Chlorination Technology

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Chlorination Technology
7 Contact Hours
9 CC 10 Hours

Chlorine is a widely used disinfectant which can be supplied in different many forms; including chlorine gas, hypochlorite solutions, and other chlorine compounds in solid or liquid from. As the utility industry seeks safer and more effective disinfectants, many treatment plants are now applying sodium hypochlorite. Operators will benefit from this one-day course designed to review the benefits and drawbacks of switching from gas chlorination to sodium hypochlorite. Topics will include principles of feeding gas chlorine and hypochlorite metering pumps as applied in the water/waste water industry. Preventative maintenance recommendations for both chlorine gas and liquid bleach feed systems will be included. The disinfection action of chlorine in water treatment is described in detail as well as the hazards associated with the safe handling and storage.

Learn Objectives:

1. List five disinfection technologies currently in use;
2. Describe the major physical and chemical characteristics of the various forms of disinfection chlorine; and
3. Demonstrate the safety procedures for storage and use of chlorine tanks

8:00 AM to 8:30 AM	Introduction Hand out materials
8:30 AM to 10:00 AM	Chemistry of Disinfection
10:00 AM to 12:00 AM	Chlorination and hypochlorite solutions
12:00 PM to 1:00 PM	LUNCH
1:00 PM to 2:30 PM	Development of Effective Control Schemes /Safety
2:30 PM to 3:30 PM	Principles of feeding gas chlorine and hypochlorite
3:30 PM to 4:00 PM	Final Exam

Chlorination Technology

MCET
ENVIRONMENTAL, HEALTH, AND SAFETY TRAINING

Disinfection !

The one process that we can't do without.

Gastroenteritis

Typhoid

Dysentery

Cholera

Hepatitis

Where does Chlorine come from ?

How is Chlorine made ?

Where else is Chlorine used ?

Let's take a look the video

Disinfection Methods

- Heat Treatment
  - Boiling water
  - Not possible on large scale, would be very expensive.
  - No residual to protect water
- Radiation Treatment
  - Uses UV light to inactivate organisms.
  - Expensive, high maintenance and operating costs
  - No residual to protect water

Is disinfection the same as sterilization ?

- To sterilize the water we would have to use much higher doses of chemicals.
  - Increased costs $$
  - Boiling water does kill bacteria
- We want to kill disease causing organisms.
  - Fecal coliform – indicator organism

How do we know the disinfection process is working?

- Coliform testing
  - State and Federal law requires testing.
  - Number of tests is based of population served.
- Federal Surface Water Treatment Rule
  - Requires all surface water to use a “treatment technique” to remove or inactivate disease causing organisms.

Chemical Treatments

- Bromine – as effective as Chlorine, have to use 2 – 3 x as much.
- Iodine – long term consumption may have health affects. Can be used in emergencies.
- Ozone – strong oxidant, costs, no residual
- Chlorine Dioxide – strong oxidant, costs, by-products ?
- Chloramines* – weak disinfectant, history of use, not costly

Benefits of using Chlorine include:

- Strong oxidizer
- Very cost effective
- Simple feeding
- Availability
- Long history of its use as a water disinfectant

What are the drawbacks to using to Chlorine ?

- Formation of Chlorinated by-products (THM's)
- Can be dangerous to handle
- Becoming more regulated
- Taste and odor problems possible

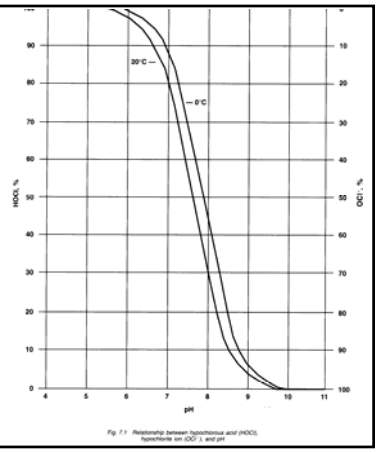
Chlorine Chemicals

- Chlorine, Cl_2 100%
  Gas compressed to liquid
- Calcium Hypochlorite, $Ca(OCl)_2$ 65%
  HTH used in swimming pools
- Sodium Hypochlorite, NaOCl 12% -15%
  Household bleach, 1% – 5 %

Chlorination Chemistry

- Cl_2 + H_2O -> HOCl + HCl
- Which one is the bacteria killer ?
  hypochlorous acid = HOCL "Killer"
- HOCl -> H+ + OCl-
  0……7……14
  pH
- How does pH effect the disinfection process ?

As pH goes up the amount of HOCl drops off.



Chlorination Chemistry

- As pH goes up, HOCl tends to break apart and weakens the disinfection action.
- Other factors important in the disinfection process include :
  - Concentration of Chlorine
  - Contact time
  - Temperature of water
  - pH of the water
  - Substances in the water, organic or inorganic

Chlorination Chemistry

- Concentration of Chlorine vs. Contact Time
  - C / T
- Temperature :
  - Cold water - disinfection process slows down.
  - Warmer water – disinfection is faster, but chlorine will not stay in water as long.
- Organic & Inorganic matter

Chlorination Chemistry

- Organic – Living or once living matter
  - Leaves, decaying living matter
- Chlorine combines with organic matter
- Inorganic – Non-living matter
  - Silt, clay, minerals
- Chlorine readily reacts with some minerals
  - Fe^{+2} (ferrous) -> Fe^{+3} (ferric)
  - Mn^{+2} -> Mn^{+3}

Chlorination Chemistry

- Chlorine combines with and readily reacts with organic matter
- Combines with ammonia to form chloramines
  - NH_2Cl Monochloramine
  - $NHCl_2$ Dichloramine
  - NCl_3 Trichloramine

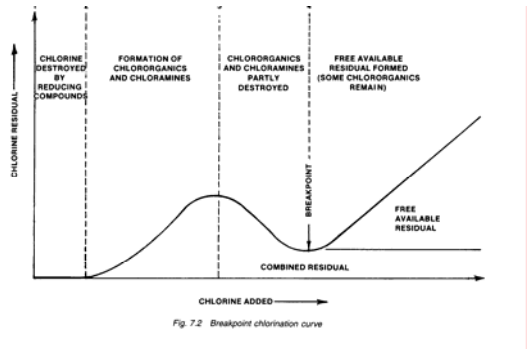


Fig. 7.2 Breakpoint chlorination curve

[12] *Breakpoint Chlorination.* Addition of chlorine to water until the chlorine demand has been satisfied. At this point, further additions of chlorine will result in a free chlorine residual that is directly proportional to the amount of chlorine added beyond the breakpoint.
[13] *Free Available Residual Chlorine.* That portion of the total available residual chlorine composed of dissolved chlorine gas (Cl_2), hypochlorous acid (HOCl), and/or hypochlorite ion (OCl^-) remaining in water after chlorination. This does not include chlorine that has combined with ammonia, nitrogen, or other compounds.
[14] *Chlororganic* (klor-or-GAN-ick). Organic compounds combined with chlorine. These compounds generally originate from, or are associated with, life processes such as those of algae in water.
[15] *Chloramines* (KLOR-uh-means). Compounds formed by the reaction of hypochlorous acid (or aqueous chlorine) with ammonia.

Important Terms

Dosage – the amount of chlorine added mg/l or ppm

Demand – the amount of chlorine required to react with the organic and inorganic substances.

Residual - Dose (-) Demand = Residual

The amount remaining after contact time.

Free Residual – Exists as Hypochlorous acid or hypochlorite

Combined Residual – Chlorine which has combined with ammonia to form Chloramines.

Total Residual – Is the sum of free and combined residual

Sodium Hypochlorite NaOCl

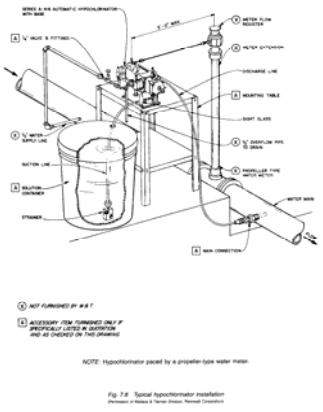
- Household Bleach 1% - 5%
- Commercial Bleach 12% - 15%
- 15% = 1.25 lbs. Cl_2 per gallon
- Yellowish in appearance
- pH 10 – 12
- In storage, strength may drop 30 – 60 days
- Temperature > 85 degrees, weakens faster
- Sunlight also has an effect

Feeding Hypochlorite

May be paced to flow.

Safety Precautions:

Wear eye protection and gloves.



Calcium Hypochlorite $Ca(OCl_2)$ HTH

HTH – 65 % available chlorine

White granular powder

Used in swimming pools

Very reactive with hydrocarbons oils & paints

Shelf life 60 – 90 days , if left open to high humidity loses strength faster.

Chlorine Characteristics

liquefied gas under pressure – 100 % available chlorine Greenish –yellow Gas / 2.5 X's heavier than air

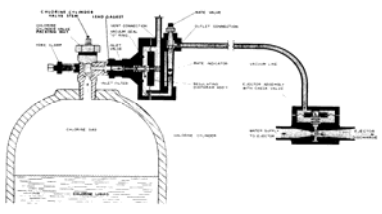
Amber colored liquid / 1.5 X's heavier than water

- Boils @ -30 F / freezes @ -150 F atmospheric pressure
- *1 volume liquid = 460 volumes of gas
- Vapor pressure varies with the temperature
- Moisture & Chlorine = corrosive acids
- Very reactive with most elements especially with moisture present

More.. Chlorine Characteristics

- Respiratory, skin eye and mucous membrane irritant.
- Non – Flammable / Non Explosive : will support combustion.
- Slightly soluble in water
- Steel burns @ 483 F in the presence of chlorine.
- Reacts with some organic compounds with explosive violence.

Simple vacuum controlled chlorinator



How many Cl_2 pressure connections do you see ?

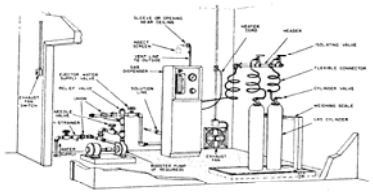


Fig. 7.12 Typical gas dispenser installation

NOTE: If chlorine gas is pulled through exhaust fan as shown, chlorine could corrode the wiring and the fan could fail when needed. A better design is to install the fan elsewhere and use "forced-air" ventilation which will push any chlorine gas out floor vents.

Typical 150 lb. chlorine set-up

Vacuum chlorinator with additional features

Designed for larger capacity feed rate.

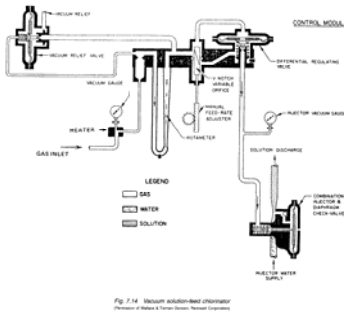


Fig. 7.14 Vacuum solution-feed chlorinator

Ton container with cylinder mount chlorinator.

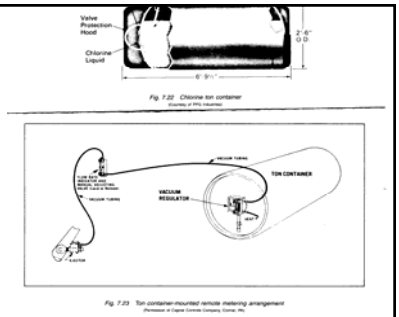
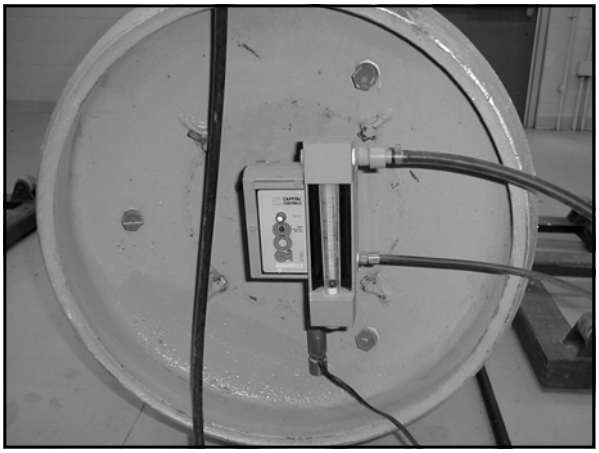


Fig. 7.22 Chlorine ton container

Fig. 7.23 Ton container-mounted remote metering arrangement



Handling Chlorine Safely

Always treat it with respect.

Never work alone when changing cylinders.

Check for leaks using ammonia fumes.

Use only new lead washers when changing cylinders.

Cylinder valves are a common area for leaks.

Fusible plugs melt at 158 – 165 degrees F

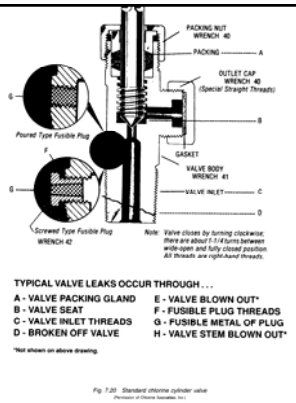
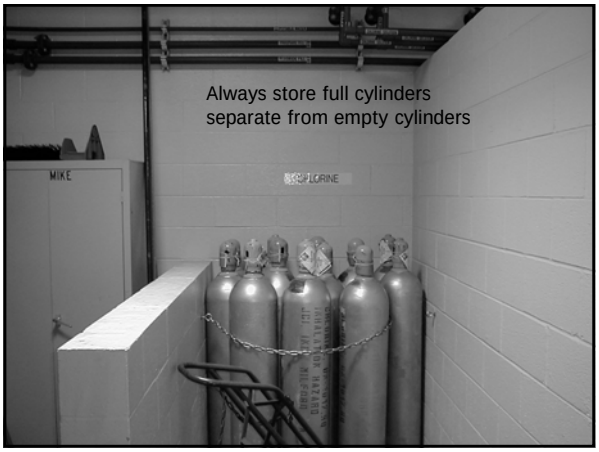


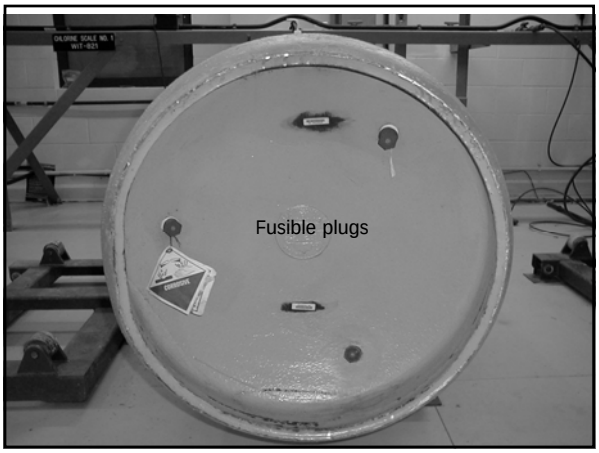
Fig. 7.20 Standard chlorine cylinder valve

Cylinder & Ton Containers

Do not :

- Store near heat systems or in direct sunlight
- Store below sub-surface areas
- Drop or store where heavy objects may fall
- Store empty & full cylinders together
- Store or move without hoods in place

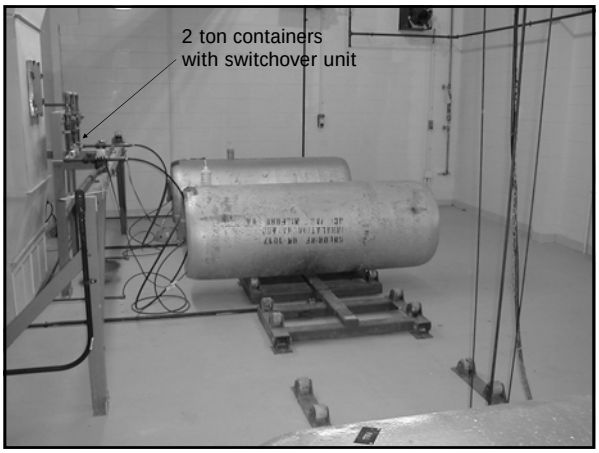


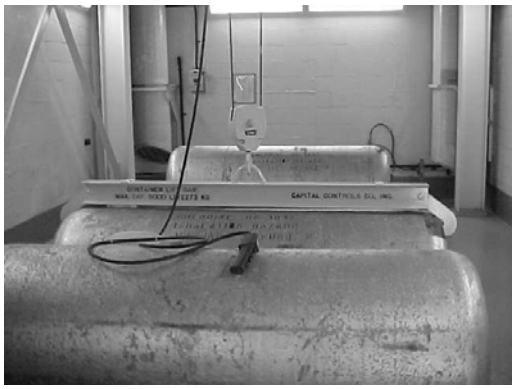


Sprinkler System in Chlorine Room ?

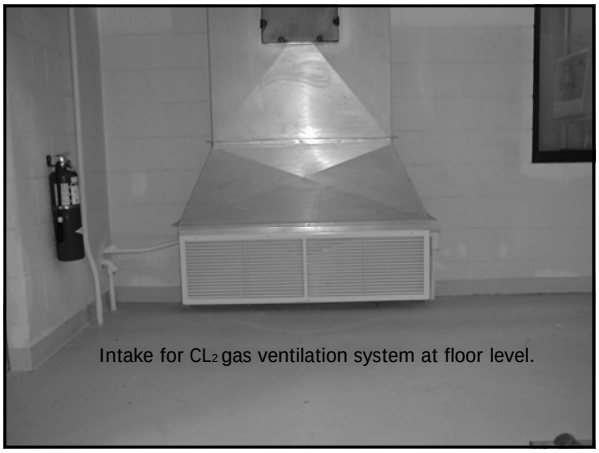
Chlorine gas detector

Chlorine gas sensor





Any overhead hoists/cranes ? Must be inspected monthly.



Intake for CL_2 gas ventilation system at floor level.

Chlorine Gas Scrubber System


Self-Contained
Breathing Apparatus

Chlorine
Dioxide
System

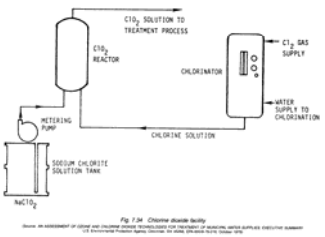
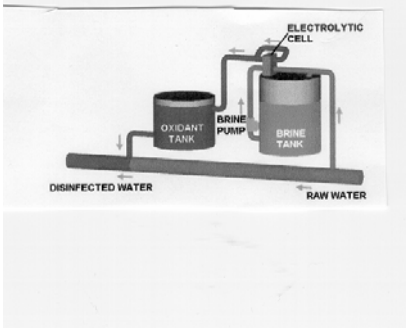
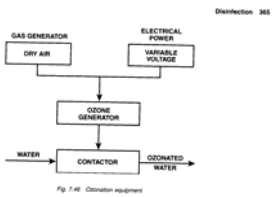


Fig. 7.34 Chlorine dioxide facility

Sodium Hydroxide produced on site



Ozone Generator



Dechlorination

Sulfur Dioxide – Colorless gas with strong odor 2.3 x heavier than air.

Liquid 1.5 x heavier than water

Vapor psi varies with temperature

Non- Flammable

Approximately 1.0 mg/l dose SO_2 required per mg/l of chlorine residual.

Let's do some chlorine calculations

Lbs./24hr. = Dose mg/l x Flow mgd x 8.34

$$\frac{\text{Lbs./24hr.}}{\text{Flow mgd} \times 8.34} = \text{Dose mg/l}$$

Any Questions ?