Electrocell Case Study – Validated Energy and Water Savings

Steven Driver Ph.D.

Global Sustainability Leader

September 2024

Measurement and Verification of Energy and Water Savings
ElectroCell System

Introduction

This presentation describes the methods for defining and verifying annual electrical and water savings resulting from the installation of two ElectroCell systems. The systems examined in this presentation were applied to open loop condenser water systems. The savings were realized in reductions in cooling plant energy and tower make-up water.

The savings definition and verification methods are consistent with the guidelines and methods established by the International Performance Measurement and Verification Protocol (IPMVP) committee. The consolidation of the energy use data was consistent with the Air Conditioning Heating and Refrigeration Institute (AHRI) Integrated Part Load (IPLV) methods for categorizing chiller kW/ton data.

There are two ElectroCell system installations in this presentation which are located in Massachusetts. First installation at building 55 NYA examined is an EC4000 installed on a 3000-ton capacity chilled water plant. The second installation examined at building 70 NYA, an EC6000 installed on a 4000-ton capacity chilled water plant.

ElectroCell EC4000 installation

ElectroCell EC4000 installation

Energy and Water Conservation Case Study

Overview of Technology (Facility Operations for 55 & 70 New York Avenue Framingham)

What is an ElectroCell?

ElectroCell is an electrostatic precipitator that removes contaminants from open condenser cooling tower water systems down to 1 micron. This low maintenance piece of equipment cleans the water through electrolysis versus using traditional sand filtration. The unit purifies the water so there is no longer build up of debris on the inside of the chiller tubes. By introducing an electromagnetic field, the surface tension of the water changes resulting in better heat transfer.

Energy Savings

Because the condenser water is now clean, internal chiller tubes are clean maximizing heat transfer. This process results in a much higher coefficient of performance *(COP)* for the chiller, the result is energy savings.

Installed EC-4000 ElectroCell skid

Water & Chemical Savings

In traditional condenser water systems, large amounts of chemicals are used to suspend solids in chemically treated condenser water and then removed by using large amounts of city water to remove particulates. Chemicals are still needed for conductivity and biocidal control; however, significant water and reduction occurs.

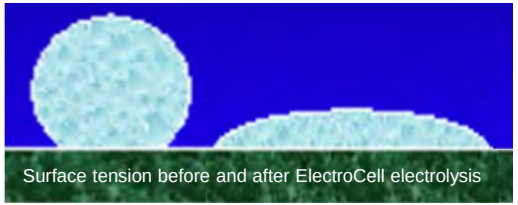
Carbon Emissions Savings

Higher chiller efficiency (COP) and reduced pumping power results in less kilowatts consumed. Less kilowatts = **Less carbon!**

How dose it work:

The ElectroCell high-voltage patented DC electrode technology acts as a capacitor within a grounded metal vessel. The energy is dissipated in the form of a static field through a dielectric insulator. This static field acts as a mechanical dissolved solid separator, which in turn relaxes the water and reduces surface tension throughout the entire system. Heat transfer resistance factors in a typical system are as follows:

1. Biofilm (R_1)
2. Mineral surface deposit (scale) (R_2)
3. Suspended Solids (R_3)
4. Boundary layer (R_4)


Surface tension before and after ElectroCell electrolysis

The fourth resistance factor is seldom mentioned because it is constant under standard conditions. ElectroCell's technology significantly reduces the BL and surface tension of the condenser water (which is closely related to viscosity). Accordingly, we transition to turbulent flow at a reduced velocity as predicted by the Reynold's (Re) number formula.

Re = rvD / μ = fluid density x fluid velocity x pipe internal diameter / fluid dynamic viscosity

Taken together, reduction in the four heat transfer resistance factors have its greatest affect in the tube bundle within the condenser heat exchanger. Significant reduction from the 4 heat transfer resistance factors increases overall heat transfer capability (heat flux) reducing system power per delivered ton as described below.

- q = heat flow rate (W = J/s)
- A = area that the heat is flowing through (m^2)
- ΔT = temperature difference across layer (°C)
- U = conductance of the layer (W/m^2K)

Decreased delta T across the temperature bundle (on the water side and refrigerant side)

$Q = U * A * (T_2-T_1)$ U = 1/RT where RT = R copper tube + R_1 + R_2 + R_3 + R_4, where R copper tube is constant. As R_1, R_2, R_3 and R_4 decrease, U increases as Q is essentially the constant that follows so T2 which must decrease. The delta T must also decrease resulting in temperature decrease across the water and refrigerant side of the condenser heat exchanger.

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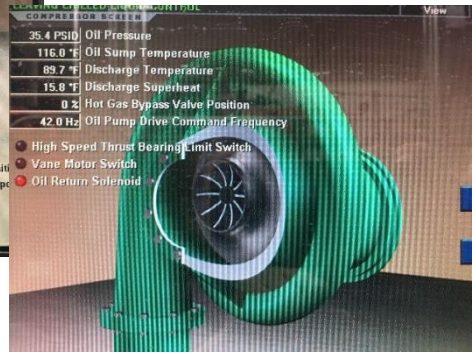
IPMVP Savings Measurement & Validation for Chiller Plants 55 & 70

International Performance Measurement and Verification Protocol (IPMVP)

General M&V Methodology

Tonnage across chiller evaporator, concurrent kW of compressor, and concurrent condenser water temperature entering condenser bundle was evaluated before and after installation of Electrocell. Before and after kW/ton values for similar tons and condenser water temperatures were used to determined overall kW/ton reduction for each plant. kW/ton reduction was applied to chilled water load profiles (average ton versus month) to determine monthly kW reduction and kWh savings (see below for details). Final electric demand reductions and energy savings includes turning off sand pumps and netted against Electrocell electric load. Water savings was calculated based on a 3 gpm/ton, 1% evaporation rate, applying kW/ton demand reduction percentage that was determined for each plant.



55 NYA York Chiller operational displays

M&V Details - 70 NYA

This variable primary chilled water plant is not connected to Cimetrics, pre and post retrofit data was collected manually. Compressor kW was calculated from recorded amps, recorded voltage, and an assumed (constant) PF. *Pre-retrofit* tonnage was determined by measuring delta T across the evaporator and apply it to an assumed pump-speed of 48 Hz (based on observations and discussions with plant supervisor) using the chiller-specific table (below) to determine flow (gpm). *Post-retrofit* tonnage was determined by dT and measured and recorded Pump Hz using the below table. 70 NYA Chiller compressor monthly kW reductions and kWh savings were determined using a 70 NYA chilled water Tonnage versus real-time load profile curve developed by Kevin Gregory PE in 2012.

Cox TAB Report

70 NYA Chiller	40 Hz (TAB)	GPM/Hz
90101	1864	46.60
90102	1820	45.50
90103	1840	46.00
90104	1619	40.48
90105	1849	46.23

M&V Details - 55 NYA

This chilled water plant had data pulled from Cimetrics which provided significant amounts of pre and post retrofit data. Compressor kW was calculated from recorded amps, assumed 460 volts, and an assumed PF vs. load curve used to convert calculated KVA to kW at all loads. Tonnage was determined by measuring delta T across the evaporator at an assumed flow of 1900 gpm. 55 NYA kW reductions and kWh savings were determined using the same load profile curve, applying a 65% multiplier to account for reduced plant size.

Energy and Water Conservation Case Study

Enthalpy Savings Method for Chiller Plants 55 & 70

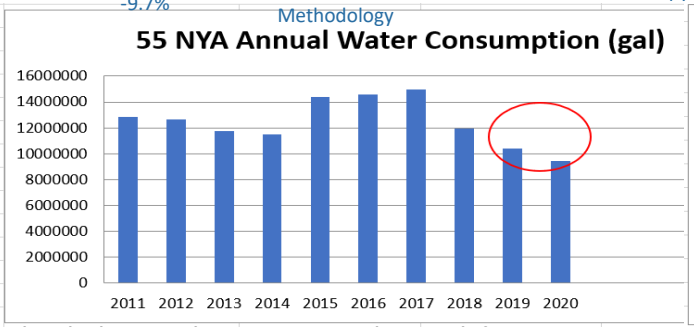
Validated ElectroCell Savings to Water

31-Aug-24

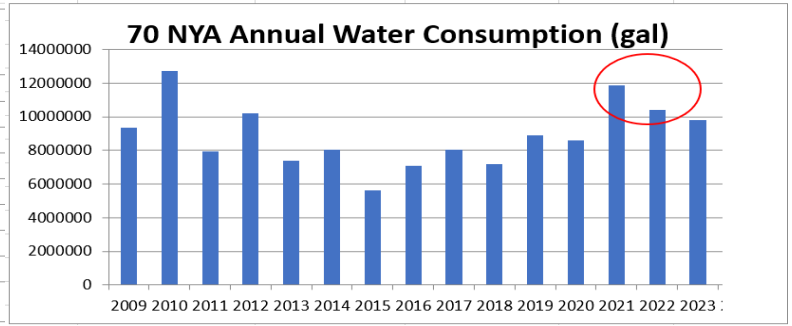
Site	Annual Water Consumption before ElectroCell (gallons)	Annual Water Consumption after ElectroCell (gallons)	Annual Water Reduction (%)	Annual Water Savings after ElectroCell (gallons)	Annual Water Cost Savings ($)	Energy Savings by IVMP Method (KWh)	Energy Savings by gallons of water (KWh)	Energy cost Savings ($)	Total Annual Savings ($)
55 NYA (3000 Tons) in service 2019	11,970,244	10,385,232	13.2%	1,585,012	$30,749	568,841	735,831	$130,833	$161,583
70 NYA (4000 Tons) in service 2021	11,853,556	10,412,160	12.2%	1,441,396	$27,963	1,108,828	1,105,180	$255,030	$282,994
Total	**23,823,800**	**20,797,392**	**12.7%**	**3,026,408**	**$58,712**	**1,677,669**	**1,841,011**	**$385,864**	**$444,576**

-9.7%

Deviation between IVMP Protocol and Enthalpy Calculation Methodology



Historical metered water consumption graph for 55 NYA



Historical metered water consumption graph for 70 NYA

Assumptions

1) .0194 cents / gallon of water.

2) .23 cents/KWh blended rate.

Chiller COP set at 3.5 as measured at both plants.

Compressor kWh per year savings = { Gallons Saved * 8.34 lbs/gal * 1070 BTU/lb * 1/3412 BTU/kWh * 1 /A } / B

Where **A** is the COP of the compressor, and excludes condenser, and chilled water pumps as well as cooling tower fan energy. Ranges 3 to 6.

Where **B** is the fraction of total annual cooling tower heat rejection due to evaporation. Typically, **B** is between 0.75 and 0.95

1070 BTU/lb is heat of vaporization for 90-degrees F ambient outdoor dry bulb air temperature.

3412 BTU to kWh is the standard conversion factor.

Energy and Water Conservation Case Study

IPMVP Savings Measurement & Validation for Chiller Plants 55 & 70

Validated Savings from (2) Electrocell Installations	Total
• Measured Electrocell Annual MwH Savings (IMVP)	1,667 MWh
• Site Energy Reduction Electricity	2.6%
• Annual Metric Tons Carbon Avoided	372 $MTCO_2$
• 15 Year Equipment Net Present Value *(at 4.5%)*	$ 2.6m
• Water Savings	$ 58k
• Opex/Capex Investment for Sanofi (2 installations)	$ 439k
• Total Savings (Water, Energy)	$ 444k
• 15 Year Internal Rate of Return	103%
• Simple Payback on Investment	1.01 years
• Gallons of water saved Annually	3.0m (12.7% avg reduction)

Note:

The first Law of Thermodynamics state that heat is a form of energy, and thermodynamic processes are therefore subject to the principle of conservation of energy. This means that energy cannot be created or destroyed. It can, however, be transferred from one location to another and converted to and from other forms of energy.

The second law of Thermodynamics states that when energy changes from one form to another form, or matter moves freely, entropy (disorder) in a closed system increases. Differences in temperature, pressure, and density tend to even out after a while. Due to the force of gravity, density and pressure do not even out vertically. Density and pressure on the bottom will be more than at the top.

IPMVP Chiller Energy Reduction Results

Chiller Plant	Compressor Demand Reduction (kW/ton)	Compressor Demand Reduction (percent)	Avg Monthly Reduction (kW)	Annual Electric Savings (MWh)
55 NYA	0.08[a]	13.9%	65	569
70 NYA	0.12[b]	14.6%	126	1100
		Total	191	1673

a – compressor demand reduction analysis completed by Cimetrics, kWh and water savings by EMA.
b – compressor demand reduction, kWh, and water savings completed by EMA.

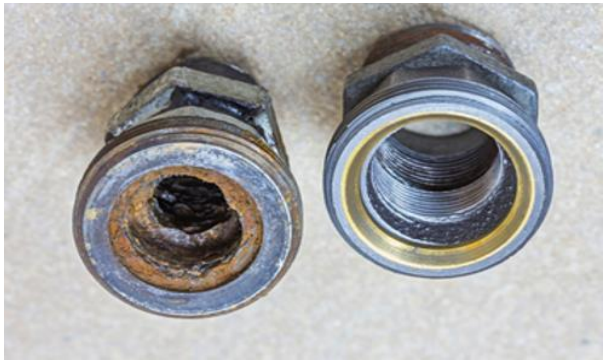
Customized installation

Energy and Water Conservation Case Study

Investment Performance Summary

Rust removed from circulating water in condenser water system by magnet.

Dissolved solids removed from cleaning of static mixers.

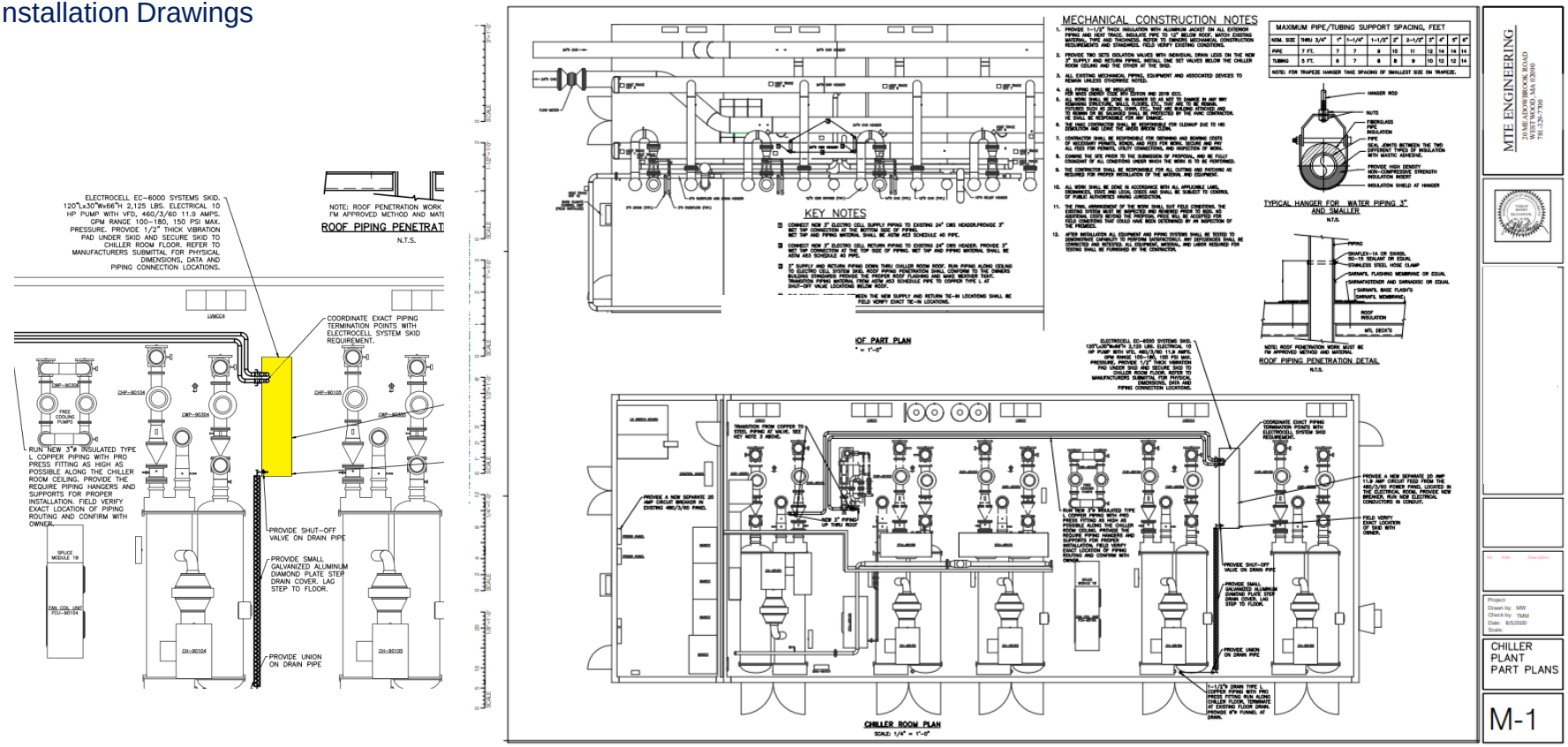


Corrosion removed on inside of piping reducing friction.

Installation on a 3,000 ton capacity central chilled water plant.

Energy and Water Conservation Case Study

Installation Drawings



Energy and Water Conservation Case Study

Suspended Water Particle Reductions (55 NYA)

ELECTROCELL SYSTEMS

PARTICLE ANALYSIS REPORT

55 NYA

95.8% particle reduction after 7.8 weeks

Sampling Source: Cooling Tower Basin Water

Electro Cell System: *XCell-4000 Particle Precipitator*

TEST METHOD: All tests completed by independent third-party laboratory. Samples analyzed by electro-optical particle analyzer employing the light scattering principle of operation with filtered water and particle data corrected Stirring was continuous.

BASELINE SAMPLE - Prior to ElectroCell Start-up - 22-OCT-2020		AFTER 7.8 WEEKS with ElectroCell System - 16-DEC-2020	
PARTICLE COUNTS PER 100mL TEST PORTION		**PARTICLE COUNTS PER 100mL TEST PORTION**	
1 - 3 micron:	425,460	1 - 3 micron:	396,835
3 - 5 micron:	86,160	3 - 5 micron:	79,229
5 - 10 micron:	104,600	5 - 10 micron:	46,577
10 - 15 micron:	40,680	10 - 15 micron:	7,926
15 - 25 micron:	43,500	15 - 25 micron:	4,693
Over 25 micron:	31,600	Over 25 micron:	1,267
TOTAL / 100mL:	**732,000**	**TOTAL / 100mL:**	**536,527**
SOLIDS PER 100 LITERS OF SYSTEM VOLUME (mm^3)		**SOLIDS PER 100 LITERS OF SYSTEM VOLUME (mm^3)**	
1 - 5 micron:	8.92	1 - 5 micron:	8.25
5 - 10 micron:	44.14	5 - 10 micron:	19.66
Over 10 micron:	21,525.48	Over 10 micron:	887.88
TOTAL / 100 Liters:	**21,578.54**	**TOTAL / 100 Liters:**	**915.79**
	216 ppm		**9 ppm**

Condenser water before start-up
Particles > 25 micron,

Debris removed from condenser water after 1 week of operation

Energy and Water Conservation Case Study

Suspended Water Particle Reduction (70 NYA)

ELECTROCELL SYSTEMS

PARTICLE ANALYSIS REPORT

70 NYA

99.84% particle reduction after 4 weeks

Sampling Source: Cooling Tower Basin Water

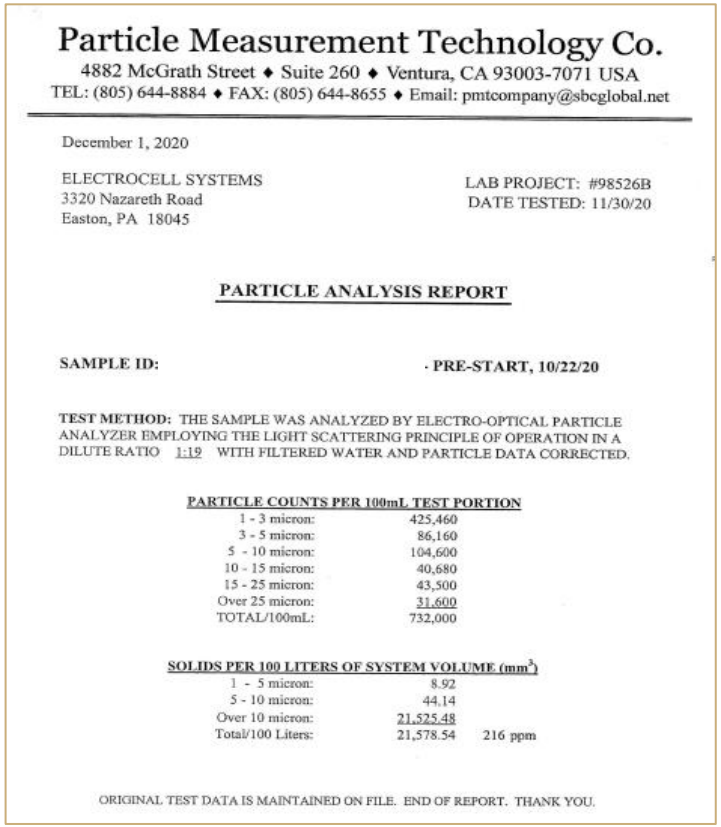
Electro Cell System: *XCell-6000 Particle Precipitator*

TEST METHOD: All tests completed by independent third-party laboratory. Samples analyzed by electro-optical particle analyzer employing the light scattering principle of operation with filtered water and particle data corrected. Stirring was continuous.

BASELINE SAMPLE - Prior to ElectroCell Start-up - 16-DEC-2020		AFTER 4 WEEKS with ElectroCell System - 13-JAN-2021	
PARTICLE COUNTS PER 100mL TEST PORTION		**PARTICLE COUNTS PER 100mL TEST PORTION**	
1 - 3 micron:	14,273,000	1 - 3 micron:	58,381
3 - 5 micron:	2,807,400	3 - 5 micron:	15,738
5 - 10 micron:	3,861,200	5 - 10 micron:	12,842
10 - 15 micron:	2,579,000	10 - 15 micron:	4,219
15 - 25 micron:	2,707,800	15 - 25 micron:	4,972
Over 25 micron:	3,403,400	Over 25 micron:	5,359
TOTAL / 100mL:	**29,631,800**	**TOTAL / 100mL:**	**101,511**
SOLIDS PER 100 LITERS OF SYSTEM VOLUME (mm^3)		**SOLIDS PER 100 LITERS OF SYSTEM VOLUME (mm^3)**	
1 - 5 micron:	293.86	1 - 5 micron:	1.47
5 - 10 micron:	1,629.43	5 - 10 micron:	5.42
Over 10 micron:	2,302,178.61	Over 10 micron:	3,630.71
TOTAL / 100 Liters:	**2,304,101.90**	**TOTAL / 100 Liters:**	**3,637.60**
	23041 ppm		**36 ppm**

Energy and Water Conservation Case Study

Third Party Water Quality Testing



Particle Measurement Technology Co.
4882 McGrath Street ♦ Suite 260 ♦ Ventura, CA 93003-7071 USA
TEL: (805) 644-8884 ♦ FAX: (805) 644-8655 ♦ Email: pmtcompany@sbcglobal.net

December 1, 2020

ELECTROCELL SYSTEMS
3320 Nazareth Road
Easton, PA 18045

LAB PROJECT: #98526B
DATE TESTED: 11/30/20

PARTICLE ANALYSIS REPORT

SAMPLE ID: · **PRE-START, 10/22/20**

TEST METHOD: THE SAMPLE WAS ANALYZED BY ELECTRO-OPTICAL PARTICLE ANALYZER EMPLOYING THE LIGHT SCATTERING PRINCIPLE OF OPERATION IN A DILUTE RATIO 1:19 WITH FILTERED WATER AND PARTICLE DATA CORRECTED.

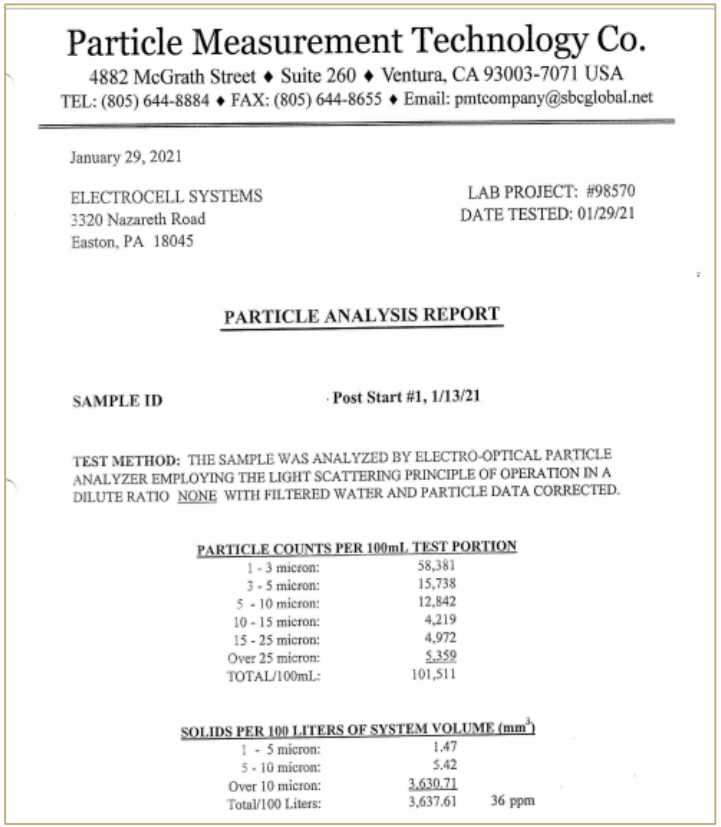
PARTICLE COUNTS PER 100mL TEST PORTION

1 - 3 micron:	425,460
3 - 5 micron:	86,160
5 - 10 micron:	104,600
10 - 15 micron:	40,680
15 - 25 micron:	43,500
Over 25 micron:	31,600
TOTAL/100mL:	732,000

SOLIDS PER 100 LITERS OF SYSTEM VOLUME (mm^3)

1 - 5 micron:	8.92	
5 - 10 micron:	44.14	
Over 10 micron:	21,525.48	
Total/100 Liters:	21,578.54	216 ppm

ORIGINAL TEST DATA IS MAINTAINED ON FILE. END OF REPORT. THANK YOU.



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January 29, 2021

ELECTROCELL SYSTEMS
3320 Nazareth Road
Easton, PA 18045

LAB PROJECT: #98570
DATE TESTED: 01/29/21

PARTICLE ANALYSIS REPORT

SAMPLE ID · **Post Start #1, 1/13/21**

TEST METHOD: THE SAMPLE WAS ANALYZED BY ELECTRO-OPTICAL PARTICLE ANALYZER EMPLOYING THE LIGHT SCATTERING PRINCIPLE OF OPERATION IN A DILUTE RATIO NONE WITH FILTERED WATER AND PARTICLE DATA CORRECTED.

PARTICLE COUNTS PER 100mL TEST PORTION

1 - 3 micron:	58,381
3 - 5 micron:	15,738
5 - 10 micron:	12,842
10 - 15 micron:	4,219
15 - 25 micron:	4,972
Over 25 micron:	5,359
TOTAL/100mL:	101,511

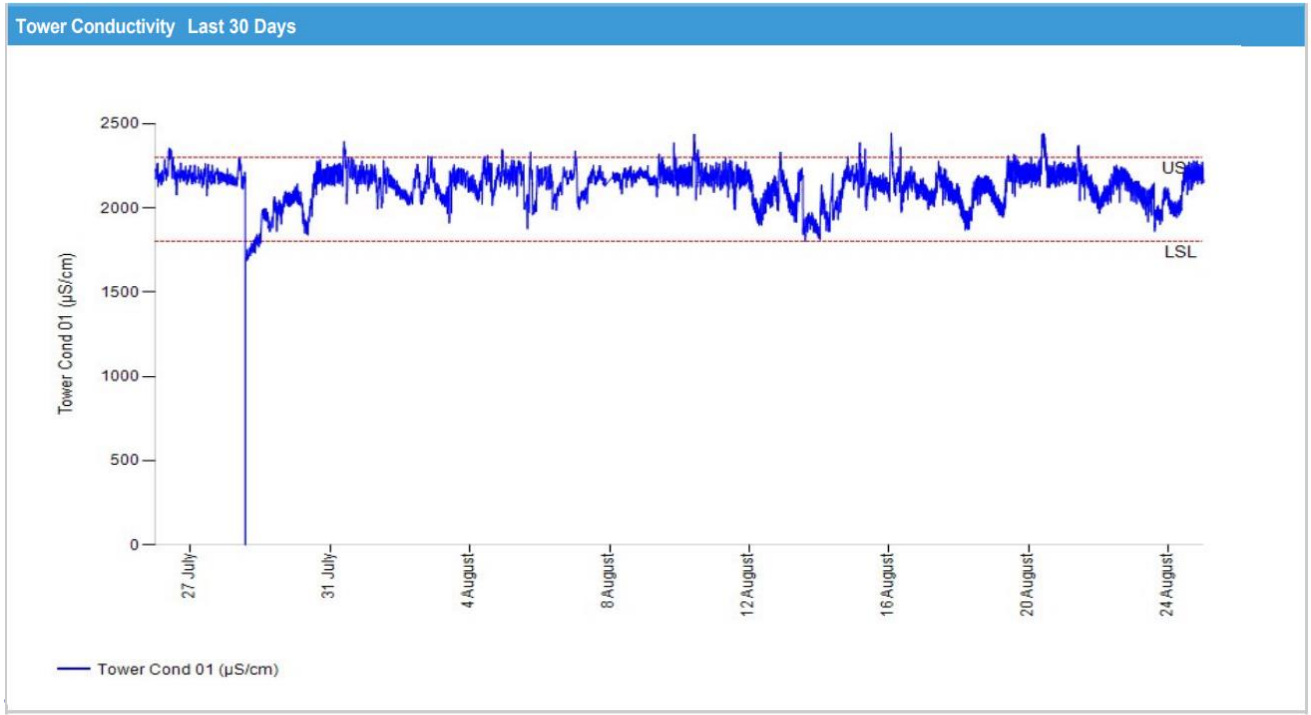
SOLIDS PER 100 LITERS OF SYSTEM VOLUME (mm^3)

1 - 5 micron:	1.47	
5 - 10 micron:	5.42	
Over 10 micron:	3,630.71	
Total/100 Liters:	3,637.61	36 ppm

Energy and Water Conservation Case Study

Water Treatment Post Installation

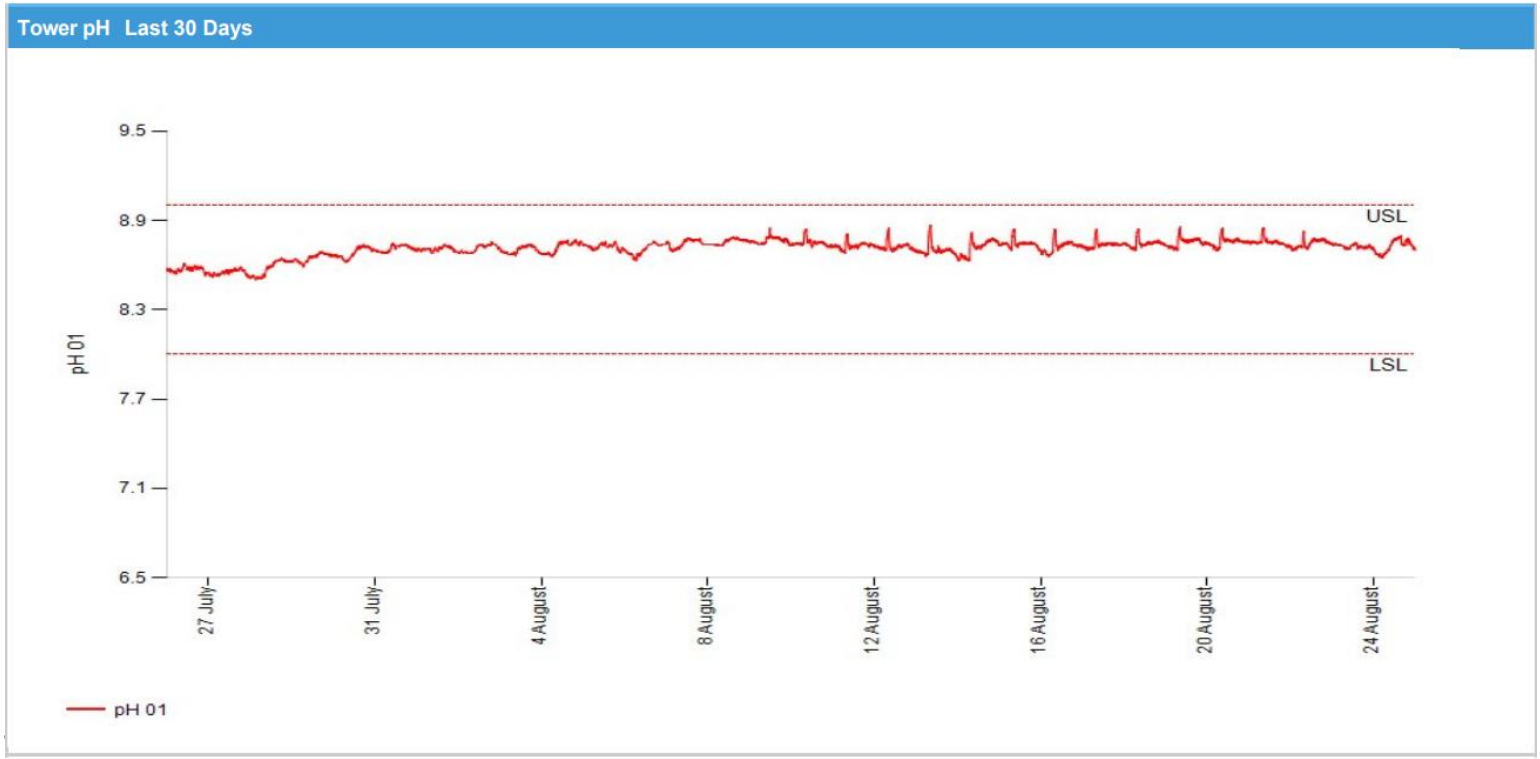
Conductivity is an indirect measurement of cycles of concentration or how long you are holding the CW in the system. The idea is to hold the water as long a possible to prevent using too much water while protecting against scale, corrosion, & microbial growth. As you can see, we have set upper and lower control limits for each cooling tower system based on key chemistry parameters in your water and you are now running well within that control band pretty much all the time.



Energy and Water Conservation Case Study

Water Treatment Post Installation

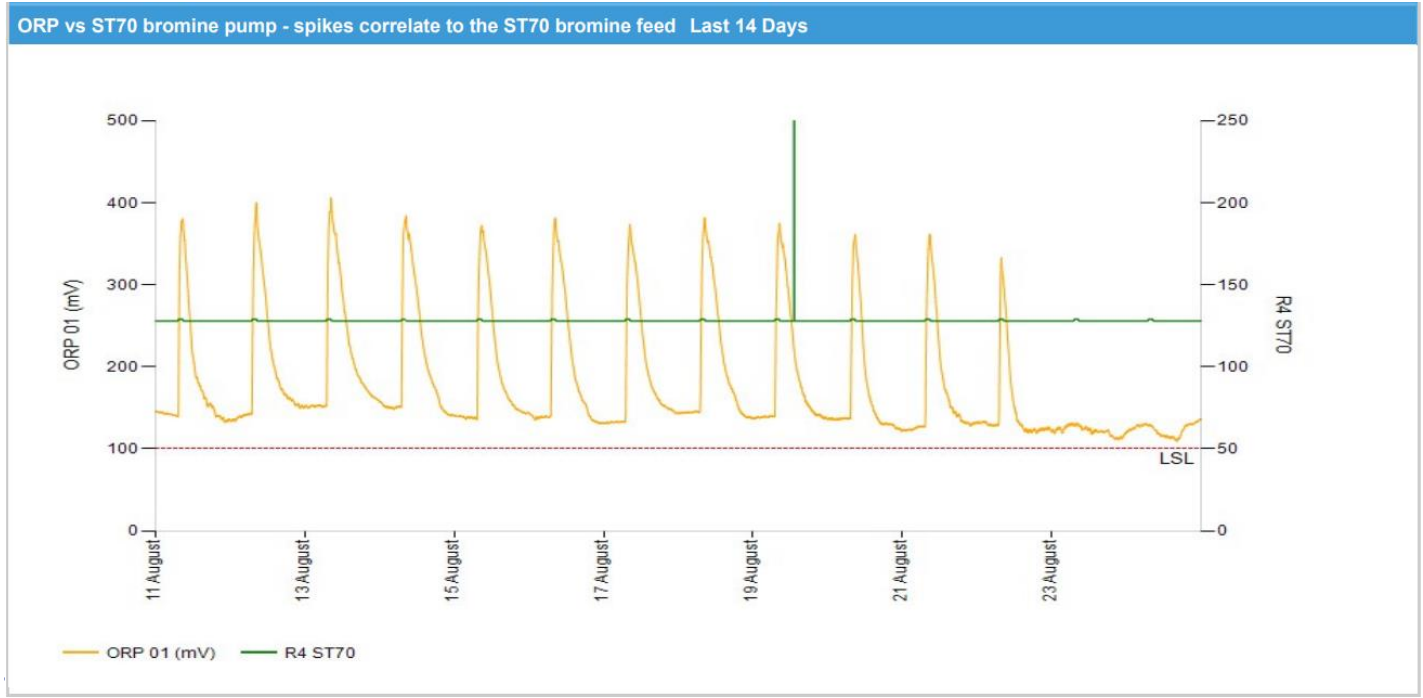
pH is a measurement to help us understand if your water is showing corrosive tendencies. We try to manage pH in a relatively neutral to high – neutral band of 8.0 – 9.0. This helps to minimize corrosion of mild steel as well as not put undue stress on the system to drive scaling or deposition. As you can see, your system is now running well within the recommended pH control band.



Energy and Water Conservation Case Study

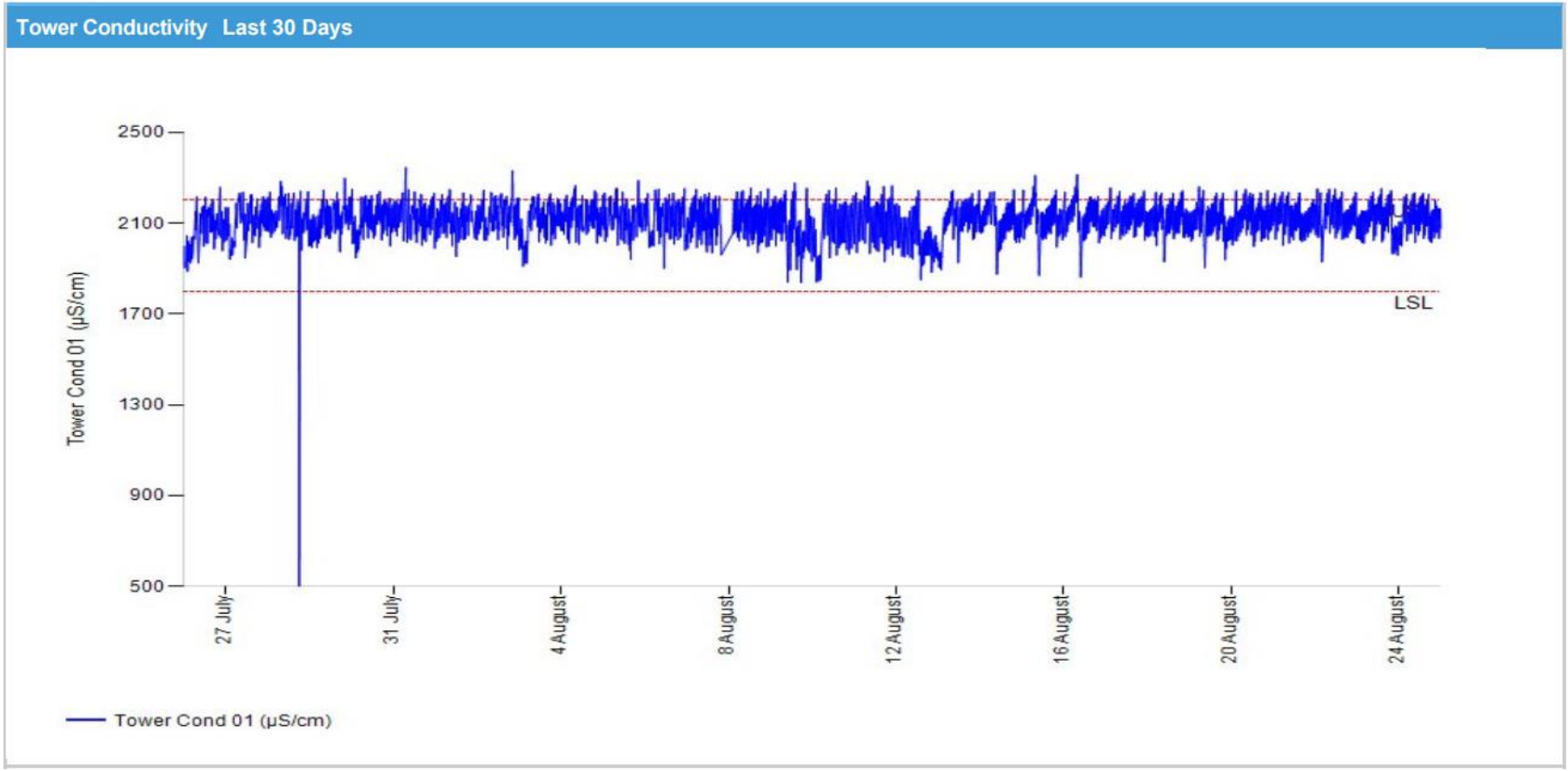
Water Treatment Post Installation

ORP if a measurement to allow us to see that we are providing an oxidizing environment to your cooling systems to reduce microbial activity. We specifically feed an oxidizing biocide on a timed basis to increase this ORP spike. We don't want a sustained ORP as this can lead to increased corrosion in the system, but a spike will allow us to manage the bacteria while not driving increased corrosion. As you can see, you are getting consistent feed and control of Oxidizing Biocide to help control microbes in your cooling water



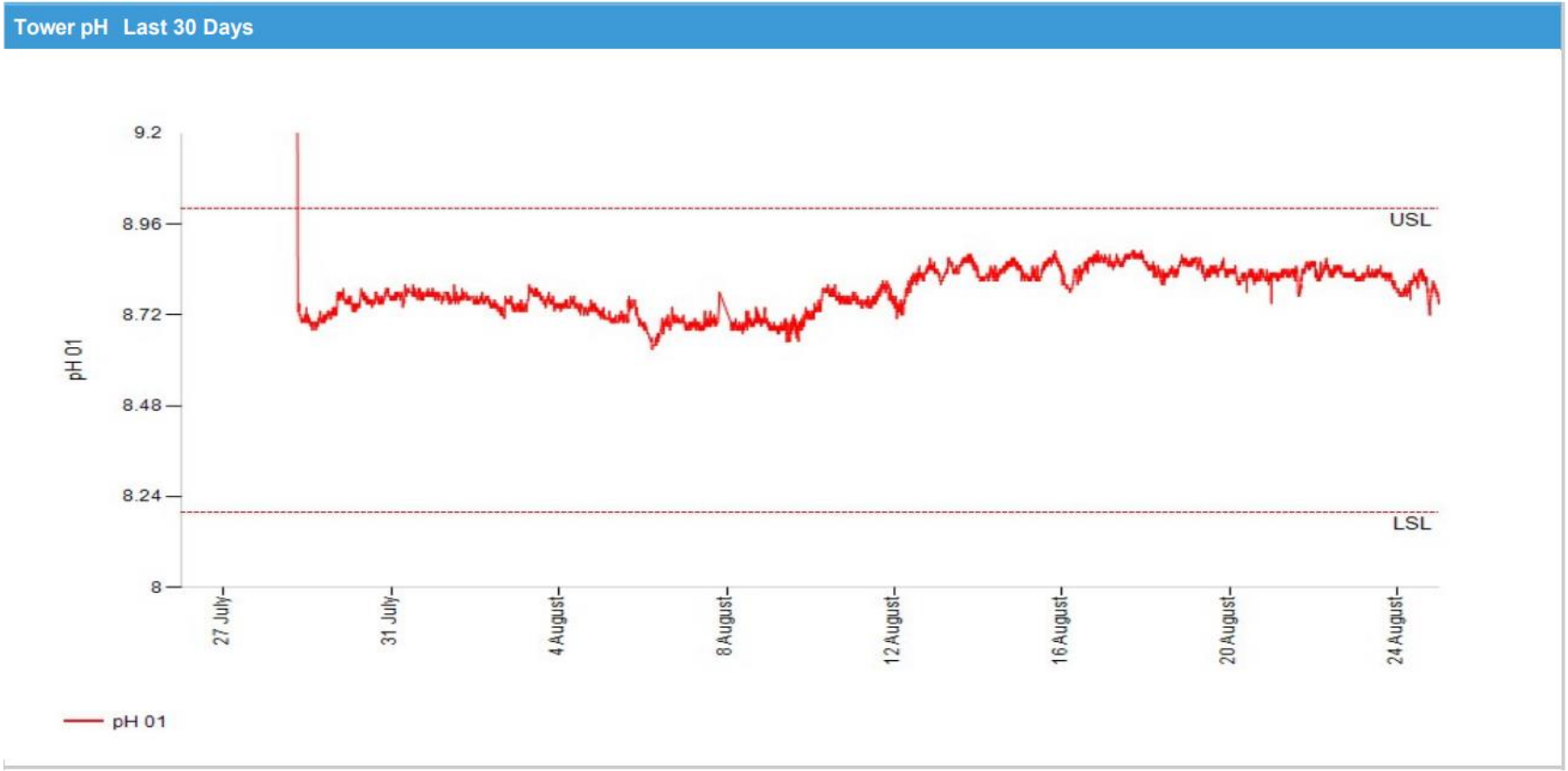
Energy and Water Conservation Case Study

Water Treatment Post Installation



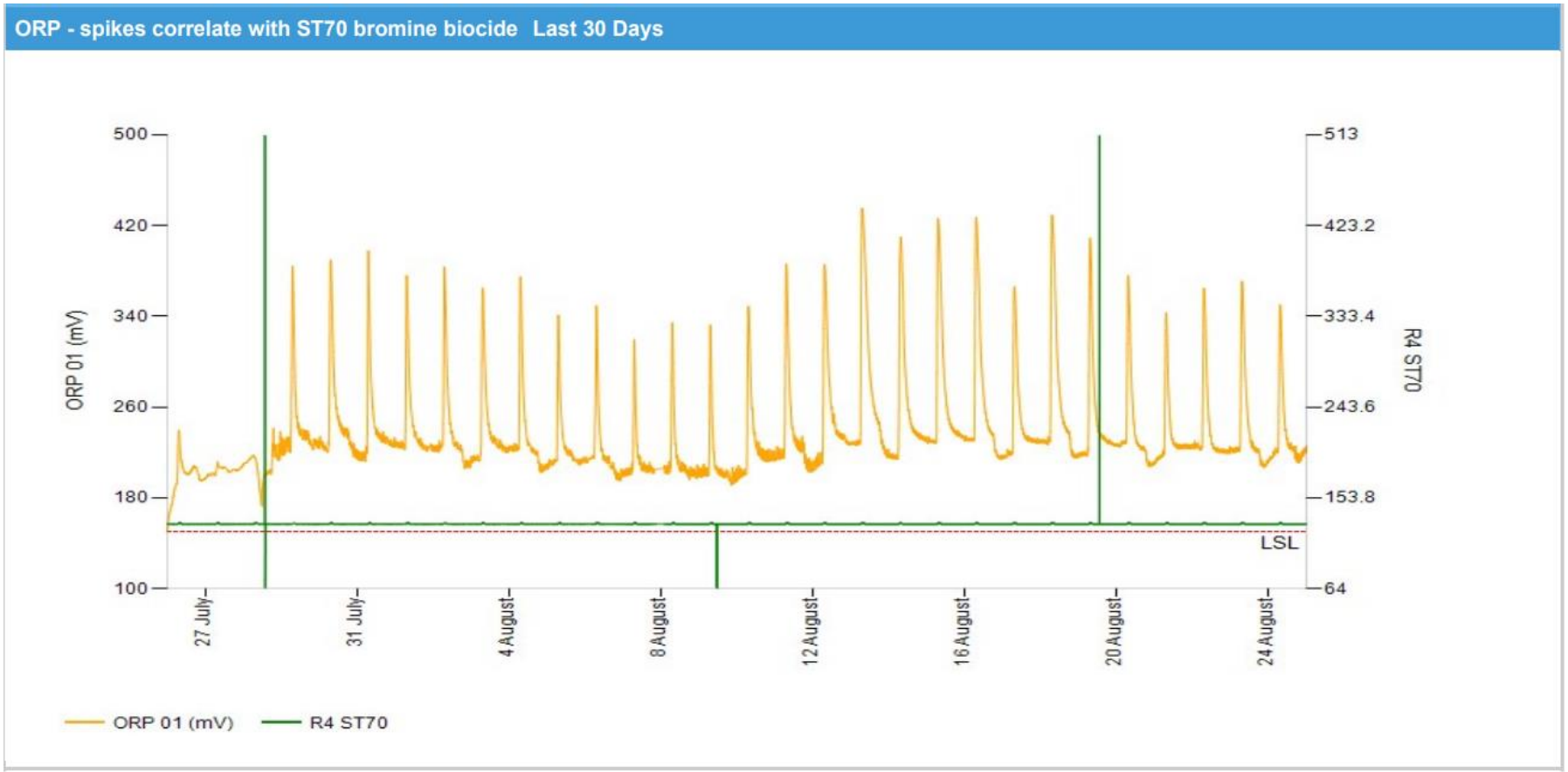
Energy and Water Conservation Case Study

Water Treatment Post Installation



Energy and Water Conservation Case Study

Water Treatment Post Installation



Energy and Water Conservation Case Study

Conclusion and Next Case Studies (Open and closed loop systems)


Cleaning of ElectroCell skid


Installation of EC-4000 skid


Installation EC-4000 skid


Installation of EC-6000

ELECTROCELL SYSTEMS

PARTICLE ANALYSIS REPORT

8 NYA

99.7% particle reduction

Sampling Source: Cooling Tower Basin Water

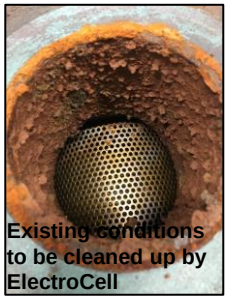
Electro Cell System: XCell-4000 Particle Precipitator

TEST METHOD: All tests completed by independent third-party laboratory. Samples analyzed by electro-optical particle analyzer employing the light scattering principle of operation with filtered water and particle data corrected. Stirring was continuous.

BASELINE SAMPLE - Prior to ElectroCell Start-up - 06-OCT-2022		POST START-UP SAMPLE with ElectroCell System - 27-FEB-2023	
PARTICLE COUNTS PER 100mL TEST PORTION		**PARTICLE COUNTS PER 100mL TEST PORTION**	
1 - 3 micron:	2,482,272	1 - 3 micron:	75,953
3 - 5 micron:	440,720	3 - 5 micron:	4,892
5 - 10 micron:	326,208	5 - 10 micron:	2,148
10 - 15 micron:	76,400	10 - 15 micron:	305
15 - 25 micron:	95,264	15 - 25 micron:	293
Over 25 micron:	99,840	Over 25 micron:	343
TOTAL / 100mL:	**3,520,704**	**TOTAL / 100mL:**	**83,934**
SOLIDS PER 100 LITERS OF SYSTEM VOLUME (mm^3)		**SOLIDS PER 100 LITERS OF SYSTEM VOLUME (mm^3)**	
1 - 5 micron:	48.06	1 - 5 micron:	0.92
5 - 10 micron:	137.66	5 - 10 micron:	0.91
Over 10 micron:	67,662.05	Over 10 micron:	232.19
TOTAL / 100 Liters:	**67,847.77** 678 ppm	**TOTAL / 100 Liters:**	**234.02** 2 ppm

Electro Cell Systems
3320 Nazareth Road, Easton, PA 18045
Phn: (800) 949-3445 Fax: (610) 438-4472 email: info@electrocellsystems.com


Wet tap filings caught on ElectroCell magnet


Existing conditions to be cleaned up by ElectroCell


Voltage testing of skid