Principals and Advantages of On-Site Hypochlorite Generation

OAWWA NWD Fall Meeting
October 20, 2016
Disinfection with chlorine has been one of the greatest public health improvements in mankind’s history.
There are three major modes of chlorine supply

- Gas Chlorine (100%)
- Bulk Sodium Hypochlorite (12.5-15%)
- On-Site Generation (0.8%)
About two thirds of US water treatment utilities utilize chlorine gas for disinfection

- Increasingly, utilities are opting to remove gas chlorine
  - Refurbishment of emergency vapor scrubbers are expensive
  - Residential and Commercial encroachment on treatment plants
  - Risk Management Plans (RMP) are becoming more complicated and onerous
  - Concerns over safety and terrorism only increasing
Chlorine Exposure – Inhalation Pathway

- ACGIH TLV
  - STEL 1 ppm @ 15 minutes
  - TWA 0.5 ppm @ 8 hours
- 1-3 ppm – Odor, irritant to eyes & nose
- 5-8 ppm – Irritant to throat, eye and mucous membrane
- 30 ppm – Intense coughing
- 34 – 51 ppm – Lethal at 1 – 1.5 hours exposure
- 1000 ppm – Fatal with a few breaths
Emergency chlorine gas scrubbers are expensive and must be maintained – replacement often triggers an opportunity to change disinfection methods

- An essential part of a facility’s risk management plan
- Must have chemical package periodically changed and tested
- System must be tested
- Fiberglass tanks can leak over time
- Refurbishment or replacement can be in the $100’s of thousands
Potential for chlorine gas releases are becoming increasingly unacceptable.

As a point of reference, a company in City of Glendale, AZ settled a class action suit for $4.8 million with residents living within a 1 mile radius of the 1,900 lb release.

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

Gilbert, AZ – Removal of gas chlorine – choice between bulk and OSHG
Generation of sodium hypochlorite (bleach) at 0.8% (8,000 ppm) requires softened water, salt and power and generates hydrogen gas as a byproduct.

\[
\text{NaCl} + \text{H}_2\text{O} + 2\text{e}^- \rightarrow \text{NaOCl}_{(aq)} + \text{H}_2
\]
An OSHG System is composed of discrete and simple subsystems.
Bulk hypochlorite degrades quickly as temperature increases
Degradation and aggressive nature of bulk hypochlorite should be considered

- Chlorine gas accidents are more commonly caused by concentrated bulk hypochlorite being improperly handled*
- Bulk hypo degrades into oxygen and chlorate – the gas will bind pumps and feed systems causing downtime and the need for chlorine concentration assessment to ensure proper dosing (titration)
- High pH of bulk hypo also encourages calcium carbonate scaling which adds to maintenance cost
- Blending Bulk hypo with softened water to minimize degradation increases handling and risk of mishap

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

**Illustrative Example – Cost of 1lb of Chlorine Equivalent**

**Bulk Delivered 12.5% Hypochlorite**
- Delivered Cost of $0.80 per gallon (same as 1lb of Chlorine Equivalent) expect degradation – higher effective cost

**On-Site Generated Hypochlorite**
- 3lbs of Salt = $0.21
- 2 kW AC ($0.085/kW) = $0.17
- OSHG Cost is $0.38 per 1lb of Chlorine Equivalent
OSHG systems generally have either horizontal cell or vertical cell configurations – hydrogen evacuation is key.

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

Microclor® vertical cell configuration allows immediate H₂ venting while operating at *atmospheric pressure and multi-pass*.
Vertical cell design facilitates H$_2$ release which improves efficiency and makes for a safer system.
The Microclor® hydraulic design ensures that brine has optimal contact with electrolytic cells. Ensures Efficiency and Safe Operation – No H₂ Carryover.
Next 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
Multiple and vertical OSHG cell configuration allows for cell removal, but continued operation. A cell can be removed and the system can still maintain 80% capacity.
The Microclor® next 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

Hand Unit – up to 200 PPD
Salt storage & handling systems is dependent on chlorine demand and customer preference

2 MGD system with 50lb 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.
Engineering and design issues that can impact reliability and owner cost

**Design Considerations**
- Product tanks greater than 6 feet in height should always be FRP versus polyethylene (due to chlorine induced degradation of polyolefin materials)
- Improper specification of controls can often double the price of a system with no owner benefit
- Inclusion of a dilution panel for emergency delivery of bulk hypochlorite can offer “belt and suspenders”

**Sizing Considerations**
- Nominal 0.8% hypochlorite product concentration can vary due to cell age, water quality and most importantly temperature (use 0.75-0.85%)
- Consumption of inputs (salt, power) can vary with temperature, water quality and age
- Opt for redundancy in design – i.e. two smaller systems versus one large system (N+1)
Selected Microclor® Installations

Large Installations Are Common

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Repeat Customers Are Common

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<td>South Coast WD, CA</td>
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Daphne Utilities, Alabama – 100 PPD Microclor® OSHG

- 100 PPD OSHG system in new water plant adjacent to high school
- Seven years of operation with about $100 of maintenance costs each year
- Purchased 2\textsuperscript{nd} system in 2016

“To me, Microclor® is the top of the line on-site generation system on the market due to low maintenance and it being very user friendly” Larry English, Water Quality Manager, Daphne Utilities
Replaced Competitor’s Failed OSHG systems

Five Years of Operation

Utilized Existing Brine and Product Tanks

Quarterly Service Contract

“Microclor has been more reliable than our experience with the previous manufacturer. UGSI Solutions has been responsive with spare parts and on-site technical service when needed” – Larry Hazlett, WTP Supervisor Lawrenceburg, KY
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)
Missouri American Water - (3) X 1,200 PPD & (3) 1,800 PPD Microclor™ OSHG systems

- 50 MGD & 40 MGD surface water plants in Missouri
- 9,000 PPD total generating capacity
- Replaced gas disinfection due to safety concerns – older plant site with encroaching neighborhoods
- In service for ~ seven years
On-Site Generation of Hypochlorite Made Easy
Microclor® OSHG

• 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 off-gassing
  Operator friendly design

• Significant Cost Savings
  Economical vs. bulk bleach with inherent self sufficiency
300 PPD Microclor® example layout

- 43-Ton brine tank A
- 4,100-Gallon sodium hypochlorite storage tank B
- Water softener and cartridge filters C
- Dilution panel (for use with tote)
- Duty/standby metering pumps with VFDs D
- (2) Hydrogen dilution blowers E
- Tanks outdoors (Southern California)
- OSHG F
Microclor® 2X MC-300 OSHG System

- Common trench for water and bring piping to generators
- (2) 24-Ton brine tanks
- (3) 8,100-Gallon hypo tanks
- Space allocated for (2) future generators