Drinking Water Operator Certification Training
Instructor Guide

Module 15:
Direct Filtration

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 15: Direct Filtration* is to introduce participants to the concept of direct filtration, its similarities and differences to other treatment methods, and its practical applications. This module has been designed to be completed in 3 hours, but the actual course length will depend upon content and/or delivery modifications 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 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 DEP.

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

Delivery methods to be used for this course include:

- Lecture
- Exercises

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

- 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
Exercise	Flip Chart
Key Definition(s)	Suggested "Script"
Key Point(s)	

Instructor text that is meant to be general instructions for the instructor is 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: <u>5 minutes</u>

Display Slide 1—Module 15: Direct Filtration.

[Welcome participants to "Module 15 – Direct Filtration." Indicate the primary purpose of this course is to introduce participants to the concept of direct filtration, its similarities and differences to other treatment methods, and its practical applications.]

[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 – Direct Filtration Overview** and **Unit 2 – Pretreatment**.

[Briefly review outline.]

If you turn the page, you will see the topical outline for Units 3 and 4**.**

[Continue to briefly review outline.]

UNIT 1: __50 minutes__

Display Slide 2—Unit 1: Direct Filtration Overview.

As a result of this unit, the learner will:

- Be able to list the pretreatment and treatment steps of direct filtration.
- Be able to describe the characteristics of source water that are appropriate for direct filtration.
- Receive information on the six mechanisms at work in granular media filtration.

PURPOSE: <u>10 minutes</u>

Compliance with Treatment Technique Regulatory Requirements

As of March 25, 1989, all existing unfiltered surface water and GUDI systems—Groundwater Under the Direct Influence of Surface Water—were mandated to provide filtration and disinfection within a compliance schedule beginning December 31, 1991 and ending December 31, 1995. Some unfiltered supplies in Pennsylvania were not able to meet this schedule. Some unfiltered surface water and GUDI systems in Pennsylvania remain unfiltered, but are now on schedule to provide filtration.

Therefore, it is important for operators to understand the concepts and processes associated with direct filtration.

We should discuss the purposes of direct filtration in water treatment. There are three purposes. First, it is intended to permit compliance with treatment technique regulatory requirements. Second, it helps to produce safe and aesthetically pleasing drinking water. Third, it targets impurities. Let's start with the first purpose: complying with the regulatory requirements.

[Review information in the workbook up to the table.]

Display Slide 3 – Treatment Technique Log Removal/Inactivation Requirements.

[Review the table information.]

Turbidity Requirements

In many cases the previously unfiltered source waters were upland reservoir supplies or spring supplies of extremely high quality. They contained low solids content or turbidity, and are therefore considered high quality supplies. Keep that information in mind, as it will be important as we continue to discuss direct filtration requirements.

*[Review the definition of **turbidity**.]*

*[Review the definition of **turbidimeter** and discuss the bulleted points listed in the workbook.]*

Turbidity and the Conventional Treatment Process

Conventional filtration, which includes the sedimentation step, is required for high turbidity source waters in order to reduce the solids loading onto the filtration process.

[*Review information in this section of the workbook.]*

Turbidity and the Direct Filtration Process

Direct filtration works best for low turbidity source water.

[*Review information in this section of the workbook.]*

Compliance with Turbidity Requirements

There are guidelines that govern the effluent turbidity requirements of a plant. Let's look at those now.

[Review information in this section of the workbook.]

[Continue reviewing information in the workbook.]

Remember that the combined filter effluent turbidity of all filters must be less than or equal to 0.3 NTU in 95% of all samples collected each month, based on sampling a minimum of every four hours. On-line turbidimeters, which are more commonly used than bench turbidimeters, continuously record turbidity. In order to meet the regulatory requirement of turbidity data recorded every four hours, software programs averages the turbidity every four hours.

[Ask participants to apply their critical thinking skills to the following question.]

How many of the monthly samples of all filters must be less than or equal to 0.3 NTU?

Ans: 171 Samples—If a minimum of six samples per day are required (one every four hours), then 180 samples are collected each month. 95% of the 180 samples equal 171 samples.

Produce Safe and Aesthetically Pleasing Drinking Water

Display Slide 4 – Safe and Aesthetically Pleasing Drinking Water Criteria

The end result of filtration will be a safe and aesthetically pleasant product for the customer. That is the second purpose of direct filtration. To be considered safe and aesthetically pleasing, the water must be free of disease-causing organisms, free of toxic substances, and have no disagreeable taste, odor, or appearance.

Free of Disease-Causing Organisms

The log inactivation/removal of pathogenic bacteria, viruses, and protozoan cysts are achieved by compliance with the disinfection and turbidity requirements that we previously discussed.

The intent of the regulations is to assure that 99.99% of the *Giardia* and 99.9% of the enteric viruses are removed and/or inactivated. The regulations stipulate that if the facility is meeting the turbidity removal requirements, then 99% of the *Giardia* and 90% of the enteric viruses are being removed. Any pathogens remaining in the filtered water must be inactivated by disinfection to achieve the sum total from removal and inactivation.

[Review information in this section of the workbook.]

Free of Toxic Substances

The water delivered to the customer must also be free of toxic substances.

[Review information in this section of the workbook.]

No Disagreeable Taste, Odor, and Appearance

The aesthetics of the water are important to the customers. No one likes to drink water that is foul-smelling or has an off-taste or appearance.

[Review information in this section of the workbook.]

Target Impurities

The final purpose of direct filtration is to target impurities in the water. There are four usual culprits that direct filtration targets.

[Review information in this section of the workbook.]

APPROPRIATE SOURCE WATERS: <u>5 minutes</u>

General Characteristics of Appropriate Source Waters

We have already mentioned one of the characteristics of appropriate source water.

What is one characteristic of source water that is appropriate for direct filtration?

Ans: It has low turbidity, generally less than 2 NTU.

Now let's look at the other parameters for source water appropriate for direct filtration.

[Review information in this section of the workbook.]

Pilot Testing of Source Waters

Pilot testing helps to establish the design criteria for the flocculation and filtration processes. You want to be aware of the studies that were performed to support the design of your facility.

[Review information in this section of the workbook, emphasizing the key point.]

DIRECT FILTRATION VERSUS CONVENTIONAL FILTRATION: 5 minutes

Direct filtration is often called an abbreviated process. This is, of course, because it does not include some of the steps used in other treatment methods.

[Review information in the workbook.]

TYPICAL PROCESS FLOW DIAGRAM: <u>5 minutes</u>

Typically, the process includes these steps. You will learn more about each step in one of the Drinking Water Operator Certification training sessions.

[Briefly review the steps that are shown in the workbook.]

GENERAL OVERVIEW OF DIRECT FILTRATION: <u>15 minutes</u>

The particle removal process that occurs in filtration is complex, consisting of electrostatic, chemical, hydrodynamic, and mechanical forces.

Process Description

We will focus on granular media filtration in this module. There are other types of direct filtration, and those are discussed in other training modules.

[Review information in this section of the workbook.]

Filter Process Objectives

[Review information in this section of the workbook.]

[Allow participants to look at the diagram in their workbooks. Ask the following questions and allow them to answer.]

What is the difference in the source waters between conventional filtration and direct filtration? Why does this affect what type of filtration is used?

Ans: Conventional filtration can use a reservoir supply or a river, for example. The river water will probably have a higher and more variable turbidity level, which makes it inappropriate for direct filtration. The direct filtration process may use reservoir source water, allowing that it meets the turbidity requirements for direct filtration.

What other differences do you see in the two diagrams?

Ans: Direct filtration does not utilize the clarification process. The source water is assumed to be of low turbidity; therefore, this process does not apply to direct filtration.

Granular Media Filtration

Now we can begin to look more in-depth at the granular media filtration process. Several mechanisms are at work here. There are six mechanisms at work in granular media filtration. Let's discuss them.

[Review the key point.]

[Review the information in the workbook.]

Depth Filtration

Depth filtration is the desired mode of operation in a properly designed and operated granular media filtration system. What is depth filtration?

*[Review the definition of **depth filtration**.]*

[Review information in this section of the workbook, emphasizing the key point.]

Filter Backwash

When a granular media filter stops providing acceptable effluent quality or headloss has risen to a maximum level, the filter is taken offline and backwashed.

*[Review the definition of **backwash**.]*

The objectives of any filter process are to produce as high quality effluent as possible and maximize the production of filtered water by long filter runs and efficient backwash processes with low backwash water requirements. We will discuss this in more detail later in the session.

This concludes Unit 1 and the overview of direct filtration. Before water can go through the filtration process, it must be conditioned. Unit 2 will present pretreatment options. Before we go to Unit 2, let's take a few minutes to review Unit 1. Turn the page to find a brief Exercise.

EXERCISE: 10 minutes

Unit 1 – Exercise

Multiple Choice – Choose the best answer

1. Which of the following pretreatment/treatment processes are parts of direct filtration? *(Choose all that apply)*
   a. rapid mixing (coagulation)
   b. flocculation
   c. sedimentation/clarification
   d. direct filtration

Answer: a., b., and d.

2. Select the characteristics of source water that are appropriate for direct filtration. *(Choose all that apply)*
   a. Turbidity is less than 2 NTU
   b. True color is less than 40 c.u.
   c. Algal blooms are less than 20,000 asu/ml
   d. Iron is less than 0.3 mg/L
   e. Manganese is less than 0.05 mg/L
   f. Coagulant demand is below 15 mg/l

Answer: a., d., e, and f.

3. One of the mechanisms at work in granular media filtration is the particle attachment to the __________ grains. *(Choose the best answer to fill in the blank)*
   a. media
   b. turbidity
   c. organic

Answer: a. media

4. Some of the criteria of safe and aesthetically pleasing drinking water are: *(Select all that apply)*
   a. Free of toxic substances
   b. Free of disease-causing organisms
   c. Disagreeable taste and odor.

Answer: a. and b.

5. To verify that a source water can be treated with direct filtration, the DEP requires that ______ testing be performed prior to the design of the facility. *(Choose the best answer to fill in the blank)*
   a. pressure
   b. sedimentation
   c. pilot

Answer: c. pilot

Key Points

[Review key points in the workbook.]

UNIT 2: <u>40 minutes</u>

Display Slide 5—Unit 2: Pretreatment.

As a result of this unit, the learner will:

- Be able define the term “pretreatment” and how it differs from the term “treatment”.
- Be able to list the reasons for pretreatment of source water prior to filtration.
- State the purpose of rapid mixing and slow mixing in the direct filtration pretreatment process.

CONDITIONING FOR FILTRATION—PRETREATMENT: 30 minutes

Pretreatment conditions the water. Although source water turbidity is relatively low, soluble metals and suspended and colloidal solids will be present. There are three pretreatment methods used in direct filtration.

*[Review the definition of **pretreatment**.]*

Chemical Addition

Adding chemicals to the water is the first pretreatment method. Operators must determine what chemical addition is necessary by first assessing the source water.

Oxidation

[Review information in the workbook, emphasizing the key point. Then ask participants the question:]

What periodic variations might be expected in consistently good quality source water? How does this affect the oxidation step?

Ans: (Various answers are possible. One is given here.) The water quality of an upland reservoir supply may only vary during a natural turnover event that occurs in the fall, as the water temperature decreases. As a result of the decrease in water temperature near the surface, it becomes denser, sinking and displacing the deeper water layers. Convection currents are set up as the less dense, deeper waters rise up, bringing along dissolved metals and nutrients from the deeper layers. Soluble fractions of metals must be oxidized.

Remember that you must regularly analyze and assess the contents of the water. Some examples of starting points for oxidation ratios are presented in your workbook.

[Review information under the following headings:]

Oxidation of Soluble Iron with Chlorine
Oxidation of Soluble Iron with Potassium Permanganate
Oxidation of Soluble Manganese with Chlorine
Oxidation of Soluble Manganese with Potassium Permanganate

[Review the key point.]

For example, if ammonia is present in the raw water, this contaminant will consume oxidant, resulting in an increase in the oxidant dose requirement. Remember to jar test—do not make assumptions.

Overdosing with the Oxidation Method

Overdosing with either of the chemical additions will have consequences.

[Review information in this section of the workbook.]

pH Adjustments with the Oxidation Method

pH levels are important when adding chemicals.

[Review information in this section of the workbook.]

[Review the key point.]

Coagulation

Along with consideration of oxidation, operators must determine the dose of coagulant to add. For conventional treatment, the optimum coagulant dose is normally determined by jar testing. In conventional treatment, the goal is to develop a large, rapidly settling floc and a clear supernatant.

Direct filtration goals are different. Since the goal of coagulation for direct filtration is the formation of a small, filterable floc that will provide depth filtration, jar testing may be of value only for providing an initial coagulant dose for use in filter studies.

Let's discuss coagulation in the direct filtration process.

[Review the key point.]

[Review the information in the workbook.]

Supplementary Alkalinity

Coagulation is also pH dependent because pH affects the coagulant species that is present. The optimal pH is dependent on the primary treatment goal.

[Review the key point.]

Display Slide 6 – Alkalinity Consumed.

[Review information on the slide and in the workbook.]

[Review the key point.]

Display Slide 7 – Alkalinity Added.

[Review information on the slide and in the workbook.]

Supplementary Acidity

[Review the key point.]

Display Slide 8 – Supplementary Acidity.

[Review information on the slide and in the workbook.]

Remember: coagulation and oxidation are pH dependent; therefore, pH adjusting chemicals are normally part of the pretreatment process.

A water treatment plant operates at a rate of 200,000 gallons per day. If the dosage of alum is 30 mg/L, how many pounds of dry alum are used each day?

- Formula: ? Pounds Per Day = Flow (MGD) x Concentration (mg/L) x 8.34 Pounds Per Gallon
  First calculate flow in GPD to MGD. Divide 200,000 by 1,000,000.
  Solve: ? lbs/day= 0.2 MG x 30 mg/L x 8.34 lbs/gal
  50 lbs/day

{You may want to suggest for participants planning to take the certification exam, math is covered under Module DW-6 General Math.]

Let's look now at the next pretreatment process, which is rapid mixing.

Rapid Mixing

Rapid mixing is sometimes called flash mixing. This is important for mixing chemicals into the water. Depending on the type of mixing equipment used for rapid mixing, operating parameters associated with rapid mixing that may be adjustable including mixing intensity and detention time. It is important for you to understand the concept of rapid mixing.

[Review information in the workbook, emphasizing the key points.]

Rapid Mixing Types

Starting with the next page, we will spend a few minutes discussing the rapid mixing types.

In-line Static Mixing

The first type is the in-line static mixer.

Display Slide 9 – Motionless (Static) Mixer.

[Review information in the workbook.]

Mechanical Mixing

The next type of mixer is mechanical. You may see a turbine type or propeller type.

Display Slide 10 – Turbine Type Mechanical Mixer.

Note where the chemicals are optimally introduced. This helps distribute them as quickly as possible.

[Review information in the workbook.]

Display Slide 11 – Propeller Type Mechanical Mixer.

Again, note the chemical addition location near the propellers.

Hydraulic Mixing

Hydraulic mixers are antiquated and are rarely seen today. Very old plants might use the hydraulic mixer, but it is not efficient by today's standards. The water flows, maze-like, around corners that create the mix action.

Rapid Mixing Parameters

[Review information in this section of the workbook.]

Instrumentation

As noted earlier, the operator does not regularly make adjustments to the mixing process. However, since the operator does adjust chemical additions, instrumentation is useful for assessing the feed rates of the chemicals.

As one example, let's talk about pH. Although for high quality source water, pH may be fairly stable, variable conditions still exist.

What variables might affect pH?

Ans: (Various answers are possible. One is given here.) Algae may be active during the day but dormant at night. Algal activity consumes carbon dioxide, which results in an increase in pH as part of the photosynthesis process. Source water under these conditions may have a pH that trends higher during the day and then decreases at night.

[Review information in the workbook up to the bullet point, "Streaming Current Detector (SCD)."]

Streaming current detectors must be calibrated. Prior to calibration, coagulant optimization must occur by some other method, such as jar tests, filtered water turbidity, particle counts, or other measurements independent of streaming current or zeta potential. The streaming current reading under optimum coagulation conditions is used as the "set point," and typically the instrument is set to zero. When the streaming current deviates from the set point, the coagulant feed is adjusted until the reading returns to the set point. The set point for streaming current will vary with a significant change in mixed water pH. At a pH above 8.0 and/or TDS above 500 mg/L, streaming current measurement becomes unreliable.

[*Review information under this section of the workbook.]*

[Finish reviewing information in the Streaming Current Detector (SCD) section, review information on Zeta Potential and other information in the workbook.]

Flocculation

Very few direct filtration treatment plants skip the flocculation step. Flocculation in direct filtration is different from the sedimentation process. Sedimentation processes are appropriate for larger, heavier floc. Direct filtration requires smaller floc.

*[Review the definition of **flocculation**.]*

[Review information in this section of the workbook.]

Advantages and Disadvantages of Flocculation

[Review information in this section of the workbook.]

Design Parameters

The key parameters include mixing intensity and detention time. Let's take a moment to look at these parameters.

[Review information in this section of the workbook.]

Types of Flocculators

There are four types of flocculators. They include vertical turbine, reel-type (or paddle) mixers, walking beam, and hydraulic flocculators.

Just to familiarize you with the types, let's take a few moments to talk about them.

[Review information in the workbook.]

This concludes Unit 2. Are there any questions about the material?

[Allow participants to ask questions as time permits. Answer them fully or, if you are unable to answer, be sure to get the necessary information from the participant so that you can follow up with him or her at a later date.]

Turn the page now and you will find some review questions for this unit. Because we didn't cover much math, let's see how you do.

EXERCISE: 10 minutes

Unit 2 – Exercise

Multiple Choice – Choose the best answer

1. In drinking water terminology, "pretreatment" is any treatment process that occurs before the filter. For the process of direct filtration, this can involve which of the following: *(Choose all that apply)*

   a. chemical addition
   b. coagulation (rapid mixing)
   c. flocculation (slow mixing)
   d. sedimentation

Answer: a., b., and c.

2. Overdosing of __________ can result in a residual that may contribute to the formation of disinfection by-products. (Choose the best answer)

   a. Potassium permanganate
   b. Soda ash
   c. Chlorine

Answer: c. – chlorine

3. The most common chemicals for raising pH are: (Choose all that apply)

   a. potassium permanganate
   b. lime
   c. caustic soda
   d. soda ash

Answer: b., c, and d.

4. Alum, ferric chloride, and PAC are the most common chemicals used in the pretreatment process of:

   a. coagulation
   b. flocculation
   c. sedimentation

Answer: a. coagulation

5. A ____ pH is necessary for most effective coagulation of organics.

   a. high
   b. low

Answer: a. low

6. The pretreatment step during which a slow, mechanical mixing process promotes the formation of floc particles is called:

   a. coagulation
   b. flocculation
   c. oxidation

Answer: b. flocculation

PRACTICE: try and solve

7. If 1,000 pounds of dry alum are required to treat 15 million gallons of water, what is the dosage?
   a. 0.125 mg/L
   b. 8 mg/L
   c. 566 mg/L
   d. 1799 mg/L

Answer: b. 8 mg/L – 1000 lbs./ (15 MGD * 8.34 lbs/gal)

8. The surface of a sand bed of a filter measures 15 by 25 feet. What is rated total capacity for a rate of 10 gpm/sq ft?
   a. 37.5 gpm
   b. 375 gpm
   c. 3,750 gpm
   d. 3,075 gpm

Answer: c. 3750 gpm -- 15ft * 25ft * 10 gpm/sqft.

9. A filter is 5 feet wide and 15 feet long. The desired backwash rate is 5 gallons per minute per square foot. What backwash flow is needed?
   a. 7,075 gpm
   b. 3,075 gpm
   c. 750 gpm
   d. 375 gpm
   e. 75.5 gpm

Answer: d. – 375 gpm -- 5ft * 15ft * 5 gpm/sqft

10. What is the weight of a 3 gallon solution which has a specific gravity of 1.05?
    a. 10 lbs.
    b. 10 mg/L
    c. 26 lbs.
    d. 26 mg/L

Answer: c. 26 lbs --3 gal * 1.05 s.p. * 8.34 lbs/gal

11. A filter 5 feet wide by 5 feet long is permitted to operate at a rate of 2 gpm/$ft.^2$. What is the maximum flow rate within the permit limitations?
    a. .035gpm
    b. .07 mgd
    c. 3.5 mgd
    d. 7.0 gpm

Answer: b .07 mgd -- 2gpm/sqft * 1440 min/day * 1mgd/1000000 gal* 25sqft

Key Points

[Review key points in the workbook.]

UNIT 3: <u>57 minutes</u>

Display Slide 12—Unit 3: Direct Filter Components.

As a result of this unit, the learner will:

- Be able to differentiate between mono, dual, and mixed media filters..
- Be able to list the four criteria of water quality that direct filtration plant operators must take into account.
- Receive information on filter performance.

FILTER COMPONENTS: 22 minutes

There are two types of filters and several types of filter bed media that you will most often encounter. In this section, we will have the opportunity to explore some of the different filter components and the properties of various media.

Types of Filters

Display Slide 13 – Typical Gravity Filter.

[Review information in this section of the workbook.]

Filter Bed Materials

Media grain size is governed by the design of the plant. It is important, however, for an operator to understand why certain media is more appropriate than others for different plant needs. In the workbook, you will find some media selection notes.

Basis for Media Selection

[Review information in this section of the workbook, emphasizing the key point.]

Types of Filter Bed Materials

There are five types of filter bed materials that are commonly used. Each has distinct advantages and disadvantages.

[Review information in this section of the workbook.]

Media Properties

Media grain size is defined by a sieve analysis performed on the media using a standard set of sieves. The results of the sieve analysis, plotted on a log graph as a gradation curve, can be used to determine the following standard media sizing units.

[*Review the definition of* ***Effective Size (ES)****.]*

[Review the definition of ***Uniformity Coefficient (UC)****.]*

In other terms "uniformity coefficient" of filter media refers to the measure of uniformity of filter media size.

[Review the definition of ***Roundness (media grain shape)****.]*

[Review the definition of ***Sphericity (media grain shape)****.]*

[Review the definition of ***Density, or Specific Gravity****.]*

[Review the definition of ***Bulk Density****.]*

[Review the definition of ***Bed Porosity, or Voidage****.]*

[Review the definition of ***Hardness****.]*

*[Review the definition of **Acid Solubility**.]*

[Review the key points. After the second key point, ask the following question.]

Is a lower backwash velocity required under cold water conditions or warm water conditions?

Ans: Temperature is an important factor since colder water is denser than warmer water. For a given media expansion, lower backwash velocities are required under colder water conditions than warmer water conditions.

Media Bed Configurations

[Review information in this section of the workbook.]

Underdrains

You might see various types of underdrains in different plants.

Display Slide 14 – Perforated Pipe Underdrain.

A Perforated Pipe System is used only at small plants or older plants.

Remember that the goal is to evenly wash the media bed. All the examples of underdrains are simply different methods to reach that goal. The perforated pipe system is not the best way to achieve the even wash.

[Review information in the first two bullet points of this section of the workbook.]

The Glazed Tile Filter Blocks' process is effective, but the glazed tile underdrain is rarely installed today because of its expense. Plastic Filter Blocks can be used in the underdrain. The system is similar to the tile block system but using plastic decreases the cost of producing this type of underdrain.

Two other types of underdrain you might encounter are porous plates and nozzle/strainer types. The similarity between these two types is that a plenum is built in.

[Review the rest of the information in this section of the workbook.]

Backwash Components

[Review information in this section of the workbook.]

There are three main components to the backwash process. Let's take a brief look at each.

[Review information in the workbook.]

Filter Valves

Valve operation can be manual, motor operated, or pneumatic or hydraulic.

What is the valve operation in your plant? What do you like or dislike about this?

Ans: Answers will vary with plant operators. Allow them to discuss the various advantages and disadvantages of their systems.

Various filter valves perform different tasks. A brief review here will familiarize you with each of the valves.

[Briefly review the information in the workbook.]

An illustration of a typical gravity filter's piping is shown in your workbook. You will notice the valves that we discussed on the last page.

[Review information in this section of the workbook.]

Filter Control Systems

Flow Controls

Flow controls are important for smooth, consistent operations.

[Review information in this section of the workbook.]

Types of Filter Control Systems

Filter control systems are divided into two primary types: equal flow rate and declining flow rate types. You might hear the term, "constant flow rate," used to describe equal flow rate systems. This is an inaccurate description because almost all plants undergo changes in daily flow due to variations in production and/or filters that are removed from, and returned to, service.

[Review information in this section of the workbook.]

Filter Backwash

There are three alternatives for an auxiliary scour. We will discuss these in more detail in just a few minutes. First, let's look at the sequence of events that occur in a filter backwash.

Display Slide 15 – Sequence of Events.

[Review information on the slide and in the workbook.]

Remember that the first step was the auxiliary scour. The first alternative for the auxiliary scour is a surface wash. In surface wash, jets of water are injected from pipes located one or two inches above the media surface. Surface wash initiates prior to media expansion and generally continues during most of the upflow wash and becomes immersed in the expanded media.

An air scour, the second alternative for auxiliary scour, distributes air either through the backwash underdrain or through a dedicated header manifold-lateral piping system. Air wash is typically the first stage of backwash and may or may not continue into the first low backwash. This depends upon the susceptibility of the filter to media loss.

The air scour is an essential step during backwash of GAC due to the required use of a low backwash rate to avoid media loss.

FILTER PERFORMANCE: <u>15 minutes</u>

Production Criteria

How do you know when your filter is operating optimally? You can check the filtration rate, filter run time, and filter production and efficiency.

Filtration Rate

[Review information in this section of the workbook.]

Filter Run Time

The length of a filter cycle is important if the operator must be present to operate or observe a backwash. Therefore, the filter run time and its subsequent production amounts and efficiency are important to know. Keeping records of these times will help to create a base and will alert the operator to possible problems if the times begin to change.

[Review information in this section of the workbook.]

Filter Production and Efficiency

[Review information in this section of the workbook.]

WATER QUALITY CRITERIA: <u>10 minutes</u>

As noted in Unit 1, the EPA Enhanced Surface Water Treatment Rule and the DEP Filtration Rule are regulatory requirements that cover direct filtration plants.

[Review the key point.]

Filter Effluent Turbidity

[Briefly review the information under this section in the workbook. It should be familiar to participants.]

Filter Particle Counts

Particle count instruments quantify the concentration of particles for specific size ranges in a continuous flow stream. They commonly function by using a laser light perpendicular to the passage of sample flow, which, when obscured by passing particles within that flow, create shadows on a light-sensitive diode that triggers an electrical signal.

One benefit particle counting can provide in filter performance assessment is increased understanding of the impact of water quality and operational changes. It is responsive to small changes in particle concentrations which may not be reflected by increases in turbidity. Particle counting is particularly beneficial for determining the impact of operational changes when turbidity is less than 0l.10 NTU, where a turbidimeter may not be as responsive.

A trend of increasing particle release often occurs late in a filter cycle; particle counters can provide an "early warning" of impending filter breakthrough before a change in turbidity is even detected.

[Very briefly review information in this section of the workbook.]

Particle counting is becoming widely used in the drinking water industry to: monitor filter ripening, assess the impact of flow changes on filter performance, detect early breakthrough; optimize coagulant; and generally maintain filter performance at a high level.

Quality versus Run Time and Headloss

Over a period of time, the quality of the filter and the filtration process changes. There are really three distinct runtime phases. They are Initial Improvement Period, also known as filter ripening, Steady State Period, and the Terminal Period.

[Review the first bullet point (Initial Improvement Period) and its sub-bullets in this section of the workbook. Ask the participants the following question.]

What do you think the amount of shearing is dependent upon?

Ans: Shearing is dependent upon both the abruptness and the rate of filter flow increase.

[Review the last two bullet points in this section of the workbook. Afterwards, ask the following question.]

What are the indicators of a terminal period?

Ans: (Answers may vary.) Turbidity and particle counts start to trend upwards to indicate that the steady state period is ending and the terminal period is beginning.

Microscopic Particulate Analysis (MPA)

[Review information in this section of the workbook. Then, ask the following question.]

What type of particles might you expect to find?

Ans: (Answers may vary. Be sure that participants name at least those given here.) Particles might include: plant debris, pollen, rotifers, crustaceans, amoeba, nematodes, insects/larvae, algae, protozoan cysts such as *Giardia* and *Cryptosporidium*.

Impact of Other Variables

Water temperature and influent water quality will affect the filter performance and, subsequently, the effluent.

Water Temperature

[Review information in this section of the workbook.]

Influent Water Quality

[Review information in this section of the workbook.]

This ends Unit 3. Are there questions?

[Allow participants to ask questions. Answer them as fully as possible.]

Let's look at the review questions for Unit 3 on the next page. They will confirm that we have met the objectives of this unit.

EXERCISE: 10 minutes

Unit 3 – Exercise

Matching: Match the letter of the corresponding filter system component with the number of the correct statement.

A. mono media-type filter
B. dual media filter
C. mixed media filter

1. _____A__ Commonly has a single media which is anthracite.

2. ____C___ Typically has a top layer of anthracite or GAC, a middle layer of silica sand, and a bottom layer of garnet sand.

3. ____B___ Has a has a top layer of anthracite or GAC, and a bottom layer of silica sand.

Listing:

4. List the four criteria of water quality that direct filtration plant operators must take into account.

____filter effluent turbidity___________
____filter particle counts___________
_____quality vs. run-time and headloss__
____microscopic particulate analysis___

True or False: Select the best answer

5. The quality of the filtration process changes over run time.
   a. True
   b. False

Answer: a. – True

6. Increased flow rates make filtration less susceptible to breakthrough.
   a. True
   b. False

Answer: b. – False – Increased flow rates make filtration MORE susceptible to breakthrough due to higher shearing forces on the previously retained material.

Key Points

[Review key points in the workbook.]

UNIT 4: <u>33 minutes</u>

Display Slide 16—Unit 4: Filter Operations.

As a result of this unit, the learner will:

- Review routine parameters for water quality monitoring, headloss, backwashing, and rinse criteria.
- Be able to describe three events that signal abnormal operation.
- Receive and explanation on the importance of record keeping and a list of the minimal types of records that must be kept.

OPERATIONAL PROCEDURES: 20 minutes

Routine Operation

Water Quality Monitoring

We have discussed the water quality monitoring criteria in detail. Listed on this page are some reminders of what indicates normal operations' monitoring needs.

[Review information in this section of the workbook.]

Headloss

Here are some important things to keep in mind.

[Review the first three bulleted items in this section of the workbook. On the fourth bullet, mention the following additional information or ask questions to prompt participants to supply the information.]

➢ Many factors, including the following, can affect loss of head.

- Depth of media

Recall that loss of head increases with depth.

- Filter rate

Loss of head increases with flow rate.

- Viscosity of the water

Remember the temperature dependency we discussed. Loss of head in a clean filter in winter can be as much as double the amount of a summer's headloss.

- Size, uniformity, and shape of the media grains

Smaller, less uniform and more rounded media grains result in greater loss of head due to having less void space.

- Filter bed porosity

Related to media size, uniformity, and shape—the larger, more uniform, and more angular the media grains, the greater the bed porosity and the lower the loss of head.

- Filter aid polymer

Polymer feed can result in filter binding and rapid headloss if overdosed due to the development of a relatively large and strong floc that tends to be retained on or near the surface of the bed.

- Algae

The presence and concentrations of certain types of algae can result in surface blinding and greater headloss.

[Review the three key points in this section of the workbook.]

Common Backwashing Criteria

We have discussed backwashing in some detail. In your workbook, you will find a chart of common backwash criteria. This information will help you establish a baseline.

[Review information in this section of the workbook. Ask the participants the following question.]

How do these criteria measure up to your own personal experiences?

[Allow participants to discuss conditions at their plants.]

Rinse Criteria

A good reminder is to return the filter to service when the turbidity is less than .10 NTU.

Indicators of Abnormal Operation

Operators should be aware of the idiosyncrasies of his or her plant. Each filter and filter process will have its own slight variations from another filter or process. Stay aware of trends in your system, and be sure to keep and check records often.

[Review information in the workbook.]

RECORD KEEPING: <u>5 minutes</u>

Record keeping is one of the most important administrative jobs required of a plant operator.

[Review the key point.]

[Review information in the workbook.]

[Continue to review information in the workbook, emphasizing the key point.]

Unit 4 is now complete. Turn the page and we will take the final review Exercise.

EXERCISE: 8 minutes

Unit 4 – Exercise

True or False: Select the best answer

1. Depth of media and filter rate are two factors which can affect filter headloss.

    a. True
    b. False

Answer: a. True

2. A common filter backwash criteria is to terminate the backwash rinse and return the filter to service when turbidity falls below 10 NTU.

    a. True
    b. False

Answer: b. False. A common rinse criterion is to terminate the rinse and return the filter to service when turbidity falls below 0.10 NTU.

Fill in the blanks:

3. Some indicators of abnormal direct filtration operations are:
    a. Rapid changes in filtered water _______________ during normal filter operations.
    b. Short __________ runs.

Answers: a. turbidity; b. filter

4. Some adjustments that can be made if a direct filtration plant is operating abnormally are:
    a. Make _______________________ modifications as necessary.
    b. Inspect the ___________ bed, including depths and conditions of media.

Answers: a. pretreatment; b. filter

5. Accurate water quality process records should be kept of the following:
    Temperature, __________, alkalinity, ______________, color, iron, manganese, and hardness.

Answers: a. pH; b. turbidity

6. Accurate process operations records should be kept of the following:
    Filters in service, filtration rates, loss of head, length of ___________ runs,
    frequency of filter ___________, auxiliary scour, and backwash rates and durations.

Answer: a. filter; b. backwash

Key Points

[Review key points in the workbook.]

Display Slide 17 – Questions

Now I will take your questions.

[Allow participants to ask questions. Answer them as fully as possible. If necessary, obtain information from participant that will enable you to follow up with an answer for him or her. Dismiss.]