DW Module 19:
Membrane Filtration
Answer Key

Calculate the flux of a membrane filter if it contains 75 sq. ft. of filter area and operates for 24 hours at a flow rate of 5 gpm. Assume that the water temperature is 20°C.

Ans: 5 gallons per minute x 60 minutes per hour x 24 hours per day = 7200 gallons per day. 7200 gallons per day / 75 sq. ft. = 96 gallons per square foot per day

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Calculate the specific flux of the system if it contains 75 sq. ft. of filter area and operates for 24 hours at a flow rate of 5 gpm. Assume that the water temperature is 20°C and the TMP of the system is 20 psi.

Ans: This relates to the previous exercise's answer. We calculated the flux to be 96 gfd. In order to calculate specific flux, divide the flux by the TMP. 96 gfd / 20 psi. = 4.8 gfd/psi

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What qualities determine the percent recovery in membrane treatment?

Ans: The three qualities are: membrane filtration level selected; the characteristics of the membrane itself; and the quality of the feed water.

Exercise

Unit 1 – Exercise

Multiple Choice – Choose the best answer unless otherwise noted:

1. Which of the following mechanisms is used by a membrane filter to remove particulate material from the water? (*Choose*)

    a. adsorption
    b. settling
    c. straining

Answer: c. - straining

2. The membrane filtration level with the smallest pore size (0.0001 – 0.001 μm) is called _____. (*Choose one to fill in the blank*)

    a. microfiltration
    b. reverse osmosis
    c. nanofiltration

Answer: b. reverse osmosis

3. The flow rate through the membrane filter itself expressed as gallon per square foot per day is: (*Choose one to fill in the blank*)

    a. permeate
    b. headloss
    c. flux

Answer: c. flux

4. Which one of the following is the name of the process of reversing the direction of water flow through the filter using filtered water? (*Choose one to fill in the blank*)

    a. back pulse
    b. reverse flow
    c. air pressure

Answer: b. – reverse flow

5. The filtered water that has been treated by a membrane filter is called _____: (*Choose one to fill in the blank*)

    a. permeate
    b. concentrate
    c. reject

Answer: a. – permeate

6. Which of the following remains the primary use of membrane filtration in water treatment? (*Choose one to fill in the blank*)

    a. the desalination of salt water to produce potable water
    b. as a pretreatment step in water treatment
    c. for filtration of surface or ground water under the direct influence of surface water

Answer: a. – the desalination of salt water to produce potable water)

If a source water has high hardness and high turbidity levels, and the utility wishes to soften the water, what pretreatment functions might be appropriate for a membrane filtration system?

Ans: Because a membrane filter would become clogged quickly if highly turbid water were added to the system, pretreatment to remove the large particulate matter would be prudent.

A source water is placed in a reservoir to reduce high turbidity. What effects could this have on the feed water quality as it applies to membrane filtration?

Ans: A raw water reservoir may encourage algae growth. This will degrade the quality of the water from a membrane filtration standpoint. While the turbidity lowers, algae present other problems.

A facility uses a high rate clarification process that utilizes a polymer to enhance settling. Could this have any negative impact on the membrane filtration process?

Ans: Yes; if there is any carryover of the polymer from the clarifier to the membranes, fouling of the filters could occur.

Exercise

Unit 2 – Exercise

Multiple Choice – Choose the best answer unless otherwise noted:

1. Select all the different forms of membrane filter construction? (*Choose all that apply*)

    a. hollow filter
    b. TMP
    c. spiral wound
    d. ceramic
    e. cross flow
    f. electrodialysis

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

2. A raw water reservoir would be an example of which membrane pretreatment method (where the goal is to reduce the loading and fouling potential of the water fed to the membrane)? (*Choose one*)

    a. filtration
    b. clarification
    c. chemical treatment

Answer: b. - clarification

3. Which of the following is a valid name for a test for testing membrane integrity? (*Choose one*)

    a. flux membrane test
    b. reversal of flow test
    c. air pressure hold test

Answer: c. air pressure hold test

4. Chlorines, acids, and bases are three types of chemicals used to do which of the following? (*Choose one*)

    a. prescreen the water in the membrane filtration system
    b. chemically clean a membrane filtration system
    c. monitor a membrane filtration system for fiber failure

Answer: b. chemical clean a membrane filtration system

5. Which of the following mechanisms are used by a membrane filter to remove particulate material from the water? (*Choose all that apply*)

    a. flux
    b. reverse flow
    c. particle counts
    d. chlorine
    e. cross flow
    f. TMP
    g. turbidity

Answer: a., c., d., f., g.

6. For surface water system, the required residual disinfectant concentration may not be less than _____mg/L for more than _____hours before the first customer.

    a. 0.2, 6
    b. 2.0, 6
    c. 0.2, 4
    d. 2.0, 4

Answer: c. 0.2 mg/L, 4 hours

Matching – Match the membrane filtration parts with the corresponding description:

7.	A	Rack	A.	A number of modules placed onto one of these, and a membrane filter systems consist of one or more of these.
8.	C	Membrane	B.	Thousands of membranes are gathered together and placed inside of one of these.
9.	B	Vessel	C.	The most common type used in water treatment resembles a very thin straw.
10.	E	Module	D.	This carries the influent and effluent.
11.	D	Piping	E.	Each pressure vessel containing the individual membranes is referred to by this term.

Exercise

Unit 3 – Exercise

Fill in the blank:

1. The Interim Surface Water Treatment Rule was enacted for the control of_____.

Answer: turbidity

2. A 3-log removal of organisms means _____ % removal of target organisms.

Answer: 99.9

3. _____ addition and _____ reduction might be employed in conjunction with micro- or ultrafiltration to reduce the formation of disinfection byproducts.

Answer: PAC and chlorine.

4. _____ and _____ membrane treatment processes that may be used to remove radon from a source water, even though they may not be cost effective treatments.

Answer: Nanofiltration and RO

5. The cost of operating a membrane filtration system is determined by _____ rate attainable, rate of _____increase, and membrane replacement frequency.

Answer: flux and TMP

6. The product water of a membrane filtration process using reverse osmosis and nanofiltration is corrosive because _____ are removed that reduce the _____ capacity of the water.

Answer: ion and buffering

What verification methods could you use to test the control system's set points?

Ans: Here is one example: Perhaps the system is programmed to alarm if the permeate turbidity from a rack of modules exceeds 0.2 NTU. It is likely that the turbidity of a membrane system will never approach this level, but it is important to verify that the system would alarm if the system did reach the level. In order to verify this, the operator can reset the alarm set point in the computer to an extremely low level, such as 0.01 NTU and wait to see if the system sounds an alarm.

Another method would involve causing the turbidimeter readout to exceed that 0.2 NTU setting by obscuring the light source in the turbidimeter itself. If this method is used, the operator should be sure to log the reason for the turbidity excursion from the membrane rack in case the reading is called into question at a later date.

What are some of the consequences of frequent CIPs?

Ans: CIPs are labor intensive; the rack undergoing the CIP is not available to produce permeate; the rack that is out of service can cause the other rack(s) to operate at a slightly higher flux rate, in turn causing the TMPs of those racks to increase. Also, frequent CIPs can shorten the lifespan of the membranes themselves.

Exercise

Unit 4 Exercise

True or False:

1. ___F___ In-line sensors are a direct method of testing membrane integrity that requires taking the membrane out of service for a short period of time.
(False because, in-line sensors do not require taking the entire membrane out of service.)

2. ___T___ A possible change in feed water; a change in the effectiveness of pretreatment; and RF process parameters should be examined when determining the cause of a rapid increase in the membrane filtration system TMP.

3. ___T___ Reversible fouling can be removed, although it can be time and labor intensive to do so.

4. ___F___ Irreversible fouling is fouling that cannot be removed from the membrane surface. It usually results in the need to replace the membrane or to operate at a much higher flux rate than originally used.
(False because, operate at a lower flux.)

5. ___T___ Permeate turbidity, particle counts, and Giardia and Cryptosporidium levels could become elevated if enough fibers are compromised. On-line integrity testing will spot a broken fiber without the use of on-line turbidimeters or particle counters.