.1	NA	<1	<0.1

Reclaim Water: Limiting Factor is phosphate levels

	Make Phosphate	4.9 ppm		7.0 ppm	
Operating Scenairos	Baseline	Scenairo 1	Scenairo 2	Scenairo 1	Scenairo 2
Tower Cycles	5.8	4.0	2.5	2.8	1.7
% Reclaimed Water	0%	100%	100%	100%	100%
Target Tower M-Alk (Acid Feed)		75	200	75	200
Tower pH (Acid Feed Adjusted)	8.9	7.4	8.2	7.4	8.2
Max Tower Phosphate (ppm)	3.0	20.0	12.5	20.0	12.5
Phosphate Polymer Req (ppm)	2.3	9.8	18.4	6.9	12.5
Water Usage / Cost					
Avg. Bleed Rate (GPD)	65,792	105,268	210,536	175,447	451,148
Avg. Makeup Rate (GPD)	381,596	421,072	526,340	491,251	766,952
Annual Water Cost ($/Yr)	**$501,418**	**$222,852**	**$278,565**	**$259,994**	**$405,910**
Chemical Usage / Cost					
Sulfuric Acid (Gal/Year)	0	13,970	10,344	15,426	8,697
Annual Sulfuric Acid Cost ($/Yr)	**$0**	**$64,820**	**$47,995**	**$71,579**	**$40,353**
Annual Inhibitor Cost (Ex Acid)	**$45,027**	**$86,973**	**$259,756**	**$144,954**	**$427,520**
Total Water / Chemical Cost	**$546,444**	**$374,645**	**$586,316**	**$476,527**	**$873,782**
Savings/Cost Versus Baseline		**$171,800**	**-$39,872**	**$69,917**	**-$327,337**

Solids Technology

Solids: Advances In Water Treatment

- Solid Water Treatment programs have become an attractive alternative to liquid programs during the last few years
- Solid chemistry that replaces the traditional boiler and/or cooling tower liquid chemicals in drums
- Solid Water Treatment System is an innovative solution for your building's water treatment needs

Solids: Feed Systems

- Concentrates + Feeder

HandiPak
Solid Bottle

+

HandiFeed
Solid Feeder

=

HandiChem
Solid System

Solids: Active Ingredients

The same active ingredients in liquid products are available as solid concentrates.

- Boiler Water Treatment
  - Typical boiler water products, such as phosphate, polymer, sulfite, and steam line treatments, are available in solid form
- Cooling Tower Treatment
  - Typical cooling water products, such as phosphonates, dispersants, tracers, and biocides are available in solid form
- Hot and Chill Closed Loop System Treatments
  - Hot or chill closed loop products, such as nitrite, molybdenum, and polymers, are available in solid form

Solids: Benefits

- Simplicity of use
  - Eliminates drum handling, storage, and disposal
  - Product loading only requires handling a bottle or block
  - Solid concentrate cases are easily moved throughout the building on a hand truck or cart
  - Ideal system for use in hard-to-reach locations
- Easier to ship
  - Simpler transportation logistics
    - Can ship anywhere UPS®* or FedEx®** deliver
    - Expedited delivery is more cost efficient
  - Available everywhere

*Registered trademark of United Parcel Service of America, Inc.

**Registered trademark of Federal Express

Solids: Benefits

- Easier to handle
  - Operator only has to handle an 11 lb bottle or block, not a 300 lb drum, to change out product
    - Reduced potential for workplace injury
    - Lower labor costs
    - Ideal for use in hard-to-reach places
  - More convenient
- Eliminates drum disposal concerns
- Environmentally sustainable
  - Lower levels of sodium hydroxide than traditional liquids
  - Reduces splash and spill concerns versus liquids
  - Reduces packaging requirements and disposal
  - Reduces fuel and greenhouse gas emissions associated with product delivery

Solids: Benefits

- Helps comply with green purchasing initiatives and certification programs
  - GSA gives preference to products and services with environmentally responsible attributes
  - State/local governments and corporations are also specifying sustainability
  - All types of organizations are seeking LEED®* (Leadership in Energy and Environmental Design) certification for their buildings

GSA

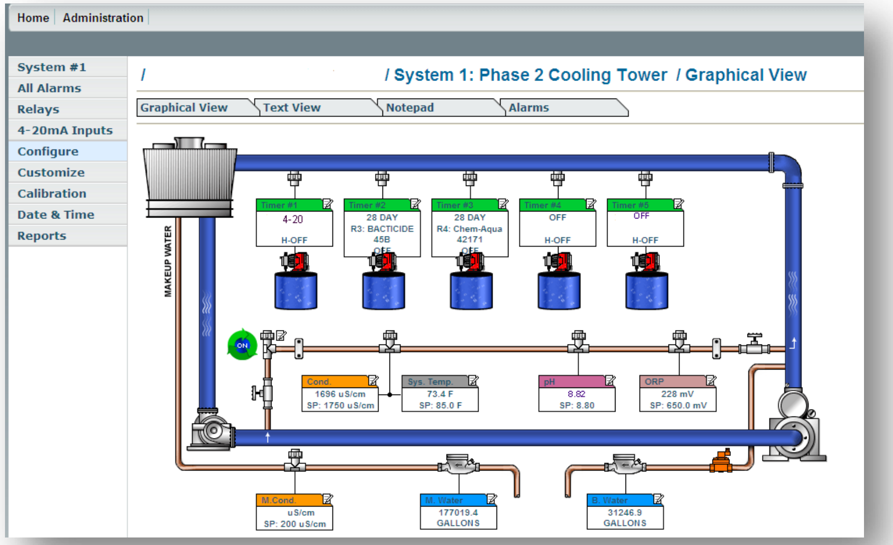
Environmentally Preferable Purchasing (EPP)

*LEED is a registered trademark of USGBC®

Advanced System Controls

Advanced Systems Control

- 24/7 real time monitoring of your system
- Notification of system imbalance for immediate adjustments
- Early warning detection of system efficiency
- Quick system corrective action
    - Minimizes utility costs
    - Protects capital investment by increasing life cycle
    - Reduces carbon footprint



Smart Controllers

- Real-time sensors continuously monitor the key parameters that determine scale, corrosion, and microbial growth
  - Conductivity and cycles
  - Corrosion/scale inhibitor
  - Biofilm potential
  - Biocide feed
  - Water usage
- Direct Analysis Response Technology uses this data to regulate blowdown and chemical feed based on changes in system demand
- Immediately communicates upset conditions to designated personnel

Smart Controller Weekly Graphs

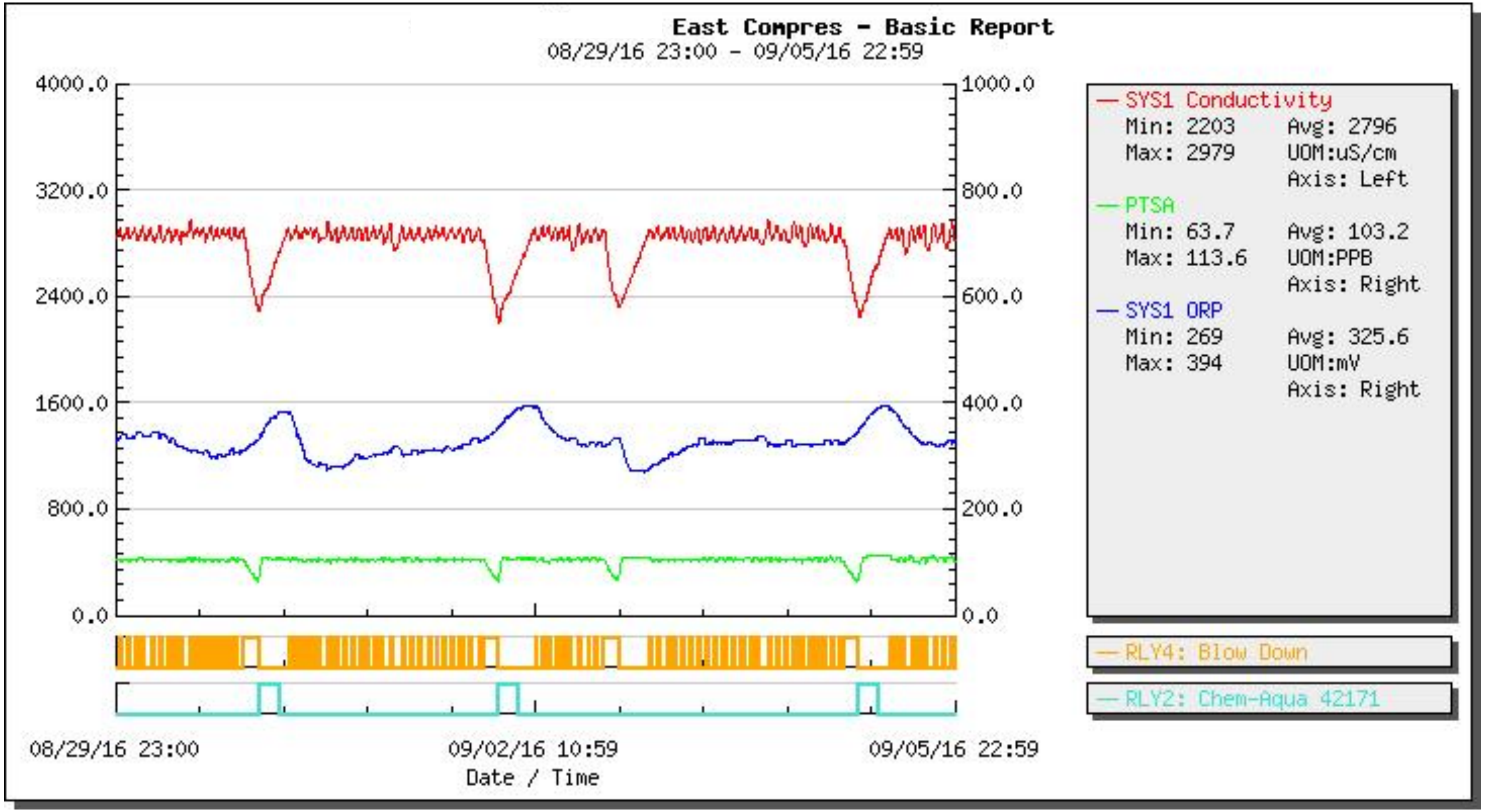
1) Halogen shows 3 feeds per week with ORP increase from base line of 325 milli-volt to 400 milli-volt.

2) Biocide bump down at least 50 milli-volts

3) Pre-Bleed to Oxidizer feeds

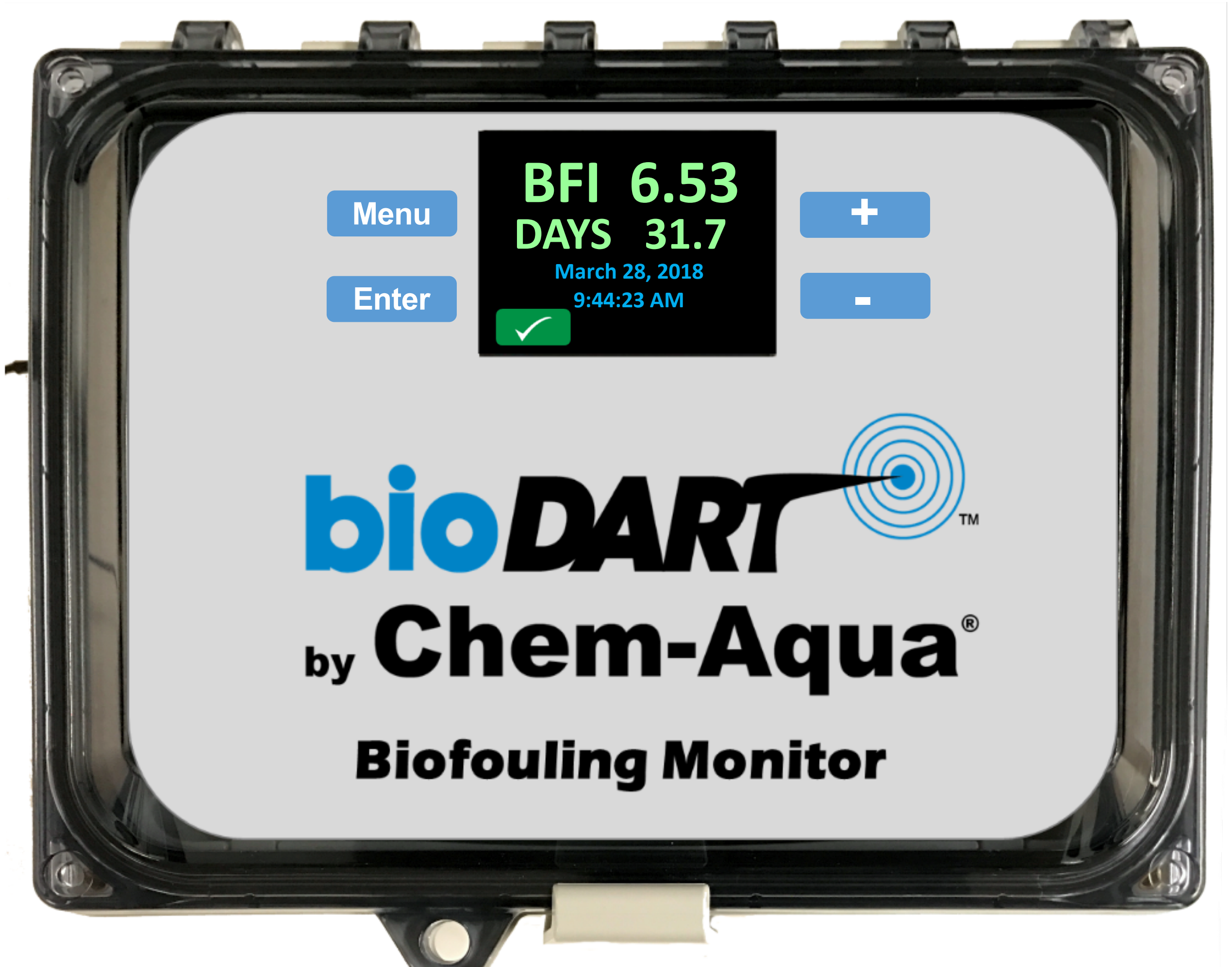
4) PTSA reductions due to pre-bleeds

5) Relay for non-oxidizer should be shown



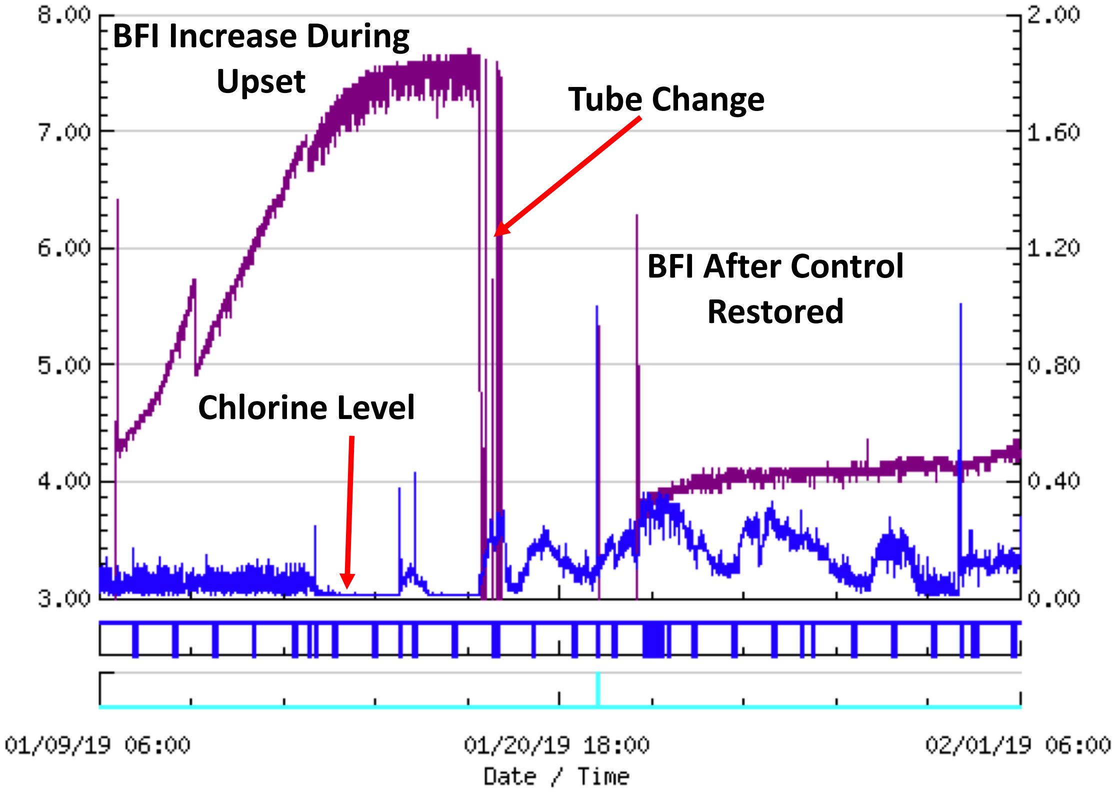
bioDART Biofouling Monitor

- Sensitive, system specific indicator of potential to form biofilm and overall microbial control
- Early warning for upset conditions that cause biofouling
- Stand alone monitor or can be connected to a controller
- Cost effective
- Patent Pending



Biofilm Monitoring

- Biofilm monitor and Smart Controller identified several significant events in air washer
  - In response to an abnormal BFI* increase, rep found biocide pump was not working
  - In response to BFR Alert, rep found roll filter chain broke dislodging debris from a sump that had not been cleaned in 18 years
  - Smart Controller was used to quantify remedial measures and identify when control restored
  - Smart Controller identified when off line systems brought on line and confirmed when regained control
  - Smart Controller used to optimize biocide program



* BFI – Biofouling Index

Questions?