

# Drinking Water Operator Certification Training Instructor Guide



## Module 24: Gas Chlorination

This course includes content developed by the Pennsylvania Department of Environmental Protection (Pa. DEP) in cooperation with the following contractors, subcontractors, or grantees:

The Pennsylvania State Association of Township Supervisors (PSATS)  
Gannett Fleming, Inc.  
Dering Consulting Group  
Penn State Harrisburg Environmental Training Center



## A Note to the Instructor

Dear Instructor:

The primary purpose of *Module 24: Gas Chlorination* is to provide an overview of the use of chlorine at a water treatment plant, including some of its basic characteristics and how to handle it safely. This module has been designed to be completed in approximately 3 hours, but the actual course length will depend upon content and/or delivery modifications and results of course dry runs performed by the Pa. DEP-approved sponsor. The number of contact hours of credit assigned to this course is based upon the contact hours approved under the Pa. DEP course approval process. To help you prepare a personal lesson plan, timeframes have been included in the instructor guide at the Unit level and at the Roman numeral level of the topical outline. You may need to adjust these timeframes as necessary to match course content and delivery modifications made by the sponsor. Please make sure that all teaching points are covered and that the course is delivered as approved by Pa. DEP.

Web site URLs and other references are subject to change, and it is the training sponsor's responsibility to keep such references up to date.











Delivery methods to be used for this course include:

- Lecture
- Exercises

To present this module, you will need the following materials:

- |   |   |
|---|---|
| <ul style="list-style-type: none"> <li>• One workbook per participant</li> <li>• Extra pencils</li> <li>• Laptop (loaded with PowerPoint) and an LCD projector <b>or</b> overheads of presentation and an overhead projector</li> </ul> | <ul style="list-style-type: none"> <li>• Screen</li> <li>• Flip Chart</li> <li>• Markers</li> </ul> |
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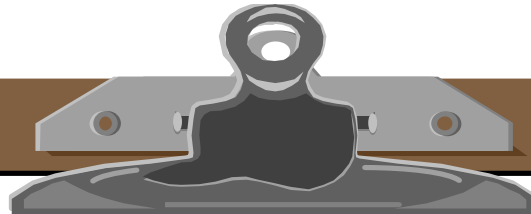
Icons to become familiar with include:

Participant Workbook	Instructor Guide
 Exercise/Activity	<p>Same icons for Participant Workbook apply to the Instructor Guide.</p> <p><b>Ans:</b> Answer to exercise, case study, discussion, question, etc.</p>  PowerPoint Slide
 Case Study	
 Discussion Question	
 Calculation(s)	
 Quiz	
 Key Definition(s)	
 Key Point(s)	
	 Flip Chart
	 Suggested "Script"

Instructor text that is meant to be general instructions for the instructor are designated by being written in script font and enclosed in brackets. For example:

*[Ask participants if they have any questions on how to read the table. Answer any questions participants may have about how to read the table.]*

If your module includes the use of a PowerPoint presentation, below are some helpful controls that you may use within the Slide Show.



### **PowerPoint Slide Show Controls**

You can use the following shortcuts while running your slide show in full-screen mode.

<b>To</b>	<b>Press</b>
Advance to the next slide	N, ENTER, or the SPACEBAR (or click the mouse)
Return to the previous slide	P or BACKSPACE
Go to slide <number>	<number>+ENTER
Display a black screen, or return to the slide show from a black screen	B
Display a white screen, or return to the slide show from a white screen	W
Stop or restart an automatic slide show	S
End a slide show	ESC
Return to the first slide	Both mouse buttons for 2 seconds
Change the pointer to a pen	CTRL+P
Change the pen to a pointer	CTRL+A
Hide the pointer and button temporarily	CTRL+H
Hide the pointer and button always	CTRL+L
Display the shortcut menu	SHIFT+F10 (or right-click)
Erase on-screen annotations	E
Go to next hidden slide	H
Set new timings while rehearsing	T
Use original timings while rehearsing	O
Use mouse-click to advance while rehearsing	M

## INSTRUCTOR GUIDE

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### INTRODUCTION OF MODULE: 5 minutes



Display Slide 1—Module 24: Gas Chlorination.

Welcome participants to “Module 24 – Gas Chlorination.” Indicate the primary purpose of this course is to provide an overview of the use of chlorine at a water treatment plant, including some of its basic characteristics and how to safely handle chlorine.

*[Introduce yourself.]*

*[Provide a brief overview of the module.]*



This module contains 4 units. On page i, you will see the topical outline for **Unit 1 – General Chemistry and Characteristics** and **Unit 2 – Chlorine Handling and Safety**.

*[Briefly review outline.]*

## INSTRUCTOR GUIDE

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On this page, you will see the topical outline for **Unit 3 – Application of Gas Chlorine** and **Unit 4 – Formation of Alternate Chlorine Compounds and Dechlorination**. Also an **Appendix** is provided with a sample **MSDS Sheet**.

*[Continue to briefly review outline.]*

## INSTRUCTOR GUIDE

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### UNIT 1: 60 minutes



Display Slide 2—Unit 1: General Chemistry and Characteristics.



At the end of this unit, you should be able to:

- Explain the purpose of chlorination.
- Describe the two forms of chlorine.
- Describe the properties of liquid chlorine and gaseous chlorine.



Display Slide 3—Unit 1: General Chemistry and Characteristics.



At the end of this unit, you should be able to:

- Explain how chlorine reacts in aqueous solutions.
- Read and explain chlorine reaction equations.

## **INSTRUCTOR GUIDE**

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**GENERAL DESCRIPTION: 10 minutes**



We will begin this unit with a general overview of chlorine, including its purpose in water treatment and the different forms of chlorine that exist.

### **Purpose of Chlorination**

*[Explain the purpose of chlorination as listed in the workbook.]*

### **Disinfection**

*[Review the information in the workbook on disinfection.]*

### **Oxidation**

*[Review the information in the workbook on oxidation.]*



### Forms of Chlorine



As you can see, the use of chlorine in water treatment is essential. At this point, our discussion will turn to the two different forms of chlorine, which are liquid and gas.

### Elemental Chlorine

*[Review the information in the workbook on elemental chlorine.]*

### Forms of Chlorine in Solution



There are two forms of chlorine in solution. Without consulting your workbook can anyone tell me what those two forms are?

*[Review the information in the workbook on the two forms of chlorine in solution.]*

### PROPERTIES OF CHLORINE: 20 minutes



Now that we have completed our general overview of chlorine, we will talk about some specific properties of chlorine, beginning with a discussion of liquid chlorine.

### Liquid Chlorine

*[Review the first bullet in the workbook.]*



Let's take a look at Table 1.1, which lists some of the properties of liquid chlorine.

*[Review the information listed in the table.]*

### Vapor Pressure



Vapor pressure is another key property of liquid chlorine that merits further discussion.

[Review the information in the workbook.]



Display Slide 4—Vapor Pressure of Liquid Chlorine.



This slide shows a plot of temperature, along the x-axis, vs. vapor pressure, along the y-axis. As we move from left to right along the x-axis, the temperature is increasing. Likewise, as we move from the bottom to the top of the y-axis, the vapor pressure is rising. Using the curve data in the table, this curve has been plotted and you can see that the vapor pressure increases along with the temperature.



**Exercise:** Using the graph in Fig. 1.1, fill in the data points that are missing in the above table.

**Answer: (In bold)**

Curve Data	
Temp. (°F)	Press. (psig)
-29.29	<b>0</b>
-10	8.29
<b>0</b>	13.81
20	27.84
40	46.58
60	70.91
80	<b>101.76</b>
100	<b>140.20</b>
120	<b>186.95</b>
140	243.33
160	310.35
180	389.17
<b>200</b>	480.97
220	587.13

### Gaseous Chlorine



As mentioned earlier, there are two forms of chlorine. We will now discuss the properties of the second form, gaseous chlorine.

*[Review the information in the workbook.]*

## INSTRUCTOR GUIDE

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### CHEMISTRY OF CHLORINE: 30 minutes



Now that we are familiar with the properties of liquid and gaseous chlorine, let's take some time to review the chemistry of chlorine.

#### Reactions in Aqueous Solutions



Display Slide 5—Chlorine Added to Chemically Pure Water.

*[Review the first bullet item in the workbook.]*



As you can see in this equation, on the left side of the equation we have the chlorine ( $\text{Cl}_2$ ) and the water ( $\text{H}_2\text{O}$ ). These react and produce the hypochlorous acid ( $\text{HOCl}$ ), and the hydrochloric acid ( $\text{HCl}$ ), which we see on the right side of the equation.

*[Review next two bullet items in the workbook.]*



Display Slide 6—Dissociation of Hypochlorous Acid.



This slide demonstrates the dissociation of hypochlorous acid we just mentioned. The hydrogen and hypochlorite ions are represented on the right side of the equation by  $\text{H}^+$  and  $\text{OCl}^-$ . It is the “+” or “-” beside the hydrogen and hypochlorite that indicate they are ions.

*[Review the next two bullet items in the workbook.]*



Display Slide 7—Distribution of  $\text{HOCl}$  and  $\text{OCl}^-$  in Water.



This slide is a visual representation of the fact that chlorine can exist in water as both  $\text{HOCl}$  and  $\text{OCl}^-$ . If you look at the left side of the x-axis, in the pH range of 4 to 6, you will see that predominately  $\text{HOCl}$  exists in water. As we begin to shift to the higher side of the pH range, for example, pH 9 to 11, we see that predominately  $\text{OCl}^-$  exists. In between the high and low pH ranges, both  $\text{HOCl}$  and  $\text{OCl}^-$  exist in water.

## **INSTRUCTOR GUIDE**

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*[Review the Key Points for Unit 1 Chemistry of Chlorine.]*

## INSTRUCTOR GUIDE

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[Allow participants ten minutes to complete the exercise and then review answers with them. Participants should complete exercise individually.]



### Exercise

1. What is the purpose of chlorination?

**Ans:** Disinfection and oxidation in water treatment.

2. What are the two different forms of chlorine?

**Ans:** liquid chlorine and gaseous chlorine.

3. What are four of the nine properties of liquid chlorine?

**Ans:** Any four of the nine answers in this table will be acceptable.

Critical Temperature	144°C; 291.2°F
Critical Pressure	1118.4 psia
Critical Density	38.77 lbs/ cu ft
Density (at 32°F & 1 atm)	91.67 lbs/cu ft
Specific Gravity (at 68°F)	1.41 (water = 1)
Boiling Point	-34.5°C; -30.1°F
Freezing Point	-100.98°C; -149.76°F
Viscosity (at 68°F)	0.342 centipoise (approx 0.35 x water)
1 pound liquid (at 32°F & 1 atm)	4.98 cu ft gas

4. What are the specific gravity and solubility in water of gaseous chlorine?

**Ans:** The correct answers are in bold type.

Density (at 32°F & 1 atm)	0.2006 lbs/ cu ft
<b>Specific Gravity (at 32°F &amp; 1 atm)</b>	<b>2.482 (air = 1)</b>
Liquefying Point (at 1 atm)	-30.1 °F
Viscosity (at 68°F)	0.01325 centipoise
<b>Solubility in Water</b>	<b>60.84 lbs/1000 gal</b>



We have now completed the first unit of this module. You should have an understanding of the general chemistry and characteristics of chlorine at this point. In our next unit, we will discuss chlorine handling and safety.

## INSTRUCTOR GUIDE

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### UNIT 2: 50 minutes



Display Slide 8—Unit 2: Chlorine Handling and Safety.



At the end of this unit, you should be able to:

- Identify a MSDS and explain its significance.
- Explain the health and environmental hazards of chlorine.
- Identify the basic personnel safety protection equipment and explain its importance.



Display Slide 9—Unit 2: Chlorine Handling and Safety.



- List and explain the appropriate first aid procedures for chlorine handling and safety.
- Explain where chlorine leaks can occur, how to detect them, and how to repair and respond to them.
- Explain the importance of a risk management plan and identify its basic components.



Display Slide 10—Unit 2: Chlorine Handling and Safety.



- Explain how the quantity of chlorine impacts the storage of it.
- List the common types of chlorine storage containers.
- List and describe the basics of a chlorine storage facility.



## INSTRUCTOR GUIDE

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### SAFETY CONSIDERATIONS AND PROGRAMS: 20 minutes



In this unit we will review essential safety considerations and programs related to chlorine as well as proper chlorine handling and storage. We will begin with safety considerations and programs.

### Material Safety Data Sheet (MSDS)



The MSDS is a document produced by the chemical manufacturer and provided to chemical users in accordance with the Federal and State requirements. It provides useful information about the chemical and can be developed in a variety of formats; however, all MSDS's contain some common elements, which we will review shortly.

*[Review the information in the workbook.]*



An example MSDS is located in the appendix. We will use that document to answer the following 3 questions.

### Chlorine Hazards



Now that you are familiar with the MSDS, we are going to use it to find out some information about the hazards of chlorine. Take five minutes to answer the questions in your workbook about chlorine.

#### Health Hazards



Using the sample MSDS in the workbook, answer the following questions about chlorine hazards:

1. What effect does liquid chlorine have on the skin and eyes?

**Ans:** It is corrosive to skin and eyes and can cause frostbite burns. Skin contact may result in skin irritation with discomfort or a rash. Eye contact can cause eye irritation with discomfort, tearing or blurred vision. Permanent eye damage is possible as well as blindness.

2. What effect does gaseous chlorine have on the nose, throat and lungs?

**Ans:** It is extremely irritating to the nose, throat and lungs. Gross overexposure can cause death.

3. What effect does exposure to gaseous chlorine have on heartbeat and pulse?

**Ans:** It may temporarily alter the electrical activity of the heart with irregular pulse, palpitations or inadequate circulation. Gross overexposure could result in death.

#### Environmental



In addition to health hazards, chlorine can cause environmental hazards as well.

*[Review the information in the workbook.]*

### Personnel Safety Protection



As a result of its hazardous nature, handling chlorine requires specific safety protection equipment, which we will now review.

### Basic Equipment

*[Review the information in the workbook.]*



Be sure to review the key point listed in the workbook.

### First Aid



In spite of all the protective equipment available, sometimes accidents will occur and someone may be exposed to chlorine; therefore, you should be familiar with some basic first aid guidelines regarding chlorine.

#### Inhalation



If someone inhales chlorine, the following first aid guidelines should be followed:

*[Review the guidelines in the workbook.]*

#### Skin Contact



In the event that chlorine comes in contact with skin, these first aid guidelines should be followed:

*[Review the guidelines in the workbook.]*

#### Eye Contact



In the event of chlorine contact with the eyes, these first aid guidelines should be followed:

*[Review the guidelines in the workbook.]*

### Ingestion



If someone ingests chlorine, these first aid guidelines should be followed:

*[Review the guidelines in the workbook.]*

### Chlorine Leaks and Response



There is always a risk of a chlorine leak. You need to be aware of where leaks may occur and how to detect them and what to do in the event a leak actually occurs. We will spend the next few minutes reviewing this information.

#### **Potential Points of Chlorine Leaks**

*[Review the information in the workbook.]*

#### **Leak Detection**

*[Review the information in the workbook.]*

#### **Leak Repair**

*[Review the information in the workbook.]*

*[Continue to review the information in the workbook.]*

### Other Chlorine Emergency Measures

#### Fire



Another potential issue with chlorine is fire. You should be aware of this potential hazard and how to respond in the event it actually happens.

*[Review the information in the workbook.]*

### Risk Management Plan



One way to minimize chlorine hazards and be prepared to handle them in the rare event that they occur is to do some up-front planning and preparation. A risk management plan can help minimize chlorine related accidents.

*[Review the information in the workbook.]*



## INSTRUCTOR GUIDE

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### CHLORINE HANDLING AND STORAGE: 30 minutes



Now that we have discussed various safety considerations regarding chlorine, you see that it can be quite a dangerous chemical. Proper handling and storage of chlorine is required and will minimize any hazards. This next section of the unit will focus on chlorine handling and storage.

### Quantities

#### Storage Requirements

*[Review the information in the workbook.]*

### Types of Storage Containers



There are several types of storage containers used for chlorine. We will discuss some of them now.

#### 100 and 150 lb. Cylinders

*[Review the information in the workbook.]*



Display Slide 11—A 150 lb Chlorine Cylinder.



This slide shows a 150 lb chlorine cylinder. You will see that it is positioned vertically as we just discussed and restraint chains are being used.

### Ton Containers



Ton containers are another form of chlorine storage.

*[Review the information in the workbook.]*



Display Slide 12—Ton Cylinders.



This slide is an example of a ton cylinder. You will see that they are positioned on roller trunions as we discussed and the valves are in the vertical position.

### Tank Cars



In some situations, tank cars are also used for chlorine storage.

*[Review the information in the workbook.]*

### Storage Facilities



Not only is chlorine stored in containers, but it is also stored in facilities. As you can imagine, there are some specific requirements that should be adhered to for chlorine storage facilities. Let's discuss them further.

### Basic Facilities and Housing

*[Review the information in the workbook.]*

[Continue to review the information in the workbook.]

### **Entrance (Ingress) and Exit (Egress) Requirements**



Because of chlorine's hazardous nature, chlorine storage facilities have specific requirements regarding access to the facility.

[Review the information in the workbook.]

### **Heating**



Specific temperature guidelines regarding chlorine should be followed.

[Review the information in the workbook.]

### **Ventilation**



The inhalation hazards related to chlorine require that storage facilities be properly ventilated.

[Review the information in the workbook.]

### **Lighting**

[Review the information in the workbook.]

### Chlorine Scrubbers



In the event of a chlorine spill, specific equipment is needed to clean the spill. Chlorine scrubbers will aid in accomplishing this task.

#### **Description of Equipment**

*[Review the information in the workbook.]*

#### **Description of Process**

*[Review the information in the workbook.]*

#### **Caustic Soda Type**

*[Review the information in the workbook.]*

#### **Solid Media Type**

*[Review the information in the workbook.]*



Although chlorine is essential for disinfection and oxidation of drinking water, it is still a chemical that presents danger if not properly handled. By now you should be aware of the hazards associated with chlorine and you should be knowledgeable about how to handle chlorine in a safe manner.

## **INSTRUCTOR GUIDE**

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*[Have the class review the Key Points for Unit 2 – Chlorine Handling and Storage.]*



### **Exercise for Unit 2 – Chlorine Handling and Storage.**

1. Explain the meaning of a MSDS.

**MSDS stands for Material Safety Data Sheet and is provided for every chemical by the manufacturer. It contains very important information concerning the chemical and should be kept in a file near where the chemical is used.**

2. List two undesirable health effects from Chlorine exposure.

**Answers may include: skin irritation, eye irritation, nausea, headache, breathing difficulties, irregular pulse and others as listed in the MSDS including death in severe cases.**

3. List two ways of detecting Chlorine leaks.

**Answers could include: your sense of smell, chlorine detection equipment, or a rag saturated with strong ammonia solution will indicate leaks by the presence of white fumes.**

4. What are three types of storage containers for Chlorine?

**Answers are cylinders (100 and 150 lb.), ton containers, and railroad tank cars.**

5. List at least three characteristics of an appropriate storage facility for Chlorine.

**Answers could include: clean, cool, well ventilated area. Storage rooms should be free of combustible materials and should be away from heat sources. Cylinder storage and chemical feed operations should be in separate rooms. Other possible answers are listed in the text for Unit 2.**

6. What are the two basic types of Chlorine Scrubbers?

**The two types of chlorine scrubbers are caustic solution and solid media types.**

## INSTRUCTOR GUIDE

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### UNIT 3: 45 minutes



Display Slide 13—Unit 3: Application of Gas Chlorine.



At the end of this unit, you should be able to:

- List and explain the components of each of the following pieces of equipment:
  - Gas feed system
  - Liquid vaporizers
  - Monitoring equipment
  - Chemical feed control
  - Perform chlorine feed computations

## INSTRUCTOR GUIDE

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### PROCESS OF DISINFECTION: 25 minutes



In this unit, we are going to discuss the actual disinfection process as well as the various types of equipment used in the process and the operation and maintenance of that equipment.

### Chlorination Mechanics and Terminology



Before we discuss the disinfection process, you should be familiar with some of the mechanics and terminology used when referring to chlorination.

*[Review the information in the workbook.]*



Review the definition of chlorine demand.



Review the definitions in the workbook.



### Breakpoint Chlorination



Now that we have reviewed the terminology, we will talk about the process of breakpoint chlorination.



Review the definition of breakpoint chlorination in the workbook.



Display Slide 14—Breakpoint Chlorination Curve.



This slide shows the breakpoint chlorination curve. Assume the water being chlorinated contains some iron, nitrate, and organic matter. The addition of a small amount of chlorine will react (oxidize) the iron and nitrate (no disinfection and no chlorine residual). Addition of more chlorine will react with the organics forming chlororganics and chloramines, as we see on the left where the curve begins. The chloramines produce a combined chlorine residual—a chlorine residual combined with other substances. Some disinfecting strength is lost since combined residuals have somewhat poor disinfecting power. As we move to the left of the curve, we see the addition of still more chlorine will destroy the chloramines and some of the chlororganics. Finally, by adding one last amount of chlorine, we get free available residual chlorine, which is the chlorine that is available and will react if necessary. This is the best residual for disinfection because it disinfects faster and with no chlorine or “swimming pool” odor associated with combined residual chlorine. Free available residual chlorine begins to form at the BREAKPOINT.

### Regulatory Requirements



The disinfection process is subject to many different regulatory requirements. We will highlight some of those requirements now.

*[Review the information in the workbook.]*

*[After the first sub-bullet, share the following with the participants:]*



1 log is 90%, 2 log is 99%, 3 log is 99.9% and 4 log is 99.99%.

*[Continue to review the information in the workbook.]*

## INSTRUCTOR GUIDE

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*[After the third sub-bullet, share the following with the participants:]*



This manual, published by the EPA, establishes the procedures and guidance for complying with the EPA Surface Water Treatment Rule (SWTR). Related to disinfection, as used in this module, it outlines the established methodology for computing the contact time (CT) and contains tables in Appendix E which outline the inactivations achieved by the several disinfectants under varying treatment plant operating conditions. It should be available at your plant.

*[Review the remaining information in the workbook.]*

*[Next, work the CT example with the class.]*



### Example:

Calculate the CT product, or Contact Time, for a ground water supply not under the influence of surface water intrusion. Assume that the concentration **C** is 0.25 mg/L and that the time **T** is 25 minutes.

**Answer:**       **$C \times T = \text{Concentration} \times \text{Time}$**

**$C \times T = 0.25 \text{ mg/l} \times 25 \text{ min.}$**

**$C \times T = 6.25 \text{ mg} \times \text{min} / \text{l}$**

### Process Calculations



Our discussion will now focus on calculations associated with the chlorination process. As a treatment plant operator, you should be able to perform these calculations.

#### Chlorine Dosage Calculation

*[Review the information in the workbook.]*

#### Chlorine Demand Calculation

*[Review the information in the workbook.]*



### Sample Calculations



Let's take a look at a sample chlorine dosage calculation.

*[Review the problem with the participants.]*

#### **Step 1: Calculate chlorine dosage in mg/l**

*[Review step 1.]*

### **Step 2: Calculate Chlorine Demand in mg/l**

*[Review step 2.]*



### Exercise

1. What is produced when chlorine reacts with organic matter in the water?

**Ans: Chlororganics and chloramines.**

2. Explain what breakpoint chlorination is.

**Ans: Breakpoint chlorination is the addition of chlorine until all chlorine demand has been satisfied. It is used to determine how much chlorine is required for disinfection.**

3. A water treatment plant operating at 750,000 gallons per day adds 3.0 mg/l of chlorine for disinfection. After a 30 minute contact period, the chlorine residual is measured at 1.35 mg/l. Compute the chlorine demand of this water.

**Ans: Compute the chlorine demand in mg/l.**

$$\text{Chlorine Demand (mg/l)} = \text{Chlorine Dose (mg/l)} - \text{Chlorine Residual (mg/l)}$$

$$\text{Chlorine Demand (mg/l)} = 3.0 \text{ mg/l} - 1.35 \text{ mg/l}$$

$$\text{Chlorine Demand (mg/l)} = 1.65 \text{ mg/l}$$

4. What is the definition of chlorine residual?

**Ans: Chlorine Residual = Chlorine Dose – Chlorine Demand**

## INSTRUCTOR GUIDE

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### CHLORINE FEED EQUIPMENT, OPERATION AND MAINTENANCE: 20 minutes



You should now have an understanding of the disinfection process and how to perform process calculations. For the remainder of this unit we are going to discuss chlorine feed equipment and its operation and maintenance.

#### Gas Feed System



Display Slide 15—Gas Chlorination System Schematic.



This slide shows a typical gas feed system. We will use this slide to review the major components of the system

### **Major Components**

*[Review each bullet item in the workbook. As you review each bullet item, point out the location on the slide.]*



### Chlorine Evaporator

#### Major Components



The next piece of equipment we will review is the chlorine evaporator.

*[Review the information in the workbook.]*

### Monitoring Equipment



In addition to the gas feed system and the chlorine evaporator, there are key pieces of monitoring equipment you should be familiar with. We will discuss some of those now.

*[Review the information in the workbook.]*

### Chemical Feed Control



Next we will highlight different types of chemical feed control equipment.

#### **Manual**

*[Review the information in the workbook.]*

#### **Start-Stop**

*[Review the information in the workbook.]*

#### **Flow Proportional**

*[Review the information in the workbook.]*

#### **Chlorine Residual**

*[Review the information in the workbook.]*

#### **Compound Loop**

*[Review the information in the workbook.]*

### System Operation

#### Normal Operation



As a treatment plant operator, you need to be knowledgeable about the operation of various parts of the chlorine feed system. You should be able to tell when the system is operating normally and when it is not.

#### Container Storage Area



Certain aspects of the container storage area should be checked on a daily, weekly or monthly basis. Let's discuss those now.

*[Review the information in the workbook.]*

### ***Chlorinators and Injectors***



Like the container storage area, parts of the chlorinators and injectors should be checked on a daily, weekly or monthly basis.

*[Review the information in the workbook.]*

### ***Evaporators***



The evaporators should be checked on a daily basis for the following:

*[Review the information in the workbook.]*

### Abnormal Operation



As mentioned previously, you should be familiar with typical abnormal operating conditions that you may encounter. Let's discuss what some of those conditions are and how you can resolve them.

*[Review the information in the workbook.]*



You should now be familiar with the components of the various pieces of equipment used in the chlorination process and you should be able to perform chlorine feed computations. In our next unit, we will learn about alternate chlorine compounds and dechlorination.

## **INSTRUCTOR GUIDE**

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[Have the class read the Key Points for Unit 3 – Chlorine Feed Equipment, Operation, and Maintenance. Discuss further as needed.]



### **Exercise for Unit 3.**

1. What is the percentage of inactivation for a 2 log and a 4 log process?

**Ans: 2 log = 99%**

**4 log = 99.99%**

2. Explain the meaning of chlorine demand.

**Ans: Chlorine Demand = Chlorine Dose – Chlorine Residual**

3. Chlorine can be provided in 150 pound **cylinders**.

4. A 150 pound cylinder can provide chlorine at a maximum rate of about **1.5** pounds per hour.

5. Gas detectors can find chlorine leaks of **1** mg/l or less and should be used in storage and feed rooms.

6. A start-stop operation of a chlorinator is typical for chlorination of **well water** where a **well** pump does not operate continuously.

7. Low chlorine residual would be considered to be an example of **abnormal** operation.

8. A chlorine residual of **a minimum of 0.02** mg/l must be maintained at the most distant points of a distribution system.

### **References**

*[There is no need to discuss the references.]*



## INSTRUCTOR GUIDE

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### UNIT 4: 25 minutes



Display Slide 16—Unit 4: Formation of Alternate Chlorine Compounds and Dechlorination.



At the end of this unit, you should be able to:

- List two alternate chlorine compounds.



Display Slide 17—Unit 4: Formation of Alternate Chlorine Compounds and Dechlorination.



Our next learning objective is:

- For chloramines:
  - Explain their purpose.
  - Identify the reactants.
  - Explain the three types.
  - List and explain the monitoring equipment.
  - List and explain the chemical feed control equipment.
  - Perform chloramine feed computations.



Display Slide 18—Unit 4: Formation of Alternate Chlorine Compounds and Dechlorination..



On this slide you will see our next learning objective, which is:

- For chlorine dioxide:
  - Explain their purpose.
  - Identify the reactants.
  - Explain the basics of its chemistry.
  - Explain the basics of sodium chlorite handling and safety.
  - List and explain the chemical feed control equipment.
  - Perform chlorine dioxide feed computations.
  - List Disinfection monitoring requirements.

**Continued**



Display Slide 19—Unit 4: Formation of Alternate Chlorine Compounds and Dechlorination.



At the end of this unit, you should be able to:

- For dechlorination:
  - Explain the basic principles.
  - Identify the reactants.
  - Explain the basics of its chemistry.
  - Explain the safety procedures and list the emergency equipment.
  - List and explain the chemical feed equipment.
  - Explain chemical feed control.

### ALTERNATE CHLORINE COMPOUNDS: x minutes

#### Chloramines



The first alternate chlorine compounds we will review are chloramines. Chloramines are compounds that contain nitrogen and chlorine. Let's take a look at the information in your workbook.

#### Purpose

*[Review the information in the workbook.]*

#### Reactants



There are two chloramine reactants, which are anhydrous ammonia and aqua ammonia. A reactant is a substance that participates in a chemical equation.

#### ***Anhydrous Ammonia***



Anhydrous means "without water."

*[Review the information in the workbook.]*

#### ***Aqua Ammonia***

*[Review the information in the workbook.]*

### Chemical Feed Equipment

*[Review the information in the workbook.]*

### Chemical Feed Control



Review the information in the workbook.

### Chlorine Dioxide



Our next type of alternate chlorine compound is the gas known as chlorine dioxide.

### Purpose

*[Review the information in the workbook.]*

### Reactants

*[Review the information in the workbook.]*

### Sodium Chlorite Handling and Safety



Because of its characteristics, sodium chlorite ( $\text{NaClO}_2$ ) needs to be handled in a safe manner. Let's talk about some of those safety precautions now.

*[Review the information in the workbook.]*

### Chemical Feed Equipment

*[Review the information in the workbook.]*

### Dechlorination



Our discussion will now focus on the process of dechlorination.

### Basic Principles



Review the definition of dechlorination.

*[Review the information in the workbook.]*

### Reactants and Chemistry

*[Review the information in the workbook.]*

**Chemical Feed Equipment, Control and Safety**

*[Review the information in the workbook.]*

### **Key Points for Unit 4.**

*[Review the Key Points for Unit 4 with the class.]*



### Exercise

1. List two alternate chlorine chemical compounds and explain the purpose of each.

**Ans:** chloramines and chlorine dioxide.

2. List three types of chloramines.

**Ans:** monochloramine, dichloramine and trichloride (trichloramine)

3. What are two advantages of using chlorine dioxide?

**Ans:** Chlorine dioxide is not affected by ammonia and does not form carcinogenic compounds. It can also be used to control taste and odor problems.

4. List the dechlorination reactants.

**Ans:** Chlorine, sulfur dioxide, sodium bisulfite, sodium sulfite and sodium thiosulfate.



This concludes Module 24 – Gas Chlorination.

*[Thank participants for their time and their good work. Encourage them to use this workbook as a resource both in their work as well as for a study aid.]*



## APPENDIX

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### A Typical Chlorine MSDS Sheet



On this page you will see the first page of a sample MSDS sheet. This page of the MSDS shows the chemical product and company identification information as well as information regarding the potential health effects of the chemical.

## APPENDIX

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This page of the MSDS continues with information about health hazards as well as first aid measures.

## APPENDIX

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This page of the MSDS is a continuation of first aid measures and it also includes fire fighting measures.

## APPENDIX

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On this page of the MSDS, we find information regarding accidental release measures. Additionally, we find details regarding proper handling and storage of the chlorine chemical.

## APPENDIX

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This page contains details about exposure controls and personal protection and information about the physical and chemical properties.

## APPENDIX

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This page of the MSDS continues with the remaining information about the physical and chemical properties and then provides information about the stability and reactivity of the chemical, as well as toxicological information.

## APPENDIX

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This page continues with toxicological information, and it also details ecological information, disposal considerations, and transportation information.

## APPENDIX

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This page of the MSDS covers regulatory information and includes a section labeled “other” information.



## APPENDIX

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The last page of this MSDS contains contact information for the manufacturer.

- Remember, not all MSDSs will look exactly like this one, although they should contain similar types of information.