DW Module 14:
Conventional Filtration
Answer Key

UNIT 1 EXERCISE:

Ans:

											[1]T						
											U						
											R						
											B						
											I						
											D			[2]C			
											I			O			
				[3]C	O	A	G	U	L	A	T	I	O	N			
											Y			V			
														E			
														N			[4]C
														T			L
										[5]D				I			A
	[6]F	L	O	C	C	U	L	A	T	I	O	N		O			R
										S				N			I
[7]S	E	D	I	M	E	N	T	A	T	I	O	N		A			F
										N				L			I
										F				[8]F	L	O	C
										E				I			A
										C				L			T
							[9]S			T				T			I
					[10]C	O	L	L	O	I	D	S		R			O
							U			O				A			N
							D			N				T			
							G							I			
							E							O			
														N			

Calculate the dose, if 1500 pounds of dry Alum are required to treat 15-mgd of water.

So let's walk through this calculation: We know the formula is:
Loading (lbs/day) = Concentration(mg/L) * Flow (MGD) * 8.34 lbs/gal
We need to solve for:
? Concentration (mg/L) = 1,500 lbs./(15-mgd * 8.34 lbs/gal)
? Concentration (mg/L) = 12 mg/L

UNIT 2 EXERCISE:

1. List the primary coagulants (3 metallic salts and 1 synthetic inorganic polymer) used in the coagulation process.

Ans: *Aluminum Sulfate*
Ferric Sulfate
Ferric Chloride
Polyaluminum Chloride

2. In the space provided, explain the importance of coagulant aids—synthetic organic polymers.

Ans: *Coagulant Aids strengthen and add density to the flocs.*

3. List two types of mechanical flocculators in common use.

Ans: Horizontal paddle wheel flocculator, and vertical flocculator.

For the following statements, make those that are true with a T, those that are false with an F.

4. *T*_____ The effectiveness of sedimentation, filtration and overall plant performance depends on successful coagulation/flocculation.

5. *F*_____ Poor coagulation/flocculation does not affect performance.

6. *T*_____ Alum will decrease pH, adding lime to the flash mixer will increase lost alkalinity.

7. *F*_____ When dissolved in water, alum generally produces negatively charged ions.

8. *F*_____ Using iron slats instead of alum for coagulation is less effective over a broader pH range.

9. *T*_____ Adding chemicals at the wrong location may cause floc to be too large.

10. *T*_____ Coagulants added in the influent line before a flash mix basin will produce better results.

11. *T*_____ Mixing is the rapid uniform distribution of a chemical in the water being treated.

12. *F*_____ Colloidal particles refer to the ions that settle out easily through gravity.

13. *T*_____ If an operator observes floc splitting and breaking up in the flocculation chamber, the rate of the flocculators should be slowed down.

14. *T*_____ The main purpose of coagulation/sedimentation is to remove turbidity.

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Theoretical Detention Time Calculation

The first thing we need to do is convert flow rate, which we note as Q, to gallons per hour.

Flow Rate, gallons per min.

$$\text{Q, gph} = \frac{\text{Q, MDG x 1,000,000}}{\text{24 hr/day}}$$

$$= \frac{\text{1.5 MGD x 1,000,000}}{\text{24 hr/day}}$$

$$= \text{62,500 gallons per hour}$$

Our second step is to calculate sedimentation basin volume in gallons.

Sedimentation Basin Volume.

Vol, gal = 2 basins x 20 ft wide x 60 ft long x 12 ft deep

= 28,000 cu ft x 7.48 gal/cu ft

= 215,424 gallons

The last step requires us to determine Detention Time (DT) in hours.

$$DT_{(t)} = \frac{\text{Vol, gal}}{\text{Q, gph}}$$

$$= \frac{215{,}424 \text{ gal}}{62{,}500 \text{ gph}}$$

$$= 3.45 \text{ hours}$$

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Surface Overflow Rate Calculation

The first thing we need to do is convert flow rate, which we note as Q, to gallons per minute.

Flow Rate, gallons per min.

$$\text{Q,gpm} = \frac{\text{Q, MGD x 1,000,000}}{\text{24 hr/day x 60 min/hr}}$$

$$= \frac{\text{1.5 mg x 1,000,000}}{\text{24 hr/day x 60 min/hr}}$$

$$= 1042 \text{ gpm}$$

The next step is to determine the surface overflow rate in gallons per minute per square foot.

Surface Overflow Rate.

$$\text{Surface Loading} = \frac{\text{Q, gpm}}{\text{2 Basins x Basin Surface Area, sq ft}}$$

$$= \frac{\text{1042 gpm}}{\text{2 x(20 ft x 60 ft)}}$$

$$= \text{0.43 gpm/sq ft}$$

Mean Flow Velocity Calculation

The first thing we need to do is to determine the flow to each basin.

Flow, Basin Rate, gallons per min.

$$\text{Q (basin), gpm} = \frac{\text{Q (plant), gpm}}{\text{2 basins}}$$

$$= \frac{\text{1042 gpm}}{\text{2 (basins)}}$$

$$= \text{521 gpm}$$

Our second step is to determine the Cross Sectional Area (CSA) of one basin in square feet.

Cross-Sectional Area (CSA) of one basin in square feet.

$$\text{CSA, sq ft} = \text{20 ft wide x 12 ft deep}$$

$$= \text{240 sq ft}$$

The last step requires us to determine the Mean Flow Velocity (MFV) in feet per minute per basin.

Mean Flow Velocity, ft/min.

$$\text{MFV, ft/min} = \frac{\text{521 gpm}}{\text{240 sq ft x 7.48 gal/cu ft}}$$

$$= \text{0.29 ft/min}$$

Weir Loading Rate (Weir Overflow Rate) Calculation

The first thing we need to do is to convert flow rate to gallons per day.

Flow Rate, gallons per day.

$$Q, \text{gpd} = Q, \text{MGD} \times 1{,}000{,}000$$
$$= 1.5 \times 1{,}000{,}000$$
$$= 1{,}500{,}000 \text{ gpd}$$

Our second step is to determine the total effluent Weir Length (WL).

Total Effluent Weir Length.

WL, ft = 2 basins x 20 ft width x 1 launder/basin x 2 sides/launder

= 80 feet of overflow weir, total

The last step requires us to calculate the Weir Loading Rate (WLR) in gallons per day per foot of weir length.

Weir Loading Rate, gal/day/ft.

$$\text{WLR, gpd/ft} = \frac{1{,}500{,}000 \text{ gpd}}{80 \text{ ft total Weir Length}}$$
$$= 18{,}750 \text{ gpd/ft}$$

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UNIT 3 EXERCISE:

Word Box

a. Water temperature	k. Electrical charge of particle
b. Particle size	l. Environmental conditions
c. Inlet zone	m. Sludge
d. Detention time	n. Clarifiers
e. Gravitational settling	o. Surface loading rate
f. Particle shape	p. Sludge zone
g. Outlet zone	q. Settling zone
h. Relationship of downward movement of particle to forward flow velocity	r. Mean flow velocity
i. Rectangular basin	s. Weir loading rate
j. Circular or Square basin	t. Tube or Plate settlers

Use the Word Box above to complete the following:

1. Identify the four zones of a sedimentation basin.

Ans: c – Inlet zone

g – Outlet zone

p – Sludge zone

q – Settling zone

2. List four operating parameters important to sedimentation.

Ans: d – Detention time

o – Surface loading rate

r – Mean flow velocity

s – Weir loading rate

3. List the settling characteristics upon which the sedimentation process is dependent.

Ans:

a – Water temperature
b – Particle size
d – Gravitational settling
f – Particle shape
k – Electrical charge of particle
l – Environmental conditions
h – Relationship of downward movement of particle to forward flow velocity

Fill in the blanks:

4. The <u>*largest*</u> portion of the horizontal flow sedimentation basin is the settling zone.

5. If the motor is normally running and the sludge collector is not moving, the most likely cause of a clarifier sludge collector problem would be that a <u>*shear pin*</u> is broken.

6. A sludge collector device should move very <u>*slowly*</u>.

7. Increase flow to the treatment plant will affect the settling tank in that the detention time will <u>*decrease*</u> and the overflow rate will <u>*increase*</u>.

8. A series of thin parallel plates installed at 45-degree angle for shallow depth sedimentation are known as <u>*lamellar plates*</u>.

9. Two methods if improving settling efficiency in a sedimentation basins are using tilted plates or ***tube settlers*** ..

10. If the weir overflow rate for a clarifier is too ***high***, floc carry over will be observed.

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UNIT 4 EXERCISE:

1 – 4. There are four performance considerations of Filtration listed below. Match each consideration with the correct explanation of that consideration.

Ans:

Performance Consideration	Explanation
Filter Media ⊙	⊙ Filter production and efficiency
Filter Underdrains ⊙	⊙ The materials used to filter out impurities
Filter Operating Parameters ⊙	⊙ The process of reversing the flow of water back through the filter media to remove trapped material.
Backwashing ⊙	⊙ Where filtered water is collected during normal operation.

5. Write your own definition of **filtration** below.

Ans: Accept answers that include minimally: process, water moving through material, to remove impurities.

6. What are the reasons for keeping good records?

Ans: Accept reasonable answers.

Should include:

- for regulatory requirements,
- to provide a history – so you can

- see what to expect,
- plan for recurring cycles, etc.

Filtration Rate Calculation

Given: A plant has four filters, each 22 feet wide by 25 feet long. When in operation, the plant treats a total flow of 10 million gallons per day. The water level drops 2 feet in 5 minutes with the influent valve closed.

Problem: Compute the filtration rate.

Once again, it took 4 steps to perform the calculation. Step 1 required us to compute the filter surface area in square feet.

A, sq ft = 22 ft wide x 25 ft long
= 550 sq ft

Step 2 required computing the velocity of the dropping water in feet per minute.

V, fpm = Water drop, ft ÷ Time, min
= 2 feet ÷ 5 minutes
= 0.4 fpm

Step 3 was the computation of the flow of water through the filter in gallons per minute.

Q/filter, gpm = V, ft/min x Area, sq ft x 7.48 gal./cu ft
= 0.4 ft/min x 550 sq ft x7.48 gal/cu ft
= 1646 gpm

And now in our final step, we put it all together by computing the filtration rate in gallons per minute per square foot.

Filtration Rate gpm/sq ft = Q/filter, gpm ÷ A, sq ft
= 1646 gpm ÷ 550 sq ft

Ans: = 2.99 gpm/sq ft

Backwash Rate Calculation #1

Given: A filter 26 feet wide by 30 feet long with the desired backwash rate of 18 gallons per minute per square foot (same as for Sample #1)

Problem: Determine the volume of water in gallons required to backwash the filter in Sample #1, if the filter is backwashed for 10 minutes.

This calculation took 3 steps. The first step was to calculate the filter surface area in square feet.

A, sq ft = (length, ft) x (width, ft)
= (30 x 26)
= 780 sq ft (same as step 1 in previous calculation).

Step 2 was to determine the required backwash pumping rate in gallons per minute.

Backwash Pumping Rate, gpm = Filter Area, sq ft x Backwash rate, gpm/sq ft
= 780 sq ft x 18 gpm/sq ft
= 14,040 gpm (same as step 2 in previous calculation.

Our third and final step it to determine the required backwash water volume in gallons.

V, gal = Backwash Pumping Rate, gpm x Backwash Duration, min.
= 14,040 gpm x 10 minutes
Ans: = 140,400 gallons

Backwash Rate Calculation #2

Given: A filter 18 feet wide by 20 feet long with a backwash rate of 20 gallons per minute per square foot.

Problem: Determine the backwash rise rate in inches per minute

This calculation took 4 steps. The first step was to calculate the filter surface area in square feet.

A, sq ft = (length, ft) x (width, ft)

= 20 feet long x 18 feet wide
= 360 sq ft

In Step 2 we determine the flow of water through the filter in gallons per minute.

Q, gpm = Backwash Rate, gpm/sq ft x A, sq ft
= 20 gpm/sq ft x 360 sq ft
= 7,200 gpm

Step 3 was calculating the velocity of the rising water in feet per minute.

V, fpm = Q, gpm ÷ (A, sq ft x 7.48 gal/cu ft)
= 7,200 gpm ÷ (360 sq ft x 7.48 gal/cu ft)
= 7,200 gpm ÷ 2693 gal/ft
= 2.67 ft/min

In our 4^{th} a final step, we converted the rise velocity to inches per minute.

V, fpm = V, fpm x 12 in/ft
= 2.67 fpm x 12
Ans: = 32 inches per minute

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UNIT 5 EXERCISE:

A. Write below the 5 components of *Normal* operations of conventional filtration.

Ans: Can be presented in any order:

1. *Process Performance Monitoring*
2. *Process Controls and Equipment*
3. *Process Support Equipment*
4. *Housekeeping*
5. *Laboratory Testing*

B. Circle all of the following which are indicators of abnormal operating conditions.

Ans:

9. Increased filtered water turbidity

12. Media cracks and shrinkage

13. Mud balls

14. Rapid filter headloss increase
15. Short filter runs

C. True/False Mark the following statements with at “T” for true or an “F” for false.
Ans:

__*T*__ 17. Process performance monitoring is an ongoing activity for plant operators.
__*F*__ 18. New analytical equipment never needs calibration.
__*T*__ 19. Some plants use air scour during filter backwash.
__*F*__ 20. Jar testing is only needed when a problem occurs.
__*T*__ 21. Equipment maintenance is a routine operating procedure.
__*T*__ 22. Good floc formation is an indicator of properly operating coagulation/flocculation equipment.
__*F*__ 23. Filters only need to be backwashed when dirty.
__*F*__ 24. Never take a filter out of service.
__*F*__ 25. Media “boils” during filter backwash are an indication of proper cleaning.
__*F*__ 26. Raw water alkalinity does not affect the water treatment process.