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Consulting Engineers



Disinfection Alternatives for Water and Wastewater

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Purpose of Disinfection

Most Basic Requirement for Sanitation and Protection of Public Health

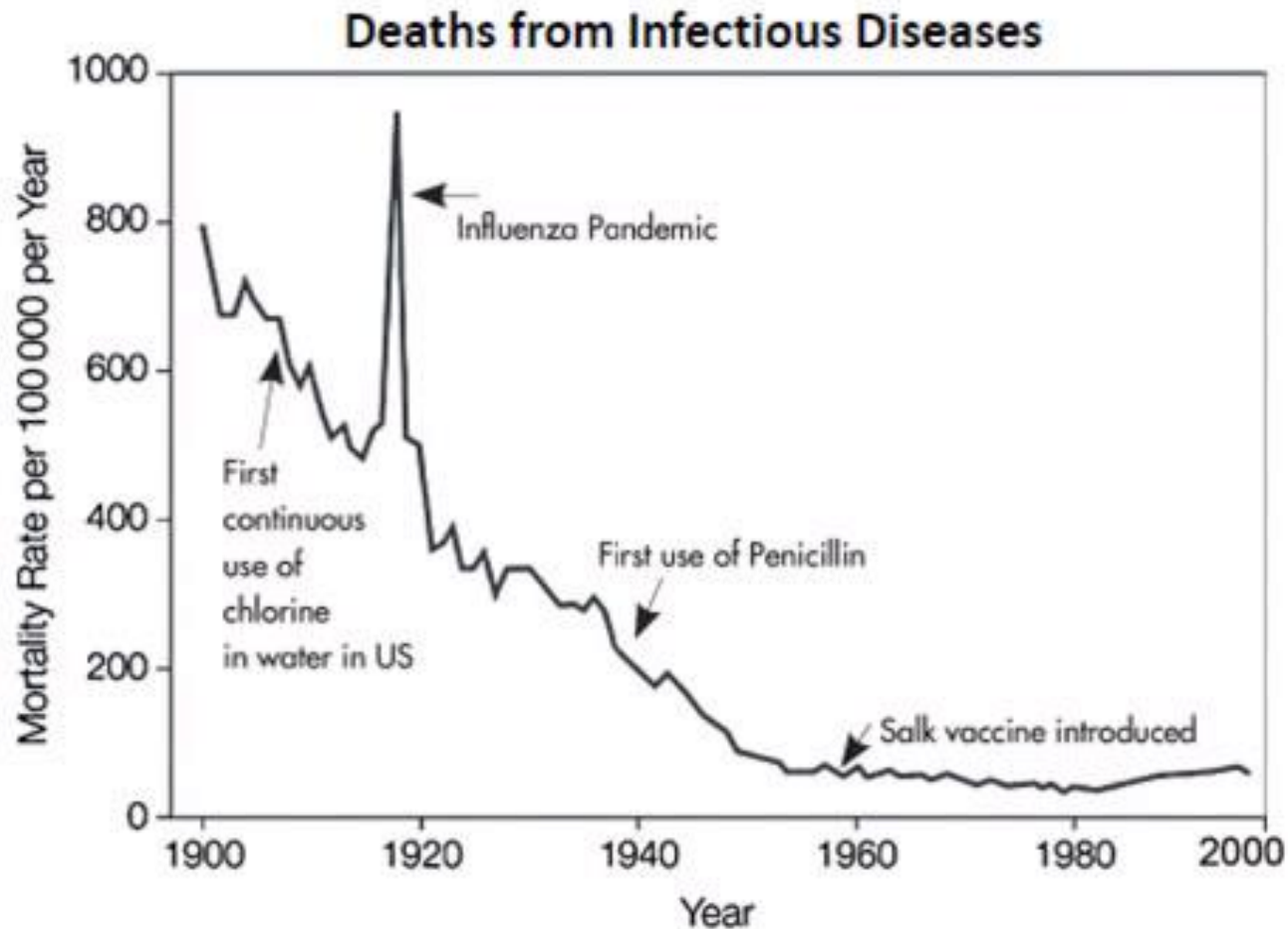
Prevent the Spread of Waterborne Disease – Typhoid, Salmonella, Cholera, Hookworm, etc.

Kills or Inactivates Most Disease Sources - Bacteria, Protozoa, Parasites, and Viruses

Used Widely Since Around the Turn of the Century with Huge Public Health Benefits

Reduced Infant Mortality & Increased Longevity

History of Water Disinfection



Purpose of Disinfection

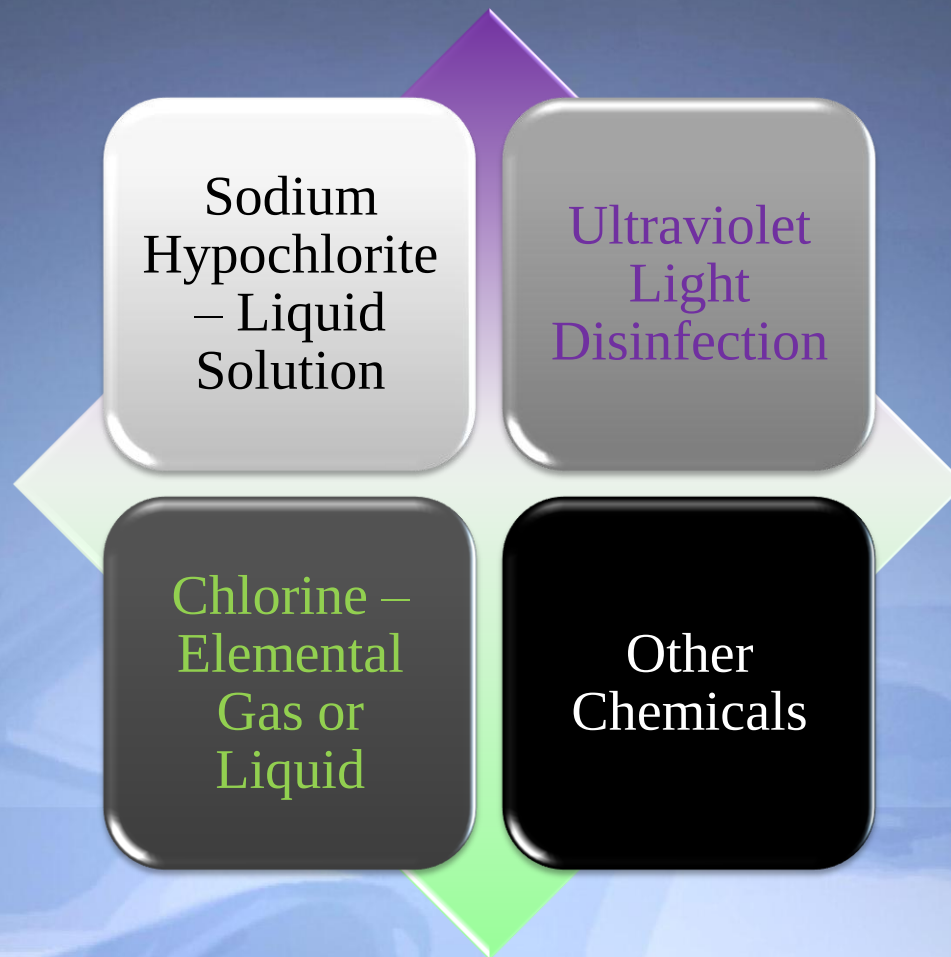
Water Treatment and Distribution

- Surface Source – Must Treat to Render it Potable and Insure Potability at the Point of Usage
- Ground Source – May Not Be Required for Treatment, but Generally Required for Distribution

Wastewater Treatment

- Surface Discharge – Required in NPDES Permit to Protect Downstream Users
- Ground Discharge – May not be required

Common Disinfection Options



Disinfection Mechanism

Chemicals

Breaks
organism
cell walls
for kill

Chemically
oxidize
organic
matter

Ultraviolet Light

Disrupts
organism
reproduction

Inactivates
viruses

Sodium Hypochlorite

Dosing

- $\text{NaOCl} + \text{H}_2\text{O} = \text{HOCl} + \text{NaOH}$ (alkaline soln.)
- 1 lbs chlorine gas = 1 gallon 12.5% NaOCl
- Comparable performance to Chlorine gas
- OCl is a powerful disinfectant and oxidant

Storage/Generation

- Bulk storage of liquid – Larger Volume than Pure Cl
- Requires secondary containment in case of leak or spill
- Must have 30 – 60 days supply in heated storage
- Degrades over time (dilute in tank)
- Safety issue if mixed with other chemicals!



THE CHLORINE INSTITUTE
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Tel 703-894-4140 Fax 703-894-4130
www.chlorineinstitute.org

Sodium Hypochlorite Only (Bleach) UN1791

**WARNING: MIXING SODIUM HYPOCHLORITE WITH
ANOTHER CHEMICAL MAY CAUSE A DANGEROUS
SITUATION**

GUIDANCE TO AVOID ACCIDENTAL MIXING

1. Verify that the shipping papers are in order
2. Verify that the tanker is loaded with sodium hypochlorite solution (UN1791)
3. Verify that the receiving tank has sufficient capacity
4. Verify that the drain sump is empty, rinsed, and isolated prior to unloading
5. Verify that the unloading connections/piping are correct (check labels, routing, etc.)
6. Verify correct connections by a second person
7. Monitor tank level during the unloading process
8. Follow applicable regulations for monitoring/attendance

Shipping Instructions



Tankage for Sodium Hypochlorite Solutions



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Sodium Hypochlorite Solution Alternative: On site generation from salt

No
containment
required

- Must maintain 1 – 3 days supply of liquid solution
- 30 – 60 days supply of salt
- Must keep it dry



Sodium Hypochlorite Feed Equipment

Pump Styles

- Diaphragm
- Solenoid
- Peristaltic

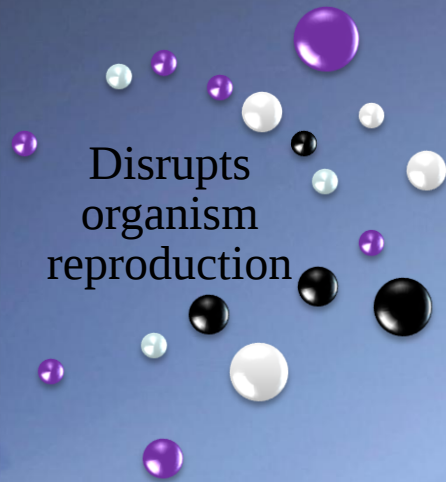


Performance Issues

- Taste/odor
- Disinfection by-products
- Gas binding
- Peristaltic pumps
- Scaling concern
- May need to feed phosphate



Ultraviolet Disinfection - Wastewater



Disrupts
organism
reproduction



Technology of
choice for most
WWTPs due to
inherent safety
advantages, simple
operation



Won't work
well if WW
effluent is
“cloudy” or
excessive
solids

- Check effectiveness for industrial uses
- Check for fixed film treatment
- CSO – too dirty; not a good option
- Transmittance testing/Collimated beam testing

UV – Wastewater System Configurations



Closed Pipe



Automatic Cleaning

UV – Wastewater



Equipment removal

Flow pacing

Level control requirements
(2" +/- light travel)

Open channel - Convert
existing chlorine contact
basins to UV channels



UV – Wastewater Flow Channels



Excellence.

Ultraviolet Disinfection - Water

Primarily used in difficult or large applications

Still need chemical feed for distribution system protection – maintain chlorine residual

Closed pipe configuration



Courtesy Water-Technology.net

Chlorine - Liquid or Gas

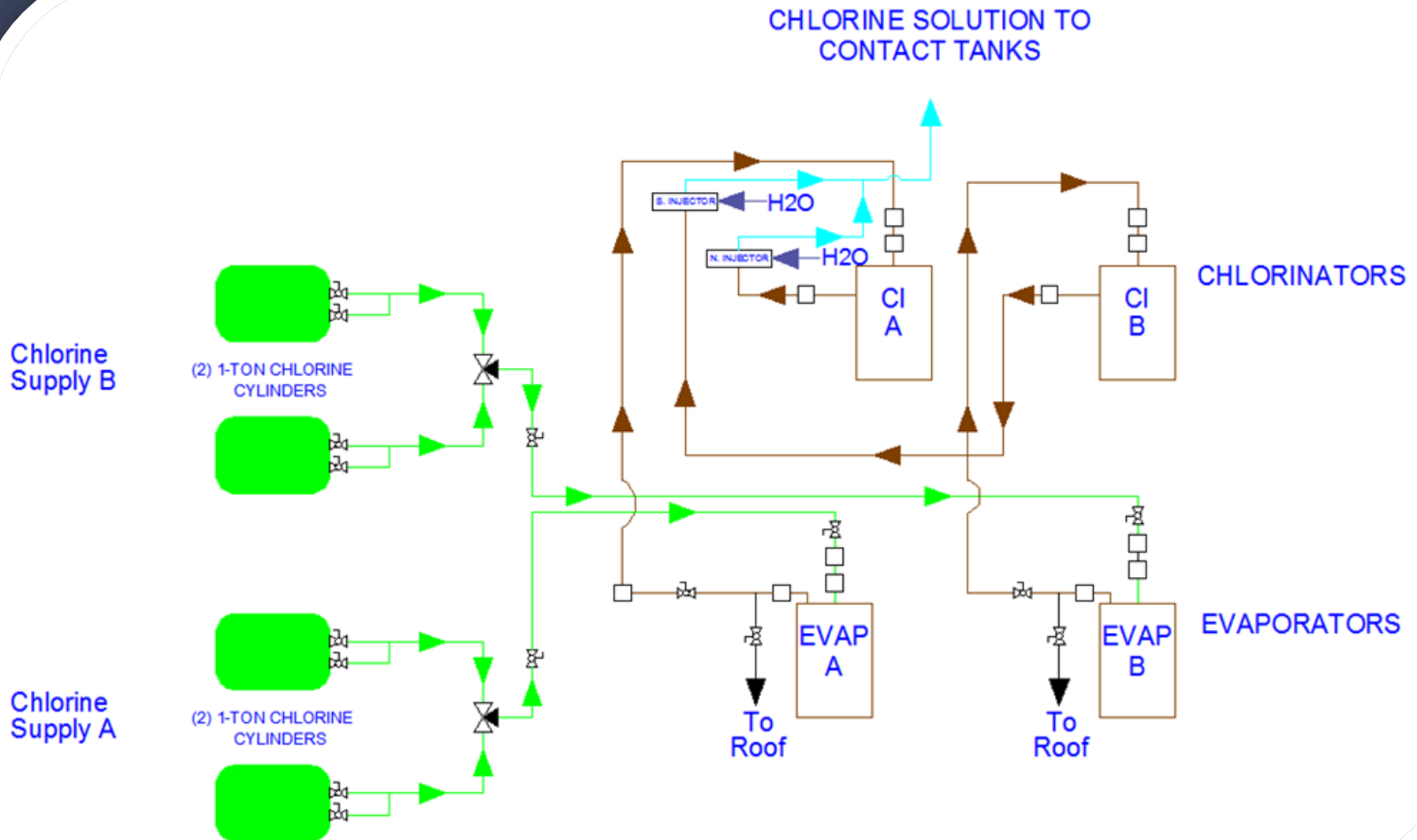
Low Cost to Operate

Reliable and Effective Under Most Conditions

Safe with Proper Use, but Many Safety Concerns

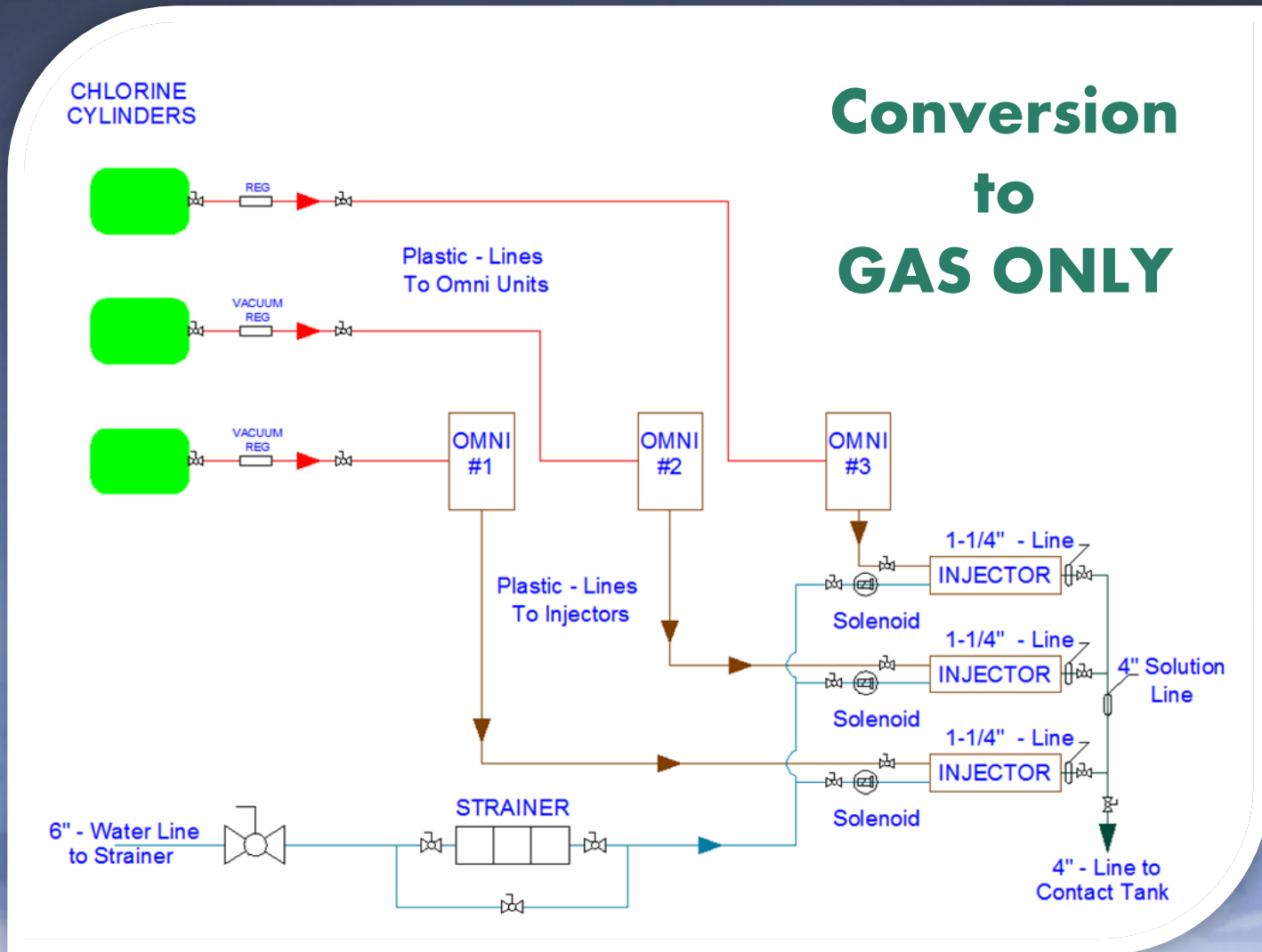
- Respiratory Irritant – 2 ppm limit for 8-hour exposure
- 10 ppm immediately dangerous to health
- Heavier than air – Can Accumulate in Low Areas
- Regulatory Burden - Process safety management - MIOSHA
- Scrubbers and Gas detection equipment required
- Homeland security concerns

Flint's Liquid/Gas WWTP Chlorination System - 2012



Green lines are under pressure

Flint's WWTP Chlorination System - 2015



All lines are under vacuum

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Chlorine Feed Regulators



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Chlorine Gas



Vacuum System – safer than liquid chlorine feed, smaller leak potential

System Operates under Vacuum

500 lb/day Capacity per Drum



Gas-Only Chlorine System

Drum with Pressure Regulator Mounted

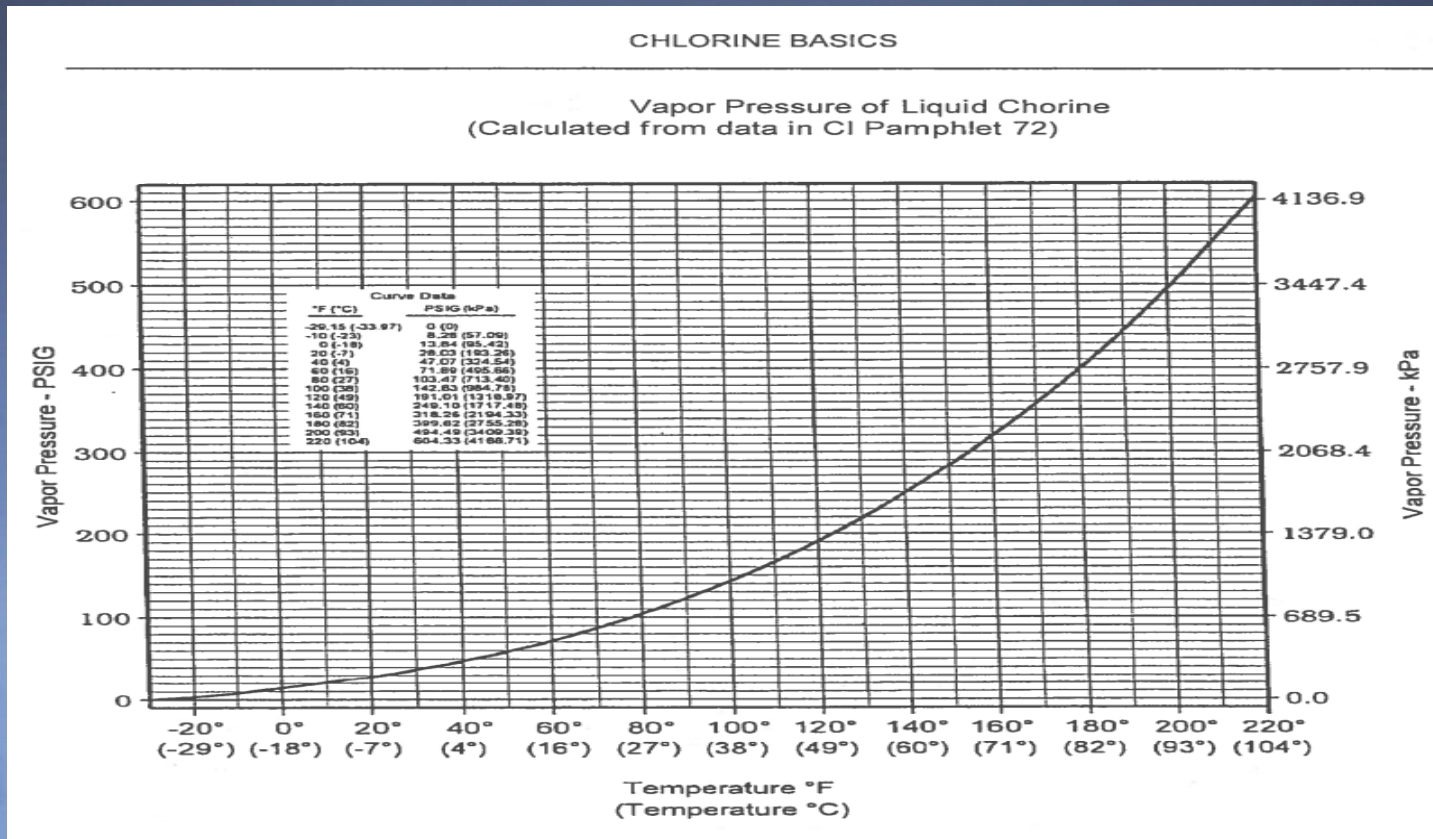


Chlorine Feed Regulators



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Rate of Liquid Chlorine Evaporation – Very Sensitive to Temperature



**Much Heat Energy Needed for
Chlorine Evaporation**

Gas-Only Chlorine System

Multiple Drum Installation – Increased Capacity



Chlorine Gas -Wastewater

Gas Dissolved in Water;
Solution To Contact Tank



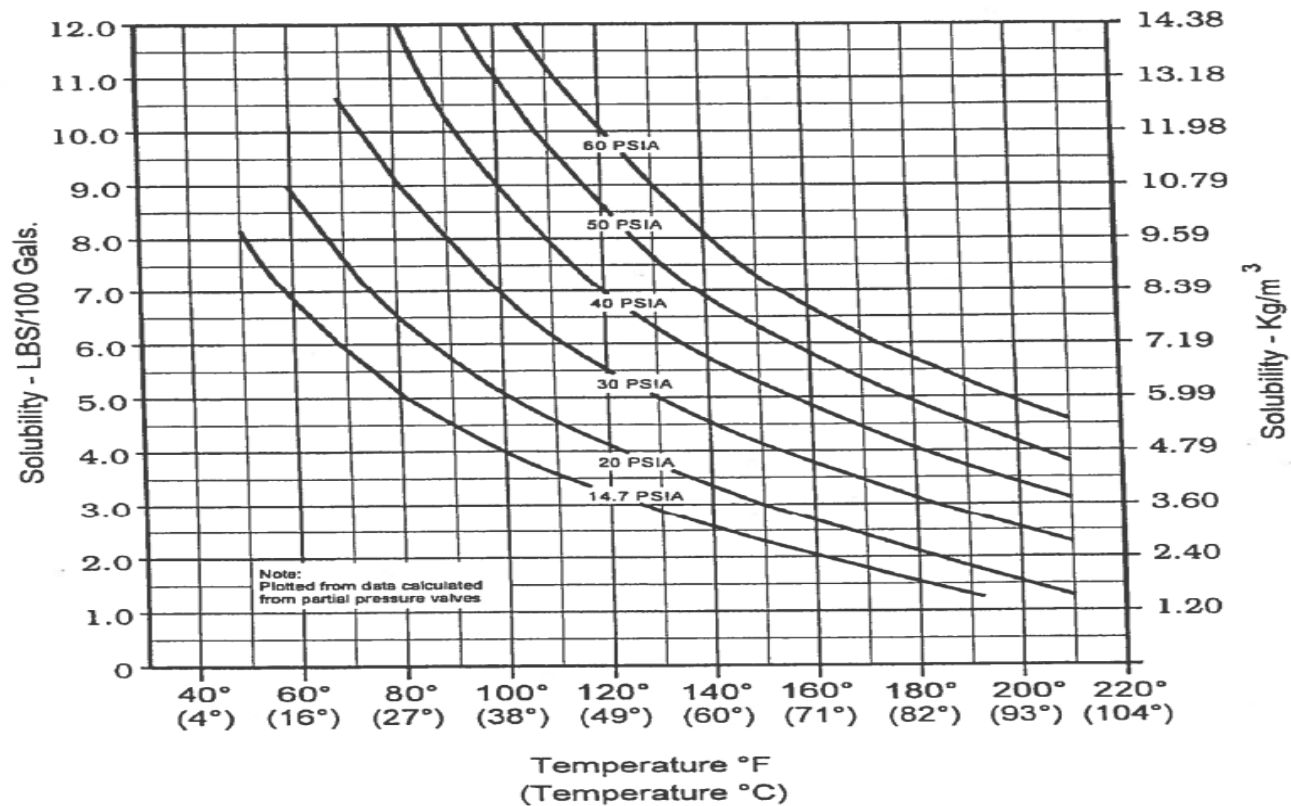
Dosing:

- **Effectiveness of kill depends on:**
 - Effluent quality
 - Contact time (15 minutes at peak flow)
 - Mixing efficiency, and
 - Temperature
 - 1-2 ppm residual, 3-10 ppm overall
 - Requires dechlorination

Chlorine is most soluble in Cold Water

CHLORINE BASICS

Equilibrium Solution of Chlorine In Water



Chlorine Gas – Potable Water

Effective kill,
though not as
effective as other
options

Disinfection
by-products
concerns

Excellent
for
system
residual

Chlorine Costs



Elemental Gas/Liquid

- Ton cylinder = \$320 - \$900.00 (depending on quantity)
- 150 lbs cylinder = \$198.00 (only one)

NaOCl Solution

- Bulk = \$0.82/gal (4,000+ gallons)
- 55 gallons = \$128.00 (only one)



Mixed Oxidant

- On site generation
- Disinfection by-products/Taste and Odor concerns (water)

Other Chemicals

**Peracetic
Acid
(Wastewater)**

Powerful - Less
concentration
& time
required

No
dechlorination
needed

New
technology;
Cost?

**Chlorine
Dioxide
(Water)**

Strong oxidant,
few (regulated)
by-products

Generate on-
site

Can be difficult
to operate

Ozone (Water)

- Generate on site
- Contact basin required
- Very strong oxidant
- No residual

Hypochlorite pellet system

- No liquid storage needed
- No safety issues with gas
- Typically smaller applications

Chloramines (Water)

- Can be used where disinfection by-products are a concern
- Not as strong of an oxidant

Relative Disinfectant Strengths of Selected Chemicals

CT Values of Selected Disinfectants for Water Treatment at 5° C

(higher value indicates weaker disinfectant)

Disinfectant	Giardia Cysts (3 log removal)	Viruses (3 log removal)
Free Chlorine	200	6
Chloramines	2,200	1,423
Chlorine Dioxide	26.0	17.1
Ozone	1.9	0.9

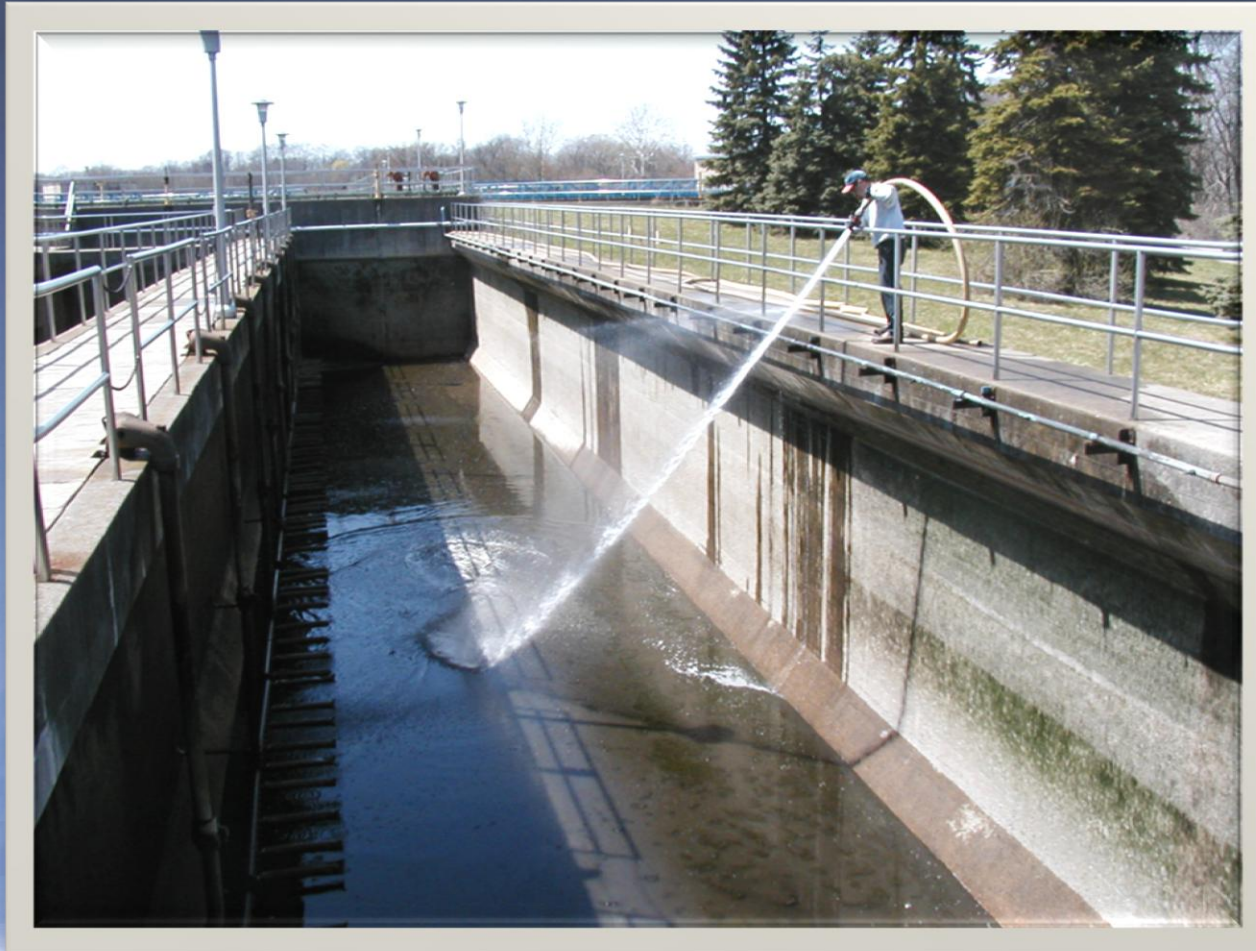


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Questions?



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