Wastewater Treatment Plant Operator Certification Training Instructor Guide

Module 7: Basics of Chemical Feed Systems

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 7: Basics of Chemical Feed Systems* is to present an overview of chemicals used in a wastewater treatment plant, explain how to safely handle those chemicals, how to calculate chemical dosages and how chemical feed systems operate. 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.

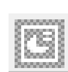
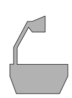
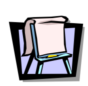
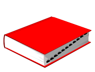
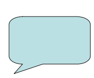
Delivery methods to be used for this course include:

- Lecture
- Exercises/Activities
- Calculations
- Quizzes

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

- One workbook per participant
- Extra pencils
- Laptop (loaded with PowerPoint) and an LCD projector **or** overheads of presentation and an overhead projector
- Screen
- Flip Chart
- Markers

Icons to become familiar with include:

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

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.

To	**Press**
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

INTRODUCTION OF MODULE: 5 minutes

Display Slide 1—Module 7: Basics of Chemical Feed Systems.

[Welcome participants to "Module 7 – Basics of Chemical Feed Systems." Indicate the primary purpose of this course is to present an overview of chemicals used in a wastewater treatment plant, explain how to safely handle those chemicals, how to calculate chemical dosages and how chemical feed systems operate.]

[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 – Chemical Usage in Wastewater Treatment and Unit 2 – Safety and Handling.

[Briefly review outline.]

If you turn the page, you will see the topical outline for Unit 3 – Chemical Dosage Calculations.

[Briefly review outline.]

If you turn the page, you will see the topical outline for Unit 4 – Chemical Feed Systems.

You will also note that there are two appendices:

Appendix A has an optional exercise

Appendix B has formulas, conversions and common scientific units. This is the same formula worksheet that will be provided when you take the drinking water and wastewater exams.

[Briefly review outline.]

[This page was intentionally left blank.]

UNIT 1: <u>40 minutes</u>

Display Slide 2—Unit 1: Chemical Usage in Wastewater Treatment.

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

- Describe the historical use of chemicals in wastewater treatment.
- List six uses of chemicals in wastewater treatment.

GENERAL HISTORICAL OVERVIEW: 10 minutes

Historical Use of Chemicals in Wastewater Treatment

The list of uses for chemicals in wastewater treatment has greatly expanded their use in 1934 for chemical precipitation to their current use in the many phases of wastewater treatment.

[Review the information the workbook on the historical use of chemicals, being sure to mention the six current uses of chemicals.]

HOW CHEMICALS ARE USED IN WASTEWATER TREATMENT: 20 minutes

Coagulation and Flocculation

We have already identified six current uses of chemicals in wastewater treatment. We will now discuss each of these in further detail, beginning with improving sedimentation and flotation.

[Review information in the workbook.]

[Be sure to review the definition of coagulation in the workbook.]

[Besure to review the definition of flocculation in the workbook.]

Sludge Conditioning and Stabilization

Sludge conditioning and stabilization are another area in wastewater treatment where chemicals are used.

Sludge Conditioning

[Review information in the workbook on sludge conditioning.]

Sludge Stabilization

[Review the definition of sludge stabilization in the workbook.]

[Review the information in the workbook on sludge stabilization.]

Disinfection

Chemicals also play an important role in the disinfection of wastewater.

[Review the information in the workbook on disinfection.]

Nutrient Removal

The fourth use of chemicals on our list is nutrient removal.

[Review the information in the workbook on nutrient removal.]

Alkalinity Supplementation

Chemicals also play a role in maintaining the pH during the wastewater treatment process. This is called alkalinity supplementation.

[Review information in the workbook on alkalinity supplementation.]

Odor Control

The final use of chemicals on our list is for odor control. As you can imagine, controlling odor during the wastewater treatment process is essential.

[Review information in the workbook on odor control. Be sure to highlight the difference between neutralization and adsorption.]

The next two pages of the workbook contain a Chemical Usage Table. Reference to this table can assist the treatment plant operator with the selection of a chemical for use in a specific treatment process. Turn the page and look at the first page of the table.

CHEMICAL USAGE TABLE: 10 minutes

Chemical Usage Table

This table offers an illustration of the most common chemicals used in wastewater treatment. Each chemical name and its formula is given, along with other valuable information, such as common uses of each chemical, the forms in which it is found and how to feed it. Let's review how the table is organized.

[Review the format of the table so that participants understand how to use it.

1st Column = Chemical Name

2nd Column = Chemical Formula

3rd Column = Common Use]

Column 3 lists some of the more common uses of each of the chemicals. Notice that some of the chemicals can have more than one use within the overall treatment process. For example, calcium oxide may be used for both pH adjustment and sludge stabilization.

[4th Column = Available Forms]

Column 4 lists the common forms of commercially available chemicals. Selection of the best form for use at any particular treatment plant depends on the available chemical feed equipment at that facility.

[5th Column = Weight]

Column 5 lists the common unit weight of the chemical; this is useful in performing dosage calculations.

[6th Column = Commercial Strength]

[7th Column = Best Feeding Form]

[8th Column = Active Chemical Strength]

Similar to the unit weight indicated in column 5, the active strength found in column 8 is useful information relative to dosage calculations.

[9th Column = Batch Strength]

[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.]

[Chemical Usage Table continued]

[Have the participants review the Key Points for Unit 1 – Chemical Usage in Wastewater Treatment.]

☑ Chemical Usage Table Exercise

[Refer to the Chemical Usage Table to answer the following questions.]

1. List the chemicals you might add to wastewater to control odor. Include the chemical name and best feeding form for each.
   Ans:
   [($KMnO_4$) Potassium Permanganate. Best feeding form: dry to form solution.
   (H_2O_2) Hydrogen Peroxide. Best feeding form: liquid.
   ($FeSO_4 \cdot 7\ H_2O$) Ferrous Sulfate (Odophos). Best feeding form: dry granular to form solution.]

2. List several chemicals that might be added to wastewater to promote phosphorus removal. Include examples of both dry and liquid chemicals and identify the normal batch strength of the food solution.
   Ans:
   ($Al_2(SO_4)_3 \cdot 14\ H_2O$) Aluminum Sulfate (Alum). Batch strength: 0.5 lb/gal
   ($Al_2(SO_4)_3 \cdot X\ H_2O$)Aluminum Sulfate (Liquid Alum). Batch strength: Neat
   (FeCl3) Ferric Chloride. Batch strength: Neat
   ($Fe_2(SO_4)_3 \cdot X\ H_2O$) Ferric Sulfate. Batch strength: 5.5 lb/gal max.
   ($FeSO_4 \cdot 7\ H_2O$) Ferrous Sulfate (Odophos). Batch strength: 0.5 lb/gal

3. Synthetic organic polymers can be used to enhance the flocculation process in wastewater treatment plants.

   a. ___X__ True b. ____ False

4. In a lime stabilization process, if the pH is allowed to fall below 9.0, __biological__ activity could resume and create the potential for offensive odors.

5. Which of the following chemicals are commonly used to supplement alkalinity in wastewater treatment processes? (Check all that apply.)

   a. ___X__ Lime

   b. ___X__ Sodium Hydroxide

   c. ____ Sulphuric Acid

   d. ___X__ Magnesium Hydroxide

   e. ____ None of the above.

UNIT 2: <u>25 minutes</u>

Display Slide 3—Unit 2: Safety and Handling.

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

- Explain the purpose of the Material Safety Data Sheet (MSDS) and describe the typical information found on an MSDS.

Display Slide 4—Unit 2: Safety and Handling.

- *[Explain the role of labels and warning signs and list three basic forms.*
- *Explain the purpose of breathing protection when handling chemicals and explain how to select appropriate protection.*
- *List common types of protective clothing used when handling chemicals and explain how proper protective clothing is selected.*
- *List five common types of protective equipment.*
- *List the five components of Chemical Handling Equipment.]*

MATERIAL SAFETY DATA SHEET: 10 minutes

Whenever we work with chemicals, handling them safely and having the right equipment is critical. Chemical companies provide Material Safety Data Sheets for each chemical to help facilities make sure they understand safety issues. Usually, each water facility keeps these in an MSDS binder for easy reference.

Material Safety Data Sheet (MSDS)

[Review the material on MSDSs and their contents.]

An example of an MSDS for Aluminum Sulfate, Liquid is found on the next few pages. Let's quickly take a look.

Example of an MSDS

This MSDS is from the Delta Chemical Corporation. Other companies may present their information in a slightly different manner; However, all MSDSs will contain essentially the same information regardless of who manufacturers the chemical.

This MSDS is divided into 9 sections. Each section presents important information on the chemical.

Section 1 – provides you with the basics, from chemical name and formula to general use and emergency phone numbers.

Section 2 – information covers composition information on ingredients. It also provides information related to any hazardous ingredients such as exposure limits established by various governmental agencies and organizations. Definitions for some of the more important abbreviations noted on the sample MSDS are as follows:

OHSA PEL – Permissible exposure limit established by OSHA

ACGIH TLV – Threshold limit values established by the American Conference of Governmental Industrial Hygienists

NIOSH REL – Recommended exposure limit established by the National Institute for Occupational Safety and Health

TWA – Time Weighted Average – the concentration for a normal 8 hour day, 40 hour week which will not result in any adverse effects.

STEL – Short Term Exposure Limit

IDLH – Immediately Dangerous to Life of Health

TEL – Total Exposure Limit

Section 3 – provides information about appearance, odor, water solubility and temperature ranges.

Section 4 – provides fire-fighting measures. The symbol to the right – NFPA sign is one method used on the MSDS to indicate the standard hazard ratings of the chemical. The number in the top diamond represents the flammability hazard associated with the chemical. The left and right diamonds represent health and reactivity, respectively. The bottom diamond is used to represent the level of special hazards associated with the chemical. Some MSDSs will not include the NFPA diamond, but will simply list the ratings (i.e. Health Rating: 2 – Moderate).

Section 5 – provides information on stability and reactivity of the chemical and is useful for assessing storage requirements.

Section 6 – health hazard information covers potential health effects of the chemical and how to handle emergency and first aid procedures.

Section 7 – provides procedures on how to handle spills, leaks and disposal of the chemical.

Section 8 – provides guidance on any special clothing or protection you may need for your personal safety.

Section 9 –would be a place to add anything not already covered. In this case, it includes DOT Transportation data as listed on the next page.

Does anyone have any questions regarding a MSDS?

[Respond appropriately.]

The MSDS provided us with a lot of information about the specific chemical it addresses and precautions as well as equipment needed. As plant operators we need to put that information to work for us. Let's turn the page to learn about different types of chemical handling equipment.

CHEMICAL HANDLING EQUIPMENT: 5 minutes

In this case, equipment includes everything from labels on containers to exhaust fans.

Labels and Warning Signs

Labels and warning signs provide clear visual reminders to help keep us safe.

[Review information in the workbook.]

Breathing Protection

There are times when breathing protection is necessary.

[Review information in the workbook.]

Protective Clothing

As with any career, wearing clothing appropriate for the job is essential. Handling chemicals requires special precautions.

[Review information in the workbook.]

The last section dealing with Chemical Handling Equipment is actual pieces of hardware that either help prevent a health hazard or help respond to an emergency. Let's turn the page.

Protective Equipment

[Review information in workbook.]

[Ask participants if they have any questions. Respond as needed.]

[Have the participants review the Key Points for Unit 2 – Safety and Handling.]

☑ Exercise for UNIT 2 – SAFETY AND HANDLING: 5 minutes

[Use the MSDS on pages 2-3 through 2-6 to complete the following.]

1. MSDS stands for

Ans: *[Material Safety Data Sheet]*

2. This MSDS is for what chemical?

Ans: *[Aluminum Sulfate, Liquid]*

3. What protective clothing precautions should you take when working with this chemical?

Ans: ***[At least:** Chemically protective gloves, boots, aprons, and gauntlets, protective chemical safety goggles, per OSHA eye-and face protection regulations. (Section 8)*

***Preferred** – All of the above **and –** Seek professional advice prior to respirator selection and use. Respiratory protection following OSHA regulations, and if necessary wear a MSHA/NIOSH-approved respirator.]*

4. List the five components of chemical handling equipment.

Ans: *[Selection of equipment*
Labels and warning signs
Breathing Protection
Protective Clothing
Protective Equipment]

UNIT 3: 90 minutes

Display Slide 5—Unit 3: Chemical Dosage Calculations.

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

- Explain what jar testing is and why it is important.
- List the equipment and chemical reagents used for the jar testing procedure.

Display Slide 6—Unit 3: Chemical Dosage Calculations.

- Explain the jar testing procedure, including the following:
    - Preparing for the test.
    - Establishing the test sequence.
    - Performing the actual test.

Display Slide 7—Unit 3: Chemical Dosage Calculations.

- Correctly perform calculations for dry, liquid, and gas chemicals.
- Define active strength and explain its importance.

JAR TESTING: 10 minutes

Overview

If you are not familiar with the Jar Test – it will soon become a procedure that you will do regularly. It is almost impossible to exactly duplicate actual plant performance; however, Jar Test results give an indication of what to expect during full-scale operation.

[Review the definition of Jar testing.]

[Review the definition of precipitation as it pertains to water treatment.]

[Complete the review of the Jar Testing Overview as presented in the participant workbook.]

[Make sure to emphasize the key point regarding the sample of water tested.]

Preparation

Recommended Equipment

[Review the recommended equipment as presented in the participant workbook. You may want to add the following information.

> *pH - Mathematically, pH is the logarithm of the reciprocal (or negative logarithm) of the hydrogen ion activity of the solution.*
>
> *ORP stands for Oxidation-Reduction Potential.]*

Once all the equipment has been secured, we need to identify the chemicals we will be using. A list of Chemical Reagents is provided on the next page.

Chemical Reagents

Chemical Reagents are chemicals that are used in the Jar Test. The actual choice is often based on those chemicals on hand at the plant but other chemicals could be used. The Chemical Usage Table in Unit 1 listed the various uses for different chemicals. The various uses would be a consideration.

[Complete the review of chemical reagents.]

Establish Test Procedures

The last piece we need to put into place in preparation for Jar Testing is Test Procedures. We need to make sure procedures are in place that would ensure accurate test results.

[As you review the material in the participant workbook, you may want to add the following:

- *Preparing fresh chemicals is necessary to ensure both accurate readings and to simulate as much as possible what would be added to the flow stream.*
- *Using data sheets organized in such a way to help with calculations later.*
- *When determining what combinations of chemicals will be tested, you will want to consider the purpose of the testing. For example, the chemicals used to determine the chemical fed rates for flocculation will usually be different from those used for metals removal.]*

It is extremely important to maintain as much control over the testing as possible so that the information you gather is reliable. It can not be overemphasized—to make only one adjustment (change only one variable) in any given test run. Accuracy is essential.

[Review the material on establishing dosage range.]

Back when we were reviewing equipment, we looked at a Multi-station Jar Test Stirrer. Notice that here we are told to have our anticipated best dosage, surrounded by or bracketed by higher and lower dosages. In the example, a total of 5 are given—the best dose, two higher doses, and two lower doses. The 6^{th} jar or beaker is used for the control.

[Ask participants if they have any questions up to this point. Answer questions as needed.]

Once everything is ready, testing begins. Let's turn the page and review the Jar Test.

Conducting the Test

Test Procedures for Coagulation/Flocculation

In this example, we are reviewing the test procedure for coagulation/flocculation. The actual test procedure may vary depending on the test being performed. For example, if we were testing for metal precipitation, we would add the chemical being tested to precipitate or oxidize the metal ions. The chemical dosage would bracket the expected best dosage and the mixing/stirring/settling times would be adjusted to imitate those variables in the actual metal precipitation process at the treatment plant.

[Review the Test Procedure as presented in the participant workbook.]

Once the best chemical dosage has been determined by our jar testing, we can calculate how much chemical needs to be added to the actual treatment plant flow and establish the proper chemical feeder settings. This varies by the type of chemical Feeder used. First, we will look at Dry Chemical Feeders.

DRY CHEMICALS: 30 minutes

Dry Feeders

[Review key concept of Feed Rate.]

In actual operating practice it is common to use the term "Feed Rate" to refer to both the total amount of chemical which is required to be added to the treatment process, AND to the actual chemical output from the chemical feeder. To assist in differentiating between the two, we will refer to the amount of chemical required as the "Feed Rate (R)" and to the chemical feeder output as the "Chemical Feed Rate." The actual chemical feeder output is also referred to as "Dosage Rate."

[Review the definition of Flow Rate.]

Feed Rate Equation

[Review the Feed Rate Equation].

Determine Chemical Feeder Setting

The feed rate will tell us how much of a chemical is needed to treat the water flow in a day. How we determine the setting for the Dry Feeder to deliver that quantity takes several steps.

First we need to determine the actual output of the feeder.

Display Slide 8—Feeder Operation Test Results (Figure 3.1 in participant workbook).

[Review the material under Determine actual output of the feeder. As you review them, point to the settings column for the first bullet, point to the Time column for the second bullet, and point to the Sample Weight column for the third bullet.]

[Continue to Display Slide 8.]

Once the data has been collected we can solve for the Feed Rate.

[Point to the fourth column – Feed Rate.]

This is done by completing the Chemical Feed Rate calculation. The example uses data from the shaded area on Figure 3.2 at a setting of 100.

[Complete the review of the calculation. Ask participants if they have any questions. Answer as needed.]

Now that we have the Feed Rate data calculated for each setting, we plot that data on a graph as in Figure 3.3 in your workbooks.

[Point out that the vertical axis of the graph is the chemical feed rate #/hr as illustrated in Figure 3.2 (4th Column) and the horizontal axis is the feeder setting (where the data from Figure 3.2 column 1 is placed).]

The final step in determining the feeder setting is completing the equation.

Display Slide 9—Feed Rate Equation.

[Review the steps for solving the equation.]

[Ask participants if they have any questions. Answer as needed.]

Now that you have the Feed Rate, you can adjust your feeder settings. Let's turn the page and try a sample calculation together.

☑ Sample 3.1 – Dry Chemical Feed Calculations

[Take participants step-by-step through the calculations and plotting the data on the graph as presented in the participant workbook by following the procedure below:]

[Read the Problem statement aloud.]

Display Slide 10—Chemical Feed Rate Equation.

[Read the Given statement aloud.]

[For Solution Step 1:]

Write the Chemical Feed Rate Equation on the top of the flip chart.

[Read the Given statement aloud a second time. This time write the chemical feed rate equation directly beneath the first one filling in the numbers.]

Complete the calculations for each and record on the chart.

[For Solution Step 2:]

Display Slide 11—Dry Feeder Calibration (Figure 3.4 in participant workbook).

[Point to the dotted horizontal line and explain to students that 10.5 #/hr is recorded on the vertical axis.

Point to the dotted vertical line and explain that where the dotted horizontal line crosses, determines the feeder setting. In this case the feeder setting is 325.

Ask participants if they have any questions. Answer as needed.]

We are now ready to review manually batched solutions of dry chemicals.

Manually Batched Solutions of Dry Chemicals

[Review the material explaining what manually batched solutions are and how they are determined.]

Batch Strength Equation

In this case, we first need to turn the dry chemicals into a liquid form or batching. In order to do this, we complete the batch strength equation.

Display Slide 12—Batch Strength Equation.

[Review the material on batch strength equation.

Continue Displaying Slide 12 – Batch Strength Equation.]

Sample 3.2 – Batching Dry Chemicals

[Read the Problem statement aloud.]

Write the Batch Strength Equation on the top of the flip chart.

[Read the Given statement aloud.]

[Solution:

Read the Given statement aloud a second time. This time write the batch strength equation directly beneath the first one filling in the numbers.]

As you work through the calculation in the workbook, record the calculation on the flip chart.

This equation gives us the information to then calculate the feeder setting. As mentioned previously, it is treated as a liquid. Let's continue on, to learn about liquid chemicals.

[If this Module is being offered in one 3 hour session, this might be an appropriate time to take a short break.]

LIQUID CHEMICALS: 30 minutes

Chemicals – Active Strength

[Review the material on Active Strength as presented in the participant workbook.]

Liquid Chemical Feed Pumps

Common Liquid Feeders

[Review the material on Common Liquid Feeders as presented in the participant workbook.]

How do we calculate feed rate for liquid chemicals? Let's turn the page to find out.

Calculate Feed Rate

Notice, that the workbook assumes we know the dosage. Remember, this data is collected from the Jar Test.

Does the Feed Rate Equation look familiar? It is the same as the one we used for dry chemicals. The equation below is how we solve for liquid feed rate.

Determining Setting

[Review the material on Determining Setting as presented in participant workbook.]

Now let's look at another sample calculation.

Sample 3.3 – Liquid Chemical Feed Calculations

[Read the Problem statement aloud.]

Write the Feed Rate Equation on the top of the flip chart.

[Read the Given statement aloud.]

[Solution Step 1:

Read the Given statement aloud a second time. This time write the feed rate equation directly beneath the first one filling in the numbers.]

As you work through the calculation in the workbook, record the steps on the flip chart.

[Solution Step 2:]

Write the Liquid Feed Rate Equation on the top of the flip chart.

[Reread the Given statement aloud and use the answer from step one to write the liquid feed rate equation directly beneath the first one filling in the numbers.

While completing the calculations aloud, write them on the chart.]

You're doing great! Let's try another one.

☑ Sample 3.4 – Liquid Feed Calculations

[Read the problem statement.]

Display Slide 13—Alum Feed Pump Output (Figure 3.5 in participant workbook).

[Read the given statement.]

[Solution Step 1: Perform feed rate calculation.]

Write equation on flip chart. Write equation using data from Slide 10.

[Solution Step 2: Develop feed pump calibration curve.]

Display Slide 14—Liquid Feeder Operation Test Results (Figure 3.6 in participant workbook).

[Note the columns for Feed Rate and Pump Setting, the two axes for our curve.
You may want to point out that the pump settings here are different from those in our first sample. An example of how they may vary by manufacturer. In this case 0 -100 %.]

[Solution Step 3: Develop feed pump calibration curve.]

Display Slide 15—Alum Feed Pump Calibration Curve

[Ask participants if they have any questions. Remind them that:]

[Feed Rate Equation is the same for dry and liquid chemicals.]

[Once batched, the chemicals are treated as a liquid.]

*[***Note to the Instructor****: An* ***Optional Activity – Class Problem*** *to determine how much aluminum sulfate is required to batch 400 gallons of solution and to also determine how long the 400 gallons of solution will last is included in the Appendix. If time permits, this would be the appropriate time for the participants to work on this activity.]*

GASEOUS CHEMICALS: 5 minutes

Gas Feeders

There are several gaseous chemicals used in wastewater treatment plants. Three examples are: Chlorine for disinfection, Ammonia for disinfection, and Sulfur Dioxide for dechlorination. The basic operating principals of gas chemical feeders, however, are similar regardless of the gas to be fed.

[Review the material on Types of Gas Feeders as presented in the participant workbook.]

[Review the Feed Rate Equation (it is the same as for Dry and Liquid Chemicals).

Review the remaining material for gaseous chemicals as presented in the participant workbook.

As participants if they have any questions. Answer as needed.]

[Have the participants review the Key Points for Unit 3 – Chemical Dosage Calculation.]

Exercise for UNIT 3 – CHEMICAL DOSAGE CALCULATION: 10 minutes

1. A 1.0 MGD treatment facility uses 12.5 % sodium hypochlorite solution for disinfection. Laboratory testing has determined that the active chemical strength of the hypochlorite is 1.04 pounds of chlorine per gallon. The desired chemical feed rate is 2.5 mg/l.

   Determine the required chemical feed pump setting assuming that the feed pump calibration curve is identical to the alum feed pump in the class problem.

   [Participants work on problem for 5 minutes. Then, provide the solution on the flip chart as follows:]

[Solution:

Step 1 – Compute the required chemical feed rate (#/day).

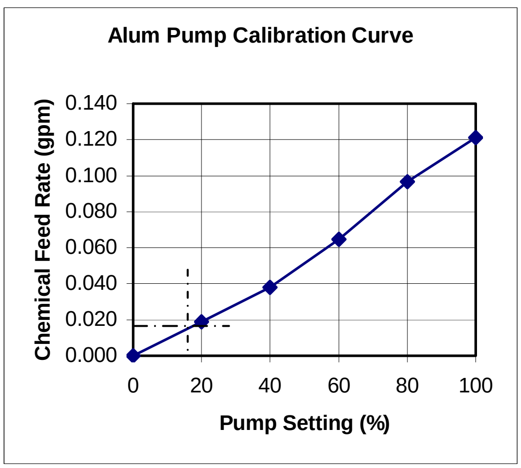
Feed Rate (R) (#/day) = 1.0 (mgd) x 2.5 (mg/l) x (8.34 #/gal)
= 20.85 #/day

Step 2 – Compute the required solution feed rate in gal/day.

Solution feed (gal/day) = 20.85 #/day ÷ 1.04 #/gal
= 20.05 gal/day

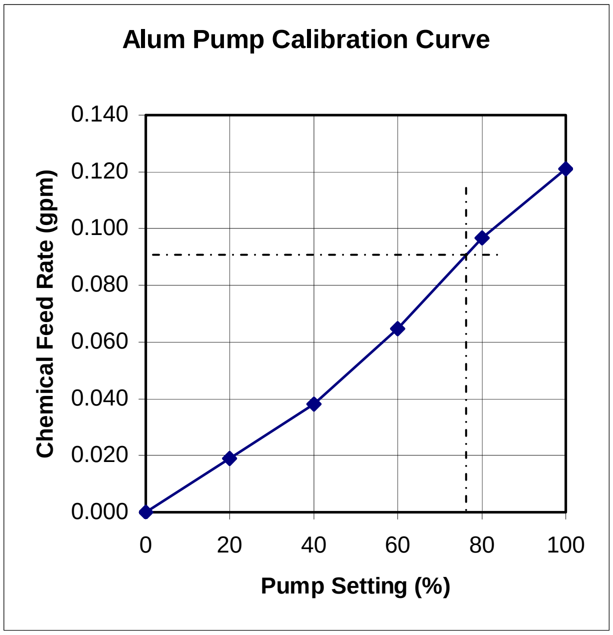
Solution feed (gal/min) = 20.05 gal/day ÷ 1440 min/day
= 0.014 gal/min

Step 3 – Determine feed pump setting using the calibration curve from the class problem.]



Ans: *[Chemical feed rate = 0.014 gal/min ➔ Feed Pump Setting = 14%]*

2. Use the graph in Figure 3.7 to answer this question. From the graph, determine the pump setting if you need a feed rate of 0.090 gpm.



Pump Setting = 75%

3. Match the common liquid feeders below with the range of feed rates needed.

Feeding Pump	Feed Rate
A. _c_ Positive Displacement	a. 0.1 to 10 gph
B. _a_ Solenoid Metering	b. less than 0.1 gph
C. _b_ Peristaltic Pump	c. 0.1 to 600 gph
D. _d_ Jet Pump	d. Not defined in our workbook

4. A multi-station Jar Test Stirrer lab equipment station usually has 4 to 6 beakers for simultaneous testing of various strengths of coagulant chemicals.

   a. _X_ True   b. ____ False

The two common types of gas feed equipment are _direct_ feed and _solution_ feed.

This brings us to the end of Unit 3. You have done a great job! Our next and last unit in this module is about the actual equipment or feeders used in the delivery of the chemicals.

[Note to the Instructor: The participant workbook has a blank page 3-18, but that page was not included in the Instructor Guide since the answers to the Exercise for Unit 3 spilled over onto page 3-17A.]

UNIT 4: <u>35 minutes</u>

Display Slide 16—Unit 4: Chemical Feed Systems.

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

- Describe the appropriate storage facilities, feed equipment, and accessory equipment for dry, liquid, and gas chemical feed systems.
- Identify the components of a typical dry, liquid or gas chemical feed system.

Display Slide 17—Unit 4: Chemical Feed Systems.

- List and describe two types of leak detection equipment.
- Describe the special activation requirements of polymers.

CHEMICAL STORAGE: <u>5 minutes</u>

Repair

Let's begin our review of storage systems with the section on Repair

[Review the material on Repair as presented in the participant workbook.].

Adequate Supply

[Review the material on Adequate Supply as presented in the participant workbook.]

As you can see, the adequate supply can be quite a large amount. Providing storage for the supply of chemicals is our next area of review.

Storage Areas

[Review the material on Storage Facilities as presented in the participant workbook.]

Over the next several pages we will be reviewing chemical feed systems for dry chemicals, liquid chemicals, polymers and gaseous chemicals. As we review each type of feed system we will look at the storage facility requirement, the feed equipment needed, and any accessory equipment. Let's turn the page and begin with dry chemical feed systems.

DRY CHEMICAL FEED SYSTEMS: 10 minutes

Storage Facilities

[Review material on Storage Facilities as presented in participant workbook.]

Feed Equipment

[Review material on Feed Equipment as presented in the participant workbook].

Accessory Equipment

[Review the material on Accessory Equipment as present in participant workbook.]

Over the next pages, you will review the schematics to point out the various components.

Pages 4-4 to 4-6 contain typical schematics for Bulk, Bag, and Batch Dry Chemical Feed Systems. Once we have reviewed the liquid chemical feed systems you will note that a Batch Dry System is generally the same as a liquid feed system. However, the operator makes-up the chemical solution rather than obtaining the chemical in liquid form from the supplier.

Typical System Schematic

Dry Feed Systems

Display Slide 18—Typical Bulk Dry Chemical Feed System (Figure 4.1 in participant workbook).

[Review the schematic by pointing out each of the following:

- *Storage Facility = Storage silo to the far right of schematic.*
- *Feed Equipment:*
  - *Feeder Hopper = Feeder Hopper No.1 and 2 on left side of schematic.*
  - *Volumetric Feeder = Indicated on left side of Feeder No.1 of schematic, but found on both.*
  - *Dissolving Tank = Solution tank indicated under Feeder Hopper No.2 of schematic, but found on both.*
- *Accessory Equipment:*
  - *Dust Collector = Two are found, one to the lower left of the storage silo and the other to the right of Feeder Hopper No.2.*
  - *Dissolving Tank Float Valve = In this system it has been replaced by high level switches. These are indicated on the upper right side of the solution tank under Hopper Tank No.1. (Serves to prevent overflow of solution or mixing tank.)*
  - *Mixer = Indicated on upper left side of solution tank under Feeder Hopper No.2, but found on both solution tanks.*
  - *Eductor = Indicated on left of solution tank under Feeder Hopper No.2, but found on both solution tanks.]*

Display Slide 19—Typical Bag Dry Chemical Feed System (Figure 4.2 in participant workbook).

[Review the schematic by pointing out each of the following:]

- *[Storage Facility = The Extension Hopper and Bag Loader in the center of schematic—combines the storage and the Feeder Hopper*
- *Feed Equipment*
  - *Feeder Hopper = Combined with Storage Facility as noted above.*
  - *Volumetric Feeder = Dry Feeder, indicated below the Extension Hopper and Bag Loader.*
  - *Dissolving Tank = Located down low to the right of the Extension Hopper and Bag Loader.*
- *Accessory Equipment*
  - *Dust Collector = Far left center of schematic.*
  - *Dissolving Tank Float Valve = Indicated upper left inside of Dissolver Tank.*
  - *Mixer = Upper right outside corner of Dissolver Tank.*
  - *Eductor = Indicated to the right of the Dissolver Tank.]*

Display Slide 20—Typical Batch Dry Chemical Feed System (Figure 4.3 in participant workbook).

[Review the schematic by pointing out each of the following:]

- *[Storage Facility = Not shown for dry chemicals on pallets in the same room; batched chemicals in Solution (SOLN) Tank on left side of schematic.*

- *Feed Equipment*
  - *Feeder Hopper = None as this is really treated as a liquid.*
  - *Volumetric Feeder = Pumps No.1 and No.2, again this is due to treating as liquid. The system pumps a certain amount of liquid but does not measure dry chemicals.*
  - *Dry Batch System Solution Tank = Solution Tank.*

- *Accessory Equipment*
  - *Mixer = Indicated on upper left corner of Solution Tank No.2.*
  - *Eductor = None, this system pumps directly.]*

Note that chemicals that are fed dry all utilize a dust collector to capture airborne chemical dust associated with feeding dry material. However, note that a dust collector is not shown on the typical batch dry chemical feed system. Since a manually batched dry chemical system is generally only used at the smallest of facilities, the amount of chemical dust associated with the batching process is limited. In such cases, the use of personal protective equipment such as dust masks during the batching process usually eliminates the need for a dust collector. However, some larger batched systems use a bag loading hopper to introduce the dry chemical into the batch tank; these systems may include dust collection equipment. Once the dry chemical has been manually batched into solution the system is similar to a liquid feed system in its components, except that liquid chemical storage (other than that associated with the batch tanks) is not included.

LIQUID CHEMICAL FEED SYSTEMS: 10 minutes

Storage Facilities

[Review material on Storage Facilities as presented in participant workbook.]

Feed Equipment

[Review material on Feed Equipment as presented in the participant workbook.]

Accessory Equipment

[Review the material on Accessory Equipment as present in participant workbook.]

Pages 4-8 and 4-9 contain system schematics for a Typical Bulk Liquid Chemical Feed System and a Typical Drum Storage Liquid Chemical Feed System.

Typical System Schematics

Display Slide 21—Typical Bulk Liquid Chemical Feeder (Figure 4.4 in participant workbook).

[Review the schematic by pointing out each of the following:]

- *[Storage Facility = Bulk Storage on left side of schematic.*
- *Feed Equipment:*
    - *Transfer Pump = To the lower right of the Bulk Storage; there are two indicated.*
    - *Day Tank = Center of schematic.*
    - *Chemical Feed Pump = Right side of schematic; there are two indicated.*
- *Accessory Equipment (found on each pump):*
    - *Calibration Chamber = Right day tank, left of Feed Pump No.1.*
    - *Pressure Relief Valve = Indicated above Feed Pump No.1, found on both.*
    - *Backpressure Valve = Indicated above Feed Pump No.2, found on both.*
    - *Anti-siphon Valve = Indicated above Feed Pump No. 1.]*

Display Slide 22—Typical Drum Storage Liquid Chemical Feed System (Figure 4.5 in participant workbook).

[Review the schematic by pointing out each of the following:]

- *[Storage Facility = Drum on left side of schematic.*
- *Feed Equipment:*
  - *Transfer Pump = Not used.*
  - *Day Tank = Not used.*
  - *Chemical Feed Pump = Pump No.1 and 2 in center of schematic.*
- *Accessory Equipment (found on each pump):*
  - *Calibration Chamber = Indicated between Drum and Pump No.1.*
  - *Pressure Relief Valve = Indicated above Pump No.1.*
  - *Backpressure Valve = Indicated above Pump No. 1.*
  - *Anti-siphon Valve = Indicated above Backpressure Valve on Pump No.1.]*

Note that a common component of a liquid feed system is liquid chemical storage. This can range in size from small (under 55 gallon) shipping drums to large bulk storage tanks filled from tank trucks.

POLYMER FEED SYSTEMS: 2 minutes

Storage Facilities

[Review material on Storage Facilities as presented in participant workbook.]

Feed Equipment

[Review material on Feed Equipment as presented in the participant workbook.]

Page 4-11 contains a system schematic for a Typical Polymer Feed Systems.

Typical System Schematics

Display Slide 23—Typical Dry Polymer Feed System (Figure 4.6 in participant workbook).

Note that all polymer feed systems include equipment for mixing and activating the polymer. This equipment can range from large specialized “autobatch” systems which mix the polymer and include aging and storage components within the unit; to the smaller “blending units” used with liquid polymers. These contain specialized mixers within the feeder for the purpose of obtaining a consistently blended polymer solution.

[Review the Dry Polymer Feed System schematic noting the following:]

- *[Storage Facility = Storage Hopper on left side of schematic, to the right of the Storage and Metering Day Tank.*
- *Feed Equipment]*

The Auto Batch System comprised of the Storage and Metering Day Tank and Storage Hopper and Dry Feeder components found on the left of the schematic, converts the dry polymer to a solution with a consistency similar to wall paper paste. From that point on, the equipment used is the same as for Liquid Feed Systems.

- o *[Chemical Feed Pump = Feed Pump No.1 and 2 in center of schematic.*

- *Accessory Equipment (found on each pump):*
  - o *Calibration Chamber = Indicated to the left of Feed Pump No.1.*
  - o *Pressure Relief Valve = Indicated above and on right side of Pump No.2.*
  - o *Backpressure Valve = Indicated above Pump No. 1.*
  - o *Anti-siphon Valve = Indicated above Backpressure Valve on Pump No.1.]*

An additional accessory found in the Dry Polymer Feed System is located on the upper right of the schematic. It is the Polymer Output Booster. This accessory blends the polymer solution with additional water so its consistency is better to feed.

Polymer can also be fed in a liquid form. Let’s turn the page.

Display Slide 24—Typical Liquid Polymer Feed System (Figure 4.7 in participant workbook).

[Review the Liquid Polymer Feed System schematic noting the following:]

- *[Storage Facility = Polymer Drums, to the left and right of center.*
- *Feed Equipment = Polymer is ready mixed in a drum. All accessory pieces are in one specialized polymer feed unit called a Polymer Blending Unit. Two are found in the schematic, each slightly above and to the right of a Polymer Drum.]*

GASEOUS CHEMICAL FEED SYSTEMS: 3 minutes

Storage Facilities

[Review material on Storage Facilities as presented in participant workbook.]

Feed Equipment

[Review material on Feed Equipment as presented in the participant workbook.

Continue on the next page with the review of Gaseous Chemical Feed Systems.]

Accessory Equipment

[Review the material on Accessory Equipment as present in participant workbook.]

Pages 4-14 and 4-15 contain system schematics for a Typical Gas Chemical Feed System (Ton Containers) and a Typical Small Gas Chemical Feed System. Note that schematics are provided only for vacuum operated systems.

Typical System Schematics

Display Slide 25—Typical Gas Chemical Feed System (Figure 4.8 in participant workbook).

[Review the schematic by pointing out each of the following:]

- *[Storage Facility = Ton Containers. There are 2 sets on the bottom portion of the top half of the schematic.*
- *Feed Equipment:*
    - *Vacuum Regulator and Automatic Switchover System = Combined into one unit on far right of top half of schematic.*
    - *Gas Feeder = Center section of lower half of schematic.*
    - *Ejector = Far right of lower half of schematic.*
- *Accessory Equipment:*
    - *Evaporator – Not shown on this schematic, would be on upper half of schematic, right side between Feeder and Ton Cylinders and near where the switchover is.*
    - *Gas Solution Distributors =Indicated on schematic by asterisked line going through the center of a pipe in the center of the lower section.*
    - *Container Scales = Indicated under right set of tanks on upper half of schematic.*
    - *Feed Water Booster = Plant Service Water indicated on far right of lower half schematic.*
    - *Gas Detectors = Not part of the Feed System but necessary safety equipment located in the gas storage and feed room areas.*
    - *Self Contained Breathing Equipment = Not part of the Feed System but necessary safety equipment located in the gas storage and feed room areas.*
    - *Emergency Repair Kits = Not part of the Feed System but necessary safety equipment located in the gas storage and feed room areas.]*

Display Slide 26—Typical Small Gas Chemical Feed System (Figure 4.9 in participant workbook).

[Review the schematic by pointing out each of the following:

- *Storage Facility = Chemical Storage Room adjacent to Chemical Feed Room, left side of schematic.*
- *Feed Equipment:*
  - *Vacuum Regulator = Indicated on top of Cylinder, left side of schematic.*
  - *Automatic Switchover System = Indicated on far right side of Chemical Storage Room.*
  - *Gas Feeder = Indicated on left side of Chemical Feed Room.*
  - *Ejector = Indicated on fare right of Chemical Feed Room.*
- *Accessory Equipment:*
  - *Evaporator = Not used because it is a small system.*
  - *Gas Solution Distributors = Inside the pipe, lower far right in Chemical Feed Room.*
  - *Container Scales = Platform Scale under cylinders on far left of schematic.*
  - *Feed Water Booster = Plant Service Water, indicated in upper right corner of Chemical Feed Room.*
  - *Gas Detectors = Not part of the Feed System but necessary safety equipment located in the gas storage and feed room areas.*
  - *Self Contained Breathing Equipment = Not part of the Feed System but necessary safety equipment located in the gas storage and feed room areas.*
  - *Emergency Repair Kits = Not part of the Feed System but necessary safety equipment located in the gas storage and feed room areas.]*

Note also that all gas feed systems utilize a weighing scale which measures the quantity of gas remaining in the cylinder and that all vacuum feed systems contain vacuum regulators somewhere in the gas feed line between the cylinder and the feed units.

[Ask participants if they have any questions regarding Chemical Feed Systems. Answer as needed.]

[Have the participants review the Key Points for Unit 4 – Chemical Feed Systems.]

Exercise for UNIT 4 – CHEMICAL FEED SYSTEMS: 5 minutes

A. Identify each of the following statements with a T for true or F for false.

_____ 1. Chemical storage should be in the vicinity of feeders to avoid necessary handling.

Ans: True

_____ 2. All chemicals should be stored in spill containment areas.

Ans: False (only liquids)

_____ 3. Gaseous chemical storage is usually in an adjacent room or outside building at a location close to the feed room.

Ans: True

_____ 4. The minimum chemical amount of chemical storage is 30 days supply at average use.

Ans: False (10 days supply)

Display Slide 27—Quiz – Type of Feeder System? (Same as Slide17 – Typical Bulk Liquid Dry Chemical Feed System

B. What type of Chemical Feed System is represented by the following schematic? Write your answer in the space provided.

Ans: Typical Bulk Liquid Chemical Feed System

C. List the two Feed Systems that require leak detection equipment.

Ans: Liquid and Gaseous

[There is no need to review the references on this page.]

This concludes Module 7 – Basics of Chemical Feed Systems.

[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

☑ Optional Activity (page 3-13) – Class Problem: <u>5 minutes</u>

[Divide the class into pairs or small groups and have them solve the problem. After 3 minutes, review the solution on the Flip Chart as with previous examples.]

[Solution: Step 1 – Compute the chemical feed rate in #/day

Phosphorous Loading = 1.0 MGD x 10 mg/l x 8.34 #/gal = 8.34 #/day

Required Aluminum Sulfate = 10 parts/part PO_4 = 10 X 8.34 #/day

= 83.4 #/day

Step 2 – Compute the required solution feed rate in gal/day

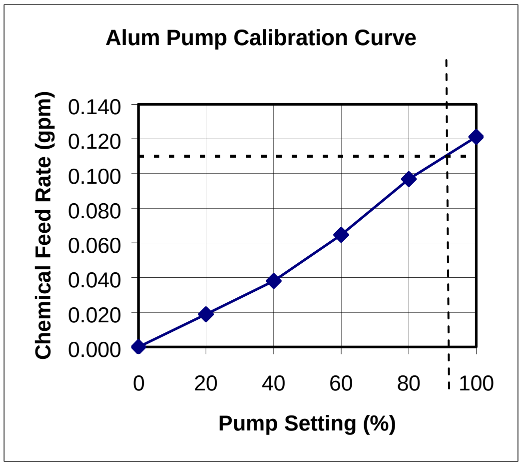
= Solution feed = 83.4 #/day ÷ 0.5 #/gal

= 166.8 gal/day

= 166.8 gal/day ÷ 1440 min/day = 0.11 gal/min (Conversion from gallons per day to gallons per minute (24 hr/day x 60 min/hr = 1440 min/day)]

Display Slide 15—Alum Feed Pump Calibration Curve.

[Step 3 – Establish Feed Pump Setting]



[= Feed Pump Setting = 91 %]

[Step 4 – Compute batching requirements

= Batch strength = 0.5 #/gal

= Batch Quantity = 400 gal

= Chemical Requirement = 0.5 #/gal x 400 gal

= 200 #

Step 5 – Compute batch life

= Batch volume = 400 gal

= Feed rate = 166.8 gal/day

= Batch life = 400 gal ÷ 166.8 gal/day

= 2.4 days]