

On-Site Generation of Sodium Hypochlorite (OSHG)



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Making Bleach Made Easy



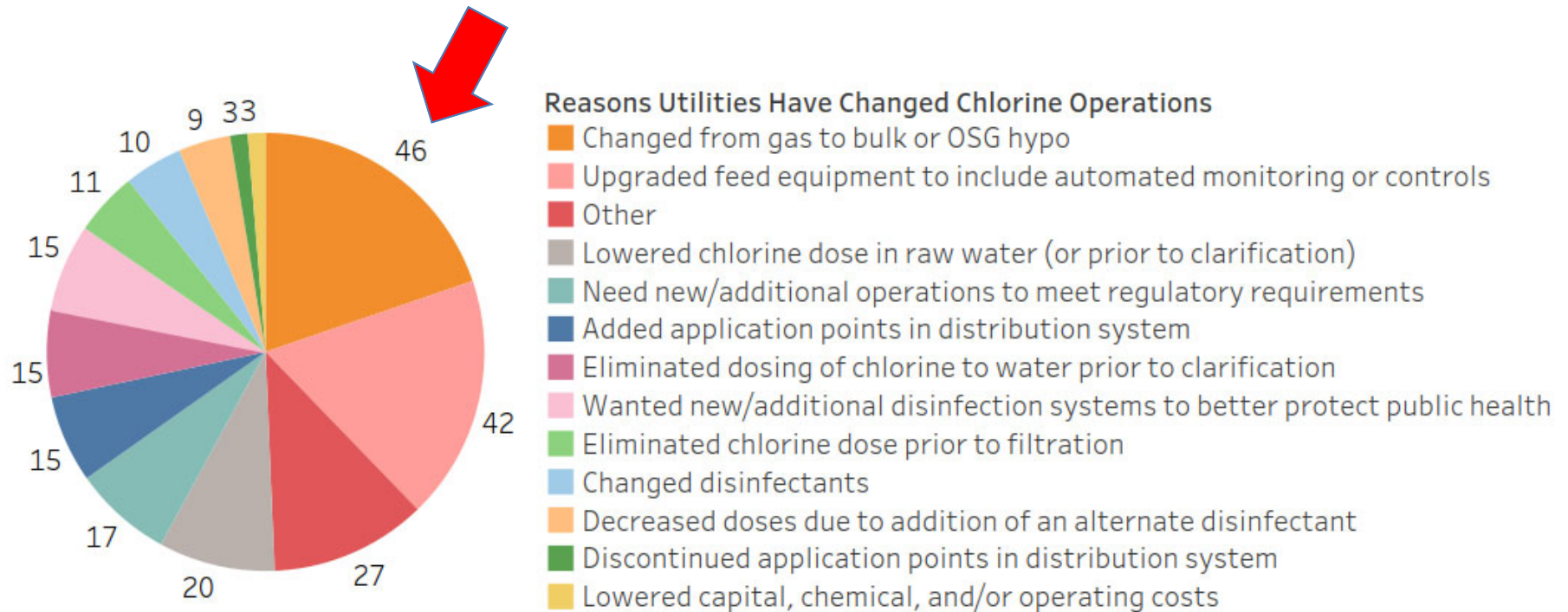
First generation of OSHG systems appeared in the 1990's in North America



The current generation of vertical cell OSHG systems improves maintainability, safety, cost and simplicity based on decades of horizontal cell field experience

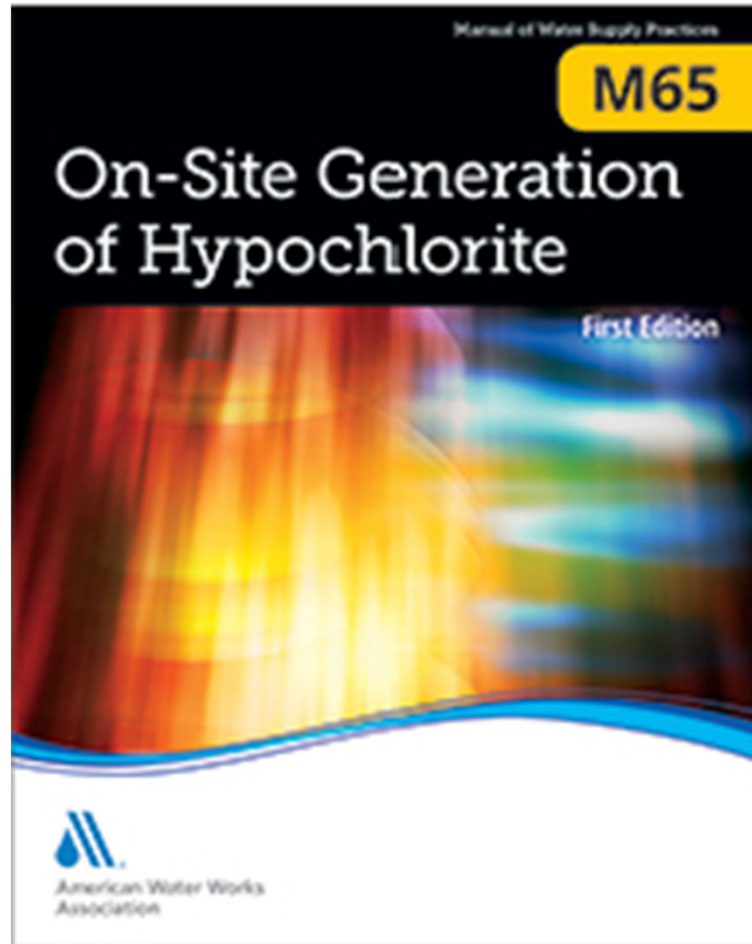


In the 2017 AWWA Disinfection Report, 37% of respondents reported that they switched from gas chlorine to bulk delivered bleach or on-site generated bleach



Reasons utilities have changed chlorine operations in the last 10 years (n = 122, inclusive)

AWWA Manual 65 (M65) gives a detailed view of OSHG technology and useful considerations



- History of OSHG
- Chemistry
- Design Considerations
- Risks and Tradeoffs
- Case Studies
- Economic Review of Alternatives



Chlorine gas has been utilized as a cost effective and powerful water disinfectant since 1910, but increasing safety concerns and regulation are causing a re-evaluation by many utilities

Most Frequently Considered Alternatives

Commercial Bulk Delivered Hypochlorite

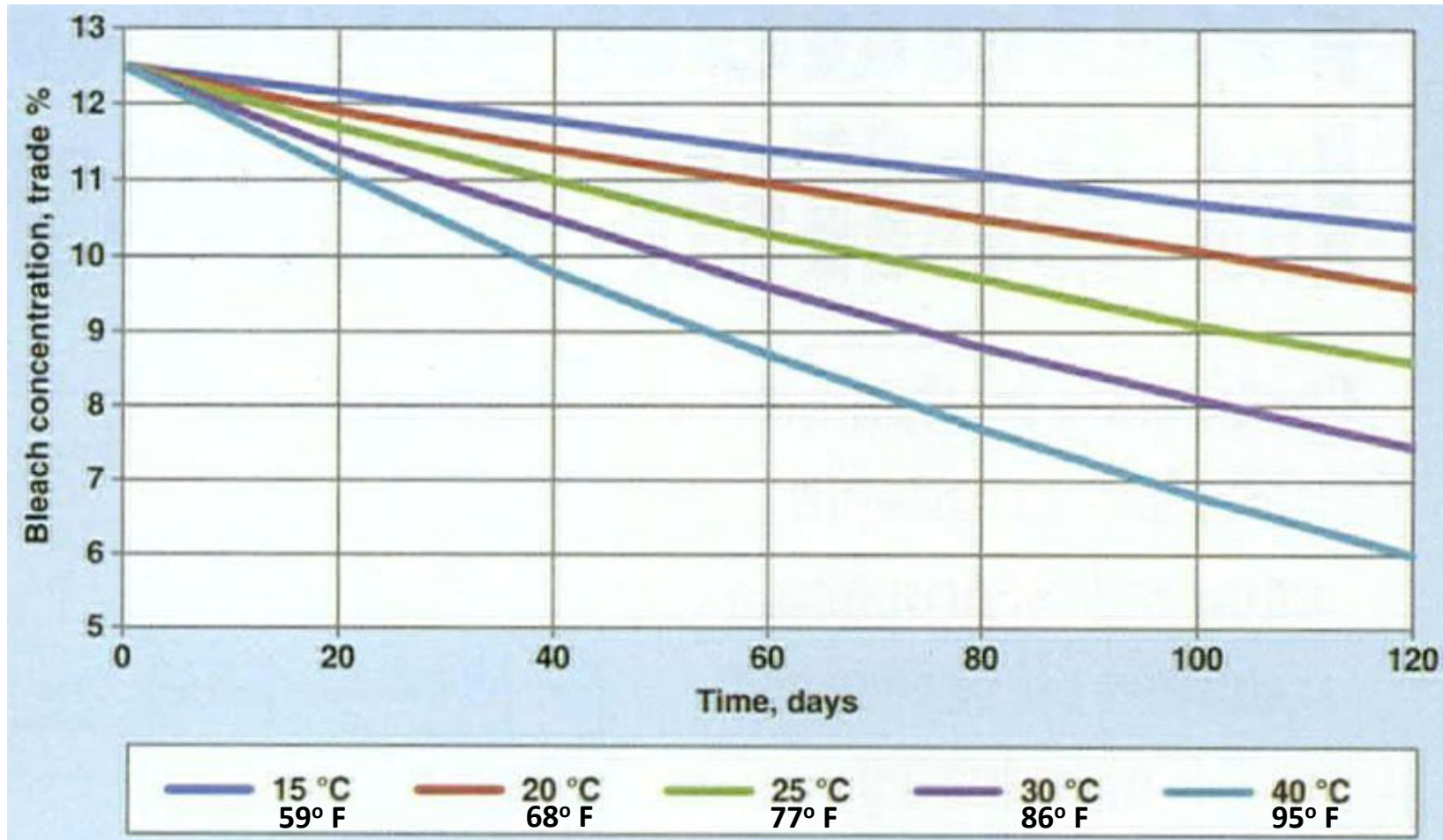
- Delivered by tank truck in 12.5-15% concentration
- Hazardous material
 - Containment and placarding 29 CFR 1910.1200
- Degradation must be factored into delivered quantities
- Off-gassing causes vapor locking in feed systems
- Fluctuation in local pricing can create planning and economic surprises
- Caustic pH >13 encourages scaling
- High operating cost
- Relatively low capital cost

On Site Generated Sodium Hypochlorite

- Generated on site 0.8% (8,000 ppm) concentration – no appreciable degradation
- No Risk Management Plan (RMP) – better risk profile for neighbors and operators
- Lower pH (~9.0-9.5) vs. bulk – limits scaling
- Simplified pumping and handling
- Higher capital cost
- Reduced operating cost
- Installed capital equipment requires periodic maintenance
- Raw materials of salt, softened water and electricity are readily available – utility self sufficiency



Bulk sodium hypochlorite (~12.5%) degrades over time and results in a loss of chlorine equivalent as temperature increases – i.e. between 8% and 20% over 40 days in summer months



Jenkins, Scott. "Sodium hypochlorite chemical production." *Chemical Engineering* Apr. 2013

Decreasing the rate of high-strength sodium hypochlorite degradation and mitigate chlorate formation increases costs – properly account for them in any evaluation

- Indoor storage can meaningfully lower temperature and decrease degradation rate
- Dilute 12.5% to at least 5% per AWWA B300a-11 (doubles storage volume)
- Decrease delivery volumes in order to have a higher “freshness” value



In addition to the hazards of bulk delivered 12.5-15% hypochlorite solution, operating economics in most regions generally favor on-site

Illustrative Example – Cost of 1lb of Chlorine Equivalent

Bulk Delivered 12.5% Hypochlorite

- Delivered Cost of \$0.80 per gallon (same as 1 lb of Chlorine Equivalent) expect degradation – higher effective cost



On-Site Generated Hypochlorite

- 3lbs of Salt (NaCl) = \$0.21
- 2 kW AC (\$0.085/kW) = \$0.17
- OSHG Variable Cost is \$0.38 per 1lb of Chlorine Equivalent

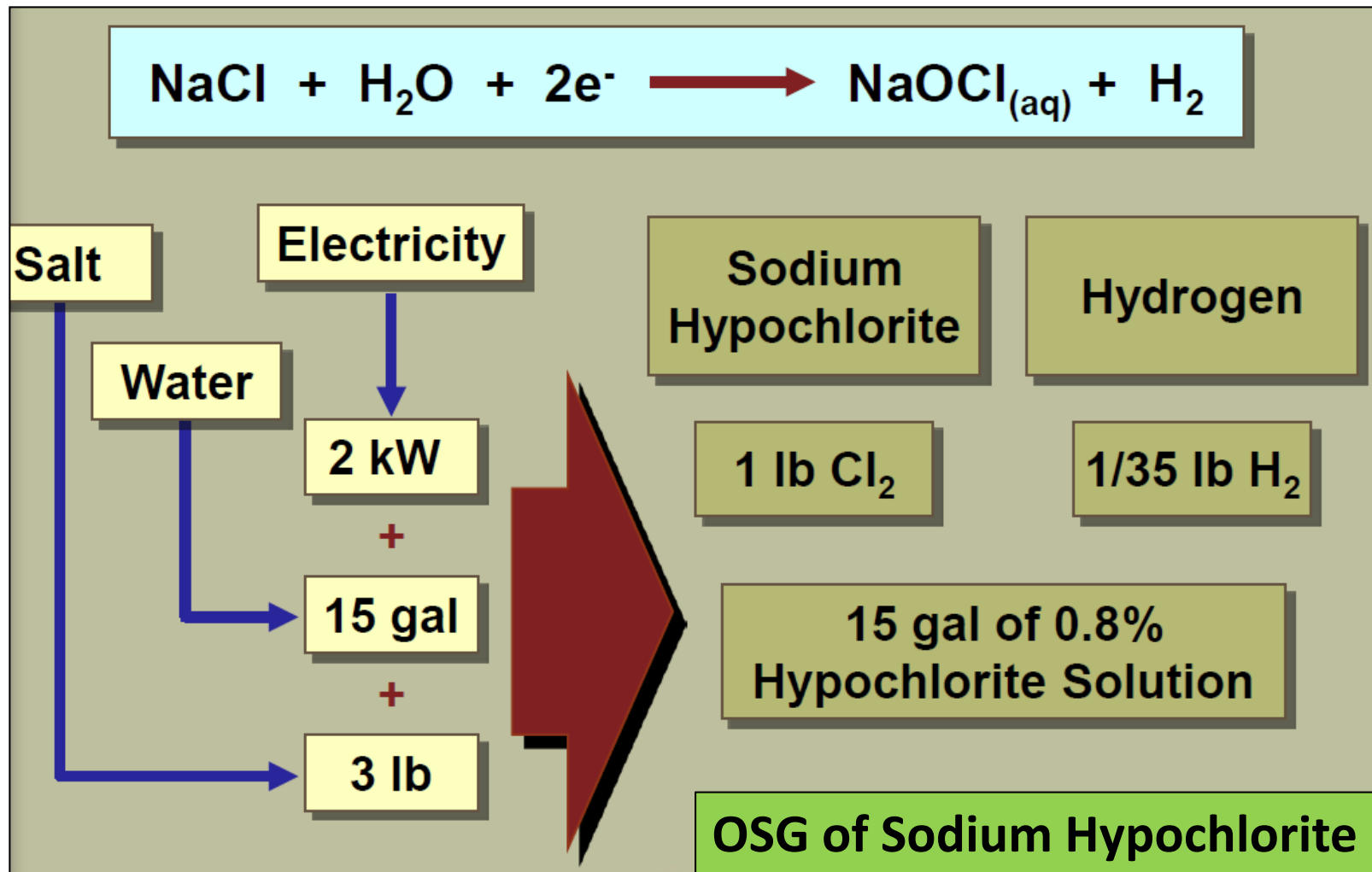


OSHG Vertical Cells in Series: The benefits of thoughtful design

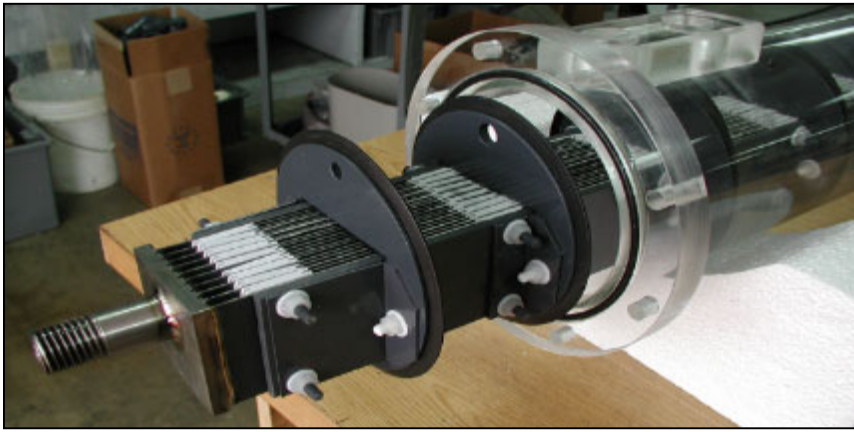


On-Site Sodium Hypochlorite Generation

Generation of sodium hypochlorite (bleach) requires softened water, salt and power (0.8% concentration product = 8,000 ppm)



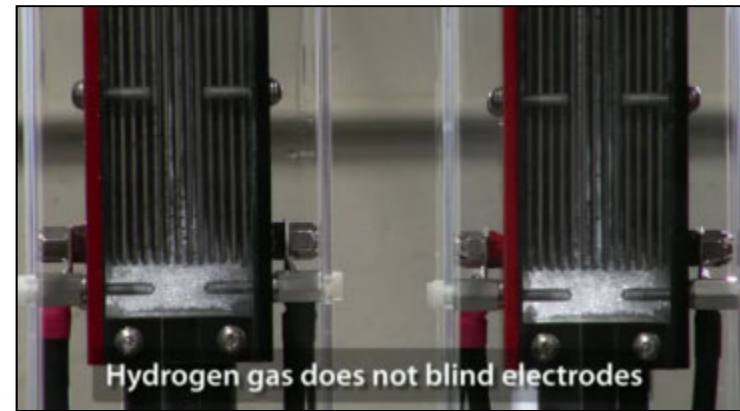
Modern OSHG systems incorporate innovations which improve reliability, safety and ease of operation



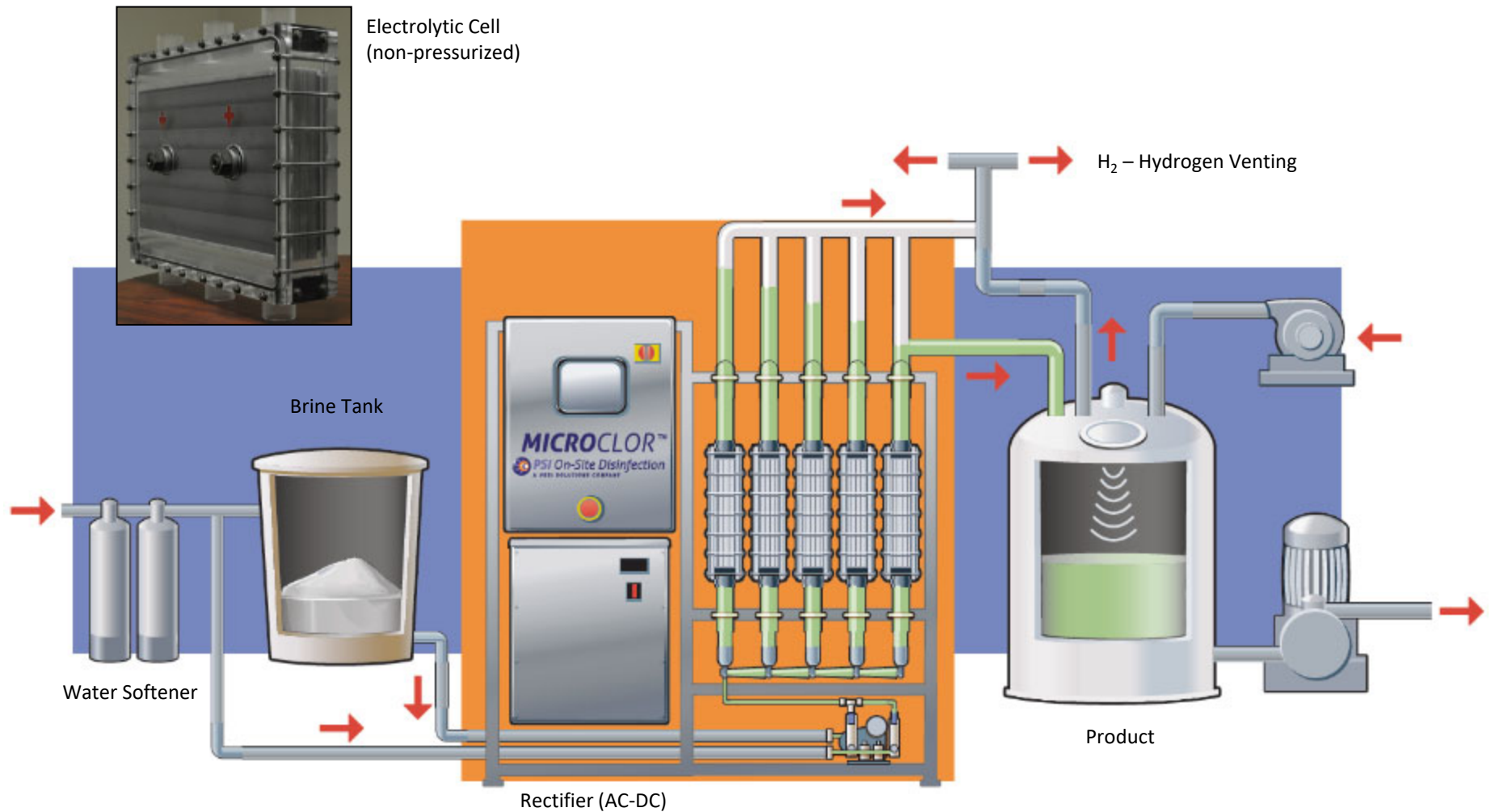
Previous generation utilizes a horizontal cell that is ***pressurized with a single pass***. Note internal hardware, baffles, rupture disks and resultant H₂ blinding of electrodes



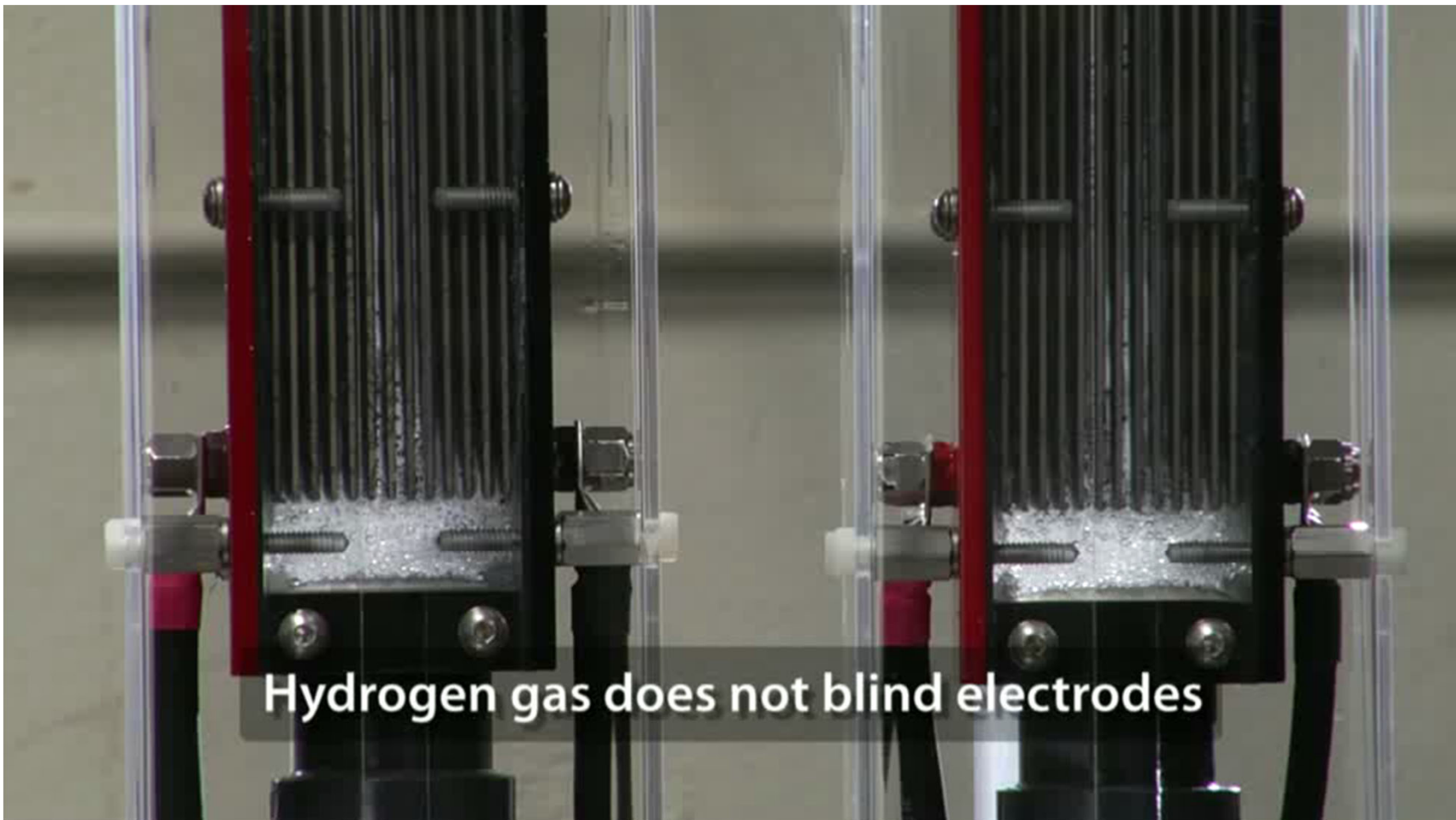
Vertical cell configuration allows immediate H₂ venting while operating without structural restriction to ***atmospheric pressure***



Modern OSHG systems are composed of discrete and simple subsystems that are easily accessible for inspection and maintenance



Vertical cell design without structural constrictions allows for facilitated H₂ release; improving efficiency and improving operator



Hydrogen gas does not blind electrodes



Current generation OSHG incorporates many innovations which improve reliability and ease of operation

Reduced Footprint Facilitates Retrofitting or Capacity Expansion

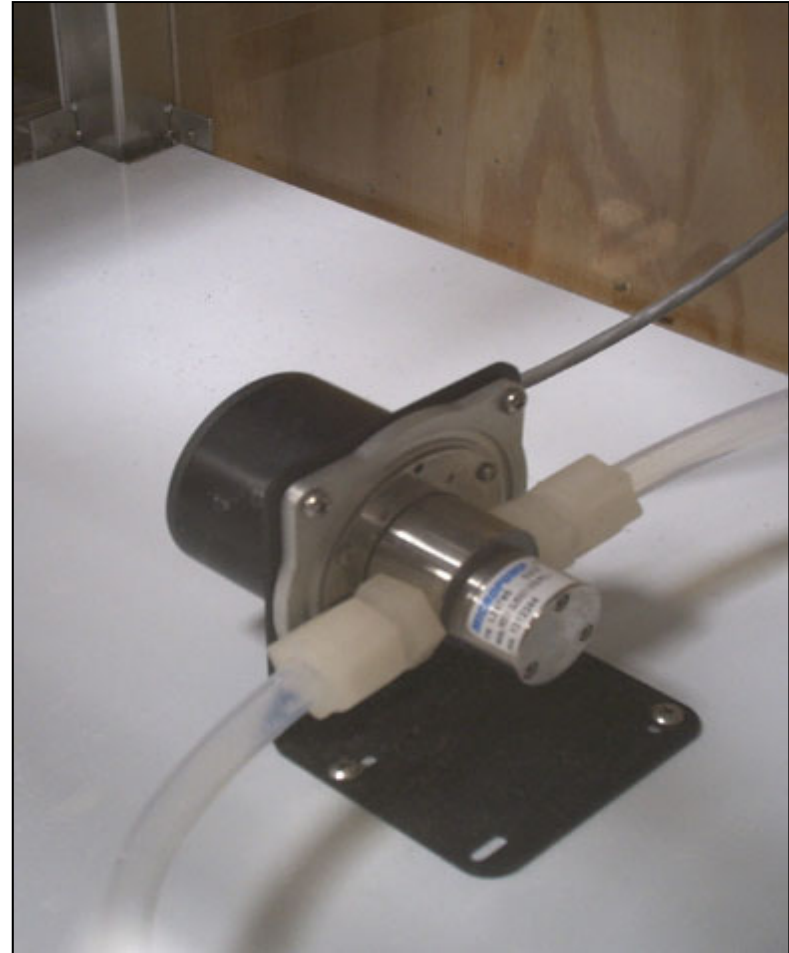


On-Site Sodium Hypochlorite Generation

Current generation OSHG incorporates many innovations which improve reliability and ease of operation

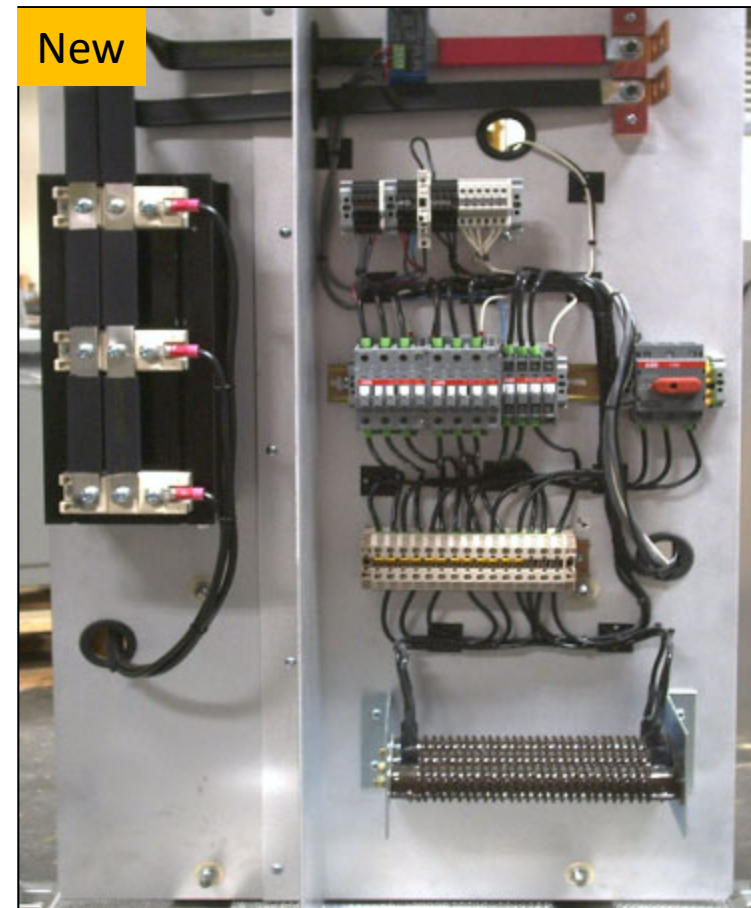
Constant current is required in all OSHG systems and is impacted by brine density, water temperature and scale.

Microclor[®] systems solve this problem with a current feedback loop that varies brine pump speed in relation to cell current



Current generation OSHG incorporates many innovations which improve reliability and ease of operation

Vastly Simplified Power Management with Fixed Voltage and 99% Power Factor simplifying Maintenance and Improving Reliability



On-Site Sodium Hypochlorite Generation

Current generation OSHG is a multi-cell design which allows for cell removal, but continued operation

A cell can be removed and the system can still maintain 80% capacity



Current generation OSHG is a multi-cell design which allows for cell removal, but continued operation



Cell cleaning is done with an external acid cart using dilute muriatic acid (pool acid) ~ two times a year; a simple fill-soak-drain procedure



Hand Unit – for OSHG units up to 200 PPD in capacity

OSHG systems use commonly available high quality salt – “food grade” salt is not necessary

2 MGD system with palletized 50 lb bags of salt



Bulk salt delivery is safe and efficient as compared to bulk bleach delivery with one truckload of salt for *three* truckloads of commercial bleach for the same treatment requirements



On-Site Sodium Hypochlorite Generation

3X MC-2000 OSHG System Salt Unloading Station



- SS salt line field welded
- Fill panel for brine, salt, and hypo levels
- Bulk hypo fill line can be added



Otay Water Treatment Plant – San Diego, California (30 MGD)

Conversion from Gas Chlorine to OSHG

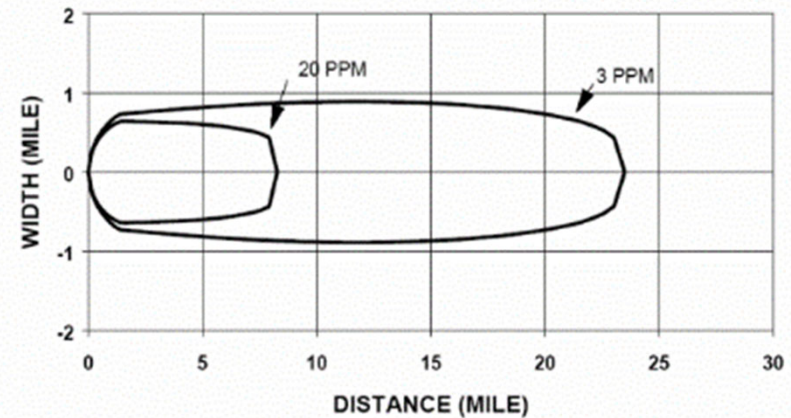


On-Site Sodium Hypochlorite Generation

San Diego's Otay Water Treatment Plant conversion from gas chlorine considered both bulk delivered hypochlorite and OSHG

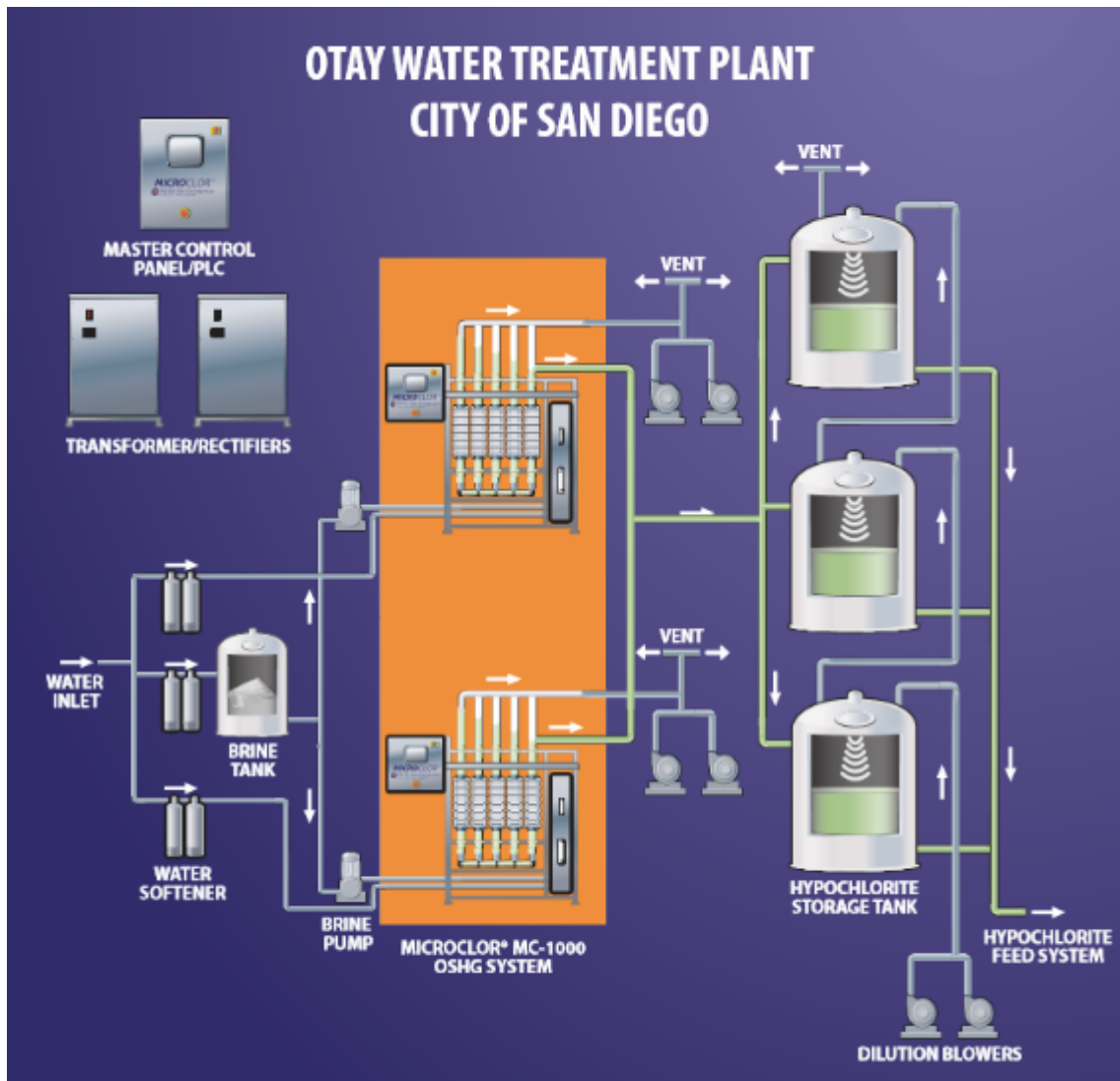
Bulk Hypo	
Annual Op Cost (\$1.20/gallon delivered)	\$375,000
Equipment replacement costs (30 years)	\$440,000
Capital Project Cost	\$900,000
Project NPV	\$9.94 million
OSHG	
Annual Op Cost (Salt \$0.03/lb, \$0.13/kWh, water)	\$107,000
Equipment replacement (incl. OSHG cells – 30 years)	\$840,000
Capital Project Cost	\$1,500,000
Project NPV	\$4.97 million

Figure 1 – Worst Case Release of 34,000 lbs of Chlorine Gas



Source: Pamphlet 74: Guidance on Complying with EPA Requirements Under the Clean Air Act by Estimating the Area Affected by a Chlorine Release, Edition 4 - Revision 1, The Chlorine Institute, February 2006

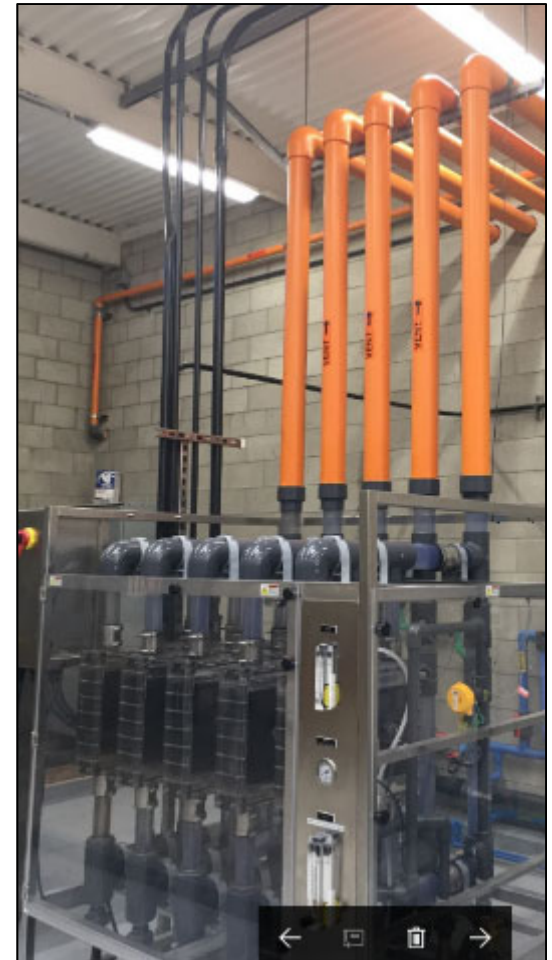
- Documented stored chlorine gas hazard (RMP)
- Homeland security issues (FBI Threat Assessment)
- Potential monopolistic gas economics (one supplier)
- Resilience of supply chain in natural disaster



- Two 1000 PPD MC units operating in lead/lag mode (8 hours per system per day – 25% duty cycle)
- 80 ton brine tank – 3 T/L salt – once per month
- Three 10,000 gallon hypo tanks
- 5-20 gpm dosing of 0.8% hypochlorite



Two 1000 lb units (ten 200 PPD cells)



Three water softeners – one for brine tank, and one for each MC-1000 unit



Water Hardness Monitor



Bulk Dilution Panel



Aided in transition from gas



Brine Tank 4m Diameter



Hydrogen Dilution Blowers

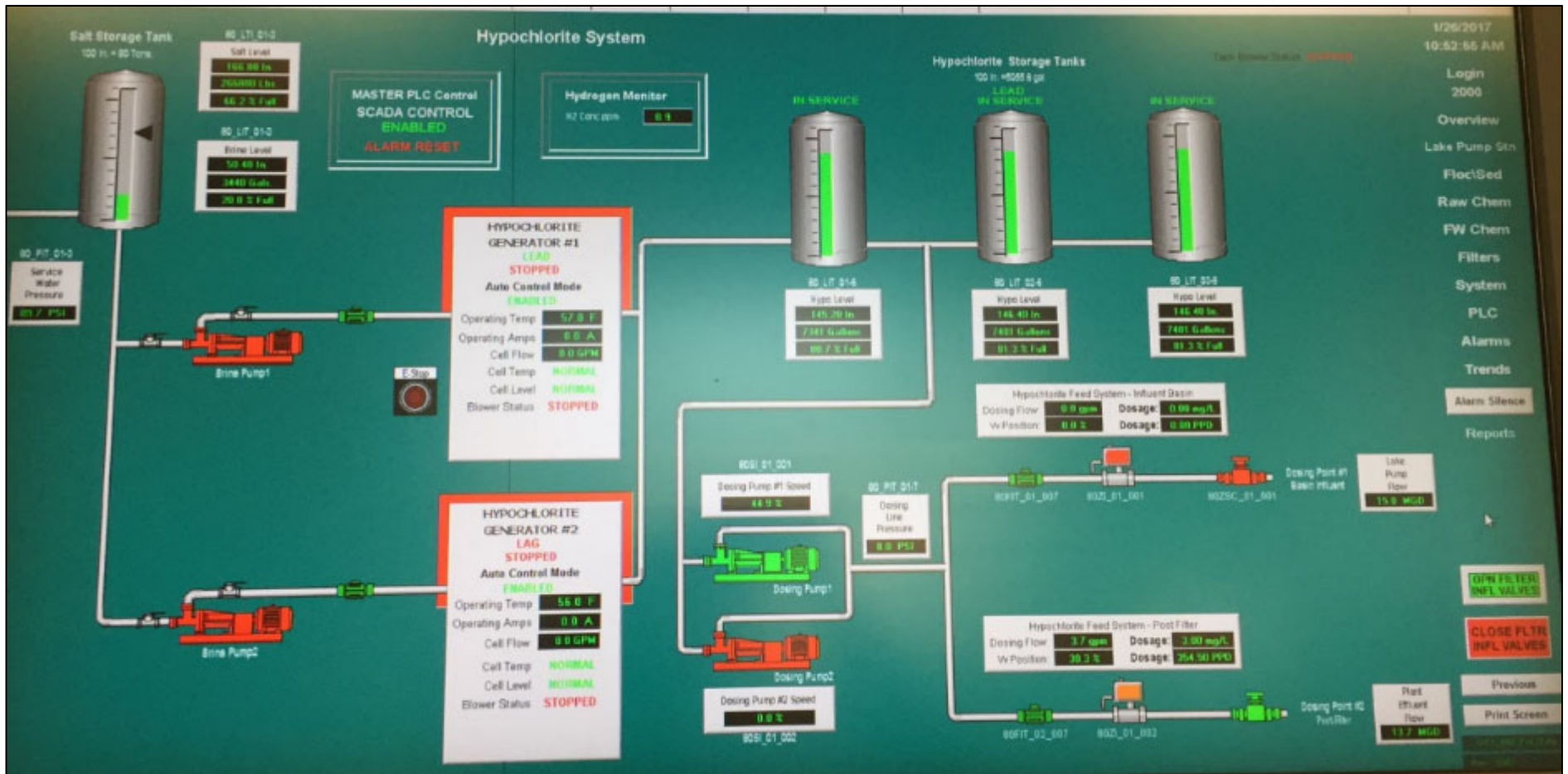


Transformer Rectifier for MC-1000



Small Rectifier Cooling Fans





SCADA Screen Shot



- K.R. Harrington and Omohundro surface water fed plants are ~ 180 MGD in total – all Metro Water Services is served by the OSHG from the two plants (190,000 water accounts)
- Replaced gas systems – 90 ton railcar and 1 ton cylinders (formerly routed through city)
- Recent 500 year flood event was driving force to re-design plants for safety and resilience
- Bulk-hypo dilution panels allowed for seamless transition to Microclor® OSHG





As featured in AWWA OpFlow Magazine 2014



Disinfectant Strategies

A California water utility's desire to move away from the dangers of gas chlorination drove operators and managers to consider bulk hypochlorite delivery and on-site hypochlorite generation as disinfection options. Ultimately, they found an on-site hypochlorite generation system was manageable, got the job done, and made the utility a better neighbor. BY SARA HARRIS

HYPOCHLORITE DISINFECTION CONSIDER AN ON-SITE SYSTEM

WHEN THE CITY OF VANDERBILT, at the city of Nashville was typical of that trend, it was presented with the opportunity to move away from chlorine gas distribution for its 12-mgd water plant. Chief Operator Richard Matusik embarked on a methodical process of evaluating hydrochloric acid-based, on-site hypochlorite generation for disinfection. Although distribution with chlorine gas has the greatest market share of all disinfection systems in North America, numerous water utilities have been evaluating the economic advantages of on-site hypochlorite generation as a method of chlorine disinfection. The process involves the electrolysis of sodium chloride (NaCl) and water to produce sodium hypochlorite (NaOCl). This process is highly efficient and produces a strong disinfectant. The system is designed to be safe and easy to operate, with built-in safety features to prevent leaks and ensure proper ventilation. The on-site generation system is a cost-effective and reliable solution for water utilities looking to improve their disinfection process.

AWWA OpFlow Magazine 2014

- Replaced earlier generation horizontal cell OSHG system – in same space as previous system
- 2,400 PPD system for Southern, CA site - a 34 MGD membrane water treatment facility
- Concerns over 12.5% commercial bleach deliveries through neighborhoods and local roads was a driver



Aqua America Hillside Tank Chloramine Boosting - 100 PPD Microclor® OSHG

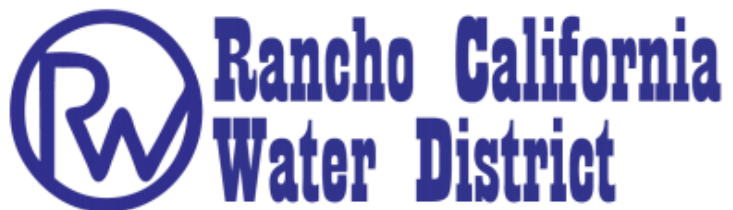


- 10 million gallon tank with seasonally poor residual levels in large distribution network near Philadelphia
- Demonstration residual control trailer was able to bring tank from 0.1 mg/l residual to 1.5 mg/l with a 40 PPD OSHG system
- Full scale design utilized a 100 PPD Microclor® OSHG system





- Replaced gas systems - no previous building at site
- Poured pad and installed fiberglass building
- Design-build by Process Solutions, Inc.
- One of 56 systems owned and operated Rancho California Water District (all well sites)

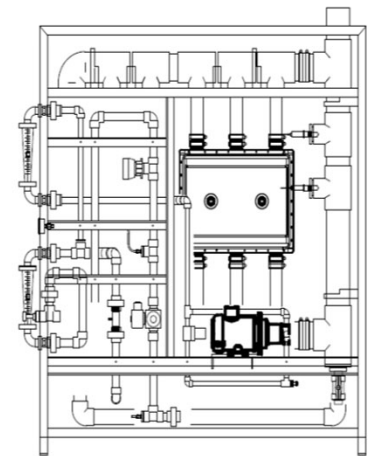
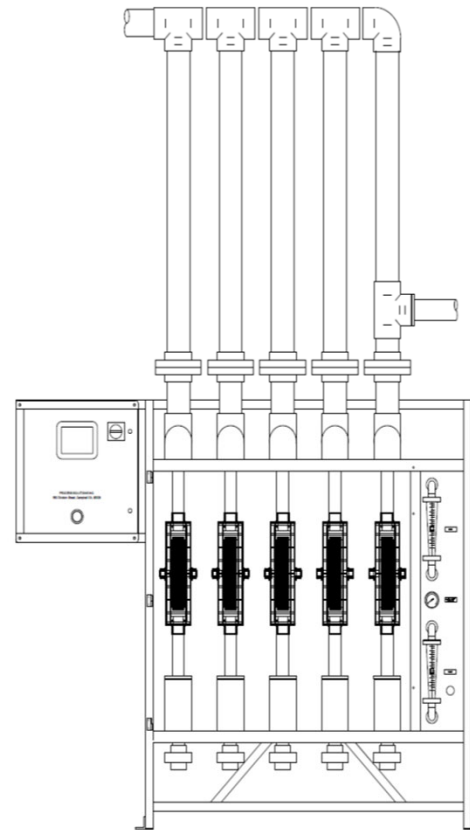
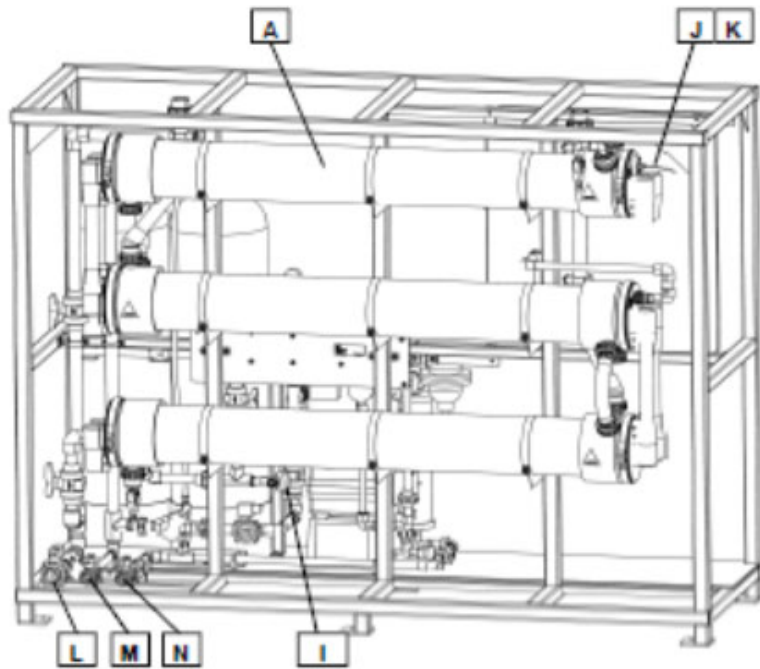


Controls – Can easily get out of control

- Allen Bradley Micrologix 1400
- Magelis 6" HMI
- Communication – Allen Bradley TCP/IP & MODBUS TCP/IP
- 304SS Cabinet – NEMA 4X
- T/R can always fit on the skid
- Simple SCADA integration
- 24" x 24" x 10" Enclosure



The three most common OSHG configurations are *dramatically* different from a design and operations perspective – “open” or combined specifications can lead to unintended consequences



On-Site Generation of Hypochlorite Made Easy and Reliable

- **Safe to Operate**

 - No hazardous material transported, produced or stored

- **Easy to Operate & Maintain**

 - Batch system with automatic controls

 - Easy system and cell maintenance with no H₂ off-gassing dangers

 - Operator friendly design

- **Significant Cost Savings**

 - Economical vs. bulk bleach with inherent self-sufficiency

