Water Conservation Technology for Recirculating Cooling Systems

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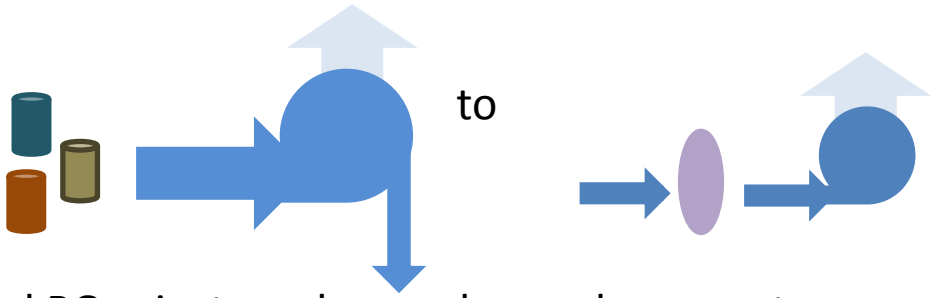
Game Changer for Cooling Water Management

- Improves efficiency by operating cooling system without blowdown or bleed, dramatically saving water and energy.
- Water reaches a natural equilibrium that is not scale forming, not corrosive and does not promote biological growth.
- Move from discharging water and feed chemicals to pre-treat and concentrate.

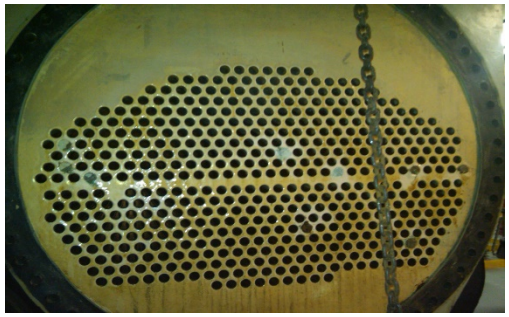
from  to

- Wastewater and RO reject can be used as make-up water, so

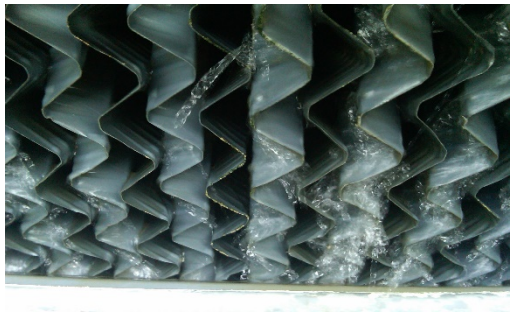
Cooling tower becomes a remediation evaporator for wastewater.

Key Benefits of Water Conservation Technology

- Water conservation, LEED credits
- Program ease
- Wastewater remediation
- Reduced risk of Legionella bacteria

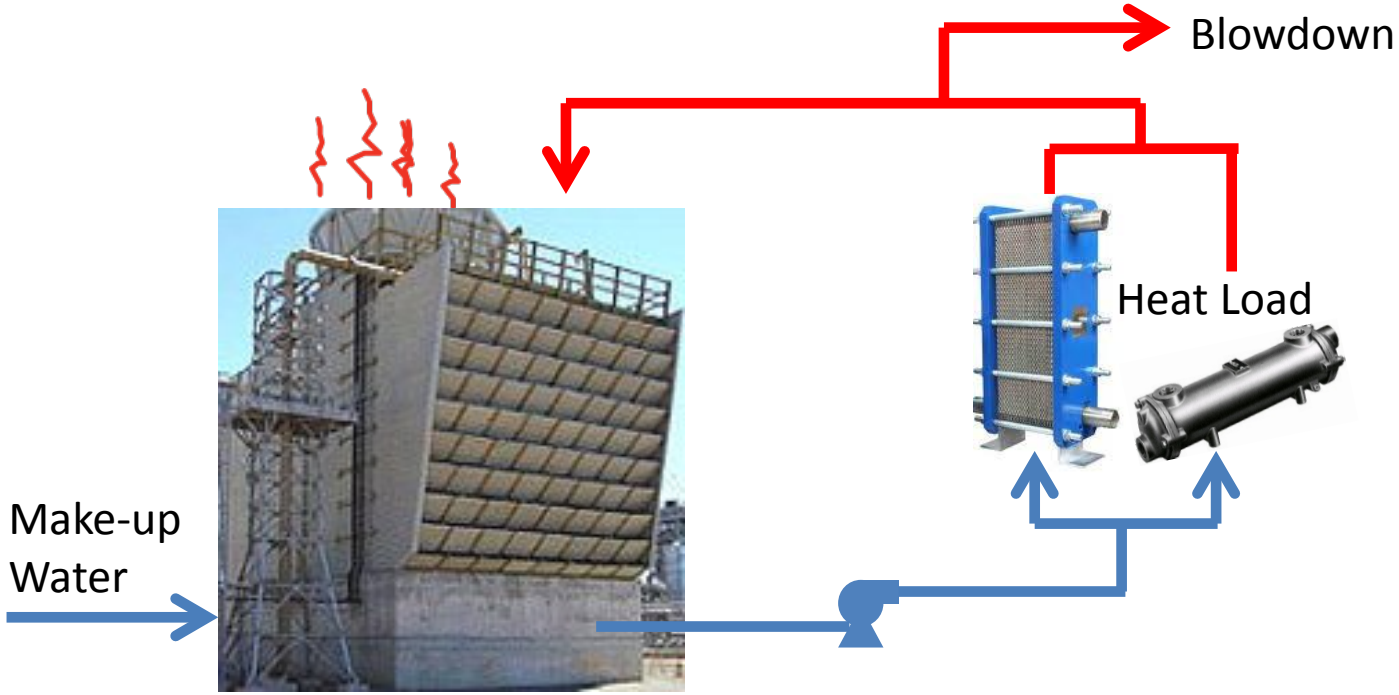


- Improved performance- clean surfaces and reduced corrosion
- ROI typically <18 months



Cooling Tower Objective

- To remove ***Heat*** Through Evaporation
- Accomplished by recirculating water



Make-up water flow = evaporation + blowdown

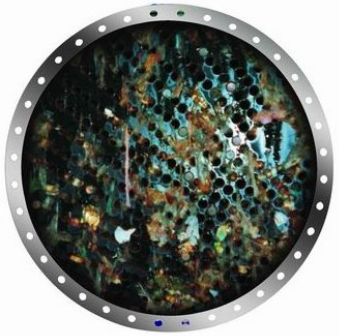
Traditional Cooling Water Treatment Issues

Shortens equipment life and increases capital expenses

Corrosion

Increases energy, maintenance and cleaning costs

Deposition



Microbiological Growth

6x more insulating than scale and health/safety risks

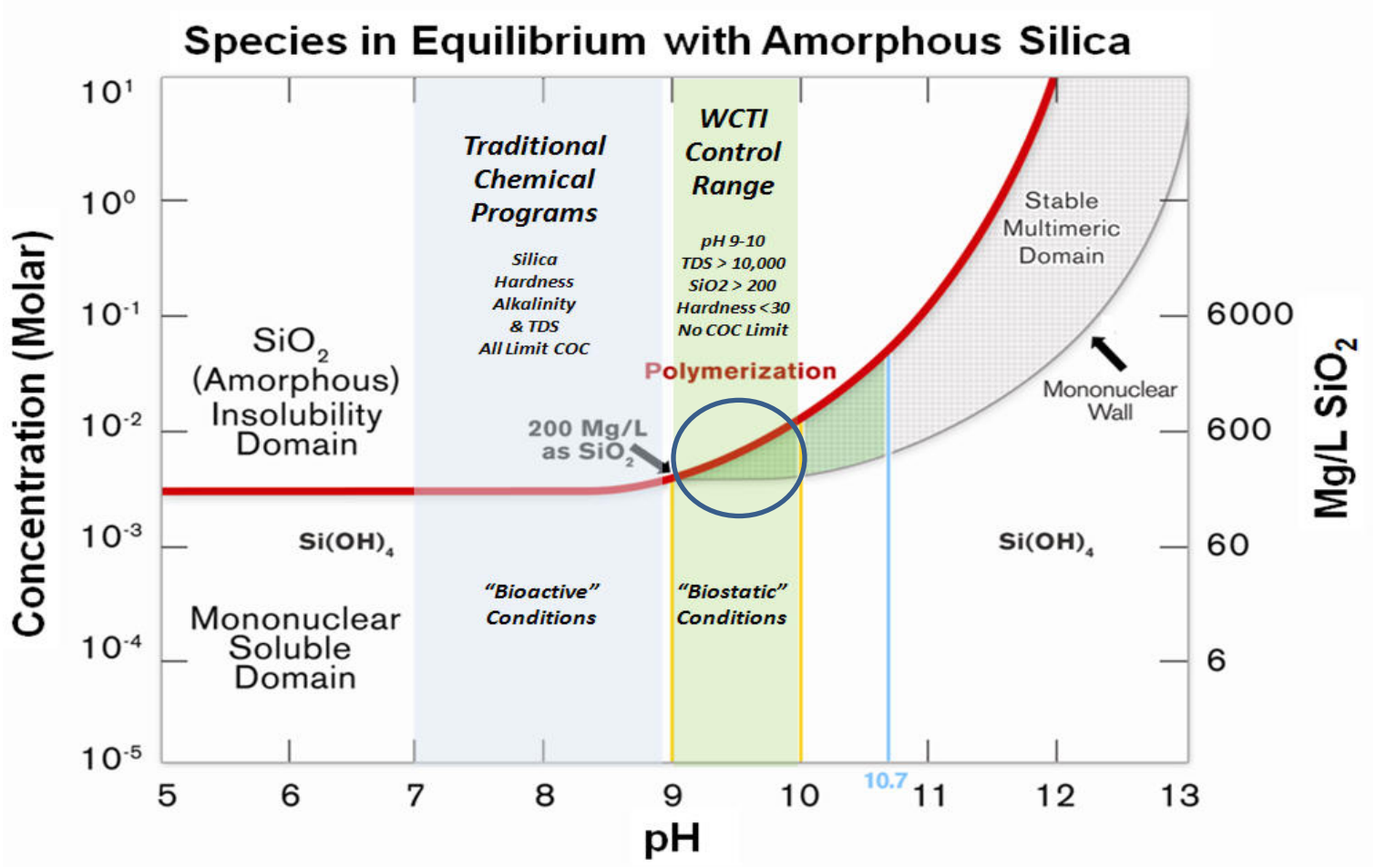
Traditionally, all require chemical treatment and blowdown to manage

The Real Cost of Cooling Water Treatment

Average Facility with 2000 ton HVAC Plant

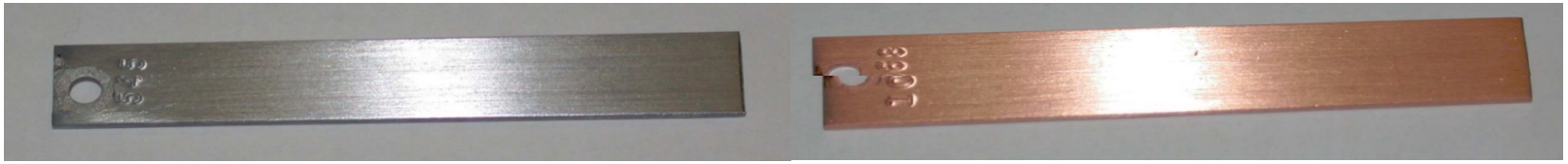
- Chiller electricity Cost - $850,000 per year
- Cooling Tower Water and Sewer Usage
  - Water usage = 9,000,000 gal or $63,000 per year
  - Sewer usage = 3,000,000 gal or $50,220 per year
- Eggshell thickness of scale on a chiller tube = 12% more electricity or $102,000/ year
- Corrosion rates determine asset life expectancy
- High human and environmental exposure risks

Changing the game in Cooling Water Program Control



Deposition, Corrosion

- High-efficiency softeners replace hardness minerals in tower makeup water with high solubility sodium salts that do not form scale
- Evaporation of tower water saturates natural silica, sodium salts and alkalinity that catalyze silica to form silicates
- Silicates are outstanding corrosion inhibitors, and do not form deposits
- Typical results are no scale, <0.2 mpy corrosion

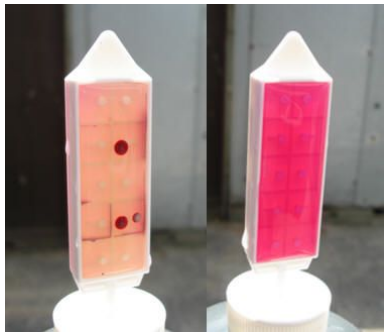


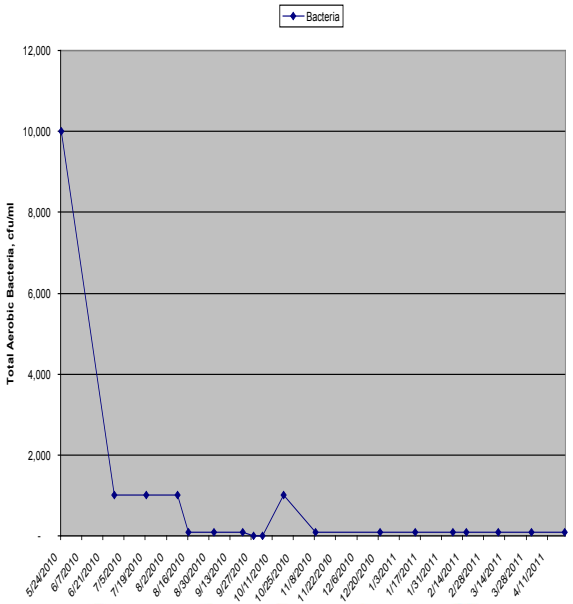
Typical Mild Steel Corrosion – 0.27 mpy

Typical Copper Corrosion – 0.02 mpy

Microbiological Growth

- Evaporation-Concentration Creates Bio-Static Water
  - pH > 9.0 (Preferably 9.7 to 10.0)
  - Not limited by organics or phosphate in makeup water
- Bacteria and Pathogens Cannot Survive
  - The technology used to clean/sanitize in food plants is low or high pH to kill bacteria
- Typical counts are less than 100 CFU





Water Reclamation

- More than 600 systems have been functioning on WCTI technology worldwide for more than 10 years, some have used recycled wastewater for more than 6 years.

How is the game changed, technically?

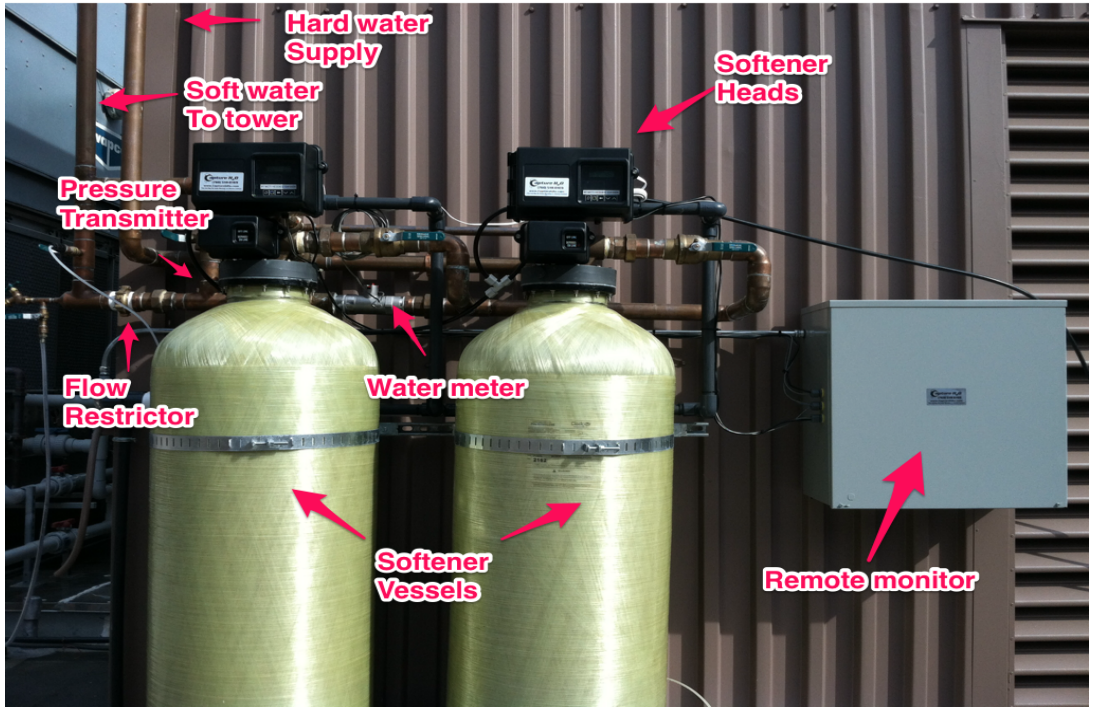
Parameter	Traditional Treatment	Water Conservation Technology
Operating pH and conditions	pH 7-9 which is ideal for corrosion, scale, biological growth and dissolved solids approach their solubility limit.	pH > 9, (9.7-10), not corrosive, does not support biological growth and scaling elements are removed.
Treatment mechanisms	Chemicals inhibit corrosion, scale and biological growth. Dissolved solids are limited by cycles of concentration.	Silica naturally present in make-up water concentrates and provides protective film.
Source Water Pre-treatment	none	Softening
Cycles of Concentration	2-10	50-200
Blowdown or system bleed as a % of make-up water	10-50%	0-1%

How is the game changed operationally?

Parameter	Traditional Treatment	Water Conservation Technology
Water Source	Limited to fairly good quality to allow some concentration of dissolved solids.	May use most any source, even wastewater, so good for zero liquid discharge.
Chemicals Required	Corrosion and scale inhibitor chemicals added. Biocides also added.	Silica and alkalinity added ***ONLY*** if natural water concentrated does not reach 200 ppm silica or desired pH.
Water Use, Water Costs	Make Up = Evap + Blowdown	**Reduced significantly-** Blowdown is negligible, Make Up = Evaporation
Corrosion Results	Industry standard with good treatment = <3 mpy	Typical results <0.2 mpy
Plant Equipment	Equipment life and heat transfer are limited by corrosion and scale.	System is kept clean and efficient for optimum performance.

Program Equipment

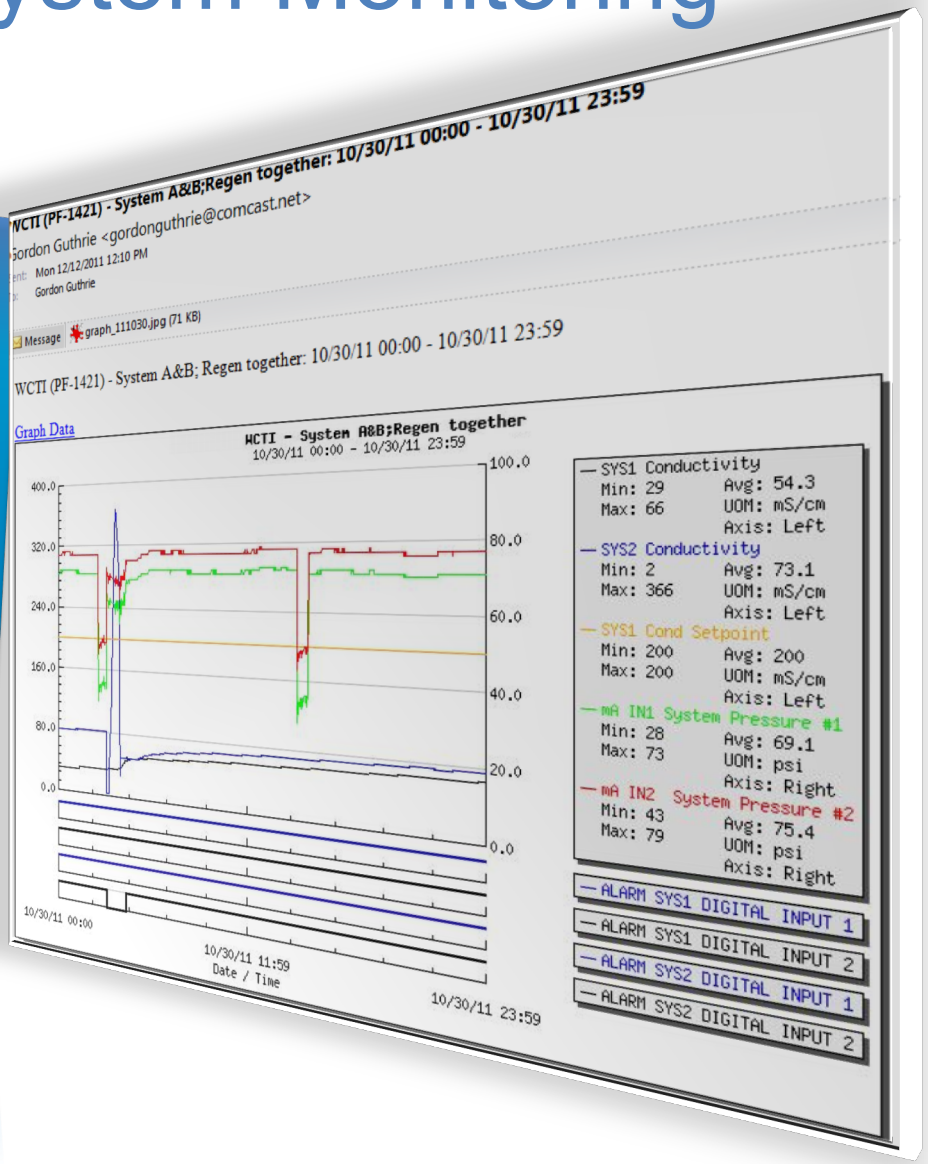
- High-Efficiency Softeners
- Remote Monitoring (RPA)
- High efficiency designs with off shelf system cost, reliability and support
- Softeners reduce softening waste from typical 6-12% to 1-2% of treated water and reduce salt requirement by 30-50%
- Commodity NaCl to regenerate



RPA 24/7 System Monitoring

Daily Emailed Status Reports on Critical plant control requirements such as:

- Water use
- Pressure
- Regeneration
- Power failure alarm



Maintenance Required

- Keep salt tank full
- Monitor softener performance via RPA
- Inspect monthly to validate no hardness, silica >200 ppm, pH 9.5

What can go wrong?

- **Run out of salt-** hardness gets into system, picked up on remote monitor and salt tank refilled
- **Cooling system has significant leaks and cannot cycle to reach equilibrium-** desired conditions can be managed with added silica and alkalinity

Water Conservation Technology ROI

- Note: Technology is applicable for **LEED** credits

Tons Tower Capacity	Avg. Flow GPM	Installed $ Cost Estimate	MGY Water Saved *	$ /yr Water & Sewer Savings*	ROI Months
250	7	9,000	1.2	9000	12
500	13	15,000	2.4	18,000	10
1000	25	20,000	4.8	36,000	7
2000	50	30,000	10	65,000	6
5000	125	65,000	24	155,000	5
10,000	250	175,000**	49	310,000	7
20,000	500	300,000**	99	590,000	6

*Southern California water, 60% of design as average load

** Includes bulk salt handling system

Water Conservation Technology Customers

(partial list)

Partial Listing by Specific Markets, Customers, Multi Site Applications, Multi Site Chains. *RW = Recycled Water

Healthcare / Bio Tech / Pharmaceutical

1. Everett Clinic
2. Fred Hutch Research Center
3. Dignity Health Hospital Group
4. UCLA Medical Center
5. St. Francis Hospital
6. Amylin / Ardea Biosciences (*RW)
7. Cambridge Healthcare Mgt.
8. Schneck Medical Center
9. OHSU Primate Center
10. U W Medicine
11. Bristol Meyers Squibb
12. Intermountain Healthcare
13. Chandler Regional Medical Center
14. Woodland Healthcare
15. St. Rose Hospital
16. U. S. Pharmaceutical

Aerospace

1. Boeing
2. Northrop Gruman
3. SPACEX

Industrial

1. California Steel Industries
2. Matheson Tri Gas
3. Honda Motors
4. Paccar
5. SAPA Anodizing
6. ESCO Furnace

Data Centers / Eng Design Consultants

1. Westin Building Data Center
2. Yahoo
3. Microsoft
4. Apple
5. AT&T
6. Verizon
7. Systecon
8. Powerloft
9. Denver Federal Center
10. NREL
11. NCAR
12. INTERNAP (*RW)
13. Latysis
14. Info Cross
15. WA State - Wheeler Data (
16. Infinity Internet
17. Sprint
18. Red Sea
19. HP/EYP - Eng. Design Cons
20. Ascent – Eng. Design Cons
21. Riker
22. Sentinel Data Centers

Commercial / Institutio

1. CBRE
2. PM Realty
3. Paramount Studios

Partial Listing by Specific Markets, Customers, Multi Site Applications, Multi Site Chains. *RW = Recycled Water

7. Municipal Landfill Gas Project, TX
8. Roseburg Forrest Co-generation
9. Cummins
10. Star Ice & Fuel
11. Oregon Crystal Growers
12. Pioneer Natural Resources
13. Cargill
14. Grief industrial
15. Caterpillar Inc.

Food Processing & Distribution

1. MCL Fresh
2. AGP
3. US Foods
4. Auburn Dairy
5. Columbia Beverage
6. Darigold
7. Glacier Water
8. Oberto Meats
9. Orca Bay Foods
10. Resers Fine Foods
11. Sukuma Bros
12. Yakima Juice
13. Larson Creamery
14. Grocery Outlet
15. Safeway
16. Baker Produce
17. Dickenson Foods
18. Fresh Express
19. Yakima Juice
20. Versa cold
21. Apex Cold Storage
22. M3 Storage
23. Freeze Pack
24. Star Ice & Fuel

Partial Listing by Specific Markets, Customers, Multi Site Applications, Multi Site Chains. *RW = Recycled Water

25. Henningsen Cold Storage
26. Earthbound Farms
27. Columbia Col-Stor
28. Albertsons
29. Americold
30. Fred Meyer
31. Stadleman
32. Webster Beverage
33. Independent Meats
34. Sysco Foods
35. Trader Joe's
36. Winco
37. Pepsi
38. QFC
39. Gallo Wineries
40. Con Agra Foods
4. So. CA Gas Company
5. Instrument Transformers
6. Commerce Casino
7. Corbis
8. Dexter Horton Bldg
9. Unico Properties
10. American Pacific Lines
11. Microsoft Bravern
12. Madison Renaissance
13. Seattle Times
14. Meadows Mechanical
15. Vulcan Block 34
16. UMC Block 32
17. McDonald Miller Company
18. OC McDonald
19. Grubb & Ellis
20. Micro Soft Corporate Facilities, WA
21. Rose Garden Arena
22. Irvine Company
23. Glenborough Properties
24. Tampa Bay Skating Academy (*RW)
25. CFO Center
26. Valley View Casino (*RW)
27. Hines (*RW)
28. Smith Barney
29. Callaway Golf
30. Qualcom
31. Johnson Controls, JCI-PCD
32. Johnson Controls, JCI-GWS
33. MDC Condominium
34. Casino Arizona
35. Paramount Studios
36. Hyatt Resorts
37. NRG Energy Center
38. The Honolulu Star
39. Universal Studios (*RW)
40. Farm Bureau Insurance
41. Southco, PA
42. Brandywine, PA

Education

1. Carnegie Observatory
2. Carlsbad USD
3. C W Middle School
4. Cypress College
5. Mt Hood Community College
6. Kansas State University
7. Portland Art Museum
8. Cal State University (*RW)
9. Los Angeles County ISD
10. Earlham College
11. Coastline Community College
12. Southwestern College (*RW)
13. Biola University

Government

1. Border Patrol Station
2. Los Angeles County DPW
3. Orient Road Detention Center
4. Naval Air Station – Whidbey Island
5. Federal Corrections Institution
6. Green-Wyatt Federal Building
7. WFLH
8. SAIF
9. Miramar AFB
10. GSA
11. UEHP Mil. Res.

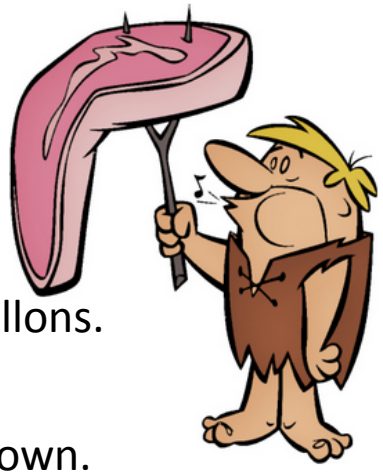
Water Conservation Technology
Case Study: Meat Processor

Meat processing facility converted from conventional bleed & feed chemicals to Water Conservation Technology to treat evaporative condensers used in ammonia refrigeration.

The main benefits anticipated were zero tower blowdown and elimination of all potentially hazardous chemicals. Also desired more efficient heat transfer & water savings.

In one year as the system transitioned…….

- Scale was completely removed from condenser tubes.
- Went from 4 to 2 compressors on line.
- Corrosion rate decreased leading to extended equipment life.
- Average blowdown rate decreased to water savings of 867,000 gallons.
- Total treatment cost decreased by 80%. ROI: 8 months.
- No chemical inhibitors & biocides used since reaching zero blowdown.



Water Conservation Technology Case Study: Software Companies Coexist With Potatoes

By 2006, a number of data centers requiring significant water supply for cooling had settled in the largest potato producing area of the US- Quincy, Washington.

Growth and new industrial discharge regulations meant water supply would exceed demand and wastewater discharge could no longer go to waste irrigation canal.

Third-party partnership built Quincy Water Reuse Utility using Water Conservation Technology to recycle municipal and industrial wastewater to meet water demand.

Results:

- Integration of agriculture, industry and utilities to co-exist. The utility relies on the industrial customers for supply and the data centers support the agriculture.
- Corrosion rates and system cleanliness are better than ever.

Water Conservation Technology
Applied to Closed Recirculating Systems

Closed systems have traditionally been treated with molybdates to inhibit corrosion. However, molybdate discharge is either banned or severely limited in many states due to the land application of biosolids.

Alternative approach:

- Maintain Hardness <50 ppm, pH 9.5-10, silicate 50-100 ppm
- Add Azoles to inhibit copper corrosion

Results:

- Steel corrosion rates 0.07 to 0.14 mpy
- Copper corrosion rates 0.001 to 0.022 mpy
- Aerobic plate counts < 1000
- Corrosion rates and system cleanliness are better than ever.

Water Conservation Resources

A big splash in savings

New water pre-treatment process reduces costs and conserves water

By Kathleen Spicer

At a Boeing building in Kent, Wash., nine cooling towers can support the production of 23,000 gallons (87,000 liters) per minute of chilled water that is used to support critical heating, ventilation and air-conditioning systems.

A conservation initiative by Site Services of Shared Services Group is expected to save 7.6 million gallons (28.9 million liters) a year there, plus eliminate harmful chemicals and significantly reduce maintenance. Similar improvements at Boeing facilities in El Segundo, Calif., are expected to save an estimated 95,000 gallons (356,600 liters) of water a month.

What is a cooling tower and why is this important? A cooling tower works in combination with a chiller to remove heat from the air inside a building and release it to the outside atmosphere. An efficiently operating chilled water system provides air conditioning for offices, labs, fabrication and assembly areas.

Optimizing cooling-tower operations is critical to maximizing a facility's performance and reducing its environmental footprint. No one knows that better than the Site Services teams and councils who sponsored an improvement pilot that resulted in a major step toward saving water, reducing chemical usage, and lowering sewage and maintenance costs.

FROM RESEARCH TO REALITY

Roger Sampair, SSG lead mechanical plant engineer at Kent said the idea started when looking for improved technology in cooling-tower operations that would be better for the environment and save on maintenance costs. Sampair learned about a process to pre-treat the water used in cooling towers that doesn't involve chemicals and softens the water to prevent scale buildup.

"The result is a more efficient tower," Sampair said. "The steel industry uses a similar process to eliminate the buildup of chemicals and scale during steel production. The same philosophy can be applied at Boeing."

The testing at the Kent site showed significant results: Fresh water entering the operation has decreased by 40 percent; maintenance costs on cleaning the towers have been reduced from once a month to a couple times a year—approximately an 80 percent reduction—and harmful chemicals have been eliminated in the process. And these savings may just be a drop in the bucket—the potential savings could be $5 million or more per year across the enterprise.

HOW IT WORKS

Cooling towers hold an average of 800 gallons (3,028 liters) of water. A building's or site's chiller operation uses the tower water to make chilled water for building, equipment and computer-room air conditioning to optimize operating temperatures.

PHOTO: Boeing heating, ventilation and air-conditioning mechanic Brett Weberg adds salt used in regeneration tank for cooling-tower water softeners at the Kent, Wash., site. The water softener is part of a new process initiated by lead mechanical engineer Roger Sampair (right) that will save water and reduce sewage and maintenance costs across Boeing. MARIAN LOCKHART/BOEING

However, as water naturally evaporates in the tower, minerals are left behind that can form hard deposits. These remains can stick to the surfaces in the cooling towers, affecting their efficiency. To reverse this, chemicals are added to keep the minerals suspended in the water, and then the water is drained out of the tower and replaced. This is known as a "blow-down" process. The cycle is periodically repeated to keep the tower maintained.

Sampair led the Kent Maintenance team in a one-year trial using the water softener with a 500-ton (454-metric-ton) tower that supports operations at the 7-107 building. Following promising results, a second system was installed in the Kent 18-54 building, where the benefits have been even greater due to high usage of the nine cooling towers.

Several groups, including the Site Services Plant Engineering and Enterprise Mechanical Technical Committee councils, identified this improvement as an enterprise operating cost reduction and championed its replication to other Boeing sites.

Cooling-tower water-saving improvements recently earned Kent's Maintenance team a Boeing Conservation Award as one of 18 projects that reduced the company's energy and water usage or increased alternative commuting and recycling rates.

The awards were recently expanded to include water initiatives, noted Jeff Nunn, SSG Conservation Initiative program manager.

PHOTO: Site Services engineer Art Kienle (left) and mechanic Doug Macpherson helped replicate water and cost savings from Kent, Wash., to El Segundo, Calif. BOEING PHOTOGRAPHER/BOEING

CHANNELING SUCCESS

The Site Services team at the Boeing satellite manufacturing facility in El Segundo, Calif., was first to replicate the improvement with a similar pilot program.

Cooling towers are an important part of the site's environmental control infrastructure because certain temperatures and the proper humidity are required when assembling and integrating satellites—and this Site Services business partner depends upon that reliability.

"The new process has made a noticeable difference," said Art Kienle, a plant mechanical engineer in El Segundo who helped facilitate the pilot program. "The piloted tower was much easier and faster to clean than the others, which means the new system is working well and minerals aren't depositing to the sides of the tower."

According to Kienle, 90,000 to 100,000 gallons (340,600 to 378,500 liters) of water per month are saved using the new process.

The benefits add up—from reducing chemicals to consuming less water to lowering sewage and water costs, Kienle said. "Even our equipment will last longer because it will run more efficiently."

Although the costs of water vary from site to site, Site Services Maintenance is looking for other opportunities across Boeing.

"That's the real value—this new process can be replicated at other Boeing sites, so we not only conserve water, help protect the environment and save on maintenance costs here," Sampair said, "but at other locations as well." ■

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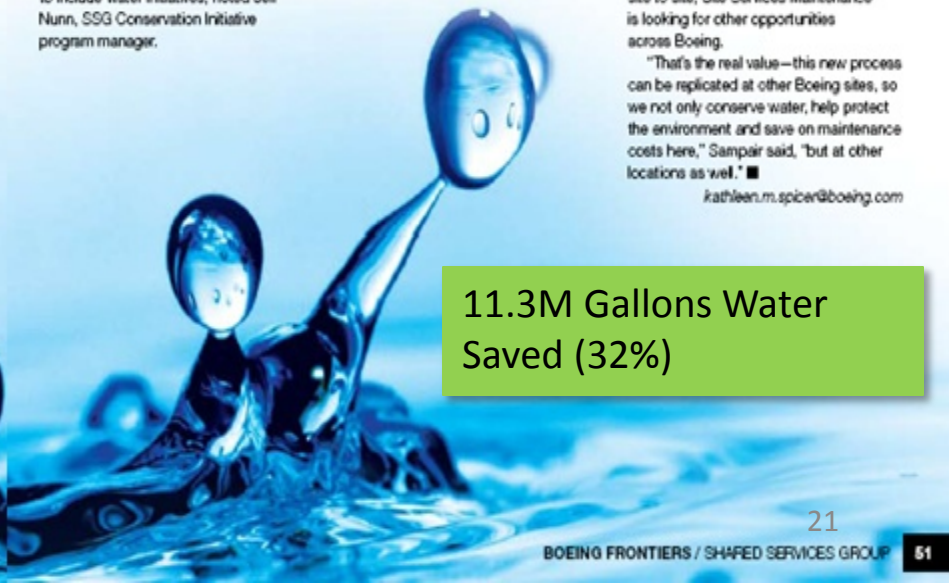

11.3M Gallons Water Saved (32%)

Water Conservation Technology for Recirculating Cooling Systems

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