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*Study guide courtesy of Morrisville State College
Sample

Exam

Questions

(Organized by Subject)
Basic Wastewater Treatment Concepts

Example Test Questions

True - False:

___ 1. Wastewater can be described as having both organic and inorganic material.

___ 2. The BOD test is an indirect measure of only the inorganic material used as food by bacteria.

___ 3. Suspended solids or filterable solids can contain both organic and inorganic material.

___ 4. One cubic foot of water would contain 8.34 gallons.

___ 5. Generally sulfide odors are not produced under aerobic conditions.

___ 6. Dissolved oxygen in wastewater usually is referred to as free or molecular oxygen.

___ 7. Although untreated wastewater contains many billions of bacteria per gallon, most of these are not harmful to humans, and some are even helpful in wastewater treatment.

___ 8. Hydrogen sulfide in addition to creating an odor nuisance, can be an explosion hazard when mixed with air in certain conditions.

___ 9. The size and nature of solids in the wastewater is of no significant concern to the wastewater treatment plant operator.

___ 10. A combined wastewater collection system handles only domestic waste and industrial waste.
11. If wastewater solids from a plant effluent are discharged into receiving waters, aerobic decomposition will take place in the presence of dissolved oxygen and aerobic bacteria.

12. Domestic wastewater generally contains only about 0.1% solids.

13. A wastewater sample with a pH of 7.2 is slightly acidic.

14. MGD and cubic feet per second are units that can be used to express flow.

15. BOD and SS are both used as a measure of the strength of the wastewater.

16. Septic sewage or sludge generally has a low pH.

17. In a typical treatment facility, it is necessary to have flow meters on both the influent and effluent to determine the incoming BOD loadings to the plant.

18. In the operation of a wastewater treatment plant, the most important consideration is the percentage of pollutants removed rather than the effluent quality.

19. In sampling wastewater for a BOD test, the best results are obtained from a 24 hour composite sample.

20. Organic wastes in a water provide a food source for aerobic bacteria which require dissolved oxygen to survive.
Multiple Choice: (circle the best answer)

21. The volatile percentage of a wastewater solids sample is measured by:
   a. dissolving the sample in acid
   b. burning the sample in an oven
   c. titrating with EDTA
   d. measuring the moisture content

22. The objective of wastewater treatment is to:
   a. remove organic material from the waste stream
   b. sterilize the wastewater before disposal
   c. eliminate disease producing agents
   d. both a and c are correct

23. If the velocity of the flow and the area through which the flow moves are known, the flow can be calculated by:
   a. multiplying the velocity by the area
   b. dividing the area by the velocity
   c. dividing the flow by the velocity
   d. this is not enough information to calculate flow

24. The influent flow coming into the treatment plant contains a BOD concentration of 225 mg/L. If the plant receives 550,000 gallons of wastewater each day how many lbs of BOD reach the plant?
   a. 2,444 lbs
   b. 1,032 lbs
   c. 925.7 lbs
   d. 14,040 lbs

25. Flow proportional composite samples are collected because:
   a. the waste characteristics are continually changing
   b. the flow is continually changing
   c. the flow and waste characteristics are continually changing
   d. this requires less time than grab samples
   e. all of the above
26. An aerobic treatment process is one that requires the presence of:
   a. ozone
   b. organic oxygen
   c. nitrogen
   d. combined oxygen
   e. dissolved oxygen

27. Which of the following is not a device for measuring flow?
   a. weir
   b. baffle
   c. parshall flume
   d. venturi meter
   e. none of the above

28. How many pounds of BOD enter a plant each day if the daily plant flow is
    2 MGD with a BOD concentration of 200 mg/L?
   a. 400 lbs/day
   b. 1,500 lbs/day
   c. 1,670 lbs/day
   d. 3,000 lbs/day
   e. 3,340 lbs/day

29. A sanitary sewer generally carries:
   a. domestic waste
   b. storm waters
   c. industrial wastes
   d. all of the above
   e. (a) and (c) above

30. Which of the following statements is false in regard to the concept of BOD?
    a. BOD is a measure of the organic strength of wastewater
    b. BOD is sometimes used to estimate the efficiency of operation of a
       wastewater treatment pond
    c. This test is run under the following lab conditions: 5 days at 20°F under
       aerobic conditions
    d. The letters BOD stand for biochemical oxygen demand
31. Which of the following statements is false in regard to hydrogen sulfide?
   a. Hydrogen sulfide is a toxic gas
   b. Hydrogen sulfide is dangerous because it could paralyze one's ability to breath
   c. Hydrogen sulfide is only a minor component of digester gas
   d. Hydrogen sulfide can cause the destruction of concrete
   e. Hydrogen sulfide is non-flammable and non-explosive

32. Which of the following sets of influent-effluent parameters would be most valuable for determining the degree of treatment efficiency in a domestic wastewater treatment plant?
   a. BOD and DO
   b. total and volatile suspended solids
   c. BOD and suspended solids
   d. COD and volatile solids
   e. temperature and pH

33. In order to obtain the greatest accuracy, dissolved oxygen (DO) tests should be performed:
   a. at a temperature of 20°C
   b. only after the sample has set for at least one hour
   c. only after thorough shaking to assure complete sample mixing
   d. as soon as possible after sample collection
   e. after a 5-day incubation period

34. How many pounds of suspended solids are applied each day to a plant that has a raw wastewater suspended solids concentration of 256 mg/L and an average flow of 2.5 MGD?
   a. 460 lbs
   b. 1,943 lbs
   c. 2,915 lbs
   d. 5,338 lbs
   e. 6,400 lbs
35. Both pH and DO meters should be standardized:
   a. hourly
   b. daily
   c. weekly
   d. monthly
   e. before each use

36. The determination of settleable solids is made with:
   a. imhoff cones
   b. erlenmeyer flasks
   c. filter papers
   d. evaporation dishes
   e. acid titrations

37. The influent flow to your treatment plant is determined to be 650 gpm. The value would be equal to what value in MGD?
   a. 0.472 MGD
   b. 0.936 MGD
   c. 1.714 MGD
   d. 1.923 MGD
   e. 6.50 MGD

38. An industry discharges 3.0 MGD with a BOD of 1,700 mg/L. The population equivalent based on BOD would be most nearly:
   (1 PE, based on BOD = 0.17 lb/day)
   a. 22,500
   b. 200,000
   c. 100,000
   d. 250,000
   e. none of the above
39. What best describes conditions in influent sewage that will have an adverse impact on treating sewage?
   a. high flow, pH 7, low DO
   b. high flow, pH 4, high DO
   c. low flow, pH 4, zero DO
   d. average flow, pH 7, zero DO
   e. all of these will have equal effect

40. One part per million dissolved oxygen in water means that the amount of oxygen present is:
   a. 1 percent of the waste
   b. 1 gallon of oxygen in 1,000,000 gallons of water
   c. 1 pound of oxygen in 1,000,000 gallons of water
   d. 1 pound of oxygen in 1,000,000 pounds of water
   e. 1 milligram of oxygen in 1,000,000 pounds of water
Answers to Example Test Questions: Section I

Answers:

2. F 12. T 22. d 32. c
3. T 13. F 23. a 33. d
5. T 15. T 25. c 35. e
6. T 16. T 26. e 36. a
7. T 17. F 27. b 37. b
8. T 18. F 28. e 38. d
10. F 20. T 30. b 40. d

Solutions to math problems:

24. \( \text{MGD} \times \frac{\text{mg/L}}{\text{gal}} \times 8.34 \text{ lbs/gal} = \text{lbs/day} \); \( 550,000 \text{ gpd} = 0.55 \text{ MGD} \)
\[ 0.55 \text{ MGD} \times 225 \text{ mg/L} \times 8.34 \text{ lbs/gal} = 1,032 \text{ lbs/day} \]

28. \( \text{MGD} \times \frac{\text{mg/L}}{\text{gal}} \times 8.34 \text{ lbs/gal} = \text{lbs/day} \)
\[ 2.0 \text{ MGD} \times 200 \text{ mg/L} \times 8.34 \text{ lbs/gal} = 3,336 \text{ lbs/day} \]
(note: answer e is the closest)

34. \( \text{MGD} \times \frac{\text{mg/L}}{\text{gal}} \times 8.34 \text{ lbs/gal} = \text{lbs/day} \)
\[ 2.5 \text{ MGD} \times 256 \text{ mg/L} \times 8.34 \text{ lbs/gal} = 5,337.6 \text{ lbs/day} \]

37. \( 650 \text{ gal/min} \times 1,440 \text{ min/day} = 936,000 \text{ gal/day} \)
\[ \frac{936000 \text{ gal/day}}{1000000 \text{ gal/MG}} = 0.936 \text{ MGD} \]

38. \( \text{MGD} \times \frac{\text{mg/L}}{\text{gal}} \times 8.34 \text{ lbs/gal} = \text{lbs/day} \)
\[ 3.0 \text{ MGD} \times 1,700 \text{ mg/L} \times 8.34 \text{ lbs/gal} = 42,534 \text{ lbs/day} \]
\[ \frac{42534 \text{ lbs/day}}{0.17 \text{ lbs/day}} = 250,000 \text{ PE} \]
Pretreatment of Wastewater

Example Test Questions

True - False:

___ 1. Sand, gravel, and mainly organics make up grit.

___ 2. A comminutor is the grinder of the pretreatment section of the wastewater treatment plant.

___ 3. Fine mesh screens are sometimes used in place of bar screens, comminutors, and grit channels.

___ 4. The normal velocity of flow through a grit chamber is designed to be between 4 and 6 ft per second.

___ 5. A grit chamber with a faster flow velocity than recommended may allow appreciable organic matter to collect in the grit.

___ 6. A Parshall Flume is a device used to divide the incoming flow for equal distribution to a plant having more than one clarifier.

___ 7. The process of preaeration in no way influences the degree of settling in a primary clarifier.

___ 8. Poor grit removal would affect all of the following: pumps and other mechanical equipment, anaerobic digestion, percent volatile and percent total solids in the raw sludge.

___ 9. The function of a comminutor is to shred rags, paper, wood, and other large wastewater solids and remove them from the flow.

___ 10. A barminutor frequently operates automatically.
11. A grit chamber with a slower flow velocity than recommended may allow appreciable organics to settle out with the grit.

12. At most treatment plants preliminary treatment is used to protect pumping equipment and to facilitate subsequent treatment processes.

13. The formula for the calculation of percent efficiency of BOD removal is: \[ \text{Efficiency} = \left( \frac{\text{In} - \text{Out}}{\text{In} - (\text{In} \times \text{Out})} \right) \times 100. \]

14. Velocity of wastewater is an important consideration both in the operation of a collection system and grit chamber.

15. If fine screens are used to remove dissolved solids.

**Multiple Choice:** (circle the best answer)

16. The objective(s) of the pretreatment processes at the front end of a wastewater treatment plant would include:
   a. protection of downstream treatment equipment
   b. protection of downstream biological treatment processes
   c. pretreatment of industrial wastes
   d. all of the above are correct

17. Which of the treatment processes listed below could **not** be considered a pretreatment step?
   a. vacuum filtration
   b. screening
   c. chemical addition
   d. grinding
   e. grit removal
18. A grit removal channel is 3 feet wide and has a wastewater flow depth of 18 inches. How far down the channel would an averaged size grit particle travel if the flow through the channel is 1.7 MGD? (Hint: average sized grit particle settles at a rate of 0.075 ft/sec)
   a. 2.6 ft
   b. 5.1 ft
   c. 11.6 ft
   d. 20 ft
   e. 75 ft

19. What is the BOD removal efficiency for a wastewater treatment plant that has an influent BOD of 250 mg/L and a final effluent BOD of 12 mg/L?
   a. 5 %
   b. 48 %%
   c. 77 %
   d. 95 %
   e. 100 %

20. Grit is composed mostly of which of the following substances?
   a. grease
   b. colloidal solids
   c. rubber goods
   d. inorganics
   e. organics

21. In order for the grit to settle in a manually cleaned grit chamber, the average velocity should be kept near:
   a. 1 ft/sec
   b. 2 ft/sec
   c. 5 ft/sec
   d. 1 ft/min
22. If, after 30 days of operation, 60 cubic feet of grit are removed from a grit chamber, what would be the rate of grit removal if the daily plant flow is 0.5 MGD?
   a. 1 cu.ft./MG
   b. 2 cu.ft./MG
   c. 3 cu. ft./MG
   d. 4 cu. ft./MG
   e. 5 cu. ft./MG

23. Which of the following statements is not true regarding a wastewater collection system?
   a. A sewer is designed to allow the waste to flow at a rate of approximately 1 ft/sec
   b. Grease can be a serious problem in a collection system
   c. Inflow and infiltration are frequently problems in older collection systems
   d. High concentrations of hydrogen sulfide in a sewer can lead to corrosion of concrete
   e. Scouring can be a problem if wastewater is flowing too fast

24. Calculate the flow through a grit chamber given the following information: the chamber is 2 foot 3 inches wide, wastewater if flowing at a depth of 8 inches, and the velocity in the chamber is 1.3 ft/sec.
   a. 1.3 MGD
   b. 1.5 MGD
   c. 2.0 MGD
   d. 2.3 MGD
   e. 2.9 MGD

25. A plant receives a flow having a BOD of 318 mg/L and is found to discharge a final effluent of 17.2 mg/L. What is the efficiency of the plant for BOD removal?
   a. 100%
   b. 95%
   c. 91.3%
   d. 85.2%
26. A manually cleaned bar screen should be raked:
   a. as often as necessary to allow reasonably free flow
   b. only when the flow is greatly hampered
   c. twice a day in hot weather and once a day in cold weather
   d. only when public odor complaints are received
   e. once a week

27. Carryover of grit from the grit chamber may indicate the need to:
   a. clean the grit chamber more frequently
   b. decrease the cross-sectional area of the channel
   c. increase the volume of the wastewater treated
   d. remove the grit at the lift station
   e. pump raw sludge at a higher rate

28. The result of inadequate grit chamber detention time on the primary
    sedimentation tank would be:
   a. decrease in raw sludge total solids
   b. compacted sludge in hopper
   c. increase in percentage of raw sludge volatile solids
   d. all of the above
   e. none of the above

29. Your town has been receiving complaints about odors in your sewer
    system. To correct the problem you have been instructed to use chlorine
    for odor control. The recommended dosage is 15 mg/L and the flow is 85
    gpm. How much must you budget per year for chlorine if the chlorine costs
    $0.17 per pound?
   a. $950
   b. $1,237
   c. $1,425
   d. $1,750
   e. $2,100
30. A float controlled pump station has a rectangular wet well that measures 8 ft wide, 12 ft long, and 4 ft between high and low levels. The pump empties the wet well 10 times an hour. Neglecting the inflow during the pumping cycle, find the flow into the pump station in gallons per minute.

a. 300 gpm
b. 480 gpm
c. 65 gpm
d. 50 gpm
e. 240 gpm
Answers to Example Test Questions: Section II

Answers:

1. F
2. T
3. T
4. F
5. F
6. F
7. F
8. T
9. F
10. T
11. T
12. T
13. F
14. T
15. F
16. d
17. a
18. c
19. d
20. d
21. a
22. d
23. a
24. a
25. b
26. a
27. a
28. b
29. a
30. b

Solutions to math problems:

18. Time to settle in 18 inch or 1.5 ft depth:

\[ T = \frac{\text{Depth}}{\text{Velocity}} = \frac{1.5 \text{ ft}}{0.075 \text{ ft/sec}} = 20 \text{ sec} \]

Velocity of flow: 1.7 MGD = 2.63 ft³/sec; Area = 3 ft x 1.5 ft = 4.5 ft²

\[ V = \frac{\text{Flow}}{\text{Area}} = \frac{2.63 \text{ ft}^3/\text{sec}}{4.5 \text{ ft}^2} = 0.58 \text{ ft/sec} \]

Distance of travel down the channel:

Distance = Time X Velocity = 20 sec X 0.58 ft/sec = 11.6 ft

19. Efficiency of BOD removal:

\[ \frac{(250 \text{ mg/L} - 12 \text{ mg/L})}{250 \text{ mg/L}} \times 100 = 95.2\% \]

22. Rate of grit removal in cu. ft./MG:

\[ \frac{60 \text{ ft}^3}{30 \text{ days}} = 2 \text{ ft}^3/\text{day}; \quad \frac{2 \text{ ft}^3/\text{day}}{0.5 \text{ MGD}} = 4 \text{ ft}^3/\text{MG} \]
24. Flow through the grit chamber: Area = 2.25 ft X 0.67 ft = 1.5 ft²

\[ Q = V \times A = 1.3 \text{ ft/sec} \times 1.5 \text{ ft}^2 = 1.95 \text{ ft}^3/\text{sec} \]

\[ \frac{(1.95 \text{ ft}^3/\text{sec} \times 86,400 \text{ sec/day} \times 7.48 \text{ gal/ft}^3)}{(1,000,000 \text{ gal/MG})} = 1.26 \text{ MGD} \]

25. Efficiency of BOD removal:

\[ \frac{(318 \text{ mg/L} - 17.2 \text{ mg/L})}{318 \text{ mg/L}} \times 100 = 94.59\% \]

29. Daily use of chlorine: 85 gpm = 0.1224 MGD

\[ \text{MGD} \times \text{mg/L} \times 8.34 \text{ lbs/gal} \times 15 \text{ mg/L} \times 8.34 \text{ lbs/gal} = 15.3 \text{ lbs/day} \]

Pounds chlorine per year:

\[ 15.3 \text{ lbs/day} \times 365 \text{ days/year} = 5,584.5 \text{ lbs/year} \]

Chlorine cost per year:

\[ 5,584.5 \text{ lbs/year} \times \$0.17/\text{lb} = \$949.37/\text{year} \]

30. Pumped volume in gallons:

\[ (8 \text{ ft} \times 12 \text{ ft} \times 4 \text{ ft}) \times 7.48 \text{ gal/ft}^3 = 2,872 \text{ gallons} \]

Flow per hour:

\[ 2,872 \text{ gal/cycle} \times 10 \text{ cycle/hr} = 28,720 \text{ gal/hr} \]

Flow per minute:

\[ \frac{28720 \text{ gal/hr}}{60 \text{ min/hr}} = 478.7 \text{ gpm} \]
Primary Treatment
Example Test Questions

True - False:

___ 1. In a primary settling tank baffles are located ahead of the outlet or effluent weir to prevent the loss of floating grease or solids over the weir.

___ 2. The primary step of the wastewater treatment process removes a high percentage of dissolved solids and a low percentage of settleable solids.

___ 3. Suspended solids are those solids that will settle easily and are removed in the primary sedimentation tank.

___ 4. Floating sludge in a primary clarifier usually means that the settled sludge has gone septic.

___ 5. The volume of sludge to be removed from a primary clarifier may be estimated by measuring the primary influent and effluent settleable solids and wastewater flow.

___ 6. Most of the colloidal and dissolved matter in wastewater will be removed in the primary clarifiers for the average, well-designed, efficiently operated wastewater treatment facility.

___ 7. Detention time can be described as the amount of time required to fill a tank at a given flow.

___ 8. Primary treatment is a process which allows substances that will settle or float to be separated from the wastewater being treated.

___ 9. An Imhoff cone is often used to measure the effectiveness of primary sedimentation.
10. The generally accepted range of BOD removal in a well operated primary clarifier would be 40 - 60%.

11. Generally speaking, the only function of flights in a primary rectangular clarifier is to move the settled sludge to the sludge hopper.

12. Hydraulic loading to a clarifier is expressed as gallons per day.

13. The solids in primary or raw sludge contain both volatile and fixed parts.

14. If a shear pin in a clarifier drive unit is constantly bending, it would be advisable to replace it with a pin of greater shear strength.

15. A primary clarifier in a treatment plant having a grit chamber and an anaerobic digester usually concentrates the grit with the settled primary sludge before pumping to the anaerobic digester.

16. The term "clarification" applies more to an operation improving the clarity of the liquid, whereas "thickening" refers more to the concentration of the solid material that settles out.

17. Successful performance of a sedimentation basin depends greatly upon biological action.

18. To collect a representative sample of raw sludge being pumped to an anaerobic digester, the operator must start the raw sludge pump and collect a sample when the sludge is thickest.

19. A septic sludge in a primary clarifier would result in foul odors, bubbles of gas at the surface, and floating clumps of solids.

20. The efficiency of the primary clarifier affects the efficiencies of any other treatment processes that might follow the clarifier.
Multiple Choice: (circle the best answer)

21. A wastewater treatment system that includes a pretreatment step, clarifier settling, and disinfection is called:
   a. advanced waste treatment
   b. aerobic/anaerobic treatment
   c. secondary treatment
   d. primary treatment

22. The efficiency of solids removal in a primary settling tank would not be affected by:
   a. hydraulic loading
   b. detention time
   c. percentage of grit removal
   d. temperature of the wastewater

23. A device called an Imhoff cone is commonly used to measure settleable solids in:
   a. percent
   b. mL/L
   c. mg/L
   d. ppm
   e. SVI units

24. Odors associated with septic sludge are caused by:
   a. large concentrations of inorganic material
   b. a neutral pH
   c. too much D.O.
   d. aerobic bacteria
   e. none of the above

25. The main objectives of primary sedimentation are to remove:
   a. finely divided particles and dissolved organics
   b. TDS and colloidal solids
   c. BOD, COD, and SS
   d. settleable solids and floatable material
26. The main difference between primary and secondary clarifiers is the:
   a. overall dimensions
   b. type of outlet weirs
   c. density of the sludge handled
   d. detention period
   e. flow distribution

27. Calculate the volume, in gallons, of a tank which is 25 ft wide, 12 ft deep, and 100 ft long.
   a. 22,440 gallons
   b. 30,000 gallons
   c. 210,000 gallons
   d. 224,000 gallons
   e. 250,000 gallons

28. The withdrawal of sludge from the clarifier should be slow in order to:
   a. protect the pump
   b. conserve electricity
   c. prevent the pumping of too much water
   d. keep the BOD stabilized
   e. not to disturb the bacteria in the digester

29. Dark floating solids with objectionable odors observed on the surface of the primary clarifier in a primary treatment plant would most likely be due to:
   a. bulking sludge
   b. broken or missing scrapers
   c. low SDI
   d. high flows
   e. an inefficient grit chamber
30. Calculate the detention time of a circular clarifier that has a diameter of 90 ft, an average depth of 12 ft, and an influent flow of 9.0 MGD?
   a. 20 min
   b. 1.5 hrs
   c. 3.2 hrs
   d. 6.0 hrs

31. Good primary sludge as withdrawn from a primary settling tank is about what percent solids?
   a. 0.1
   b. 1 - 2
   c. 4 - 6
   d. 10 - 20

32. The average detention time in a primary clarifier at an average flow rate is:
   a. 2 days
   b. 1 day
   c. 2 hours
   d. 15 min
   e. 5 hours

33. What is the detention time of a clarifier with a 250,000 gallon capacity if it receives a flow of 3 MGD?
   a. 1 hr
   b. 1.5 hr
   c. 2 hr
   d. 2.5 hr
   e. 3 hr

34. A sludge pump is set to pump 5 minutes each hour during the day. The pump has a capacity of 35 gpm. How many gallons of sludge are pumped each day?
   a. 175 gpd
   b. 840 gpd
   c. 2100 gpd
   d. 4200 gpd
35. A POTW receives a flow of 3.1 MGD. The raw influent has a BOD of 210 mg/L and a SS of 190 mg/L. The primary clarifier removes 55% of the SS. Calculate the pounds of SS discharged in the primary effluent.
   a. 2210 lbs/day
   b. 2440 lbs/day
   c. 2700 lbs/day
   d. 2990 lbs/day
   e. 4910 lbs/day

36. At a 2.5 MGD wastewater treatment plant the primary clarifier has a detention time of 2 hours. How many gallons does this clarifier hold?
   a. 104,000 gallons
   b. 208,000 gallons
   c. 250,000 gallons
   d. 500,000 gallons
   e. 5,000,000 gallons

37. Calculate the weir loading for a sedimentation tank that has an outlet weir 480 ft long and a flow of 5.0 MGD.
   a. 9,220 gpd/ft
   b. 9,600 gpd/ft
   c. 9,920 gpd/ft
   d. 10,420 gpd/ft
   e. 12,090 gpd/ft

38. How many pounds of dry solids would be contained in 19,000 gallons of liquid sludge at 4% concentration?
   a. 76,000 lbs
   b. 760 lbs
   c. 6,338 lbs
   d. 3,000 lbs
   e. 12,090 lbs
39. A volume of 6,000 gallons of raw sludge is pumped to an anaerobic digester. Lab tests show \( %TS = 5.5\% \) and \( %VS = 74.8\% \). Calculate the pounds of VS pumped to the digester.
   a. 1,850 lbs
   b. 2,060 lbs
   c. 2,470 lbs
   d. 2,750 lbs
   e. 37,430 lbs

40. A wastewater treatment plant has an influent SS concentration of 240 mg/L and an influent flow rate of 2.1 MGD. After passing through a primary clarifier the primary effluent contains a SS concentration of 125 mg/L. How many gallons of primary sludge should be pumped each day if the primary sludge concentration is 3.2% ?
   a. 7,500 gallons
   b. 8,200 gallons
   c. 32,200 gallons
   d. 63,000 gallons
Answers to Example Test Questions: Section III

Answers:

2. F  12. F  22. c  32. c
3. F  13. T  23. b  33. c
4. T  14. F  24. e  34. d
5. T  15. F  25. d  35. a
7. T  17. F  27. d  37. d
8. T  18. F  28. c  38. c
10. F  20. T  30. b  40. a

Solutions to math problems:

27. Volume in gallons:

\[(25 \text{ ft } \times 12 \text{ ft } \times 100 \text{ ft}) \times 7.48 \text{ gal/ft}^3 = 224,400 \text{ gallons}\]

30. Calculate the detention time:

Tank area = \(\pi r^2 = (3.14)(45ft)^2 = 6,358.5 \text{ ft}^2\)
Volume = \((6,358.5 \text{ ft}^2 \times 12 \text{ ft}) \times 7.48 \text{ gal/ft}^3 = 570,739 \text{ gal}\)

Plant flow = 9.0 MGD = 375,000 gal/hr

\[\text{DT} = \frac{570739 \text{ gal}}{375000 \text{ gal/hr}} = 1.52 \text{ hours}\]

33. Calculate the detention time:

Plant flow = 3.0 MGD = 125,000 gal/hr

\[\text{DT} = \frac{250000 \text{ gal}}{125000 \text{ gal/hr}} = 2 \text{ hours}\]

34. Gallons of sludge pumped:

\[(5 \text{ min } \times 35 \text{ gpm}) \times 24 \text{ hr/day} = 4,200 \text{ gpd}\]
35. Pounds of SS discharged:

55% of SS removed: 190 mg/L * 0.55 = 104.5 mg/L

% SS remaining: 190 mg/L - 104.5 mg/L = 85.5 mg/L

Pounds of SS discharged:

\[ \text{MGD} \times \frac{\text{mg/L}}{8.34 \text{ lbs/gal}} = \text{lbs/day} \]
\[ 3.1 \text{ MGD} \times \frac{85.5 \text{ mg/L}}{8.34 \text{ lbs/gal}} = 2,210.5 \text{ lbs/day} \]

36. How many gallons does it hold: 2.5 MGD = 104,167 gal/hr

\[ DT = \frac{\text{Volume}}{\text{Flow}} \implies 2 \text{ hr} = \frac{\text{Volume}}{104167 \text{ gal/hr}} \]

\[ 104,167 \text{ gal/hr} \times 2 \text{ hr} = \frac{\text{Vol} \times 104167 \text{ gal/hr}}{104167 \text{ gal/hr}} = 208,334 \text{ gal} \]

37. Calculate weir loading rate: Flow = 5.0 MGD = 5,000,000 gpd

\[ \text{WLR} = \frac{\text{Flow}}{\text{Weir length}} = \frac{5000000 \text{ gpd}}{480 \text{ ft}} = 10,417 \text{ gpd/ft} \]

38. Pounds of dry solids:

19,000 gal = 0.019 MG; 4% = 40,000 mg/L

\[ \text{MG} \times \frac{\text{mg/L}}{8.34 \text{ lbs/gal}} = \text{lbs} \]

0.019 MG X 40,000 mg/L X 8.34 lbs/gal = 6,338.4 lbs

39. Pounds of VS pumped:

6,000 gal = 0.006 MG; 5.5% = 55,000 mg/L

\[ \text{MG} \times \frac{\text{mg/L}}{8.34 \text{ lbs/gal}} = \text{lbs} \]

0.006 MG X 55,000 mg/L X 8.34 lbs/gal = 2,752.2 lbs TS

2,752.2 lbs TS X 0.748 = 2,058.65 lbs VS
40. Gallons of primary sludge pumped:

Solids collected in primary:

\[240 \text{ mg/L} - 125 \text{ mg/L} = 115 \text{ mg/L}\]

\[2.1 \text{ MGD} \times 1.15 \times 8.34 \text{ lbs/gal} = 2,014 \text{ lbs/day}\]

Gallons pumped at 3.2%: 3.5% = 32,000 mg/L

\[
\text{MGD} \times 32,000 \text{ mg/L} \times 8.34 \text{ lbs/gal} = 2,014 \text{ lbs/day}
\]

\[
\frac{\text{MGD} \times 32000 \text{ mg/L} \times 8.34 \text{ lbs/gal}}{32000 \text{ mg/L} \times 8.34 \text{ lbs/gal}} = \frac{2014 \text{ lbs/day}}{32000 \text{ mg/L} \times 8.34 \text{ lbs/gal}}
\]

\[
\text{MGD} = \frac{2014 \text{ lbs/day}}{32000 \text{ mg/L} \times 8.34 \text{ lbs/gal}} = 0.0075 \text{ MGD} = 7,547 \text{ gal}
\]
Secondary Biological Treatment

Example Test Questions

True - False:

1. Waste stabilization ponds or lagoons are considered primary treatment processes.

2. Secondary biological treatment processes take material in the wastewater that does not settle easily and converts it into a form that does settle.

3. In a trickling filter system, the BOD and suspended solids applied are physically filtered or strained out of the wastewater flow by the filter media.

4. In a wastewater stabilization lagoon system the DO will drop during the night because the algae shift from producing oxygen to consuming oxygen.

5. The ABF treatment system is a combination attached growth and suspended growth system.

6. In a facultative pod, the bottom layer of the pond will generally contain more dissolved oxygen than the surface layer.

7. The color of the algae at the surface of a facultative pond can be an indication of its operational condition.

8. The flow to a wastewater treatment pond may be expressed in units of acre-ft.

9. In conventional secondary wastewater treatment processes, aerobic decomposition of solids will occur.
10. Wastewater treatment ponds that receive untreated raw wastewater are called waste stabilization ponds.

11. Compared to activated sludge, trickling filters are sturdy works units not easily upset by shock loads.

12. Sandstone, because of its ability to provide excellent ventilation, usually is used for media in a trickling filter.

13. At an activated sludge plant, the BOD is always greater than the chemical oxygen demand.

14. The most important factors in wastewater treatment in the plant are the same factors of natural "self-purification" in a stream, but are duplicated on a more intensified scale.

15. Photosynthesis is an essential part of the biological activity in a facultative pond.

16. The quantity and composition of sludge varies with the character of the wastewater from which it is removed and depends upon the treatment process by which it is obtained.

17. Activated sludge and trickling filters are treatment processes which convert nonsettleable, suspended and dissolved organics to settleable solids.

18. It is generally accepted that at least 1 mg/L of residual D.O. should be available everywhere in an aeration tank of an activated sludge wastewater treatment.

19. The removal of nitrogen and phosphorus by wastewater processes is receiving particular attention because of the role each nutrient plays in the acceleration of eutrophication in receiving waters.
20. Secondary clarifier influent suspended solids have the same settling characteristics as the primary clarifier influent solids.

21. An operator observes a light white foam on the surface of the aeration tank. One probable explanation is that the MLVSS is too low.

22. Both RBCs and trickling filter systems are attached growth, biological treatment processes.

23. The term "sloughing" refers to the process of removing the biological slimes that grows on the effluent weir of a primary clarifier.

24. A trickling filter reduces the strength of the wastewater applied to it by the filtering and straining action of the stones or support media.

25. The white, billowing foam common during the start-up of an activated sludge wastewater treatment plant results from a low F/M ratio.

Multiple Choice: (circle the best answer)

26. A wastewater stabilization lagoon can lose its natural level of DO if the lagoon is organically overloaded. What chemical is normally added to provide a source of oxygen?
   a. carbon monoxide
   b. sodium chloride
   c. sodium nitrate
   d. aluminum sulfate

27. Microorganisms that might be found in activated sludge would include:
   a. bacteria
   b. fungi
   c. protozoa
   d. rotifers
   e. all of the above
28. Several environmental growth "factors" or "pressures" will affect how well the treatment organisms in a secondary treatment system will grow. Which condition listed below is not a biological growth pressure?
   a. temperature
   b. oxygen
   c. tank volume
   d. pH
   e. toxic materials

29. What is the hydraulic loading for a trickling filter system that has a diameter of 60 ft and an influent flow of 0.25 MGD?
   a. 69.4 gpd/ft²
   b. 9.3 gpd/ft²
   c. 88.5 gpd/ft²
   d. 8.9 gpd/ft²

30. A 20 acre facultative pond is operated at a depth of 4 ft. Calculate the volume of the pond in MG.
   a. 0.11 MG
   b. 0.47 MG
   c. 6.52 MG
   d. 26.1 MG
   e. 29.4 MG

31. Which of the following microorganisms are involved in the stabilization of wastewater in a facultative wastewater treatment pond?
   a. aerobic bacteria
   b. anaerobic bacteria
   c. facultative bacteria
   d. all of the above
   e. (a) & (c) only
32. The laboratory tests most frequently used to monitor a facultative pond on a daily basis are:
   a. pH, color, BOD
   b. pH, BOD, SS
   c. pH, DO, temperature
   d. DO, BOD, SS
   e. microscopic examination, color, DO

33. Which of the following conditions is generally not an operational problem in the operation of a trickling filter?
   a. foaming
   b. odors
   c. ponding
   d. clogging of distribution arm orifices
   e. filter flies

34. Which of the following units would be used to pretreat industrial waste for BOD reduction before applying the wastewater to an activated sludge system?
   a. sand filter
   b. aerobic digester
   c. fine mesh screen
   d. roughing filter
   e. high rate filter

35. If the sludge removed from a secondary clarifier following a trickling filter is gray in color, it probably indicates:
   a. inadequate sludge removal
   b. inefficient biological treatment
   c. too much DO
   d. filamentous growth
   e. excellent operation
36. Which of the following is not a parameter normally considered in the operation of an activated sludge plant?
   a. F/M ratio
   b. Sludge Age
   c. MCRT
   d. SVI
   e. %VS reduction

37. The primary purpose of the final settling tank following the aeration tanks at an activated sludge plant is to:
   a. hold the sewage long enough to allow excess oxygen to escape to the atmosphere before discharging the effluent to a stream
   b. hold the mixed liquor long enough to allow the activated sludge floc to use up all the available oxygen
   c. provide a longer period of contact between the activated sludge and the sewage
   d. provide conditions that will allow the activated sludge to settle and separate from the water
   e. provide for flow equalization between clarifiers

38. The sludge volume index (SVI) is:
   a. the percentage of the final settling volume occupied by the sludge
   b. an indication of the probable settling properties of the activated sludge
   c. the volume of sludge added to the digester each day
   d. the volume of sludge after settling one hour in an Imhoff cone

39. A good quality, domestic activated sludge would be one that:
   a. is black in color with a septic odor
   b. is brown in color with a musty odor
   c. is brown in color with quantities of dark brown foam
   d. has a settleability of 900 mLs in a 1 - L cylinder after 30 minutes
40. Two wastewater stabilization lagoons treat the wastewater flow from a summer resort. The combined area of the ponds averages 150 ft by 250 ft with a depth of 4 ft. If the influent flow averages 25,000 gpd what is the detention time of this system?
   a. 20 days
   b. 45 days
   c. 50 days
   d. 55 days
   e. 80 days

41. The application of stale, septic sewage to a trickling filter system may result in:
   a. break-up of the rock media because of the low pH
   b. the destruction of the filter fly population
   c. severe odor problems
   d. increase in the efficiency of the filter since the incoming solids and BOD loading is higher than normal

42. RBC treatment stands for:
   a. Red Blood Count
   b. Reactivated Bio Control
   c. Return Balance Control
   d. Return By Concentration
   e. Rotating Biological Contactors

43. What would be the hydraulic loading to a trickling filter 50 ft in diameter and 6 ft deep? The flow equals 1.8 MGD with a 50% recirculation rate.
   a. 720 gpd/ft²
   b. 917 gpd/ft²
   c. 1080 gpd/ft²
   d. 1376 gpd/ft²
   e. none of these are close
44. What would be the detention time in a 1.5 MG aeration tank if the daily flow is 2.9 MGD and the return flow brought back 12,000 lbs of suspended solids each day at a concentration of 0.6%?
   a. 11.5 hrs
   b. 8.5 hrs
   c. 12.4 hrs
   d. 2.0 hrs
   e. 4.3 hrs

45. A small town of 5,000 people is served by a 30 acre facultative pond. Flow to the pond if 0.8 MGD. The pond is operated at a depth of 5 ft. Calculate the organic loading to the pond.
   a. 7 lbs BOD/acre/day
   b. 28 lbs BOD/acre/day
   c. 33 lbs BOD/acre/day
   d. 45 lbs BOD/acre/day
   e. 53 lbs BOD/acre/day

46. The rotational speed of the air driven RBC system is controlled by:
   a. air pressure
   b. air velocity
   c. automatic pressure gauges
   d. air volume
   e. diffuser head setting

47. A flow of 1.0 MGD is applied to a 50 ft diameter trickling filter. Calculate the hydraulic loading on the filter.
   a. 560 gpd/ft²
   b. 540 gpd/ft²
   c. 510 gpd/ft²
   d. 480 gpd/ft²
   e. 680 gpd/ft²
48. A flow of 2.5 MGD is applied to a 85 ft diameter trickling filter with a 6 ft depth. If the primary effluent BOD is 152 mg/L, calculate the organic loading on the filter.
   a. 1,000 lbs BOD/day/ft³
   b. 45 lbs BOD/day/1,000 ft³
   c. 85 lbs BOD/day/1,000 ft³
   d. 1,000 lbs BOD/day/1,000 ft³
   e. 680 lbs BOD/day/1,000 ft³

49. Given the following information calculate the F/M ratio for this system.
   Aeration tank = 25 ft X 75 ft X 12 ft
   Clarifier = 35 ft diameter X 10 ft depth
   MLVSS = 2200 mg/L  Alkalinity = 119 mg/L
   Influent flow = 0.51 MGD  RAS flow = 0.17 MGD
   Primary effluent BOD = 160 mg/L
   a. 0.22
   b. 0.36
   c. 0.50
   d. 0.67
   e. 1.60

50. Given the following information about a 6.5 MGD activated sludge plant operating at an MCRT of 13 days, determine the number of gallons of sludge that should be wasted each day.
   Aeration tank volume = 2.0 MG
   Clarifier volume = 1.5 MG
   MLSS = 2,600 mg/L
   WAS SS = 7500 mg/L  Final effluent SS = 23 mg/L
   a. 9,310 gallons
   b. 43,368 gallons
   c. 93825 gallons
   d. 111,106 gallons
   e. 148,798 gallons
Answers to Example Test Questions: Section IV

Answers:

1. F 11. T
2. T 12. F
3. F 13. F
4. T 14. T
5. T 15. T
6. F 16. T
7. T 17. T
8. F 18. T
10. T 20. F

21. T 31. d 41. c
22. T 32. c 42. e
23. F 33. a 43. d
24. F 34. d 44. d
25. T 35. e 45. b
26. c 36. e 46. d
27. e 37. d 47. c
28. c 38. b 48. c
29. c 39. b 49. a
30. d 40. b 50. d

Solutions to Math problems:

29. Calculate the hydraulic loading:

\[
\text{Flow} = 0.25 \text{ MGD} = 250,000 \text{ gpd} \\
\text{Filter area} = \pi r^2 = (3.14)(30 \text{ ft})^2 = 2,826 \text{ ft}^2
\]

\[
\text{Loading} = \frac{250000 \text{ gpd}}{2826 \text{ ft}^2} = 88.5 \text{ gpd/ft}^2
\]

30. Volume of the pond in MG:

20 acres X 43,560 ft²/acre X 4 ft = 3,484,800 ft³

3,484,800 ft³ X 7.48 gal/ft³ = 26,066,304 gallons or 26.1 MG

40. Find the detention time: Flow = 25,000 gpd

\[
\text{Volume of ponds: (150 ft X 250 ft X 4 ft) X 7.48 gal/ft}^3 = 1,122,000 \text{ gal}
\]

\[
\text{DT} = \frac{\text{Volume}}{\text{Flow}} = \frac{1122000 \text{ gal}}{25000 \text{ gpd}} = 44.88 \text{ days}
\]

43. Calculate the hydraulic loading:

Total flow : 1.8 MGD + (1.8 MGD X 0.50) = 2.7 MGD or 2,700,000 gpd

\[
\text{Filter area} = \pi r^2 = (3.14)(25 \text{ ft})^2 = 1,962.5 \text{ ft}^2
\]

\[
\text{Loading} = \frac{2700000 \text{ gpd}}{1962.5 \text{ ft}^2} = 1,375.8 \text{ gpd/ft}^2
\]
44. Find the detention time of the aeration tank:

Return flow: MGD X mg/L X 8.34 lbs/gal = lbs/day
MGD X 6,000 mg/L X 8.34 lbs/gal = 12,000 lbs/day

\[
\text{MGD} = \frac{12000 \text{ lbs/day}}{6000 \text{ mg/L X 8.34 lbs/gal}} = 0.2398 \text{ MGD}
\]

Total flow to aeration: 2.9 MGD + 0.2398 MGD = 3.14 MGD

\[
\text{DT} = \frac{\text{Volume}}{\text{Flow}} = \frac{1.5 \text{ MG}}{3.14 \text{ MGD}} = 0.477 \text{ days X 24 hrs/day} = 11.5 \text{ hrs}
\]

45. Calculate organic loading: population equivalent = 0.17 lbs/capita/day

Total BOD: 5,000 people X 0.17 lbs BOD/capita/day = 850 lbs BOD/day

\[
\text{Loading} = \frac{850 \text{ lbs BOD/day}}{30 \text{ acres}} = 28.3 \text{ lbs BOD/acre/day}
\]

47. Calculate the hydraulic loading:

Filter area = \( \pi r^2 = (3.14)(25 \text{ ft})^2 = 1,962.5 \text{ ft}^2 \)

\[
\text{Loading} = \frac{1000000 \text{ gpd}}{1962.5 \text{ ft}^2} = 509.6 \text{ gpd/ft}^2
\]

48. Calculate the organic loading:

Pounds BOD: 2.5 MGD X 152 mg/L X 8.34 lbs/gal = 3,169.2 lbs BOD/day

Volume of filter: (3.14)(44.5 ft)2(6 ft) = 37,307.9 ft³ or 37.31 - 1,000 ft³

\[
\text{Loading} = \frac{3169.2 \text{ lbs BOD/day}}{37307.9 \text{ ft}^3} = 0.085 \text{ lbs BOD/day/ft}^3
\]

Or: \[
\text{OR} = \frac{3169.2 \text{ lbs BOD/day}}{37.31 - 1000 \text{ ft}^3} = 84.9 \text{ lbs BOD/day/1,000 ft}^3
\]

Note: be careful with the units of volume.
49. Calculate the F/M ratio:

Aeration vol: \((25 \text{ ft} \times 75 \text{ ft} \times 12 \text{ ft}) \times 7.48 \text{ gal/ft}^3 = 168,300 \text{ gal}\); 0.168 MG
Aeration lbs: \(0.168 \text{ MG} \times 2,200 \text{ mg/L} \times 8.34 \text{ lbs/gal} = 3,082.5 \text{ lbs MLVSS}\)

BOD lbs: \(0.51 \text{ MGD} \times 160 \text{ mg/L} \times 8.34 \text{ lbs/gal} = 680.5 \text{ lbs/day}\)

\[
\text{F/M ratio} = \frac{680.5 \text{ lbs}}{3082.5 \text{ lbs}} = 0.22
\]

50. Number of gallons of sludge wasted:

\[
\text{MCRT} = \frac{\text{Aeration lbs + Clarifier lbs}}{\text{WAS lbs + Eff lbs}}
\]

Rearrange:

\[
\text{WAS} = \frac{\text{Aeration lbs + Clarifier lbs}}{\text{MCRT}} - \text{Eff lbs}
\]

Aeration: \(2.0 \text{ MG} \times 2,600 \text{ mg/L} \times 8.34 \text{ lbs/gal} = 43,368 \text{ lbs}\)
Clarifier: \(1.5 \text{ MG} \times \frac{2600 \text{ mg/L} + 7500 \text{ mg/L}}{2} \times 8.34 = 63,175.5 \text{ lbs}\)
Effluent lbs: \(6.5 \text{ MGD} \times 23 \text{ mg/L} \times 8.34 \text{ lbs/gal} = 1,246.8 \text{ lbs/day}\)

\[
\text{WAS} = \frac{43368 \text{ lbs} + 63175.5 \text{ lbs}}{13 \text{ days}} - 1246.8 = 6,948.85 \text{ lbs/day}
\]

Change to gallons:

\[
\text{MGD} = \frac{6948.85 \text{ lbs/day}}{7500 \text{ mg/L} \times 8.34 \text{ lbs/gal}} = 0.11 \text{ MGD or } 111,093 \text{ gpd}
\]
Sludge Digestion

Example Test Questions

True - False:

__ 1. An anaerobic digester is routinely filled with air to keep the biological process in balance and to create a safe working area.

__ 2. Percent volatile solids reduction is a measure of the stabilization of the digested sludge and the effectiveness of the digestion process.

__ 3. The aerobic digestion process closely resembles the extended aeration variation of the activated sludge process.

__ 4. The composition of the gas produced in an anaerobic digester is approximately 30% methane and 70% carbon dioxide.

__ 5. Conditioning chemicals which are used to pre-process wastewater sludges are designed to help the sludge thicken or increase in solids concentration.

__ 6. Gravity thickening is a solids handling process which resembles normal sedimentation.

__ 7. Flotation thickening is a process of mixing gas bubbles with sludge to carry the sludge particles to the tank surface. Only primary sludges are recommended for flotation thickening processes.

__ 8. Wastewater sludges can be dewatered through the use of drying beds. This can be called a two stage process: filtration and evaporation.

__ 9. The determination of the pH on an anaerobic digester is one of the best early warning systems of digester upset.
10. The volume of gas produced by anaerobic digestion depends on the pounds of volatile solids destroyed.

11. The main function of a secondary digester in normal operation is to provide storage space for seed sludge.

12. The pH of digested sludge in a healthy anaerobic digester will be near 7.0.

13. A high rate anaerobic digester is always heated and mixed.

14. In computing anaerobic digester loadings, it is necessary to take into account the solids lost in the supernatant system.

15. A good maintenance program should be established for all flame arresters to ensure that they are all set at the recommended "pop-off" pressures.

16. The volatile acid/alkalinity relationship is useful in digester control because it is an early indicator that the digestion process is starting to get out of balance.

17. The processing of sludges that are produced and removed in the wastewater treatment plant is one of the most costly tasks that the operator faces.

18. When an aerobic digester is first started, extremely odorous gases are produced, including a number of nitrogen and sulfur compounds.

19. Centrifuges, vacuum filter presses, and belt presses are commonly used dewatering process units which produce a sludge cake with a solids content of 10 - 20% when aided by polymers.

20. One advantage of anaerobic digestion over aerobic digestion is that the anaerobic digestion process recovers some of the energy put into the digestion process.
Multiple Choice:  (circle the best answer)

21. The required detention time of an aerobic digestion process depends on the source or type of sludge that is treated. If a mixture of primary and secondary sludge are pumped to the digester you will probably have to:
   a. heat the tank to get things to grow
   b. put a second tank on line
   c. add chlorine to correct the odor problem
   d. increase the treatment or detention time

22. Monitoring and controlling the operation of an anaerobic digester can be tricky. Of the operational measurements listed below, which measurement would be the least helpful in determining the status of the digestion system?
   a. pH
   b. alkalinity
   c. volatile acid concentration
   d. gas composition

23. The anaerobic digester gas handling system is made up of many different components. Which component is designed to allow digester gas to escape and/or let outside air enter the tank under certain conditions?
   a. pressure regulating valve
   b. sediment and drip trap
   c. vacuum-pressure relief valve
   d. digester gas meter
   e. none of these will do it

24. A belt filter press mechanically squeezes the water out of the sludge. The belt filter uses ________?_______ to squeeze the sludge to remove the water.
   a. two belts
   b. one looped belt
   c. a set of rollers
   d. a stack of plates
   e. a hydraulic press
25. The sludge centrifuge is made up of a container into which is placed a volume of conditioned sludge. This container is then spun at a high RPM. The spinning generates centrifugal force which causes:
   a. the solids to be broken down
   b. a decrease in pathogen activity
   c. a sludge cake to form in the center of the bowl
   d. the heavier material to move towards the outside wall

26. When a digester is not being mixed, normally the solids settle to the bottom, leaving a liquid above the sludge known as:
   a. sloughings
   b. secondary effluent
   c. primary effluent
   d. supernatant
   e. waste activated sludge

27. A decrease in anaerobic digester gas production can be caused by which of the following?
   a. a drop in temperature
   b. an increase in organic loading rate
   c. a shock load of raw sludge
   d. toxic compounds in raw sludge
   e. all of the above

28. Anaerobic digester gas is composed mainly of:
   a. carbon dioxide and hydrogen sulfide
   b. methane and carbon dioxide
   c. methane and hydrogen sulfide
   d. methane and carbon monoxide
   e. ammonia and oxygen
29. Which of the following statements is false in regard to the anaerobic digestion process?
   a. anaerobic digester supernatant is often high in dissolved BOD, suspended solids, colloids, and immediate oxygen demand
   b. the major function of the secondary digester in normal operation is to allow solids-liquid separation
   c. either internal or external heat exchangers may be used in anaerobic digester
   d. the gas pressure in an anaerobic digester is measured in inches of mercury
   e. pumping large amounts of very thin sludge to the digester may tend to decrease the digester's temperature

30. The volatile acid/alkalinity ratio relationship in an anaerobic digester is an indication of the buffer capacity of the digester. When this ratio increases it indicates:
   a. an increase in alkalinity
   b. a decrease in alkalinity
   c. an increase in volatile acids
   d. either (b) or (c)
   e. the pH will soon rise

31. Anaerobic digestion is a very complex process. Which of the following phrases does not refer to this process?
   a. reduction of organic solids
   b. methane gas production
   c. volatile acid formation
   d. solid-liquid separation
   e. aerobic biological activity

32. Which of the following laboratory tests is most commonly used to determine the calculation for organic loading to a digester?
   a. BOD
   b. COD
   c. TOC
   e. %VS

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33. The first indicator that an anaerobic digester is in trouble would be:
   a. a drop in pH
   b. a turbid effluent
   c. an increase in methane content
   d. a drop in CO₂ content of the digester gas
   e. an increase in the ratio of VA/ALK ratio

34. Which of the following is not an consideration in the operation of a gravity thickener?
   a. BOD
   b. type of sludge
   c. age of sludge
   d. temperature
   e. sludge blanket depth

35. A volume of 35,000 gallons/day of waste activated sludge are pumped to a flotation thickener at a concentration of 0.4%. If this sludge is concentrated to 4.2% before it is sent to the digester, how much digester volume would be saved?
   a. 1,168 ft³
   b. 4,234 ft³
   c. 24,933 gal
   d. 31,667 gal

36. An anaerobic digester that has a diameter of 60 ft and a side wall depth of 20 ft. What would be the volatile solids loading if 9,500 lbs of sludge are pumped to this tank each day at a volatility of 70%?
   a. 0.12 lbs/day/ft³
   b. 0.17 lbs/day/ft³
   c. 0.31 lbs/day/ft³
   d. none of these are even close!
37. A volume of 6,000 gallons of raw sludge are pumped to an anaerobic digester. Lab tests show that the %TS = 5.5% and the %VS = 74.8%. Calculate the pounds of volatile solids pumped to the digester.
   a. 1,850 lbs
   b. 2,060 lbs
   c. 2,470 lbs
   d. 2,750 lbs
   e. 37,430 lbs

38. What would be the volatile solids loading (lbs VSS/ft\(^3\)/day) if the digester receives a daily sludge flow of 10,000 gpd with a solids concentration of 3.5%, of which 70% are volatile? The digester has a diameter of 28 ft and an average wall depth of 27.5 ft.
   a. 0.08 lbs VSS/ft\(^3\)/day
   b. 0.12 lbs VSS/ft\(^3\)/day
   c. 0.17 lbs VSS/ft\(^3\)/day
   d. 0.02 lbs VSS/ft\(^3\)/day
   e. 1.21 lbs VSS/ft\(^3\)/day

39. One of the digesters in your plant has a potential liquid level of 36 ft. What would be the pressure in psi if the digester were filled to that level? (note: 1 ft = 0.433 psi)
   a. 36 psi
   b. 3.6 psi
   c. 15.58 psi
   d. 25.44 psi
   e. 83.16 psi

40. The sludge pumped to an anaerobic digester has a volatile solids content of 71.5%. After the normal digestion period the digested sludge is measured to have a volatile solids content of 57%. Calculate the percent volatile solids reduction.
   a. 14.5%
   b. 20%
   c. 47%
   d. 57%
Answers to Example Test Question: Section V

Answers:
2. T  12. T  22. a  32. e
3. T  13. T  23. c  33. e
4. F  14. F  24. a  34. a
5. T  15. T  25. d  35. b
7. F  17. T  27. e  37. b
8. T  18. T  28. b  38. b
10. T  20. T  30. d  40. c

Solutions to Math Problems:

35. Find digester volume saved:

Pounds of solids pumped at 0.4%: 0.4% = 4,000 mg/L
0.035 MGD X 4,000 mg/L 8.34 lbs/gal = 1,167.6 lbs/day

Volume pumped at 4.2%: 4.2% = 42,000 mg/L
MGD X 42,000 mg/L 8.34 lbs/gal = 1,167.6 lbs/day

MGD = \frac{1167.6 \text{ lbs/day}}{42000 \text{ mg/L} \times 8.34} = 0.0033 \text{ MGD or 3,333 gpd}

Difference in volume: \frac{35000 \text{ gal} - 3333 \text{ gal}}{7.48 \text{ gal/ft}^3} = 4,233.6 \text{ ft}^3

36. Volatile solids loading:

lbs VS: 9,500 lbs X 0.70 = 6,650 lbs VS

Volume of tank: (3.14)(30 ft)^2(20 ft) = 56,520 ft^3

VS loading = \frac{6650 \text{ lbs VS/day}}{56520 \text{ ft}^3} = 0.12 \text{ lbs VS/day/ft}^3

37. Pounds VS pumped to digester:

lbs TS pumped: 5.5% = 55,000 mg/L
0.006 MGD X 55,000 mg/L X 8.34 lbs/gal = 2,752.2 lbs/day TS

LBS VS pumped: 2,752.2 lbs/day \times 0.748 = 2,058.65 lbs/day VS

\( \gamma \)
38. Volatile solids loading:

\[ 0.010 \text{ MGD} \times 35,000 \text{ mg/L} \times 8.34 \text{ lbs/gal} = 2,919 \text{ lbs/day} \]

Lbs VS: \[ 2,919 \text{ lbs} \times 0.70 = 2,043.3 \text{ lbs VS} \]

Volume of tank: \( (3.14)(14 \text{ ft})^2(27.5 \text{ ft}) = 16,924.6 \text{ ft}^3 \)

\[ \text{VS loading} = \frac{2043.3 \text{ lbs VS/day}}{16942.6 \text{ ft}^3} = 0.12 \text{ lbs VS/day/ft}^3 \]

39. Pressure due to 36 ft liquid level:

\[ 36 \text{ ft} \times 0.433 \text{ psi/ft} = 15.59 \text{ psi} \]

40. Calculate %VS reduction:

\[ \%\text{VS Reduction} = \frac{\text{VS in} - \text{VS out}}{\text{VS in} - (\text{VS in} \times \text{VS out})} \times 100 \]

\[ \%\text{VS Reduction} = \frac{0.715 - 0.57}{0.715 - (0.715 \times 0.57)} \times 100 = 47.2\% \]
Effluent Chlorination and Disinfection

Example Test Questions

True - False:

___ 1. Chlorine, chlorine dioxide, or sulfur dioxide can be used as a disinfectant.

___ 2. The chlorine dosage minus the chlorine residual will give you the chlorine demand.

___ 3. Hypochlorous acid (HOCl) is a stronger disinfectant than hypochlorite ion (HOCl⁻).

___ 4. The membrane filter or MPN test directly measure the number of pathogenic bacteria present in the sample.

___ 5. All 100 and 150 lb chlorine cylinders should be restrained or safety chained to sturdy supports even when empty.

___ 6. An operator should never enter a room containing high concentrations of chlorine gas without having self-contained breathing equipment or oxygen supply and help standing by.

___ 7. Chlorine demand is defined as the amount of chlorine remaining in the wastewater at the end of a specific contact period.

___ 8. Sufficient chlorination and adequate contact time of a well treated wastewater usually will result in essentially a complete kill of pathogenic organisms.

___ 9. Sulfur dioxide generally has replaced chlorine as a disinfectant, due to it's low energy requirements for production.
10. It is often necessary to pre-chlorinate wastewater to prevent odors. When this is done it is not necessary to satisfy a chlorine demand or expect a chlorine residual.

11. The proper technique for collecting a sample of chlorinated effluent for a coliform test would include: rinsing the bottle with the sample to be collected, filling the sample bottle all the way to the top to exclude air, and then capping the bottle tightly.

12. Chlorine is used to sterilize wastewater in order to insure protection of public health.

13. The MPN test is used to measure pathogen concentrations in wastewater.

14. Pre-chlorination is frequently used to disinfect raw or untreated wastewater.

15. Chlorine feed rate and chlorine residual are usually expressed in units of ppm.

16. When taking a chlorinator out of service, the chlorine valve at the container is shut off and the chlorine ejector is operated for a time to remove the remaining chlorine gas.

17. Coliform bacteria are generally considered to be harmless, but their presence may be indicative of disease causing organisms.

18. The chemical that is commonly used for the detection of chlorine gas that may be leaking out of the system is orthotolodine.

19. An increase in organic matter in the effluent would cause an increase in the chlorine demand.

20. The primary usage of sulfur dioxide (SO₂) in wastewater treatment is for dechlorination.
Multiple Choice: (circle the best answer)

21. Besides effluent disinfection, chlorine is sometimes also added:
   a. in the collection system
   b. to an activated sludge system
   c. to a trickling filter
   d. all of the above are correct

22. Which of the following factors listed below would influence the effectiveness of the chlorination process?
   a. suspended solids level
   b. contact time
   c. temperature
   d. chlorine dosage rate
   e. all of the above are correct

23. Minor chlorine leaks in a gas chlorine supply system can be detected by:
   a. spraying water on the pipes and looking for bubbles
   b. using a weak ammonia solution and looking for white fumes
   c. sniffing around the connections for chlorine smell
   d. none of these methods will work

24. The chlorine demand of the final effluent is 1.7 mg/L. The chlorine residual is measured to be 0.6 mg/L. If the plant flow rate is 1.8 MGD at what rate (lbs/day) would you set the gas chlorinator?
   a. 25.5 lbs/day
   b. 8.5 lbs/day
   c. 2.3 mg/L
   d. 34.5 lbs/day
25. At a wastewater treatment plant, the amount of chlorine used from the cylinder or tank that is in service is normally determined by:
   a. knowing both the pressure and temperature of the cylinder
   b. pressure gauges
   c. rotameter readings.
   d. weighings of the cylinder
   e. the chlorine residual

26. If 80 lbs of chlorine are applied each day to a flow of 1.5 MGD, what is the dosage in mg/L?
   a. 4.0 mg/L
   b. 5.2 mg/L
   c. 6.4 mg/L
   d. 7.0 mg/L
   e. 8.5 mg/L

27. What is the chlorine demand if the chlorine dosage is 15 mg/L and the residual is 2 mg/L?
   a. 2.0 mg/L
   b. 13 mg/L
   c. 15 mg/L
   d. 17 mg/L
   e. 30 mg/L

28. How many pounds of chlorine should be used each day to maintain a chlorine dosage of 12 mg/L at a 5.0 MGD plant?
   a. 60 lbs/day
   b. 450 lbs/day
   c. 500 lbs/day
   d. 600 lbs/day
   e. 6,700 lbs/day
29. Chlorine is fed at a rate of 60 lbs/day. Plant flow is 600,000 gallons/day. The chlorine residual is found to be 1.5 mg/L. Calculate the chlorine demand.
   a. 4.3 mg/L
   b. 10.5 mg/L
   c. 11.7 mg/L
   d. 12.0 mg/L
   e. none of the above

30. Which of the following discharges would, in general, require the lowest chlorine dosage to ensure adequate disinfection?
   a. primary plant effluent
   b. activated sludge plant effluent
   c. trickling filter plant effluent
   d. sand filter effluent
   e. stabilization pond effluent

31. Which of the following statements is false regarding chlorine?
   a. minor leaks of chlorine gas may be detected using an ammonia soaked rag
   b. chlorine gas is most often supplied in 150 lb cylinders and one-ton containers
   c. since chlorine is lighter than air, the ventilator exhaust in the chlorine room should be located near the ceiling
   d. chlorine is a gas at atmospheric pressure and room temperature
   e. chlorine is a greenish-yellow gas at normal temperatures and pressure, but is shipped as a liquid to save space

32. Which of the following are factors that may influence the effectiveness of chlorine?
   a. chlorine dose rate
   b. contact time
   c. suspended solids concentration
   d. only (a) & (b)
   e. (a), (b), & (c)
33. Chlorine is being fed at a rate of 75 lbs/day. Plant flow is 1,200,000 gpd. The chlorine residual is found to be 1.2 mg/L. Calculate the chlorine demand.
   a. 6.3 mg/L  
   b. 7.5 mg/L  
   c. 7.8 mg/L  
   d. 8.7 mg/L  
   e. 9.0 mg/L

34. Which of the following chemicals could be used to dechlorinate a sample of effluent waste?
   a. hydrochloric acid  
   b. HTH  
   c. sodium thiosulfate  
   d. calcium bicarbonate  
   e. alkaline iodide azide

35. If the flow to a plant is 1.8 MGD and you wished to maintain a chlorine residual of 1.5 mg/L when your chlorine demand is 9 mg/L, how often would you have to change a 1-ton chlorine cylinder?
   a. every 22.5 days  
   b. every 12.7 days  
   c. once a month  
   d. every 14.8 days  
   e. every 88.8 days

36. Chlorine used for disinfection can be obtained in which form?
   a. liquid  
   b. gas  
   c. powder  
   d. HTH  
   e. all of the above
37. The laboratory test used for the detection and titration of free chlorine is the:
   a. DPD
   b. orthotolodine
   c. PVC
   d. EDTA
   e. none of these will work

38. Seeded dilution water must be used in the determination of BOD in chlorinated effluent because:
   a. the amount of DO in the sample must be restored to its original level
   b. bacterial nutrients in the sample have been destroyed
   c. microorganisms in the sample have been killed
   d. the ratio of chlorine to DO must be in equilibrium
   e. my boss tells me to

39. The fecal coliform level of sewage plant effluent is considered important since it is the measure of:
   a. the organisms most commonly found in the digesters of sewage treatment plants
   b. those organisms that can satisfactorily survive the disinfection process
   c. the organisms associated with the oxidation of organic matter in activated sludge plants
   d. the type of organisms found in the intestinal tract of warm blooded animals and man
   e. all organisms that will reproduce in receiving streams

40. The fusible plug that is in all chlorine cylinders:
   a. should be removed after the cylinder is emptied
   b. may be used as a tap for a chlorine source
   c. should never be removed or tampered with
   d. is used as an electrical connection for evaporating coils
   e. is connected to cold water lines
Answers to Example Test Questions: Section VI

Answers:

2. T  12. F  22. e  32. e
3. T  13. F  23. b  33. a
4. F  14. F  24. d  34. c
5. T  15. F  25. d  35. b
7. F  17. T  27. b  37. a
8. T  18. F  28. c  38. c
10. T  20. T  30. d  40. c

Solutions to Math Problems:

24. Calculate the chlorine fed rate:

Dosage = demand + residual = 1.7 mg/L + 0.6 mg/L = 2.3 mg/L

1.8 MGD X 2.3 mg/L X 8.34 lbs/gal = 34.5 lbs/day

26. Find the dosage:

MGD X mg/L X 8.34 lbs/gal = lbs/day

1.5 MGD X mg/L X 8.34 lbs/gal = 80 lbs/day

rearrange:

mg/L = \frac{80 \text{ lbs/day}}{1.5 \text{ MGD} \times 8.34} = 6.4 \text{ mg/L}

27. Find the chlorine demand:

Demand = Dosage - Residual = 15 mg/L - 2 mg/L = 13 mg/L

28. Calculate the pounds of chlorine:

MGD X mg/L X 8.34 lbs/gal = lbs/day

5.0 MGD X 12 mg/L X 8.34 lbs/gal = 500.4 lbs/day

\text{?}
29. Calculate the chlorine demand:

First find the dosage: flow = 0.6 MGD

0.6 MGD X mg/L X 8.34 lbs/gal = 60 lbs/day

rearrange:

mg/L = \frac{60 \text{ lbs/day}}{0.6 \text{ MGD} \times 8.34} = 12 \text{ mg/L}

Demand = Dosage - Residual = 12 \text{ mg/L} - 1.5 \text{ mg/L} = 10.5 \text{ mg/L}

33. Find the chlorine demand:

First find the dosage: flow = 1.2 MGD

1.2 MGD X mg/L X 8.34 lbs/gal = 75 lbs/day

rearrange:

mg/L = \frac{75 \text{ lbs/day}}{1.2 \text{ MGD} \times 8.34} = 7.5 \text{ mg/L}

Demand = Dosage - Residual = 7.5 \text{ mg/L} - 1.2 \text{ mg/L} = 6.3 \text{ mg/L}

35. How long will a 1-ton cylinder last:

Dosage = demand + residual = 9 \text{ mg/L} + 1.5 \text{ mg/L} = 10.5 \text{ mg/L}

1.8 MGD X 10.5 \text{ mg/L} X 8.34 \text{ lbs/gal} = 157.63 \text{ lbs/day}

\frac{2000 \text{ lbs/ton}}{157.63 \text{ lbs/day}} = 12.7 \text{ days}
Pumps and Maintenance
Example Test Questions

True - False:

___ 1. A centrifugal pump can be operated for a limited period of time with the discharge valve closed without causing serious damage.

___ 2. You would be able to tell if a centrifugal pump impeller becomes worn because the pump will pump more water faster.

___ 3. Brake horsepower is the energy transferred from the motor to the pump.

___ 4. The pressure against which a pump must operate is measured as feet of head.

___ 5. Over lubrication of motor bearings is a serious mistake and has been the cause of many motor failures.

___ 6. Entering a manhole while working alone is not an acceptable practice under any circumstances.

___ 7. Training in first aid, gas detection, CPR, and the use of safety equipment should be taken before entering a confined space.

___ 8. If the packing on a pump is water lubricated, it's alright to primary effluent as the lubrication source.

___ 9. When changing the packing in a pump, if a lantern ring is found it can be disregarded because new packing requires no lantern ring.

___ 10. Sudden cavitation in a previously normally operating centrifugal pump might be caused by an obstruction in the suction side of the pump.
11. The flow of electrical current is measured in volts.

12. A centrifugal pump is running, but no water is being delivered. This might be caused by the discharge head being too low.

13. All the energy that it takes for a pump to move water from one elevation to a second elevation can be added up to equal the TDH.

14. The wire-to-water efficiency of a pumping system refers to the efficiency of energy transfer from the electrical wire to the motor, from the motor to the pump, and from the pump to the water.

15. Controlling the flow rate of a pumping system by using a valve on the suction side of the pump will have no negative effect on the pump operation.

**Multiple Choice:** (circle the best answer)

16. The total energy that it takes to pump water from the inlet elevation to the discharge elevation is called:
   a. total static discharge head
   b. net positive suction head
   c. dynamic discharge head
   d. total dynamic head

17. The component of the centrifugal pump that uses its shape to transfer the energy of the water from velocity head to pressure head is called the:
   a. volute case
   b. impeller
   c. motor shaft
   d. inboard bearing
18. A hydrant in town is tested for pressure level. If the pressure read during the test id 47 psi, how many feet of head would be required to create this pressure?
   a. 47 ft
   b. 20 ft
   c. 94 ft
   d. 108 ft

19. Usually the capacity of a pump is expressed as:
   a. ft/sec
   b. lbs/day
   c. gpm
   d. mL/l
   e. ppm

20. Which of the following statements regarding pumps used in wastewater treatment is not true?
   a. one common type of a positive displacement pump is a diaphragm pump
   b. positive displacement pumps are best suited to pumping both low and high viscosity sludges because these sludges can maintain good control of flow rate
   c. starting a positive displacement pump against a closed valve may be damaging to both the pump and piping
   d. an air lift pump is easily calibrated and thus can be used to deliver accurate volumes of sludge
   e. screw lift pumps can be used to pump unscreened, raw wastewater

21. Which of the following types of pumps is commonly used in wastewater treatment facilities?
   a. centrifugal pump
   b. diaphragm pump
   c. submersible pump
   d. piston pump
   e. all of the above
22. The impeller in a centrifugal pump will become worn after a period of use. Upon this occurrence, the time it takes to pump 1,000 gallons of sewage will be:
   a. longer
   b. doubled
   c. shorter
   d. about the same

23. A lantern ring is:
   a. a metal ring for lowering an explosive gas detector into man-holes and wet wells
   b. a shaft coupling that was completely worn through in spots or that has "daylighted"
   c. spacer ring in a pump stuffing box to improve seal water distribution
   d. a metal ring used for lowering lights into confined spaces

24. A sludge pump with a piston of 10 inches in diameter and a stroke of 6 inches runs for 20 minutes at a rate of 50 strokes per minute. What would be the volume of sludge pumped during this time?
   a. 185 gal
   b. 6,116 gal
   c. 2,040 gal
   d. 22,550 gal
   e. 25,67 gal

25. You should never attempt to install, troubleshoot, maintain, repair, or replace electrical equipment panels, controls, wiring, or circuits unless:
   a. a manhole is overflowing in the street
   b. a pump is plugged
   c. you are receiving lots of odor complaints
   d. you are qualified and authorized to do the work
   e. you have excess time on your hands
26. In operating a small sewage pumping station which is provided with two identical pumps it is best to adjust the control so that:
   a. one pump does all the work and the second pump is held in reserve
   b. the pumps alternate in operation
   c. the pumps operate on the shortest cycling period possible
   d. both pumps turn on together

27. Maintenance of couplings between the driving and driven elements includes:
   a. keeping proper curvature
   b. keeping proper alignment, even with flexible couplings
   c. replacing oil on a regular basis
   d. keeping the electrodes greased
   e. all of the above

28. You can determine the shaft speed of a pump or motor by using:
   a. pressure regulator
   b. wattmeter
   c. tachometer
   d. odometer
   e. your eyes

29. Find the capacity of a pump in gallons per minute that requires 14 hours to fill a tank 132 ft long by 12 ft wide to a depth of 10 ft.
   a. 20 gpm
   b. 140 gpm
   c. 710 gpm
   d. 840 gpm
   e. 325 gpm
30. A centrifugal pump system delivers 850 gpm against a head of 65 ft. The pump itself has an efficiency rating of 82%. If the motor runs at 95% efficiency how many kilowatts (kW) of power must be supplied to the motor to produce this output from the pump?

a. 55.25 kW
b. 13.4 kW
c. 18 kW
d. 78 kW
e. this pump will not pump water
Answers to Example Test Questions: Section VII

Answers:

1. T  
2. F  
3. T  
4. T  
5. T  
6. T  
7. T  
8. F  
9. F  
10. T  
11. F  
12. F  
13. T  
14. T  
15. F  
16. d  
17. a  
18. d  
19. c  
20. d  
21. e  
22. a  
23. c  
24. c  
25. d  
26. b  
27. b  
28. c  
29. b  
30. b

Solutions to Math Problems:

18. Find the head at the hydrant:

\[ 1 \text{ psi} = 2.31 \text{ ft}; \quad 47 \text{ psi} \times 2.31 \text{ ft/psi} = 108.6 \text{ feet} \]

24. Calculate the volume of sludge pumped:

Volume pumped at 1 stroke: 10 in = 0.83 ft; 6 in = 0.5 ft

Area = \( \pi r^2 = (3.14)(0.42 \text{ ft})^2 = 0.54 \text{ ft}^2 \); Vol = 0.54 \text{ ft}^2 \times 0.5 \text{ ft} = 0.27 \text{ ft}^3

Volume each stroke: 0.27 \text{ ft}^3 \times 7.48 \text{ gal/ft}^3 = 2.02 \text{ gal}

Total volume pumped:

2.02 gal/stroke \times 50 strokes/min \times 20 \text{ min} = 2,020 \text{ gallons}

29. Find the pump capacity:

Volume pumped: (132 ft \times 12 \text{ ft} \times 10 \text{ ft}) \times 7.48 \text{ gal/ft}^3 = 118,483.2 \text{ gal}

Pump rate in gpm:

\[ \text{gpm} = \frac{118483.2 \text{ gal}}{14 \text{ hrs} \times 60 \text{ min/hr}} = 141 \text{ gpm} \]
30. Calculate the kilowatts:

First calculate water HP:

\[
HP = \frac{850 \text{ gpm} \times 65 \text{ ft} \times 8.34 \text{ lbs/gal}}{33000} = 13.96 \text{ hp}
\]

HP coming into the motor:

\[
HP = \frac{13.96 \text{ hp}}{0.82 \times 0.95} = 17.92 \text{ hp}
\]

Convert to kW:

\[
17.92 \text{ hp} \times 0.746 \text{ kW/hp} = 13.37 \text{ kW}
\]