

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

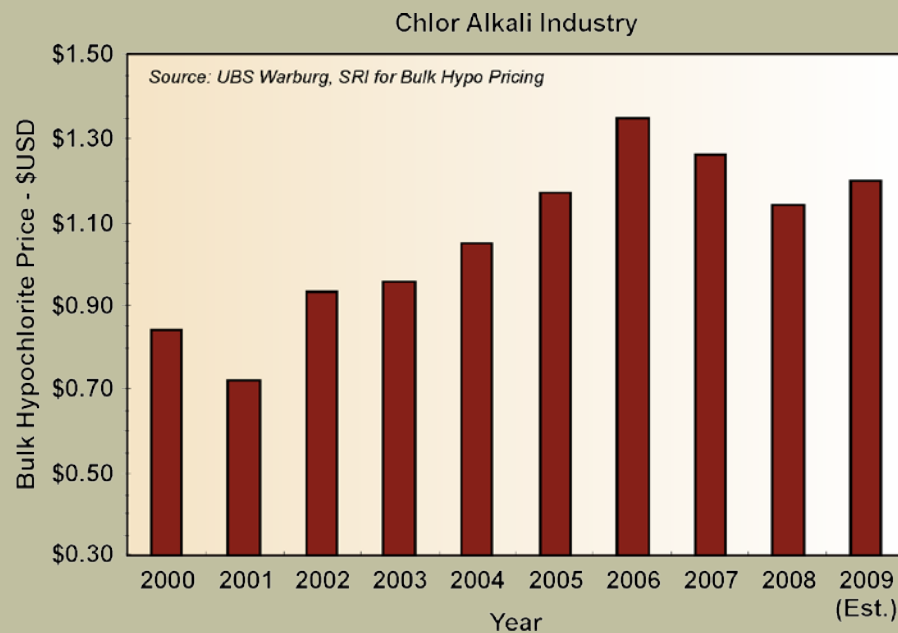


Commercial Bulk Sodium Hypochlorite



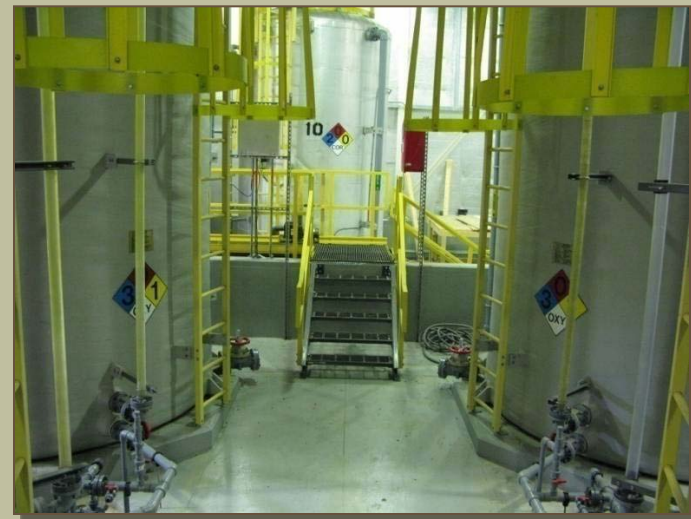
Bulk Sodium Hypochlorite Commercial Truck Delivery – Typical

- 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 Cl₂)



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 Cl₂

Hydrogen

1/35 lb H₂

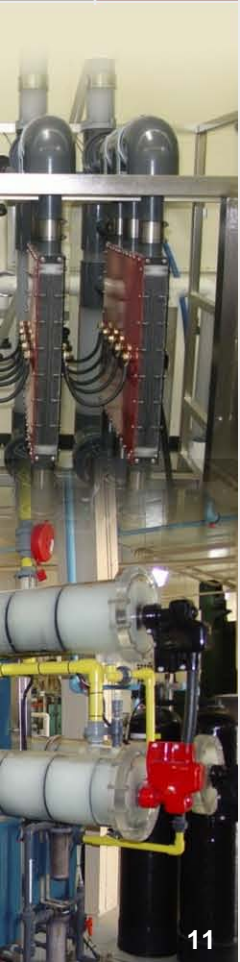
15 gal of 0.8%
Hypochlorite Solution

On-Site Hypochlorite Generation Schematic



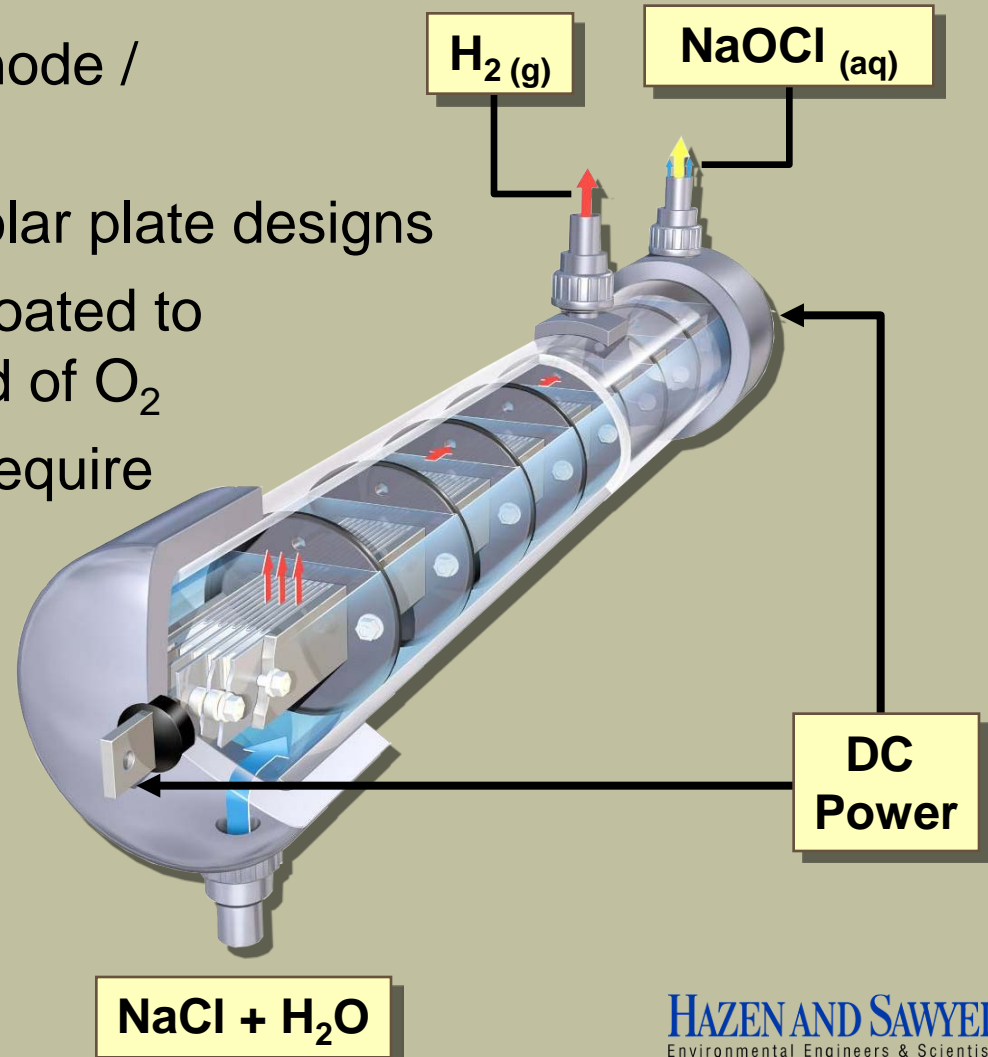
Salt and Product Storage

- 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



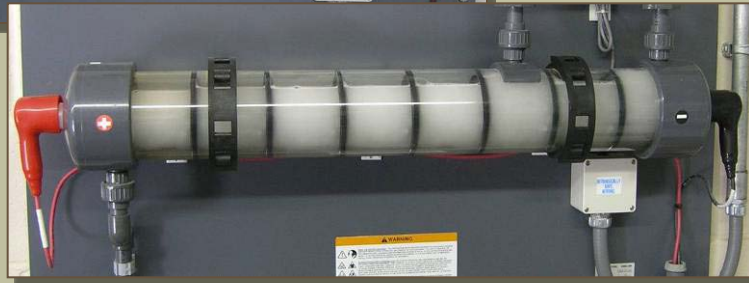
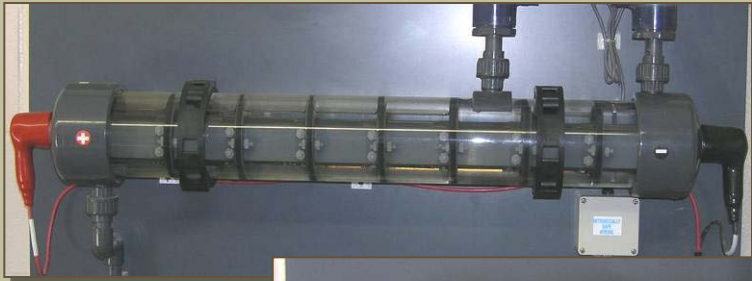
Electrolyzer Cell

- Multiple titanium anode / cathode plates
- Bi-polar & mono-polar plate designs
- Anode plates are coated to produce Cl_2 instead of 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 Cl₂
 - Salt consumption = 2.5 lb salt / lb Cl₂
- 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)



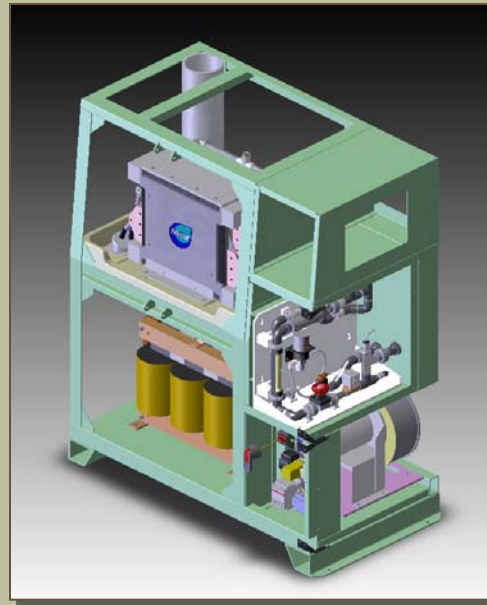
On-Site Hypochlorite Generation System Summary

- 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



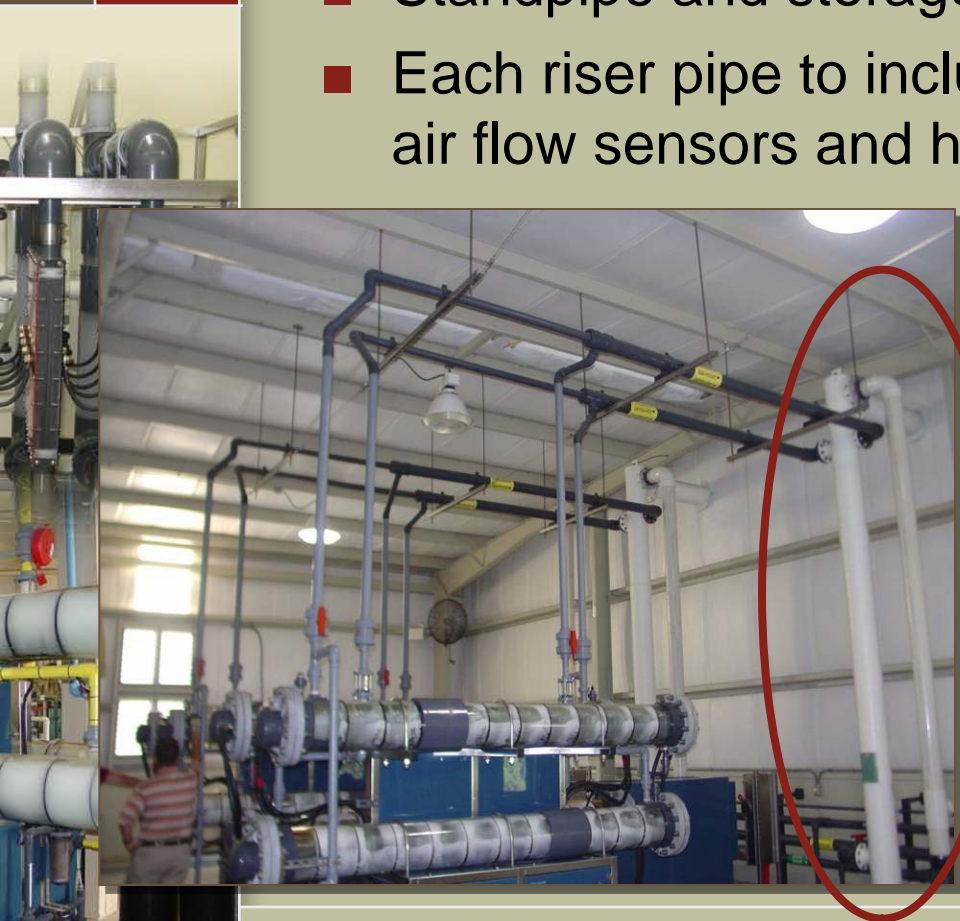
On-Site Hypochlorite Generation Vendors

- 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 ²) | \$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 |
| Total Annual O&M Cost | \$228,400 |

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 ²) | \$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 |
| Total Annual O&M Cost | \$168,500 |

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 cylindrical tanks.

| | 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

