Wastewater Treatment Plant Operator Training
Instructor Guide

Module 25:
Introduction to Flowmeters

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

A Note to the Instructor

Dear Instructor:

The primary purpose of this course, *Introduction to Flowmeters* is to provide a basic understanding of flowmetering in the operation of collection systems and small wastewater treatment plants. This module has been designed to be completed in approximately 3 hours, but the actual course length will depend upon content and/or delivery modification and results of course dry runs performed by the DEP-approved sponsor. The number of contact hours of credit assigned to this course is based upon the contact hours approved under the 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 adjust these timeframes as necessary to match course content and delivery modification made by the sponsor. Please make sure that all teaching points are covered and that the course is delivered as approved by DEP.

Delivery methods to be used for this course include:

- Lecture
- Class activities and calculations
- Group discussions

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)	

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 25: Introduction to Flowmeters.

Welcome participants to Module 25 – Introduction to Flowmeters.

This is a basic course about flowmetering. By the end of the course, you should be able to understand why a knowledge of flowmetering is important in the operation of collection systems and small wastewater treatment plants. We have included several appendices that will be useful not only during this course but during normal operations at your facility.

We will only deal with flowmeters related to wastewater. You may have flowmeters at your facility for air flow and also potable water usage. Although these are important, we need to limit our scope in this introductory course.

Introduce yourself.

Provide a brief overview of the module.

This module contains 5 units. On page i, you will see the topical outline for Unit 1 – Introduction and Unit 2 – Flowmeter Technologies.

Briefly review the outline.

If you turn the page, you will see the topical outline for Unit 3 – Calibration and Unit 4 – Maintenance.

Continue to briefly review outline.

If you turn the page once more, you will see the topical outline for Unit 5 – Problems/Troubleshooting.

Continue to briefly review outline.

Now let's begin our course with Unit 1—An introduction to flowmeters.

UNIT 1: 40 minutes

Display Slide 2—Unit 1: Introduction.

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

- Explain why flow is measured.
- List two types of data output.
- Describe four factors that affect flow rates.
- Calculate flow when given area and velocity.

INTRODUCTION: 5 minutes

Review the paragraph at the top of the page to stress the scope of this course and the “Advanced Flowmeters” course.

Before we discuss why flow is measured, let’s take a quick look at some key definitions.

Definitions

Review the definitions in the workbook.

Now that we have covered some basic definitions, let’s discuss why flowmeters are used.

WHY USE FLOWMETERS?: 10 minutes

Review the two reasons for flowmetering that are discussed at the top of the page.

Regulatory Requirements

Section 64.8 of the Domestic Wastewater Facilities Manual-10/97

Review the material in the workbook. Include the information below in your discussion of each bullet.

- Devices should be installed in all plants to indicate flow rates of raw wastewater or primary...

  Knowledge of the wastewater and sludge flow through the plant is important in order to adjust the equipment for optimization of treatment efficiency. We will not worry about airflow in this course because it is dependent on air density, temperature, elevation, and humidity. In addition, the density of water at the temperatures we deal with does not vary enough to affect the measurements of our flowmeters.

- Plants designed for flows of 100,000 gallons per day (gpd) or more should totalize and record flow.

  If you only have an instantaneous flow value, you will not know what is happening throughout the day.

  Discussion Question

  How many of you know your minimum flow through the wastewater treatment plant (WWTP) or pumping station? What is the maximum flow rate? This can be critical if you are sizing equipment to handle the flows or need to consider bypassing a unit. You do not want to store wastewater in a collection system except under dire and unusual conditions.

National Pollutant Discharge Elimination System (NPDES) Permit

Continue reviewing material in workbook. Include the information below in your discussion of each bullet.

- The NPDES Permit requires flow-paced composite sampling of Wastewater Treatment Plant...
  - Part A of most NPDES Permits contains the following verbiage under “Composite Sample”….

    This means the flow must be determined in some way so that the volume of sample is representative of the flow through the WWTP. If you do not have a flowmeter, how do you comply with this portion of your NPDES Permit?

    – Automatic flow-paced composite sampler.

      If there is not a connection between the flowmeter and the sampler, it is not flow-paced.

    – A discreet sampler and the use of a strip chart showing hourly flows.

      This is covered in more detail in the “Advanced Flowmeters” module.

PADEP Chapter 94 Requirements

A full copy of Chapter 94 is attached as Appendix A. We are only going to review specific requirements.

Review the material in the workbook. Include the information below in your discussion of each item.

- Section 94.12. Annual report.

  The report shall include the following:

  (5) A discussion of sewer system monitoring, maintenance, repair and rehabilitation….

  Monitoring of a system could include a program that evaluates drainage areas in a collection system as part of a program to determine base flow and the flow attributed to Infiltration/Inflow (I/I). This portion of a program may involve the use of portable v-notch weirs which we will discuss later.

- Section 94.13. Measuring, indicating, and recording devices.

  Flow measuring, indicating, and recording equipment shall be calibrated annually.

  In the Chapter 94 requirements, PADEP has highlighted and underlined this task because it is critical to understanding what is occurring through a system. Flowmetering equipment that is working but providing inaccurate readings will cause an operator to make faulty decisions. If you suspect inaccurate readings, consider putting a monitoring process in place so that a solution can be developed and implemented.

Potential Requirements

Review the material in the workbook.

Process Control

Review the material in the workbook. Include the information below in your discussion of each bullet.

- Able to adjust process equipment or ensure adequate pumping capacity is available.

  To use an analogy, "How far can you drive without knowing how much fuel is in the tank?"

- Able to control downstream chemical feed systems.

  A chemical feed system may be something at a WWTP such as a disinfection system. A chemical feed system may also be an odor control system at a pumping station.

- Able to determine when you are reaching the capacity of a system (sewer line, pumping station, or treatment unit).

  If you do not know what the average and maximum flows are—how can you be sure that when you take a pump out of service, you will not create backups?

Now that we have talked about reasons for using flowmeters, let's discuss some devices used to determine flows and the utilization of the resulting information. A flow can be determined for one point in time, totaled for a given period, or averaged over a given time period.

DATA OUTPUT: 5 minutes

We will begin this section on data output by first looking at instantaneous flowmeters.

Instantaneous Flowmeters

Review the material in the workbook. Include the information below in your discussion of each item.

- May be the only flowmeter used by small facilities.

  Very small WWTPs may only have an instantaneous flowmeter. Instantaneous flowmeters only provide a snapshot of what is happening. Therefore, it is not recommended that a WWTP rely solely on an instantaneous flowmeter.

- Used to spot check flowmeters (calibration).

  When a meter is calibrated, the test is performed at one point in time and compared to the main flowmeter. A spot check is also useful to quickly verify that a meter is reading properly.

Display Slide 3—Instantaneous Flowmeters.

Briefly review the two examples of instantaneous flowmeters.

- In-line flowmeter: Example of a flowmeter used for chemical dilution lines.
- Volumetric weir: Example of a weir set used in determining the flow rate in a sewer line.

The next data output method we will look at is continuous recording.

Continuous Recording

Display Slide 4—Continuous Recording.

Review the bullet in the workbook. Then mention the following items:

- Ask the students if they think it is possible to record the totalized flow if they do not have continuous metering. Some may think so; therefore, use the example of the speedometer and odometer of a car. As you drive your car, the speed will change but if you only look at the speedometer, how will you know how far you drove? Similarly the flow through a pipe or channel will vary. Therefore, you must have a totalizer which for the car is the odometer. In a WWTP, it is the totalizer flowmeter.
- Mention that typically the small WWTPs have greater flow fluctuations than larger facilities. This is due to many factors but the primary factor is that a large WWTP may have more customers with rotating work schedules that generate a more uniform flow. Therefore, if a small WWTP would only read their flowmeter once a day, depending when it is read, it could lead to a misleading estimate of the average flow for the day.

We will only discuss two types of pipe conditions in this session. Let’s review them.

FLOW HYDRAULICS: 20 minutes

Types of Conditions

Review the material in the workbook. Include the information below in your discussion of the following bullet.

- Open Channel/Pipes

  Since this is the most common flowmetering application you will encounter, we will devote more time to open channel flow measurements.

Factors Affecting Flow Rate

Review the material in the workbook. Include the following information in your discussion.

- Approach and Departure Conditions

  There must be a sufficient length of straight pipe at the proper slope before the flowmeter, otherwise the conditions will create problems through the meter. For example, you cannot have a very steep slope right before a meter and then have a short length into the meter and expect good results. Also, the pipe leaving the meter must be steep enough that there are no backwater effects which will cause the wastewater to back up through the meter.

- Channel Shape

  Unless it is a highly controlled hydraulic structure, such as a Parshall Flume, it cannot have sides that suddenly increase or decrease to be usable as a metering location. Additionally, the bottom of the channel cannot suddenly have a bump in it, unless it is a highly controlled hydraulic structure, such as a Palmer-Bowlus flume. The channel cannot make a sudden turn, such as a right angle and be useable as a metering location. These hydraulic shapes will be illustrated later.

- Liquid Depth

  As an example, you cannot use a submerged area-velocity probe if the depth in the channel is less than a few inches. Conversely, you can not use a location where the depth is very deep as a measuring point either. Have you ever seen a flowmeter in the middle of a treatment tank?

- Liquid Velocity

  You cannot measure flow through a tank or other very slow moving fluid unless you use a very specialized flowmeter but such meters do not function in wastewater applications due to the solids. Additionally, you cannot measure flow if the velocity is too great. Ever try to measure flow over a waterfall or over fast moving water?

One of the most basic equations used in wastewater treatment determines the flow in a conduit. The conduit can be either a round pipe, such as a force main, or an irregular shaped channel. Let's review the equation and do some calculations.

$$Q = AV$$

Display Slide 5—Q = AV

Review the material in the workbook. Include the information below in your discussion of the following item.

- All units in the equation must be the same.

  As an example, you can not multiply a velocity that is in feets per second (fps) by an area calculated in square inches. You must convert the area into square feet. The final result will be in cubic feet per second.

Review the example by writing it on a flip chart or whiteboard. For the second half of the example, indicate that the number of gallons in a cubic foot is 7.48 gallons.

Calculation

For each calculation, ask a volunteer to share his or her answer. Record the correct calculation and answer on a flip chart or whiteboard.

1. If you have a channel that is 1 foot wide, the flow is 6 inches deep, and the velocity is 2.5 feet per second (fps), what is the volume in cubic feet per second and gallons per minute?

Ans: (1 foot x 2.5 feet x 0.5 foot) = 1.25 cfs

(1.25 cfs x 7.48 gals/cu ft x 60 second/minute) = 561 gpm

2. If you have an 8 inch diameter pipe and the velocity is 2.5 fps, what is the volume? (Hint: $A = \pi r^2$)

Ans: The area of a circle is expressed as $A = \pi r^2$, where π is the Greek letter pi (pronounced pie) and r is the radius. Pi is a constant that is used in many computations involving circles and is commonly approximated by the number 3.14

Remember to keep units the same, therefore, convert 8 inches to feet.
8 inches/12 inches = 0.667 ft

The radius is equal to half the diameter.
0.667 ft/2 = 0.333 ft

Determine the area.
$A = (3.14)\ (0.333\ \text{ft})^2 = 0.348$ sq ft

Now determine the volume.
Q = AV = 0.348 sq ft x 2.5 fps = 0.87 cubic feet per second

If we want to convert this to gallons, we multiply by 7.48 gallons per cubic feet.
Q = 0.87 cfs x 7.48 gallons = 6.5 gallons per second

3. Given a flow of 0.87 cfs conveyed in a 12 inch diameter sewer line, what would be the velocity?

Ans: Remember to keep units the same, therefore, convert 12 inches to feet.
12 inches/12 inches = 1 ft

The radius is equal to half the diameter.
1 ft/2 = 0.5 ft

Determine the area.
$A = (3.14)\ (0.5\ \text{ft})^2 = 0.78$ sq ft

Now determine the velocity.
V = Q/A = 0.87 cfs/ 0.78 sq ft = 1.11 fps

This is the end of Unit 1. Are there any questions before we move on?

Respond accordingly.

References need not be mentioned.

Now that we covered the legal and practical requirements for flowmetering in Unit 1, let's discuss the technologies used to gather flowmetering information in Unit 2.

UNIT 2: 60 minutes

Display Slide 6—Unit 2: Flowmeter Technologies.

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

- Define an open channel.
- Describe the purpose of the primary hydraulic control element.
- List two open channel primary hydraulic control elements.
- List four open channel measuring devices for measuring depth.
- List three types of flowmeters used on closed pipes.
- Identify two installation considerations for closed pipes.

We will begin this section with a discussion of flowmeter technologies in an open channel.

OPEN CHANNEL: 45 minutes

Review the material at the top of the page.

Accuracy

Review the material in the workbook.

Primary Hydraulic Control Element

Review the material in the workbook.

On the next page are examples of weirs and flumes.

Discussion Question

Ask students where they have seen these types of devices. Their response should be that weirs are normally on the effluent point from a WWTP, which has low suspended solids. You cannot use a weir for raw wastewater for a prolonged period of more than a few hours because sediment will accumulate behind it and render inaccurate flowmeter readings. A flume may be used on the raw wastewater or located out within a collection system. Flumes tend to require very specific construction techniques and operators cannot fabricate their own flume and try to install it in an existing location. However, a skilled operator may be able to evaluate possible locations on a WWTP effluent line, where solids would not be, and possibly install a weir.

Weir

Review the definition in the workbook.

Let's take a look at the different types of weirs.

Sharp-Crested

Display Slide 7—Sharp-Crested Weir

Review the material in the workbook.

- Emphasize that it is a sharp crested weir. Ask students how thick the weir is at the point where water passes over top of it. Ans: 1/8 inch or beveled to 1/8 inch.

V-Notch Weir

Review the material in the workbook. Include the following information:

- A narrow V-notch provides for the measurement of flows in a narrow range with good accuracy. However, maintenance of the V-notch to prevent clogging becomes more critical. A wider V-notch does not give good accuracy at low flows, but it does not clog as easily.

Exercise/Activity

We have an effluent flow that ranges from 10 gpm to 1,500 gpm from a well-operated WWTP. We do not anticipate an unacceptable amount of solids. What are possible V-notch weir options? Use Appendix D - ISCO Table 5-3A.

Ans: Either a 30 or 45 degree V-notch weir as shown in ISCO Table 5-3A.

Rectangular Weir

Display Slide 8—Rectangular Sharp-Crested Weir

Review the material in the workbook.

Display Slide 9—Rectangular Weir

Exercise/Activity

If we have a 2 ft rectangular weir without end contractions and the depth is 0.33 feet, what is the flow? Use Appendix D - ISCO Table 11-3.

Ans From ISCO Table 11-3, the flow is 567 gallons per minute.

Now let’s turn our attention to the other main type of primary hydraulic control element we will cover in this course—flumes.

Flume

Review the material in the workbook.

As with weirs, there are many different types of flumes.

Parshall Flume

Display Slide 10—Parshall Flume

Review the material in the workbook. Include the following information about the diagram once you have covered the bullets on the page.

- Draw the students attention to the location Ha which is 2/3 A. This is the normal measuring point for a Parshall Flume in 99% of the applications the students will be exposed to during their work.

In addition to the diagram of a Parshall Flume in the workbook, have the participants take a look at ISCO Table 4.1A in Appendix D. Note the numerous dimensions of a Parshall flume and point out that it is a carefully constructed device. Note that the table also shows the minimum length necessary for a flume.

Also have participants review Table 4.2A in Appendix D. This table shows the flow ranges of Parshall flumes.

Palmer-Bowlus Flume

Review the material in the workbook.

Trapezoidal Flume

Display Slide 11—Trapezoidal Flumes

Continue to review the information in the workbook. Include the following information:

- Metering manholes can be used with either Parshall, Trapezoidal, or Palmer-Bowlus flumes.

Instructor Note: Be sure to point out the staff gauge at the measuring point in the photograph.

Weirs vs. Flumes

Let's take a look at the advantages and disadvantages of using the two types of hydraulic controls.

Review the tables in the workbook.

We have discussed how we control the hydraulic conditions, such as depth, in the channel. Now we need to discuss methods of determining the level in the channel.

Measuring Devices

Review the material in the workbook.

Depth

Review the material in the workbook.

There are a number of ways to measure depth. Let's review those now.

Bubbler System

Display Slide 12—Bubbler System

Review the information in the workbook. When reviewing back pressure, include the following information:

- As depth increases, it becomes more difficult to push a small bubble out the end of a submerged pipe. Think of blowing down a straw in a glass which is full versus almost empty.
- Only a small volume of air is required. Some less expensive systems actually use a small aquarium pump.

Ultrasonic

Review the material in the workbook. Include the following information:

- Although the sensor never touches the water, it is exposed to vapors. This might be a concern if the vapors are corrosive or might create a lot of humidity which can create a “fog” at the sensor.
- The signal may be false if there is a layer of foam on the water or if there is high humidity in the air.
- It is common to hear a pinging sound when the unit is operating.

Display Slide 13—Turbulence

Continue to review the material in the workbook.

Submerged Pressure Transducer

Display Slide 14—Submerged Pressure Transducer in Flume

Review the material in the workbook. Include the following information:

- Used with some portable flowmeters.

Float

Review the material in the workbook.

Portable Meter

Review the material in the workbook. Include the following information:

- Emphasize that the battery life of the portable meter is a limitation which must be understood. If the meter is checking the flow every few minutes, the battery life will be less than if the same meter is only checking the flow every hour. The time interval between how often the flow is checked is programmed by the operator and will be different depending on the application. For example: if the flow from an industry is being checked and the flow tends to be uniform, the time interval may be every hour. However, if the industry has a batch process and may empty a tank, the time interval may be set at every 5 minutes to catch when a flow is occurring or varying.
- The selection of portable meters should be coordinated with your consultant engineer and meter manufacturer so that you select the proper sized meter.
- Depending on the amount of time the flow may be measured, it may be advantageous to retrofit a manhole into a metering manhole instead of using a portable meter. The metering manhole may also be better if the data collected is critical.

Velocity

In addition to measuring depth, some measuring devices are used to measure flow velocity in an open channel.

Area Velocity

Review the material in the workbook. Include the following information:

- You must know the size of the pipe when selecting an area-velocity meter because the size of the pipe is programmed into the meter when it is set up for measuring.
- The area velocity meter pictured in the workbook is intended for monitoring only one sewer line. A similar looking device from the manufacturer, model 930, can monitor multiple sewer lines that attach probes to a single data collection module.

Open channels are the main focus of this course. But let's talk briefly about closed pipes.

- Closed pipes are covered more in the "Advanced Flowmeters" course.

CLOSED PIPE: 15 minutes

Flow Measuring Components

Primary Hydraulic Control Element

Review the material in the workbook.

Measuring Device

Review the material in the workbook.

Now that we have discussed the types of closed pipe meters, let’s take a look at flowmeter installation considerations.

Installation Considerations

Orientation

Review the material in the workbook.

Separation Distances

Review the material in the workbook.

Ask participants to complete the calculation. Ask participants for their answers. Review the calculation on a flipchart or whiteboard.

Calculation

If we have a pipe of 4 inch diameter, using the separation distance guidelines, what is the absolute minimum distance of straight pipe that is needed (excluding the width of the meter)?

Ans 10 D = (10) (4 inches) = 40 inches upstream

5 D = (5) (4 inches) = 20 inches downstream

40 + 20 = 60 inches. We will need at least a 60 inch section or 5 feet of straight unobstructed pipe, excluding the width of the meter.

► Note to the class that the most common metering problem is inadequate separation distance. Inadequate flow through a meter may account for 50% of improper installations.

Calculation

Look at Appendix D and use Table 9-5 (90 degree V-notch weir). Compare how ½ inch makes a difference in flow reading. Compare 6 inch (0.50 feet) with 6.5 inch (0.54 feet).

Ans: The flow at 0.50 feet is shown as 198 gpm, but at a depth of 0.54 feet the depth is 240 gpm. For a day, the difference between 240 gpm and 198 gpm would result in a difference of 42 gpm or 60,480 gallons.

This is one reason why measurement of depth with an accurate tool is essential. It must be perfectly vertical and perpendicular to the flow.

Now that we have reviewed the various types of flowmeters, let's discuss the calibration of flowmeters in the next unit.

References need not be mentioned.

UNIT 3: 40 minutes

Display Slide 15—Unit 3: Calibration.

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

- List two flowmeter calibration techniques.
- Describe how to identify the correct location for a sensor.
- Discuss two techniques for calibrating a flowmeter using measured volume.
- Calculate known volumes for comparison to meter readings.

INTRODUCTION: 2 minutes

Review the material in the workbook. Include the following information:

- For open channels, the depth of flow at the correct location on a primary hydraulic control…

  This will normally be the preferred technique for verification of flow through an element with a reading on a meter. If this needs conducted on a regular basis, consider installation of a staff gauge.

The site condition is an important factor in the calibration of a flowmeter.

SITE CONDITIONS: 3 minutes

Open Channel

Review the material in the workbook. Include the following information:

- Clean the area before calibration.
  - Clean the walls of any algae.

    It may be necessary to clean walls weekly at a WWTP during summer.
  - Verify there is no sediment on the bottom.

    This could be a problem if a weir is installed on a primary clarifier effluent channel.
  - Check for spider webs that may interfere with the signal.

    This is more of a problem with an ultra-sonic sensor which may have an inverted cone at the transmitter.
- Verify that it is an open channel installation (i.e. pipe not flowing full).

  If the pipe is not flowing full, this may actually be an open channel configuration.

Closed Pipe

Review the material in the workbook. Include the following information:

If the pipe is not always full, then a closed pipe type meter cannot be used.

In addition to the site conditions, the location of the sensor is very important to the proper operation of a flowmeter.

LOCATION OF SENSOR: 5 minutes

To calibrate a flowmeter, it is important to have the sensor in the correct location. Let's first discuss the location of the sensor in an open pipe or channel

Open Pipe or Channel

Review the material in the workbook. Include the following information:

- All weirs and flumes have a designated point that is used to determine head differential...

  This should be one of the first things you check when attempting to calibrate a flow measurement device. You cannot look at the end of a pipe or the flow right at the end of the weir and determine the flow with any accuracy—except with specialized devices.

- Each hydraulic control element has its designated point for measurement…

  For example, the measurement point for a 6 inch (0.5 ft) Parshall flume is different than a 3 foot Parshall Flume.

Display Slide 16—Location of Sensor for weirs.

Instructor Note: Note that the staff gauge in the PowerPoint presentation marks the measurement point.

Display Slide 17—Location of Sensor for parshall flume.

- The figure below shows the location where flow is measured for a Parshall Flume (Ha).

  This is 2/3 A also identified as Ha.

Now let's discuss the location of the sensor in a closed pipe.

Closed Pipe

Review the material in the workbook. Include the following information with the bullets.

- Some sensors must be installed with a specific orientation to the pipe.

  If there is a metal tab on the sensor, it may state to always be mounted in the vertical or top position. Therefore, if the staff disassembles some piping and reinstalls the pipe later with the tab in the incorrect orientation, accuracy may be compromised.

- Once the sensor is installed properly and working, the downstream or upstream conditions…

  As an example, the staff cannot decide to install a pipe tee at the meter without first contacting the meter manufacturer.

Now that we have discussed the location of the sensors, let's go over various calibration options.

CALIBRATION OPTIONS: 10 minutes

Open Channels

Review the material in the workbook. Include the information below in your discussion.

- Vary the flow through the flowmeter and measure with a device that is more accurate...

  For example, you cannot calibrate a meter rated at 1% to 3% accuracy with a device that is only accurate to within 10%.

- Have an electronic calibration procedure performed by a qualified instrumentation company…

  This is a great time to learn a little more about flowmeter and calibration. When the instrumentation person is at your site, ask questions. This is a great opportunity to learn more about your system.

Closed Pipes

Review the material in the workbook.

Measured Volume

Bucket and Stopwatch Method

Review the material in the workbook.

Continue to review the information on the Bucket and Stopwatch Method.

Discharge Into a Known Size Tank (Tanker, WWTP Tank)

Review the information in the workbook. Include the following information your discussion:

- If the exact tank volume is not known or the time it takes to fill the tank is not known, the results will be inaccurate and possibly useless.
- You can not decide to break a flanged connection to allow the flow to discharge at another location or through a hose connection. This would affect the total dynamic head for a pump, which affects a non-positive displacement type pump. As an example, if you wanted to determine the flow rate for a waste activated sludge pump on a final clarifier that normally discharges into an anaerobic digester, you cannot break a flange, connect a hose, and fill a 5,000 gallon tanker.

We've covered the various calibration options, now let's go over the accuracy limits of flowmeter readings from weirs and flumes.

ACCURACY LIMITS: 20 minutes

Weirs

Review the material in the workbook. Include the following information with the bullets.

- The depth of the flow is either used in a lookup table or put into a formula that has…

  The initial data calculation, depending on the formula, will give the result in cubic feet per second (cfs). The user must then convert it to gpm or mgd.

- Use of a lookup table is easier than using the formulas.

  This will be the emphasis of this module. However, the appendix only contains only a partial list of weirs and flumes for use in this course.

☑ Exercise/Activity

1. We want to meter the effluent flow from a small wastewater treatment system that serves the community of King Village of approximately 200 homes. It is assumed that each home uses approximately 250 gpd, for a total daily flow of approximately 50,000 gpd. The discharge is temporary stored within the system and discharged with a pump during a 12 hour period instead of continuously over a 24 hour period. Use Appendix D and look at tables 9-1 through 9-5 to select a V-notch weir which would be appropriate and state why. Do not allow more than a maximum of 1 foot of head over weir.

Ans: If the 50,000 gallons is going to discharge during 12 hours, the flow rate would be (50,000 gallons) divided by 12 hours divided by 60 min/hour; or about 69 gpm, if the rate would be constant.

Table	V-Notch size	Min flow @ head, ft	Depth of head at 69 gpm	Flow at 1 ft depth
9-1	22 ½ degree	3.99 gpm at 0.20 ft	0.63 ft	223 gpm
9-2	30 degree	5.43 gpm at 0.20 ft	0.56 ft	303 gpm
9-3	45 degree	8.31 gpm at 0.20 ft	0.47 ft	465 gpm
9-4	60 degree	11.58 gpm at 0.20 ft.	0.41 ft	648 gpm
9-5	90 degree	20.07 gpm at 0.20 ft.	0.33 ft	1,122 gpm

Discussion Items:

- The minimum flow rate for the larger V-notch is close to the anticipated flow rate and should not be used. As an example, the 90 degree V-notch minimum rate is 20 gpm and the probable flow is 69 gpm.
- The 22 ½ or 30 degree V-notch weirs provide much better coverage of the range.
- To make a decision, you would need to compare the accuracy of the 22 ½ degree V-notch weir and its associated higher maintenance requirements to the 30 degree V-notch weir and its lower maintenance requirements.
- If the 22 ½ degree weir is selected, it should be shielded from the sun to reduce growth of algae. It should also be easily accessible for cleaning.

2. Having taken this course, a WWTP operator measured the following depths at the proper location upstream of a 1 foot rectangular weir without end contractions. What are the flows? Use Appendix D - ISCO Table 11-1.

Ans:

Measured Depth (inches)	Calculated Depth (feet)	Reading (gpm)	Reading (mgd)
2.40	0.200	133.7	0.19
2.52	0.210	143.9	0.21
2.76	0.230	164.9	0.24
3.00	0.250	186.9	0.27
3.60	0.300	245.7	0.35
4.32	0.360	322.9	0.46
4.92	0.410	392.5	0.56

Note: The readings in the mgd column have been rounded to the appropriate significant figure. Avoid creating false accuracy.

Flumes

Display Slide 18—Rate of Flow Equation for Single Point Measurement of a Parshall Flume.

Review the material in the workbook.

Exercise/Activity

The WWTP staff was able to measure the depth of the flow in a 6 inch Parshall flume at Ha with good accuracy and they determined the following depths. What are the flows? Should an instrumentation person be contacted to inspect the flume?

Ans:

Measured Depth (inches)	Calculated Depth (feet)	Reading (gpm) Table 13-4
1.2	0.10	24
3.0	0.25	103
4.5	0.38	200
6.0	0.50	309
7.5	0.62	434

Note that the depth of flow through the meter was able to be measured with good accuracy and all readings were within the ranges listed in the Table. Unless there are other concerns with the meter (e.g., the meter is due for its annual calibration), it does not appear an instrumentation person needs to be contacted.

For a flowmeter to work properly, it must not only be calibrated, but it must also be maintained. The next unit of our course covers flowmeter maintenance. The maintenance of a flowmeter is minimal but critical. Sometimes, the only required maintenance is to calibrate the meter once a year to ensure that cobwebs or other debris have not obstructed the sensor.

References need not be mentioned.

UNIT 4: <u>10 minutes</u>

Display Slide 19—Unit 4: Maintenance.

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

- Name two considerations for sensor maintenance.
- List three site conditions that affect the performance of a flowmeter.
- Discuss two maintenance considerations for portable flowmeters.

SENSOR MAINTENANCE: 2 minutes

A sensor is often exposed to liquid or vapors and may develop a coating. This can adversely affect the performance of the flowmeter. Depending on the situation, there are several steps that might be possible to properly maintain a sensor.

Review the information in the workbook.

Now let's review a few site conditions that can affect the performance of a flowmeter.

SITE CONDITIONS: 5 minutes

Review the material in the workbook. Include the information below along with the material in the workbook.

- Solids deposition

  Example: The stilling well for nozzles that use floats to determine flow levels, such as a Kennison nozzle, may require a flush at least every two weeks.

- Primary hydraulic control element—is it level?
  - It is critical that the weir or flume be level and perpendicular to the flow.

    For example, if staff is cleaning algae from a trough area, they may step on the weir, causing it to no longer be level. Use a carpenter's level to check the weir and adjust it, if necessary.

Exercise/Activity

Display Slide 20—Potential Problem?

What potential problem exists in this picture? Which types of sensors would this problem affect?

Ans: There is a foaming problem.

An ultrasonic sensor is the sensor most affected by foam.

Portable flowmeters require special maintenance and care. Here are a few portable flowmeter considerations.

PORTABLE FLOWMETERS: 3 minutes

Review the material in the workbook. Include the following information:

- Batteries play an important role in the operation of portable flowmeters…

  The manufacturers of flowmeters have designed their systems for a predictable voltage and discharge capacity. Switching to cheaper batteries that are not identical to the manufacturer's specifications is not recommended.

Now that we have reviewed various maintenance issues, in the next unit we'll take a look at some problems that may occur when using flowmeters.

References need not be mentioned.

UNIT 5: 25 minutes

Display Slide 21—Unit 5 – Problems/Troubleshooting

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

- Name two ways a sensor can become fouled.
- List three post-installation problems inside the pipe that create meter inaccuracies.
- Describe three common problems associated with the use of a V-notched weir.

Let's begin by taking a look at improper conditions.

IMPROPER CONDITIONS: 5 MINUTES

Improper Initial Flow Estimates

Improper Initial Flow Estimates

Review the material in the workbook. Include the following information:

- The wider the range that a flowmeter can detect, the more inaccurate the meter may be. As a result, it is best to match the range of the meter to the estimated flow range as much as possible.
- There are circumstances where you cannot measure the estimated minimum, average, and maximum flow rates. In those cases, a meter that only measures the two most important readings must be selected.

Exercise/Activity

Assume a 120 degree v-notch weir, with an average flow of 500 gpm. After initial operation, it was recognized that the flow could range from 20 gpm to 900 gpm. Is there a better v-notch weir for this application? Use Appendix D - ISCO Tables 9-3, 9-5, and 9-6.

Ans Using ISCO Table 9-5, a 90 degree v-notch weir has a range from 20 gpm to 1,122 gpm. This is a better v-notch weir for this application.

Several problems can develop after a flowmeter has been installed. Let's review some of these.

POST INSTALLATION PROBLEMS: 10 minutes

Sensor Fouling

When evaluating the operation of a flowmeter in an open channel, sensor fouling is probably one of the easiest items to check. In a closed pipe, sensors may be more difficult to inspect. However, it is important that sensors be checked on a regular basis to ensure the proper operation of the flowmeter.

Review the material in the workbook.

Discussion Question

How often do you flush closed pipes at your plant?

How often do you need to clean the V-notch weirs at your plant?

There are several problems that can result from the power source. Let's take a look at a few of those issues.

Power Source

Review the material in the workbook.

Discussion Question

Name some portable units at your plant and tell us how often you replace the batteries.

Other Common Problems

Review the material in the workbook. Include the information below along with the material in the workbook.

▶ Encrustation in a pipe

- If encrustation develops inside a pipe, the encrustation should be removed...

    The manufacturer should be contacted if chemicals will be used, since some chemicals can harm the sensor element.

▶ Temperature fluctuations

- If temperature changes are frequent or extreme, it may adversely affect accuracy.

    For example, if the pipe line is not designed for high temperatures but steam or hot water is sent through the line, the meter may be adversely affected.

Display Slide 22—Evidence of Surcharging by Debris on Top of the Nozzle

Continue to review the material in the workbook.

Display Slide 23—Improper Installation

Let's quickly look at some problems specific to insertable v-notch weirs.

PORTABLE FLOWMETERS AND INSERTABLE V-NOTCH WEIRS: 10 minutes

Review the material in the workbook. Include the following information.

- Common v-notch weir problems:
  - Debris clogging the v-notch

    You want to remove debris only and not alter the weir. As an example, do not use a wire brush on a fiberglass weir because you will change its shape.
  - Weir orientation is damaged

    As an example, if someone stepped on the weir it may not be at the correct height or it could be tilted to one side. Place a carpenter's bubble level on the weir to check if it is level. If the weir is still level but lower, this may affect where the reading is taken. The weir must be perpendicular to the flow.

    You can not force a weir into a different size pipe. For example, you can not put a short 8 inch pipe inside a 10 inch pipe and then try to use an 8 inch weir.

This ends our course on flowmeters. In summary:

- A variety of factors will determine how flow is measured.
- Sometimes, you may not be able to directly measure the flow so you will need to use alternative procedures such as bucket/stopwatch or reference to tables such as air lift (covered in the advanced course).
- Technology is changing with flowmetering and many improvements are being made.
- Every flowmetering technique has its advantages and disadvantages.
- There is a limit on accuracy for each metering technique. The most accurate method is to capture all flow in a given time but this is impractical.
- Hydraulics must be considered when measuring flow.
- Suggest that even small WWTPs may find information in the advanced course useful.

- Ask the class if they have any additional questions.
- Thank them for participating in the course.
- Remind them that the appendices contain information that can be used for future reference.

References need not be mentioned.