IDEA2017

Sustaining Our Success

108TH ANNUAL CONFERENCE & TRADE SHOW

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Energy & Water Strategies for Sustainable Operation

IDEA2017
Sustaining Our Success

Water and Energy Conservation with Ozone Treatment of Cooling Towers to Improve Sustainability

Presented by LaMotte Water Management

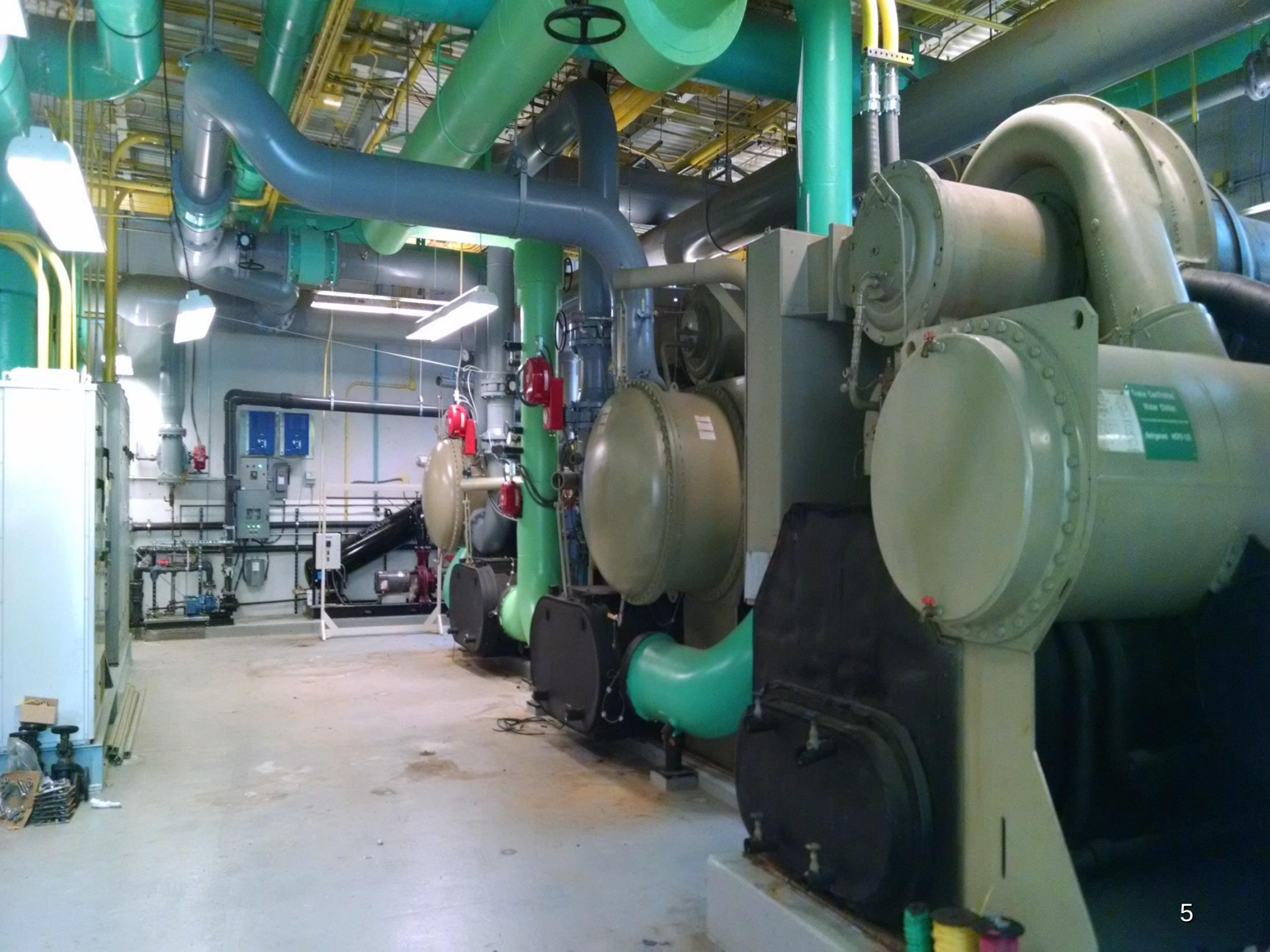
Purpose of Presentation is Two Fold

- Discuss Improved Sustainability with Energy Conservation Through the Removal of Bio-Film
- Discuss Improved Sustainability with Water Conservation Through Increased Cycles of Concentration
- Also Touch on Additional Benefits –
  - Removal of all hazardous chemicals
  - Minimization of infectious disease hazard
  - Reduced maintenance

Energy Conservation Through the Removal of Bio-Film

University Chiller Plant Study

The intent of this study was to demonstrate the impact of bio-film on water cooled condenser heat transfer surfaces in an electric driven chiller plant and the associated increase in electrical usage.



Energy Conservation University Chiller Plant Study

This study was designed to demonstrate if the use of Ozone as a stand alone treatment system to provide superior Bio-film control and resultant increase in heat transfer efficiency is a viable and benefical option.

The study measured Fouling Factor and Bio-Film on operational water chillers.

University Chiller Plant Study Process Description

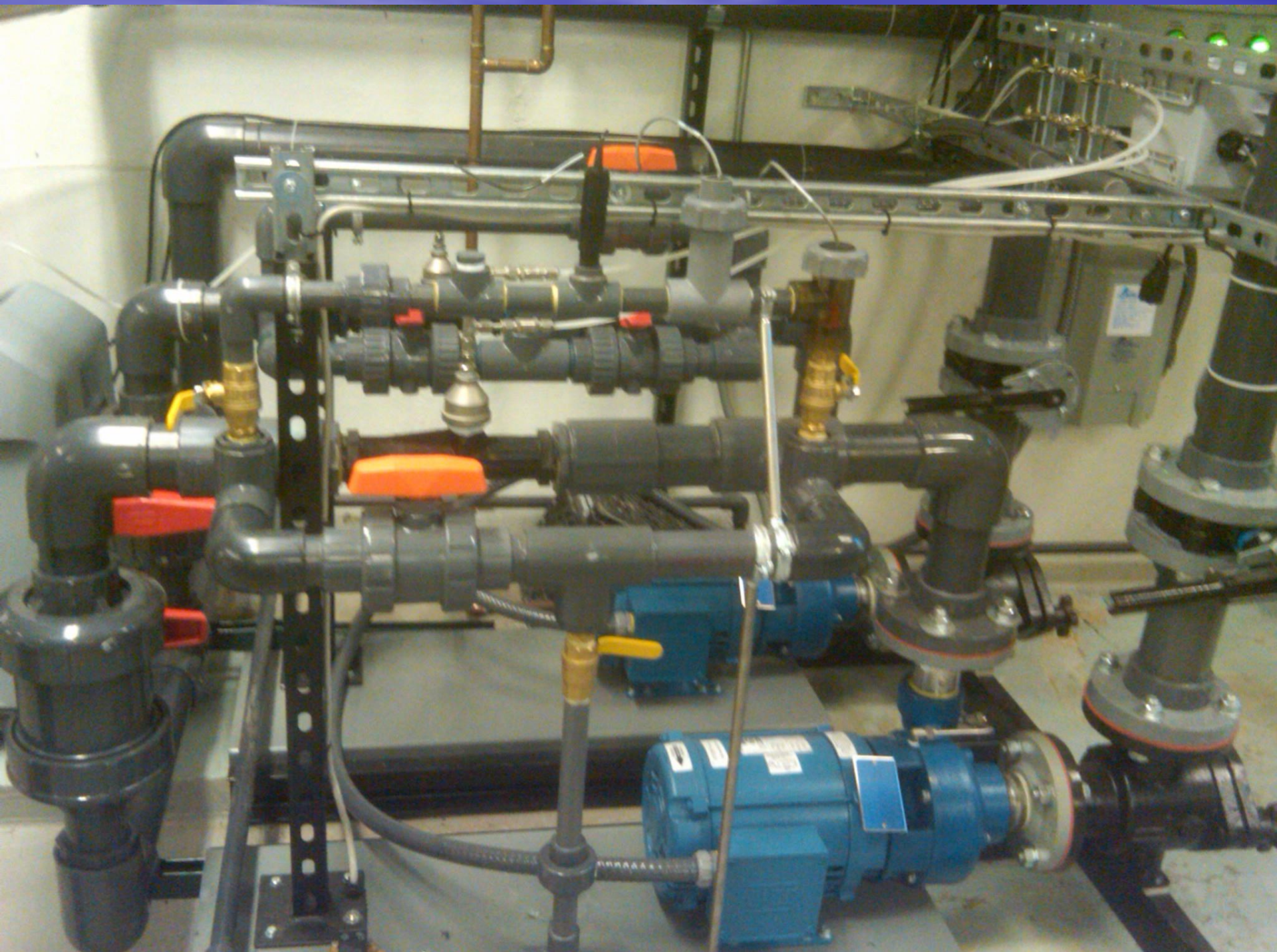
- Tower water is recirculated from/to the tower sump in a bypass loop
- Tower water is dosed with Ozone in this recirculating loop
- Ozone is manufactured on site by feeding dry, oxygen rich gas to a plasma block Ozone generator
  - Ozone gas is drawn into the bypass loop by negative pressure via a venture'
  - Ozone production is regulated by a feedback loop from an ORP sensor
  - ORP set point is maintained by varying electrical charge in the Ozone generator
- Conductivity of the cooling water is controlled by a TDS/Conductivity monitor and bleed valve
  - Conductivity set point is calculated to maintain
    - Langelier Saturation Index and
    - Phosphate Saturation Point

University Chiller Plant Study Process Description

- Monthly service requirements
  - On site make-up water and tower water chemistry
  - Clean ORP probe
  - Test oxygen generator feed gas concentration
  - Visually inspect cooling tower
  - Check Approach Temperature
  - Bacteria and/or Corrosion Coupon Testing

University Chiller Plant Study

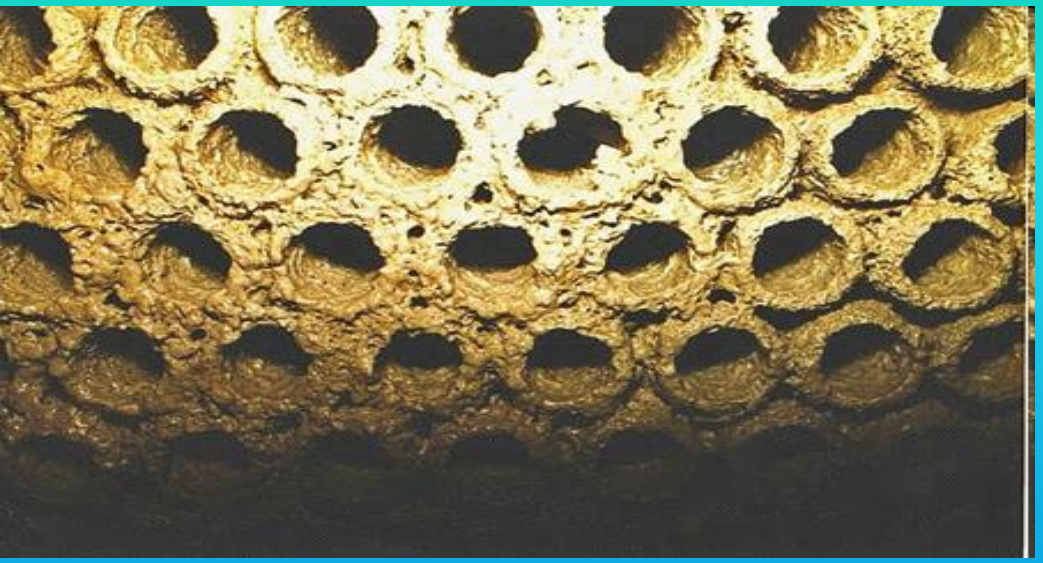
- System Components
  - Ozone Treatment Package
    - Two 300 gpm circulation pumps
    - Four Oxygen generators providing 36 LPM
    - Two Plasma Block Ozone generators providing a total of 120 gm/hr
    - ORP controller for linier control of Ozone production
  - pH Control
    - Replace 66° Baume` Sulfuric Acid with CO_2



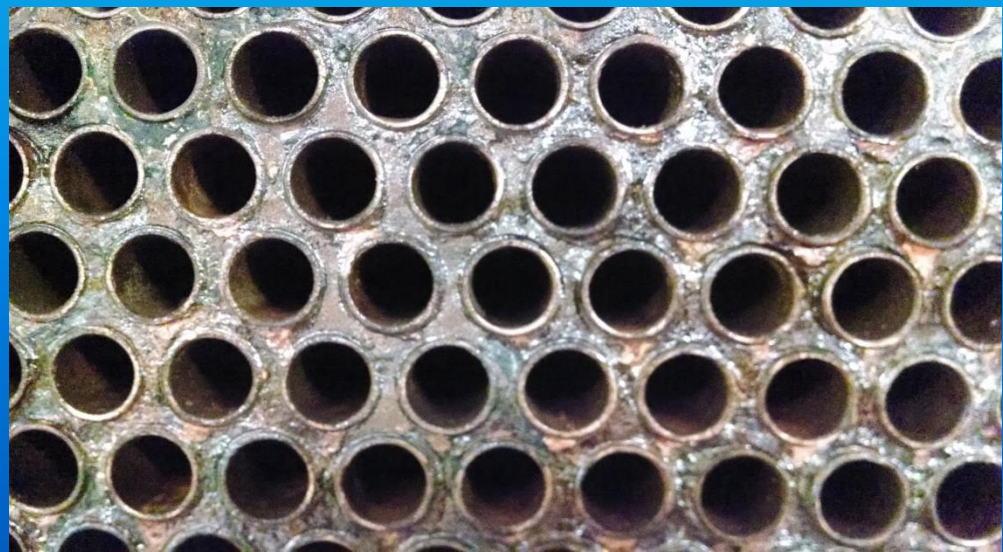
Why use Fouling Factor?

- Our primary concern is Bio-film and it's ability to foul and insulate condenser tubes.
- With measured and recorded Fouling Factor we get demonstrable, not theoretical, but actual energy savings.

Bio-Film and Fouling



Fouled vs. Clean



Concept for Use of Fouling Factor

The Fouling Factor is independent of loadings, demands and degree days. Less Bio-film on the tubes means a lower Fouling Factor with measurable improvement on heat transfer with corresponding reduction of energy consumption.

The Fouling Factor Formula Used

- $F_{(Fouling\ Factor)} = 1/U - 1/U_c$
  - Where U is the Heat Transfer Coefficient and the Clean/New Heat Transfer Coefficient respectively.

$U = Q/(A \times F \times LMTD)$ is used to calculate the actual Heat Transfer Coefficient

Where Q is the Condenser Load, A is the Condenser Heating Area, F is the Temperature Correction Factor, and LMTD is the Log Mean Temperature Difference.

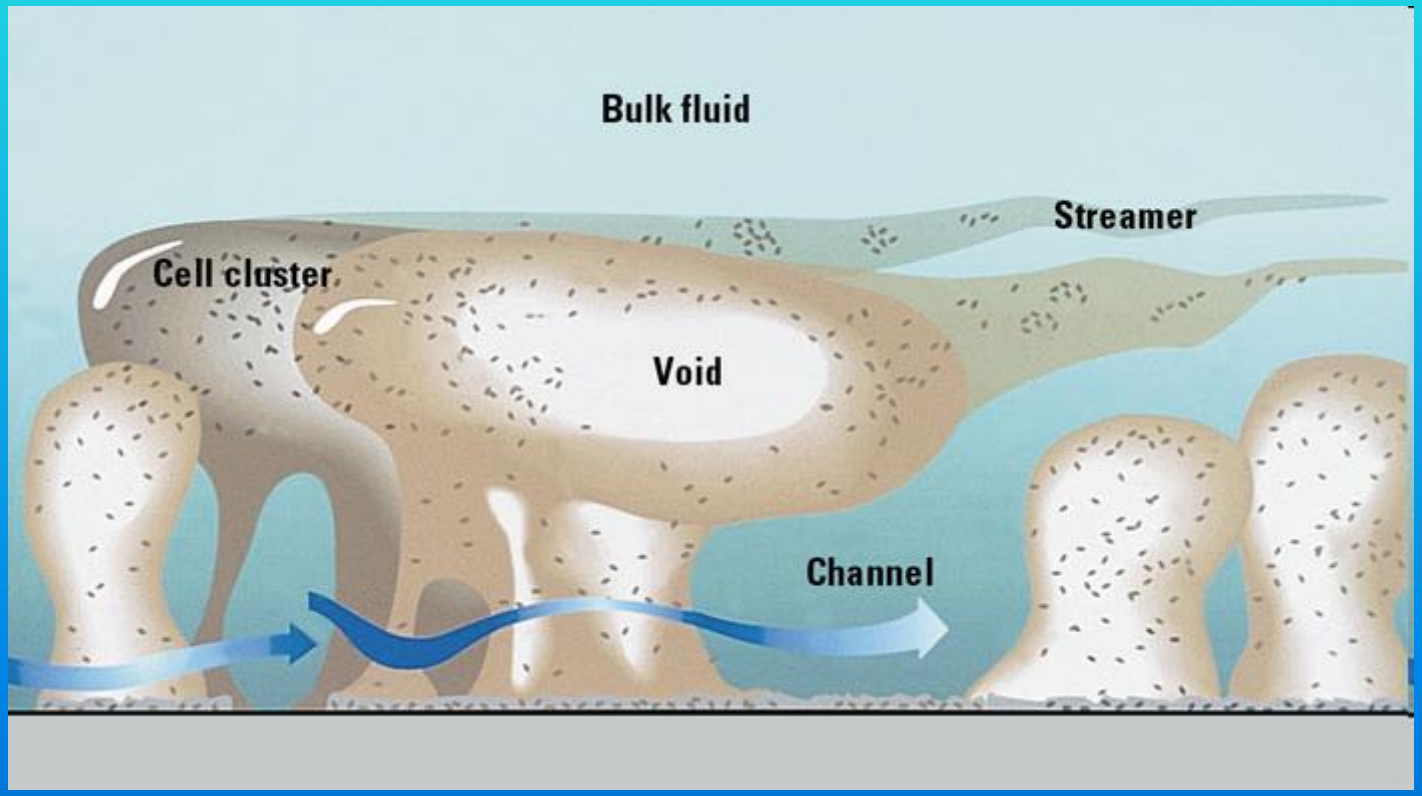
Significance of Bio-Film to Energy Loss

- Old thinking:
  - Bio-film was a concern.
- Current understanding:
  - New data and studies indicate that Bio-film is the single biggest contributor to energy loss.

Power of Bio-Film

- Thermal Conductivity
  - Calcium Carbonate 2.6
  - Calcium Phosphate 2.6
  - Calcium Sulfate 2.3
  - Iron Oxide 2.9
  - **Bio-film** **0.6**
- Bio-Film is 5 times more insulating than scale.

Porous Mixture of Organic and Inorganic Material



Biofilm Prevention and Removal

Ozone

Bio-film's Worst Enemy

What is Ozone?

- 0_3 - an unstable form of oxygen with three atoms
- Powerful oxidizing biocide
  - 500% more effective than chlorine
- Short life in evaporative cooling water (around 15 minutes)
- Environmentally Safe - breaks down to oxygen

How Is Ozone Produced?

- Naturally produced
  - Ultraviolet Light
    - Ozone layer
  - Lightning (Electric discharge)
- On-site Generation
  - Ozone Generator
    - Corona discharge
      - High Efficiency
      - Automatically controlled ozone output
      - Oxygen Fed

Biofilm Prevention and Removal

- Keep system clean
  - Mechanically - physical removal
  - Chemically- micro-biocides, dispersants
- Reduce Food
  - Filtration
  - Oxidation
  - Location of Equipment
  - Process Leaks

Benefits of Ozone

- Helps Keep system cleaner
  - Mechanically – by removing bacteria from the system, mechanical cleaning is much easier
  - Chemically - removes need for hazardous chemicals while providing superior performance
- Reduce Food
  - Filtration - often not necessary
  - Oxidation - far superior to chlorine, bromine, chlorine dioxide, etc. Not effected by system debris of pH
  - Location of Equipment - still must be addressed, but not as critical
  - Process Leaks – oxidizes organic process leak materials, reducing food and fouling

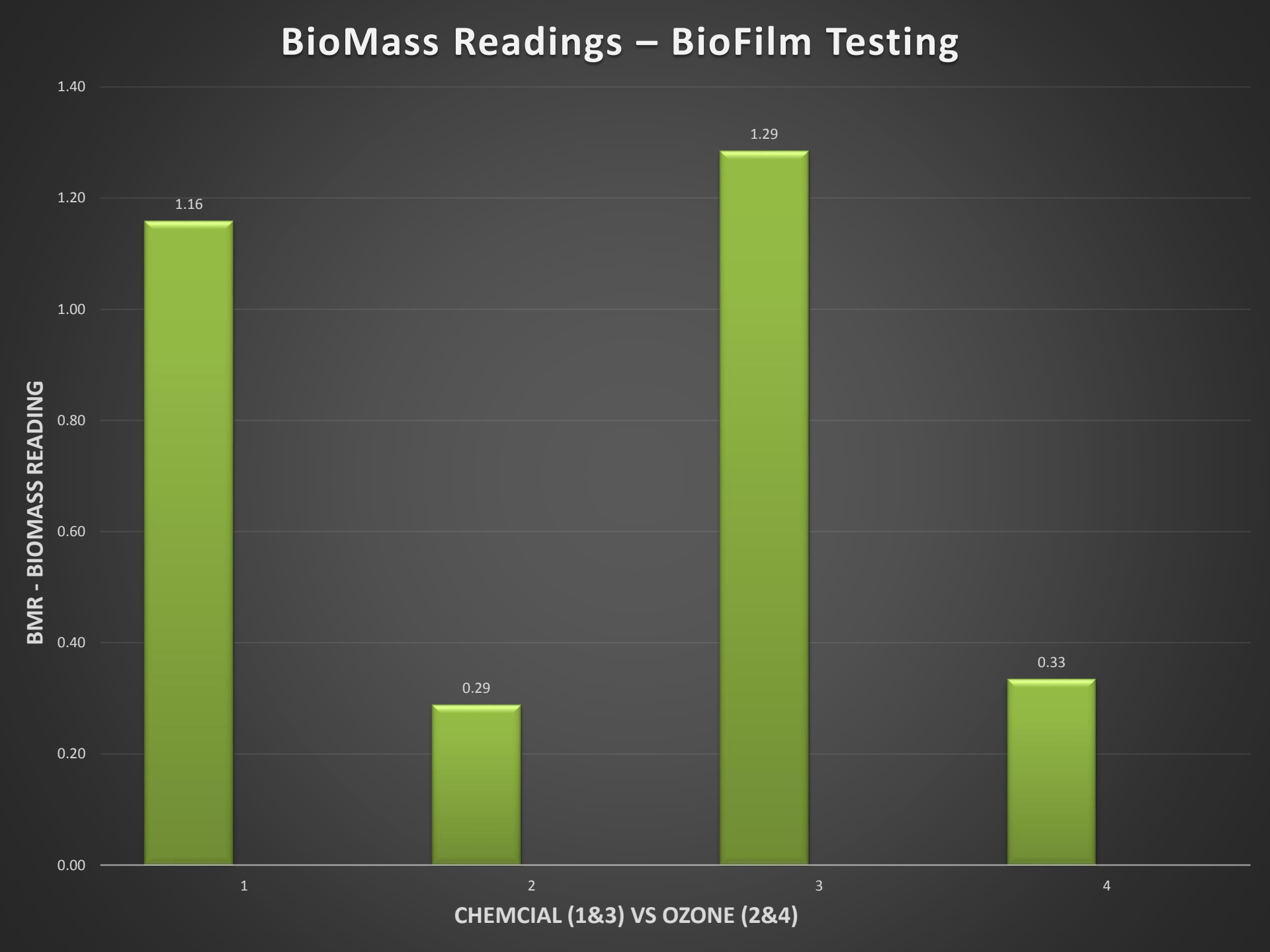
Study Data Collection

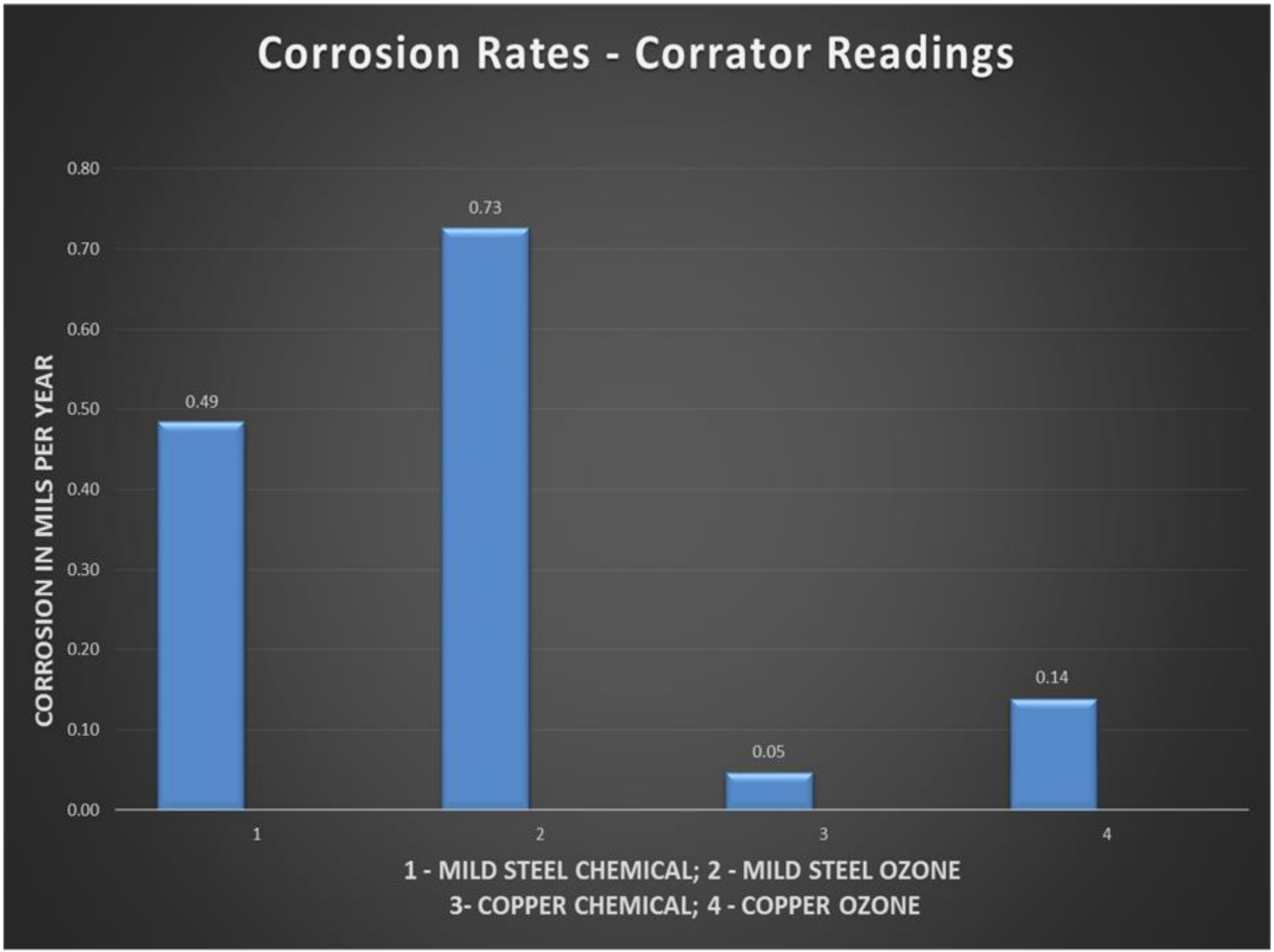
- Fouling Factor
  - Data collected prior to changeover to Ozone
  - Data collected after changeover to Ozone
- Bio-film
  - Readings collected with the use of a coupon and results from a 15 minute reaction – all readings in BMR, or Bio-Mass Reading
  - Range – from <0.3 indicating no problem to >4.0 indicating severe Bio-fouling
  - Average readings prior to changeover to Ozone
  - Average readings after changeover to Ozone

Data Points, Calculations and Display

- The Chiller Plant maintains sensors on the Chillers installed to monitor all necessary data – system temperatures, lift, approach temperatures – necessary to calculate the FF.
- Since some of the necessary constants are considered proprietary by the Chiller manufacturer, they have built the calculation into their programming so that we can log FF for before and after comparison.
- The data collection software provides a readout of this calculated number on the Dashboard of the University's monitoring programs, allowing University personnel to see the FF at any given time.

BioMass Readings – BioFilm Testing




Corrosion Rates - Corrator Readings
CORROSION IN MILS PER YEAR
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
0.49
0.73
0.05
0.14
1
2
3
4
1 - MILD STEEL CHEMICAL; 2 - MILD STEEL OZONE
3- COPPER CHEMICAL; 4 - COPPER OZONE

Program Results

- Electrical Savings of 3.58%
- Fouling Factor Improvement of 17% Over Chemical Program
- Significantly Higher Savings When Chiller Load Above 840 Tons (on a 1200 Ton Chiller)
- Bio-film Readings Significantly Reduced
- Corrosion Rates Maintained in the Excellent Range
- Eddy Current Test Results Identify No Impact
  - Results of Test Backed by Excellent Copper Corrosion Results

Ozone Economics Example:

- COOLING TOWER DATA:
  - Total cooling loading: 1,000 tons
  - Operating hours/day: 24
  - Operating days/year 365
  - Makeup water cost/1000 gals: $2.85
  - Sewer cost/1000 gals: $6.49
  - Electricity cost/kw hour: $ .075

Water Savings

	Chemicals	Ozone
Cycles of concentration	3	6
Evaporation rate-gals/day	43,200	43,200
Blowdown rate-gals/day	21,600	8,640
Makeup + sewer cost/year	$118,575	$74,393

Total annual water cost savings: $44,182

Total water saved: 4,730,400 gallons

Energy Savings

	Chemicals	Ozone
Ozone generation cost /year:	0	$3,750
Chiller operating cost/year:	$525,600	$504,576
(Efficiency Improvement Factor of only 4% used)		
Total Energy Costs:	$525,600	$508,326

Energy savings with ozone: **$17,274/year**

Total Annual Savings

	Chemicals	Ozone
Treatment Cost/yr:	$17,500	$3,750
Total Operating Cost/yr.:	$644,175	$578,969
Total Cost/yr.:	$661,675	$582,719

Savings with ozone: **$78,956/yr**

(Simple payback: 13.1 months to recoup a capital outlay of $85,700 for ozone system)

What are Evaporative Cooling Towers?

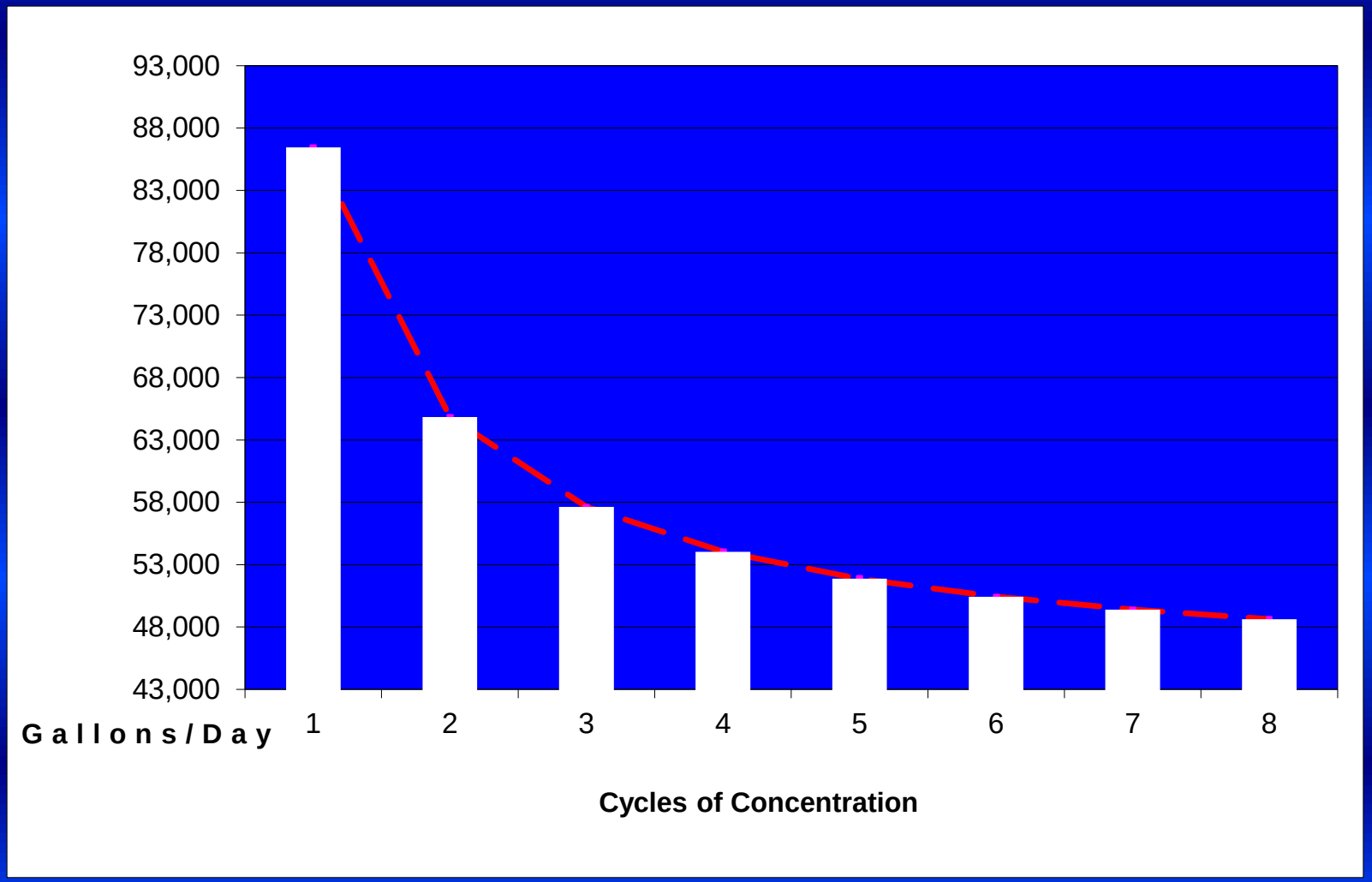
- Water Conservation Tools
  - Reuse water by rejecting process heat
  - (Chillers, Refrigeration, Manufacturing Processes, etc.)
- Release water's latent heat through evaporation
- Cooling Towers may use 40-80% of building's water
- Low cost energy users vs. air cooled cooling systems

Water Conservation by Increased Cycles of Concentration

With the use of Ozone

- System is kept significantly Cleaner
- Bio-Film is removed from heat transfer surfaces
  - No "glue" to attach scale to tubes
  - No insulating biofilm
- Can increase the saturation index, allowing higher levels of scaling minerals in the tower water
- Increased minerals = higher COC = Decreased bleed
- Bleed can be discharged to environment or reused

Water Conservation in a 1,000 Ton Cooling Tower



Cooling Tower Problems

- Corrosion:
  - reduces equipment service life
- Scaling:
  - increases energy cost
  - 1 mm scale ≈ 10% increase in electrical demand
- Deposits
  - Decreased efficiency
  - Increased labor costs
- Microbiological growth- Biofilm
  - Reduced heat exchange
    - Up to 5X more than the same thickness of mineral scale
  - Liability (Legionella and other infectious diseases)

Water Treatment Solutions

- Short Comings of Standard Solutions
  - Chemicals
    - Hazardous and requires handling precautions
    - Requires substantial facility labor
    - Continual high cost for quality program
    - Environment precautions necessary
  - Filtration
    - Must always be combined with other programs
  - Mechanical/Electromechanical
    - No proven effectiveness against biological growth (see University of Pittsburg study)

Ozone Cooling Water Treatment

- Replaces all chemical programs for the tower
- Reduces water usage
  - @ 2.5 to 5.0 million gallons/year per 1,000 tons of cooling tower)
- Provides safer, more effective:
  - Microbiological control
  - Corrosion control
  - Scale control
- Protects welfare of clients and staff by reducing potential for airborne contagion (Legionella) and toxic chemicals
- Environmentally friendly
- Less maintenance required-fewer cleanouts

What does the ozone actually do?

- Disinfects the water- no bacteria is known to be immune to ozone
- Oxidizes organics- Cold Combustion
  - Bacteria and Nutrients
- Permits "cycling up" cooling tower water
  - "Cycling up" is when system water is allowed to evaporate until the mineral salt concentration is 5-12 times that of the makeup water. (cycles of concentration) The water is now alkaline. The pH is high, so general corrosivity of the water is reduced.

Scale Control

Scale is composed of organic and inorganic material found in cooling water

- Needs a “glue” to stick to surfaces.
- That glue is provided by biofilm. (bacteria)
- There is virtually no bacteria in ozone-treated water. No glue. No scaling.
- The scale materials are expelled with the blowdown water.

Thanks for Listening