


Module 5: Disinfection and Chlorination

Wastewater Treatment Plant Operator Certification Training

Learning Objectives

- State the purpose of disinfection in wastewater.
- Identify the three types of chlorine used as disinfectants in wastewater.
- Describe the breakpoint chlorination curve.
- Identify alternate feed points and the use of chlorination in wastewater treatment.

Pathogen Removal

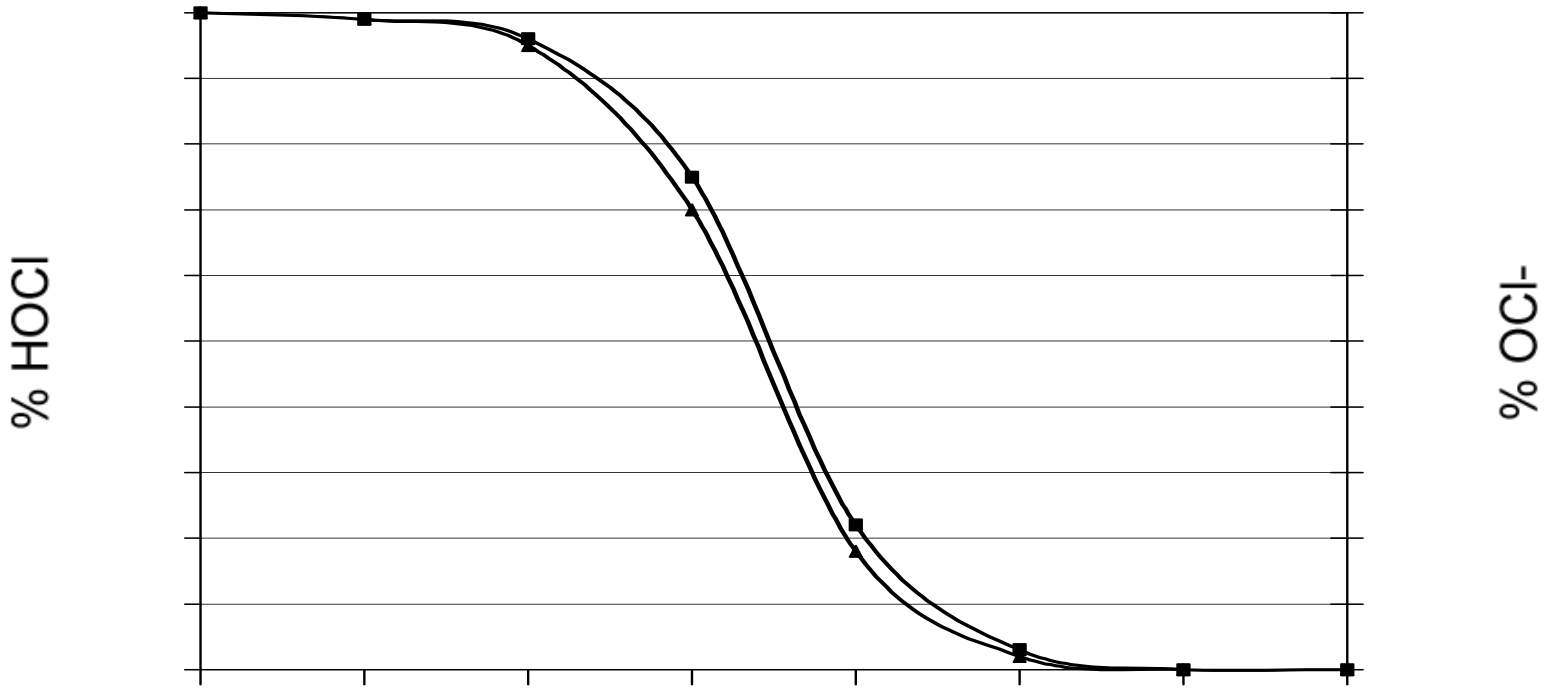
Treatment Process	Microorganism Removal	Type
Screening	10-20%	Physical Removal
Grit Removal	10-25%	Physical Removal
Primary Sedimentation	25-75%	Physical Removal
Chemical Precipitation	40-80%	Physical Removal
Trickling Filters	90-95%	Physical Removal
Activated Sludge	90-98%	Physical Removal
Chlorination	98-99%	Disinfection

Elemental Chlorine (Cl_2) Chemistry

Chlorine + Water ⇨ Hypochlorous Acid + Hydrochloric Acid

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

Distribution of HOCL and OCL-



Sodium Hypochlorite (OCl-) Chemistry

Sodium Hypochlorite + Water ⇨ Sodium Hydroxide + Hypochlorous Acid + Hypochlorite- + Hydrogen

$$2NaOCl + 2H_2O \Rightarrow 2NaOH + HOCl + OCl^- + H^+$$

Calcium Hypochlorite Chemistry

Calcium Hypochlorite + Water ⇨ Calcium Hydroxide + Hypochlorous Acid

$$Ca(OCl)_2 + 2H_2O \Rightarrow Ca(OH)_2 + 2HOCl$$

Chlorine Dioxide (ClO_2) Chemistry

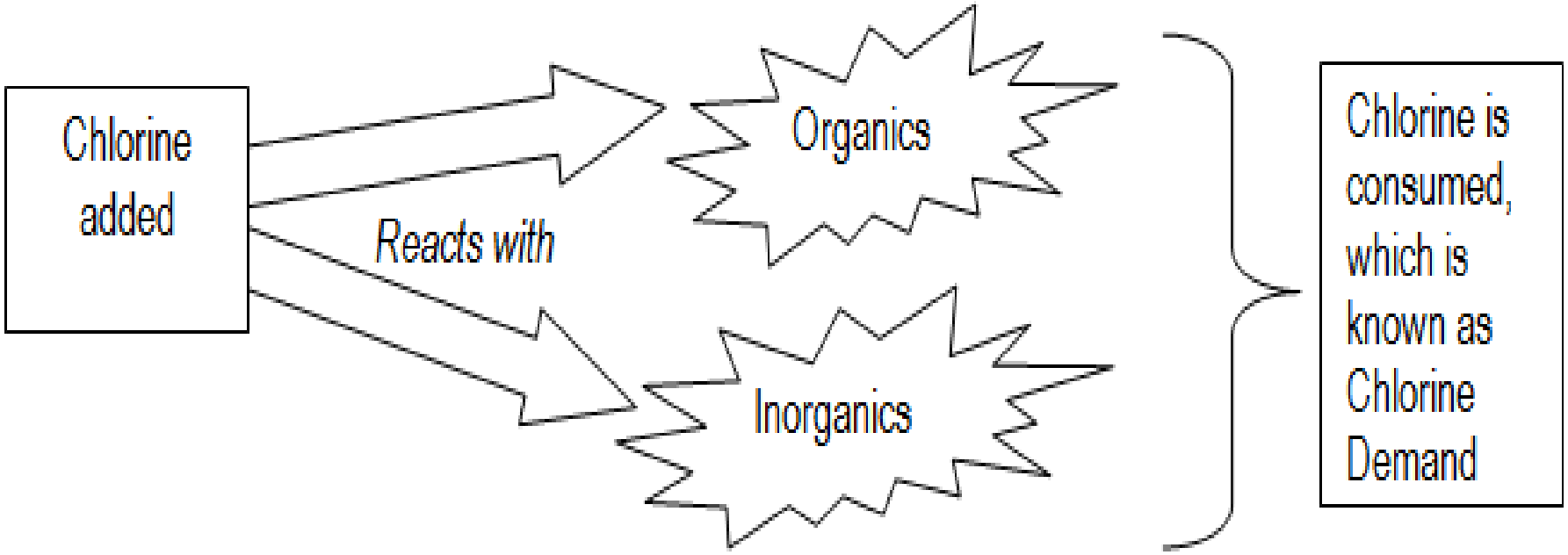
Sodium Chlorite + Chlorine ⇨ Sodium Chloride + Chlorine Dioxide

$$2NaClO_2 + Cl_2 \Rightarrow 2NaCl + 2ClO_2$$

Chlorine dioxide + Water ⇨ Chlorate Ion + Chlorite Ion + Hydrogen Ion

$$2ClO_2 + H_2O \Rightarrow ClO_3\text{-} + ClO_2^- + 2H^+$$

Chlorine Demand



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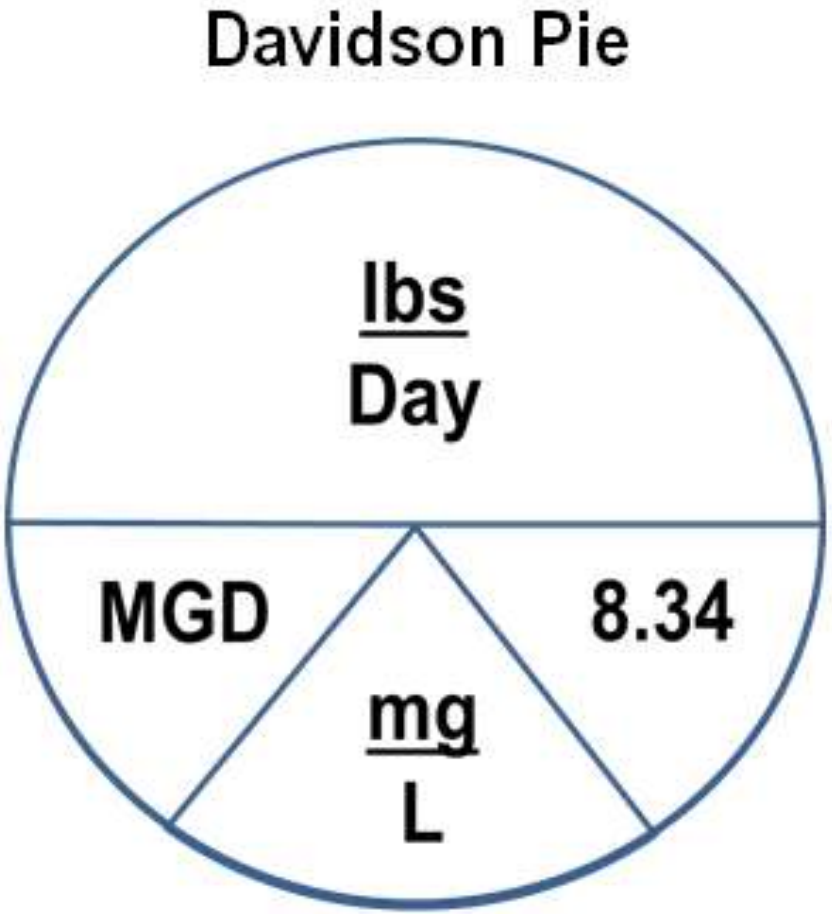
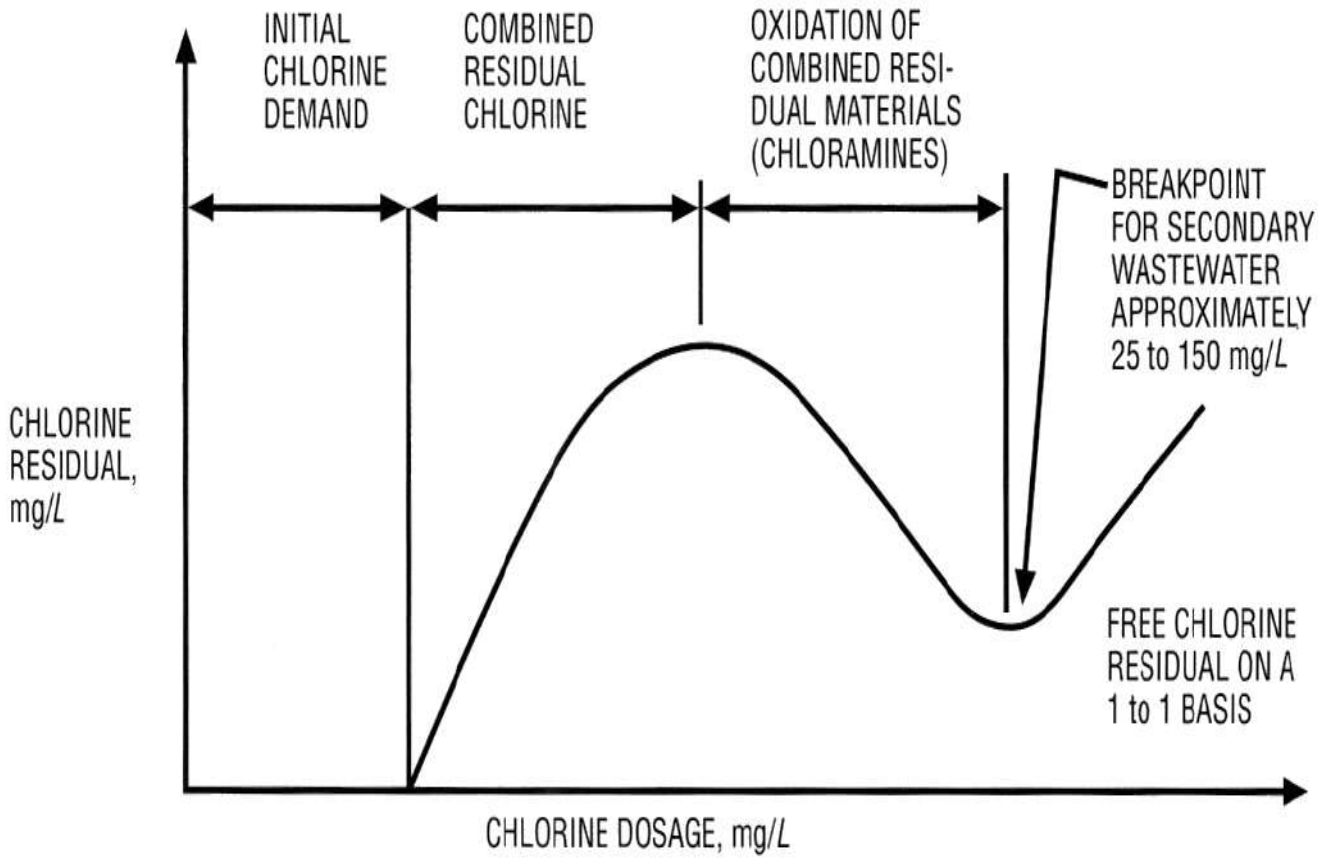
Chlorine Residual

Establishing Dosages

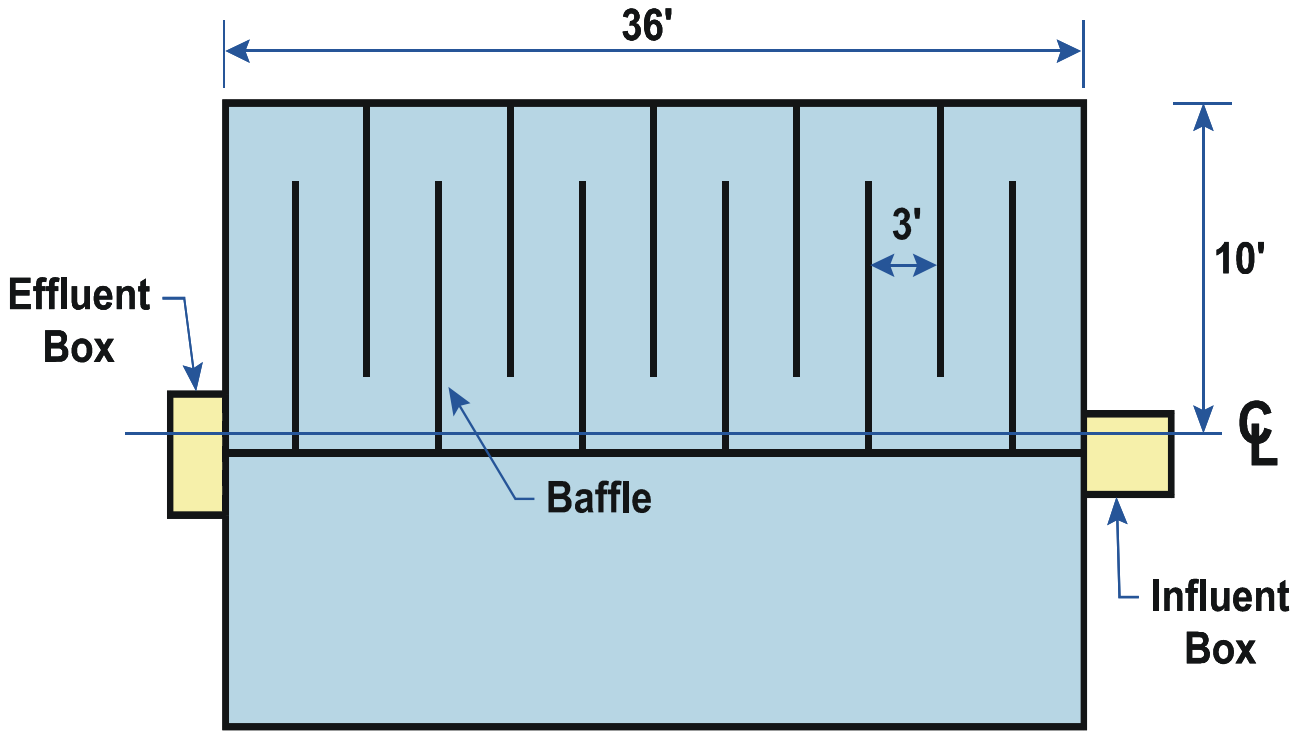


Feed Rate, lbs/day = Flow (MGD) x Dosage (mg/L) x 8.34 lbs/gal

Breakpoint Chlorination Curve

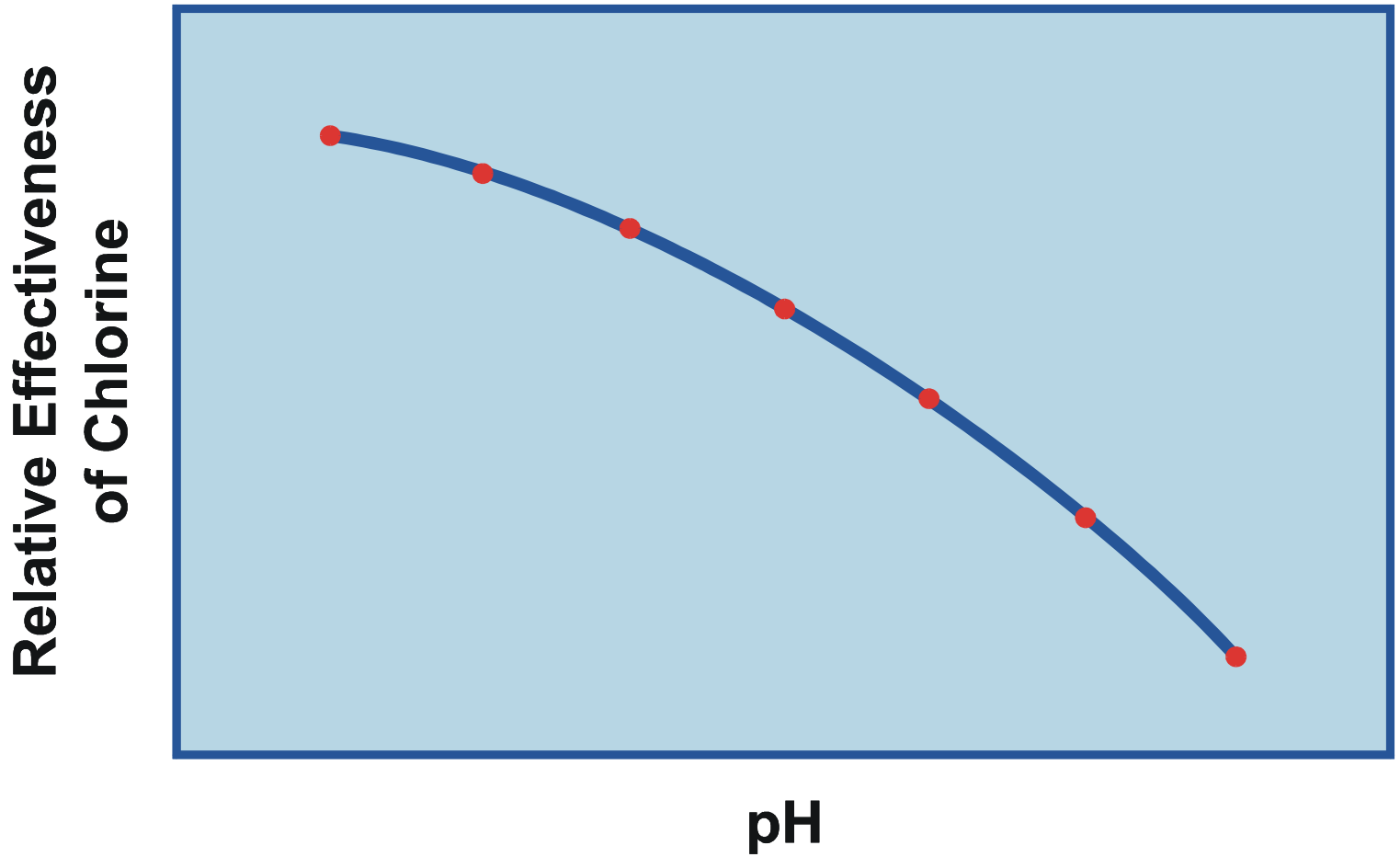


Factors Influencing Disinfection



Requirements:
- 40:1 length to width
- 15 min. contact time at peak hourly flow
- 30 min. contact time at maximum monthly average flow

Relative Effectiveness vs. pH



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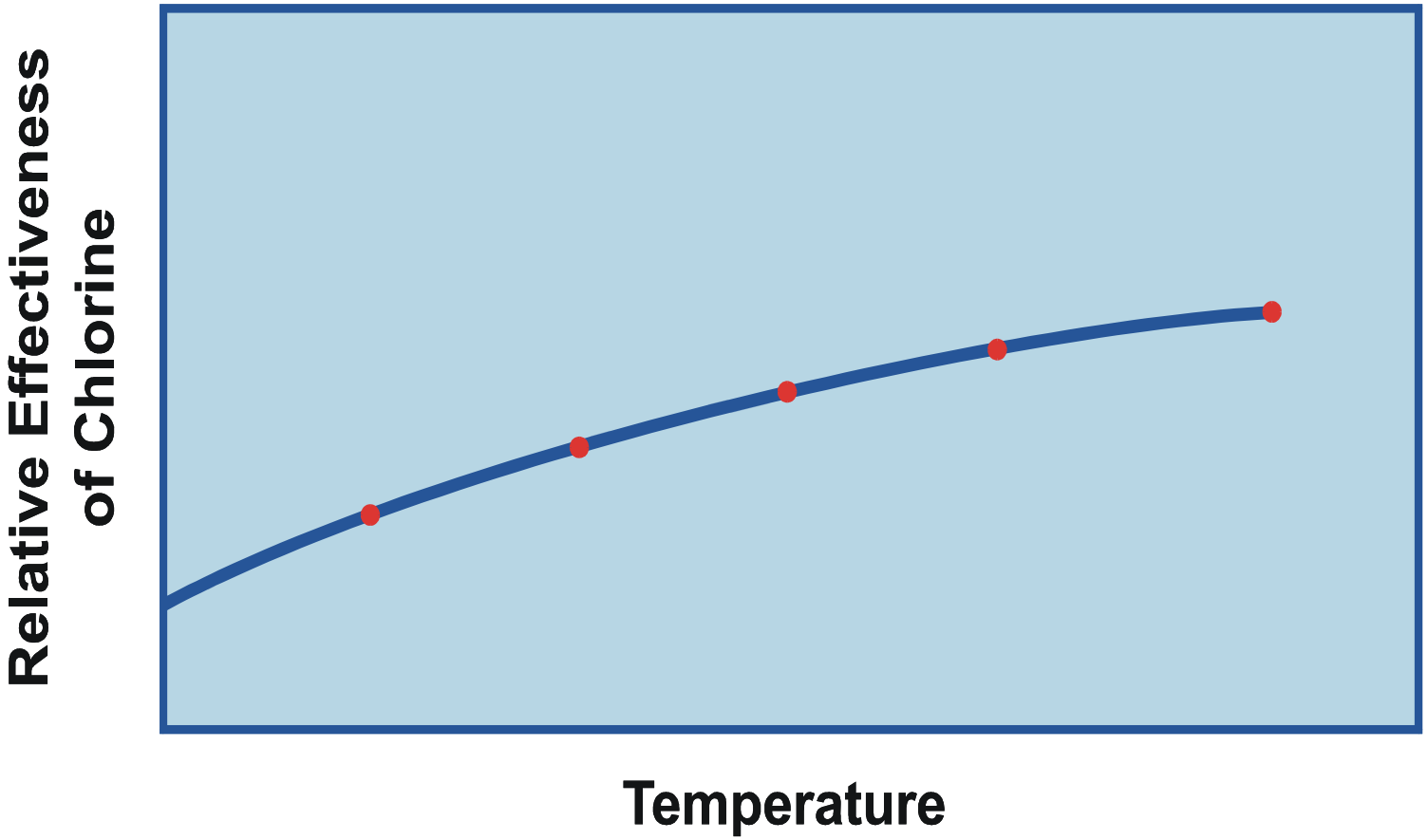
Relative Effectiveness vs. Temperature



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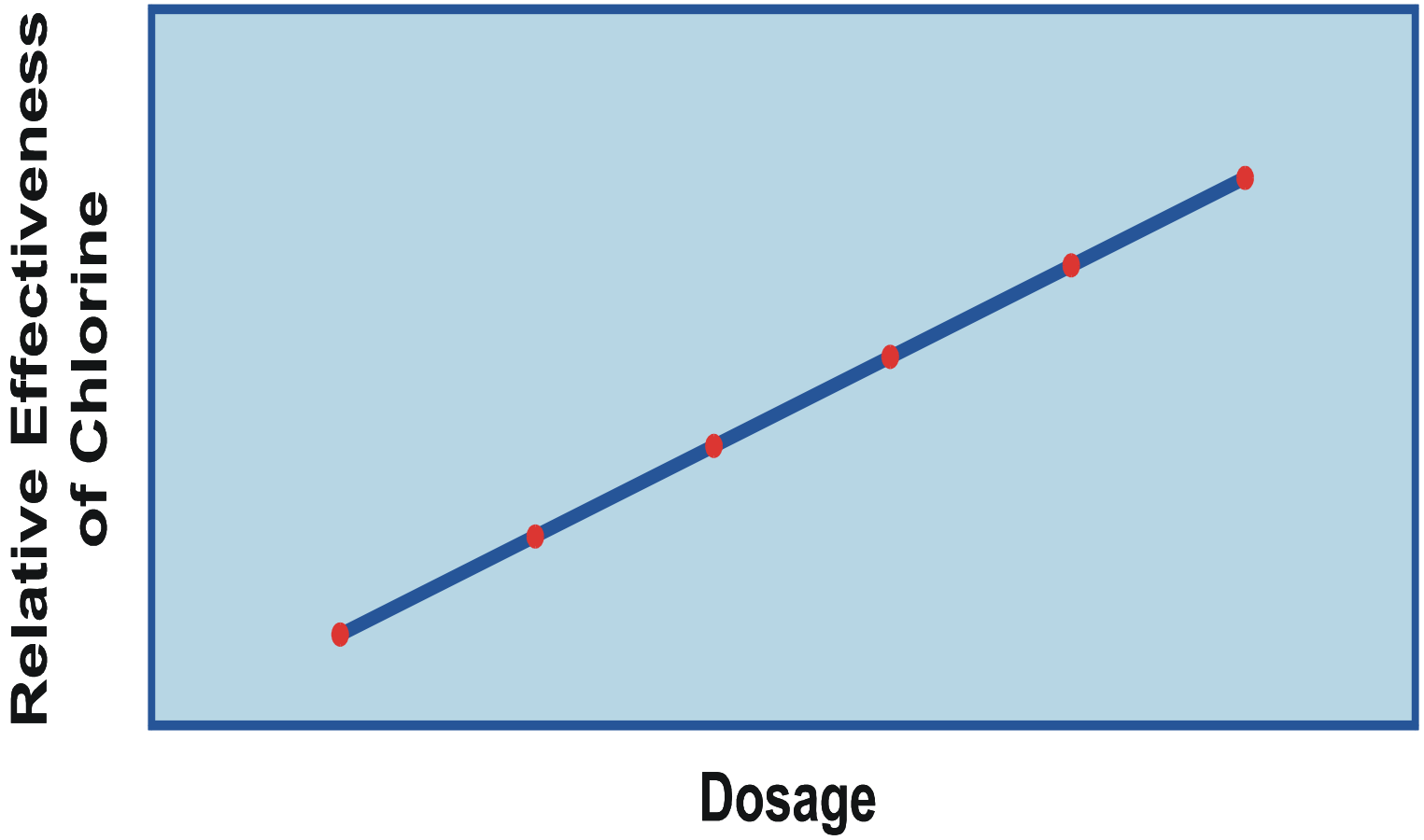
Relative Effectiveness vs. Dosage



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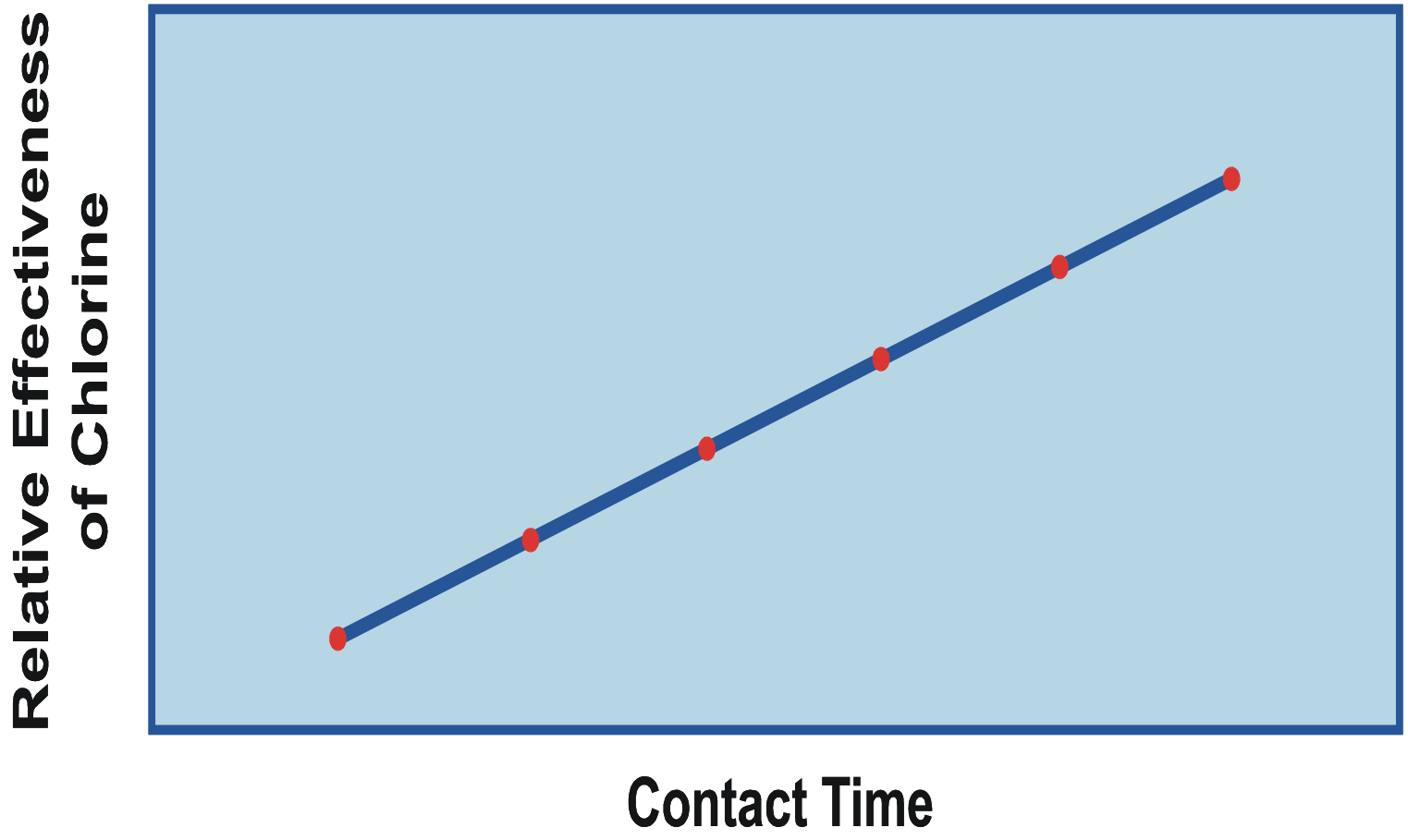
Relative Effectiveness vs. Contact Time



Application Points

- Collection Systems
- Pre-chlorination
- Plant Chlorination
- Chlorination prior to filtration
- Post filtration chlorination

Key Points and Exercise

- Turn to page 1-18 to summarize the unit key points.
- Turn to page 1-19 for exercise

Unit 1 Exercise

1. kill, inactivate
2. bacteria, viruses, cysts
3. screening, grit removal, primary sedimentation
4. chlorination
5. All of the above
6. 6.5 mg/L
7. Short-circuiting

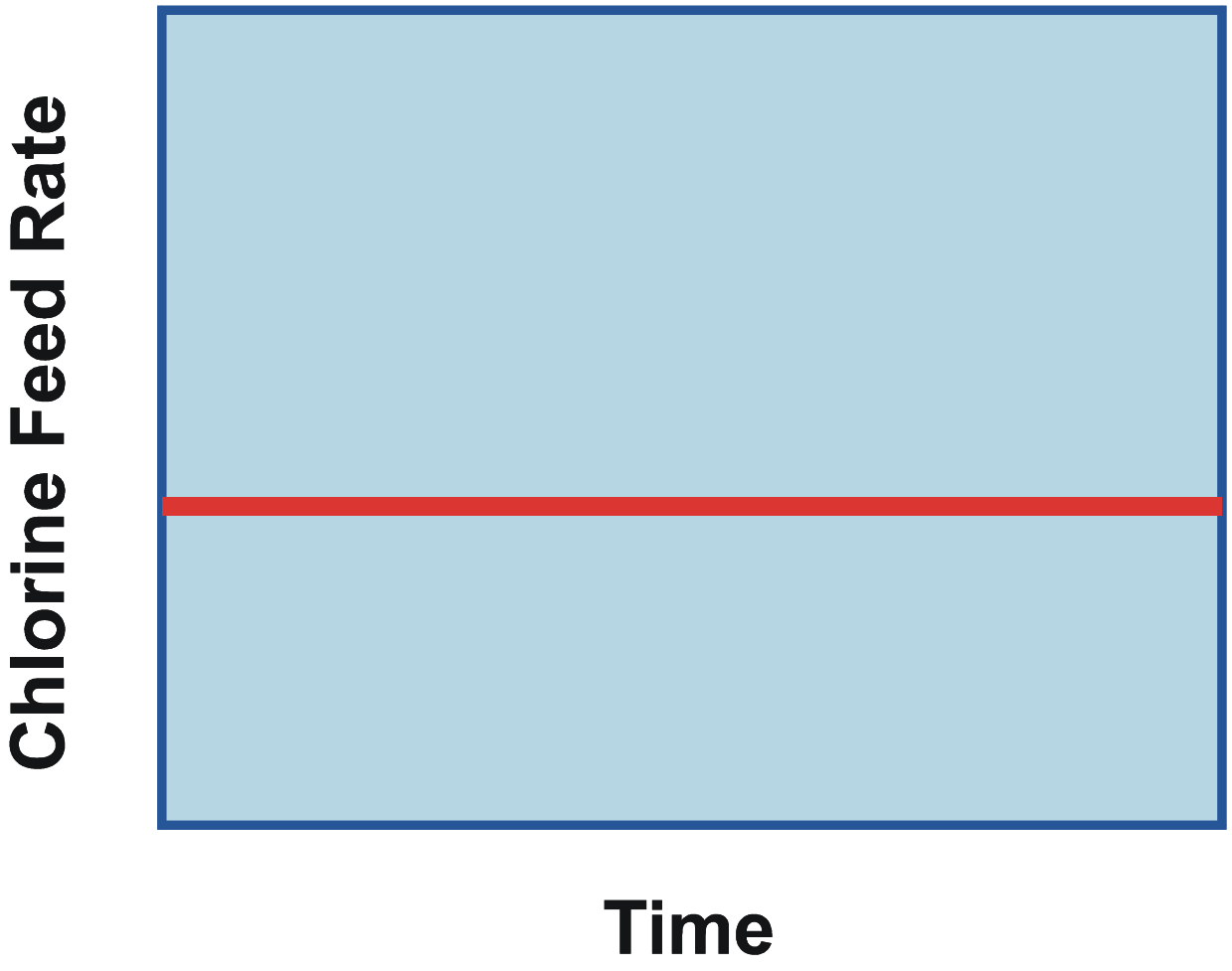
Unit 1 Exercise con't

8. All of the above
9. A, C, C, B, C, D, D, B

Learning Objectives

- List the ways in which a chlorine feed can be controlled.
- Describe chlorine residual and identify the types of chlorine residuals expected to be present during disinfection.
- Describe the common methods used for measuring chlorine residual in wastewater operations.

Manual Control



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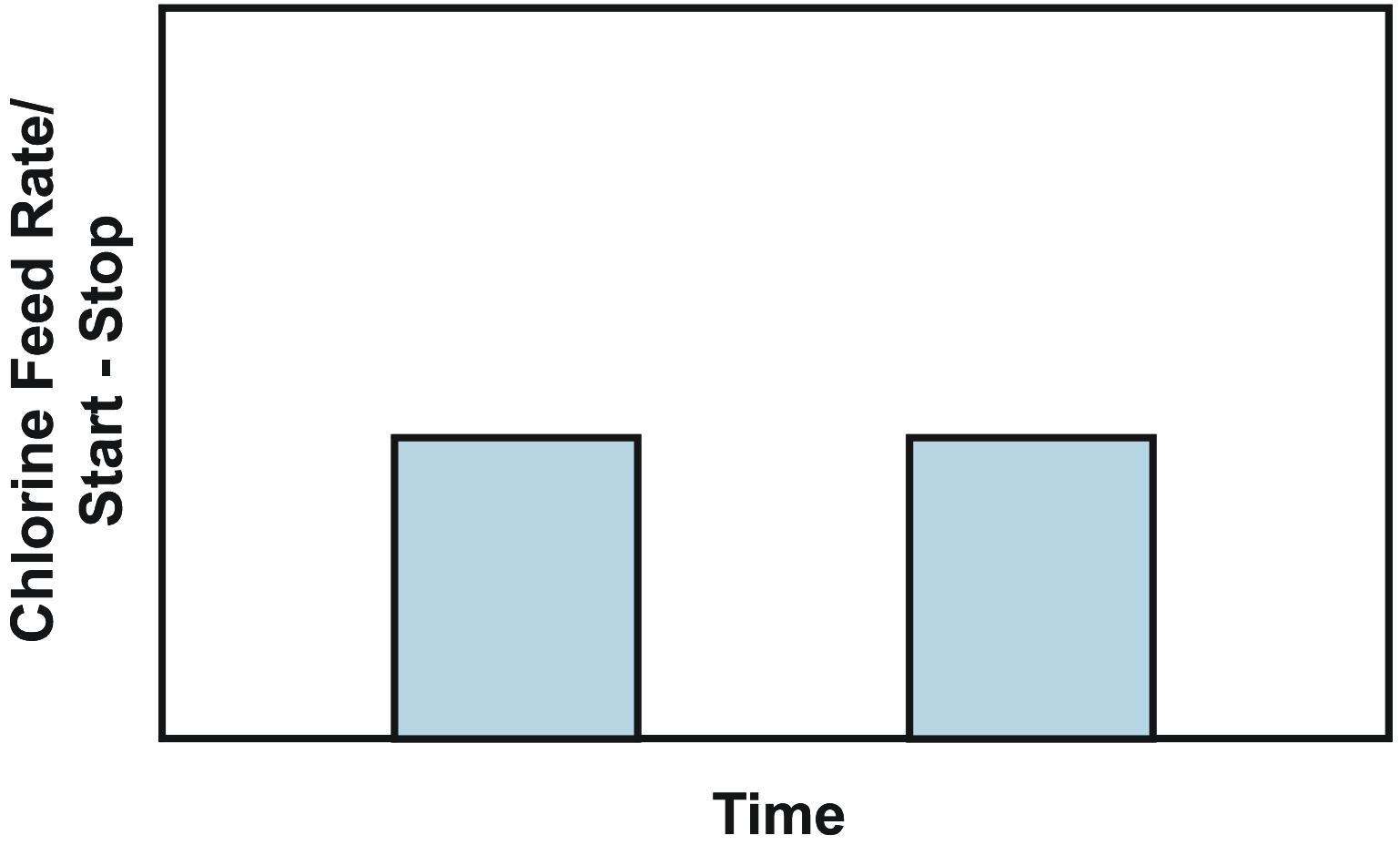
Start Stop Control



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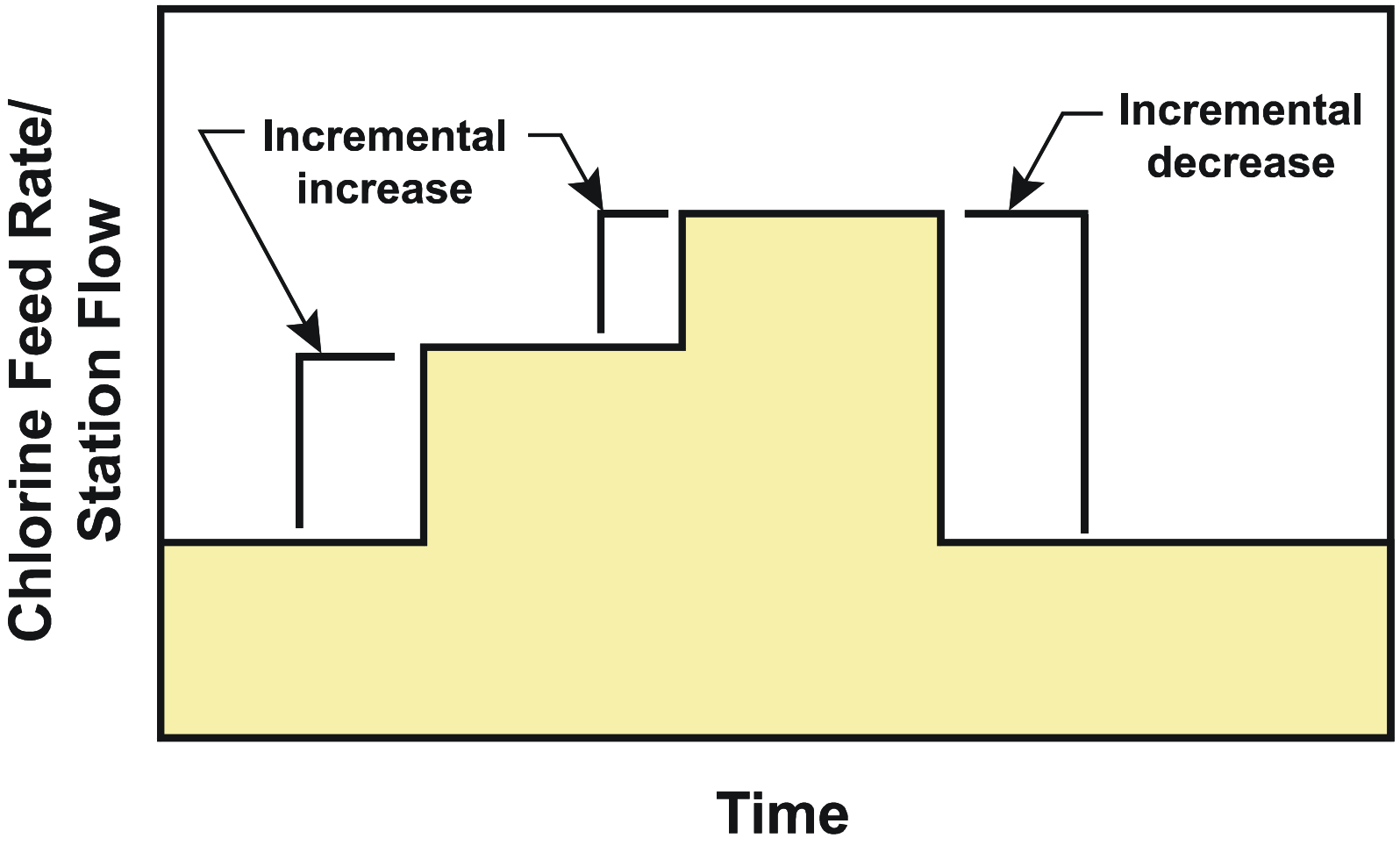
Step Rate Control



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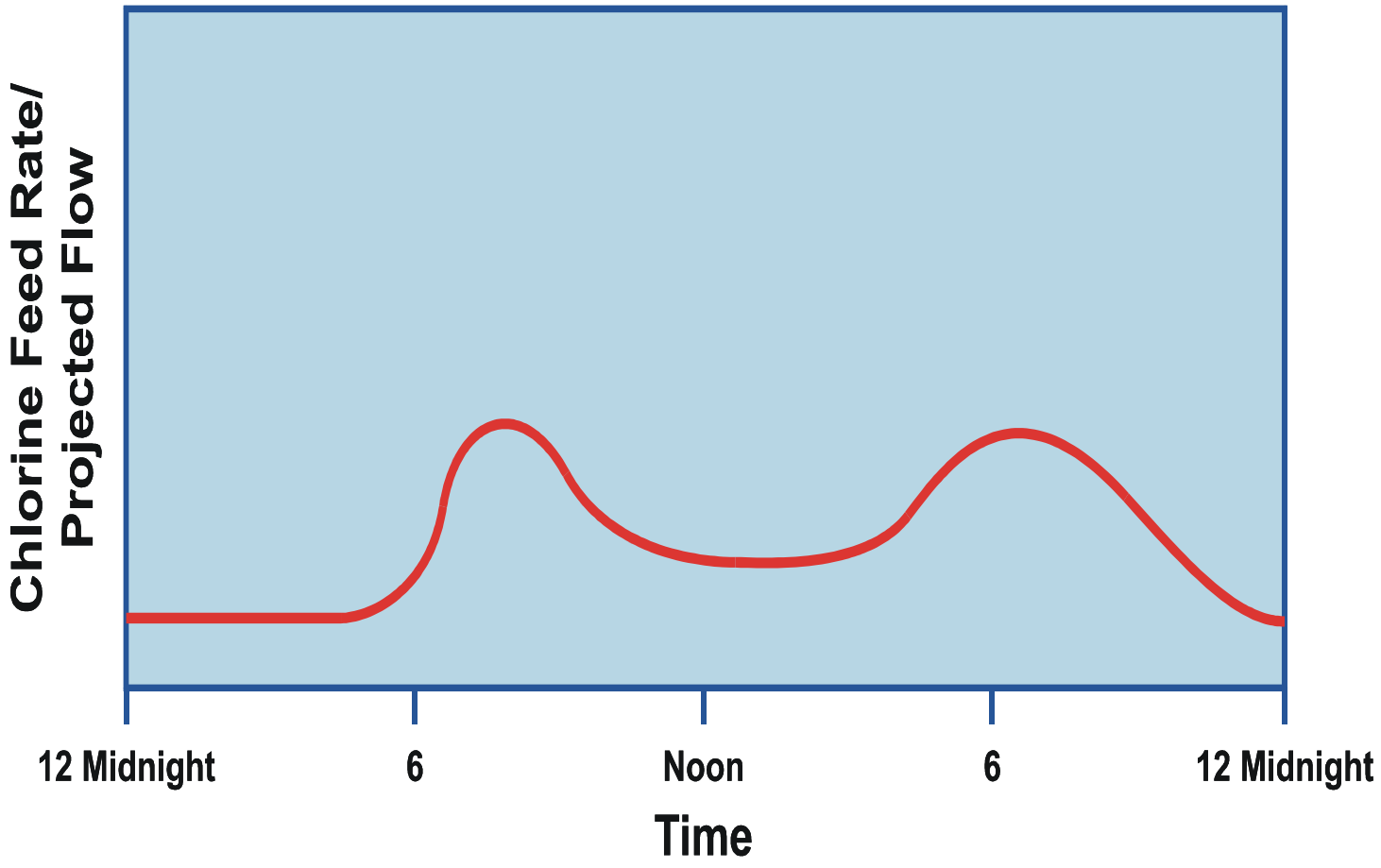
Timed Program Control



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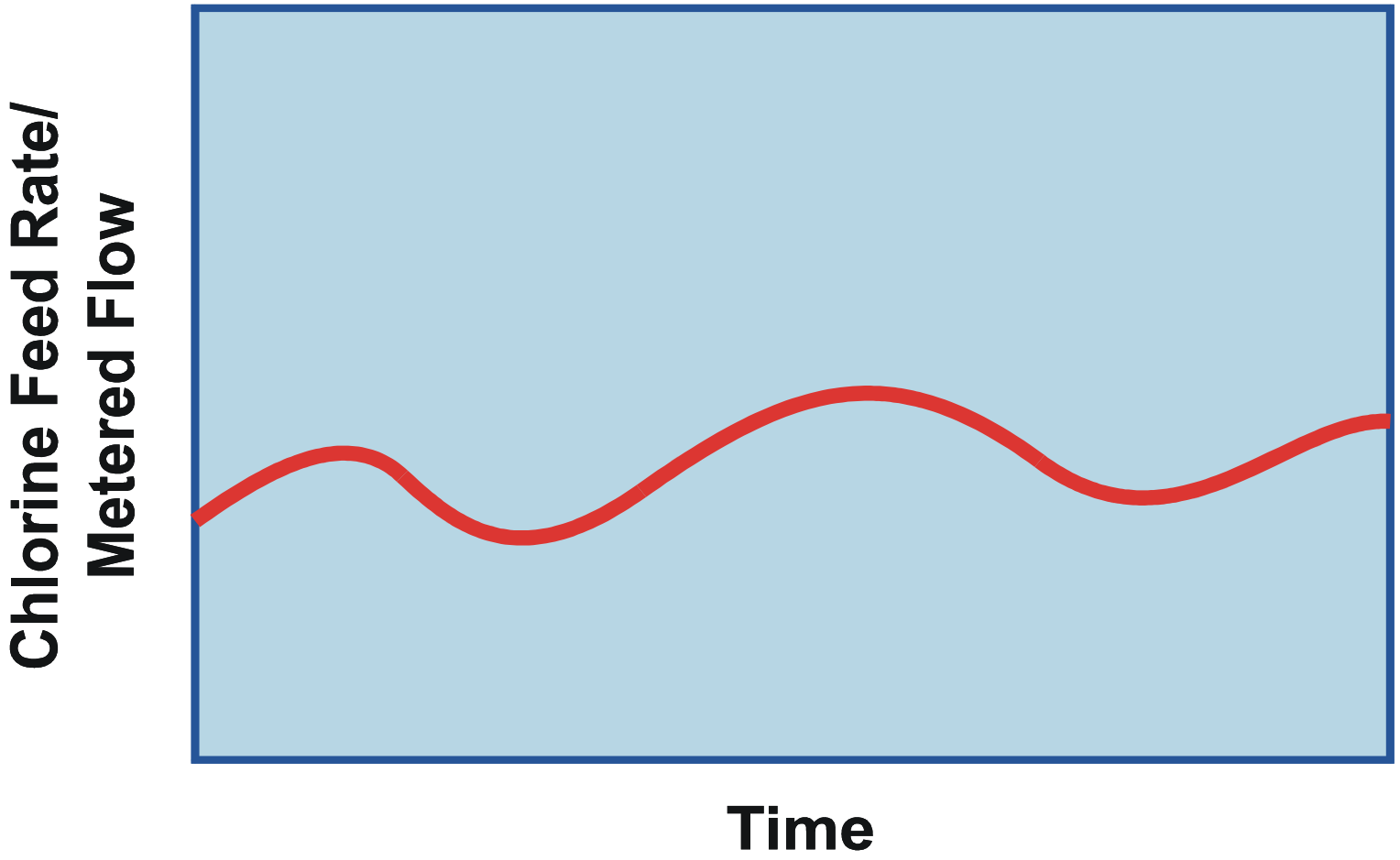
Flow Proportional Control



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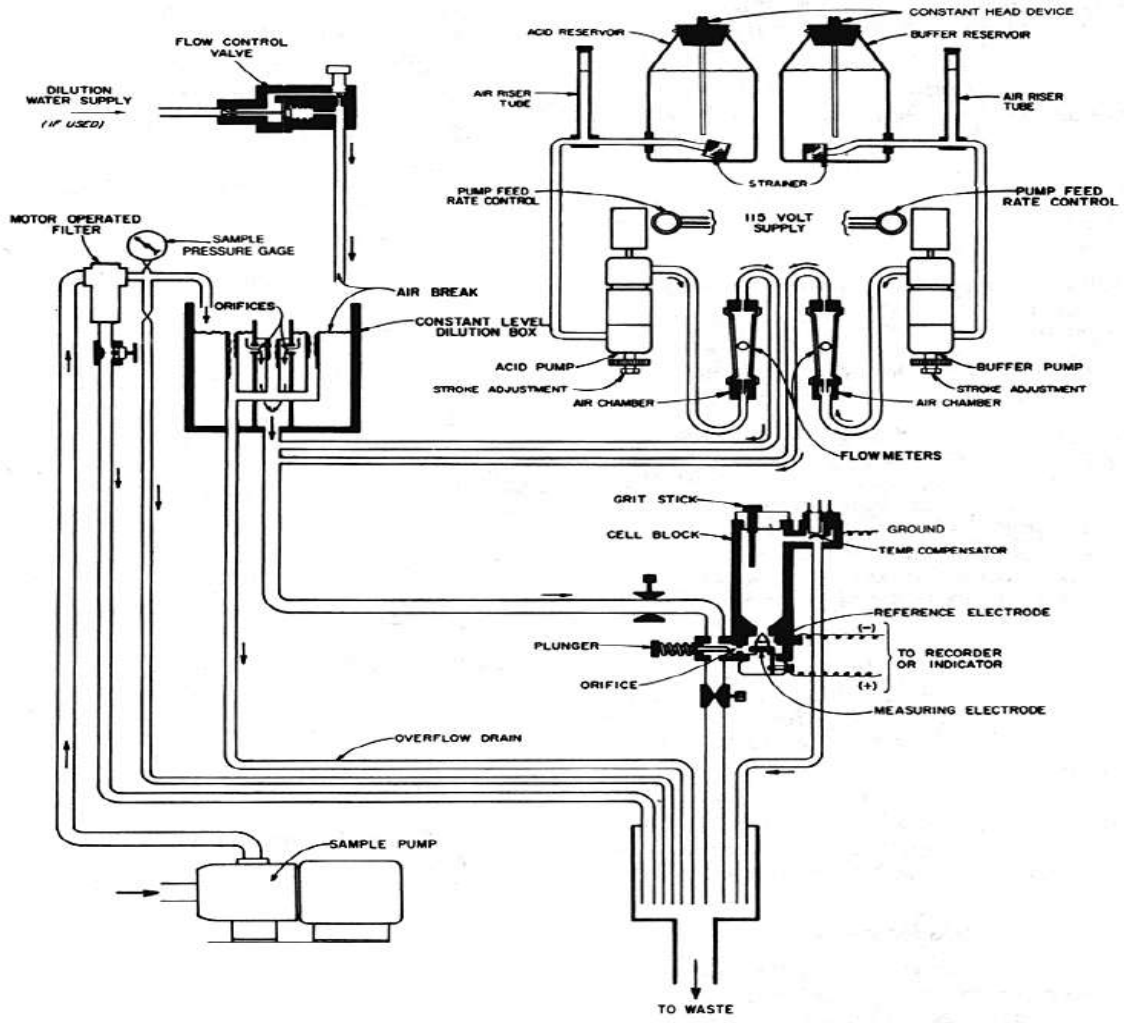
Chlorine Residual Analyzer



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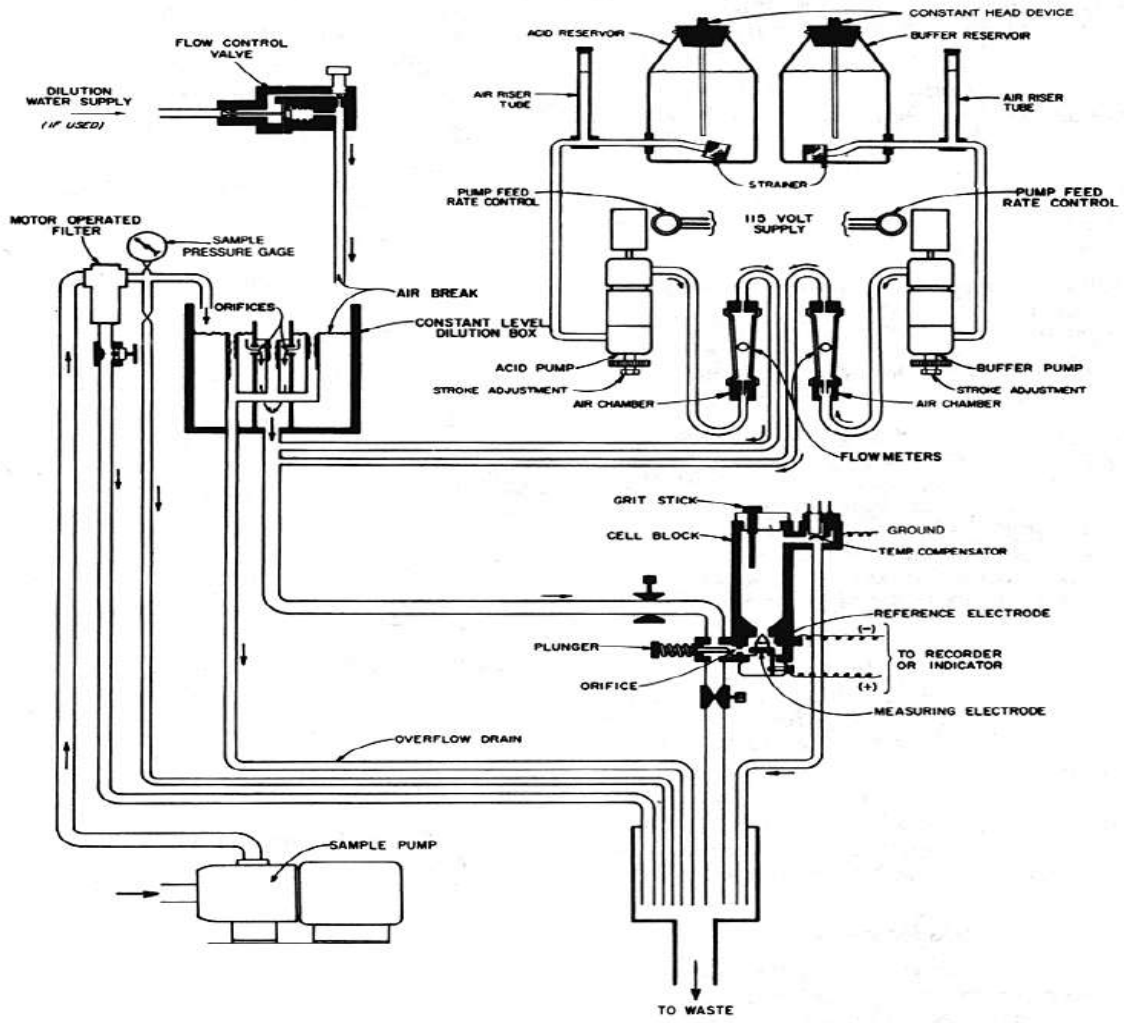
Measurement of Chlorine Residual



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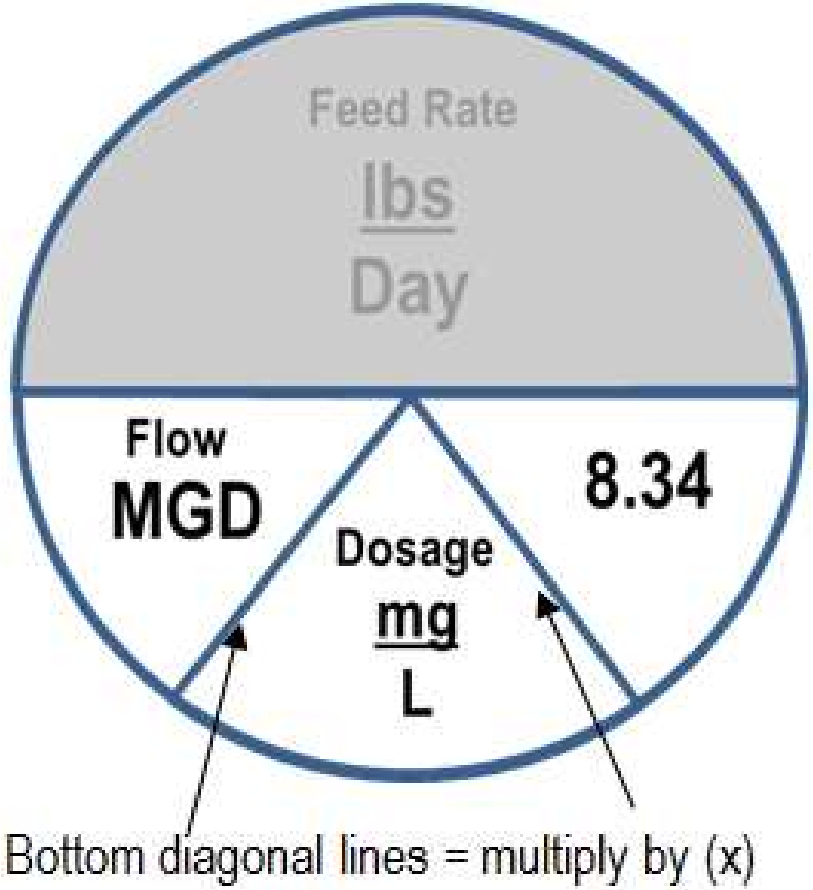
Determining Chlorine Feed Rate



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Key Points and Exercise

- Turn to page 2-10 to summarize the unit key points.
- Turn to page 2-11 for exercise

Unit 2 Exercise

1. d
2. e
3. 93.8 lbs/day
4. 0.6 mg/L

Unit 3 – Chlorine Safety & Handling

Learning Objectives

- Describe an effective chlorine safety program.
- Describe the handling procedure for each chlorine container and some of the related safety devices provided.
- Describe the measures to take in the event of a chlorine leak.

Physiological Response to Chlorine Gas

PHYSIOLOGICAL RESPONSE TO CONCENTRATIONS OF CHLORINE GAS

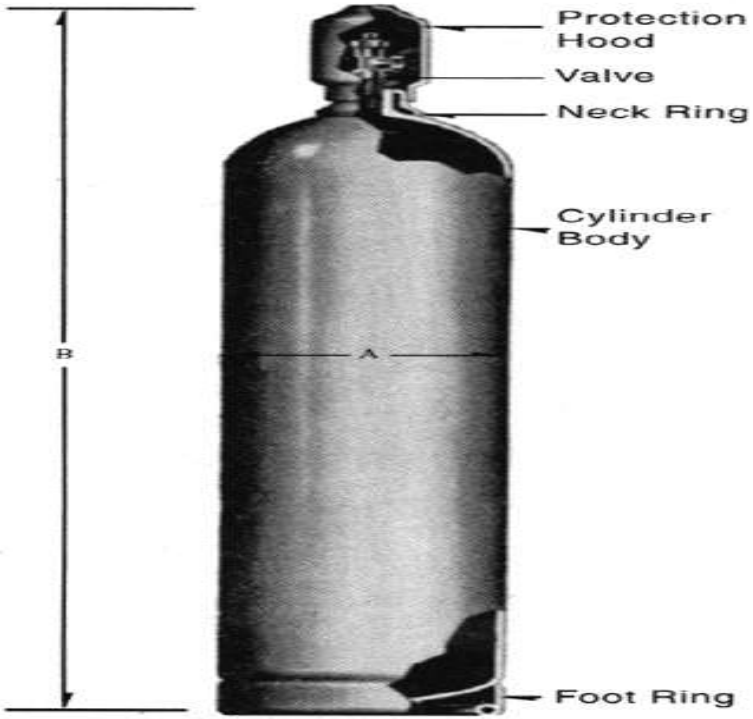
Effect	Parts of Chlorine Gas Per Million Parts of Air By Volume (ppm)
Slight symptoms after several hours' exposure	1[a]
Detectable odor	0.08 – 0.4
60-minute inhalation without serious effects	4
Noxiousness	5
Throat irritation	15
Coughing	30
Dangerous from one-half to one hour	40
Death after a few deep breaths	1,000

[a] OSHA regulations specify that exposure to chlorine shall at *NO* time exceed 1 ppm.

Personnel Safety, Protection & First Aid

Chlorine Cylinder

Chlorine Cylinder



Net Cylinder Contents	Approx. Tare, Lbs.*	Dimensions, Inches	
		A	B
100 Lbs.	73	8¼	54½
150 Lbs.	92	10¼	54½

* Stamped tare weight on cylinder shoulder does not include valve protection hood.

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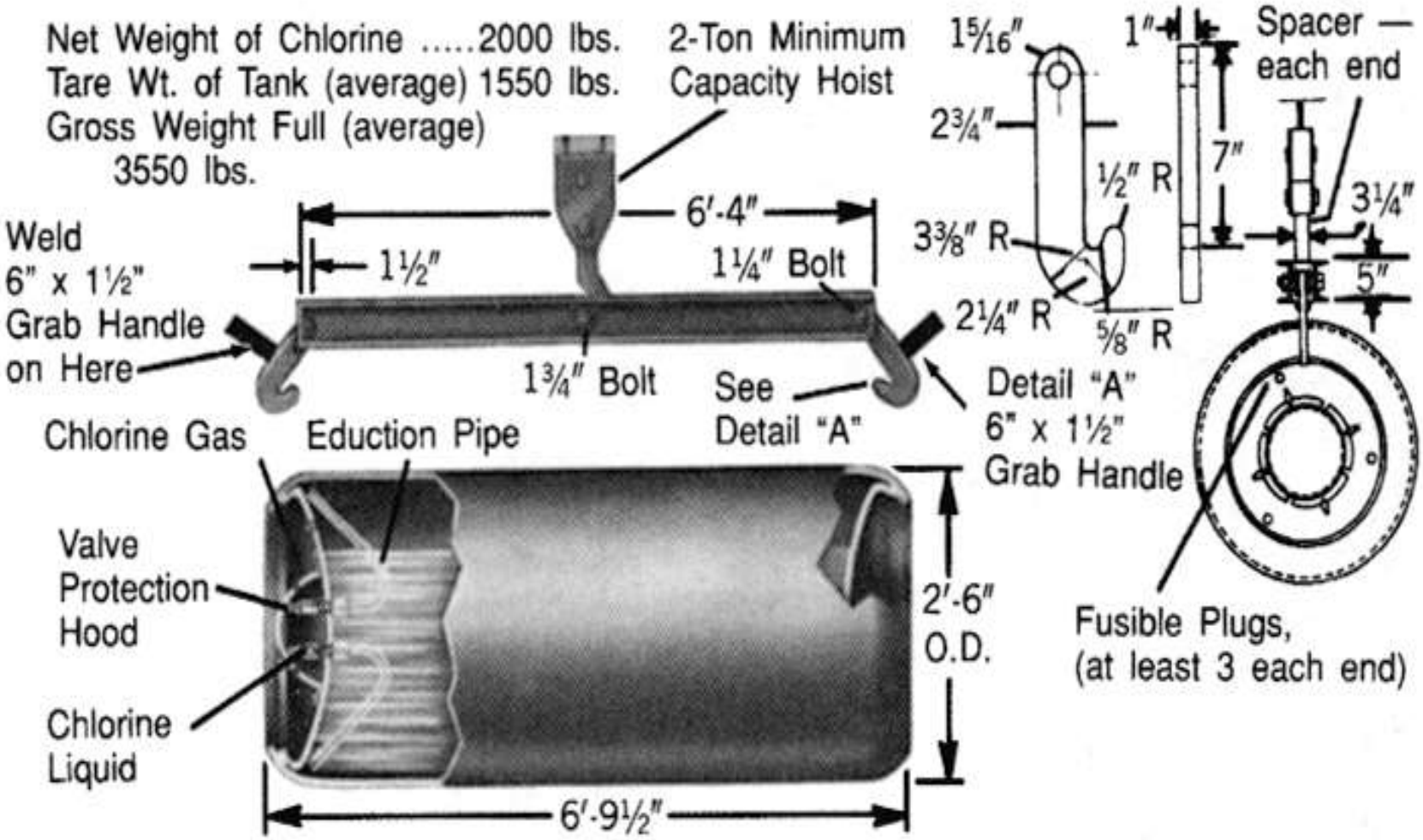
Ton Container



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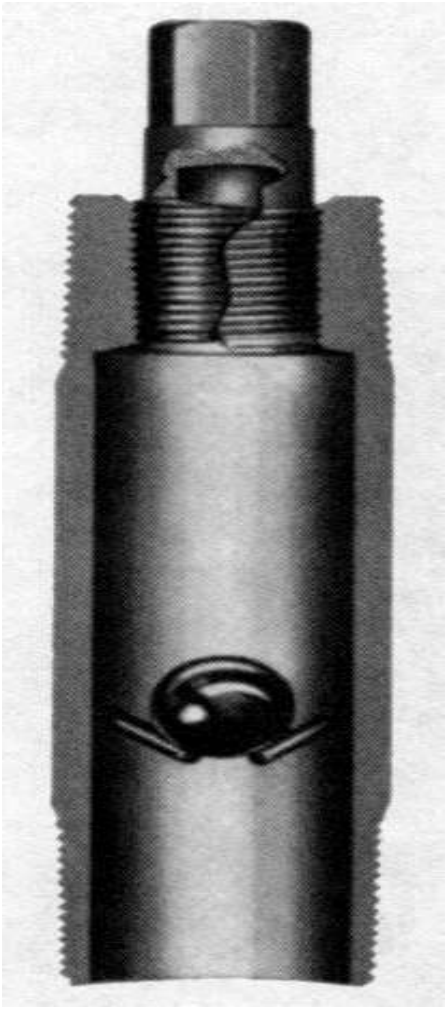
Trunnions

Excess Flow Valve



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Chlorine Leaks & Response

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Chlorine Repair Kit

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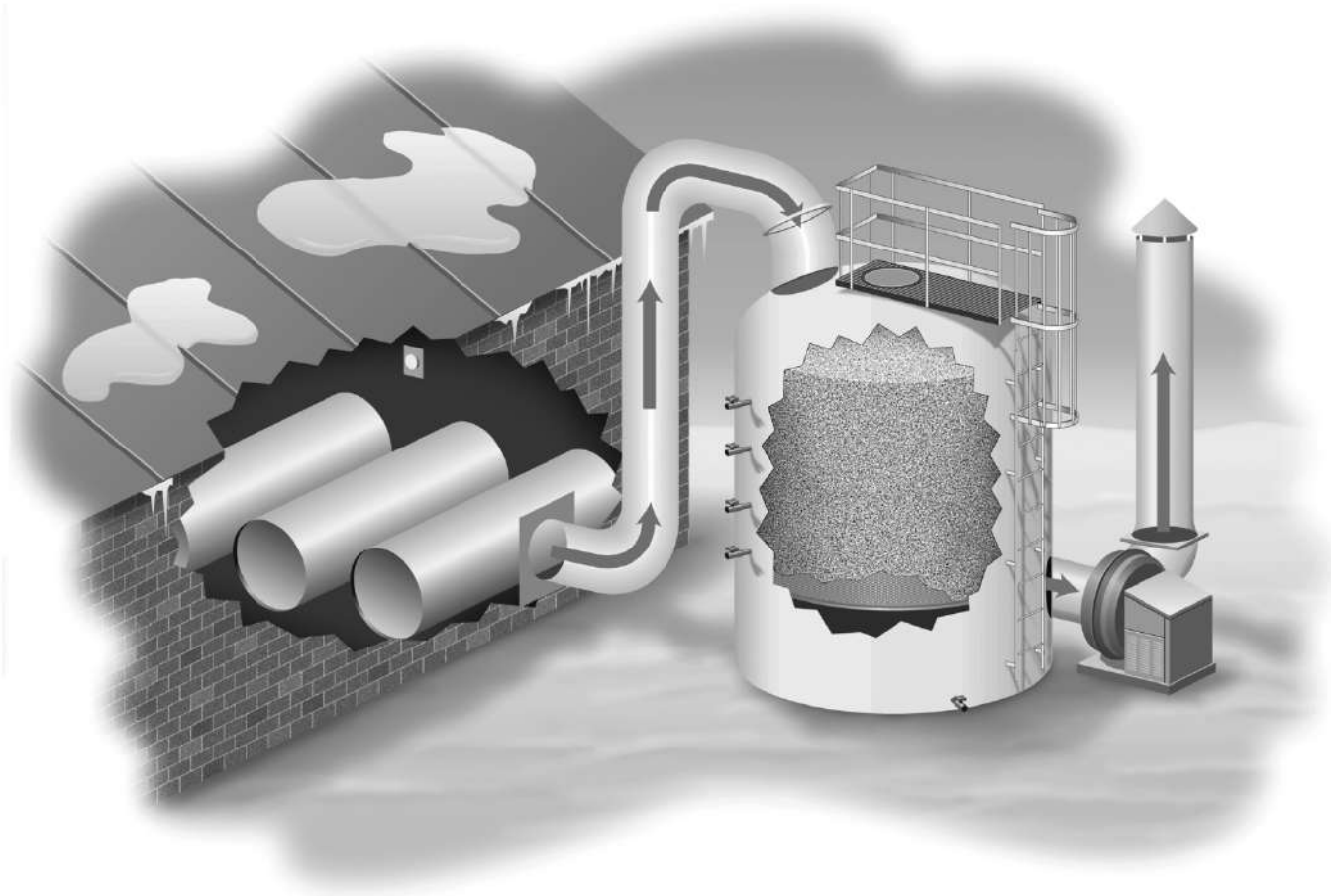
Chlorine Scrubber



Key Points and Exercise

- Turn to page 3-12 to summarize the unit key points.
- Turn to page 3-13 for exercise

Unit 3 Exercise

1. a
2. safety
3. 10
4. Risk Management
5. 158 to 165
6. 6 and 12
7. top

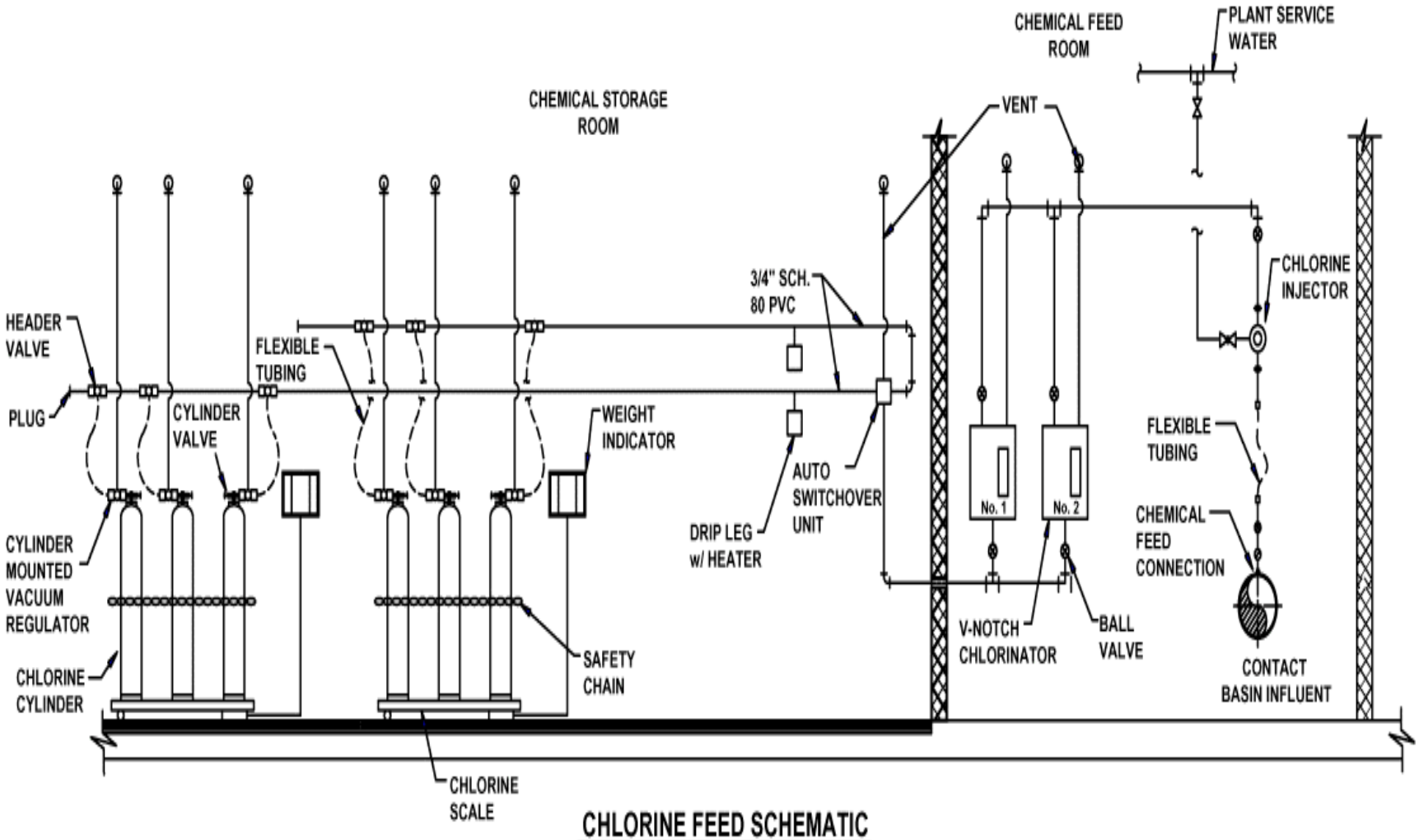
Unit 3 Exercise

8. trunnions
9. a
10. railroad tank
11. ammonia, white smoke

Learning Objectives

- Identify equipment related to a gas feed system.
- Identify equipment related to a hypochlorite feed system.
- Identify equipment related to a chlorine dioxide feed system, and how it differs from the gas and hypochlorite feed systems.

Gas Feed System



CHLORINE FEED SCHEMATIC

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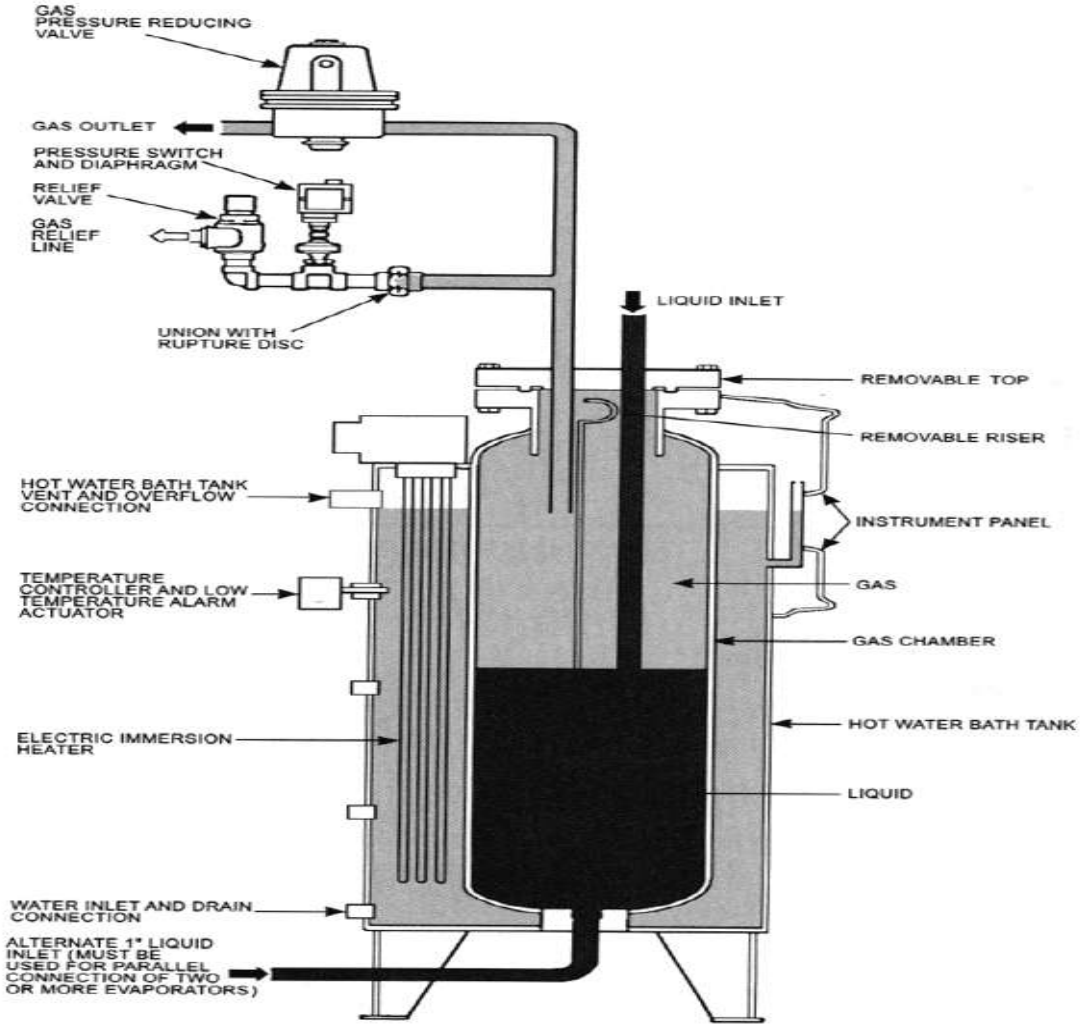
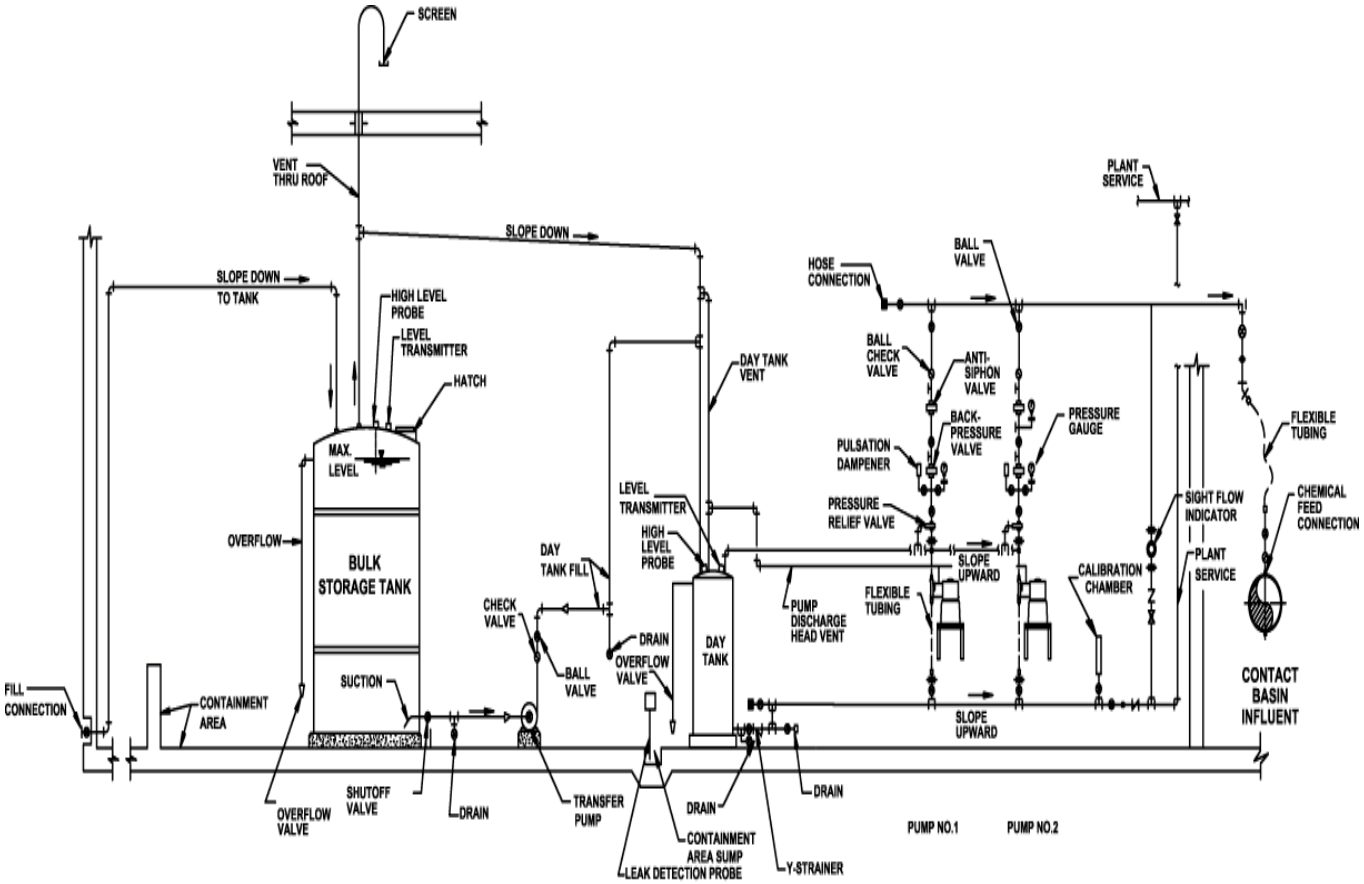
Evaporator


GAS PRESSURE REDUCING VALVE
GAS OUTLET
PRESSURE SWITCH AND DIAPHRAGM
RELIEF VALVE
GAS RELIEF LINE
UNION WITH RUPTURE DISC
LIQUID INLET
REMOVABLE TOP
REMOVABLE RISER
HOT WATER BATH TANK VENT AND OVERFLOW CONNECTION
INSTRUMENT PANEL
TEMPERATURE CONTROLLER AND LOW TEMPERATURE ALARM ACTUATOR
GAS
GAS CHAMBER
HOT WATER BATH TANK
ELECTRIC IMMERSION HEATER
LIQUID
WATER INLET AND DRAIN CONNECTION
ALTERNATE 1" LIQUID INLET (MUST BE USED FOR PARALLEL CONNECTION OF TWO OR MORE EVAPORATORS)

Sodium Hypochlorite Feed System



SODIUM HYPOCHLORITE FEED SCHEMATIC

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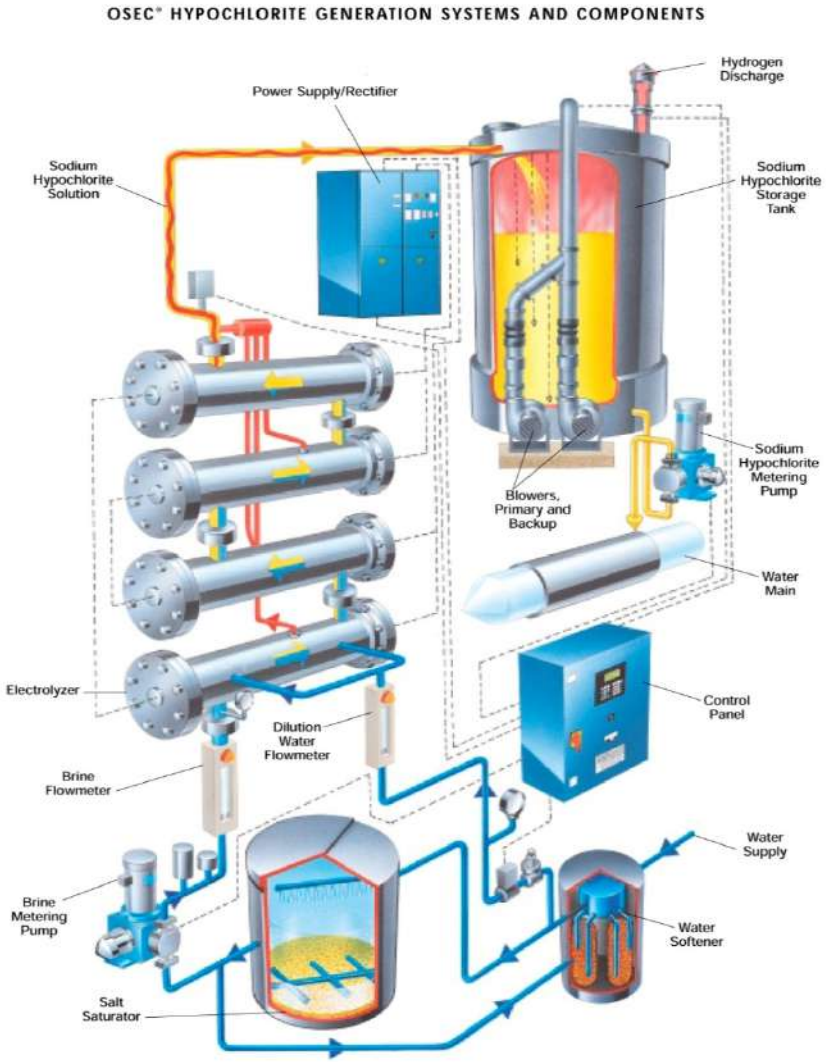
Hypochlorite Generator



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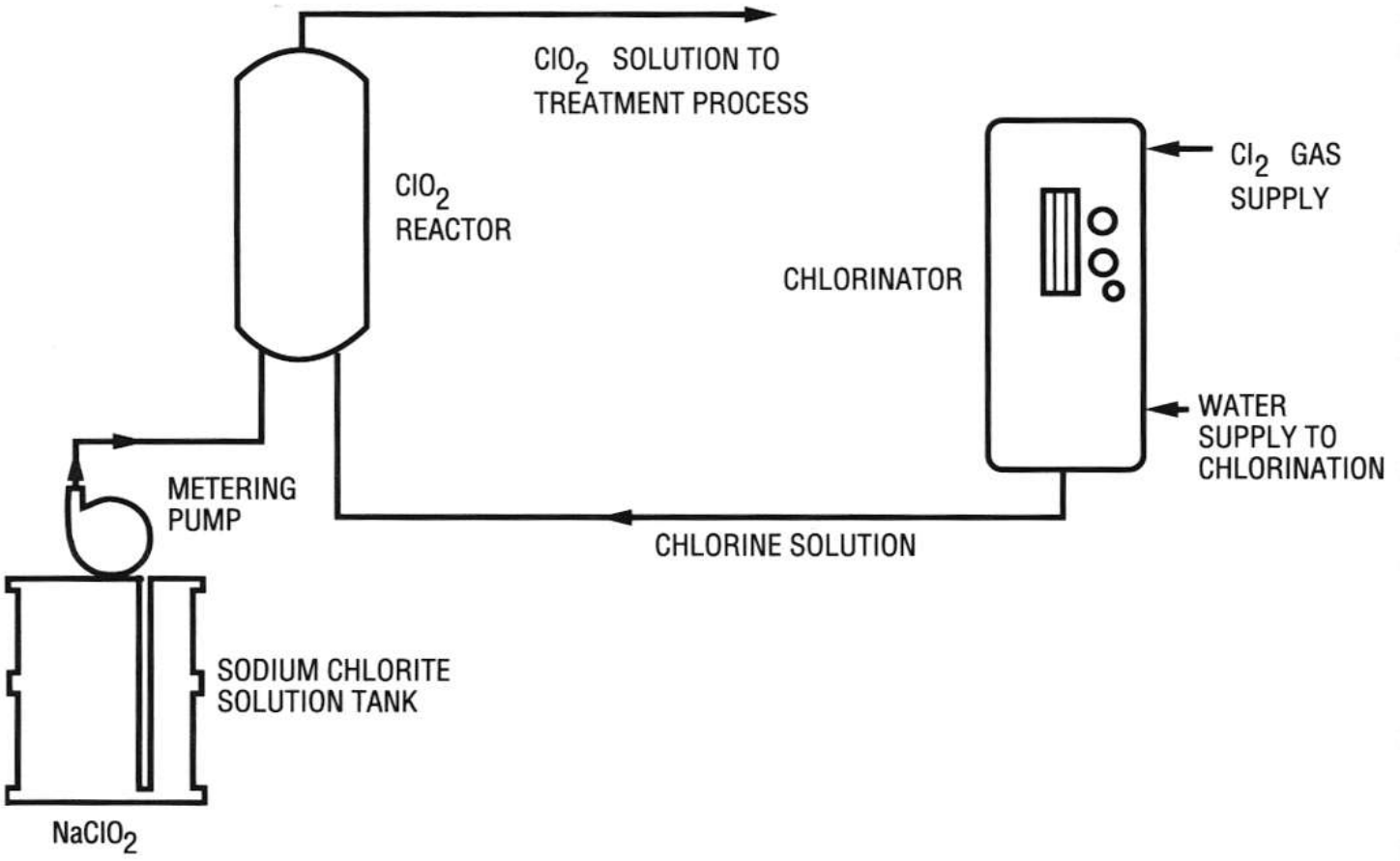
Chlorine Dioxide Facility



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Key Points and Exercise

- Turn to page 4-13 to summarize the unit key points.
- Turn to page 4-14 for exercise

Unit 4 Exercise

1. d
2. b
3. a
4. a
5. Answers may vary and include any of the components listed on pages 4-2 to 4-5.
6. Answers may vary. See page 4-7 for a list of items suggested for a maintenance plan.

Unit 5 – Dechlorination

Learning Objectives

- Describe the need for dechlorination and how it is usually accomplished.
- State the differences between the sulfur compounds used for dechlorination.

Sulfur Compounds

Checkpoint

Example 5.1: How many pounds per day of SO_2 must be fed if the plant is operating at a flow rate of 3.0 MGD, and has a chlorine residual of 5.0mg/l and the desired SO_2 residual is 0.5mg/l?

Feed Rate, lbs/day = Flow (MGD) x Dosage (mg/L) x 8.34 lbs/gal

Sulfur Dioxide Safety

Key Points and Exercise

- Turn to page 5-6 to summarize the unit key points.
- Turn to page 5-7 for exercise

Unit 5 Exercise

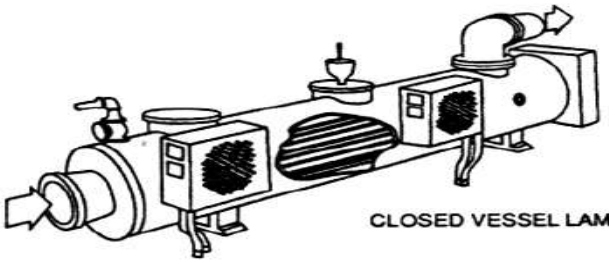
1. a
2. detention ponds, aeration, sunlight, activated carbon, and the addition of sulfur compounds.
3. c
4. a
5. 67 lbs/day

Unit 6 – Ultraviolet Radiation

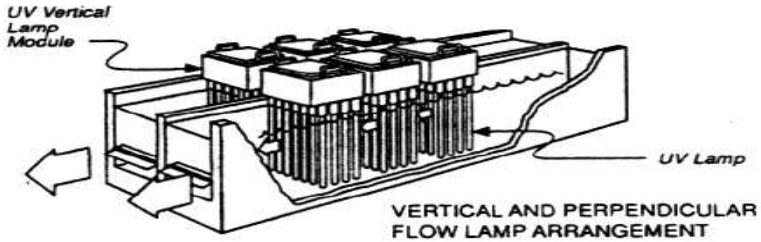
Learning Objectives

- Describe why ultraviolet (UV) radiation is an effective means of disinfection.
- State the differences between the three types of UV systems.
- Describe the UV radiation process.

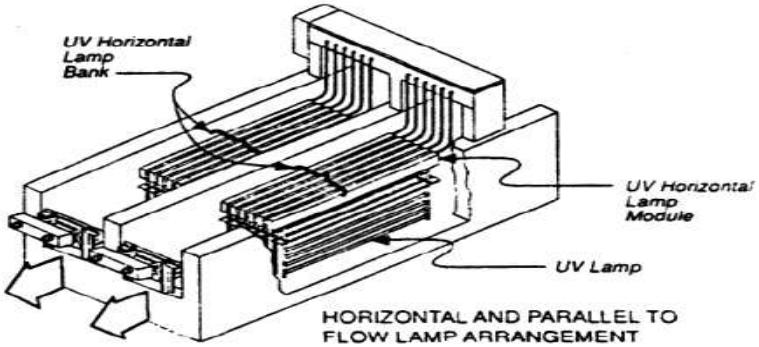
Typical UV Lamp Configurations



CLOSED VESSEL LAMP ARRANGEMENT



VERTICAL AND PERPENDICULAR TO FLOW LAMP ARRANGEMENT



HORIZONTAL AND PARALLEL TO FLOW LAMP ARRANGEMENT

WB 6-3

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Key Points and Exercise

- Turn to page 6-8 to summarize the unit key points.
- Turn to page 6-9 for exercise

Unit 6 Exercise

1. effluent turbidity
2. Sleeve, lamp
3. c
4. Closed vessel lamp, vertical & perpendicular to flow lamp, horizontal & parallel flow to lamp
5. a
6. flow pacing

Unit 6 Exercise

7. c
8. a
9. a, b & c
10. b
11. a