

# Bulk or On-Site Generation: What's Your Hypochlorite Solution

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# Outline

- Comparison of Sodium Hypochlorite Systems
- Design Details of On-Site Hypochlorite Generation System
- Cost Evaluation of Bulk Delivery vs. On-Site Generation at 25 MGD WWTP



# Chlorine Gas

- Traditional disinfectant of choice
- A gas at normal room temperature and pressure
- The gas is compressed into a liquid and delivered in 90-ton railcars, 1-ton containers, or 150 pound cylinders
- The Department of Homeland Security has concerns about chlorine gas storage and transport, proposing Chemical Security Rules and Regulations for users
- Many utilities are evaluating alternative disinfectants to address these concerns with chlorine gas



# Alternative Disinfectant Strategies

- Non – Chlorine Based
  - Ultraviolet Light Technologies
  - Ozone Technologies
- Chlorine Based
  - Bulk Delivered Sodium Hypochlorite
  - On-site 0.8% Sodium Hypochlorite Generation

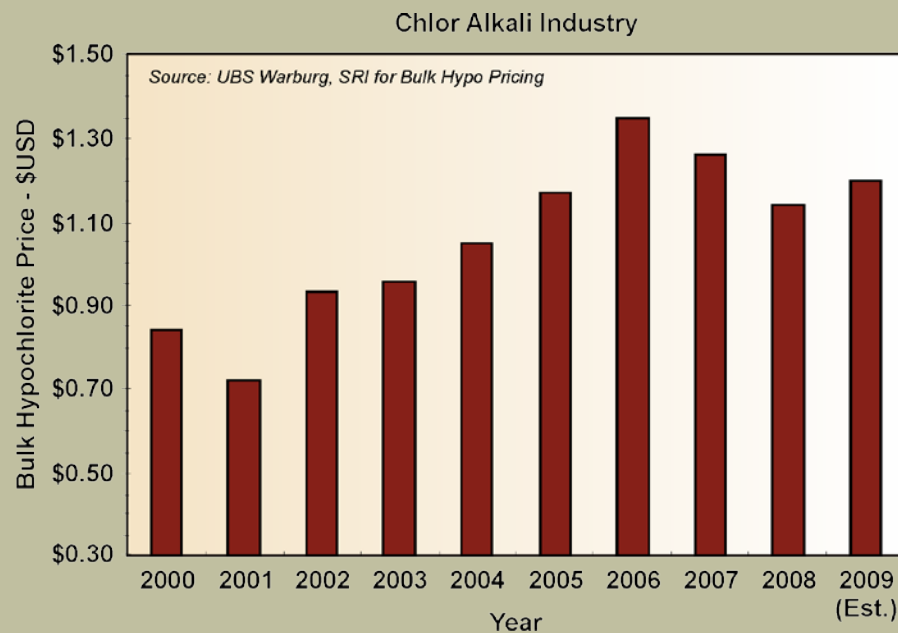


# Commercial Bulk Sodium Hypochlorite



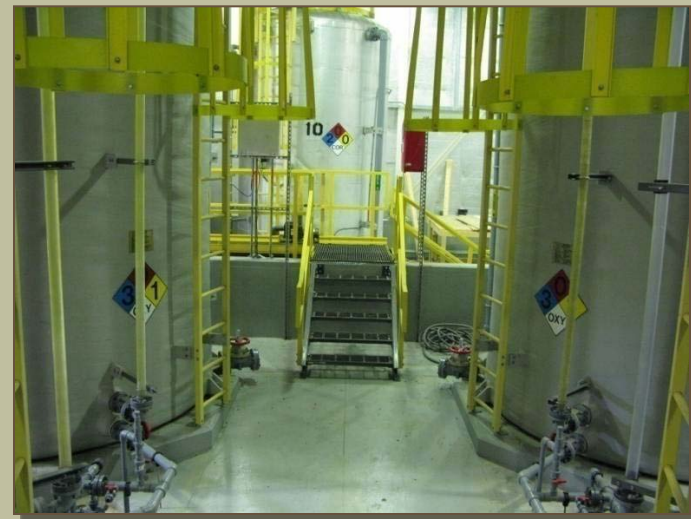
# Bulk Sodium Hypochlorite Commercial Truck Delivery – Typical

- Manufactured chemically or by membrane electrolysis
- Typically delivered by tanker trucks at a concentration of 12.5% by volume
- Requires on-site tank farm for storage (30 days undiluted, 15 days diluted)
- Typical chemical cost
  - Price continues to fluctuate
  - 2010 TN cost = \$0.79 / gallon (1 gal = 1 lb Cl<sub>2</sub>)



# Bulk Sodium Hypochlorite Commercial Truck Delivery – Typical

- Stability
  - Off-gassing (difficult to pump)
  - Strength degrades over time
  - Use climate control or 50% dilution for longer storage life and reduced off-gassing
  
- Safety
  - Concentrated solution presents risk
  - Chemical containment required



# On-Site Sodium Hypochlorite Generation





# Electrolysis of Brine



Salt

Electricity

Water

2 kW

+

15 gal

+

3 lb

Sodium Hypochlorite

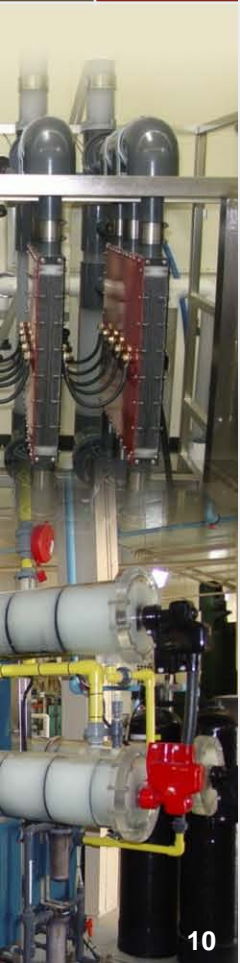
1 lb Cl<sub>2</sub>

Hydrogen

1/35 lb H<sub>2</sub>

15 gal of 0.8% Hypochlorite Solution

# On-Site Hypochlorite Generation Schematic



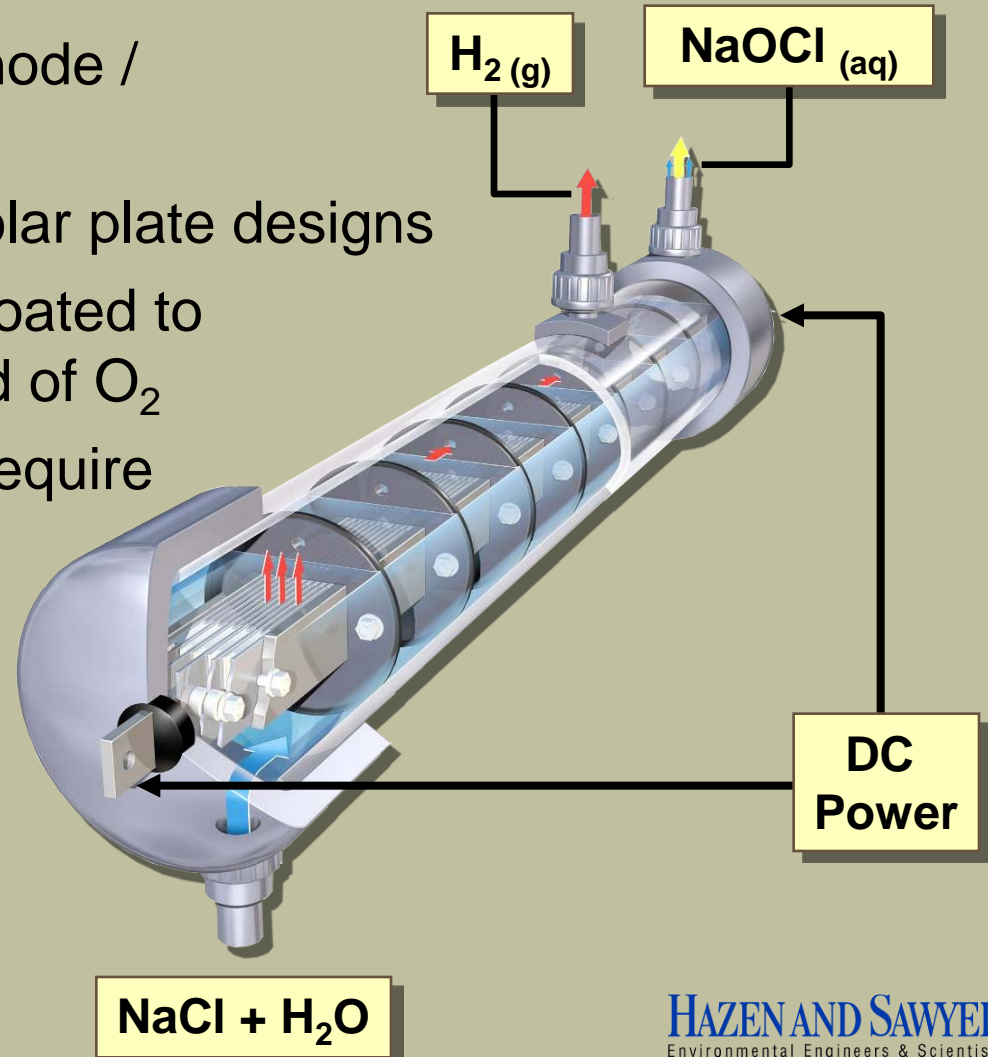
# Salt and Product Storage

- High Density Polyethylene
  - Low cost
  - Limited capacities
  - Lifespan (2-5 years)
- Fiberglass Reinforced Plastic
  - Moderate cost
  - Larger capacities
  - Lifespan (10-20 years)
- PVC Lined Concrete Tank
  - Most efficient use of space



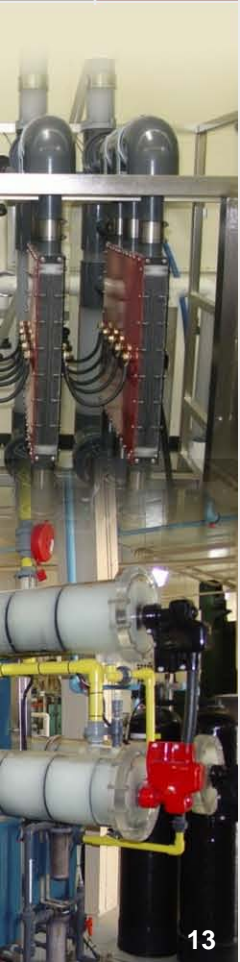
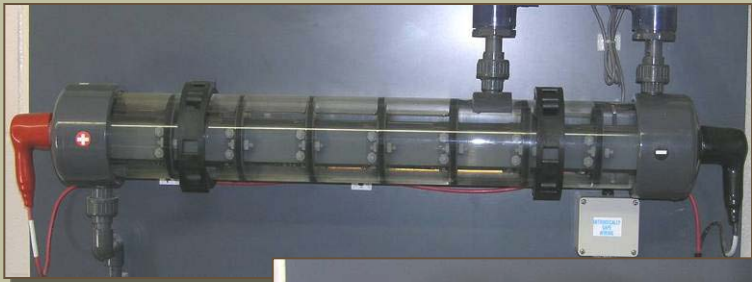
# Electrolyzer Cell

- Multiple titanium anode / cathode plates
- Bi-polar & mono-polar plate designs
- Anode plates are coated to produce  $\text{Cl}_2$  instead of  $\text{O}_2$
- Typically, anodes require replacement after 7 – 10 years of service



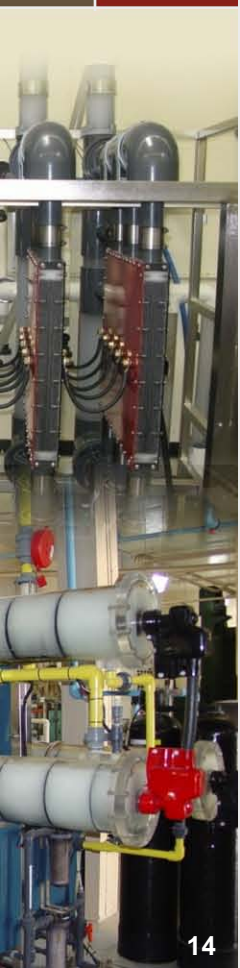
# Cell Configurations

- Horizontal tubes with vertical plates
- Rectangular cassettes with vertical plates



# On-Site Hypochlorite Generation System Efficiencies

- Typical electrolyzer skid efficiency:
  - Power consumption = 2.0 kWh / lb Cl<sub>2</sub>
  - Salt consumption = 2.5 lb salt / lb Cl<sub>2</sub>
- Variables affecting electrolyzer skid efficiency:
  - Water temperature (55° < TEMP < 80 °F)
  - Brine concentration
  - Anode coating life
  - Deposits on cathode surface
- Efficiency will change over the life of system until plates are replaced (7-10 year life cycle)



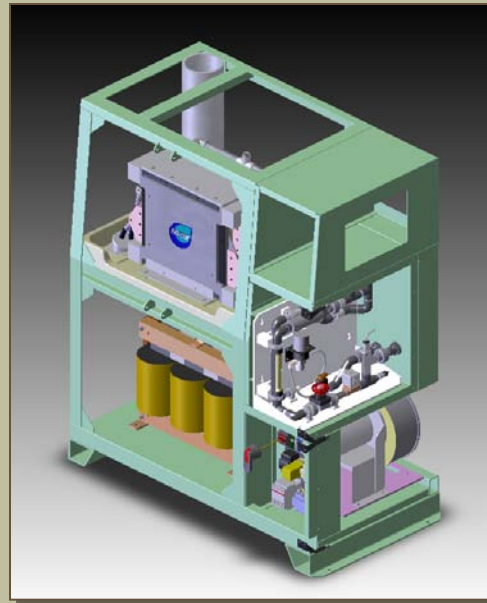
# On-Site Hypochlorite Generation System Summary

- Generate dilute sodium hypochlorite solution (0.8%)
  - Typically higher capital cost but lower operating cost relative to bulk delivery
- Safety
  - Dilute hypochlorite solution reduces risk
  - Electrolyzer vessels could over-pressurize
    - Requires appropriate safeguards
  - Hydrogen gas by product can be hazardous
    - Proper venting and dilution is KEY
- Dilute hypochlorite product is stable .... Longer shelf life



# On-Site Hypochlorite Generation Vendors

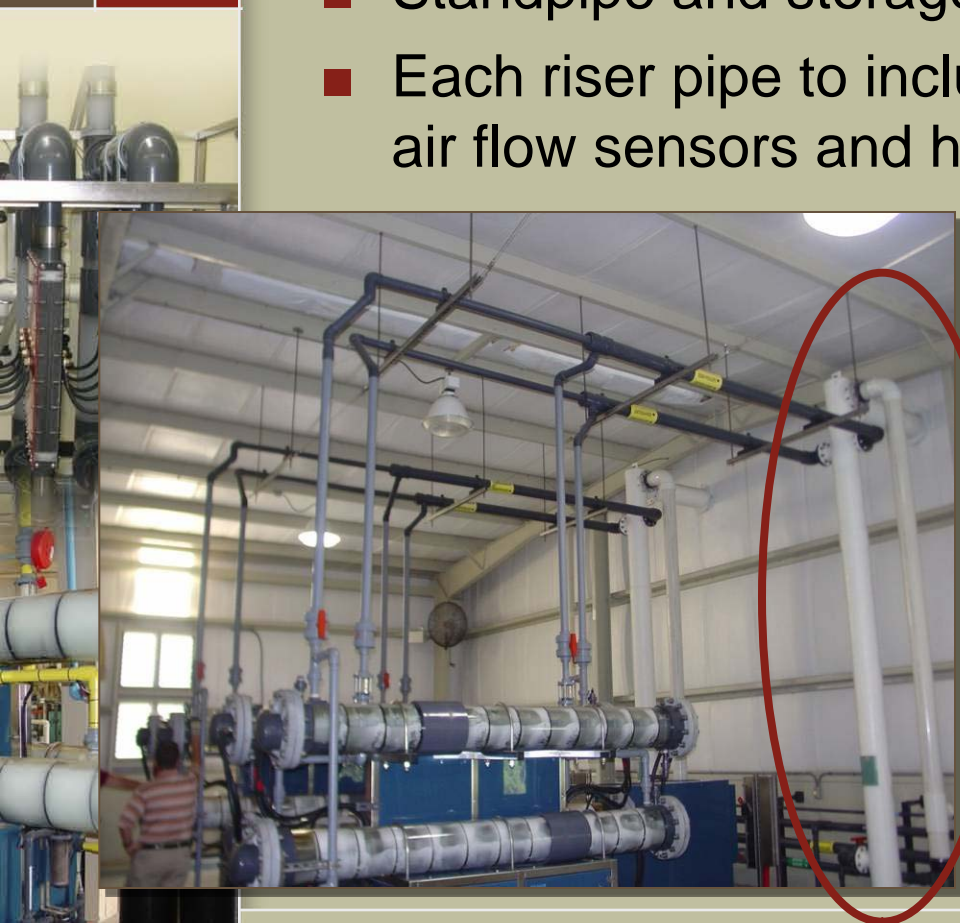
- Severn Trent: CLORTEC
- Siemens: OSEC
- Process Solutions, Inc.: MicrOclor
- Miox
- Pepcon





# Facility Design Considerations – Hydrogen Gas Management

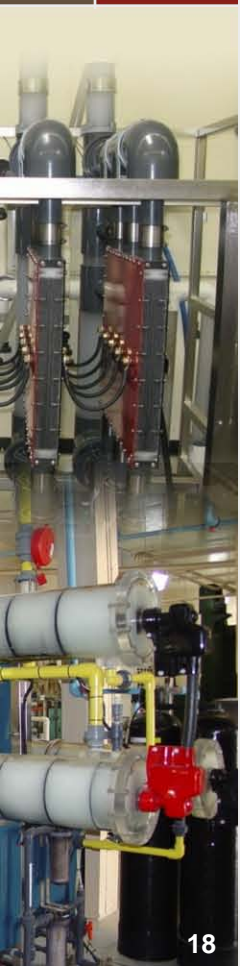
- High room air exchange rate: 18-24 changes/hr.
- Standpipe and storage tank purge air dilution ratio 100:1
- Each riser pipe to include redundant purge air blowers, air flow sensors and hydrogen gas monitor
- Each storage tank to include redundant purge air blowers, air flow sensors and hydrogen gas monitor



**Riser Pipe Vent  
System**

# Recommended Design Criteria

- Hypochlorite Generators:  
Typically size to meet the maximum day chlorine demand
- Operation:
  - Generally runs as a batch operation to maintain storage tank level
  - Consider 20 hour/day (or less) operating cycle
  - Consider plant power load management control.
- Hypochlorite Storage:  
1.5 days of storage for the maximum day chlorine demand
- Salt Storage:  
30 days of storage for the annual average chlorine demand
- Feed Pumps:  
Size to provide peak hour chlorine demand



# Recommended Design Criteria

- Bulk Chemical Backup:  
Provisions for backup delivery and storage of 12.5% bulk hypochlorite in the event of an extended power outage or catastrophic equipment failure
- Dilution System:  
Provide dilution / product transfer system with bulk backup system
- Back-up Power System – Option A:  
Provide backup power sized to provide power for the bulk backup feed system with dilution
- Back-up Power System – Option B:  
Same as option A except that the backup power system would be sized to provide power to the hypochlorite generators and the auxiliary systems



# Cost Evaluation: Clarksville, TN WWTP

- Plant was severely damaged by flood in 2010, completely destroying existing UV disinfection system
- Owner combined flood recovery effort with long-term improvements to evaluate new disinfection system
- Currently disinfecting with temporary bulk sodium hypochlorite storage and feed system

	Maximum	Average	Blended w/ Secondary Bypass
Plant Flow, mgd	75	25	50
Chlorine Dose, mg/l	8	6	10

# Bulk Sodium Hypochlorite Equipment

## Equipment Requirements

Bulk Storage	Two (2) 20,000-gallon tanks 15 days storage of 6.25% hypo @ avg flow & dose
Water Softener	One (1) 30-gpm dilution water softener
Recirculation/Transfer Pumps	Two (2) 200-gpm pumps Recirculate bulk tank in under 2 hours
Metering Pumps	Three (3) 125-gph metering pumps for secondary effluent Two (2) 250-gph metering pumps for blended primary and secondary effluent



# Bulk Sodium Hypochlorite Construction Cost

## Construction Cost Estimate

Structural (\$200/ft <sup>2</sup> )	\$400,000
Bulk Hypochlorite Equipment (Includes Installation)	\$335,000
Electrical and Instrumentation	\$53,600
Contingencies and Contractor OH&P	\$390,400
Total Construction Cost (Sept 2010 dollars)	\$1,179,000

# Bulk Sodium Hypochlorite O&M Cost

## Annual Operation and Maintenance Cost Estimate

Hypochlorite (\$0.74/gallon @ 12.5%)	\$204,600
Potable Water (\$9.22/1000 gallons)	\$2,400
Power (\$0.077/kW-hr)	\$7,400
Equipment Maintenance	\$14,000
<b>Total Annual O&amp;M Cost</b>	<b>\$228,400</b>

# Bulk Sodium Hypochlorite Life Cycle Cost

## Cost Summary

Total Construction Cost	\$1,179,000
Total Annual O&M Cost	\$228,400
Present Worth of Total Annual O&M (20 years, 8% discount rate, 0% inflation)	\$3,398,000
Life Cycle Cost	\$4,577,000



# On-site Hypochlorite Generation Equipment

## Equipment Requirements

Brine Saturator	One (1) 80-ton brine saturator
Water Softeners	Three (3) 20-gpm water softeners
Brine Pumps	Three (3) 25-gph brine metering pumps
Hypochlorite Generators	Two (2) 1,500-ppd hypochlorite generators
Solution Tanks	Three (3) 20,000-gallon storage tanks 3 days storage of 0.8% hypo @ avg flow & dose 25 days storage of 6.25% hypo @ avg flow & dose
Hydrogen Gas Blowers	Four (4) blowers 2 @ 2,200 scfm, 2 @ 300 scfm
Recirculation Pumps	Two (2) 200-gpm pumps
Metering Pumps	Three (3) 1,000-gph and three (3) 125-gph (6.25% bulk hypo) metering pumps for secondary effluent Three (3) 2,000-gph metering pumps for blended primary and secondary effluent

# On-site Hypochlorite Generation Construction Cost

## Construction Cost Estimate

Structural (\$200/ft <sup>2</sup> )	\$430,500
Bulk Hypochlorite Equipment (Includes Installation)	\$1,927,500
Electrical and Instrumentation	\$308,000
Contingencies and Contractor OH&P	\$1,320,000
Total Construction Cost (Sept 2010 dollars)	\$3,986,000

# On-Site Hypochlorite Generation O&M Cost

## Annual Operation and Maintenance Cost Estimate

Salt (\$180/ton)	\$61,700
Potable Water (\$9.22/1000 gallons)	\$37,900
Power (\$0.077/kW-hr)	\$52,300
Equipment Maintenance	\$16,600
<b>Total Annual O&amp;M Cost</b>	<b>\$168,500</b>

# On-Site Hypochlorite Generation Life Cycle Cost

## Cost Summary

Total Construction Cost	\$3,986,000
Total Annual O&M Cost	\$168,500
Present Worth of Total Annual O&M (20 years, 8% discount rate, 0% inflation)	\$2,506,000
Life Cycle Cost	\$6,492,000

# Sodium Hypochlorite Systems Cost Comparison

A vertical strip on the left side of the slide shows industrial water treatment equipment, including pipes, valves, and tanks, with a red valve being prominent in the lower half.

	Bulk Delivery	On-Site Generation
Construction Costs	\$1,179,000	\$3,986,000
Present Worth of Annual O&M	\$3,398,000	\$2,506,000
Life Cycle Cost	\$4,577,000	\$6,492,000

**Recommended Bulk Delivery of Sodium Hypochlorite over On-Site Generation based on \$1.9M savings on a 20-year life cycle cost basis.**

# Questions

