
CRESTON™
WATER SOLUTIONS
ELECTRICHLOR
Leading innovation in hypochlorite generation

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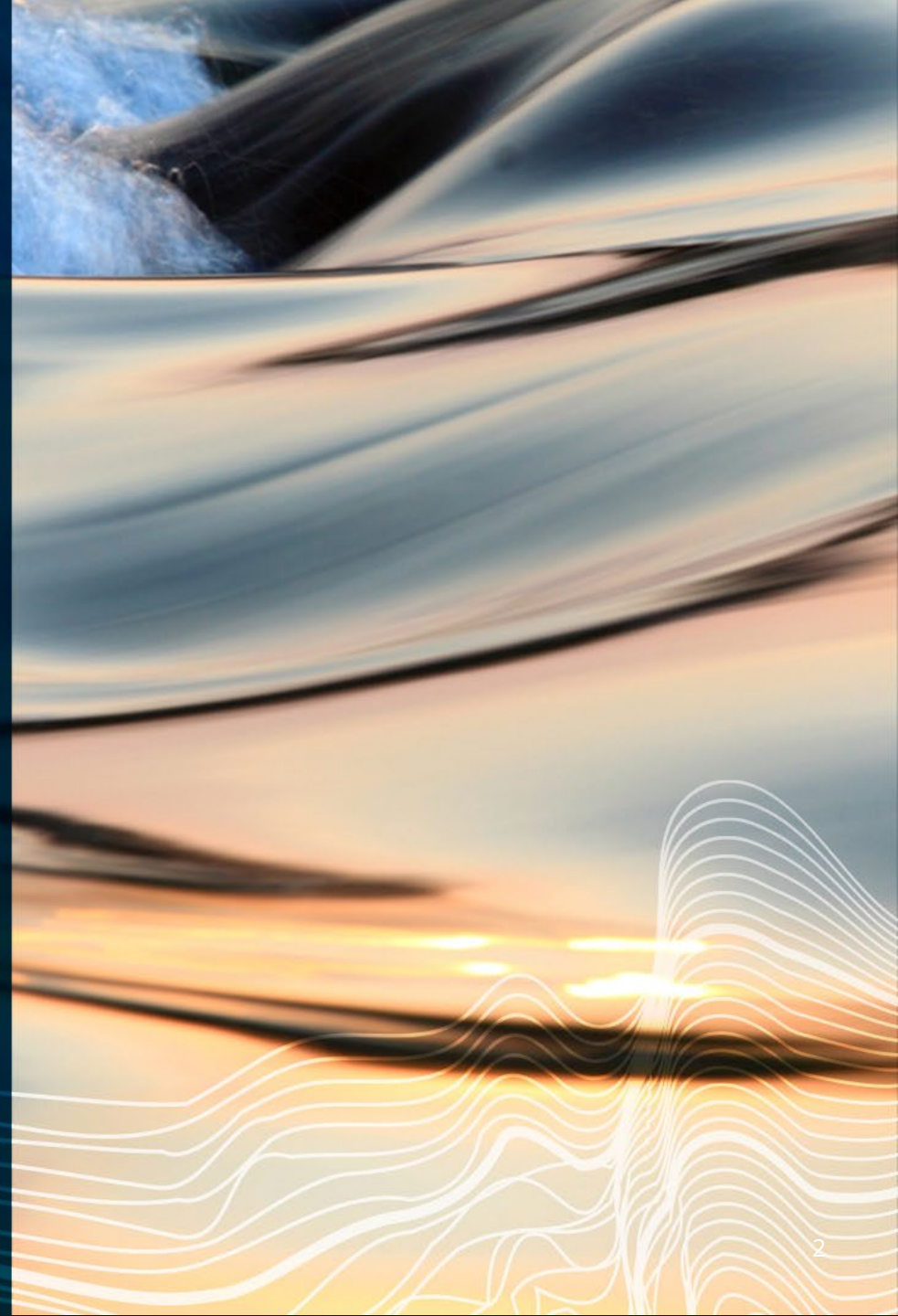
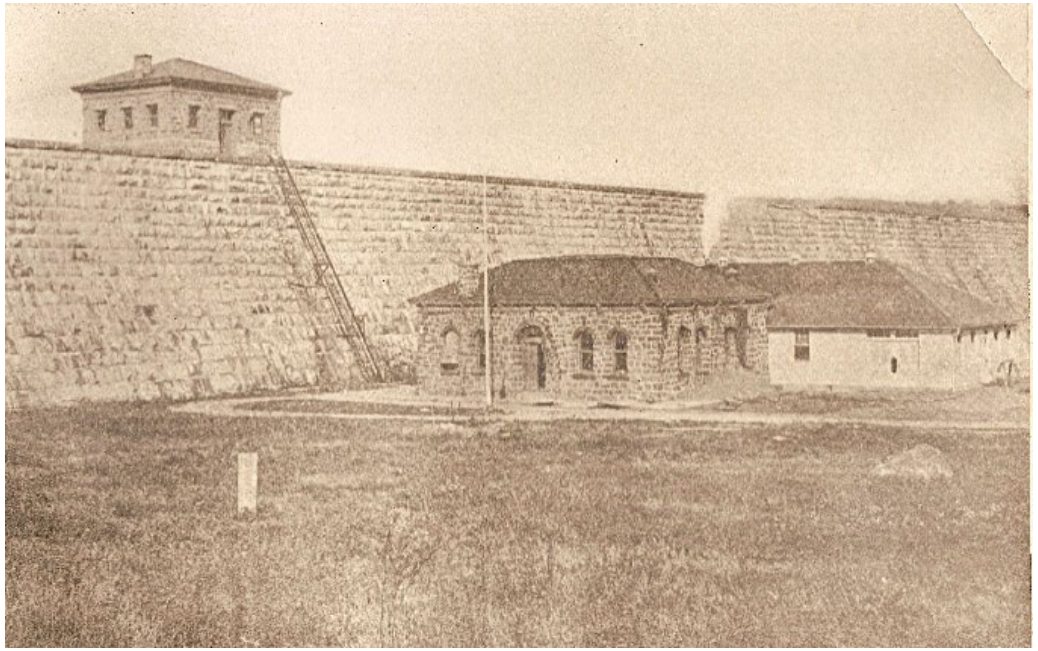
Chlorination - a quick review



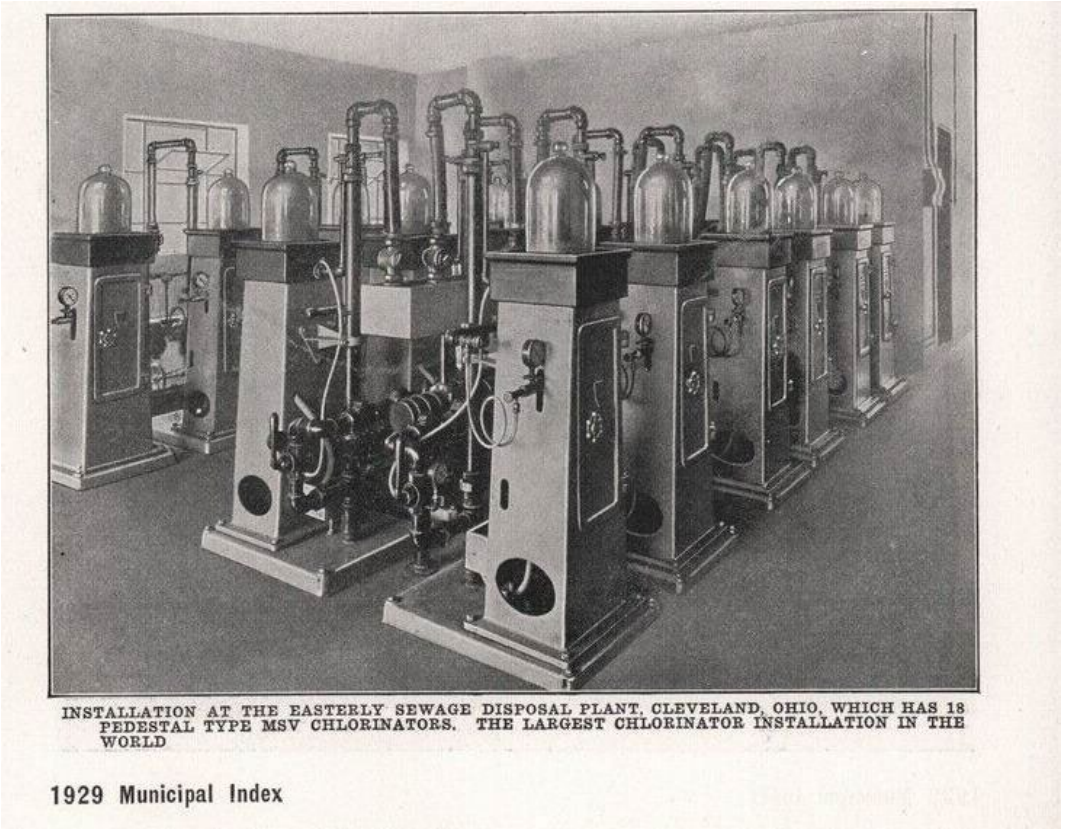
Chlorine has been used for more than 100yrs

Jersey City, NJ was first to chlorinate drinking water



Boonton Reservoir – Chlorination Plant. 1909. Jersey City, NJ.
waterandhealth.org

Cleveland, OH was first to chlorinate wastewater



INSTALLATION AT THE EASTERLY SEWAGE DISPOSAL PLANT, CLEVELAND, OHIO, WHICH HAS 18 PEDESTAL TYPE MSV CHLORINATORS. THE LARGEST CHLORINATOR INSTALLATION IN THE WORLD

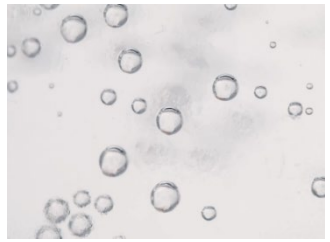
1929 Municipal Index

When added to water, Cl_2 dissociates into ClO^- and HOCl

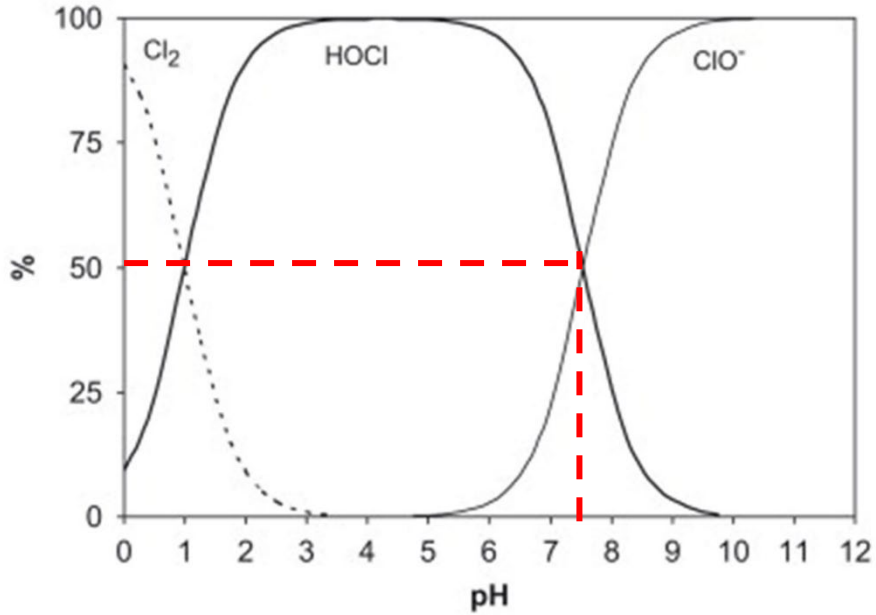
Historically, chlorine was available as liquified gas stored in pressurized containers

Cl_2

chlorine gas



readily dissolves in water

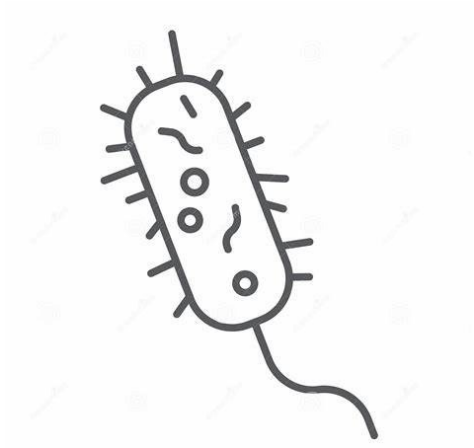


and **depending on pH**, it dissociates into a mix of:

- ClO^- (hypochlorite ion)
- HOCl (hypochlorous acid)

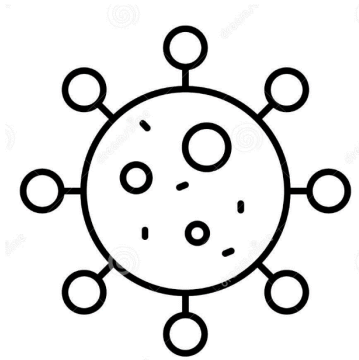
Both, ClO^- and HOCl, are effective disinfectants

BACTERIA



HOCl disrupts cell membrane (cell spills its guts)

VIRUS



HOCl damages virus DNA (can't replicate)

ClO^- damages virus "injection" sites (can't infect host cell)

And both are effective in biofouling control

MUSSELS & BARNACLES

Hypochlorous acid (HOCl) disrupts basic cell functions of barnacle larvae. Both, ClO- and HOCl affect adult mussels' ability to filter water and shell valve movement.

ALGAE

Hypochlorous acid (HOCl) spreads along the surface of the algae cell, penetrating the membrane and oxidizing intracellular protein, resulting in the inhibition of algae growth.

Efficacy depends on Dose and contact Time

Ct CONCEPT

C

(mg/L)

Concentration

Chlorine concentration in water after demand is satisfied

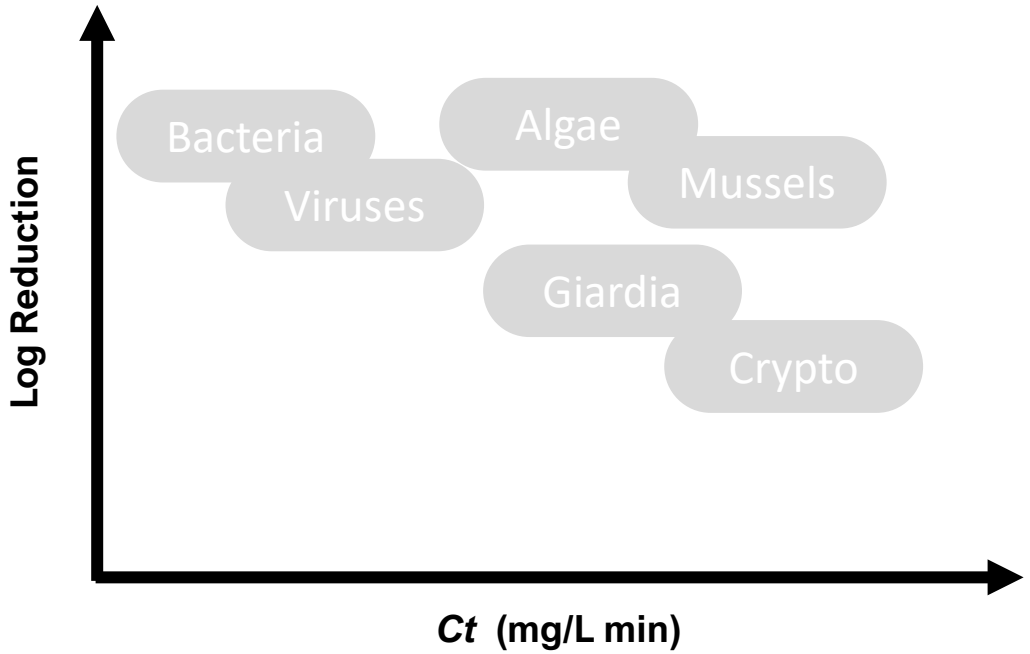
t

(min)

Contact Time

Length of time chlorine is in contact with microorganisms in water

DOSE RESPONSE



The right dose depends on target organism and available contact time

Up until the 1990s, chlorine gas was the standard, but…

Chlorine available at lowest cost as liquified gas in pressurized containers

Chlorine Gas is highly toxic to humans

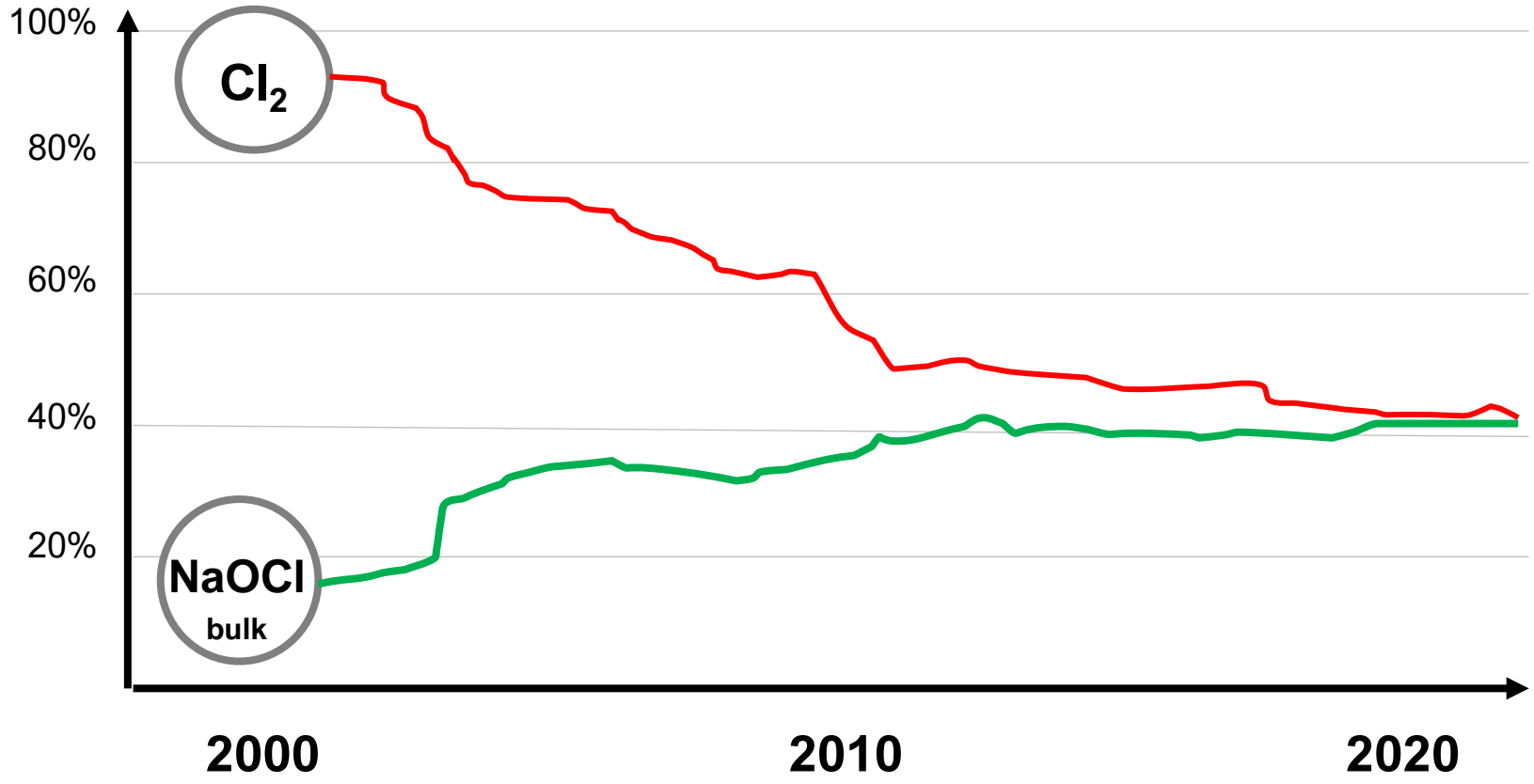
Public safety concerns increased after 2001

Chlorine gas users implemented safety measures to minimize risks; but alternatives were needed…

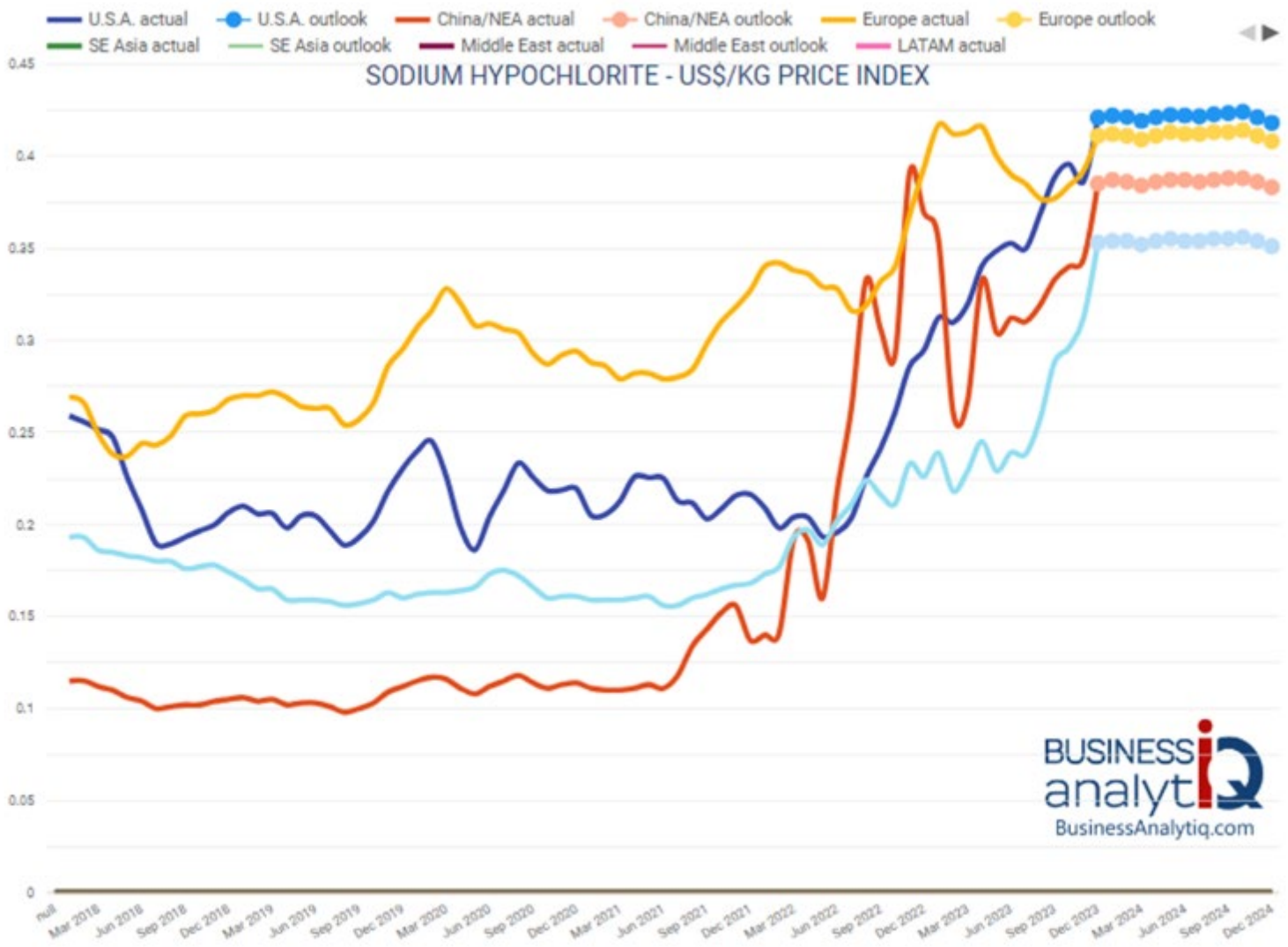
Chlorine is available in different forms

	GAS	LIQUID	SOLID
	Chlorine	Sodium Hypochlorite	Calcium Hypochlorite
AVAILABILITY	150 lb bottles Ton containers (2,000 lb) Rail Cars (80,000 lb)	Bulk @ 12 to 15%	Tablets
ADVANTAGES	Very Cheap ($0.50/lb)	Easy to store and handle	Easy to store and handle Relatively Safe
DISADVANTAGES	Extremely toxic Hard to contain leaks	Loses strength in storage Volatile price (>$2/gal)	Expensive ($2/lb) Only practical for small sites

Bulk hypo has been the main alternative to Cl 2



But hypo is becoming too expensive



Hypochlorite prices expected to remain at twice what they were in 2021

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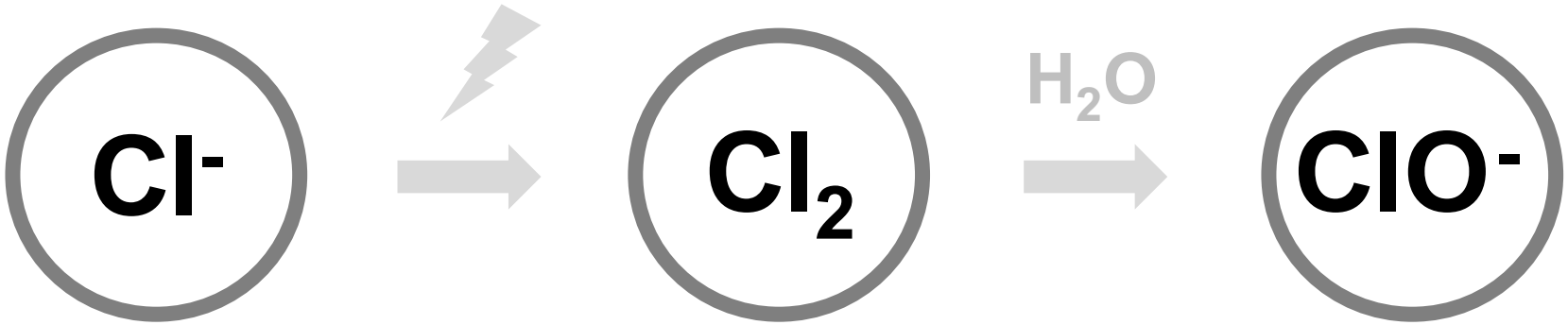
On-site Hypochlorite Generation

Using electricity to make Hypochlorite from brine



CHLORIDE

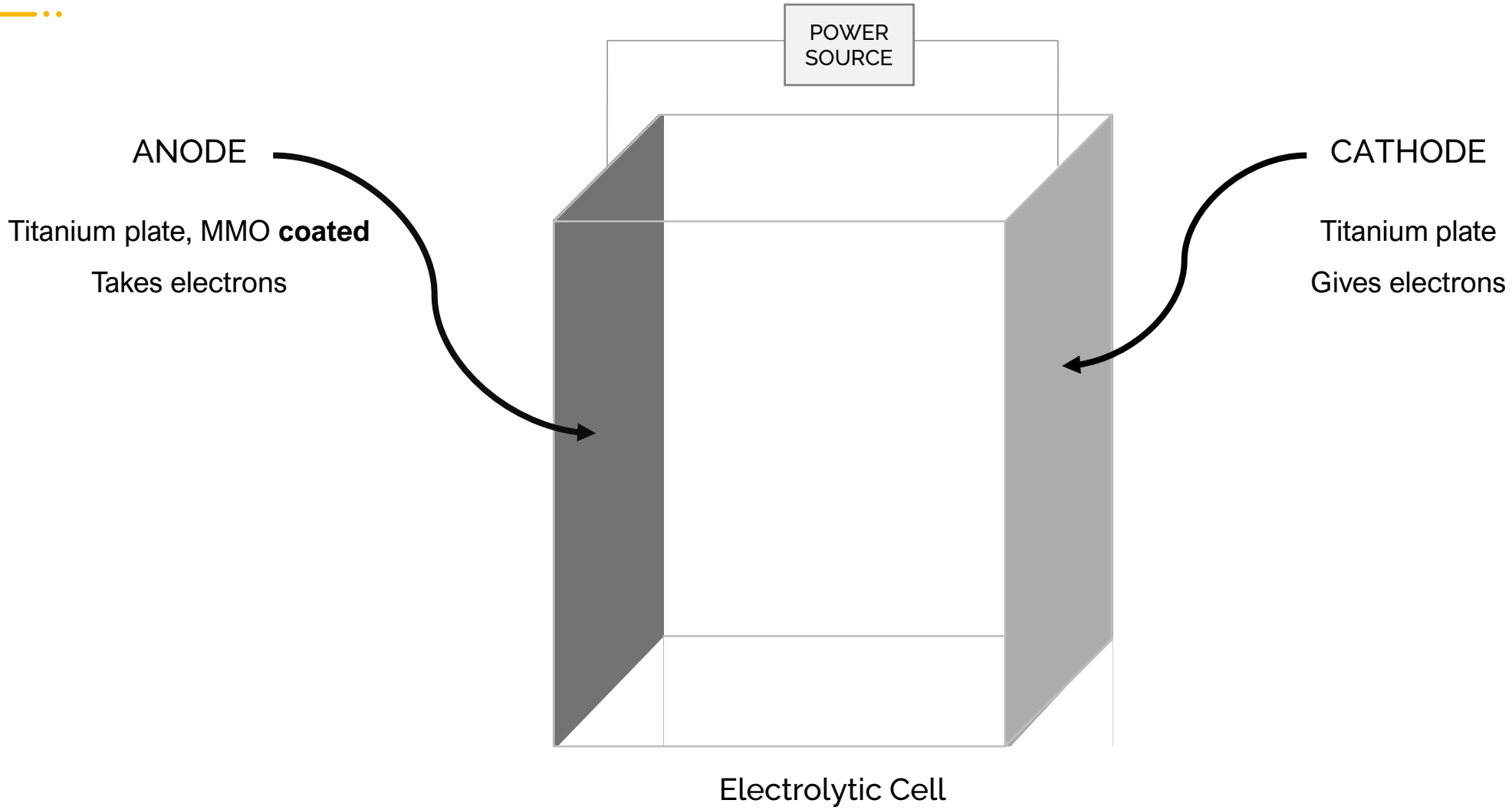
from salt, brine or seawater

CHLORINE

Quickly dissolves in water

HYPOCHLORITE

Electrolysis of brine takes place in an electrolytic cell



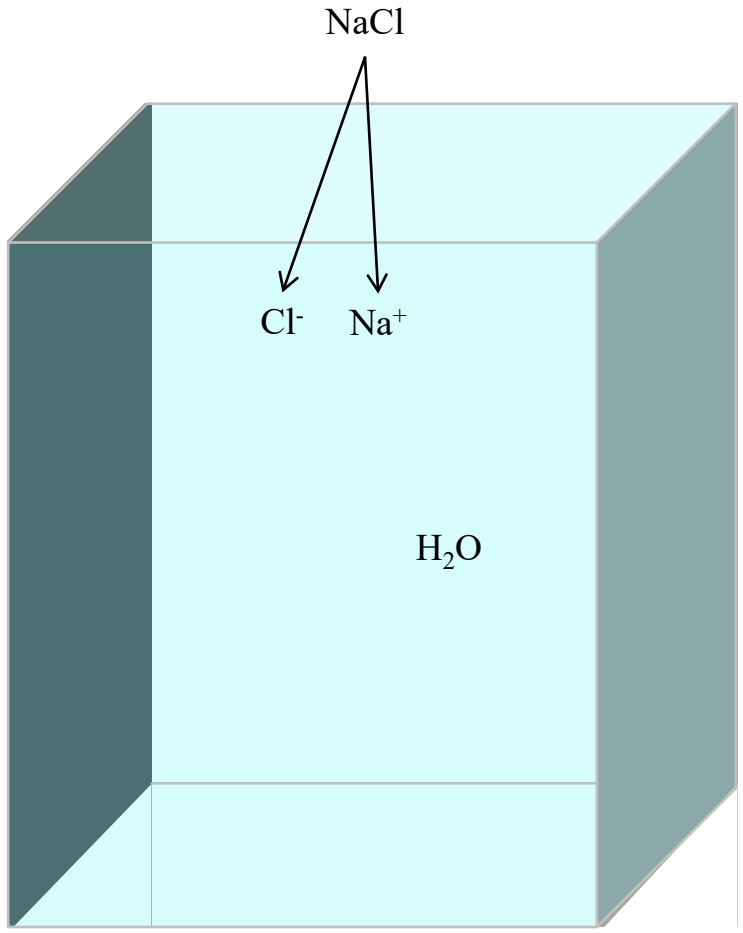
A chloride source (salt, brine or seawater) is needed

Cell filled with water

Salt (NaCl) dissolves and dissociates into Na+ and Cl-

$$NaCl \rightarrow Cl^- + Na^+$$

When seawater is used, chloride ions are already present.

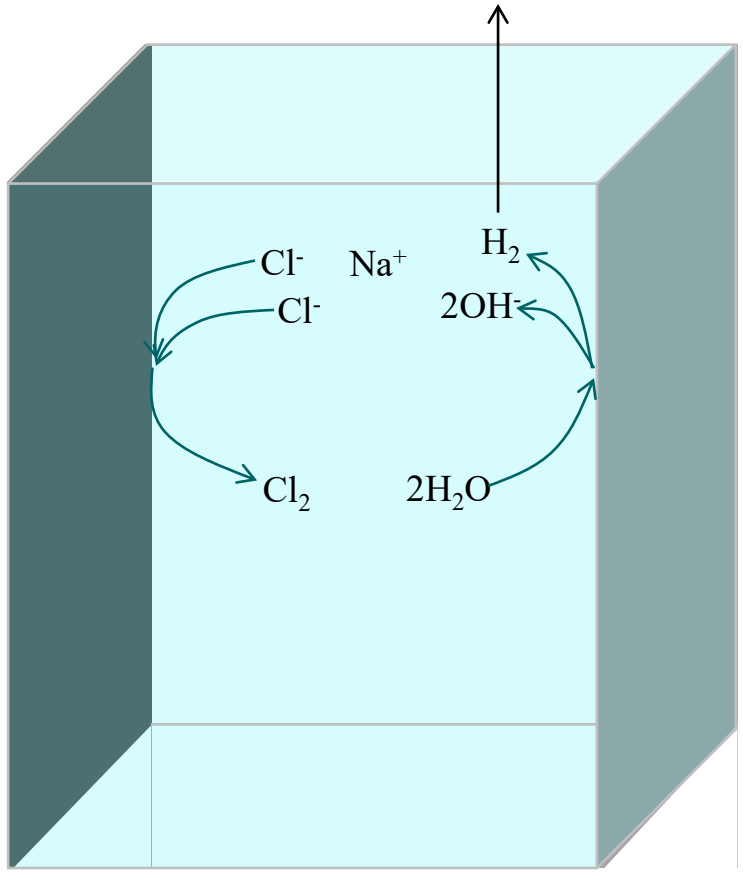


The cell produces Cl_2 (dissolves) and H_2 (bubbles out)

ANODE

Two chloride ions give away their electrons to form one molecule of chlorine gas.

$$2Cl^- \rightarrow Cl_2 + 2e^-$$



Sodium ions do not react during the electrolysis process

CATHODE

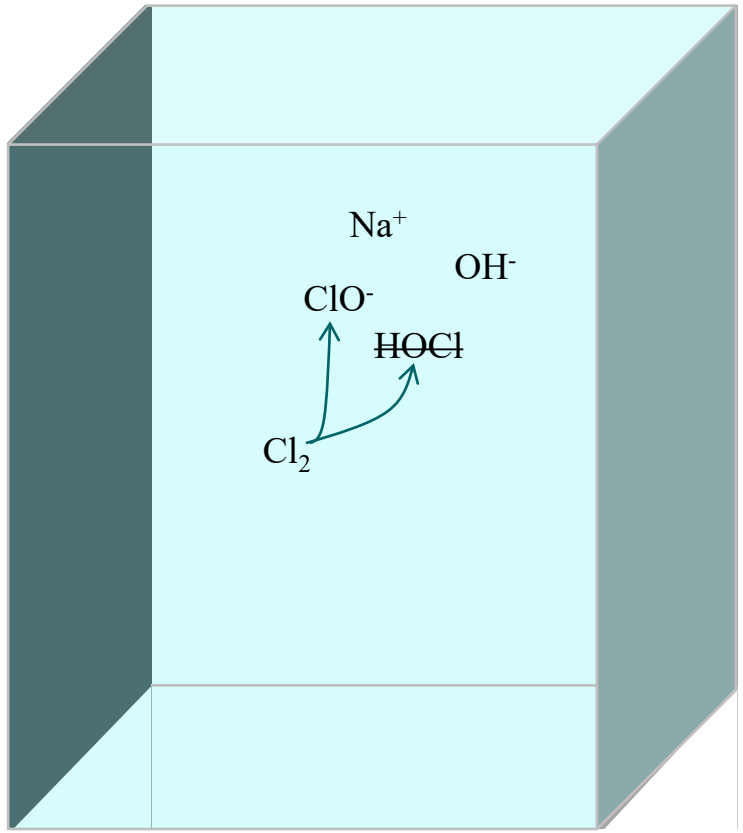
Two molecules of water take electrons and get electrolyzed (split) into hydrogen ions and hydroxide ions. Hydrogen ions combine to form hydrogen gas.

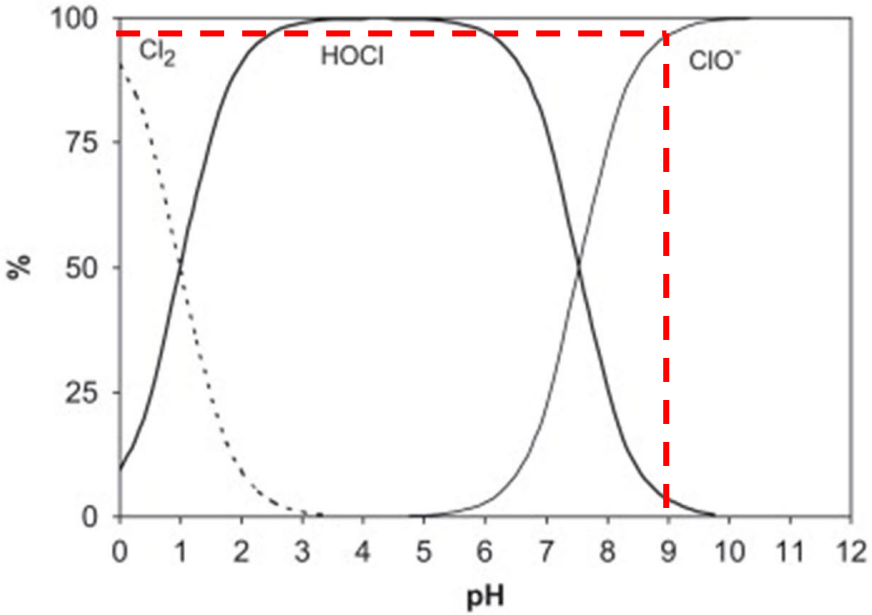
$$2H_2O + 2e^- \rightarrow 2OH^- + H_2$$

At a high pH, dissolved chlorine turns into hypo

Excess OH (hydroxide) ions increase pH

At higher pH, Chlorine is present primarily as hypochlorite ion.

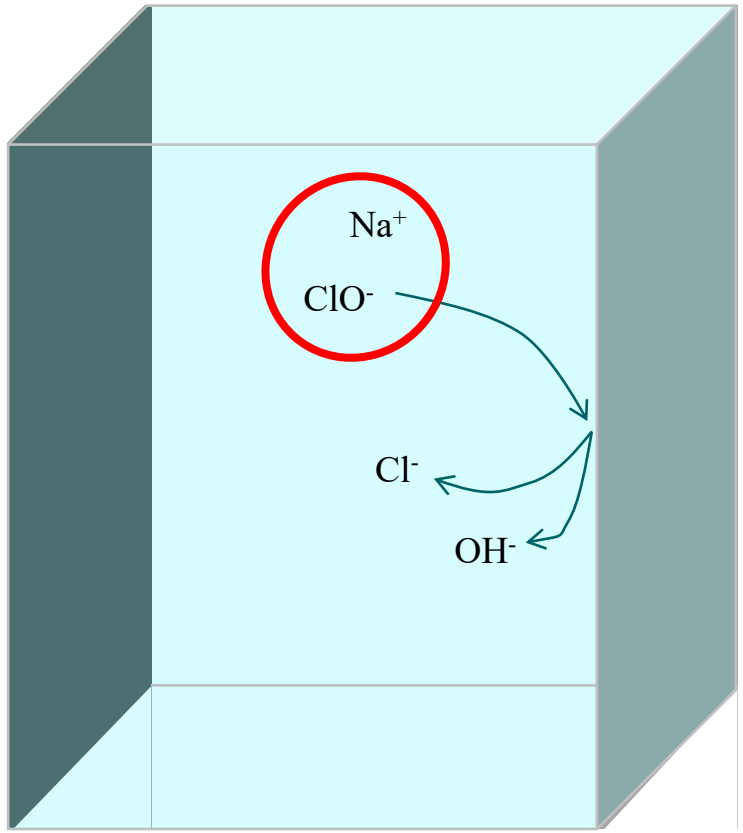




This process yields < 1% Hypo

The final product is a sodium hypochlorite (NaOCl) solution.

Unseparated cells (*no membrane between anode and cathode*) produce low strength hypochlorite (<1%)

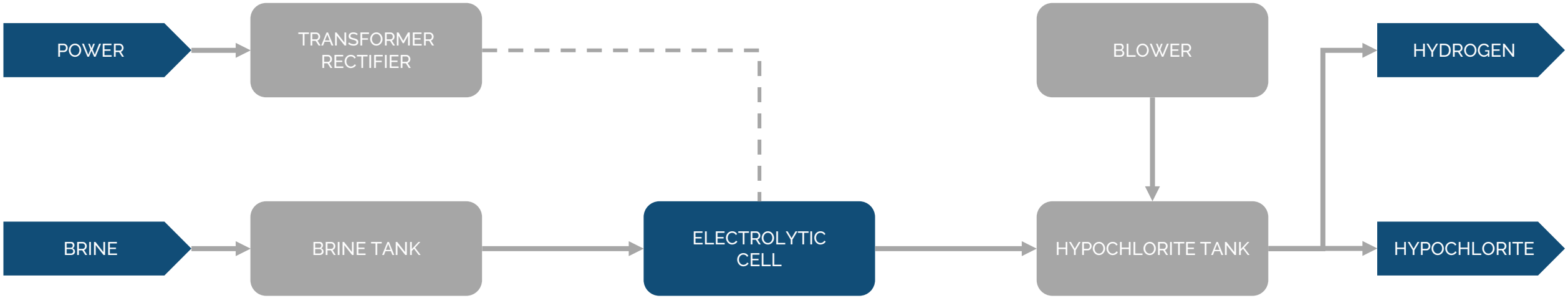


If the hypochlorite concentration were to increase **beyond 1%, a parasitic reaction**, destroying ClO^- would be favored.

$$ClO^- + H_2O + 2e^- \rightarrow Cl^- + 2OH^-$$

This is why most OSHG systems rate their hypochlorite strength at **0.8%**

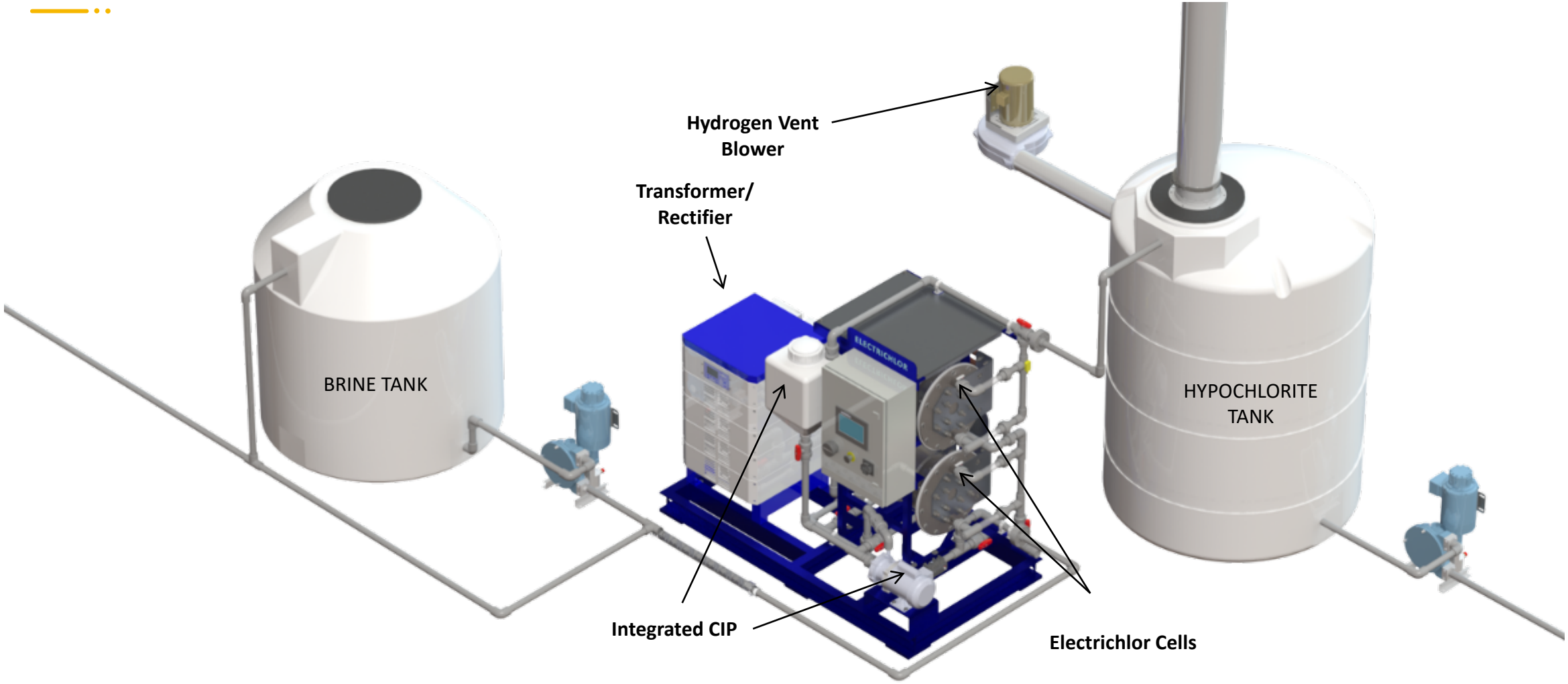
Typical On -site Hypo Generation Process



The heart of the system is the electrolytic cell

All other components are essentially the same for all manufacturers

Electrichlor's skid includes all critical components



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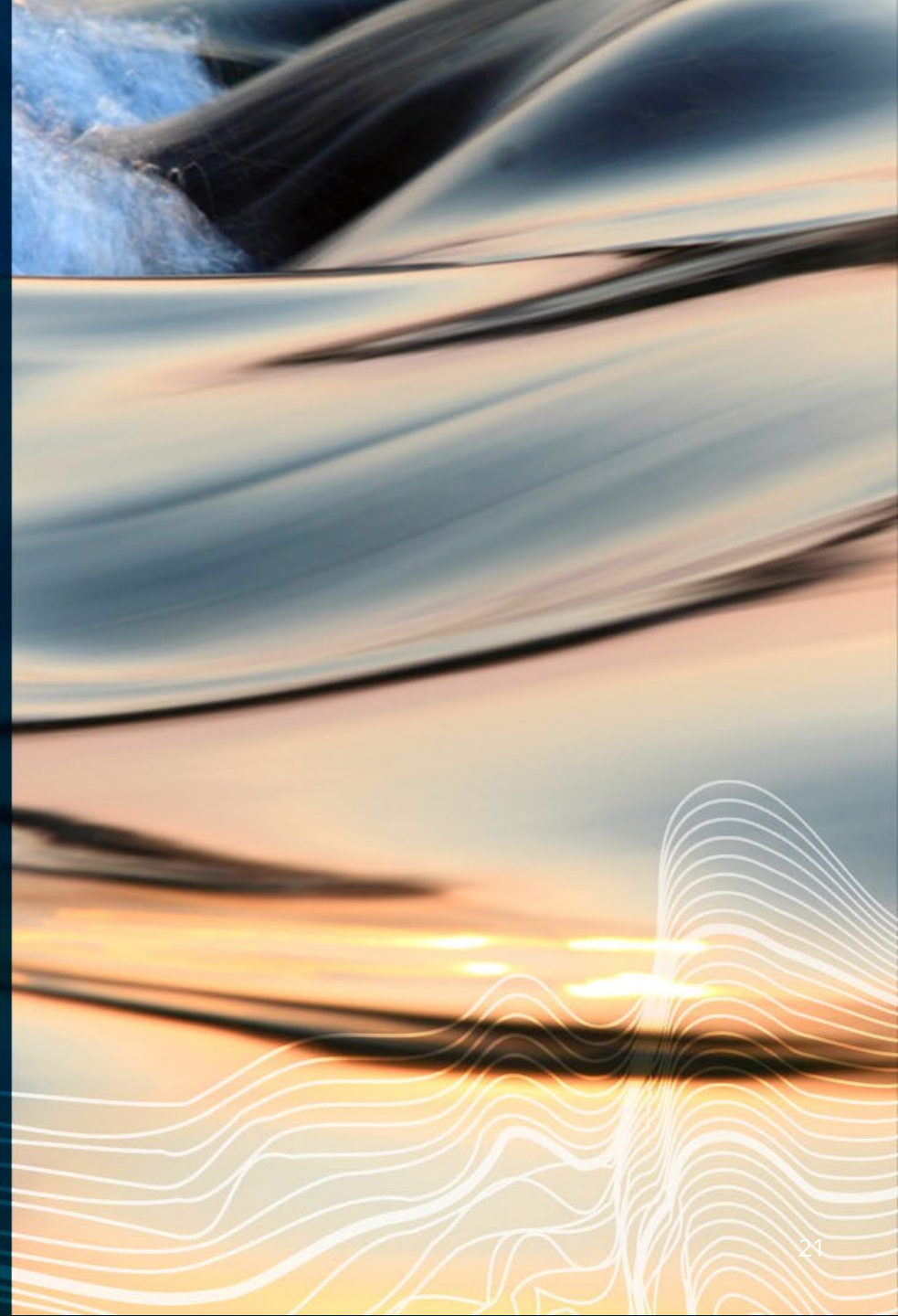
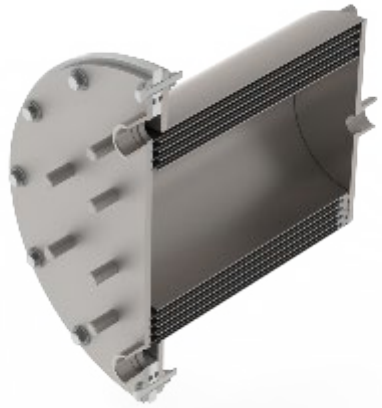
The Electrichlor Cell Design



The Electrichlor cell is different than any other cell

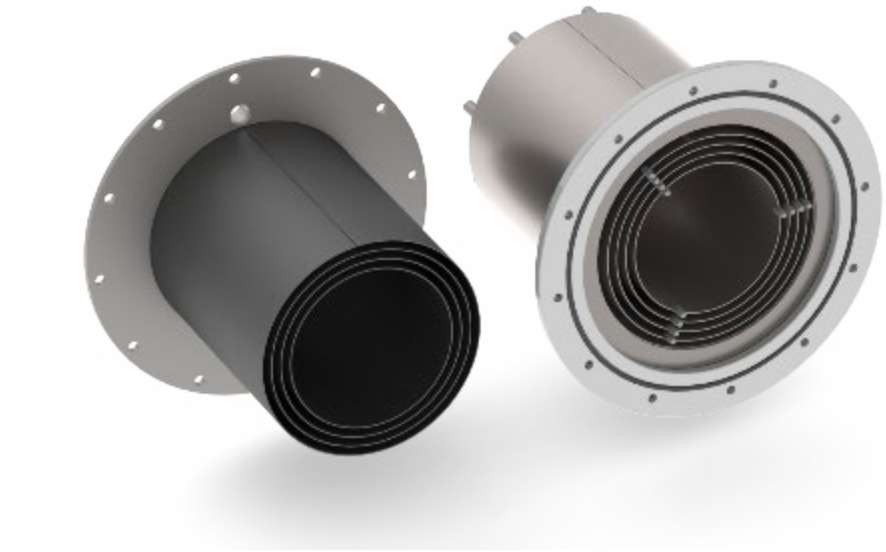


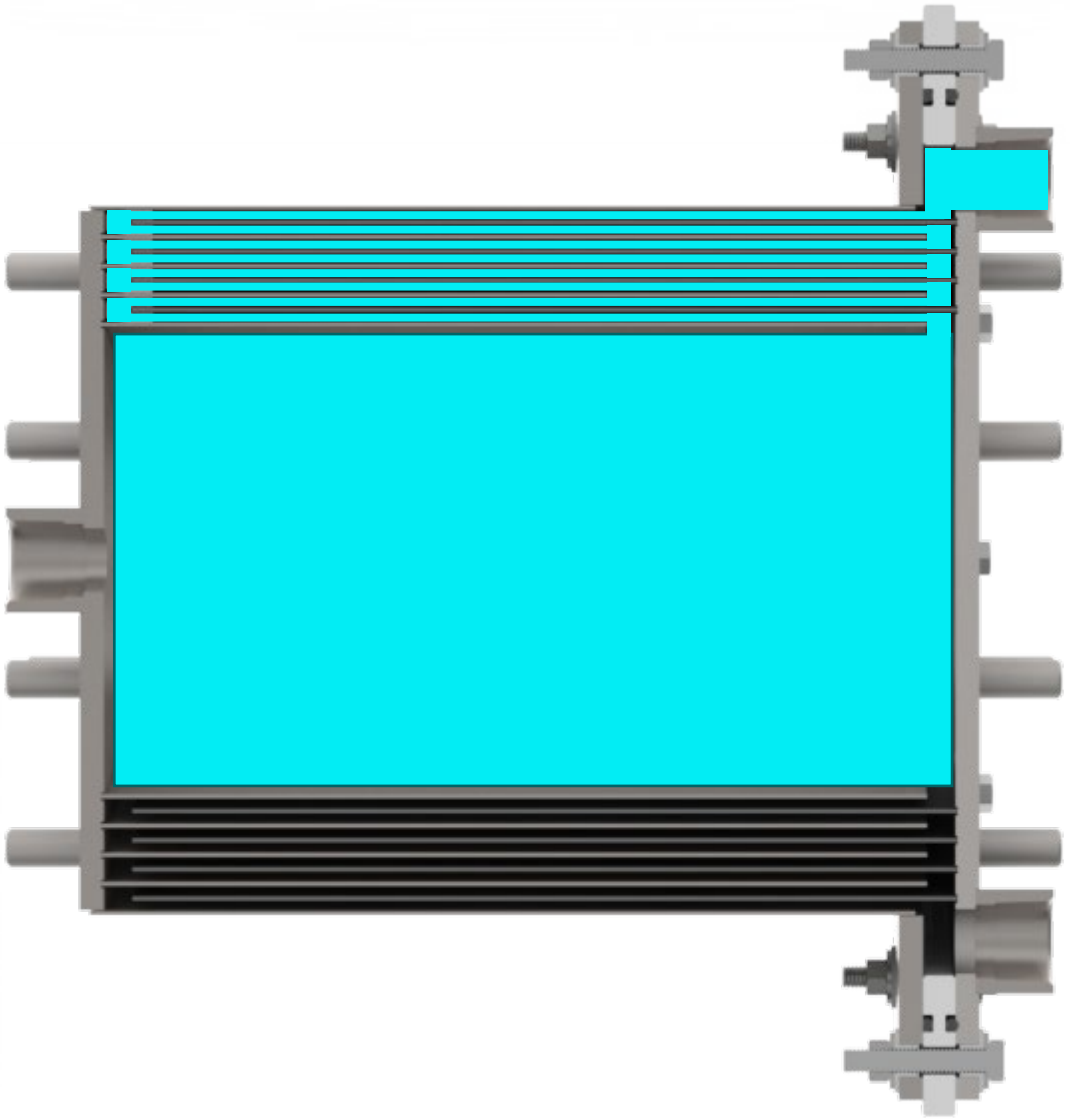
Others	Electrichlor
Parallel Rectangular Plates	Concentric Nested Tubes
High Voltage	Low Voltage (safer)
Bi-Polar Anode	Monopolar Anode
Calcium scaling is a big issue	Scaling is mitigated
Narrow water temp range	Wide water temperature range
Tight Water quality spec	Wide range (inc. secondary effluent)
Venting of each cell	Hydrogen Vented at the Hypo Batch Tank

Electrichlor Cell Design

Optimized for RELIABILITY

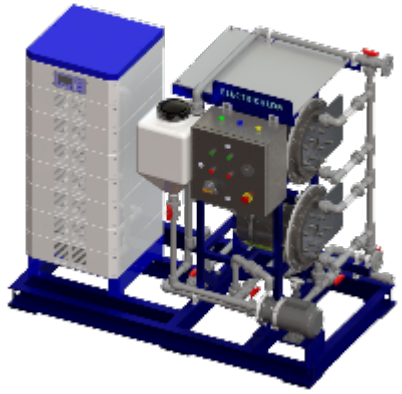
- Cathode is used as cell housing (no plastic)
- Nested tube forces multi-pass flow path
- Larger gap between electrodes
- Lower voltage

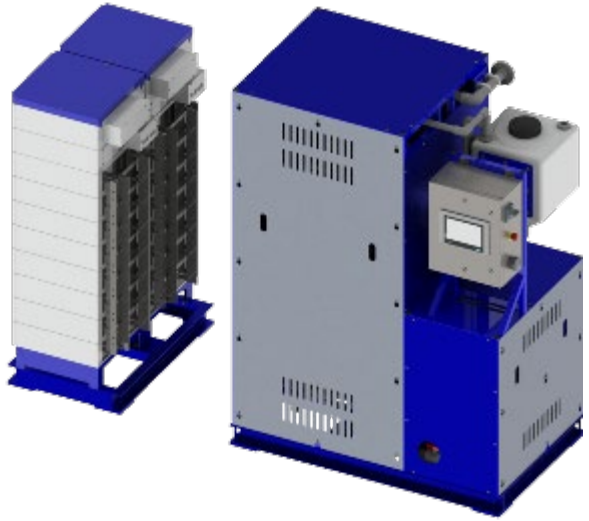




Electrichlor Generator Lineup

Generator Size (number of cells)	2X	4X	8X
Capacity @ 2,000 ppm (0.2%) - seawater	210 ppd (4 kg/hr)	420 ppd (8 kg/hr)	840 ppd (16 kg/hr)
Capacity @ 4,000 ppm (0.4%) - brine	150 ppd (3 kg/hr)	300 ppd (6 kg/hr)	600 ppd (12 kg/hr)
Capacity @ 8,000 ppm (0.8%) - brine	100 ppd (2 kg/hr)	200 ppd (4 kg/hr)	400 ppd (8 kg/hr)





Running at 0.4% vs 0.8%

Running at 0.8% requires cell to work at limit conditions.

Goal was to get concentration as high as possible, even if operating conditions result in higher temperatures (degradation) and shorter anode coating life.

Running at 0.4% allows cell to run “cooler”

- Reduce scaling
- Reduce hypo degradation
- Extend anode coating life

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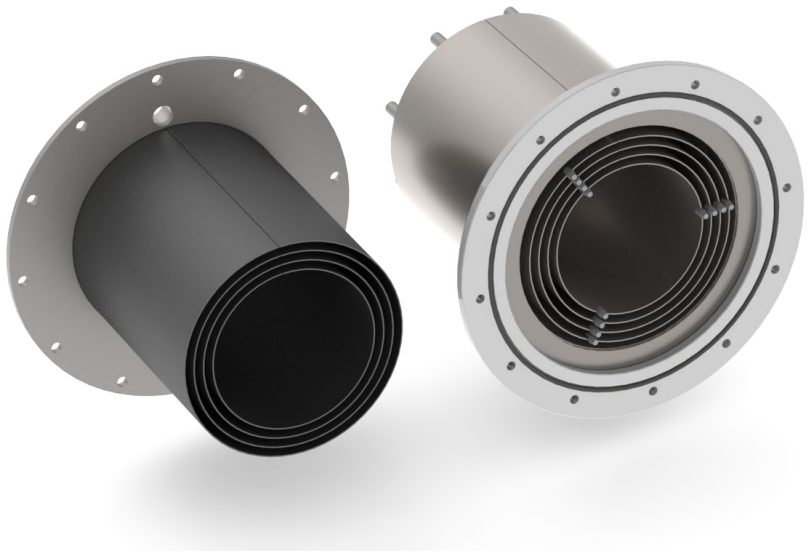
Electrichlor Dosing Advantages

Safe. Mitigated sparking inside the cell.



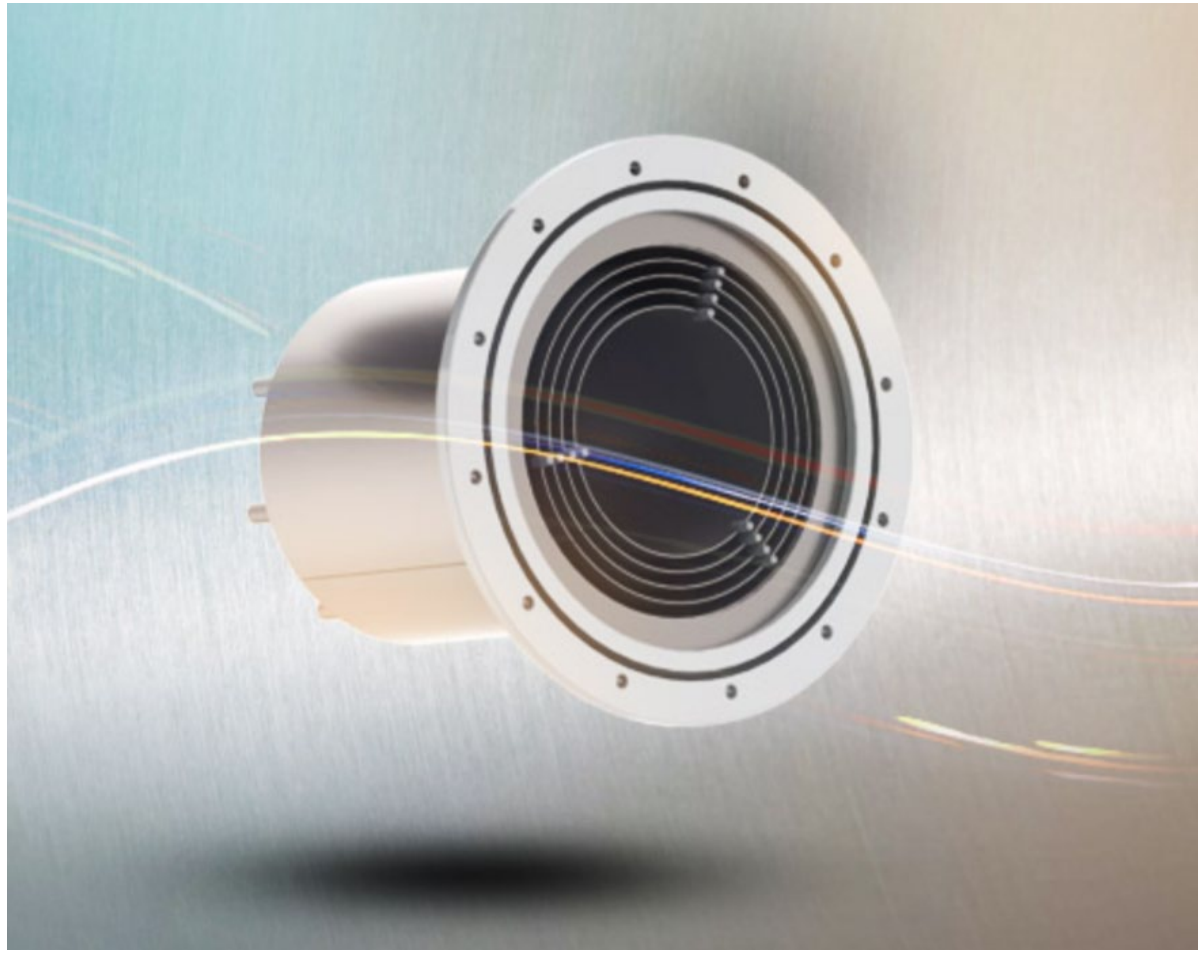
Our cell design approach mitigates the risk of sparking inside the electrolytic cell through:

- optimized electrode spacing
- low operating voltage
- optimized fluid dynamics

While other systems manage hydrogen risk by venting each cell, the Electrichlor generators remove the ignition source altogether while also maintaining appropriate ventilation throughout the system.

No cracks, no leaks. All titanium cell.

The unique design of our cell utilizes the cathode assembly as housing, eliminating the use of acrylic, clear PVC or other plastics that experience embrittlement and cracking over time, which leads to leaks, increased maintenance expenses, lower productivity and risk of operator exposure to hypochlorite.



Ability to produce 0.4 or 0.8% strength

The Electrichlor cell can generate either 0.8% or 0.4% hypochlorite solutions operating at the same industry standard efficiencies of 3.0 pounds of salt and 2.0 kilowatt-hour per pound of chlorine.

This flexibility results from Electrichlor's optimization of operating parameters, however, **operating at 0.4% hypochlorite significantly increases the reliability** of the system by minimizing scaling and anode coating degradation, resulting in much longer cell life.

Reliable with low quality brine / water

When operating at 0.4% hypochlorite strength, the Electrichlor cell allows for the use of alternative water sources such as municipal secondary effluent, and alternative chloride sources such as RO reject brine without sacrificing efficiency or output.

This is possible thanks to the combination of reduced scaling and greater electrode spacing. This flexibility enables wastewater treatment plants to significantly reduce their cost of disinfection.

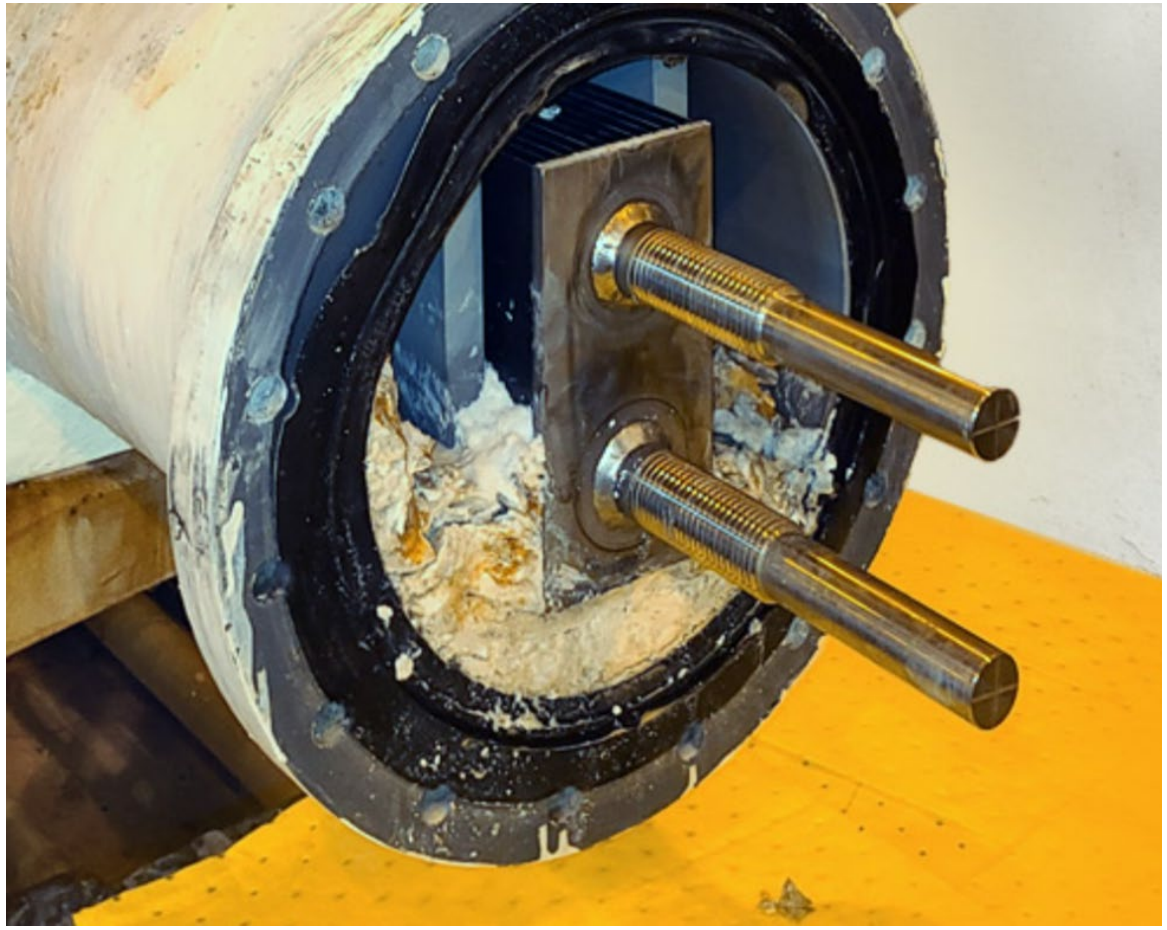
Increase capacity on -the-fly

When operating at 0.4% hypochlorite production, the Electrichlor cell can be operated at production rates 30% above the rated capacity to respond to a sudden increase in chlorine demand.

While the salt efficiency drops under these operating conditions, it enables wastewater plants to quickly respond to plant upsets or changing water quality without the need for more or larger equipment.

Less cleaning; happier operators

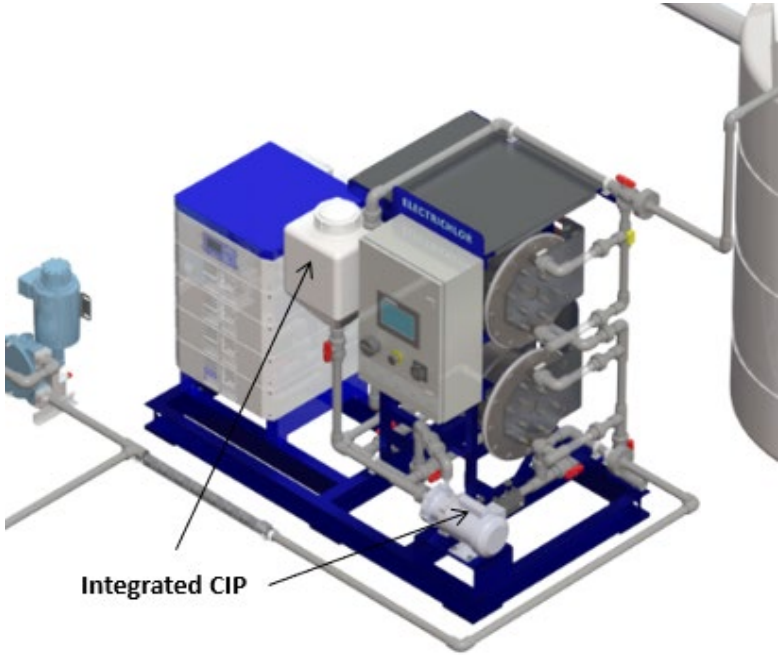
When operating at 0.4% hypochlorite production, the Electrichlor cell minimizes scaling rates, resulting in much longer intervals without cleaning, which reduces overall maintenance cost and improves the reliability of the plant



Less cleaning; happier operators

On skid CIP

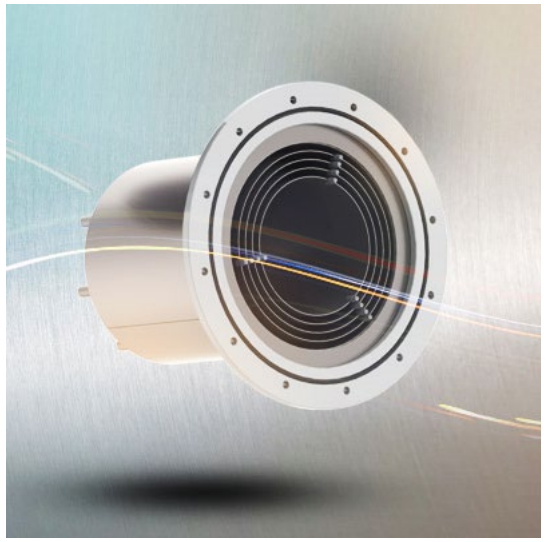
Electrichlor systems have built in CIP systems with smart tracking and varying levels of automation.



10yr anode life; lower cost of ownership

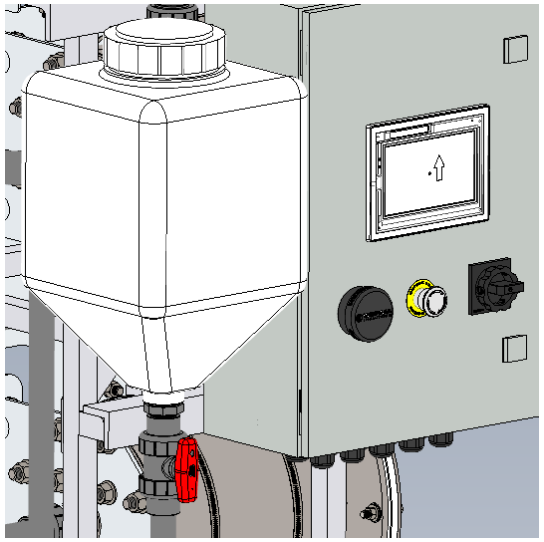
When operating at **0.4%** hypochlorite production, the Electrichlor cell experiences a much slower anode coating degradation, which results in an unparalleled 10-year anode warranty.

Advantages of Electrichlor



No cracks, no leaks. All titanium.

Compact cell design with no overhead space requirement.

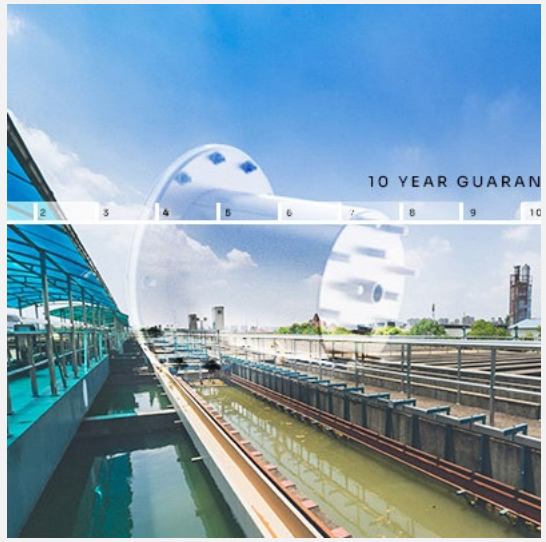


On skid CIP

Electrichlor systems have built in CIP systems with smart tracking and varying levels of automation.

Wider range of influent conditions

Due to the optimized cell geometry, a wider range of influent water conditions can be tolerated. Wider temperature range, high hardness, etc. Our system can operate with wastewater secondary effluent and salty RO reject.



10 year warranty option

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Best-fit Applications

Applications

Power Plant Cooling Water

- Biofouling control in condensers
- Seawater or cooling tower water

Off-Shore Rig Service Water

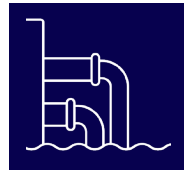
- Biofouling control in seawater lines
- Disinfection of service and fire protection water (seawater)

Ballast Water

- In-tank ballast water treatment
- On-shore ballast water treatment

Municipal Drinking Water

- Disinfection of drinking water
- NSF61
- Replacing chlorine gas or bleach



Municipal Wastewater

- Disinfection of wastewater
- Use of secondary effluent to make hypo
- Replacing chlorine gas or bleach

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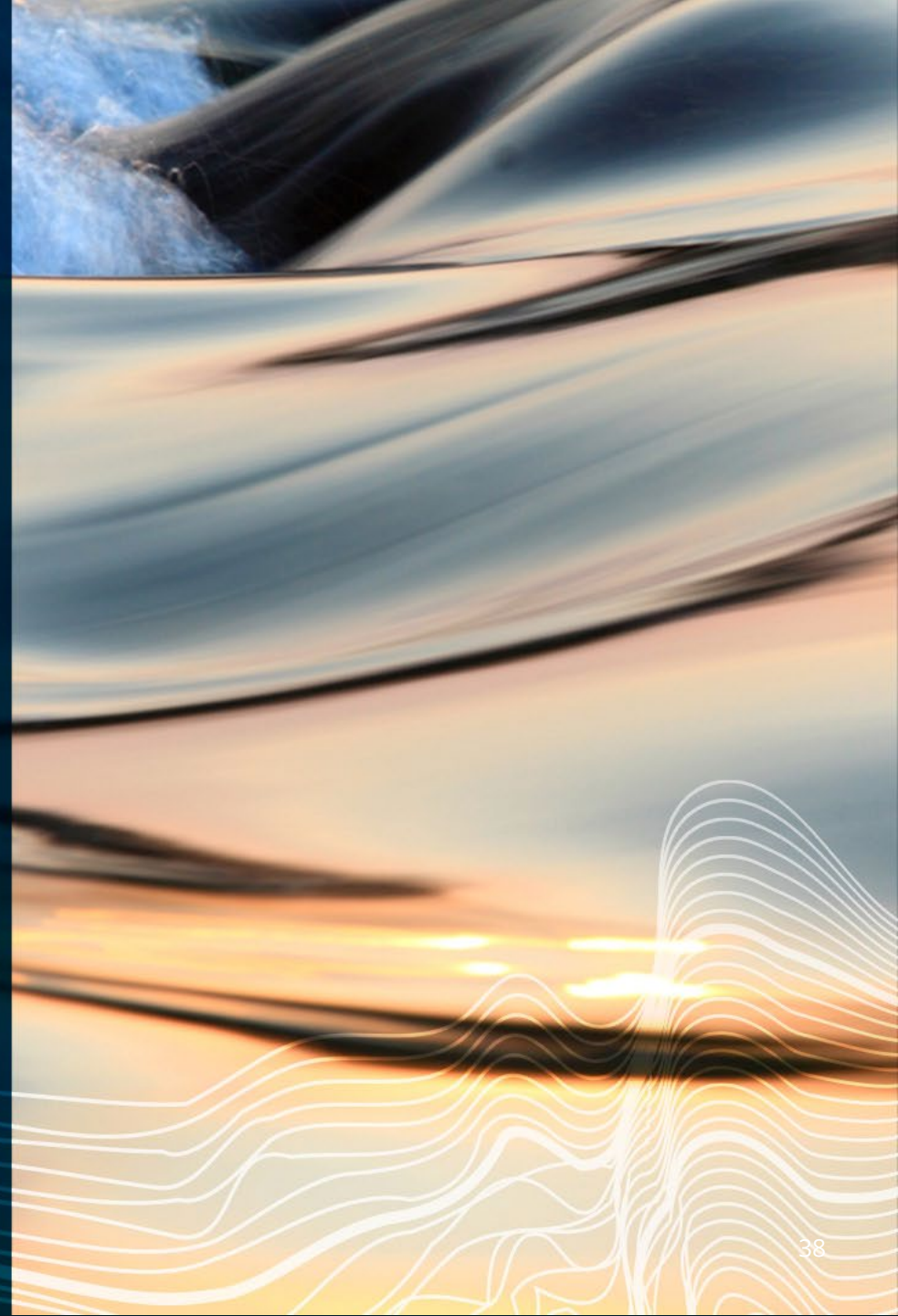
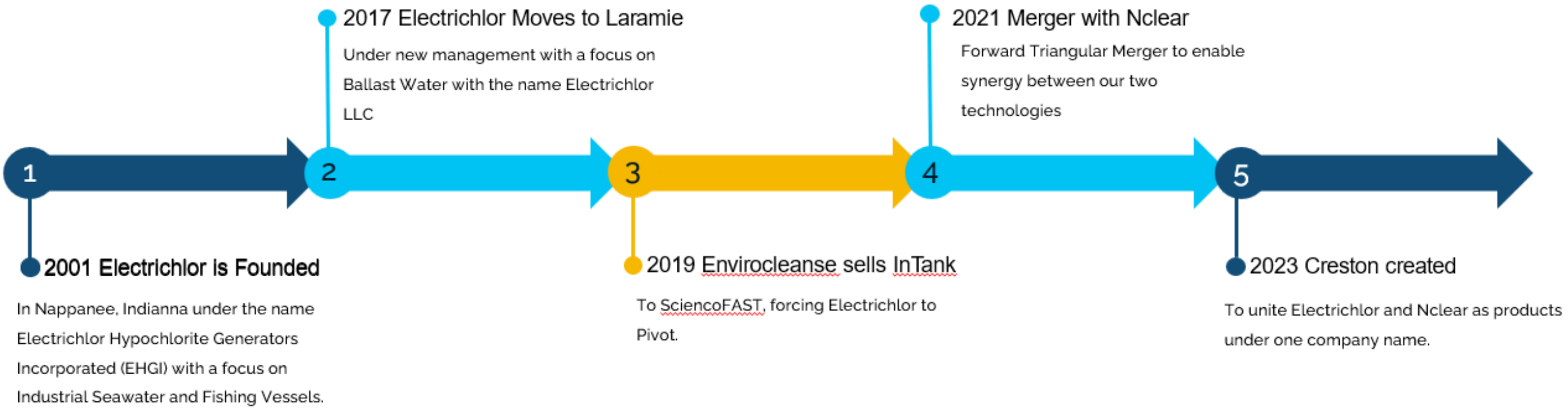
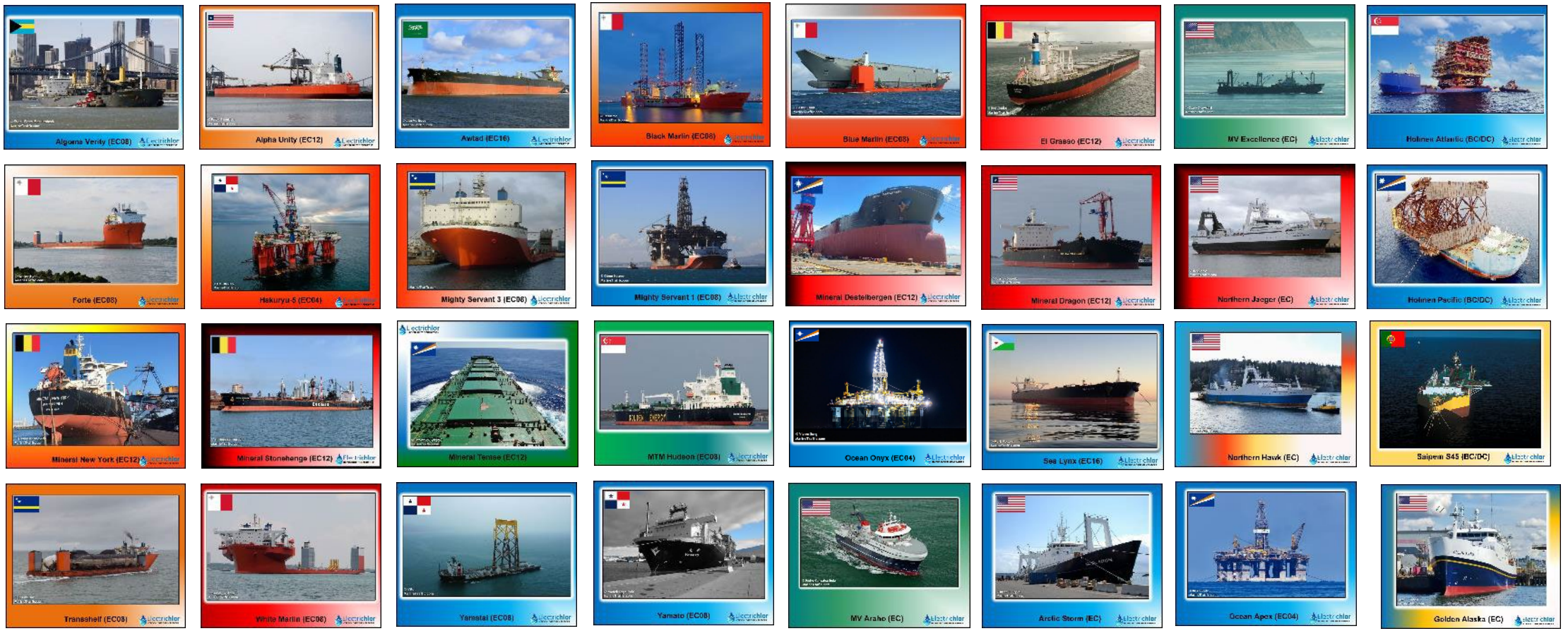
Our Experience



Brief Timeline of Electrichlor



Where it all started



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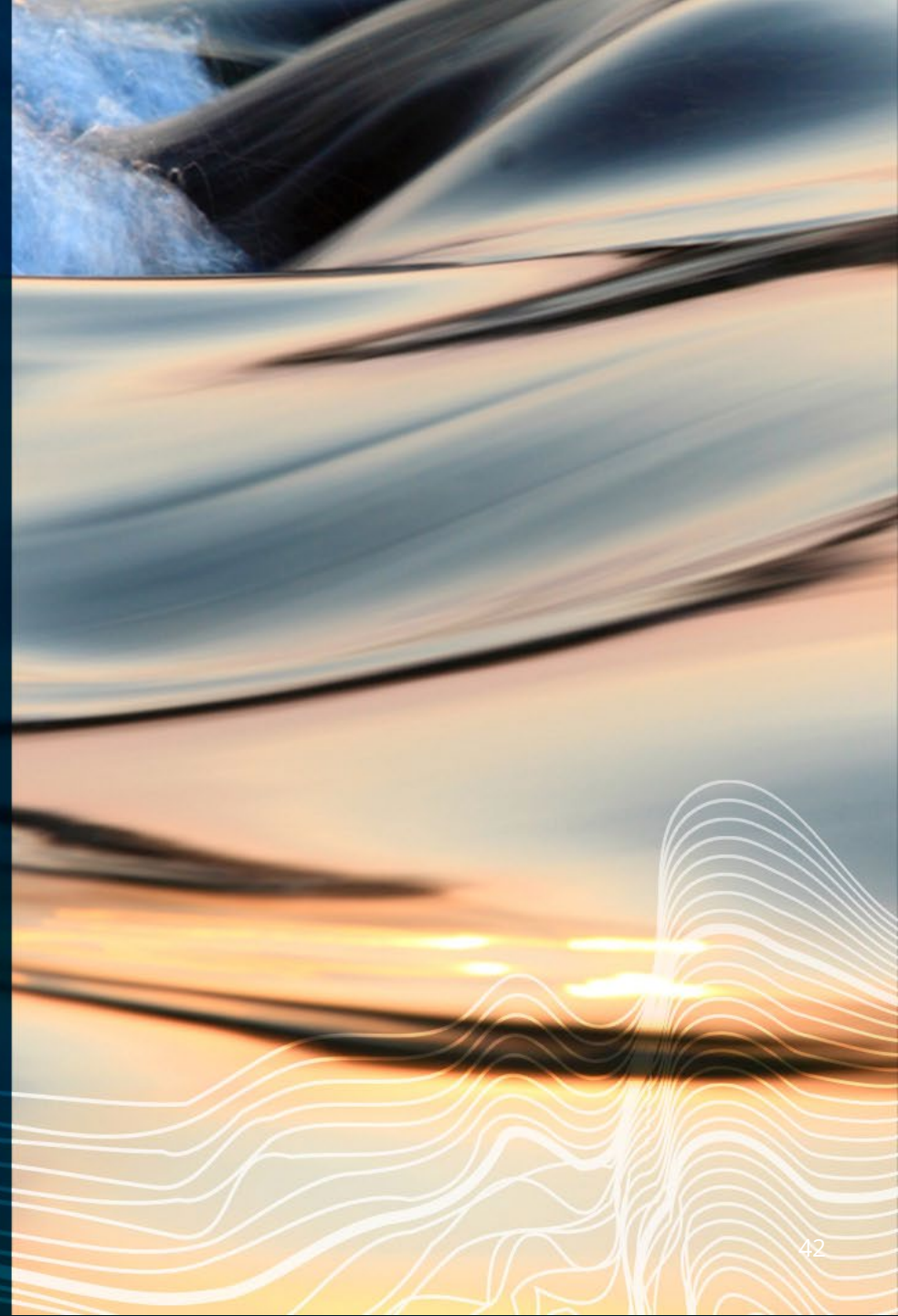
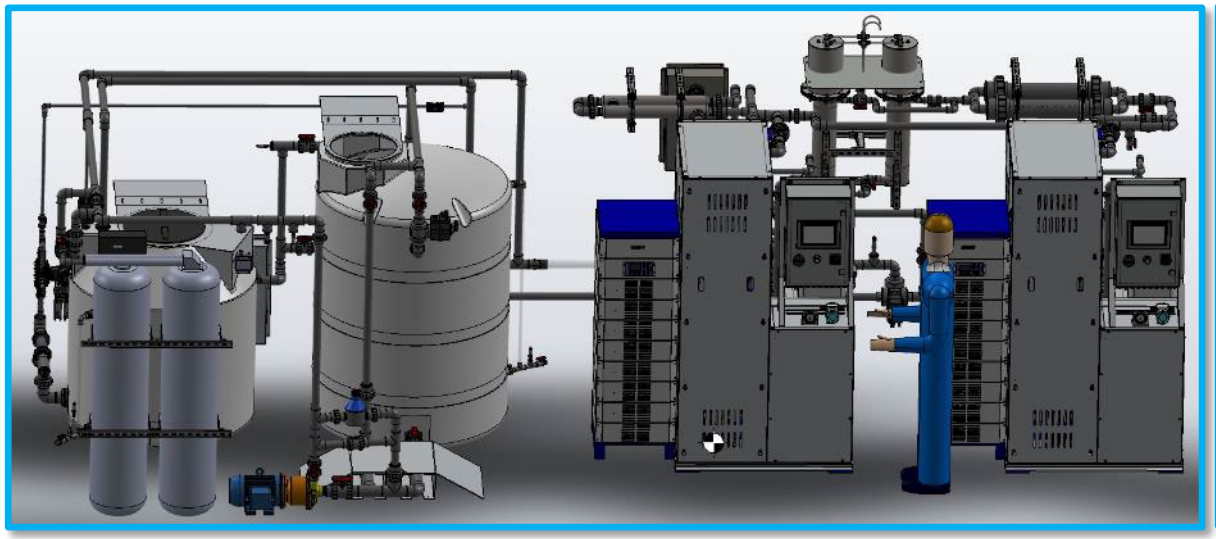
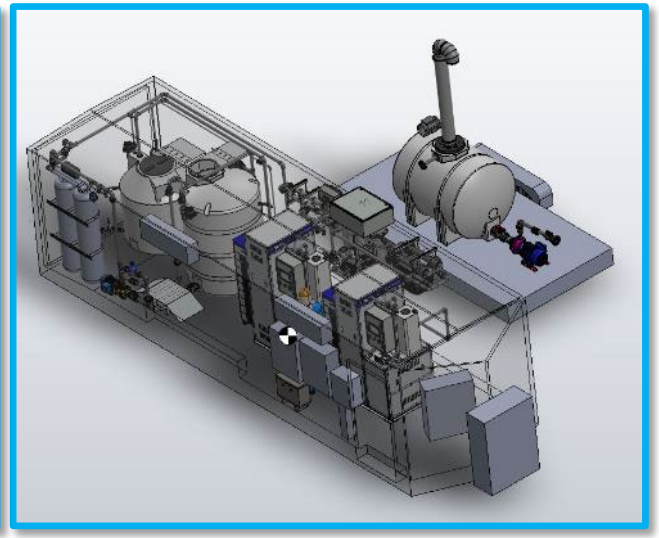
Piloting Trailers

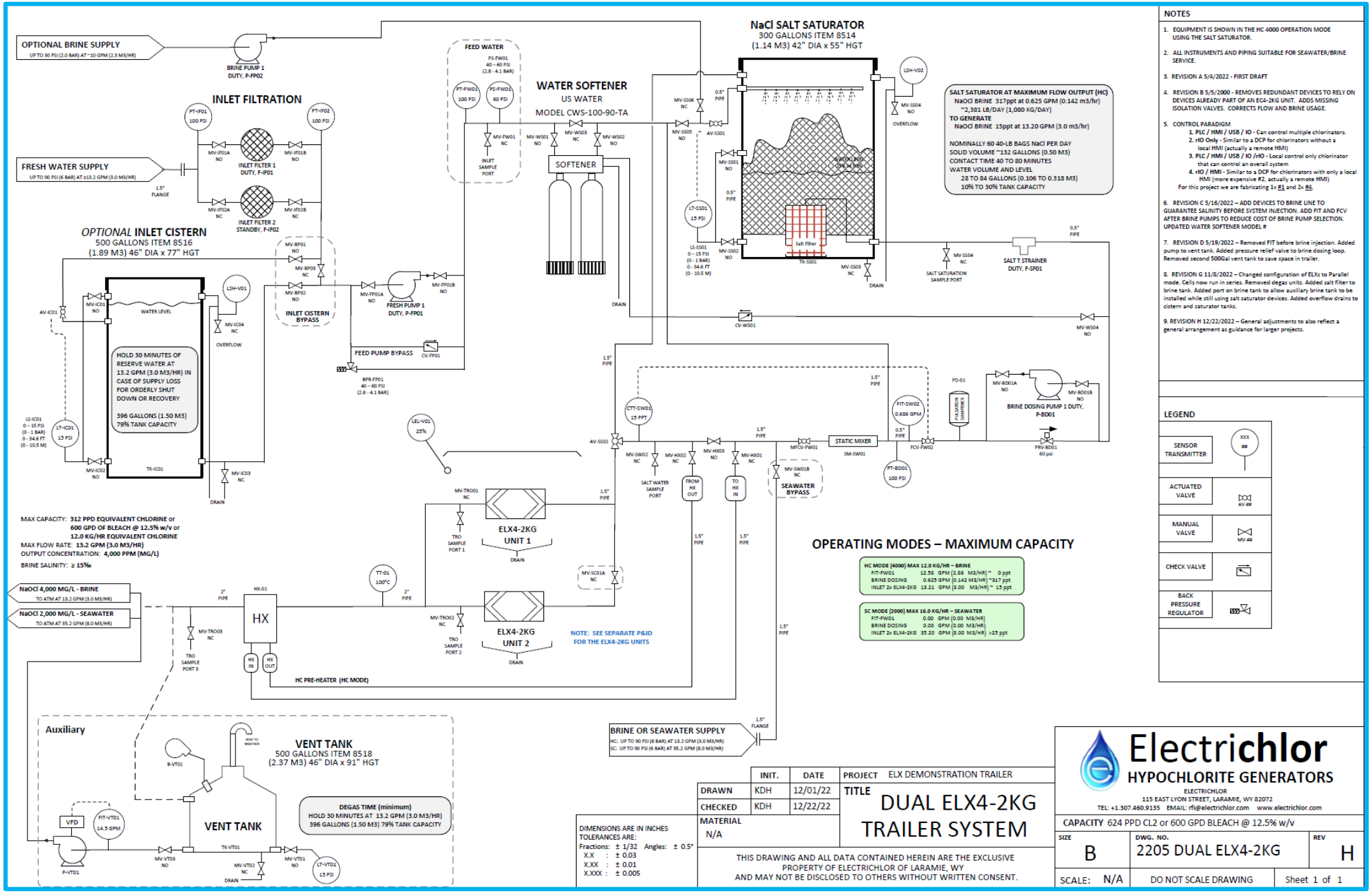


28 ft Mobile Based Chlorinator

28’ Long Trailer
13,000 pounds
Can replace up to 600 gallons per day of 12.5% bleach
Self-contained OSG
External residence/storage tank
Separate 200 kW diesel generator
Available for:
- Demonstrations
- Temporary site operations
- Emergency Response
- Lease, Time-based
- Lease, Output-based
- Purchase







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16 ft Mobile Based Chlorinator - 150 lbs/day

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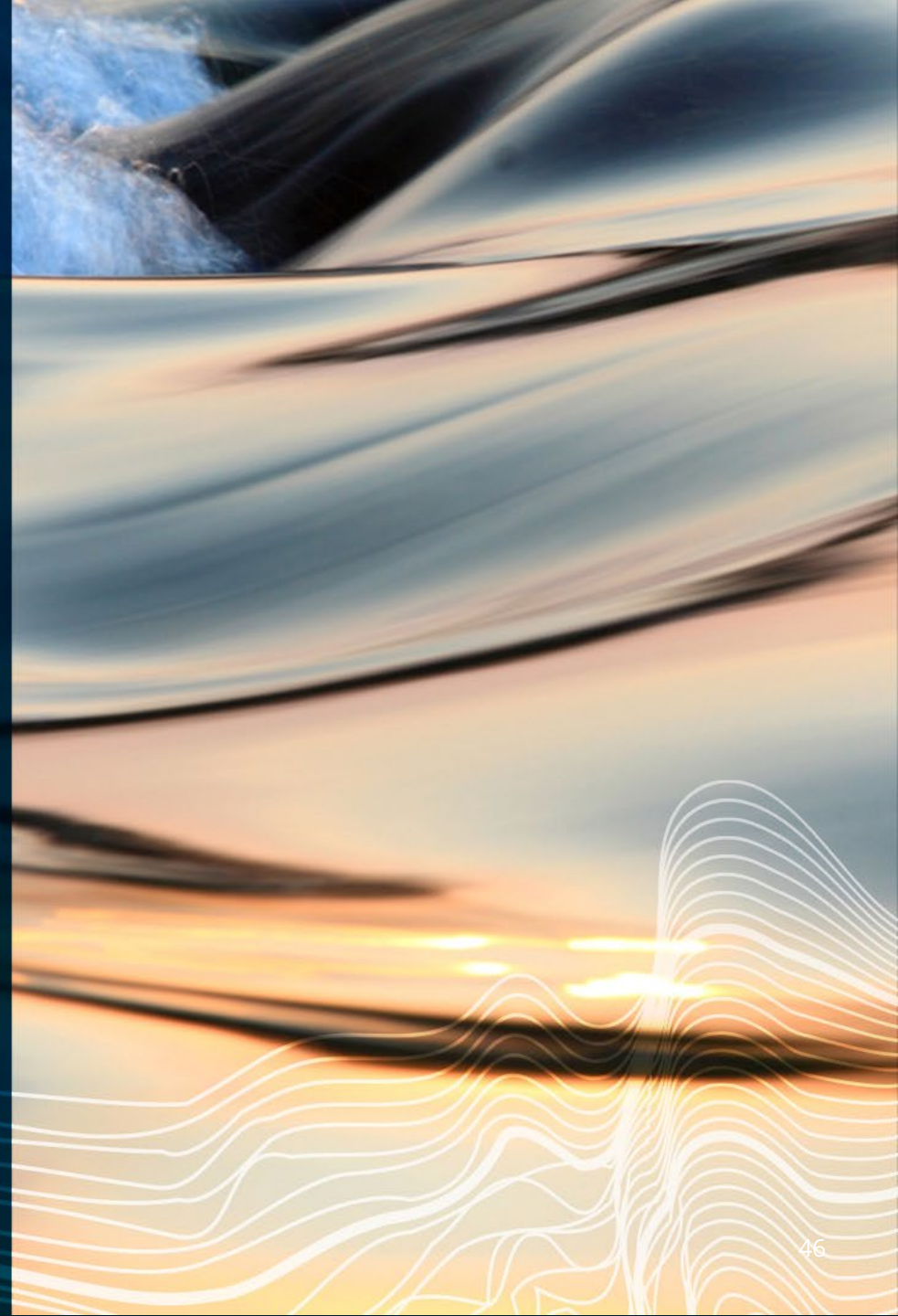
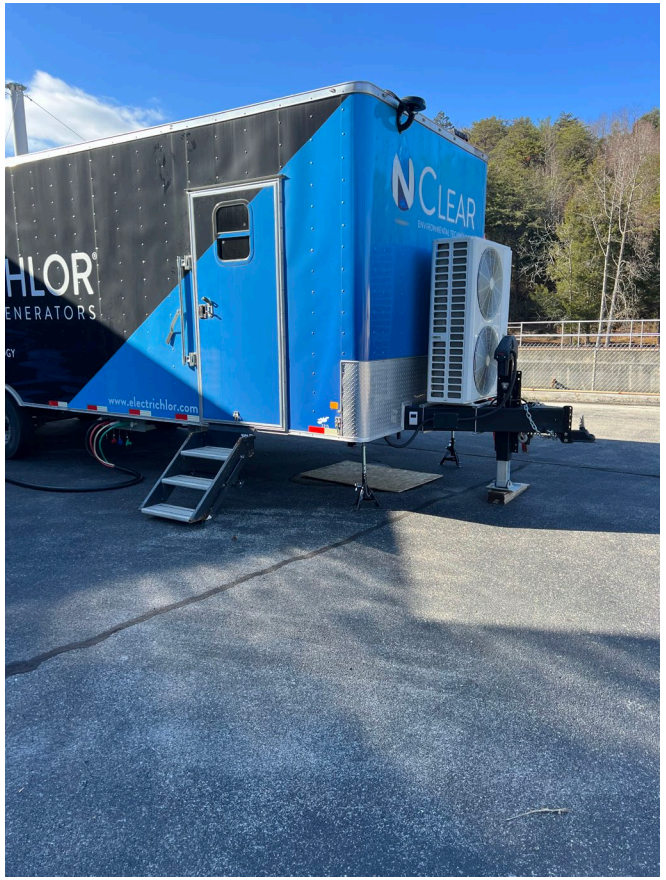
Case Study:

City of Morristown TN
Roy S. Oaks WTP

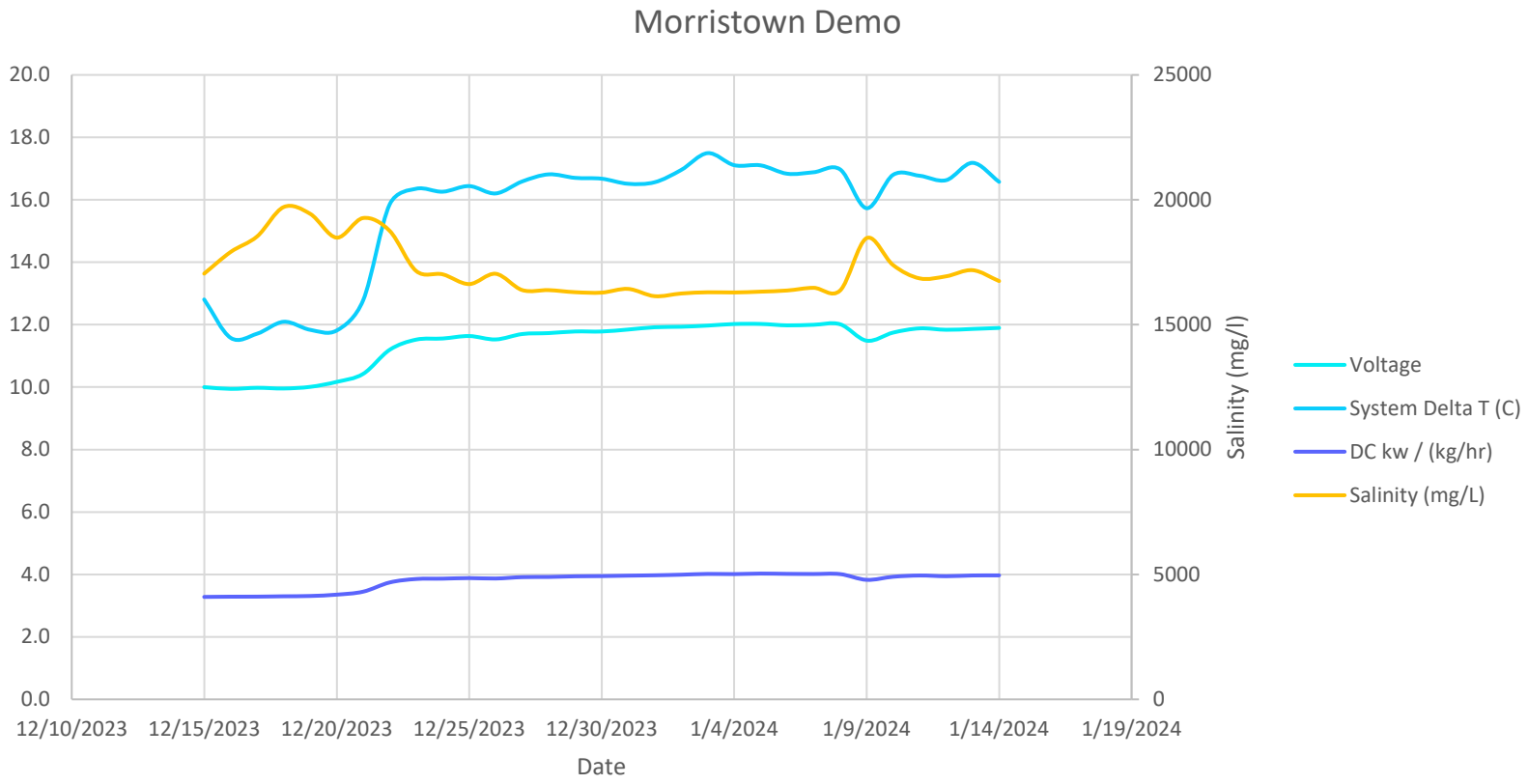


City of Morristown TN - Roy S. Oaks WTP



City of Morristown TN - Roy S. Oaks WTP

Number of Days	32
Gallons NaOCl Dosed	173250 GAL
Total Displaced Bleach (lbs)	5670
Average PPD	189
Cost of Bleach for month	$15,000
Cost of Demo (elec + food grade salt) for month	$6,567
Cost of Standard Operation (elec. & salt) for month	$3,578
Average Salinity (mg/l)	17,811
Water Hardness (PPM)	149



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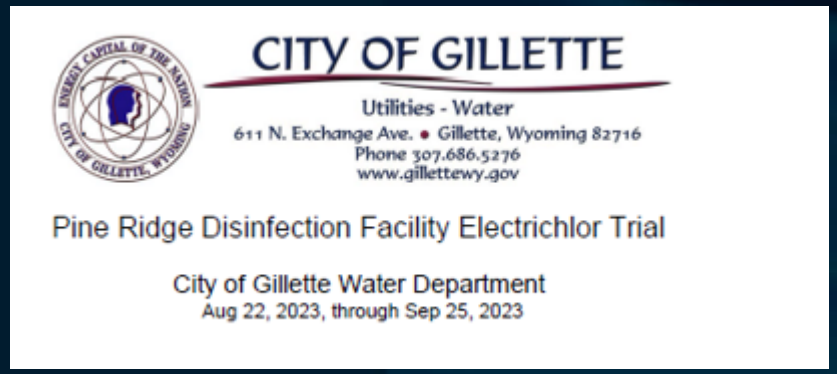

City of Gillette WY

City of Gillette - Pine Ridge WTP

City of Gillette Data Summary

Subject:	Data Summary and Analysis for Gillette Water Treatment Plant
Date:	07/14/2023
By:	Eric Gunderson & Kent Henry
Client:	City of Gillette

Purpose of Report:
This report details the measurements recorded from the MicroClor system at the Gillette Pine Ridge treatment plant. There is a brief analysis of the data and comparison to Electrichlor products.

Raw Data:

MicroClor System (Rated for 200 PPD or 3.78 kg/hr) Measured 7/14/2023

Measurement	Value	Method
DC Amperage	96 Amps	Fluke 381 Remote Display (Verified w/ rectifier)
DC Voltage	268 V	Fluke 381 Remote Display cell 1 to cell 5
Inlet Temp	80.1 °F	Nubee® Temperature Gun Non-contact Infrared
Outlet Temp	122.0 °F	Nubee® Temperature Gun Non-contact Infrared
Inlet Salinity	28.8 ‰	Calculated based on saturator dilution ratio
Outlet TRO	7,796 ppm	Hach Pocket Colorimeter II measured in triplicate
Tank TRO	6,400 ppm	Hach Pocket Colorimeter II measured in triplicate
Water Flow Rate	2.00 GPM	MicroClor inline flowmeter, manual read
Brine Flow Right	0.20 GPM	MicroClor inline flowmeter, manual read

Electrichlor System (Rated for 150 PPD or 2.83 kg/hr) Measured 4/6/2023

Measurement	Value	Method
DC Amperage	2000 Amps	Fluke (Verified w/ rectifier)
DC Voltage	10.1 V	Fluke (Verified w/ rectifier)
Inlet Temp	55.6 °F	YSI 30 Conductivity Probe
Outlet Temp	74.8 °F	YSI 30 Conductivity Probe
Inlet Salinity	15.0 ‰	YSI 30 Conductivity Probe
Outlet TRO	5,267 ppm	Hach DR300 measured in triplicate
Tank TRO	N/A	N/A
Water Flow Rate	3.15 GPM	Keyance FD-Q Flowmeter, PLC and local read
Brine Flow Rate	0.15 GPM	Keyance FD-Q Flowmeter, PLC and local read

Analysis

Metric	MicroClor	Electrichlor	% Reduction
Total Production	3.89 kg/hr	3.94 kg/hr	
Total Production	205 PPD (102%)	208 PPD (138%)	
Actual Salt Consumption	3.70 lb NaCl/lb NaOCl	2.85 lb NaCl/lb NaOCl	23%
Actual Electrical Efficiency	3.01 DCKWhr/lb NaOCl	2.33 DCKWhr/lb NaOCl	23%
Brine Inlet to NaOCl Outlet Temperature Change	41.9 °F	19.3 °F	54%

The City of Gillette ran a side by side comparison at the Gillette Pine Ridge WTP Site

CITY OF GILLETTE
Utilities - Water
611 N. Exchange Ave. • Gillette, Wyoming 82716
Phone 307.686.5276
www.gillettewy.gov

Pine Ridge Disinfection Facility Electrichlor Trial

City of Gillette Water Department
Aug 22, 2023, through Sep 25, 2023

Objective:

The City of Gillette (COG) is currently in the process of engineering design for an onsite sodium hypochlorite generation (OSHG) system at our Pump Station #1 facility (PS#1). The objective of this trial is to collect and analyze data from Electrichlor's ELA-150 unit in comparison to the City of Gillette's current OSHG system (PSI MicroChlor) at the Pine Ridge Disinfection Facility (PRDF) for the purpose of developing true cost input, cost comparison per pound of chlorine produced at the injection point, and validation of or failure to meet advertised performance specifications of the two OSHG systems being analyzed. The outcome of this trial will provide a factual basis upon which to base purchase specifications of an OSHG system for the Pump Station #1 disinfection project. To provide safe and reliable disinfection of the City of Gillette's potable drinking water supply.

Results:

The Electrichlor trial results will be broken into the following five categories:

- Reliability
- Operation and maintenance
- Units' ability to meet advertised specifications.
- Chemical Dosing and Integration
- Customer service

All categories will be given a numerical grade ranging from the numbers 1-5. Number 1 being unsatisfactory, number 3 being satisfactory, and 5 being above expectations. All categories will be averaged for an overall rating.

Reliability (4):

After initial start-up and implementation, the COG water department had no emergency call outs or shortage of sodium hypochlorite for disinfection. The only issue the ELA-150 had was a "low product flow" through the unit, that was caused by scaling built up by the extreme hardness (470 mg/l) of the service water provided during the trial. This issue was easily mitigated by performing a standard acid wash. In a normal long-term setup, the service water would be softened below 10-mg/l hardness which would resolve all scaling build up and longer run times.

Service With P.R.I.D.E.
Productivity Responsibility Integrity Dedication Enthusiasm

Operation and Maintenance (4):

The operation and maintenance of the ELA unit during the 30-day trial proved to be very easy and operator friendly. Electrichlor staff was very interested in feedback on the optimization of the HMI screen layout and acid wash procedure, Electrichlor staff noted all comments made by COG operators. At the end of the trial Electrichlor demonstrated their new HMI screen layout and acid wash procedure aimed towards the municipal treatment application. From an operator's point of view, they took an already good product and improved it.

Meeting Advertised Specifications (5):

After initial start-up the ELA unit met all advertised production specifications. Throughout the 30-day trial the COG's operators recorded an average feeding strength of 4335 PPM and an average production strength of 4767 PPM.

Chemical Dosing and Integration (5):

The integration of the ELA unit into the COG's water disinfection system was easy and seamless. The COG water department doses sodium hypochlorite to maintain a .95 to 1.2 mg/l free chlorine residual (after contact time). During the 30-day trial our average cl2 residual was 1.1 mg/l. The only change COG staff made to the disinfection process to obtain the desired free residual of 1.1 mg/l was a 27% increase to our current peristaltic dosage pump (due to increased gph of the 4335 PPM product as compared to the advertised 8000 PPM* product). During this trail our daily raw water production was ranging from 5.1-7.4 MGD.

*COG staff reviewed the last 18 months of solution strength data sampled at the injection pump location. The PSI MicroChlor had an average injection solution strength of 6265 PPM.

Customer Service (5):

Electrichlor's staff is extremely knowledgeable and experienced in their company's products and the sodium hypochlorite generation process. COG staff were very impressed with Electrichlor's eagerness to get an operator's "point of view" and they were genuinely interested in what our team of operators had to offer. Electrichlor staff implemented many of the ideas that our water operators suggested, to help better refine their system into our existing injection infrastructure and programing.

Conclusion (4.6 Total):

Electrichlor's ELA-150 unit met and exceeded all expectations. The forced flow cell design, the small overall footprint, and the ease of operation and maintenance of the unit make this product an excellent candidate for our upcoming PS#1 OSHG project. The COG water department staff saw no problem with the chemical injection of the ELA unit's lower strength sodium hypochlorite solution in comparison to our current OSHG system. The ELA-150 unit's solution strength over this 30-day trial averaged to be only 27% weaker(*) than the COG's current PRDF OSHG system, at the injection point sample location. Overall, The COG water department viewed the 30-day Electrichlor trial as a success and COG water department staff look forward to working with Electrichlor in the future.

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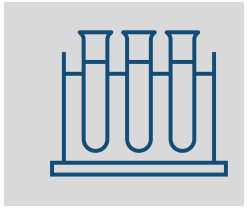
Capabilities

Design & Engineering

- Equipment sizing and selection
- Integration to existing SCADA
- Hypo dosing automation



Piloting & Testing

- Integration to existing SCADA
- Hypo dosing automation

Installation & Startup

- Turn-key projects
- Mechanical & electrical installation
- System startup
- Performance and acceptance testing

Short & Long Term Leasing

- Temporary lease during upgrades and plant upsets
- Lease to buy
- Month-to-month lease

Service & Troubleshooting

- Preventive maintenance
- Sampling and analysis
- Refurbishment

Our Corporate Leadership

Alberto Garibi
CEO

David Shekhtman
Technology Director
Engineering Systems

Philip Block, Ph. D.
Technology Director
Chemical Systems

Jonathan Dick
Senior Product
Manager, Electrichlor

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