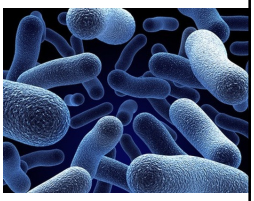
Disinfection

Pre-certification Training

Pathogenic

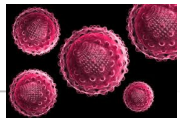
- **Disease causing organisms**
- **Includes viruses, cysts, or bacteria**
- **Causes diseases such as typhoid, cholera and dysentery**
- **Organisms that don't cause disease are non-pathogenic**
- **Process to kill is called disinfection**



Bacteria

Organism	Disease	Primary Source
Shigella	Bacillary disentary	Human Feces
Salmonella	Salmonellosis	Human/animal Feces
E. Coli	Gastroenteritis	Human Feces
Vibro Cholerae	Cholera	Human Feces

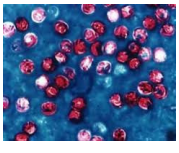
Viruses



Organism	Disease	Primary Source
Hepatitus A	Infectious Hepatitis	Human Feces
Coxsackievirus A&B	Aseptic meningitis	Human Feces
Rotavirus	Gastroenteritis	Human Feces
Adenoviruses	Upper respiratory & Gastrointestianilln	Human Feces

Protozoans

Organism	Disease	Primary Source
Giardia lamblia	Giardiasis	Human/animal Feces
Cryptosporidium	Cryptosporidiosis	Human/animal Feces
Entamoeba histolytica	Aomebic dysentary	Human/animal Feces

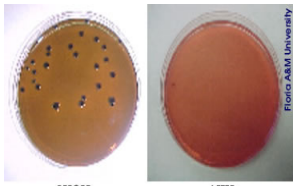


Methods of Detection

- Membrane Filter Test
- Multiple-tube Fermentation Test
- Colilert, P/A

Disinfection

- Process to kill or inactivate most microorganisms in water.
- There are several ways to disinfect
- Chlorine is most popular method because of cost and it leaves a residual throughout the system
- Other methods include UV and ozone



BEFORE
UV Light Exposure

AFTER
UV Light Exposure

Methods of Disinfection

- Heat; boiling
- Radiation; UV light
- Chemical
  - *Bromine
  - *Ozone
  - *Chlorine Dioxide
  - *Chloramination
  - *Iodine

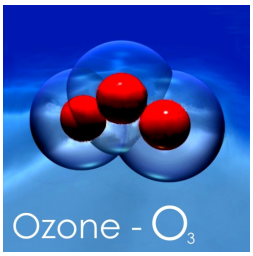
Oxidizing Reagent	Oxidizing Potential
Ozone	**2.00**
Permanganate	**1.67**
Hypobromous acid	**1.59**
Chlorine dioxide	**1.50**
Hypochlorus acid	**1.49**
Chlorine	**1.36**
Oxygen	**1.23**
Bromine	**1.09**
Hypochlorite	**0.94**

What is OZONE?

- Ozone is a natural component of the earth's upper atmosphere, where it is primarily formed photo chemically.
- Ozone doesn't leave a lasting residual

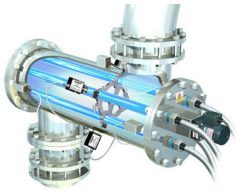
Ozone

- Ozone or trioxygen molecule contains three oxygen atoms, having the chemical symbol O3.
- Ozone is nothing more than another molecular form of oxygen, the chemical symbol for oxygen is O2.



UV

- **Is the only method of disinfection that does not alter the pH, taste, or affect the chemical composition of water.**
- **Operates best when Suspended Solids is <10 – 15 mg/L & Turbidity is <5 – 10 NTU.**



Gas Chlorine Properties

- Heavier than air
- Used primarily for disinfection
- Boiling Point -34 C , -29 F
- Liquid form expands 460 times
- Lowers pH of the water

Testing and Safety

- When changing cylinders, shut gas off at cylinder first, evacuate lines
- DPD kit to test residual, should take samples from several locations, reagent turns chlorinated water pink
- SCBA should be stored away from chlorine building

Three Types of Chlorine

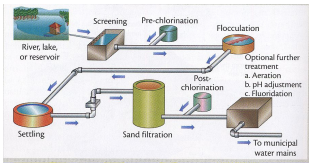
- **Calcium Hypochlorite or HTH (High Test Hypochlorite) Dry Powder 65%**
- **Sodium Hypochlorite is Liquid:**
  ***Bleach 5%**
  ***T-Chlor 15%**
- **GAS 99.9% considered 100% for calculations**
  ***extremely corrosive with water/humidity**
  ***compressible**
  ***changes to liquid at 82 psi**
  ***68 deg. F**
  ***2.5 times heavier than air**
  ***greenish-yellow color**
  *** Must meet NSF approval**

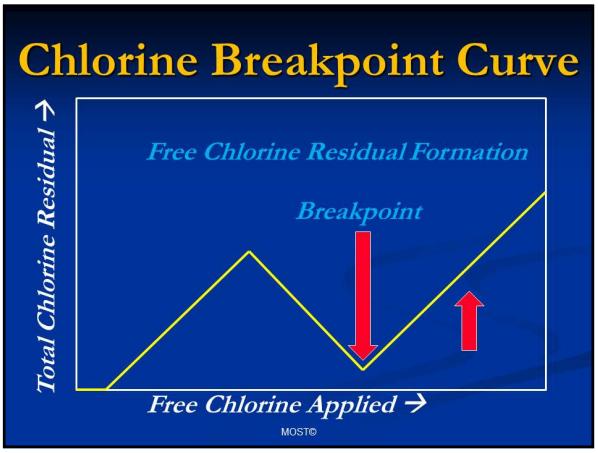
Chlorine Terms

- **Free Chlorine-** chlorine remaining in water after chlorination
- **Total Chlorine-** sum of combined residual chlorine & free available chlorine
- **Demand-** difference between the chlorine added and the chlorine remaining

Chlorine Processes

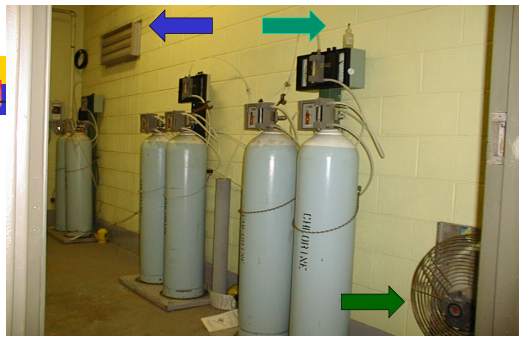
- Pre-chlorination- injected prior to treatment
- Post-chlorination- injected after treatment
- Breakpoint chlorination- amount of chlorine added to the water until the demand is satisfied.





Chlorinators

- Gas- Dry or Direct Feed (uses pressure from cylinder)
  *Solution feed
  -gas mixed w/H2O under pressure
  -vacuum feed the water pulls Cl2
- Hypochlorinators - Dry or Liquid Uses
  -Systems with Low flows
  -Emergencies
  -Intermittent- seasonal (winter use)
  -Clean deposits on pump parts with an acid solution



Note air intake at top, exhaust fan at bottom, ammonia bottle for checking leaks (vapors look like white smoke).

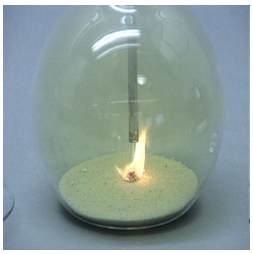
Cylinders chained down, wrench on shutoff, exhaust fan near the floor.

Chlorine Scales

Typical Hypochlorinator

Safety Hazards

- When chlorine comes in contact with petroleum or other combustibles, the reaction can cause a fire
- When mixed with hydrogen sulfide it reacts to cause sulfuric acid



Chloramines

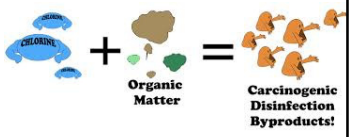
- Formation of chloramines is a chemical reaction
- The reaction is between **hypochlorous acid (or aqueous chlorine)** with **ammonia**.
- Formation of chloramines **weakens** the disinfecting strength of chlorine

Chloramination

- Cloramines are a reaction between applied chlorine and ammonia
- When done intentionally it can reduce tastes and odors
- Chloramines are a weaker disinfection than chlorine

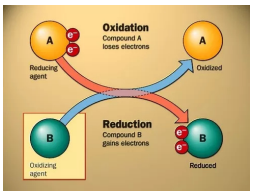
Disinfection By-products

- TTHM- Total Trihalomethanes
- Combination of free chlorine and organics
- Warmer temperatures and pH form THM's faster



Reducing Agents

- Readily give up electrons
- Opposite of oxidizing agents
- React with chlorine
- Cause a demand on chlorine
- Ferrous, Nitrite & Hydrogen Sulfide ions are examples
- Suspended Solids
- Chlorine reacts with hydrogen sulfide to form sulfuric acid

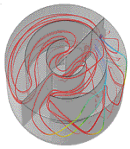


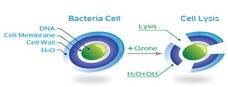
5 Principles of Chlorine Disinfection

- Concentration
- Contact time
- Temperature of the water
- pH of the water
- Foreign substances in the water

Concentration & Contact Time

- If chlorine concentration is decreased then the contact time must be increased
- Longer detention times would have higher bacteria kill rates
- A minimum of 0.2 mg/L leaving the chlorination station and a measurable residual should be maintained at the extremities of the distribution system
- Chlorine penetrates the cell wall





Dt = volume (in gallons) / flow rate (in gallons/time)

Temperature

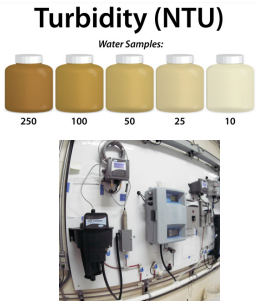
- **Low temperatures the bacteria kill rate is lower**
- **Chlorine residual will remain longer in cold water**
- **Chlorine dosages should be adjusted with changes in water temperatures**
- **Higher temperatures cause faster rates of THM formation**

pH

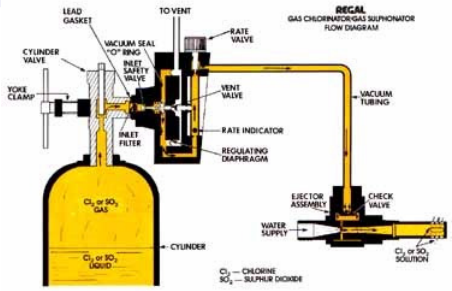
- pH should be checked routinely
- If the pH of the water system is raised for corrosion control, then the chlorine dose needs to be raised to maintain an effective level
- Chlorine is most effective at a pH of 7.0

Turbidity

- **Chlorine is effective only if it comes in contact with bacteria**
- **Turbidity can prevent good contact time and protect pathogens**
- **Chlorine also reacts with organic matter & ammonia**
- **Can mask the bacteria**

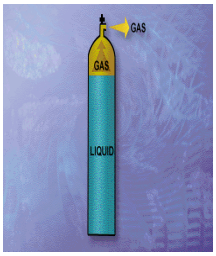


Gas Chlorine System



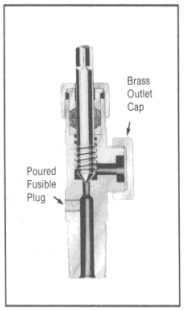
150 lb. Chlorine Cylinders:

- **The proper position for the withdrawal of chlorine gas is upright.**
- **Maximum feed rate is 40 lb/day for each**
- **A yoke is the connection between the tank & regulator or gas piping**



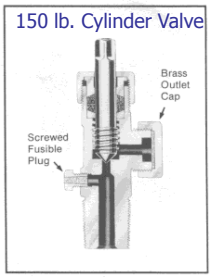
Chlorine Cylinder Valve

- **Always inspect the cylinder valve before opening.**
- **Check cylinder fittings for leaks with ammonia gas**
- **Once the connection has been made, the valve should only be opened 1/4 of a turn & check for leaks.**
- **Close cylinder valve first to allow gas drain from pigtail**



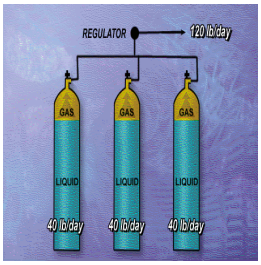
Fusible Plug

- **Safety Device**
- **Made out of lead**
- **Melts between 160 to 165 degrees**
- **Keep cylinders away from direct heat**

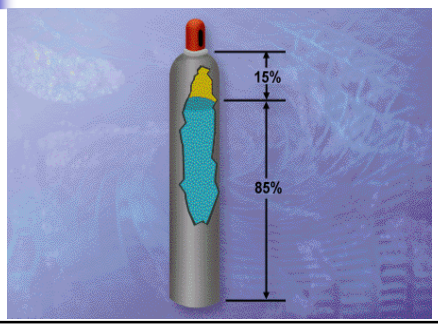


Maximum Chlorine Feed Rates

- When the feed rates exceed the maximum rates icing can occur
- For higher feed rates you can manifold the cylinders in a series to prevent icing

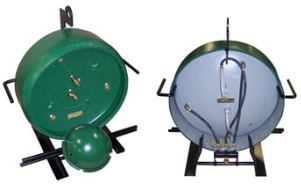


85% Full for Expansion



One Ton Cylinder

- 6 fusible lead plugs- 3 on each end
- Valves are aligned vertically
- Upper is for gas
- Lower for liquid
- 85% full for expansion
- Weigh 3550 lbs. full



Chlorine Cylinders

- **Rupture or tank failure most serious type of leak**
- **For leaks on ton chlorine cylinders, rotate the cylinder until leak is on top**
- **400 lb/day max feed rate for each ton cylinder**

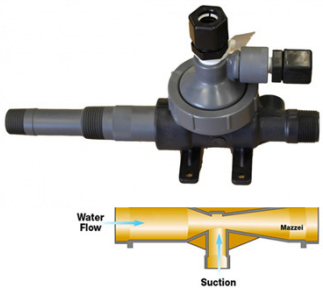
Ton cylinders on scales

Rotometer for Ton Cylinders

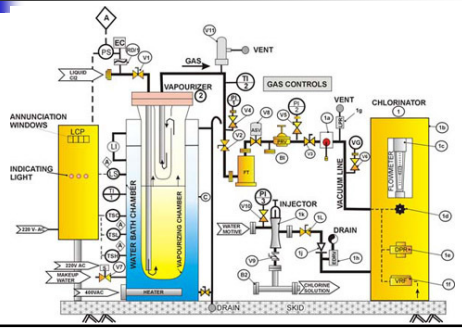
Rotometer, continued

Scales, Ton Cylinders

Chlorine Ejector



Evaporator



Ton Cylinder Lifting Bar

Lead Gasket

- **Never** re- use a lead gasket.
- **Never** stack lead gaskets on top of each other
- Tighten connection 1/2 to 3/4 of a turn after making contact with the lead gasket

Preventive Maintenance (PM)

- After one year of service, pm kits should be installed
- Always use new diaphrams, o-rings, etc. "Never re-use parts"
- O-rings need to be made of viton
- Use special grease to lube o-ring before installing
- Inspect pvc parts for damage or cracking
- Use an acid solution to clean parts

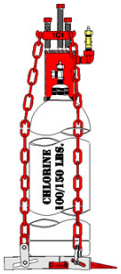
Chlorine Train Cars

- C kit for repairs
- Used for larger sized plants

Repair Kits

- A kit for 150 lb.
- B kit for ton cylinders
- C kit for train cars

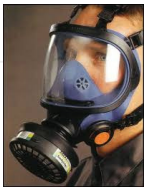
150 lb Cylinder A Kit



Ton Cylinder Valve Repair

Respirators

- **Canister type masks should be worn during the changing of cylinders**
- **Canister type masks should be used only for escape purposes only, because they don't work in an oxygen deficient environment**
- **SCBA's or fresh air masks should be worn for repairs, troubleshooting, and finding leaks**



Self Contained Breathing Apparatus (SCBA)

- Never enter a room suspected of leak without SCBA

PVC Piping

- Only corrosion resistant piping should be used
- Schedule 80 PVC is not recommended in chlorine
- Plastic can deteriorate in a relatively short period of time
- Schedule 80 PVC is used because of the cost & should replace every 5 to 10 years.
- Polyvinyldene Fluoride (PVDF) should be used
- Chlorine Institute sets standards for piping, valves, & manifolds

Chlorine Valves

- **Should be replaced or maintained annually**

Stainless Steel

- 300 have useful properties for low temperature service
- Can fail due to chloride stress corrosion cracking
- Particularly in the presence of moisture at ambient or elevated temperatures.

Water Needs to be Metered

New & Repaired Water Mains

- **Disinfected in accordance with AWWA standard C651**
- **Must be disinfected with some type of chlorine**
- **Tablet or a solution are typically used**
- **Chlorine must be flushed with potable water**
- **Take bacti samples**

Reservoir Maintenance

- After entry reservoir must be disinfected
- AWWA standard C652
- Take bacti samples

Disinfection

- Prevent Contamination From Entering Pipe During Construction Or Repair
- Flush Out Contamination
- Chlorinate Pipe For Required Time
- Flush Out Super Chlorinated Water
- Determine Bacteriological Quality

Prevent Contamination

- Keep pipe clean and dry
- Plug pipe ends when not working
- Use only approved pipe lube
- Clean and swab pipes as necessary
- Keep trench dewatered while working or disinfect submerged pipe
- Keep a positive pressure in pipe when doing repairs if possible

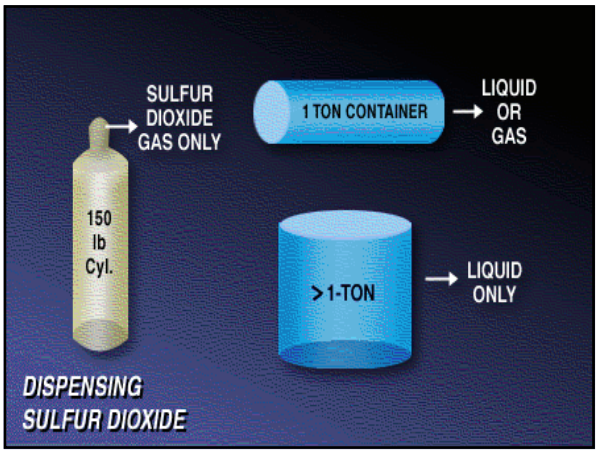
Flushing

- Flush at a velocity 2.5 fps or greater
- Required gpm flow for velocity

4" pipe	100 gpm
6" pipe	200 gpm
8" pipe	400 gpm
10" pipe	600 gpm
12" pipe	900 gpm

CHLORINE NEUTRALIZING CHEMICALS

- SULFUR DIOXIDE
- SODIUM BISULFITE
- SODIUM SULFITE
- SODIUM THIOSULFATE



Fluoride

- Fluoride shall not exceed 4 mg/L
- If fluoride levels exceed 2 mg/L, the water system must notify the public.
- Water system must notify the public in their first set of water bills after the violation
- Must provide specific health effects language

Over Feeding Fluoride

- Can Mottle Teeth