Hypochlorite Disinfection

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Hypochlorite Disinfection

7 contact hours
9 CC10 hours

This course focuses on the properties, use, and feed equipment when using hypochlorite for disinfection. Hypochlorites - sodium and calcium - are the most common form of disinfection used in water treatment. Students will be introduced to the uses and properties of hypochlorites, chemical handling including safety, regulatory requirements, and feed equipment. Various mathematics principles will be addressed throughout the workshop including changing % concentrations, dosage/feed rates, chlorine demand/dose, and CT calculations.

Learning Objectives:

1. Explain how hypochlorite is produced.
2. Perform mathematical calculations for changing % of concentrations of chemicals, dosage/feed rate/flow, chlorine demand or dose and CT.
3. Identify chemical feed equipment and explain important operation and maintenance considerations.
4. Use the MSDS sheet to identify the first aid measures to be taken in the event of a chemical burn.

8:15 - 8:30 Registration
8:30 - 9:30 Unit 1 (1 hr)
- Basic Hypochlorite Information
- Basic Hypochlorite Properties

9:30 - 10:15 Unit 2 (45 min)
- Storage and Handling
- Safety

10:15-10:30 Break
10:30-11:30 Unit 3 (1 hr)
- Math terms, principles, and rules for solving equations
- Unit Cancellation steps

11:30-12:30 Lunch
12:30 - 2:30 - Unit 3 (2 hr)
- Calculation changing % concentration of a chemical
- Dosage/Feed Rate/Flow
- Chlorine Demand or Dose

2:30 - 2:45 Break
2:45 - 3:30 Unit 3 (45 min)
- CT
- Review

3:30 - 4:15 Unit 4 (45 min)
- Regulatory Requirements
- Chlorination Mechanics and Terminology
- Feed Equipment

4:15 - 5:00 review questions (45 min)

Hypochlorite Disinfection

Presented by
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Disinfection

- Goal
  - To remove, destroy, or inactivate pathogenic microorganisms including bacteria, cysts, algae, spores and viruses.
- Problem
  - Chemical disinfectants form disinfection byproducts

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Potential Health Issues

- Microbial Health Concerns
  - Cryptosporidiosis and Giardiasis
    - ✓ Vomiting and diarrhea, potentially life threatening for immune compromised, elderly and young
- Disinfection By-Product Health Concerns
  - Cancer
    - ✓ Bladder, colon and rectal
  - Reproductive
    - ✓ Neural tube defects and miscarriages
  - Brominated compounds are thought to pose a greater health risk than chlorinated compounds
  - Nitrogenated compounds may be even worse???

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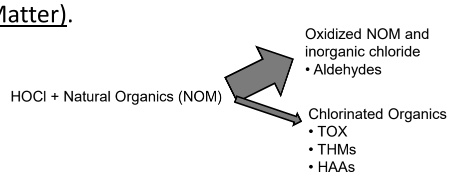
Disinfection By-products (DBPs) Formation

- Disinfection by-products arise in water treatment through the reaction of a Disinfectant and background water constituents (most often Natural Organic Matter).



Waterborne Diseases

- Many human diseases are caused by infectious microorganisms in drinking water
- Most of the bacteria, viruses, and protozoa that cause waterborne diseases affect the digestive system and thus propagate themselves via sewage
- Wastewater disinfection provides part of a multi-barrier to prevent disease spread in drinking water
- Wastewater disinfection is the only barrier to disease spread from direct contact activities like swimming

Common Waterborne Diseases

Disease	Organism	Organism Source	Symptom
Gastroenteritis	Salmonella (bacteria)	Animal/human Feces	Acute diarrhea and vomiting
Typhoid	Salmonella typhosa (bacteria)	Human Feces	Inflamed intestine, high temperature – **fatal**
Dysentery	Shigella (bacteria)	Human Feces	Diarrhea
Cholera	Vibrio comma (bacteria)	Human Feces	Severe diarrhea and vomiting – **fatal**
Infectious hepatitis	Virus	Human Feces	Yellowed skin, enlarged liver
Amoebic dysentery	Entamoeba histolytica (protozoa)	Human Feces	Diarrhea
Giardiasis	Giardia lamblia (protozoan)	Animal/human Feces	Diarrhea
Cryptosporidiosis	Cryptosporidium (protozoa)	Animal/human Feces	Acute diarrhea and vomiting

Coliform Bacteria

- MPN of coliform bacteria are estimated to indicate the presence of bacteria originating from the intestines of warm blooded animals
- Coliform bacteria are generally considered harmless
  - But their presence may indicate the presence of pathogenic organisms

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Coliform Bacteria

- Comprises all the aerobic and facultative anaerobic gram negative, nonspore-forming, rod-shaped bacteria that ferment lactose within 48 hours at 35 °C
- Coliform bacteria can be split into fecal and nonfecal groups
- The fecal group can grow at higher temperatures (44.5 °C) than the non-fecal coliforms

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Coliform Indicator Organisms

Total coliform	Some from fecal sources
Fecal coliform	**Subset of total coliform** **Human and non-human fecal sources**
Escherichia coli (E. coli)	Subset of fecal coliform Likely human source in wastewater
Enterococci	Human-specific strains of fecal streptococci, survive in marine waters

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Disinfection

- Often, disinfection is the most critical step in protecting consumers against pathogenic microorganisms
- Pathogens are killed (or "inactivated") by reaction with various chemical oxidants
- Commonly-used disinfectants:
  - **"Free" chlorine** – Applied as $Cl_{2(g)}$ or NaOCl: HOCl is the active disinfectant in either case
  - **Chloramines, or "Combined" chlorine** – Applied either as pre-formed NH_2Cl, or by mixing NH_3 and HOCl
  - **Ultraviolet light** – Applied via submerged UV lamps

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Types of Disinfection Systems

- Chemical agents
  - Chlorine chemicals:
    - ✓ Gas (Chlorine {Cl_2 – 100% Cl})
    - ✓ **Liquid (Sodium Hypochlorite {NaOCl – 12.5% Cl})**
    - ✓ **Solid (Calcium Hypochlorite {$Ca(OCl)_2$ – 65% Cl})**
    - ✓ Chlorine dioxide {ClO_2}
    - ✓ Chloramines
  - Ozone {O_3}
  - Peracetic Acid – PAA (CH_3CO_3H)
- Physical agents
  - UV radiation
  - Heat (Pasteurization)
  - Membrane Filtration

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Why is chlorine gas usage declining?

- Risk Management Program
  - Focus on operator training and maintenance
  - Minimize the risk of accidental release
    - ✓Operator safety
    - ✓Public safety
- Process Safety Management

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Chlorination Chemistry

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Factors Affecting Chlorination

- Type and concentration of target organism
- Temperature
- pH
- Turbidity
- Interfering/inorganic substances
- Disinfectant species
- Concentration of disinfectant
- Contact time

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Reaction in Water

- Chlorine and hypochlorite compounds form hypochlorous acid:

$$Cl_2 + H_2O \Leftrightarrow HOCl + Cl^- + H^+$$

$$NaOCl + H_2O \Leftrightarrow HOCl + Na^+ + OH^-$$

- HOCl is in equilibrium with hypochlorite (OCl):

$$HOCl \leftrightarrow H^+ + OCl^-$$

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Reaction in Water

- The reaction is almost instantaneous
- The reaction is dependent on temperature and pH
- The reaction is reversible
- Hypochlorous Acid is a more effective disinfectant than hypochlorite ion
- Together they are free chlorine residual

$$HOCl \leftrightarrow H^+ + OCl^-$$

Free Chlorine

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Hypochlorous Acid and Hypochlorite

$NaOCl + H_2O \Leftrightarrow HOCl + NaOH$

$Ca(OCl_2) + H_2O \Leftrightarrow HOCl + Ca(OH)_2$

Hypochlorous acid, HOCL !

$HOCl \; \text{->} \; H^+ + OCl^-$

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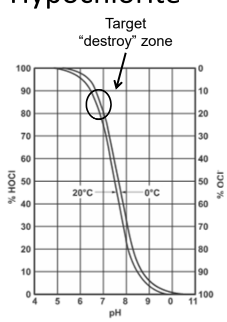
pH

Hypochlorite tend to increase pH

Which form destroys bacteria best?



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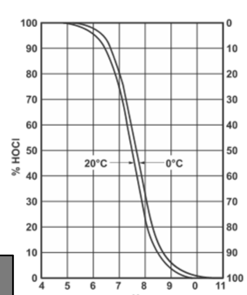
Hypochlorous Acid and Hypochlorite

- More HOCl at pH's below 7.5
- HOCl disinfects best
- At higher pH's, chlorine doses and contact times must increase

Hypochlorous Acid is much better at disinfection than hypochlorite. pH should kept below 8.5 to remain as hypochlorous acid



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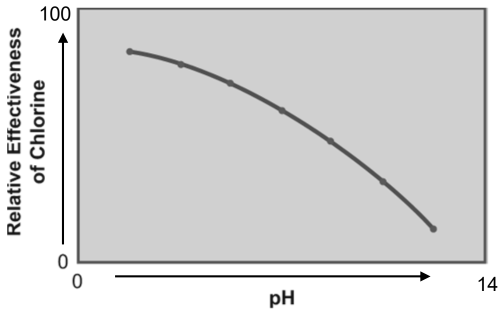
pH and Chlorine Effectiveness



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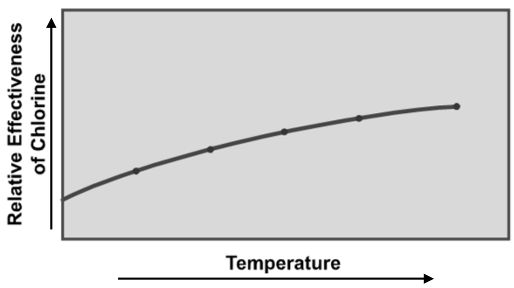
Temperature and Chlorine Effectiveness



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- As pH increases, what happens to the effectiveness of chlorine?
- As temperature increases what happens to the effectiveness of chlorine?

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Cl_2 Dose, Demand, and Residual

- **Dose:** **Total amount delivered**
- **Demand:** **What's consumed by constituents in the water**
- **Residual:** **What's left over**

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Residual Chlorine

- Total Residual = Free + Combined
  - Free chlorine = HOCl + OCl^-
  - Combined Residual = HOCl + ammonia

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A residual in the form of ________________ ________________ residual chlorine has the highest disinfecting ability.

A. Combined available
B. Total available
C. Minimum available
D. Free available

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Chlorine Demand - Inorganic

		Cl_2 Demand per part
Hydrogen Sulfide	H_2S	8.34 mg/L
Nitrite	NO_2^--N	5.1 mg/L
Manganese	Mn^{+2}	1.3 mg/L
Iron	Fe^{+2}	0.64 mg/L

Source: White's Handbook, 2010

Cl_2 Dose, Demand, and Residual

DOSE = demand + residual

Demand = DOSE - Residual

Residual = DOSE - Demand

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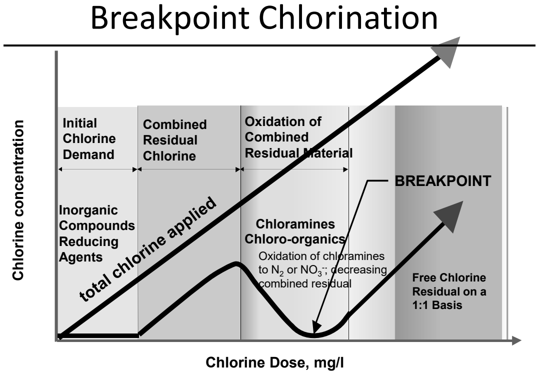
Breakpoint Chlorination



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Chlorine Demand

- In un-nitrified effluents, most chlorine will be combined and disinfection will be by chloramines
- "Combined" = Chlorine + Ammonia
  - Monochloramine

    $HOCl + NH_3 \Leftrightarrow NH_2Cl + H_2O$
  - Dichloramine

    $NH_2Cl + HOCl \Leftrightarrow NHCl_2 + H_2O$
  - Trichloramine

    $NHCl_2 + HOCl \Leftrightarrow NCl_3 + H_2O$

Total Chlorine Residual– Tastes and Odors

Compound	Threshold of Odor
Free HOCl	20 mg/l
Monochloramine	5.0 mg/l
Dichloramine	0.8 mg/l
Nitrogen Trichloride	0.02 mg/l

Chloramines

- Not effective for *Cryptosporidium* inactivation
- Used to provide a residual in the distribution system
- Persistent residual & Higher concentration
- "Halts" the formation of THMs or HAAs
- May control biofilms/regrowth better than free Cl_2
- Relatively inexpensive

At breakpoint, further addition of chlorine will result in a:

A. Free chlorine residual that is indirectly proportional to the amount of chlorine added beyond the breakpoint.
B. Free chlorine residual that is directly proportional to the amount of chlorine added beyond the breakpoint.
C. Free chlorine residual that is disproportional to the amount of chlorine added beyond the breakpoint.
D. Total chlorine residual that is indirectly proportional to the amount of chlorine added beyond the breakpoint.

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Total Residual Monitoring

- The US EPA Standard Method 4500-Cl outlines different methods to detect residual chlorine, including:
  - Iodometric Method
  - Amperometric Titration Method
  - Low-Level Amperometric Titration Method
  - DPD Colorimetric Method
  - Syringaldazine (FACTS) Method
  - Iodometric Electrode Technique
- Detection limits are as low as 0.010 mg/L (or 10 g/L (ppb), depending on the sophistication of the equipment.

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"CT" Values

- Disinfection proportional to "C x T"
  - **C = concentration of disinfectant, mg/l**
  - **T = contact time, minutes**
- CT = Cl_2, mg/l x t, minutes
- CT values specific to:
  - Disinfectant
  - Target organism
  - Reduction requirements

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Chlorination

With Sodium Hypochorite

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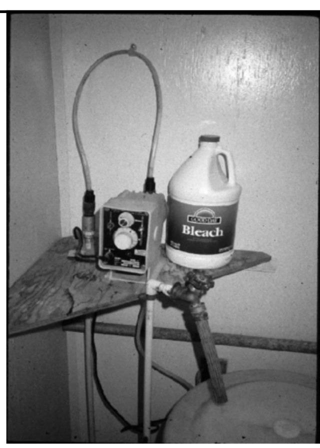
Hypochlorite Compounds

NaOCl
Bleach,
10 - 15% Cl_2

$Ca(OCl)_2$
HTH,
65 - 70% Cl_2



Consist of:
- Solution Tank
- Rotometer (flow control)
- Tube for Tablets

Operation depends on:
- o Rate of flow
- o Water temperature
- o Quantity of tablets

Production of Hypochlorite

- Bulk Sodium Hypochlorite Production
  - Chlorine and Caustic
    $Cl_2 + 2NaOH \rightarrow NaOCl + NaCl + H_2O + Heat$
  - Electrolytic Formation
    $NaCl + H_2O + 2e^- \rightarrow NaOCl + H_2$
- Bulk Calcium Hypochlorite

Lime or Calcium Chloride + $Cl_2 \rightarrow Ca(OCl)_2$

Chlorination with Hypochlorite

- Usually in the form of liquid NaOCl
- Sometimes, in solid form - $Ca(OCl)_2$
- NaOCL degrades over time
- Higher cost than gaseous chlorine

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Properties of Sodium Hypochlorite

- Mildly Corrosive with chlorine odor
- Has Free Sodium Hydroxide (Caustic Soda)
- pH= 9 to 12 range
- Pale Yellow Solution, 12.5% to 15% By Volume
- Specific Gravity ~ 1.19
- Non-Flammable
- Incompatible with many other chemicals
- **Relatively Short Shelf Life** - Concentration, heat, and sunlight (UV) cause decomposition

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Hypochlorite should be kept separate from:

A. Nothing
B. Organic material
C. Water
D. All other chemicals

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Properties of Sodium Hypochlorite

- Sodium Hypochlorite used in water and wastewater treatment is typically delivered in 12.0% trade concentrations
- Common household bleach concentration is typically about 5.25% trade; not greater than 8%
- Off-gassing occurs with sodium hypochlorite due to decomposition of the chemical
  - Chlorine and oxygen are the most prevalent gases to consider when designing piping
  - Hypochlorite trapped between two closed valves can build pressure until the pipe fails

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Properties of Calcium Hypochlorite

- Granular white powder or solid cake
- Solution is strongly alkaline and corrosive
- Strong chlorine odor
- Soluble in either warm or cold water
- pH= ~ 11.5 with 5% solution
- HTH 65 – 70% available chlorine
- Specific Gravity ~ 2.35
- Incompatible with many other chemicals
- Can burn and explode if temperature above 350 F
- **Relatively Long Shelf Life** - If kept covered and out of heat, and sunlight lose 3-5% / yr.

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Calcium hypochlorite will lose _____________of available chlorine per year.

A. 1-2%
B. 3-5%
C. 7-8%
D. 10-12%

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Sodium Hypochlorite Concentration

Trade %	Freezing Point, ºF	pH
0.8	32	Maintain between 12 and 13 w/ excess caustic
5	22	
10	7	
15	-8	

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Sodium Hypochlorite Concentration

Trade % (available chlorine)	Specific Gravity (@ 10 gpl excess NaOH)	Weight % (available chlorine)	Available Chlorine, lb/gal
0.8	1.017	0.79	0.067
5	1.076	4.65	0.417
10	1.146	8.76	0.834
15	1.205	12.44	1.25

To find available chlorine in lb/gal, multiply trade % by 0.08345.

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Delivery to End-User

- Bulk Delivery in 5,000-gallon tanker truck
- “Poured” from Small Delivery 26’ Flat-Bed Truck w/installed HDLPE totes or tanks
- 300-gallon totes (forklift)
- 55 gallon drums
- 15, 30 gallon totes
- 5 & 2.5 gallon “jugs”

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NaOCL Degradation/Decomposition

- Hypochlorite decomposes to:
  - Salt (NaCl), Chlorates (ClO_3^-), and Oxygen (O_2)
  - $3NaOCl \rightarrow 2NaCl + NaClO_3$ (Sodium Chlorate)
  - $2NaOCl \rightarrow 2NaCl + O_2$ (Gassing)
- Factors:
  - Temperature (Heat)
  - UV (e.g., Sunlight)
  - Impurities (Primarily Heavy Metals)
  - Concentration (Strength of solution)

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Sodium Hypochlorite Degradation

- Hypochlorite has a relatively short shelf life
- The concentration of the hypochlorite will degrade over time
  - Degradation results in chlorate ion formation and out-gassing of oxygen
- The rate of degradation is a function of impurities, heat, UV (i.e., sunlight) and hypochlorite concentration

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Stability of Sodium Hypochlorite

Decomposition of Hypochlorite

- Loss of Product Concentration
  - Wasted money
  - Feed equipment no longer sized correctly
- Production of chlorate and perchlorate
  - SDWA regulated disinfection by-product

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NaOCL Degradation/Decomposition

- Time of Manufacture - 12.5 Trade Percent
- Average Manufacturer @ 80 Degrees
  - 2 Days Later – 12.34 Trade Percent
  - 7 Days Later – 11.96 Trade Percent
  - 14 Days Later – 11.47 Trade Percent
  - 21 Days Later – 11.01 Trade Percent
  - 28 Days Later – 10.59 Trade Percent
  - 35 Days Later – 10.21 Trade Percent

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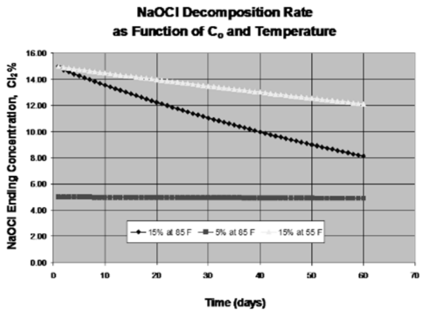
NaOCL Degradation/Decomposition



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Bulk Hypochlorite System Design

- Sodium hypochlorite solution is usually delivered at 12 to15% trade
  - If 10% sodium hypochlorite is desired, 2,000 gallons of water should be added to the 4,000 gallons of 15% hypo.
  - If 5% sodium hypochlorite is desired, 8,000 gallons of water should be added to the 4,000 gallons of 15% hypo.

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The most stable solutions of sodium hypochlorite are:

A. Purchased solution of about 12% strength.
B. Solutions of about 10% strength stored at 77°F.
C. On-site generated solution of about 1% strength.
D. Sodium Hypochlorite has no stability issues and never deteriorates.

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Perchlorate

Common name	Stock name	Oxidation state	Formula
Hypochlorite	Chlorate(I)	**+1**	**ClO^-**
Chlorite	Chlorate(III)	+3	**ClO_2^-**
Chlorate	Chlorate(V)	**+5**	**ClO_3^-**
Perchlorate	**Chlorate(VII)**	+7	**ClO_4^-**

Perchlorate adversely affects human health by interfering with iodine uptake into the thyroid gland.

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Perchlorate
(EPA Notice - January 2012)

- EPA Will Regulate Perchlorate
  - EPA considering a Maximum Contaminant Level Goal
  - CA MCL = 6 µg/L; MA MCL = 2 µg/L; NV Action Level = 18 µg/L
  - EPA's Federal Register notification from 2010: MCL as low as 1 µg/L
- Sources of Perchlorate
  - Munitions
  - Rocket fuel
  - Industrial sites
  - Fireworks, flares
  - **Hypochlorite (Bleach) - Drinking water and wastewater treatment!!!**

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Hypochlorite Degradation Reduction Strategies

- If possible store indoors
- If possible air condition the storage room to maintain temperature at 65° Fahrenheit
- Reduce storage volume so that the average retention period is about 15 days

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Production of Sodium Hypochlorite

- Bulk Hypochlorite Production
  - Chlorine and Caustic

    $$Cl_2 + 2NaOH \rightarrow NaOCl + NaCl + H_2O + Heat$$

  - Electrolytic Formation

    $$NaCl + H_2O + 2e^- \rightarrow NaOCl + H_2$$

- Onsite Hypochlorite Generation

  $$NaCl + H_2O + 2e^- \rightarrow NaOCl + H_2$$

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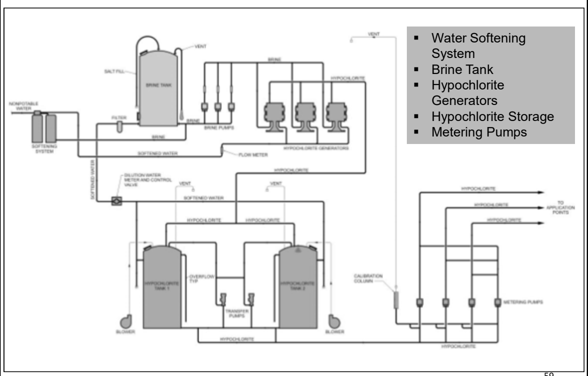
On-Site Hypochlorite- Simplified Schematic



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On-Site Hypochlorite Generation

- Growing interest in generating sodium hypochlorite on site
  - Produces a dilute solution (0.8%) that isn't prone to degradation, so loss of concentration and off-gassing aren't an issue
  - Produced on site from salt solution, so fluctuations in hypochlorite pricing are less of an issue
  - Equipment is more complex to operate and maintain than bulk hypo equipment

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On-Site Generation- Disadvantages

- By-product of process is hydrogen gas
- Salt used needs to be solar or food-grade-potential source of bromate
- High Capital Costs
- Energy usage
- Instrumentation

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Safety and Building Code Compliance

- Corrosive chemical at >12%, irritant at 5%
- Sprinkler system for indoor storage area for corrosive chemicals
- Secondary containment
  - Largest container plus sprinkler water for a period of 20 minutes
- Positive mechanical ventilation
- Tank overfill protection
- Check local building codes

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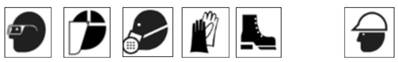
Chemical Information – Health Effects

- Inhalation:
  Respiratory irritant
- Skin Contact:
  Can cause burns to skin and eyes
- Eye Contact:
  Permanent loss of sight
- Ingestion:
  Convulsions and coma if ingested

PPE: 

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Chemical System Design

- Delivery
- Bulk Storage
- Chemical Feed Equipment
- Piping

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Bulk Delivery by Tanker Truck

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Fill Station Design

- Design the fill lines to make it nearly impossible for someone to accidentally fill the sodium hypochlorite tank with sodium bisulfite and kill themselves

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Bulk Delivery Site Should Have . . .

- 2” Supported Male Connection w/Cap
- Safety Shower/Eye Wash/Running Water
- Security/Lights
- Hook Up Protection / Labeled Lines
- Proper Venting for Blow Off
- “Catch Bucket”
- Accessible Roadway and Turn Around

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Fill Line

- Air Pressure – 15 to 25 psi
- Trucks Carry Up to 60’ Hose
- Long Length – Consider Upsizing to 3”
- Length Proportional to Offload Time
- Maximum Length – 200’
- Proper supports – 45 Degree Down
- Keep Line Vented

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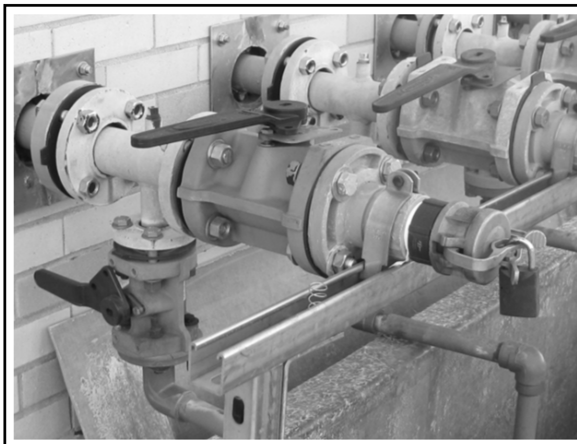

Chemical System Design

- Equipment
  - Bulk storage tanks – dilution, mixing and storage
  - Recirculation/transfer pumps – mixing and transfer to day tanks
  - Air mixing system
  - Day tanks – short-term storage
  - Metering pumps – transfer to application point
  - Instruments – tank level, pump flow measurement

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Bulk Hypochlorite System Design

- Sodium hypochlorite is delivered in 4,000-gallon tanker truck loads
- Bulk storage tanks should be sized to hold a full load of chemical plus dilution water required to dilute chemical to the desired concentration
- Because of the rapid degradation of sodium hypochlorite, tanks should be sized to hold no more than 30 day supply but preferably 15 to 20 days supply of chemical

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Bulk Hypochlorite System Design

- Day tanks should be sized according to the owner's preference.
  - Tanks sized to hold a day's supply of 5% sodium hypochlorite can be fairly large.
  - If a smaller day tank is desired, it can be sized to be refilled once per shift.

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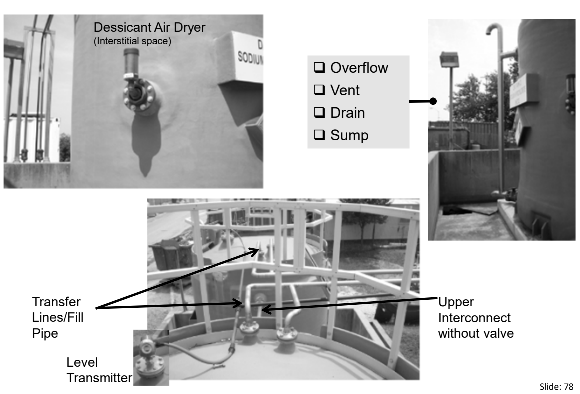
Sodium Hypochlorite Day Tanks



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Bulk Hypochlorite System Design

- Recirculation and Transfer Pumps
  - Recirculate contents of bulk tank and transfer to day tank in reasonable amount of time
- Air Mixing System
  - Designed based on capacity of bulk tank
- Metering Pumps
  - Cover full range of required NaOCl feed rates

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Bulk Hypochlorite Equipment Air Mixing System

- Air Mixing System
  - Pulses of air are released beneath a round accumulator plate fastened to bottom of tank
  - Bubbles rise toward surface of tank, creating mixing action
  - No moving parts

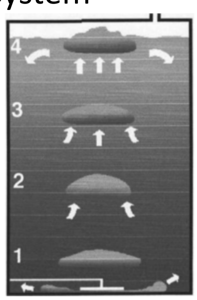

Photo courtesy of Pulsair.com

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Bulk Storage Tanks

- Bulk – Drum – Tote
- Storage of organic materials in separate room
- Spill Containment (110% of largest)
- 30 day storage
- Cool & Dry atmosphere
- Room Temperature 60 – 70º F
- Forced ventilation

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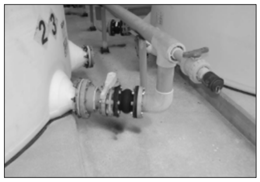
Flexible Connections

- Flexible connections are required, in the lower 1/3 of the HDPE tank wall, to increase tank longevity
- **The tank warranty is VOID if flexible connections are not used**



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Chemical Feed Equipment

- Eductors vs. Positive Displacement Pumps
- PD Pumps – Peristaltic vs. Diaphragm
- Pump Skids vs. Wall /Floor Mounting
- Height of Equipment – Suction Lift Issues
- Degasification Valves – When To Use
- Vapor Lock Issues – Bleed Valve or Vent
- Control Issues – Flow Meters / 4-20 ma
- 99% of Most Operational Problems Come from Over-sizing Pumps

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Bulk Hypochlorite Equipment - Pumps

- Recirculation and Transfer Pumps
  - Magnetic drive centrifugal pumps
    - ✓Plastic construction
    - ✓Titanium construction
    - ✓Teflon-lined
  - Centrifugal pumps with seal water
    - ✓Fiberglass pump body with titanium shaft and hardware
  - Viton o-rings and gaskets

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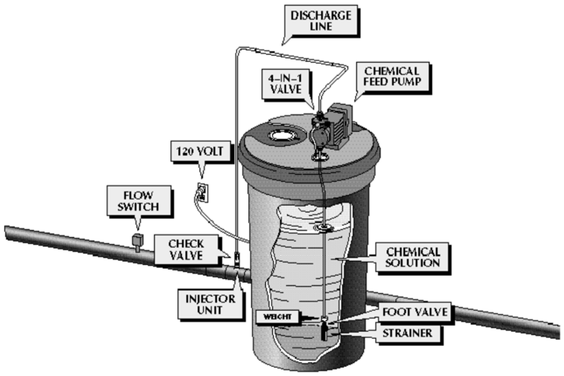
Liquid Chemical Feeder



Bulk Hypochlorite Equipment Metering Pumps

- **Mechanically-actuated diaphragm**
  - Elastomer-faced diaphragm
  - Common pump head materials – PVC, Kynar, stainless steel
- **Hydraulically-actuated diaphragm**
  - Flat and tube diaphragms available
  - Common pump head materials – PVC, Kynar, stainless steel, cast iron (for tube diaphragms)
- **Peristaltic**
  - Tube must be compatible with pumped chemical
- **Accessories include:**
  - Pressure relief valves, pulsation dampeners, backpressure valves

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Bulk Hypochlorite Equipment Metering Pumps

- Diaphragm Pumps
  - Mechanical or hydraulic diaphragm pumps
  - Solenoid pumps for low feed rates
  - Good range of capacities
  - Good turndown – stroke length and frequency can be adjusted
  - Heads can be equipped with degassing valves

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Bulk Hypochlorite Equipment Metering Pumps

- Diaphragm Pumps
  - Flat Diaphragm – Kynar or PVC pump head
  - Suction and Discharge Valve Assemblies – PVC, Kynar or Teflon
  - O-rings and gaskets – Viton
  - Exterior – Plastic or painted with protective epoxy coating

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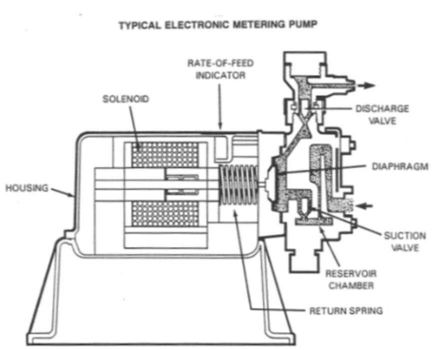

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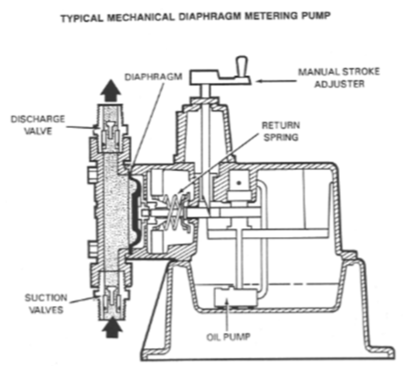

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Bulk Hypochlorite Equipment Metering Pumps

- Peristaltic Pumps
  - Great range of feed rates
  - Pump heads don't get air-locked from off-gassing
  - Turndown not as good as diaphragm pumps because only motor speed can be adjusted
  - Tube - Hypalon
  - Exterior – Plastic or painted with protective epoxy coating

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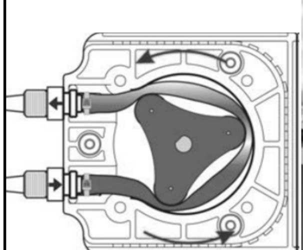
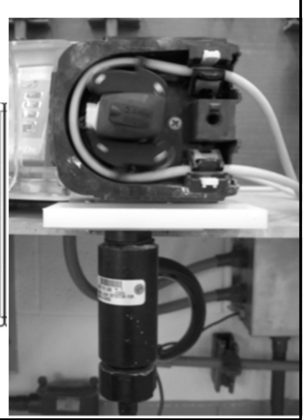
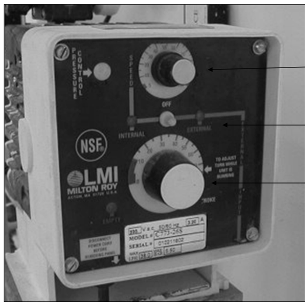
Hose Pump

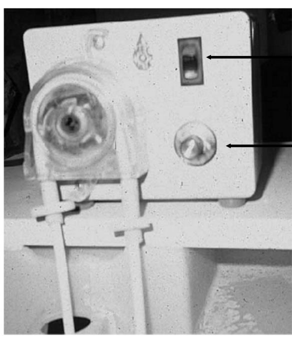




Diaphragm-Type Metering Pump



Perastaltic Pump



Chemical Injection Systems

4-log treatment systems must have redundancy
or backup equipment immediately available.

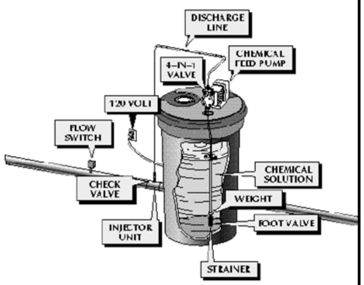
Hypochlorination Systems

<u>Sodium Hypochlorite</u>

- 5% - 15% Chlorine
- UN #1791

<u>Calcium Hypochlorite</u>

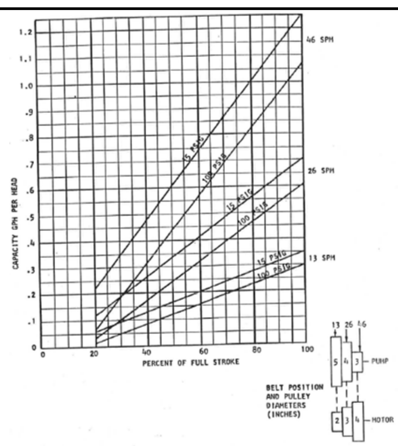
- 67% Chlorine
- Usually make up a 1% - 3% solution
- UN #1748
- DOT Hazard clarification 5.1

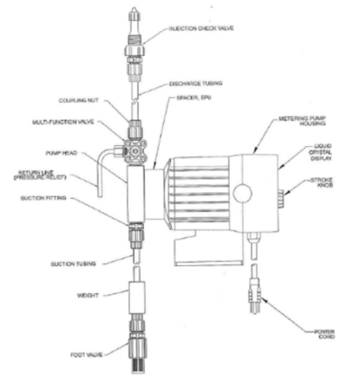


Bulk Hypochlorite Equipment Metering Pump Accessories

- Calibration chamber
- Pulsation dampener
- Pressure relief valve
- Backpressure valves
- Pressure gauges

98





Metering Pump Component Diagram

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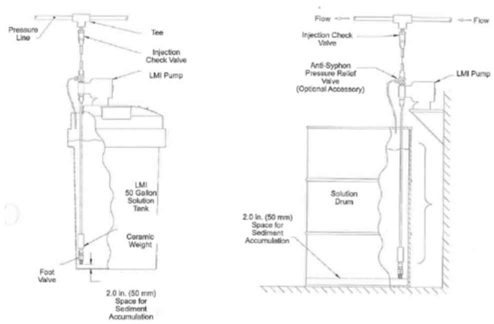

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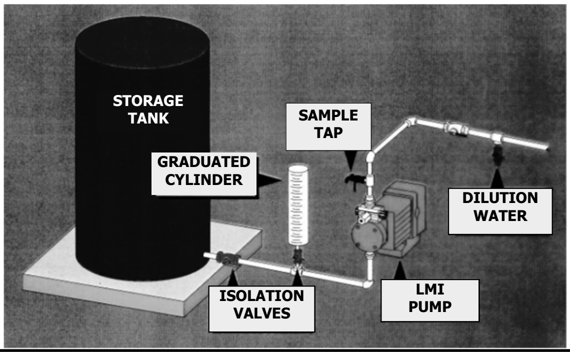
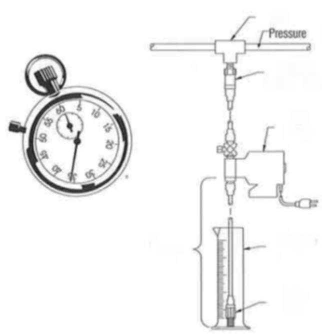
Chemical Injection Unit (CIU)

Liquid Chemical Feed System With Calibration Column



Metering Pump Calibration



1. Cut off auto control and use manual.
2. Set speed and stroke length
3. Cut off the pump
4. Fill the cylinder – record volume
5. Start pump
6. Run for several minutes
7. Observe and record end volume
8. Calculate flow rate
9. Retest at multiple speed and stroke settings

Metering Pump Calibration

20% Frequency - based on one minute samples

Stroke	Start level	Stop level	mL	mL/min
20%	1,000	993	16	16
40%	985	947	38	38
60%	920	860	60	60
80%	800	724	76	76

40% Frequency - based on one minute samples

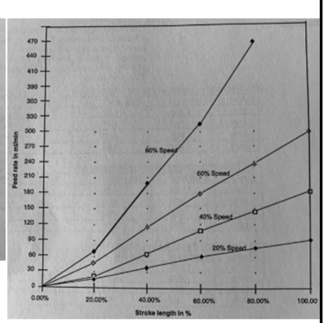
Stroke	Start level	Stop level	mL	mL/min
20%	1,000	978	22	22
40%	950	885	65	65
60%	850	742	108	108
80%	700	555	145	145.8

60% Frequency - based on two minute samples

Stroke	Start level	Stop level	mL	mL/min
20%	1,000	905	95	47.5
40%	875	645	230	115
60%	600	244	356	178
80%	1.0	9.8	475	237.5

90% Frequency - based on one minute samples

Stroke	Start level	Stop level	mL	mL/min
20%	1,000	967	33	33
40%	900	803	97	97
60%	775	617	158	158
80%	600	442	232	232



To develop a feed pump calibration curve, you need:

A. Pump feed rate
B. Pump Speed Setting
C. Only A
D. Both A and B

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Materials of Construction

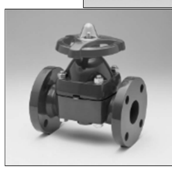
- Plastics
  - PVC
  - CPVC
  - PTFE (Teflon®)
  - PVDF (Kynar®)
  - HDPE

Materials of Construction

- Unsuitable Materials – Metals
  - Stainless Steel
  - Carbon Steel
  - Monel
  - Brass
  - Copper

Materials of Construction

- Suitable Valves
  - Valves in hypochlorite service will eventually leak
  - PVC/CPVC Vented Ball Valves
  - PVC/CPVC Diaphragm Valves



Materials of Construction

- Ball Valves
  - Service Life: 3 to 6 years
  - Ball valves have wetted stems that are sealed with o-rings
    - ✓It's likely that ball valves may begin to leak

Materials of Construction

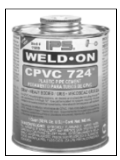
- Diaphragm Valves
  - Service Life: 3 to 6 years
  - The diaphragm seals the valve's bonnet compartment
    - ✓The stem of a diaphragm valve is neverexposed to the chemical

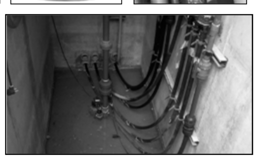
Multi Function Valve

Injection check valve

112

Piping





Piping to Chemical Feed Equipment

- Purpose – Minimize Off-Gassing
- Pipe Sizing – Optimize velocity
- Minimize Length – Maximum 50’
- Stack Vents/Sightglasses – Carry Off Gases
- Minimize Bends – Keep Gases in Solution
- Use of Flexible Piping/Tubing
- Eliminate “High Spots” – Piping Pitch
- Use of Strainers – “Catch” PVC shavings

Materials of Construction

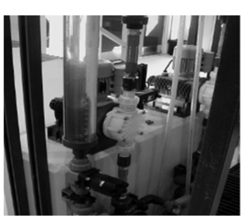
- Unsuitable Materials – Elastomers & Plastics
  - Plasticized PVC (e.g., clear PVC tubing)
  - Buna-N
  - Nitrile
  - Many resins used in FRP construction
  - Hypalon
  - Silicone
  - Ethylene Propylene Diene Monomer (EPDM)
  - Polypropylene

Materials of Construction

- Piping - PVC and CPVC **(recommended)**
  - PVC and CPVC has a tendency to become more brittle over time due to chemical attack (PVC & CPVC Service Life: 15+/- years)
  - CPVC can shatter like glass after it becomes brittle
  - Many chemical piping systems above ground are exposed to the sun (high temperatures). As temperature goes up the pressure capacity of the pipe decreases
  - **CPVC is generally recommended over PVC**

Materials of Construction

- Pipe Joints- they will leak- keep them accessible



Bulk Hypochlorite Equipment

- Safety Equipment
  - Local alarm horn and lights to signal high tank level, high level in containment area
  - Emergency shower and eyewash stations
  - Fire extinguishers
  - Hazard identification signs
  - Person protective equipment (PPE) – goggles, aprons, gloves

A system is switching from gas chlorine to sodium hypochlorite. They typically use about 37 pounds of gas chlorine. How many pounds of 12.5% sodium hypochlorite can the system expect to use each day?

119

In 24 hours, 4.2 gallons of 12% hypochlorite solution is fed. How much (in gallons) would you have to use if the concentration was 7%?

120

A free chlorine residual of 1.7 mg/L is measured at the end of the clearwell after 4 hours of detention time, what is the CT value in mg-min/L?

121

The chlorine demand of a water is 1.4 mg/L. If the desired chlorine residual is 0.5 mg/L, what is the desired chlorine dose, in mg/L?

122