



Wisconsin Department of Natural Resources  
Wastewater Operator Certification

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# Introduction to Mechanical Sludge Handling Study Guide

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Subclass G

Wisconsin Department of Natural Resources  
Bureau of Science Services  
Operator Certification Program  
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## Preface

This operator's study guide represents the results of an ambitious program. Operators of wastewater facilities, regulators, educators and local officials, jointly prepared the objectives and exam questions for this subclass.

How to use this study guide with references

In preparation for the exams you should:

1. Read all of the key knowledges for each objective.
2. Use the resources listed at the end of the study guide for additional information.
3. Review all key knowledges until you fully understand them and know them by memory.

It is advisable that the operator take classroom or online training in this process before attempting the certification exam.

### Choosing A Test Date

Before you choose a test date, consider the training opportunities available in your area. A listing of training opportunities and exam dates is available on the internet at <http://dnr.wi.gov>, keyword search "operator certification". It can also be found in the annual DNR "Certified Operator" or by contacting your DNR regional operator certification coordinator.

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## **Chapter 1 - Principle, Structure and Function**

### **Section 1.1 - Principle of Mechanical Sludge Handling**

#### 1.1.1 Discuss the purposes of mechanical sludge processing.

The main purpose of mechanical sludge processing is to reduce the amount of water in the sludge which reduces the volume of material to be handled, stored, or transported. This reduction in volume represents a cost-saving to the facility. The addition of chemicals conditions the sludge changing its characteristics.

In the case of the wet air oxidation process (zimpro) sludge solids are oxidized under heat and pressure which provides additional stabilization and reduction of pathogens.

The two processes in sludge handling are generally referred to as thickening and dewatering. The thickening process refers to reducing moisture content prior to dewatering. Dewatering refers to producing a sludge cake (greater than 10% solids) for final disposal.

#### 1.1.2 Describe the basic purpose of preconditioning sludge before thickening or dewatering.

Preconditioning of sludge before thickening or dewatering usually involves chemical processes. Chemical methods include: the use of organic and inorganic flocculation chemicals, the use of polymers, and chlorine oxidation. The purpose of preconditioning is to get better solid/liquid separation in the mechanical processes which follow. One physical process thermal conditioning (wet air oxidation-zimpro) is used to stabilize sludge prior to dewatering.

#### 1.1.3 Discuss the difference between batch processing and continuous sludge handling operations.

Batch processing uses a fixed amount of material (sludge) to complete an operation. Examples of batch operations would be gravity thickening or sludge drying beds. The sludge is placed in a thickener or bed and the entire process is completed without any other flow-through.

Continuous processing implies that material (sludge) is being fed continuously. Examples of continuous operations would be vacuum filtration, centrifugation, gravity and filter presses, dissolved air flotation, and gravity thickening. The continuous process is a flow-through system.

### **Section 1.2 - Structure and Function**

#### 1.2.1 Describe the gravity thickening process and the percent solids in thickened product.

Gravity thickening is the use of tankage very similar to clarifiers (either round or rectangular) to allow settling and compactions of the sludge.

Gravity thickening can be either a batch or continuous type operation and usually involves the use of preconditioning chemicals. Detention times are usually much longer than with regular clarifiers. The sludge collection arms on round clarifiers may have vertical pickets ("picket fence") installed to provide gentle stirring to help release entrapped moisture and

gases.

Depending on the type of sludge or combined sludges being thickened, the thickened sludge concentrations can vary as follows:

Type of sludge --- Concentration

Primary --- 5-10% solids

Activated --- 2.5-3% solids

Trickling filter --- 7-9% solids

Combined sludges --- Concentration

Primary and waste activated --- 4-6% solids

Primary and trickling --- 7-9% solids

- 1.2.2 Describe the belt press thickening process and the percent solids in thickened product.  
The belt press consists of an endless belt of filter media rotating around a drum. The sludge is dewatered by gravity drainage and the pressing of the sludge with additional rollers. The belt press is similar in operation to a papermaking machine. With a belt press the dewatered sludge can have a solids concentration of 10-28% depending on the type of equipment.
- 1.2.3 Describe the vacuum filter thickening process and the percent solids in thickened product.  
Solids are separated from liquid with the use of a round drum which rotates partially submerged in a tank of sludge. The drum is divided into sections by seal strips. Vacuum is applied between the drum deck and filter media causing filtrate to be removed. The filter cake stays on the media. Solids capture with vacuum filtration ranges from 85% for coarse-mesh media to 99% with close-weave fabric media. Filtrate solids cause a load on the treatment process and should be kept as low as possible. Cake solids concentration varies from 20-30% by weight depending on the type of sludge and cycle time.
- 1.2.4 Explain the wet air oxidation process (zimpro).  
This is a thermal process using heat and pressure to oxidize organic matter. This process is carried out in a closed system operating at 250 degrees to 700 degrees F with a pressure range of 100 to 400 PSI. The sludge to be processed is "ground" to reduce particle size and pumped to the process using a positive displacement high-pressure pump. The supernatant from this heat/pressure conditioning is high in ammonia, volatile acids, and BOD. The over-all strength is similar to supernatant from an anaerobic digester. The process produces bacteriologically sterile sludge that is easily dewatered without chemical conditioning.

Problems with this process comes in the handling of the supernatant (larger secondary treatment facilities), the acid condition of the sludge (which may require ventilation), and odor problems from the gases generated (may need a catalytic combustion unit).

- 1.2.5 Describe the air flotation thickening process including percent solids capture and percent solids in thickened product.

Air is fed into the sludge under pressure (40-80 PSI) so a large amount of air can be dissolved. Sludge flows to an open tank where much of the air comes out of solution as small air bubbles attaching themselves to sludge solids particles floating them to the surface. Flotation works well on activated sludge which is difficult to thicken by gravity. Effluent recycle ratios can range from 30-150% of the influent flow. Sludge particles are floated to the sludge blanket and the clarified effluent flows over the weirs. Thickened sludge is removed by skimmers. Bottom sludge collectors are used to remove any settled sludge or grit. A 3-7% flotation solids concentration can be expected. Using flotation 90-95% of suspended solids can be removed with flotation aids (polymers) or 70-90% without the aid of polymers.

- 1.2.6 Describe the frame press thickening process and percent solids in thickened product.

A frame press is a batch device used to process sludge that is difficult to dewater. Filter cloth covers each plate. Frame presses usually need a pre-coat material (incinerator ash or diatomaceous earth) to assist in binding reduction and help release cake. Water passes through the cloth while solids are held on the cloth. Sludge pumping is stopped when the section between trays is completely filled. Filtrate quality should be good. Frame presses can be operated at pressures ranging from 5,000 - 20,000 times the force of gravity. The percent solids in the thickened product could range between 15-30% depending on sludge type and pressure applied.

- 1.2.7 Identify the locations in a mechanical sludge handling plant that should have ventilation equipment.

Ventilation equipment should be provided in all areas where sludge gases might be released. This would include: storage of mixing tanks, open feed lines, at any of the dewatering devices, any conveyor systems, or sludge storage areas.

- 1.2.8 List the types of pumps used for mechanical sludge handling.

1. Piston pump (positive displacement pump)
2. Progressive cavity pump
3. Centrifugal pump (not as commonly used as piston or progressive pumps)

## **Chapter 2 - Operation and Maintenance**

### **Section 2.1 - Operation**

- 2.1.1 Explain the purpose of the following chemicals used for sludge conditioning:

1. Polymers
2. Ferric chloride
3. Lime
4. Hydrogen peroxide
5. Soda ash
6. Sulfuric acid

1. Polymers: are used as preconditioning chemicals prior to dewatering; causes coagulation and flocculation by reducing particle surface charge affects
2. Ferric chloride: is used as a preconditioning chemical prior to dewatering; assists with pH control and phosphorus removal; acts as a coagulant to aid in concentrating solids
3. Lime: is used for pH control, odor control, and as a conditioner for digestion or filtration
4. Hydrogen peroxide: is used for odor prevention; it is an oxidant and assists in elimination of common gases (hydrogen sulfide)
5. Soda ash: is used for pH control
6. Sulfuric acid: is used for pH control

2.1.2 Describe the physical appearance of sludge at the following solids concentrations:

- A. 5 percent
- B. 15 percent
- C. 40 percent

A. A 5% solids sludge has the appearance of thick slurry; flows and pumps readily

B. At 10-15% solids sludge has the appearance of damp soil; it will hold its shape (stands-up) but is not suitable for conventional pumping; it is normally handled with conveyor equipment

C. A 40% solids sludge has the appearance of dry soil; it can only be handled with mechanical equipment, such as end loaders or shovels

Note: There are pumps available for industrial applications that can pump sludge at 25% solids.

2.1.3 Discuss the operating procedures that will help maintain the quality of the sludge product.

To ensure a good quality sludge product an operator needs to properly operate and maintain upstream sludge treatment units, provide good preconditioning by using jar testing to optimize chemical additions, apply good operation and maintenance of sludge dewatering equipment, and perform good sampling and testing procedures to verify that results are correct. Good historic recordkeeping will aid in determining if operational problems are occurring.

2.1.4 State the importance of sludge blanket depth measurement in gravity thickening.

It is critical in determining the concentration of removed sludge and in avoiding pumping and/or odor problems.

2.1.5 List the data needed to evaluate pumping rates from a gravity thickener.

1. The moisture content of the sludge

2. The sludge blanket depth

- 2.1.6 Describe the relationship of the depth of the sludge blanket to pumping rates while under routine operating conditions.
- A high blanket would indicate not enough sludge is pumping. A low blanket would indicate too much sludge is pumping.
- 2.1.7 Describe how to change the flow rates for the following equipment:
- A. Piston pump (positive displacement)
  - B. Progressive cavity pump
  - C. Diaphragm pump (positive displacement)
  - D. Telescoping valves and sludge pits
- A. Piston pump: adjust the stroke travel of the pump
- B. Progressive cavity pump: adjust the motor speed
- C. Diaphragm pump:
- 1. For air driven pumps - adjust the air flow
  - 2. For oil driven pumps - adjust the oil delivery rate
  - 3. You also can adjust the motor RPM
- D. Telescoping valves and sludge pits: adjust (raise/lower) the valve position to increase or decrease flow
- 2.1.8 List the operational measurements the operator must accurately take for the following equipment:
- A. Chemical feed pumps
  - B. Sludge pumps
  - C. Sludge density meters
- A. Chemical feed pumps:
- 1. Flow measurement
  - 2. Pressure measurement
  - 3. Time-of-run measurement
  - 4. Chemical concentrations
  - 5. Characteristic of the raw sludge (total suspended solids) to be treated
- B. Sludge pumps:
- 1. Flow measurement
  - 2. Pressure measurement
  - 3. Sludge concentration
  - 4. Time-of-run measurement
  - 5. Temperature

6. Discharge point

C. Sludge density meters:

1. Comparative laboratory test

- 2.1.9 Explain the reasons why secondary sludge should be aerated if being stored.  
The reason that secondary sludge should be aerated if stored is to prevent it from becoming anaerobic (septic). This can cause odor problems and changes in sludge characteristics. Aeration also provides mixing and some minor reduction in organic content.
- 2.1.10 Discuss the relationship of sludge pH to odor control and pathogen content.  
Low pH (less than 6.6) - causes more odor problems and higher pathogen content  
  
High pH (greater than 9) - causes less odor problems and lower pathogen content
- 2.1.11 List three purposes for ventilation regarding the following:
1. Safety
  2. Odor control
  3. Corrosion prevention
1. Safety: ventilation removes toxic gases from work areas  
2. Odor control: ventilation pulls outside air into work areas and reduces odor  
3. Corrosion prevention: ventilation keeps the humidity and hydrogen sulfide down which reduces corrosion
- 2.1.12 List two operating strategies that will reduce the harmful affects caused by return streams on wastewater treatment.
1. Gradually feed filtrate into headend of the plant to minimize shock loading
  2. Maximize efficiency of dewatering equipment (i.e. minimal solids in the return flows)
- 2.1.13 List the factors that affect the costs of operating mechanical sludge handling equipment.
1. The type of equipment (gravity thickener, vacuum filter, gravity belt, belt press, dissolved air flotation, and thermal processing, etc.)
  2. The type of sludges being processed
  3. Chemical costs
  4. Power costs for pumping and operating other equipment
  5. Maintenance and repair costs
  6. Hauling costs for final disposal
- 2.1.14 Compare direct hauling of sludge versus hauling dewatered sludge.  
The hauling of sludge is primarily a matter of cost and time spent in actual hauling. For example going from a 5% sludge to a 15% sludge would reduce the volume needed to be hauled by two thirds. This would directly affect the total hauling costs.
- 2.1.15 Compare direct land spreading of sludge to the incorporation of sludge into the soil.

Direct land spreading of sludge may result in some immediate minor odor problems, the possibility of run-off, and the visual appearance of drying sludge on the field. Incorporation into the soil virtually eliminates all of the problems but requires more power and specialized equipment to accomplish.

2.1.16 List the sludge qualities that make its disposal difficult.

1. Odor problems
2. High or low pH
3. Possible organic toxics
4. Heavy metals content
5. Large volumes if moisture content is high

2.1.17 Describe the qualities that improve public acceptance of sludge end-products.

The most important factor in the acceptance of dewatered sludge is to have a good educational program explaining the benefits of sludge in terms of nutrient value (fertilizer) and the soil conditioning it provides. The sludge should be well digested to minimize odors. Direct soil incorporation or "tilled-in" application aids the acceptance. Low moisture content of the sludge is desirable to reduce traffic to the application site. All spreading equipment should be clean and well maintained to provide a good overall appearance.

## **Section 2.2 - Maintenance**

2.2.1 List three major categories of maintenance.

1. Scheduled lubrication
2. Equipment inspection and adjustment
3. Routine repair/parts replacement

2.2.2 Lists three major categories of equipment information operators should have for a planned maintenance program.

1. Lubrication schedule
2. Detailed maintenance records
3. Operating procedures/manuals

2.2.3 Discuss special housekeeping and maintenance considerations associated with mechanical sludge handling.

- A. Avoid sludge spillage
- B. Keep areas clean and ventilated
- C. Control noise, temperature, and pressure

## **Chapter 3 - Monitoring and Troubleshooting**

### **Section 3.1 - Monitoring**

3.1.1 Describe the laboratory equipment needed to test for solids content.

The laboratory equipment needed to determine solids content is basically the same as that needed to run a suspended solids test. This would include glass-fiber filter discs, gooch crucible, suction flask, vacuum source, drying oven (103 degrees - 105 degrees C.),

desiccator, and an analytical balance. If it is desired to determine volatile solids a muffle furnace (550 degrees C.) is needed.

- 3.1.2 Describe the sampling locations and sampling frequency necessary to ensure good sludge thickening/dewatering operations.

For sludge thickening/dewatering equipment the sample locations would include: the raw feed sludge to the thickening/dewatering equipment and the finished sludge from the thickening/dewatering equipment which is sludge cake from mechanical equipment, underflow from gravity thickening, or float from dissolved air flotation (DAF) units. The sampling frequency should be sufficient to ensure good operations (the unit should be operating within the normal range based on historic sampling results). Additional sampling should be done if there are any changes in the feed sludge characteristics, any changes to polymer feed, any apparent change in the finished sludge, or any abnormalities in the return sidestream flow characteristics from the thickening/dewatering unit.

- 3.1.3 Discuss how to determine volume and solids content of sludge being pumped.

A. Volume:

1. Flow meter
2. Graduated tank
3. Pump/motor hour meter

B. Solids:

1. Suspended solids test

- 3.1.4 Describe the jar test and its uses.

A jar test is a method of determining optimal chemical dosages. A number of jars are set-up using different chemicals at different concentrations to determine the best settling characteristics. When the best chemical dosage is determined it can be applied to the sludge handling process.

- 3.1.5 List two methods of sludge blanket measurement.

1. Core samples (sludge judge)
2. Electronic sludge blanket monitoring

- 3.1.6 Describe the primary monitoring test used in sludge thickening/dewatering processes.

The primary monitoring test for sludge thickening/dewatering is used to determine the amount of water removed in the process. The essential test would be either the solids content or the moisture content of the sludge. The suspended solids test is used to determine the percent solids in a given sludge. This test is normally run on both the feed sludge and the sludge cake. Suspended solids are normally reported as percent solids rather than mg/L. A 1% suspended solids result is equal to 10,000 mg/L.

- 3.1.7 Describe the difficulty in determining average moisture content in quantities of sludge and describe ways to compensate for the difficulties.

The difficulty in determining moisture content of sludge is not a laboratory problem but in

getting a representative sample. To overcome this difficulty composite samples should be taken (flow proportional if possible) and care should be taken to make sure the composite sample is well mixed before analyzing.

- 3.1.8 Discuss tests and measurements that should be run on return streams and the importance of this flow on plant operations.

The return flows from mechanical sludge processing units should be tested for BOD and suspended solids along with a flow volume measurement. In some cases pH and ammonia might also be important. The main reasons for testing is to determine the organic strength and suspended solids loading that is being returned to the treatment plant. These tests are important to ensure that the treatment process will not be upset by these sidestream flows.

- 3.1.9 List the problems associated with sludge flow measurement and with obtaining representative samples for lab tests.

1. The high viscosity of the sludge and high solids concentration
2. Flow measurement is difficult because it is usually being pumped (it is not in an open channel)
3. Sampling taps do not necessarily give a representative sample
4. A dirty flow stream (effects of grease, hair, and debris)

## **Section 3.2 - Troubleshooting**

- 3.2.1 Discuss the possible causes of odor at a mechanical sludge handling plant.

The main cause of odor with mechanical sludge handling of an anaerobically digested sludge is the release of hydrogen sulfide. For aerobically digested sludge or waste activated sludge there should be minimal odor (unless these sludges are allowed to become anaerobic/septic). If sludge becomes septic hydrogen sulfide will cause odor problems.

- 3.2.2 Explain the potential damage to equipment if proper start-up and shut-down procedures are not followed in operation of:

- A. Wet air oxidation
- B. Incineration
- C. Positive displacement pump

A. Wet air oxidation: pressure and heat could damage the equipment and could be a safety problem to operators

B. Incineration: excessive heat or even an explosion could damage equipment and be a safety problem to operators

C. Positive displacement: there could be pump damage (sheared pump pin, packing blow-out, or bent pump arm) and the possibility of valve damage or pipe rupture.

- 3.2.3 List the various operational problems that can be expected from the sidestream return flow.
1. Hydraulic loading: reduced detention times possible

2. Organic loading: might affect secondary process
3. Toxic loading: metals and chemicals
4. Shock loading: temperature, BOD, suspended solids, and ammonia

## **Chapter 4 - Safety and Calculations**

### **Section 4.1 - Safety**

4.1.1 Outline a safety training program designed to avoid the following hazards associated with sludge handling:

- A. Suffocation and toxic gas
  - B. Bumps, slips, and falls
  - C. Fires and explosions
  - D. Eye injury
  - E. Infections
  - F. Getting caught in slow moving equipment
- A. Suffocation and toxic gases:
1. Use a gas monitor
  2. Utilize proper ventilation
  3. Use a protective breathing apparatus if necessary
  4. Use the buddy system
- B. Bumps, slips, and falls:
1. Walk slowly in areas where polymers are used
  2. Keep floors clean
  3. Use railing when climbing stairs or ladders
- C. Fires and explosions:
1. No smoking in critical areas
  2. Store combustibles in a designated area
  3. Properly store chemicals to prevent accidental mixing
- D. Eye injury:
1. Always use eye protection
  2. Use care around pressurized lines
  3. Use full-face shield when handling chemicals
- E. Infections:
1. Practice good sanitary wash-up procedures
  2. Avoid hand to mouth contact
  3. Provide protection for cuts and/or scratches

F. Getting caught in slow moving equipment:

1. Do not wear loose clothing around running equipment
2. Shut equipment down and lock-out before doing maintenance
3. Do not wear rings around running equipment

4.1.2 Describe the special safety considerations for the following:

- A. Centrifuge
- B. Belts in belt presses
- C. Sludge and scum pipelines

A. Centrifuge: before opening the bowl all equipment should be shut-off and locked-out using proper lock-out tags

B. Belts in belt presses: all belts should be stopped and associated equipment shut-down, locked out, and properly tagged; use care when hosing belts to prevent flying debris and slippery work surfaces; sharp objects and tight spaces should be carefully watched to prevent cuts and other injuries

C. Sludge and scum pipelines: care should be taken when cleaning pipes overhead to avoid falling debris; avoid climbing on wet pipes

4.1.3 List the elements to include in an emergency plan.

1. Personnel with extensive safety training should be available
2. Emergency first aid kits should be strategically located throughout the area
3. Gas analyzers should be available, breathing equipment (SCBA, mask, or others), and safety lines (confined space)
4. Chlorine repair kits should be available
5. Emergency evacuation plans should be developed and posted
6. Police, fire, and rescue personnel should be alerted

4.1.4 List the possible hazards at a treatment plant that would merit an emergency plan.

1. Chlorine leak
2. Chemical spill
3. Fuel spill
4. Confined space entry

4.1.5 Describe the safe storage requirements and personal hazards in handling the following chemicals:

- A. Powdered chemicals (in general)
- B. Lime
- C. Alum

All chemicals must be stored according to the manufacturers label instructions.

A. Powdered chemicals (in general):

Storage: store in a dry area; make sure containers are tightly closed (to keep out moisture); keep in original containers and make sure they are protected from physical damage

Hazards: depending on the powdered chemical, hazards could include: the possibility of fumes, toxic gases, and the general problem of inhaling dust

B. Lime:

Storage: lime is generally supplied in two forms-

A. Quick lime (un-slaked) - store in its original container in a dry location as the powder is very hygroscopic (readily absorbing moisture)

B. Hydrated lime (slaked) - is supplied as a slurry and should be stored in its original container; slaked lime is a very corrosive chemical and containers used for mixing should be rubber, PVC, or iron/steel

Hazards: dust from lime in powdered form can cause irritation of eyes, nose, and respiratory system; of special concern when adding water to unslaked lime is that heat is generated and splattering can occur; these chemicals are very corrosive and can cause severe burns; protective clothing with full face protection is required when using lime

C. Alum:

Storage: alum is hydrated aluminum sulfate and is usually supplied in a liquid form; it is moderately corrosive and can be stored in fiberglass reinforced plastic, 316 stainless steel, steel lined with rubber or saran, PVC, or other plastic tanks; alum tanks must be kept above 25 degrees F.

Hazards: alum is moderately corrosive and protective clothing, gloves, and goggles should be worn; in addition, chemical storage tanks are a level 2 confined space requiring meeting the requirements of state and national safety standards.

4.1.6 Describe the safe storage requirements and personal hazards in handling the following chemicals: [Continued]

- D. Ferric chloride
- E. Polymers
- F. Acids (in general)
- D. Ferric chloride:

Storage: ferric chloride is very corrosive and fume producing; it is usually supplied as a 35-43% liquid product; it needs to be stored in tanks made of fiberglass, reinforced plastic, rubber, or saran lined steel; certain other plastics and rubber are also adequately resistant; the tank should be surrounded with a containment area equal in volume to the tank in order

to control possible leaks

Hazards: ferric chloride is very corrosive; rubber protective clothing with a full face guard should be used when handling this product; as with alum chemical storage tanks are a class 2 confined space

E. Polymers:

Storage: polymers are supplied in either liquid or powder form and should be stored in their original containers; some of the liquid polymers can be fed directly using a "drumhead" feeder; for dilution or mixing of polymers of most types storage containers can be used (e.g. fiberglass, polyethylene, PVC, rubber, and various steels, etc.); since there are so many different kinds of polymers it is best to check with the chemical supplier for any special storage requirements for the polymer being used

Hazards: polymers are relatively benign chemicals as some are used in potable water supplies for treatment purposes; the powdered forms do pose problems with the dust being an irritant to the mucus membranes; the main problem with polymers is to thoroughly clean-up spills as they cause extremely slippery surfaces that can cause falling accidents

F. Acids (in general):

Storage: all acids should be stored in recommended acid proof containers; in most cases this will be glass or various types of plastic materials and almost never any metal containers; one exception to using glass container would be for forms of hydrofluoric acid which etches glass; acids should be stored in a safe location to prevent physical damage as they are extremely corrosive spilled

Hazards: all acids are extremely corrosive especially the metals; they can cause severe burns and fumes can cause respiratory problems; acids should be handled with extreme care using rubber protective clothing, full face shields, and adequate ventilation; when diluting acids it is very important to add acid to water; if water is added to a concentrated acid splattering could occur and heat release

## **Section 4.2 - Calculations**

4.2.1 Given data, calculate the proper setting for a chemical feed pump in gallons per minute.

Given:

432 pounds of undiluted polymer required per day

1% feed concentration of polymer

10 pounds/gallon density of undiluted polymer

1 day = 1,440 minutes

Formula:

gallons of undiluted polymer used/day = polymer used ÷ density

$$\text{gallons} = 432 \div 10 = 43.2 \text{ gal/day}$$

$$\text{diluted polymer used per day} = \text{gal/day} \div \text{concentration}$$

$$\text{diluted polymer} = 43.2 \div 0.01 = 4,320 \text{ gal/day}$$

$$\text{diluted polymer used per min.} = \text{gal/day} \div \text{min/day}$$

$$\text{diluted polymer} = 4,320 \div 1,440 = 3 \text{ gal/min.}$$

4.2.2 Given data, calculate the pounds of chemical to feed for a given sludge volume.

Given:

Desired chemical concentration = 10 mg/L

Sludge volume = 200,000 gallons

Formula:

$$\text{pounds of chemical} = \text{volume (MGD)} \times \text{concentration (mg/L)} \times 8.34$$

$$\text{pounds} = 0.20 \times 10 \times 8.34 = 16.7 \text{ pounds}$$

4.2.3 Given data, calculate the pounds of dry solids in a given sludge.

Given:

Solids = 4% (40,000 mg/L)

Volume = 100,000 gallons

Formula:

$$\text{pounds} = \text{concentration (mg/L)} \times \text{volume (MG)} \times 8.34$$

$$\text{pounds} = 40,000 \times .1 \times 8.34 = 33,360 \text{ pounds of dry solids}$$

4.2.4 Given data, calculate solids loading in dry tons.

Given:

Flow = 300 GPM =  $300 \times 10 \times 60 = 0.18 \text{ MG}$

Feed suspended solids = 3.5% or 35,000 mg/L

Run time = 10 hours

Formula:

$$\text{tons} = \text{flow (MG)} \times \text{concentration (mg/L)} \times 8.34 \div 2,000 \text{ lbs/ton}$$

$$\text{tons} = .18 \text{ MGD} \times 35,000 \times 8.34 \div 2,000 \text{ lbs/ton} = 26.3 \text{ tons}$$

4.2.5 Given data, calculate the wet sludge in tons when percent solids and dry tons are known.

Given:

Tons of dry solids = 20  
% solids = 14%

Formula:

tons of wet sludge = tons of dry sludge x 100 ÷ %solids

wet sludge = 20 x 100 ÷ 14 = 143 tons

4.2.6 Given data, calculate the percentage solids capture of a thickening process.

Given:

Feed sludge solids = 2%

Return flow solids (filtrate) = 1,000 mg/L = 0.1%

Formula:

percent solids capture = (feed sludge % - return solids % ÷ feed sludge %) x 100

solids = (2 - 0.1 ÷ 2) x 100 = 95 %

4.2.7 Given data, calculate the "mass balance" of solids in gallons.

Given:

Initial flow = 500 gallons per minute

Initial concentration = 3%

Final concentration = 10%

Formula:

initial flow x initial concentration = final flow x final concentration

500 x 3 = flow x 10

final flow = 500 x 3 ÷ 10 = 150 gallons per minute

4.2.8 Given data, calculate the percent volume reduction through a sludge handling process.

Given:

Input = 100,000 gals of sludge at 5% solids

Output = thickened sludge at 15% solids

Formula:

C1V1 = C2V2

(5%) 100,000 = 15% V2

V2 = 33,300 gallons (thickened)

percent volume reduction = (volume in - volume out ÷ volume in) x 100

volume reduction = (100,000 - 33,300 ÷ 100,000) x 100 = 67%

## References and Resources

### **1. ADVANCED WASTE TREATMENT.**

1st Edition (1987), Kenneth D. Kerri. California State University, 6000 J Street, Sacramento, CA 95819-6025. Phone (916) 278-6142.

<http://www.owp.csus.edu/training/>

### **2. CONTROLLING WASTEWATER TREATMENT PROCESSES.**

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