DOCUMENT RESUME

ED 151 216 SE 024 027

TITLE	Sedimentation. Training Module 2.105.2.77.
INSTITUTION	Kirkwood Community Coll., Cedar Rapids, Iowa.
SPONS AGENCY	Department of Labor, Washington, D.C.; Iowa State Dept. of Environmental Quality, Des Moines.
PUB DATE	Sep 77
NOTE	103p.; For related documents, see SE 024 025-047; Contains occasional light type
EDRS PRICE	MF-$0.83 HC-$6.01 Plus Postage.
DESCRIPTORS	*Instructional Materials; *Post Secondary Education; Secondary Education; *Teaching Guides; *Units of Study; *Water Pollution Control
IDENTIFIERS	Operations (Wastewater); *Waste Water Treatment

ABSTRACT

This document is an instructional module package prepared in objective form for use by an instructor familiar with operation and maintenance of primary and secondary wastewater treatment sedimentation units. Included are objectives, instructor guides, student handouts and transparency masters. The module considers purposes, functions, components, design criteria, operation, maintenance and safety. (Author/RH)

SEDIMENTATION

Training Module 2.105.2.77

Prepared for the

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by

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The publication of these training materials was financially aided through a contract between the Iowa Department of Environmental Quality and the Office of Planning and Programming, using funds available under the Comprehensive Employment and Training Act of 1973. However, the opinions expressed herein do not necessarily reflect the position or policy of the U. S. Department of Labor, and no official endorsement by the U. S. Department of Labor should be inferred.

September, 1977

GLOSSARY OF VERBS

As used in the Sedimentation Module No. ____

Describe. To represent by words written or spoken for the knowledge or understanding of others, to transmit an image of the identifying features, the nature and characteristics of objects, events and action.

Explain. To make plain or clear, to present in detail by words written or spoken for the knowledge or understanding of others, to transmit an image of the identifying features, the nature and characteristics of objects, events and actions.

Identify. To establish the identity of, pick out or single out an object in response to its name by pointing, picking up, underlining, marking, matching or other responses.

Indicate. To state or express without going into detail. The identity of, pick out or single out an object in response to its name by pointing, picking up, underlining, marking, matching or other responses.

Locate. To stipulate the position of an object in relation to other objects.

Select. To choose something from a number or group usually by fitness, excellence, or other distinguishing features.

Module No:	Module Title: Sedimentation
Approx. Time: 19 hours	Submodule Titles: 1. Introduction to Sedimentation Process 2. Primary and Secondary Sedimentation 3. Imhoff Tanks 4. Safety in Sedimentation Units

Overall Objectives

Upon completion of this module the learner should be able to describe the purpose of the sedimentation units, how it functions, the various types of units, the components, design criteria, normal and abnormal operation, routine and planned maintenance and safety.

Instructional Aids:

Handouts
Diagrams
AV (overhead transparency)
Slides if available

Instructional Approach:

Discussion
Demonstration if possible

References:

Operation of Wastewater Treatment Plants, a field study training program, Kenneth Kerri, Sacramento State College.

Manual of Instruction for Water Plant Operators, Health Education Service, Albany, N.

Manual of Instruction for Sewage Treatment Plant Operators.

Water and Wastewater Technology, Mark J. Hammer, John Wiley & Sons, N. Y.

Class Assignment:

1. Read handout.
2. Given diagrams of sedimentation units for component identification

Module No:	Topic: SUMMARY

Instructor Notes:	Instructor Outline:
1. Give handout 2. Show slides if available 3. Show diagrams of separate units for sedimentation 4. Diagrams and figures are to be used as handouts and overhead transparency masters.	1. Discuss/demonstrate and identify the purpose of the sedimentation units, how it functions, the various types of units, the components, design criteria, normal and abnormal operation, routine and planned maintenance and safety. 2. Give evaluation of 30 questions.

Module No:	Module Title: Sedimentation
	Submodule Title: Introduction
Approx. Time: 3 hours	Topic: Sedimentation Process

Objectives:

1. The learner will describe the process of sedimentation.
2. The learner will identify a sedimentation unit.

Instructional Aids:

Handouts
AV (slides if available)
Diagram

Instructional Approach:

Discussion
Demonstration

References:

Operation of Wastewater Treatment Plants, a field study training program, Kenneth Kerr, Sacramento State College.

Water and Wastewater Technology, Mack J. Hower, John Wiley & Sons, N. Y.

Class Assignments:
1. Read handout
2. View diagrams and identify if unit is used for sedimentation process.

Module No:	Topic: Sedimentation Process

Instructor Notes:	Instructor Outline:
Show photograph of each unit.	1. Discuss the meaning sedimentation. 2. Discuss the factors that influence the sedimentation process. a. Flow b. Size of particles 3. Discuss where sedimentation is used. a. Water Process 1. Reservoirs 2. Surface water pre-treatment basin b. Wastewater Process 1. Lagoons 2. Grit chambers 3. Imhoff tanks 4. Primary clarification 5. Secondary Treatment c. Processes used in either water or wastewater systems 1. After chemical addition and flocculation a. Alum addition b. Chemical softening process c. Ferric chloride addition d. Polymer

Module No:	Module Title: Sedimentation
	Submodule Title: Primary and Secondary Sedimentation
Approx. Time: 2 hours	Topic: Components

Objectives:

Upon completion of this module the learner should be able to:

1. Identify the components of a sedimentation unit.
2. Explain the purpose of each components of a sedimentation unit.
3. Describe how each component of a sedimentation unit functions.
4. Explain the importance of each component in a sedimentation unit.

Instructional Aids:

Handouts
Diagrams
AV (overhead transparency)
Slides if available

Instructional Approach:

Discussion
Demonstration if possible

References:

1. Operation of Wastewater Treatment Plants, a field study training program, Kenneth Kerri, Sacramento State College
2. Manual of Instruction for Water Plant Operation, Health Education Service, Albany N. Y.
3. Manual of Instruction for Sewage Treatment Plant Operators.
4. Water and Wastewater Technology, Mark J. Hammer, John Wiley & Sons, N. Y.

Class Assignments:

1. Read handout
2. Identify components on a given diagram

Module No:	Topic: Components

Instructor Notes:	Instructor Outline:
1. Show a photograph of each if possible. 2. Provide a diagram of typical sedimentation units.	Discuss each component of a sedimentation unit and explain the function, purpose and importance of each component. 1. Baffle 2. Chain 3. Drive motor 4. Flight 5. Gear box 6. Grease pit 7. Influent gate 8. Piping 9. Pump 10. Rail 11. Shaft 12. Shoe 13. Skimmer arm 14. Skimmer trough 15. Sludge well 16. Sprocket 17. Telescopic valve 18. Weir

Module No:	Module Title: Sedimentation
	Submodule Title: Primary and Secondary Sedimentation Units
Approx. Time: 2 hours	Topic: Normal Operation

Objectives:

Upon completion of this module the learner should be able to:

1. Describe the normal operation procedures for a sedimentation unit, to include making adjustments, routine sampling, routine calculations, routine lab tests, routine record keeping.
2. Describe the start up and shut down procedures for a sedimentation unit.

Instructional Aids:

Handouts
Diagrams
AV (overhead transparency)
Slides if available

Instructional Approach:

Discussion
Demonstration if possible

References:

1. Operation of Wastewater Treatment Plants, a field study training program, Kenneth Kerri, Sacramento State College.
2. Manual of Instruction for Water Plant Operation, Health Education Service, Albany, N. Y.
3. Manual of Instruction for Sewage Treatment Plant Operators.
4. Water and Wastewater Technology, Mark J. Hammer, John Wiley & Sons, N. Y.

Class Assignments:

1. Given handouts to be read.

Module No:	Topic: Normal Operation

Instructor Notes:	Instructor Outline:
1. Indicate what components should be operating a. Indicate what components operate intermittently	1. Describe and discuss the normal operation procedures for a sedimentation unit. a. Normal open b. Removal 2. Describe and discuss the points of sampling: a. Influent b. Effluent c. Raw sludge 3. List the routine lab tests performed on sedimentation units, their significance to operation control. a. Influent and effluent 1. Settleable solids 2. Total solids 3. Total suspended solids 4. pH 5. Temperature 6. Turbidity b. Sludge 1. Total solids 2. Total volatile solids 3. Oil and grease c. If sedimentation unit is "indoors" 1. Hydrogen sulfide 2. Methane

Module No:	Topic: Normal Operation

Instructor Notes:	Instructor Outline:
4. Refer to Module No. ___ Module Title: Intermediate Mathematics Submodule Titles: 1. Detention time 2. Surface settling rate 3. Weir overflow rate 4. Percent removal (efficiency)	4. Discuss/demonstrate routine calculations and use in making adjustments: a. Detention time b. Surface settling rate c. Weir overflow rate d. Percent removal (efficiency) e. % total solids and volatile solids 5. Discuss the importance of routine record keeping on lab results and on breakdowns and maintenance performed on component. 6. Describe and discuss the start up procedure of a sedimentation unit. 7. Describe and discuss the shut down procedure of a sedimentation unit.

Module No:	Module Title: Sedimentation
	Submodule Title: Primary and Secondary Sedimentation Units
Approx. Time: 4 hours	Topic: Preventive Maintenance

Objectives:

Upon completion of this module the learner should be able to describe the preventive maintenance procedures for sedimentation unit components--cleaning, lubrication, mechanical adjustment, painting, replacement and wear measurement.

Instructional Aids:

Handouts
Diagrams
AV (overhead transparency)
Slides if available

Instructional Approach:

Discussion
Demonstration if possible

References:

1. Operation of Wastewater Treatment Plants, a field study training program, Kenneth Kerri, Sacramento State College
2. Manual of Instruction for Water Plant Operation, Health Education Service, Albany, N. Y.
3. Manual of Instruction for Sewage Treatment Plant Operators.
4. Water and Wastewater Technology, Mark J. Hammer, John Wiley & Sons, N. Y.

Class Assignments:

1. Given handouts to be read.

Module No:	Topic: Preventive Maintenance

Instructor Notes:	Instructor Outline:
1. Handout	1. Describe the preventive maintenance procedures for the components of sedimentation units. a. Cleaning 1. Baffle 2. Chain 3. Drive motor 4. Flight 5. Gear box 6. Grease pit 7. Pump 8. Rail 9. Skimmer and skimmer trough 10. Sludge well 11. Sluice gate 12. Telescopic valve 13. Weir b. Lubrication 1. Chain 2. Drive motor 3. Gear box 4. Pump 5. Sprocket 6. Valve c. Mechanical adjustment 1. Baffle 2. Chain 3. Drive motor 4. Flight 5. Gear box 6. Pump 7. Shaft 8. Squeeges - sludge collection unit

Module No:	Topic: Preventive Maintenance

Instructor Notes:	Instructor Outline:

9. Skimmer arm
10. Sprocket
11. Time clock
12. Valve
13. Weir

d. Painting

1. Drive motor
2. Gear box
3. Piping
4. Pump
5. Telescopic valve
6. Weir

e. Replacement

1. Baffle
2. Chain
3. Fire-fighting equipment
4. First aid kit
5. Flight
6. Pumps
7. Shear pin
8. Shoe
9. Sprocket
10. Squeeges

f. Wear measurement

1. Chain
2. Drive motor
3. Flight
4. Pump
5. Shoe
6. Skimmer arm
7. Sprocket

Module No:	Module Title: Sedimentation
	Submodule Title: Imhoff Tanks
Approx. Time: 1 hour	Topic: Components

Objectives:

Upon completion of this module the learner should be able to:

1. Identify the components of an Imhoff Tank.
2. Explain the purpose of each component of an Imhoff Tank.
3. Explain the importance of each component in an Imhoff Tank.

Instructional Aids:

Handouts
Diagrams
AV (overhead transparancy)
Slides if available

Instructional Approach:

Discussion
Demonstration if possible

References:

1. Operation of Wastewater Treatment Plants, a field study training program, Kenneth Kerri, Sacramento State College.
2. Manual of Instruction for Water Plant Operation, Health Education Service, Albany, N. Y.
3. Manual of Instruction for Sewage Treatment Plant Operators.
4. Water and Wastewater Technology, Mark J. Hammer, John Wiley & Sons, N. Y.

Class Assignments:
1. Read handout
2. Identify components on a given diagram

Module No:	Topic: Components
Instructor Notes:	**Instructor Outline:**
1. Handout	Discuss each component of an Imhoff Tank and explain the function, purpose and importance of each component. 1. Baffle 2. Flow through slot 3. Gas vent 4. Grease pit 5. Piping 6. Pump 7. Rail 8. Valves 9. Weir

Module No:	Module Title: Sedimentation
	Submodule Title: Imhoff Tanks
Approx. Time: 2 hours	Topic: Normal Operation

Objectives:

Upon completion of this module the learner should be able to:

1. Describe the normal operation procedures for an Imhoff Tank, to include making adjustments, routine sampling, routine calculations, routine lab tests and routine record keeping.
2. Describe the start up and shut down procedures for an Imhoff Tank.

Instructional Aids:

Handouts
Diagrams
AV (overhead transparency)
Slides if available

Instructional Approach:

Discussion
Demonstration if possible

References:

1. Operation of Wastewater Treatment Plants, a field study training program, Kenneth Kerri, Sacramento State College.
2. Manual of Instruction for Water Plant Operation, Health Education Service, Albany, N. Y.
3. Manual of Instruction for Sewage Treatment Plant Operators.
4. Water and Wastewater Technology, Mark J. Hammer, John Wiley & Sons, N. Y.

Class Assignments:

1. Read handout

Module No:	Topic: Normal Operation

Instructor Notes:	Instructor Outline:

1. Describe and discuss the normal operation procedures for an Imhoff Tank.
2. Describe and discuss the points of sampling in an Imhoff Tank.
   a. Influent
   b. Effluent
   c. Raw sludge
3. List the routine lab tests performed on Imhoff Tank process.
   a. Influent and effluent
      1. BOD or COD
      2. Chlorine residual
      3. Floating material
      4. Odor
      5. Oil and grease
      6. pH
      7. Settleable solids
      8. Temperature
      9. Total solids
      10. Total suspended solids
   b. Sludge
      1. Oil and grease
      2. Total solids
      3. Total volatile solids
   c. If tank is "indoors"
      1. Hydrogen sulfide
      2. Methane
4. Discuss/demonstrate routine calculations and use in making adjustments.
   a. Detention time
   b. Surface settling rate
   c. Weir overflow rate
   d. Percent removal (efficiency)
   e. % total solids and volatile solids

Module No:	Topic: Normal Operation

Instructor Notes:	Instructor Outline:
	5. Discuss the importance of routine record keeping on lab results and on breakdowns and maintenance performed on components.
	6. Describe and discuss the start up procedure of an Imhoff Tank.
	7. Describe and discuss the shut down procedure on an Imhoff Tank.

Module No:	Module Title: Sedimentation
	Submodule Title: Imhoff Tank
Approx. Time: 3 hours	Topic: Preventive Maintenance

Objectives:

Upon completion of this module the learner should be able to describe the preventive maintenance procedures for Imhoff Tank components -- cleaning, lubrication, mechanical adjustment, painting, replacement and wear measurement.

Instructional Aids:

Handouts
Diagrams
AV (overhead trasparancy)
Slides if available

Instructional Approach:

Discussion
Demonstration if possible

References:

1. Operation of Wastewater Treatment Plants, a field study training program, Kenneth Kerri, Sacramento State College.
2. Manual of Instruction for Water Plant Operation, Health Education Service, Albany, N. Y.
3. Manual of Instruction for Sewage Treatment Plant Operators.
4. Water and Wastewater Technology, Mark J. Hammer, John Wiley & Sons, N. Y.

Class Assignments:

1. Handouts to be read.

Module No:	Topic: Preventive Maintenance

Instructor Notes:	Instructor Outline:

1. Describe the preventive maintenance procedures for the components of Imhoff Tanks

   a. Cleaning

      1. Baffle
      2. Flow through slot
      3. Gas vents
      4. Grease pit
      5. Influent gate
      6. Piping
      7. Pump
      8. Rail
      9. Valves
      10. Weir

   b. Lubrication

      1. Pump
      2. Telescopic valve
      3. Valve

   c. Mechanical adjustment

      1. Baffle
      2. Pump
      3. Valve
      4. Weir

   d. Painting

      1. Piping
      2. Rails
      3. Telescopic valve
      4. Valves
      5. Weirs

Module No:	Topic: Preventive Maintenance

Instructor Notes:	Instructor Outline:
	e. Replacement 1. Baffle 2. Fire fighting equipment 3. First aid kit 4. Piping 5. Rails 6. Weir f. Wear Measurement 1. Baffle 2. Pump 3. Telescopic valve 4. Valve 5. Weir

Module No:	Module Title: Sedimentation
	Submodule Title: Safety
Approx. Time: 1 hour	Topic:

Objectives:

Upon completion of this module the learner should be able to describe the safety procedures for operation of sedimentation units.

Instructional Aids:

Handouts
Diagrams
AV (overhead transparancy)
Slides if available

Instructional Approach:

Discussion
Demonstration if possible

References:

1. Operation of Wastewater Treatment Plants, a field study training program, Kenneth Kerri, Sacramento State College.
2. Manual of Instruction for Water Plant Operation, Health Education Service, Albany, N. Y.
3. Manual of Instruction for Sewage Treatment Plant Operators.
4. Water and Wastewater Technology, Mark J. Hammer, John Wiley & Sons, N. Y.

Class Assignments:

1. Read handout

Module No:	Topic: Safety

Instructor Notes:	Instructor Outline:
1. Handout 2. Show visuals if available	1. Identify the hazardous conditions that exist in and around sedimentation units. a. Lack of rails and catwalks. b. Slippery catwalks WALKWAYS c. Maintaining electrical equipment while unit still on. d. Performing operation and maintenance tasks unsafely. e. Entering confined areas without proper ventilation and breathing apparatus. f. Lack of protective head gear, hand and feet covering and clothes. g. Performing difficult tasks without help. h. Attempting to lift and carry heavy items or components. i. Many other unsafe procedures attempted by operators and visitors.

SEDIMENTATION

Sedimentation is the process of removing physically solids that settle easily in water or wastewater processes.

The principles of the settling of suspended solids depend on several factors. The most common factors are:

1. Size of particle
2. Gravitational pull (constant)
3. Velocity of flow
4. Temperature of water
5. Viscosity of the water
6. Characteristics of water; freshness, staleness, strength, biological activity, chemical composition.

Velocity

The usual velocity of flow entering a treatment plant is above two feet/second. This velocity allows the solids to remain in suspension. By allowing the velocity to be reduced to below 2.0 feet/second, most particles will begin to settle.

Particle Size

The larger the size of the solids, the higher percentage of removal and the faster the settling rate. Since many of the solids would not be in the size to settle (colloidal) or (suspended), by gently mixing the solution, the solids bump together and adhere (stick) together to form a larger particle which then will settle. This process is called flocculation-coagulation.

Temperature of the water/Viscosity of the water

The temperature and viscosity of water are interrelated. As the temperature increases the viscosity decreases and as the temperature decreases the viscosity increases. The denser the water (more viscosity) the particle settling rate decreases, the lower the efficiency. This is why in winter or cold weather the efficiency of clarifiers decreases.

Characteristics of water

The characteristics of water depends upon

a. The amount of solids in the water. The more the solids, the greater the settleability efficiency.

b. The freshness. The term freshness is more applicable to wastewater systems. It is a term indicating the stage of degradability. The more septic the wastewater is the less the freshness the slower the settling rate of the solids. This reduction in the rate is due to the fact that gases generated during decomposition will adhere (cling) to the solids and therefore make the solid boyant. An example is when sludge "burps" to the surface in primary and secondary sedimentation units.

Biological activity

The biological activity especially in the anaerobic condition (lack of oxygen) generates gases that adhere (cling) to solids which cause buoyancy.

Chemical composition of solids

Since water is a universal solvent some solids are dissolved and some remain suspended, but the change in condition (pH, temperature, acidity, alkalinity, etc. could change the state of the solid from suspended to dissolved or visa versa (dissolved to suspended).

In water processing the sedimentation process is used in

a. Reservoirs. These units are large areas that reduce the velocity of flow through or all together arrest the flow which allows the gravitational pull to act upon the suspended solids in the water (sand, silt, gravel) which will settle to the bottom.

Reservoirs usually do not have the components to easily remove the solids that settle easily to the bottom. If the solid level in the reservoir becomes too high/deep then the reservoir is drained and cleaned. Remember that alternate sources of water source should be developed before putting a reservoir out of service.

b. Pre-treatment units for surface water sources. Such units function in removing heavy solids such as (sand, grit, gravel) that may be in the surface water source. The unit also aids in removing floating material such as leaves. These units have components that continuously collect the settled solids and floating material for removal. Removal can be continuous or intermittent, automatically ~~(timed) activated~~ or manually activated.

In wastewater systems sedimentation is used in

a. Waste stabilization ponds (lagoons). The flow is reduced to extremely low velocity or contained completely which allows the suspended solids to settle to the bottom which allows biological activity to decompose them.

b. Grit chambers. The sedimentation process in grit chambers is designed to remove sand, grit, coffee grounds, egg shell, abrasive matter that is harmful to pumps, piping, scrapers, flights, valves etc.

Since grit chambers are designed to remove specific types of solids the velocity through the chamber is reduced to a rate between 0.8 ft/sec. 1.2 ft/sec. This velocity allows the grit to settle but not the organic solids.

c. Imhoff tanks. Imhoff tanks are considered to be a full system process. The unit has basically two compartments (1) the sedimentation channel and (2) the digestion chamber. The sedimentation channel reduces the velocity of the flow which causes the solids to settle through a slot in the bottom of the channel to the digestion chamber.

d. Primary clarifiers. Primary clarifiers remove the suspended solids in the wastewater by reducing the velocity. The settled solids (sludge) is collected in a sump for removal. Most primary clarifiers have a scum removal component. Scum is any material that floats to the surface of the clarifier.

e. Secondary clarifiers. These are units placed after biological processes (trickling filters, activated sludge, rotating biological discs) that allow the settling of solids, which are collected and removed.

The sedimentation process is also used in processes that utilize chemical addition for flocculation and coagulation after (a) adding the chemicals (b) flashmixing and (c) coagulating (gentle mixing), by allowing the water and solids to remain undisturbed, the solids will settle to the bottom of the clarifier and can be removed.

Processes such as alum addition, lime softening, ferric chloride ($FeCl_3$) addition and polymer addition, coagulate solids suspended in the water, enlarge the size of solids which causes the ease of precipitation, or react with chemicals in the water to form insoluble solids that settle out.

To summarize, sedimentation is the process of removing by physical means suspended solids that are present in water and wastewater flows. The process of sedimentation is accomplished in many processes.

a. Reservoirs

b. Pre-treatment basins

c. Lagoons

d. Grit chambers

e. Imhoff tanks

f. Primary clarifiers

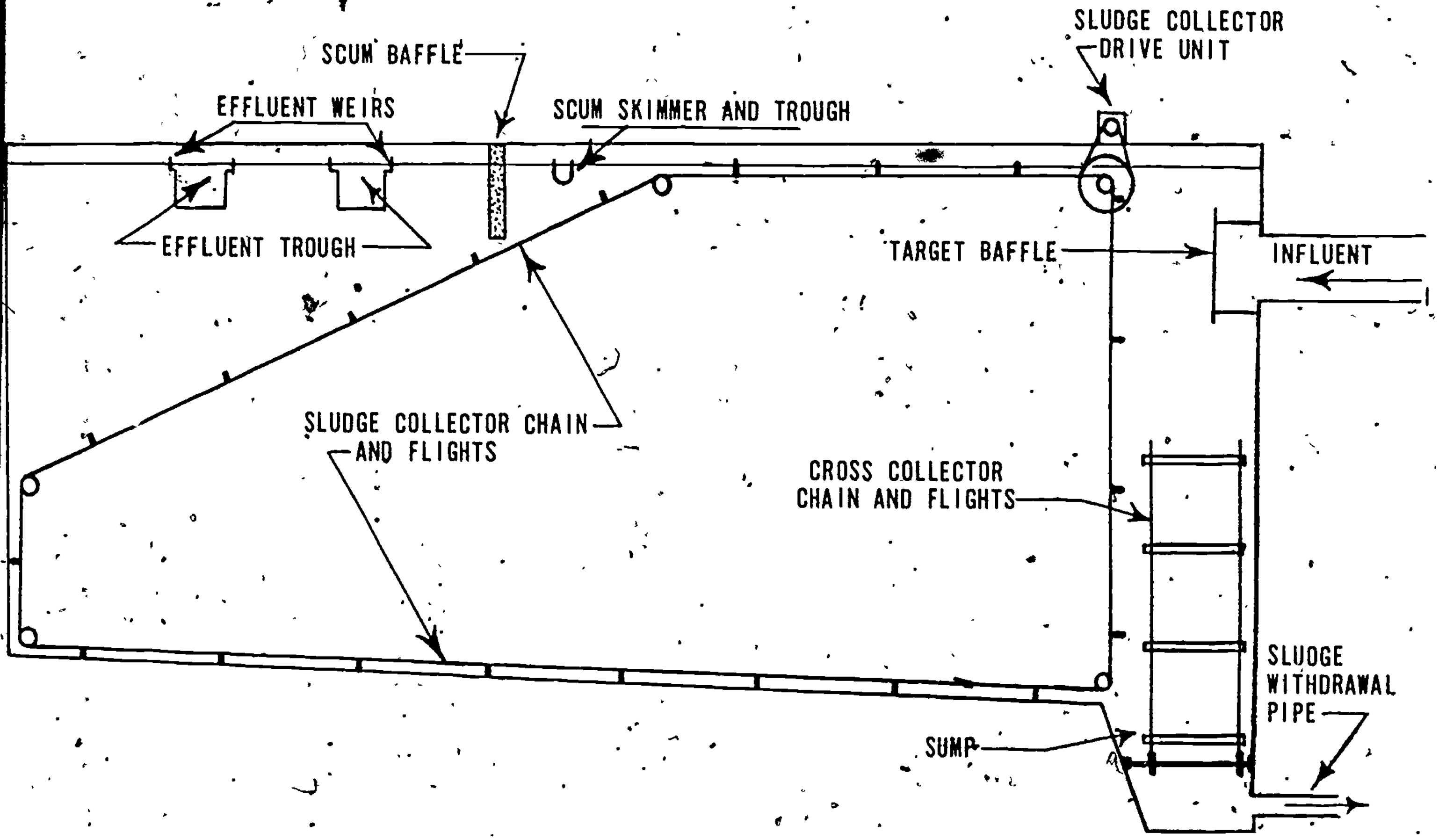
g. Secondary clarifiers

h. Post chemical addition

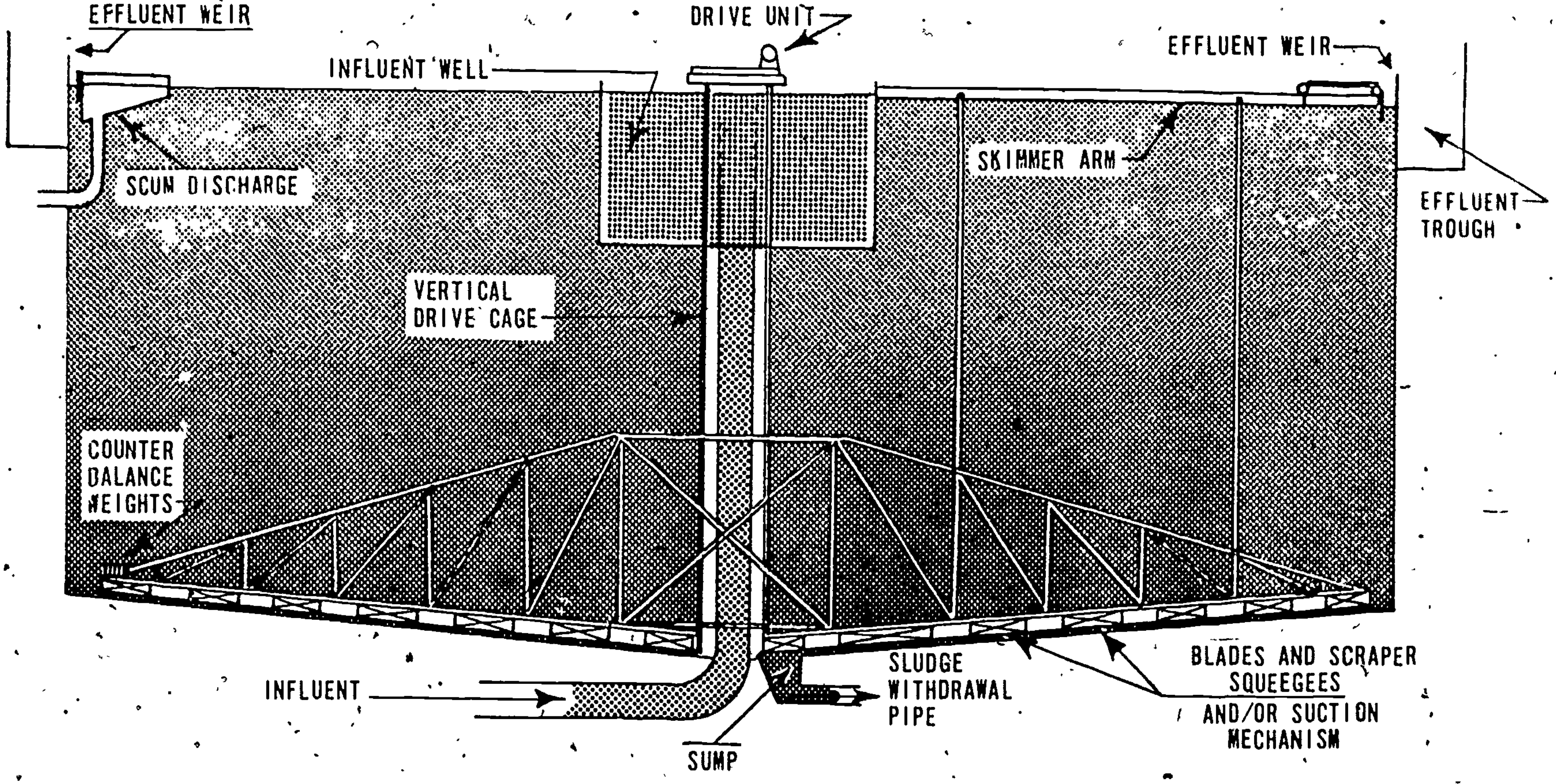
The principle of the sedimentation process is to

a. Slow the velocity of flow to below 2 ft/sec.

b. Coagulate the suspended solids to larger particles for ease of settling.



Rectangular sedimentation basin



Circular clarifier

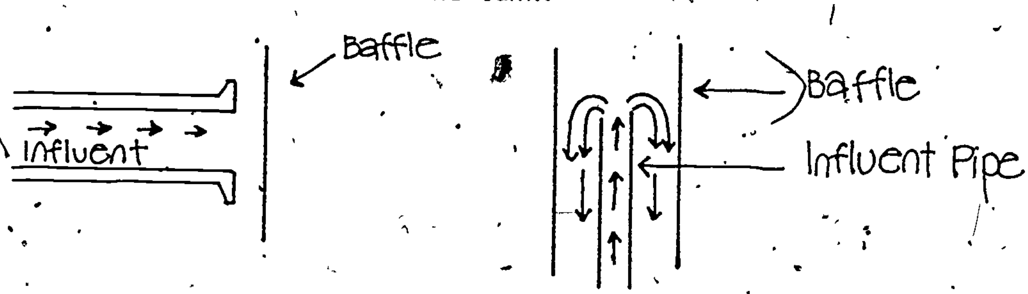
PRIMARY AND SECONDARY SEDIMINTATION UNITS

Sedimentation units vary in shape, size and types of components. The two basic shapes are:

1. Rectangular -- see diagram
2. Circular -- see diagram

The following is a description of functions of components that are sometimes parts of sedimentation units.

1. BAFFLES- Baffles are made up of wood or steel. The function of the baffle close to the inlet pipe to the clarifier is to retard the velocity of the flow into the clarifier and reduce the turbulence due to the mixing of the water in the tank and the flow being introduced to the clarifier. Baffles also can be used to guide the solids to the bottom of the tank.



Baffles placed at the end of the clarifiers provide a barrier between the matter that floats and the discharge wire or pipe. Normally baffles are positioned where a portion of it is above the surface of the water and the rest is below the surface of the water.

2. CHAIN - A chain in clarifiers provide the path for continous movement in collecting the sludge to a central removal unit and also to collect the solids that float for removal.

Chains are also used to transfer motion from one pulley (sproketed) to another.

3. DRIVE MOTOR - An electric motor that will provide the power to operate the sludge or scum collection systems or any component that needs power to function.

4. FLIGHTS - Are sections of lumber that are attached between two parralel operating chairs. These flights provide the mechanism to push the sludge to a central location for removal.

5. GEAR BOX - A component used to transfer the direction of the power. Example, a horizontal motor used to drive a vertical shaft uses a gear box for such operation. Gear boxes are also used to (mainly) decrease the revolution which the motor shaft rotates at, to very slow RPM that is necessary to operate the sludge collection mechanism. Gears also are used to increase the available power generated by the motor.

6. GREASE PIT - A grease pit is a component where scum removed from the clarifiers is stored for disposal.

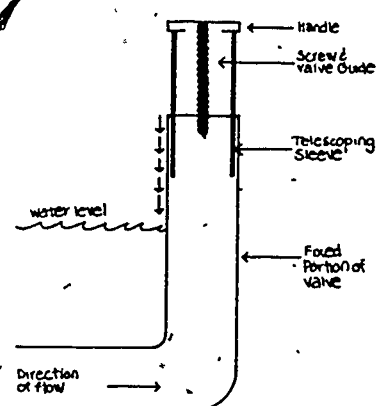
7. INFLUENT GATE - This component provides the methods of allowing the flow to enter the clarifier. This component is usually a pipe that either is placed in the middle or at the edge of the clarifier depending on the shape of the unit.

8. PIPING - The basic piping in a clarifier is used to provide
   a. Influent - Effluent flow
   b. Scum removal
   c. Sludge removal
9. PUMPS - Pumps that are part of clarifiers are usually positive displacement types. The sludge being removed using the pump is high in solids (3% - 8% total solids content) and many times fiberous that needs special handling.
10. RAIL - Rails are safety components used around walkway, edges, and sludge or grease pits. It is very important to see that such retainers are present and installed.
11. SHAFT - Are components used in extending the power generated by the motor to the sprokets or sludge collection system, or pump.
12. SHOE - Is a component attached to the bottom of flights that is used to provide smoother movement of the flights across the bottom of the clarifier. The shoe also will be the component that will wear out first rather than the expensive flights.
13. SKIMMER ARM - This is a component that is used to collect the material that floats (scum) to the surface of the clarifier. If the clarifier is rectangular in shape the sludge flights and skimmer arms usually are the same units. See diagram of circular and rectangular clarifier.
14. SKIMMER TROUGH - This is a component that will remove the collected floating material (scum) from the surface to the grease pit by allowing the skimmer arm to deposit the scum in it (the trough)

15. SLUDGE WELL - This is a component that is the central area where the sludge collectors "move" the sludge to for removal from the clarifier. If the clarifier does not have sludge collectors, the design will allow the sludge to be deposited in the sludge well. Sludge wells are shown as sludge pump.

16. SPROCKETS - They are components that rotate on a shaft that makes the chain with flights move through the clarifier.

17. TELESCOPIC VALVE - A valve that has the discharge end capable of moving vertically below the horizontal plane of the surface of the water. This type of valve allows the withdrawal of sludge evenly and uniformly.



Telescoping Valve

18. WEIR - Weirs are the units where the water leaves the clarifier. Weirs come in different types and shapes.

OPERATING SEDIMENTATION units is to make sure that all components are functioning and that the effluent from the unit contains the least amount of solids.

Normal operation takes into account the design specifications, routine lab tests. Typical primary clarifiers remove

Settleable solids	90 - 95%
Suspended solids	40 - 60%
Total solids	10 - 15%
Biochemical oxygen demand	25 - 35%
Bacteria	25 - 75%

Typical design specifications are

Detention time	2 hrs. - 4 hrs.
Surface settling rates	600 GPD/ft^2
Weir overflow rate	10 - 15,000 GPD/ft.

There are exceptions to the above specifications. It is important that operators know the design factors for the units they operate.

Operation of flights and sludge collection units

Flights and sludge collection units should not be operated at high speed. This could cause turbulence and the quality of sludge to be poor. The units should operate at the slowest speed possible without the possibility of stalling.

Sludge collection units that have stalled should have the cause determined immediately and corrected.

A good visual observation in regards to the function of sludge collection units is the operation of the scum skimmer. Since most scum skimmers are mechanically attached to or are the flights of the sludge collection unit then one can observe the proper speed and uniformity of operation. To function effectively scum skimmers should:

a. In circular tanks barely touch the surface.

b. In rectangular tanks the flights should rise sufficiently above the surface of the water to cause a skimming effect. Any excessive drop by the flights upon the surface causes turbulence.

SLUDGE REMOVAL

Removing sludge from a clarifier is the primary function of an operator. Since most sludges are removed to another

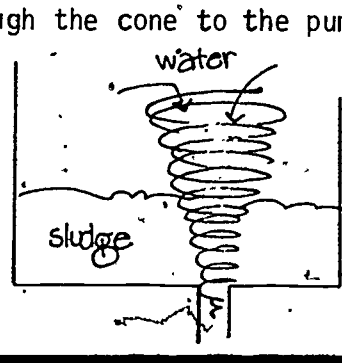
a. Anerobic digesters

b. Aerobic digesters

c. Drying beds

d. Incinerators

the sludge drawn should be a thick sludge with a total solid content of 3 to 8%. That is for every 100 gallons of sludge 3 to 8 gallons should be solids. Some pumps may not be able to handle a thick sludge. Then refer to manufacturers specifications. Normal operation of clarifiers is to withdraw sludge in a slow and uniform rate. By withdrawing sludge at an excessive rate CONNING will take place. CONNING is an effect where the solids form the shape of a cone and allow water or the top thin layer to flow through the cone to the pump.



REMEMBER withdraw the thickest sludge that can be pumped.

By providing too long a detention time for the sludge in a clarifier the process of decomposition will be observed.

a. Change in pH

b. Odors

c. Gases which could accumulate especially indoors and cause dangerous conditions.

d. Sludge floating on the surface caused by gas trapped in the sludge making the solids buoyant.

By allowing the process of decomposition to take place in the clarifier or by pumping thin sludge defeats the purpose of the clarifiers.

Remember that clarifiers are units used to separate solids from water and not to digest or decompose the solids.

The rate and volume of sludge drawn is

a. Set by automatic timers.

b. Set by experience an operator obtains.

Experience is obtained by relating

1. Total solids tests
2. Pressure gauge reading on the discharge side. Thicker sludge gives a higher gauge reading.
3. Sound of the sludge pump. As the density of the sludge changes, the sludge pump will give off a different sound.
4. Visual observation by pumping into a hopper or a sight glass in the sludge line.

5. Obtaining samples at intervals during pumping for visual observations. Many operators neglect the use of sampling ports in sludge lines. If a unit does not have one, install one and use it.
6. Centrifuge. This is a fast and reliable test that will compare the volume of water to the volume of sludge.

By relating laboratory tests (suspended solids, total solids, specific gravity, centrifuge) to visual observation, volume of sludge pumped, and volume of flow one can gain experience in pumping a thick consistent sludge.

Normal operation of a clarifier is also to provide a daily routine in "housekeeping". Housekeeping is to

a. Clean the inlet pipe or sluice gate using a brush and water.
b. Clean the influent weir and baffle using a brush and water.
c. Clean the effluent weir and baffle using a brush and water.
d. Clean the scum trough and skimmer using a brush and water.
e. Clean the effluent trough using a brush and water.
f. Clean the grease pit using a brush and water.
g. After withdrawing sludge, if possible pass clear water through the pipes. This avoids any solid buildup in the pipes. This can be accomplished by pumping some of the water in the clarifier.

Keeping weirs, baffles and pipes clean not only provides a better atmosphere and environment but also discourages any excess growth of algae, filamentous and sewer buildup.

Under certain conditions such as

a. Industrial flows

b. Excessive flows

c. Turbid influent

it may be necessary to take extra measures in keeping with the efficiency of the clarifier. These steps may be

a. Direct flow to a holding tank if possible.

b. The addition of chemicals such as polymers, lime, ferric chloride ($Fe\ Cl_3$).

Chemical addition should be monitored very carefully. Too high a concentration could provide problems in the stages of process after clarification and also is a waste of money.

SAMPLING

There are three main areas that a sample for testing is needed to be able to determine the performance of the clarifier.

1. INFLUENT. The influent sample to a sedimentation unit should be the influent flow to the process.
   a. Water treatment chemical addition for sedimentation or softening. The influent sample is the raw water before flash mixing.
   b. Primary treatment. The influent is the flow before it enters and mixes in the clarifier.
   c. Secondary treatment. Trickling filters, activated sludge, rotating biological filters, oxidation ditches, the influent is the flow that enters the process not just the clarifier.
   d. Waste stabilization ponds (lagoons). The influent flow is the flow that enters the lagoon.

2. EFFLUENT. The effluent sample of a sedimentation unit is the flow that leaves the unit. Usually there is a single discharge point from the unit from where the effluent sample should be drawn. Influent and effluent samples should be taken.

   a. Grab. Grab samples are single samples taken for analysis. The results are indicative of the flow at the time the sample was taken. Grab samples should be taken at regular intervals and where conditions warrant such samples. Ex. industrial flows, high flows.

   b. Composite samples. Composite samples are grab samples that are combined together to make a single sample. A 24 hour composite usually means a grab sample taken every 2 hours. An 8 hour composite usually means a grab sample taken every hour or every 2 hours. Operators can also set the frequency of sampling depending on their flow. PROPER RECORDS OF AMOUNT AND FREQUENCY SHOULD BE KEPT. Sample compositing depends on the flow rate at the time of sampling and the total volume of sample needed to complete the tests.

SLUDGE

Sludge is the solids that have settled to the bottom of the sedimentation units. Sampling should be done when the sludge being withdrawn is at its maximum solid content. The usual point of sampling is at the discharge end of a pump.

When withdrawing a sample through a pipe and a valve always allow some flow to be wasted before collecting the sample. This action will clear the lines and provide a better representation of the flow.

When sampling directly from the flow using a container make sure that the container is clean. The routine lab tests performed on sedimentation units are

a. Influent and effluent. Depending upon the process and treatment units before and after the clarifiers the routine lab tests performed are

   1. BOD or COD. Especially useful for aid in loading determination of secondary biological processes.

   2. Chlorine residual. Water process and wastewater process usually allow a maximum total chlorine residual in process flows. If the maximum is surpassed the cost for treatment rises.

   3. Hydrogen sulfide. Hydrogen sulfide (H_2S) is a dangerous gas generated due to the decomposition of sulfur containing organic matter. It is a prime chemical that combines with chlorine. A high concentration is not only dangerous especially in enclosed areas but also the odor level is increased.

   4. Floating material. Floating material especially in effluent samples indicate

      a. The flow through the unit is too fast.

      b. Short circuiting taking place.

      c. Skimmer is not working properly.

      d. Baffles in the clarifier are below the surface and therefore allow floating matter to flow over the weir.

The Federal and State regulations explicitly indicate in their permits that "no floating material should be present in discharge flows".

5. ODOR. Constant bad odor is an indication of poor housekeeping.
6. OIL AND GREASE. The rise in level of oil and grease in an influent sample is an indication of an industrial contributor to the flow.
   a. Food processing
   b. Meat processing
   c. Machine maintenance operations

   Oil and grease is a detriment to a system. It provides extra operational problems such as grease balls. They have to be removed. They tend to plug lines, pumps and valves. They allow grit to not only become buoyant but hard to remove and maintain. Oil and grease contribute to excessive odors. The build up of oil and grease against baffles, scum removal units and weirs causes additional time necessary in cleaning.
7. pH. In treatment processes a range in pH is tolerable. It is preferred to maintain a constant pH but since it is costly, a pH range is the next step. Certain biological systems cannot maintain proper activity at high or low pH's.

   A drastic change in pH in influent samples is an indication of industrial discharge and should be located and corrected. A low pH deteriorates pipes, valves, pumps, tanks and other components. A high pH usually forms deposits on unit components causing excessive problems in repair, maintenance and component performance.

8. TEMPERATURE. The change in temperature in the sedimentation units contribute:

   a. The increase or decrease of the viscosity of water in turn increases or decreases the settling rate of solids.

      REMEMBER cold temperatur higher viscosity lower settling rate.

   b. The introduction without proper mixing of two liquids with different temperatures, leads to stratification. Stratification is when there are two layers or more of liquid in the same container such as oil and water. Placing cold water in with warm water allows the cold to "settle" to the bottom. Placing warm water in with cold water allows the warm water to "float" to the top. By causing stratification there will be a good possibility of short circuiting. Short circuiting is when velocity in a clarifier is greater in some areas then another which causes poor settling.

9. SETTLEABLE SOLIDS. Settleable solids tests provide a quick visual observation of rate or settleability of solids; the amount of solids settled, the composition of the sludge and the visual quality of the water.

10. TOTAL SUSPENDED SOLIDS. This test will indicate the amount of suspended matter in the flow. Design of plants takes into consideration the suspended solids concentration in the influent, and the amount removed by sedimentation process.

11. TOTAL SOLIDS. A test indicating the total solids in the flow. Total solids is composed of suspended solids and dissolved solids.

12. TURBIDITY. A test indicating the amount of fine suspended matter in water. A very practical test that can be used in treated wastewater systems.

The most common tests for sludges are:

1. TOTAL SOLIDS. This test will indicate the % of solids in a sludge sample. Remember that the thickest sludge that can be pumped should be removed from the sedimentation units.
2. TOTAL VOLATILE SOLIDS. This test will indicate the amount of organic matter available in the sludge for decomposition. By comparing the volatile solids with fixed solids one can conclude
   a. Pretreatment in efficiency. Too high a fixed solids for example indicates a high velocity through the grit chamber, and too high an infiltration.
   b. Possible infiltration.
   c. Possible misuse of sanitary sewers by industrial users i.e. grit basins not cleaned in car washes, truck washes etc.
   d. Possible excessive matter in surface water sources which cause taste and odor, increased frequency for filter clogging, and possible interference in flocculation processes.
3. OIL AND GREASE. Oil and grease in sludges provide problems in decomposition of sludge especially in anaerobic digestion processes.

   Many treatment plants are designed "indoors". That is units are covered. This covering provides excellent opportunity for dangerous gases to build up. Gas such as
   a. Hydrogen sulfide, a very dangerous gas. Though H_2S has a definite odor after while one loses the sense to smell the

odor and provides unsafe working environment. One should test for H_2S gas in enclosed units, wet wells, dry wells, sludge pits, grease pits, pump houses and any area that is not ventilated or where a possibility of H_2S accumulating.

b. Methane, a very dangerous gas from two points.

1. Methane mixed with air at 5 - 15% by volume if ignited will explode.

2. Methane gas will displace oxygen and cause suffocation.

Tests for gases are performed by use of special equipment (easy to operate) for individual gases and also an oxygen deficiency indicator.

CLARIFIER PERFORMANCE depends upon design criteria established by the designer. Each type of process and shape of clarifier will have a range of design criteria. Operation of these units should be with the range set unless determined that a new range provides a better performance.

The main indication of proper operation is the efficiency. Efficiency is defined as how well a clarifier or process removes the pollutants it is designed to remove. The formula is:

$$\frac{\text{Influent} - \text{Effluent}}{\text{Influent}} \times 100$$

The formula is used for any parameter that needs removal from the stream, such as BOD, suspended solids, turbidity, settleable solids.

Example

Tests indicate a influent flow to a clarifier contains 263 mg/l of suspended solids. The effluent flow from the clarifier contains 123 mg/l of suspended solids. Calculate the efficiency.

Solution

$$\frac{\text{Influent} - \text{Effluent}}{\text{Influent}} \times 100$$

$$\frac{(263 - 123)}{263} \times 100$$

= 53.2% of suspended solids was removed by the clarifier.

Design criteria of

a. Detention time

b. Surface settling rate

c. Weir overflow rate

are guidelines an operator should meet. They are easier to calculate for than determining through lab tests the performance of the unit. By having a higher detention time the percent removal is higher. By having the surface settling rate and/or weir overflow higher the percent removal is lower. REMEMBER THAT THE ULTIMATE GUIDELINE IS THE HIGHEST PERCENT REMOVAL ONE CAN ACHIEVE WITHOUT CAUSING PROBLEMS.

Detention time is calculated by using the formula

$$DT = \frac{\text{Volume of clarifier}}{\text{Flow Rate}}$$

Where DT is in units of time

Volume of clarifier is in gallons or cubic feet.

Flow rate is in gallons or cubic feet per unit time (sec., min., hrs., days).

If the detention time rises and no problems arise then no adjustment is necessary. But if adjustment is necessary DT too low or too high then by adjusting the flow rate will provide the ~~necessary~~ correction for detention time.

The larger the flow rate the less the detention time.

The smaller the flow rate the higher the detention time.

Example

The volume of a clarifier is 32,000 gallons. What is the detention time in hours if the flow rate is 307,200 gallons per day.

Solution

$$DT = \frac{\text{Volume}}{\text{Flow Rate}}$$

$$= \frac{32,000}{307,200}$$

$$= 0.104 \text{ days}$$

Since the answer should be in hours and 24 hours = 1 day, then

0.104 = 2.5 hours

Surface settling rate is calculated by using the formula

$$SSR = \frac{Q}{SA}$$

SSR = Surface settling rate usually has a unit value of GPD/ft^2

Q = Flow rate in GPD

SA = Surface area of clarifier in ft^2.

Example

A clarifier has a surface area of 6,000 sq. ft^2. The flow rate applied to the clarifier is 4,500,000 GPD. What is the SSR?

Solution

$$SSR = \frac{Q}{SA}$$

$$= \frac{4,500,000}{6,000}$$

$$= 750 \text{ GPD/ft}^2$$

Weir overflow rate is calculated using the formula

$$WOR = \frac{Q}{WL}$$

WOR = Weir overflow rate in GPD/ft.

Q = Flow Rate in GPD

WL = Weir length in ft.

Example

A circular clarifier with a weir diameter of 94 ft. and a flow rate of 4.5 MGD. Calculate the weir overflow rate.

Solution

$$WOR = \frac{Q}{WL}$$

$$= \frac{4,500,000}{3.14 \times 94}$$

$$= 15,246 \text{ GPD/ft.}$$

In calculating for the % total solids and total volatile solids, laboratory experiments are necessary.

- TOTAL SOLIDS
  - Suspended Solids
    - Fixed Solids
    - Volatile Solids
  - Dissolved Solids
    - Fixed Solids
    - Volatile Solids

- TOTAL SOLIDS
  - Fixed Solids
  - Volatile Solids

TOTAL SOLIDS is defined as all solids present in water/wastewater flows, be they dissolved or undissolved.

SUSPENDED SOLIDS is defined as the solids present in water/wastewater flows that are undissolved and that will not pass through a glass fiber filter.

VOLATILE SOLIDS is defined as the solids present in water/wastewater flows that are capable of being burned at a maximum temperature of 600° C. Volatile solids are solids that decompose to bacterial action.

FIXED SOLIDS is defined as the residue solids after burning at 600° C. They are the solids that do not decompose easily due to bacterial action.

Remember, to make adjustment in operation the most flexible adjustment is the pumping rate. By slowing down the pumping rate one can change SSR, WOR, DT and therefore influence % removal.

RECORD KEEPING

It is important to maintain routine records not only on lab results but also on plant operation.

An operator should develop records pertaining to:

a. Type of component to include manufacturer, supplier, model number, date purchased, date placed into service.

b. Type of lubricant used by the component and what substitute can be used.

c. If it is an electric motor the original amperage drawn by the motor and motor + pump, motor + drive mechanism.

d. Routine maintenance performed on components.

e. Date and length of time component is out of service.

f. Any pertinent information necessary to maintain units and components.

Record keeping aids the operator in completing his work efficiently. It reduces wasted time trying to find the information necessary to repair the units. It provides the flexibility necessary by operators knowing about all facets of plant operation. That is no one person keeps the information and knowledges in their "heads".

START UP

In starting up a clarifier an operator should before allowing any water to flow into the unit:

a. Become familiar with the positions of the components that will be below water. A good way of recording such information is to take photographs wide shots and closeups.

b. Remove all debris in the clarifier, ports, pipe wells, pipe outlets, sludge sumps.

c. Make sure that chains, sprockets are in the proper position.

d. If the sludge collector has squeegee blades or flights that they are properly aligned and positioned from the floor of the tank and are free and not stuck to the bottom.

e. All valves are functioning smoothly.

f. While the unit is still empty, turn the mechanism on and let is make several revolutions. Check for smooth operation. Remember, some units have water lubricated bearings. Make sure that the bearings are lubricated.

g. If the sludge collector has flights make sure that they are operating correctly and are not askew, & that clearances from the walls are met.

SHUTDOWN

In shutting down a clarifier, the operator should take into consideration the anticipated length of time the unit is out of service. It may be wise to make repairs ahead of schedule if the unit is being put out of service for a few days. Example: A clarifier is being drained for repair of broken and jammed flights. One should schedule an inspection of chain and sprockets or any component even though the routine schedule is scheduled for a month later.

The procedure to shut down a clarifier is to:

a. Shut off or divert all flows from the unit.

b. Turn off all electric power to components of the unit.

c. Start draining the unit. Remember a sedimentation unit contains a large volume of water which will have to be disposed of.

d. As the draining process is going on wash and scrub all components above the water level. This prevents any drying and hardening of solids, grit, sludge and grease to the components which will reduce the cleanup time later.

e. Make sure that flights and squeeges are remained wet if the unit is not going to be out of service a long time.

f. If the unit is out of service for a long time remove the flights and protect them from drying up. Store in a damp place.

g. Any exposed metal should either be re-painted or coated with oil or grease to stop any oxidation (rusting) taking place.

h. Photograph and record any damage to components. This will provide a better understanding of unit operation and length of operation of each component. This also could provide information of next possible repair or problem area.

PREVENTIVE MAINTENANCE

The primary function of the operator is to keep the plant operating correctly which in turn will provide the "environment" to remove pollutants from the water.

To correctly operate the plant one has to consider preventive maintenance (PM). PM is defined as reducing the possibility of major repair.

Preventive maintenance takes into consideration:

a. Cleaning
b. Lubricating
c. Mechanical adjustment
d. Painting
e. Replacement of worn components
f. Wear measurement

CLEANING. An operator should clean all components especially components that are above the water surface.

The best help an operator has in cleaning is a water hose and brush.

1. Baffles - The baffles in a sedimentation unit should be cleaned regularly by hosing down the unit, and any hard "caked" material removed with a scraper or brush. Do not allow material and growths to accumulate on the baffles. They are unsightly and cause problems by making removal of nuts and bolts more difficult.
2. Chains - Chains should be kept clean, free of dirt and solids build up if the unit is not the type that is lubricated a simple rinsing removes the solids. If not removed a brush will come in handy.
3. Drive Motor - To clean the motor turn off the area around the motor should be cleaned. DO NOT SPRAY ANY WATER ONTO THE MOTOR. Use a damp rag to remove any solids accumulated. If any lubricant has adhered to the motor, clean it up using:
   a. Rags
   b. Solvent after most of the lubricant is removed.
4. Flights - Flights that surface and are also used as scum skimmers should be cleaned. This cleaning will provide a better visual observation of the conditions of the flights.
5. Gear Box - The gear boxes should be cleaned. Use a damp rag to remove solids. Use rags to remove excess lubricant. You may have to use solvents. Make sure that a limited amount is used. Do not use excess solvents.

6. Grease Pit - Grease pits should periodically be drained and cleaned using hot soapy water and for hard to remove grease, a brush.
7. Pump - Turn off the power to the motor. Pumps should be cleaned using a damp rag. If there is a need to use solvents to remove any grease do not use an excess of solvent. Make sure that the hard to get places are also cleaned.
8. Rails - By cleaning hand rails and guard rails the plants will look better and provide a cleaner and healthier environment to work in.
9. Skimmer and Skimmer Trough - Use a hose to remove any solids build up. This will provide ease of scum removal. Since scum is mainly grease, you may have to use hot water. Turn off the power to the skimmer if brushing and scraping has to be done.
10. Sludge Well - After pumping of sludge make sure that the well is cleaned and rinsed with water. This will reduce odor, flies and solid buildup.
11. Sluice Gate - Clean the gate using water. By allowing solids to build up against the seal of the face plate or gate guides, the closing and openings of the gate will be difficult.
12. Telescopic Valve - Clean the valve using water. Do not allow the sludge to remain on the outside of the valve. If the sludge dries, the movement of the valve will be difficult.
13. Weir - Clean the weirs of any solids and biological growths. Use a brush or broom if necessary.

LUBRICATION. Lubrication of any component depends upon the manufacturer's specifications. Do not over lubricate the components.

Use safety practices where lubricating. Example: When lubricating a chain do not apply the lubricant while the chain is in motion. Turn the power off and then apply the lubricant. Most units should be lubricated while the unit or component is NOT in motion.

MECHANICAL ADJUSTMENT. Mechanical adjustments are a very strong part of preventive maintenance.

1. Baffles - should be adjusted to provide the proper retention of floating material and/or directing the downward flow of solids. Baffles should be raised or lowered to stop the escape of solids to the effluent.
2. Chains - Chains should be inspected for free movement of the links. It should be adjusted to provide minimum slack. Remember that too tight a chain will cause problems too. If the chains are used to move the flights for sludge collection an indication of the need of adjustment for slackness is when the flights that surface for skimming remain below the surface assuming the water level has not changed.

   Too tight a chain and the unit will strain. This tightness can be observed by the rigidity of the chain. A properly adjusted chain should have some give.
3. Drive Motor - A drive motor can be adjusted to be aligned with the gear box or pulley or pump shaft. The indication that a drive motor may need alignment is a wobbly shaft or excessive vibration.

4. Flights - Flights should not rub against the walls of the unit. All flights should be parallel to each other.
5. Gear Box - The gear box should be aligned with the motor and drive shaft. An operator should make sure that such units (motor, gear boxes etc.) should remain aligned or else excessive wear of shafts, sleeves and/or gears will happen.
6. Pumps - Pumps are adjusted for:
   a. Alignment with drive motor
   b. Seal water rate of flow
   c. Impeller clearance.
   d. Volume of sludge per stroke using a positive displacement pump.
7. Shaft - Shafts are adjusted by making sure that they are aligned with drive mechanisms. Also the rotational path is circular and not eliptical, that is there is no wobble in the shaft as it rotates.
8. Sludge Collection Units - Squeeges are adjusted for distance from the floor of the clarifier. The sludge collection mechanism (flights or rails) are balanced. A drag by one side will cause stalls or excessive wear.
9. Skimmer Arm - The arm is adjusted to skim the surface and not drag below the water surface. Adjustment of arm is also done if the mechanism stalls at the skimmer trough.
10. Sprockets - The sprockets are adjusted for:
   a. Wobbliness
   b. Increasing or decreasing the slack in the chain

11. Time Clock - If any unit operates due to a pre-set time clock, such clocks can be adjusted to increase or decrease the frequency of operation. That is, suppose the sludge pump operates from a timer to operate 5 minutes every 30 minutes. This rate may be too slow, since one notices sludge floats, then the frequency or rate of operation should be increased to 7 minutes every 30 minutes or 5 minutes every 20 minutes.
12. Valves - Valves are adjusted to allow more flow (fully open) to less flow (partially open). Adjustment is also done on valves that do not seat properly. That is they allow leakage when fully closed.
13. Weir - By raising or lowering adjustable weirs, the depth of the clarifier is changed. Therefore the design factors of detention time is changed. Weir adjustment is necessary when the weir overflow rate is not uniform across the whole length of the weir. This misalignment will cause short circuiting, and hydraulic overloading upon the weir and poor settling of solids.

PAINTING. Painting is one of the most important PM done by an operator. High humidity and corrosive gases can increase the rate of plant deterioration. Painting surfaces such as:

1. Drive motors (casing)
2. Gear boxes
3. Piping (color coded)
4. Pumps
5. Rails

Do NOT paint over name plates and numbers. If possible, do not paint over nuts and bolts and screws, especially the threads. Removal of hardened paint is very difficult. If nuts and bolts and screws have to be painted, apply a light coat and if re-painting is needed to remove the old paint and apply a new coat. Keep the paint on such components one layer thick.

Painting components that will be in contact with water continuously should be painted with epoxy paint. Mix only what will be used.

REPLACEMENT. Replacement should be done of components indicating wear or that have malfunctioned and which cannot be repaired. In some cases it may be cheaper to replace a unit rather than repair it. Take into consideration man hours, repair tools and material.

Replacement of components such as:

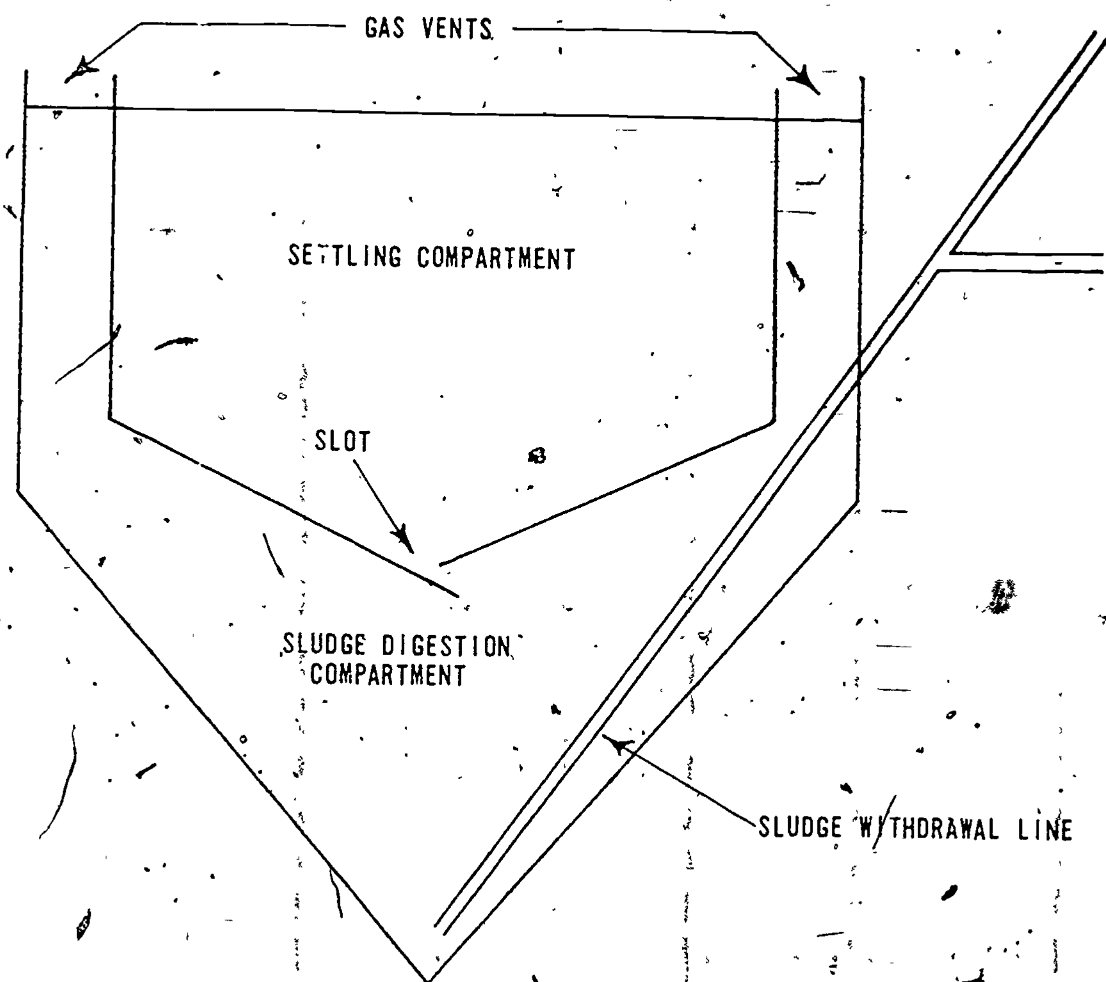
1. Baffles that have corroded.
2. Chains that are worn or broken.
3. Fire-fighting equipment that are corroded and deteriorated.
4. First aid kits that have dated material.
5. Flights that are worn or broken.
6. Pumps
7. Shear pins that are worn, broken, or have been used several times.
8. Shoes on flights that are worn, loose or broken.
9. Sprockets that are broken.
10. Squeeges that are worn.

WEAR MEASUREMENT. Wear Measurement of components is important. This is why it is essential to know the original measurement of the components. If no such record exists then start a set even though the unit has been in service. This will give a starting point.

Wear measurements are done on such components as:

1. Chains
2. Drive Motors - The amperage it is drawing - a change from the original amperage indicates a change in durrent drawn on which translates to money.
3. Flights/sludge collection units - a change in this component indicates either a drag upon the drive mechanism or an improper sludge collection.
4. Pump wear measurement of pumps usually are done upon shafts or sleeves, impellers and pistons and piston walls.
5. Shoe - wear measurement should be done on random numbers of shoes in the clarifier. A high rate of wear indicates an excessive drag by the flights and chain.
6. Skimmer arm - the wear is usually upon the guides of the skimmer trough and the skimmer arm. These components need constant attention.
7. Sprockets - the wear on the sprockets could cause the teeth to break off which could cause improper movement of the chain.

Any moving part that makes contact with metal, concrete or even wood should be checked for wear. A record of the observation or wear determination should be kept and reviewed. Such review could provide advance warning of possible breakdowns and interruption in operation.


GAS VENTS
SETTLING COMPARTMENT
SLOT
SLUDGE DIGESTION
COMPARTMENT
SLUDGE WITHDRAWAL LINE

Imhoff tank

IMHOFF TANKS

Imhoff tanks are units that incorporate two principles of waste treatment:

1. Sedimentation and
2. Sludge digestion

The shape and design of Imhoff tanks vary. It may be circular or rectangular or have a single or double sludge digestion compartment. The sludge may be removed mechanically (usina a pump) or manually. However the shape or size of Imhoff tanks have these basic sections:

1. Settling compartment
2. Sludge digestion compartment
3. Gas vents
4. Sludge draw-off line

SETTLING COMPARTMENT - In this compartment the process of settling takes place. Settling is a physical process that separates the solids from the water which they are suspended in. The separation is due to the force of gravity that is acting upon the solids. The flow containing the solids has a velocity over 2 ft/sec. and by slowing the flow to below 0.8 ft/sec. the solids will begin to settle.

The influent to the settling compartment is controlled by the INFLUENT BAFFLE. Influent baffles in Imhoff tanks provide the barrier needed to:

a. Slow the water
b. Stop the turbulent mixing of water in the tank and water being added to the tank.

c. Direct the settling solids to the bottom of the compartment.

There is also an EFFLUENT BAFFLE. This baffle provides a barrier between the oil, grease and floating material and the effluent weir.

The bottom of the settling compartment has a SLOT in it to cause the solids to fall through to the sludge digestion compartment. The slot is designed where one side overlaps the other with a space between them of approximately 8 inches. The overlaps in the slot is to prevent any solids that rise in the digestion compartment to re-enter the settling compartment.

Since the sludge is decomposed a by-product is methane gas. This gas if accumulated in quantity could be used as a source of power but in Imhoff tanks the amount of gas generated is not in large quantities to be useful but if allowed to build up in the tank could be a source of danger. To avoid the dangers of explosion GAS VENTS are built into the unit to allow any gas generated to be vented into the air.

Since the process of settling allows the water to be slowed down to cause the solids to settle, the process also causes any oil or grease to float to the surface. Also oil and grease floats to the surface of the gas vents. The oil and grease should be removed and disposed of properly (incineration or landfill for burial). The oil and grease sometimes stored in a unit known as a GREASE PIT.

PIPING in Imhoff tanks is used to provide:

a. Influent - effluent flow

b. Sludge removal

PUMPS are mainly used in Imhoff tanks systems to pump the influent flow from the wet well in the plant to the settling compartment, or to pump the effluent from the settling compartment to the next stage of treatment.

In some cases sludge is removed from the sludge digestion compartment using a pump but in most cases sludge is removed by gravity and the pressure exerted by the weight of water above the sludge.

Since there are open areas and edges in Imhoff tanks and that such areas are dangerous, then RAILS are used to provide the necessary safety in preventing someone from falling.

VALVES come in many shapes and styles. The most common used in Imhoff tanks are gate valves and telescopic valves.

WEIRS are components of the Imhoff tank at the end of the settling compartment where the effluent flows over to the next unit which could be:

a. Trickling filter

b. Stream - river

c. Sand filter

NORMAL OPERATION

Operation of an Imhoff tank is to make sure that the maximum amount of solids is removed. Imhoff tanks have no movable parts that an operator can maneuver except pumps and the valves.

The operation of an Imhoff tank is:

a. Making sure that the pumps are functioning correctly.

b. The removing of sludge disposal.

The removing of sludge from the digestion compartment should be done slowly. Spread over a period of time. Sludge withdrawn too fast causes the raw sludge to rise to the surface in the gas vents. If this happens dilute the sludge with water.

SAMPLING

To be able to determine the effectiveness of the Imhoff tanks, one should sample the:

a. Influent flow
b. Effluent flow and
c. The digested sludge

The influent flow should be sampled before any mixing in the tank takes place. The best point of sampling is on the discharge side of the pump. If the flow is gravity fed to the tank and there is no place of sample from in the influent side of the tank then one should sample the flow from the last manhole before the Imhoff tank.

The effluent sample should be taken after the flow is over the weir. The samples of digested sludge can be taken when sludge is being removed from the digestion compartment for disposal.

LABORATORY TESTS

Samples should be stored in proper containers. In most cases a plastic container is acceptable. The containers for storing samples for oil and grease should be glass.

The typical lab tests performed on samples from the influent and effluent are:

1. BIOCHEMICAL OXYGEN DEMAND (BOD) OR CHEMICAL OXYGEN DEMAND (COD)
   A test useful in determining the loadings upon secondary biological process.

2. CHLORINE RESIDUAL - This test is performed only on the chlorinated effluents in determining the maximum total chlorine residual in process flows.

3. FLOATING MATERIAL - Floating material in effluent samples could indicate:
   a. The flow through the settling compartment is too fast.
   b. Short circuiting is taking place.
   c. Baffles in the settling compartment are below the surface, therefore allow floating material to flow over the weir.

   Federal and State regulations explicitly indicate in their permits that "No floating material should be present in discharge flows".

4. ODOR - A test that mainly depends upon the small/sensitivity of the operator. An excessive odor indicates poor processes, bad housekeeping, or higher than normal sludge digestion.

5. OIL AND GREASE - The rise in the level of oil and grease in an influent sample is an indication of an industrial contributor to the flow such as:
   a. Food processing
   b. Meat processing
   c. Machine maintenance operation

   Oil and grease is a detriment to a system. It causes such problems as odor, plugging of lines, pumps and clogging of gas vents.

6. pH - A very simple test that could indicate an industrial discharge. A pH lower than 6.5 could cause a faster rate of deterioration of plant components. Very low pH or very high pH alters the biological activity of the microorganism in sludge digestion. It may even destroy the microorganisms and therefore halt the digestion process.

7. SETTLEABLE SOLIDS - A very simple test that provides a quick visual observation of rate of settleability of solids, the amount of solids settled, the composition of the sludge and the visual quality of the water (color and floating material).

8. TEMPERATURE - The change in temperature affects the sedimentation and digestion process. The increase or decrease of the viscosity of water in turn increases or decreases the settling rate of solids. Remember cold temperature   higher viscosity   lower settling rate.

The introduction without proper mixing of two liquids with different temperatures, leads to stratification. Stratification is when there are two layers or more of liquid in the same container such as water and oil. Placing cold water in with warm water allows the cold to "settle" to the bottom. Placing warm water in with cold water allows the warm water to "float" to the top. By causing stratification there will be a good possibility of short circuiting and therefore poor settling. Short circuiting is defined as the velocity in the settling compartment is greater in some areas than another.

9. TOTAL SUSPENDED SOLIDS - This test will indicate the amount of suspended matter in the flow.

10. TOTAL SOLIDS - This test will indicate the amount of total solids in the flow.

Tests conducted on sludge samples are:

Oil and Grease

Total Solids

Total Volatile Solids

Sludge analysis of Imhoff tanks can only indicate the condition of the sludge being withdrawn. It is difficult to determine the condition of the sludge in the sludge digestion compartment because of sampling difficulty and that the sludge is not being heated and mixed, therefore layers are formed and a representative sample cannot be taken.

There are two (2) basic gas tests that should be performed if the Imhoff tank is indoors.

1. HYDROGEN SULFIDE (H_2S) - A very distinct odor of rotten eggs indicates the presence of H_2S. It is a very dangerous gas that not only displaces oxygen but also is a poisonous gas. This gas has the capability of deadening the sense of smell after prolonged exposure to it which could cause the operator to feel secure.
2. METHANE - Methane gas (CH_7) is a dangerous gas if it accumulates and not only displaces oxygen but the right mixture of air and methane can cause explosions if ignited.

A simple oxygen deficiency test will indicate if the environment is unsafe to work in.

If the tank is indoors make sure that the ventilation system is working properly.

The operation of any Imhoff tank depends upon the design criteria that is established by the designer.

The main indication that the process is removing the maximum amount of solids is the efficiency criteria (percent removal).

The formula to use is

$$\frac{\text{Influent Concentration - Effluent Concentration}}{\text{Influent Concentration}} \times 100$$

or $\frac{\text{In - Out}}{\text{In}} \times 100$

Example

Determine the efficiency of an Imhoff tank if the suspended solids concentration is 165 mg/l and the effluent concentration is 85 mg/l.

Solution

$$\frac{\text{In - Out}}{\text{In}} \times 100$$

$$= \frac{165 - 85}{165} \times 100$$

$$= \frac{80}{165} \times 100$$

$$= 48.5\%$$

An Imhoff tank is built to basic specifications of:

a. Detention time

b. Surface settling rate

c. Weir overflow rate

These design criteria set by the designer are guidelines an operator should meet. It is easy to calculate these criteria. An operator should remember that the ultimate guideline for proper operation is the highest percent removal achieved without causing problems. To achieve a knowledge of performance efficiency one should try and alter the design criteria of the Imhoff tank.

Detention time is calculated by using the formula

$$DT = \frac{\text{Volume of settling compartment}}{\text{Flow Rate}}$$

Where DT is in units of time (hours, minutes or seconds)

Volume of settling compartment is in gallons or cubic feet.

Flow rate is in gallons or cubic feet per unit of time.

Ex. GPM or GPD.

The usual geometric shape of the settling compartment is a prism. Therefore, the formula to use is

Vol. of prism = ½ x h x b s L

h = Depth of the compartment

b = Width of the compartment

L = Length of the compartment

To change the detention time, the usual variable factors are

a. The depth of the compartment

b. The flow rate

If the tank has an adjustable weir by raising the weir the volume is increased and the detention time will increase. If the weir is not adjustable decreasing the flow increased detention time and increasing the flow decreases detention time.

Since the only variable for determining the surface settling rate (SSR) and weir overflow rate WOR is the flow rate, then calculating for SSR and/or WOR is very easy.

$$SSR = \frac{Q}{SA}$$

SSR = Surface settling rate in GPD/ft^2

Q = Flow rate in GPD

SA = Surface area in ft^2

$WOR = \frac{Q}{WL}$

WOR = Weir overflow rate in GPD/ft.

Q = Flow rate in GPD

WL = Weir length in ft.

Example

The volume of the settling compartment of an Imhoff tank is 450 gallons. What is the detention time if the flow is at a rate of 110 GPM?

Solution

$DT = \frac{Vol.}{Q}$

$= \frac{2450 \text{ Gal.}}{110 \text{ Gal. per minute}}$

= 86 Minutes

or = 1.4 hours

Example

The dimensions of the settling compartment of an Imhoff tank is 9 ft. wide, 8 ft. deep and 35 ft. long. Calculate the surface settling rate if the pump capacity is at 110 GPM. Answer in GPM/ft^2

Solution

$SSR = \frac{Q}{SA}$

$= \frac{110 \text{ GPM}}{8 \text{ ft.} \times 9 \text{ ft.}}$

$= 1.53 \text{ GPM/ft}^2$

Example

What is the weir overflow rate in an Imhoff tank 9 ft. wide (the weir length), 8 ft. deep and 35 ft. long if the flow rate is 110 GPM. Answer in GPM/ft.

Solution

$$WOR = \frac{Q}{WL}$$

$$= \frac{110 \text{ GPM}}{9 \text{ ft.}}$$

$$= 12.2 \text{ GPM/ft.}$$

In calculating for the % total solids and total volatile solids, laboratory experiments are necessary.

TOTAL SOLIDS

- Suspended Solids
  - Fixed Solids
  - Volatile Solids
- Dissolved Solids
  - Fixed Solids
  - Volatile Solids

TOTAL SOLIDS

- Fixed Solids
- Volatile Solids

TOTAL SOLIDS is defined as all solids present in water/wastewater flows, be they dissolved or undissolved.

SUSPENDED SOLIDS is defined as the solids present in water/wastewater flows that are undissolved and that will not pass through a glass fiber filter.

VOLATILE SOLIDS is defined as the solids present in water/wastewater flows that are capable of being burned at a maximum temperature of 600° C. Volatile solids are solids that decompose to bacterial action.

FIXED SOLIDS is defined as the residue solids after burning at 600^0 C. They are the soldis that do not decompose easily due to bacterial action.

Remember to make adjustment in operation the most flexible adjustment is the pumping rate. By slowing down the pumping rate one can change SSR, WOR, DT and therefore influence % removal.

An operator should develop records pertaining to:

a. Type of component to include manufacturer, supplier, model number, date purchased, date placed into service.

b. Type of lubricant used by the component and what substitute can be used.

c. If it is an electric motor the original amperage drawn by the motor and motor + plum, motor + drive mechanism.

d. Routine maintenance performed on components.

e. Date and length of time component is out of service.

f. Any pertinent information necessary to maintain units and components.

Record keeping aids the operator in completing his work efficiently. It reduces wasted time trying to find the information necessary to repair the units. It provides the flexibility necessary by operators knowing about all facets of plant operation. That is no one person should keep the information and knowledge in their "heads".

STARTUP

In starting up an Imhoff tank an operator should before allowing any wastewater to flow into the unit:

a. Become familiar with the positions of the components that will be below the water surface. A good way of recording such information is to take photographs - wide shot, closeups.

b. Remove all debris left behind during construction.

c. Make sure that all valves function properly.

d. Make sure that the sludge withdrawal line is not plugged. This can be accomplished by pouring water through the pipe.

SHUTDOWN

In shutting down an Imhoff tank the operator should take into consideration the anticipated length of time the unit is out of service. If the wastewater has to be by-passed, permission from the Department of Environmental Quality should be obtained.

The procedure for shutdown is to:

a. Shut off or divert all flows from the unit.

b. Start draining the unit using the sludge withdrawal line or an auxiliary pump. Remember the tank contains a large volume of water and solids that have to be disposed of properly.

c. As the draining process is going on, wash and scrub all components above the water level. This prevents any drying and hardening of solids, grit, sludge and grease which makes repair easier.

d. Any exposed metal or wood should be either re-painted or coated with oil or grease to stop any oxidation or deterioration taking place.

e. Photograph and record any damage to components. This will provide a better understanding of operation of the Imhoff tank and in keeping track of breakdown and repair of the components.

PREVENTIVE MAINTENANCE

The primary function of the operator is to keep the plant operating correctly which in turn will provide the "environment" to remove the pollutants from the water.

The operation of an Imhoff tank is mainly preventive maintenance. Preventive maintenance takes into account:

a. Cleaning.
b. Lubricating
c. Mechanical adjustment
d. Painting
e. Replacement of worn components
f. Wear measurement

CLEANING - An operator should clean all components. The best help an operator has in cleaning is a water hose and brush.

1. Baffles - Baffles should be cleaned regularly by hosing down and if need be by using a brush. Do not allow solids and biological growth to accumulate. Such growths are unsightly and make repairs more difficult.
2. Flow through Slot - In cleaning the slot one should drag a chain across each edge of the slot. Once a week is enough. This action will allow the solids to "slide" easier into the digestion compartment.
3. Gas Vents - The gas vents should be cleaned to allow the gas to escape rather than build up in the tank. Breakup or remove any oil and grease that is built up in the vents. Break up any sludge buildup.

4. Grease Pit - Grease pits should periodically be drained and cleaned with hot soapy water. For hard to remove grease, use a brush.
5. Influent Gate - A daily hosing and if need be use of a brush reduces solid buildup and therefore provides a smoother flow.
6. Piping - By keeping the piping clean a cleaner environment for one to work in.
7. Pump - Pumps and pump motor that are easily accessible should be cleaned regularly. Before cleaning, turn off the power. Pumps and motors should be cleaned using a damp rag. If there is a need to use solvents to remove any grease do not use any excess of solvent. Make sure that hard to get places are also cleaned. Dirt and grime accumulating on the pump and motor tend to allow heat buildup which reduces the efficiency of the units.
8. Rails - By cleaning hand rails and guard rails, the plant will look better and provide a cleaner and healthier environment to work in.
9. Valves - Clean the valves using water and if need be a brush. Do not allow solids to build up on the valves. Dried solids cause the turning of valves to be difficult.
10. Weirs - Clean the weirs of any solids and biological growths. Use a brush if necessary.

LUBRICATION - Lubrication of any component depends upon the manufacturer's specifications. Do not over lubricate the components.

MECHANICAL ADJUSTMENT - Mechanical adjustment in Imhoff tanks processes are very limited. Adjustment are done to:

1. Baffles - Baffles should be adjusted to provide the proper retention of floating material and/or directing the downward flow of solids. Baffles should be raised or lowered to stop the escape of solids to the effluent.
2. Pump - Pumps are adjusted for:
   a. Alignment with drive motor
   b. Seal water rate of flow
   c. Impeller clearance
   d. Volume of sludge per stroke using a positive displacement pump
3. Valves - Valves are adjusted to allow more flow (fully open or less flow partially open.
4. Weirs - By raising or lowering adjustable weirs, the depth of the settling compartment is changed which in turn changes the design factor of detention time. Weir adjustment is also done when the weir loading is not uniform across the weir. This weir misalignment will cause short circuiting, hydraulic overloading upon the weir and poor solid settling.

PAINTING - Painting is an important preventive maintenance done on especially metal components. High humidity and corrosive gases can increase the rate of deterioration.

Painting such surfaces as:

a. Drive motors (casing)
b. Gear boxes
c. Piping (color coded)
d. Pumps
e. Rails, hand rails and guard rails.

Do not paint over name plates and numbers. If possible do not paint over nuts, bolts and screws, especially the threads. Removal of hardened paint is very difficult. If such components have to be painted, apply a light coat and if re-painting is needed, remove the old paint and apply a new coat.

Painting components that will be in contact with water continuously should be painted with epoxy paint. Mix only what will be used.

REPLACEMENT - Replacement should be done of components indicating wear or that have malfunctioned and which cannot be repaired. In some cases it may be cheaper to replace a unit rather than repair it. Take into consideration man hours, repair tools and materials.

Replacement of components such as:

1. Baffles that are corroded or rolled.
2. Fire fighting equipment such as hoses and valves that are corroded and deteriorated.
3. First aid kits have dated material that need replacing.
4. Piping - corroded
5. Pumps and motore.
6. Rails that are corroded
7. Weirs that are corroded

WEAR MEASUREMENT - Wear measurement of components is important. This is why it is essential to know the original measurement of the components. If no such record exists then start a set even though the unit has been in service. This will give a starting point.

Wear measurements are done on such components as:

1. Baffles
2. Pumps - Pump wear measurement of pumps usually are done upon shafts or sleeves, impellers, pistons and piston walls.
3. Drive motore - The amperage it is drawing.
4. Valves - Especially telescoping valves.
5. Weirs

Any moving part that makes contact with metal, concrete or even wood should be checked for wear. A record of the observations or wear determination should be kept and reviewed.

SAFETY - Operating a sedimentation unit should be done safely. Catwalks, open pits, wells, stairways, walkways, tank edges should have railings and guards. Sometimes such guards and railings could increase the hazard by hindering operations. Then the operator should provide an adequate safeguard. Example. If an open space has to be crossed then use a catwalk. Don't jump from edge to edge.

Many walkways come to be very slippery since they are close to water and organic solids. Caution should be exercised while walking and/or working on wet walkways. Do not allow biological growths to accumulate upon the surfaces where one has to work from.

Maintenance of electrical equipment should be approached with caution. It is preferred that the equipment should be

a. Grounded
b. Turned off from the power source if possible before maintenance is done.
c. If the unit has to be on, make sure that the area is dry, rubber mats are used to work from.

d. That others are made aware of the fact that the electrical equipment is being maintained.

Many accidents happen when one performs their work unsafely.

a. Do not lean into the tank.

b. Make sure that the feet are firmly situated.

c. Proper tools should be used in performing a specific task.

d. Do not over extend your normal reach.

e. While entering confined areas such as manholes, pits, etc., make sure that proper ventilation is available or that the proper breathing apparatus is being used.

f. Make sure that protective head gear (hard hats), gloves, steel tipped shoes, work overalls are being used.

g. Do not attempt to work in possible hazardous conditions alone. Make sure that others know where you are working and what tasks you are performing.

h. Do not attempt to lift and carry heavy items. Back injuries are one of the most common injuries that occur to treatment plant operators. Use fork life, hoist, crane or other devices in lifting and moving heavy objects.

i. Make sure that signs indicating dangerous areas are posted. Such signs as No Smoking.

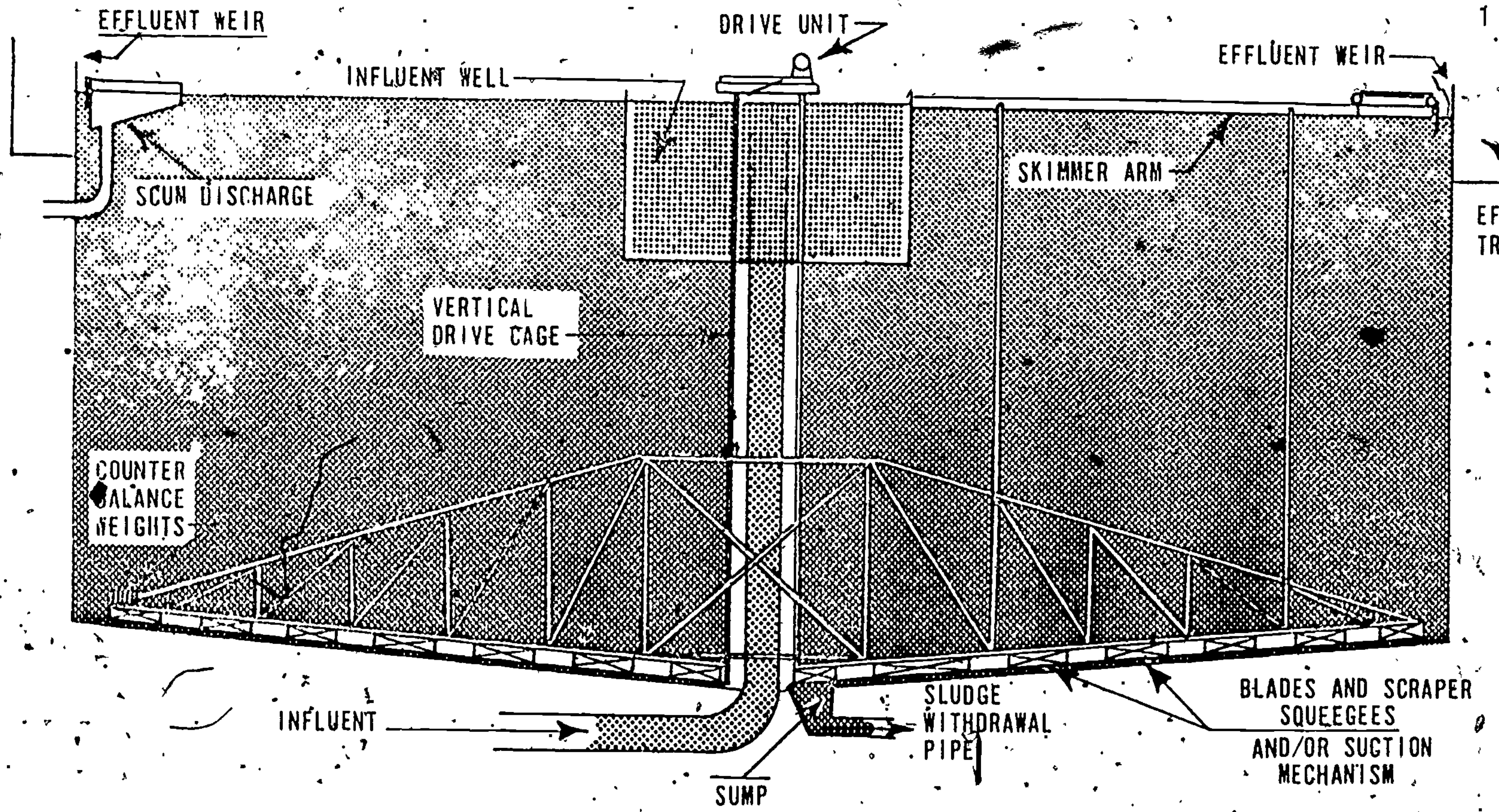
j. Clean your work area by washing and scrubbing and by painting.

k. Maintain proper personal hygiene such as:

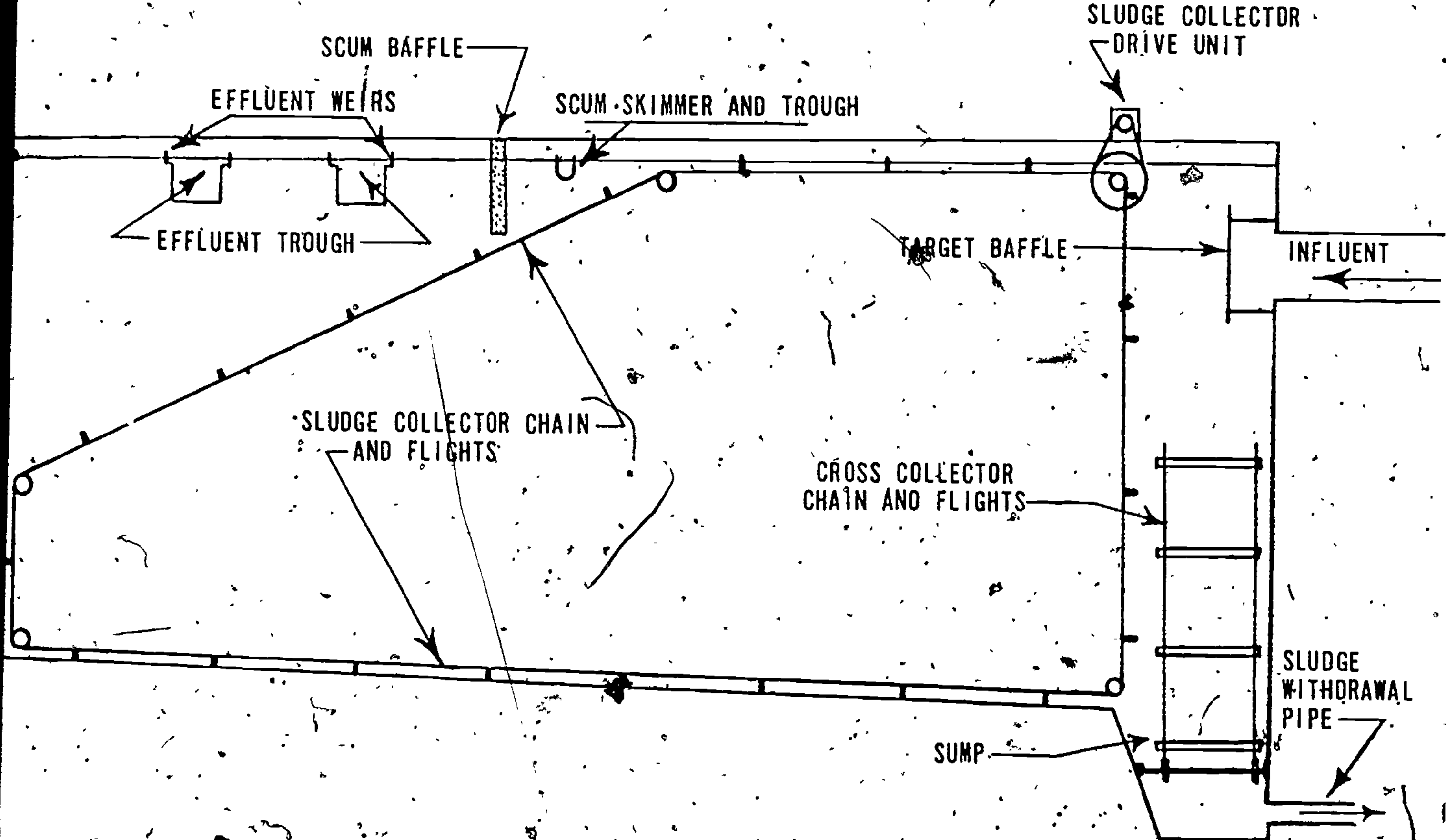
1. Washing hands with soap and water
2. Showering
3. Change clothes at the plant

4. Maintain your health. Shots - tetanus, typhoid, polio, etc.

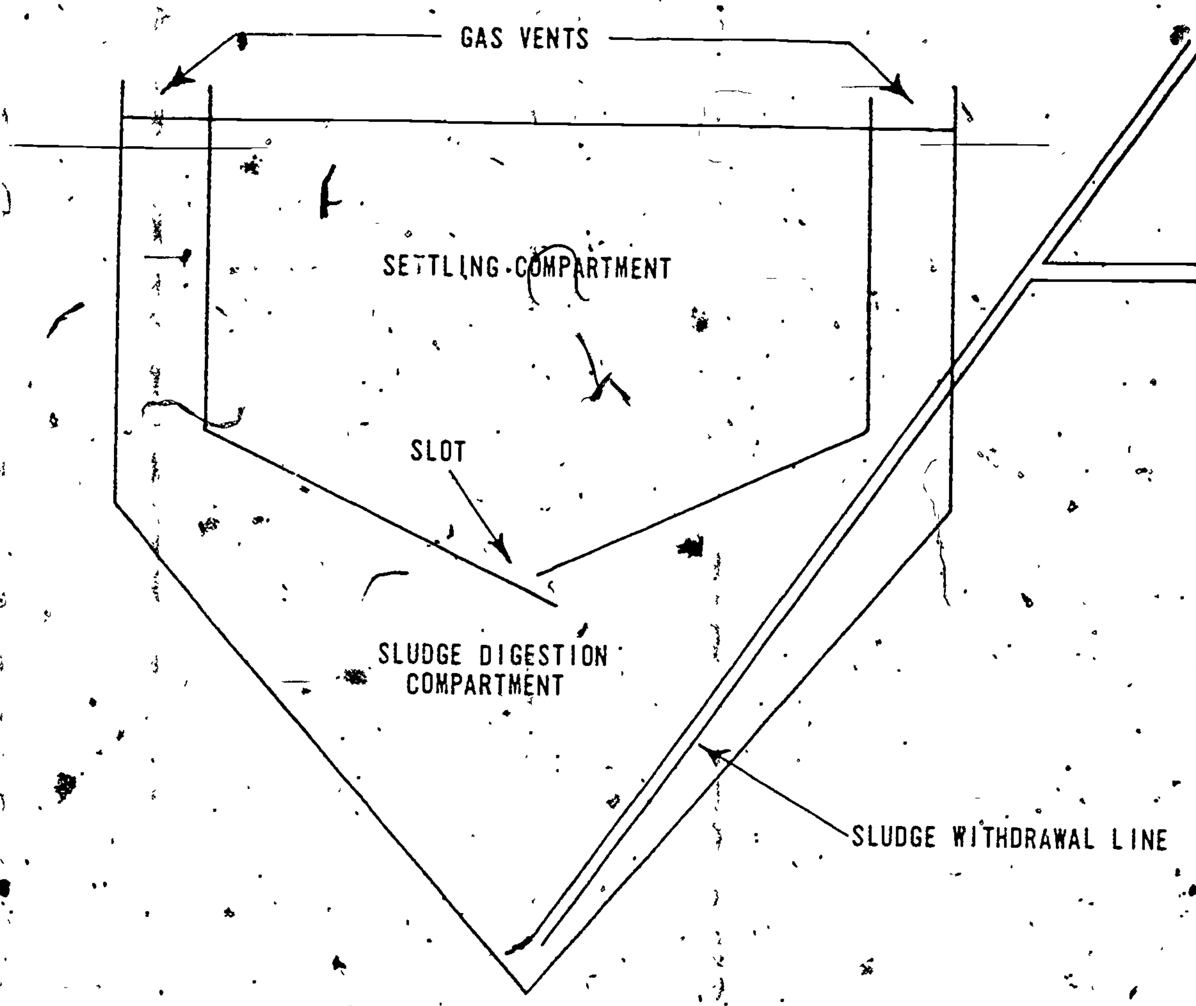
1. Report all unsafe conditions and work sites to your supervisor.



Circular clarifier



Rectangular sedimentation basin


GAS VENTS
SETTLING COMPARTMENT
SLOT
SLUDGE DIGESTION COMPARTMENT
SLUDGE WITHDRAWAL LINE

Imhoff tank

Typical Problems Related to Sedimentation

1. A circular clarifier has a radius of 30 ft. and a depth of 12 ft. The flow rate is 117 GPM. Calculate
   a. Detention time
   b. Surface settling rate
   c. Weir overflow rate

2. A rectangular clarifier has the dimensions of 20 ft. long, 12 ft. wide and 8 ft. deep. It takes 30 seconds to raise the water level 1 ft. in the tank. Calculate
   a. Detention time
   b. Surface settling rate
   c. Weir overflow rate if the weir is the width of the tank

3. A settling tank 65 ft. in diameter, 9 ft. deep receives a flow of 2,085 GPM. Calculate the
   a. Detention time
   b. Surface settling rate
   c. Weir overflow rate

4. The BOD of the raw BOD is 310 mg/l. The BOD of a primary effluent is 214 mg/l. Calculate the percent reduction.

5. An imhoff tank digestion chamber has a volume of 16,000 ft^3. The digestion chamber receives 14 ft^3 of dry solids per day. What is the time it will take to fill the digestion chamber.

6. A primary settling tank 70 ft. in diameter and 8.5 ft. deep receives a flow of 38 GPS. Calculate

a. Detention time

b. Surface settling rate

c. Weir overflow rate

7. Given:

Flow rate 1,200 GPM

BOD influent 300 mg/l

Primary effluent 150 mg/l

Final effluent 20 mg/l

Primary Clarifier

Length 53 ft.

Width 26 ft.

Depth 13 ft.

Determine:

a. The detention time in the clarifier

b. The surface settling rate in the clarifier

c. The BOD percent removal by the clarifier

d. The BOD percent removal by the plant

8. What is the retention time in a primary clarifier if the flow rate is 3.8 MGD and the radius of the tank is 30 ft. and the height is 15 ft.

9. The hardness concentration of the raw flow is 680 mg/l. After treatment the hardness concentration is 98 mg/l concentration. Calculate the percent removal.

Module No:	Module Title: Sedimentation
	Submodule Title:
Approx. Time: 1 hour	EVALUATION

Objectives:

The learner will demonstrate the ability to determine correctly the answers to 25 out of 30 problems related to the process, unit components, operation and maintenance of sedimentation units.

Circle the best possible answer.

1. The process of sedimentation is to remove the dissolved solids from the water.

   a. True

   b. False

2. The solids that settle during a sedimentation process is acted upon by the gravitational pull.

   a. True

   b. False

3. To cause settling the velocity of flow should be

   a. Increased

   b. Decreased

4. The particle size of the solids has no effect upon the settling rate.

   a. True

   b. False

5. An increase in temperature decreases the viscosity, therefore increases the settling rate.

   a. True

   b. False

6. The primary activity in a sedimentation process is to degrade the solids by biological activity.

   a. True

   b. False

7. The settling rate of solids is not effected by the change of the pH..

   a. True

   b. False

8. The primary function of the influent baffle is to

   a. Reduce the flow velocity

   b. Direct the sludge to the bottom of the unit

   c. Catch the oil and grease

   d. None of the above.

9. Short circuiting in sedimentation processes is caused by

   a. Electricity

   b. Different velocities within the unit

   c. Excessive turbulance

   d. A very slow flow rate

10. A skimmer trough is a component that will

    a. Remove extra flow from the clarifier

    b. Remove floating material from the surface of the clarifier

    c. Be used to store sludge

    d. Be used to store oil and grease

11. Sludge collection units should be operated at a high speed.

    a. True

    b. False

12. Conning is an effect caused by

    a. Too fast a ratio of sludge pumping

    b. Too slow a rate of sludge pumping

    c. Operating a skimmer too fast

    d. A very thick sludge

13. The solid concentration of sludge is determined by

    a. The suspended solids test

    b. The total solids test

    c. The dissolved solids

    d. None of the above

14. An indication of proper operation of the sedimentation process is to achieve

    a. The highest amount of solids removal

    b. The two hour detention time

    c. The pumping of sludge

    d. The accumulation of biological growths

15. An operator can tell if the solids content of the sludge changes from

    a. The sound of the sludge pump

    b. Pressure gauge reading or the suction and discharge

    c. Visual observation

    d. All of the above

16. In obtaining samples for tests the positions should be

    a. Influent

    b. Effluent

    c. Sludge

    d. All of the above

17. A composite sampoe is composed of

    a. Influent samples

    b. Effluent samples

    c. Mixing influent samples and effluent samples

    d. Grab samples taken from a point added together proportionately according to flow rate.

18. Sampling sludges is done

a. While the sludge is in the sedimentation unit

b. After all the sludge is withdrawn

c. While the sludge is being withdrawn

d. Sludge sampling is a waste of time.

19. Oil and grease if allowed to accumulate causes

a. Cleaning problems

b. Plugged lines

c. Odor

d. All of the above

20. Determination for solids is

a. An easty test to perform

b. A test that provides no useable information to an operator

c. Is a difficult test to perform and therefore should be left to experts

d. None of the above

21. Circle the correct answer(s)

Gases generated due to decomposition of solids if allowed to accumulate cause hazards are:

a. Methane

b. Hydrogen sulfide

c. Nitrogen

d. Argon

22. The test indicating hazardous working environment to the operator is

a. Oxygen deficiency test

b. Nitrogen deficiency test

c. Volatile solids tests

d. Dissolved oxygen test

23. In starting up a sedimentation unit it is best to take photographs of the unit empty.

a. True

b. False

24. List two things an operator must do before adding water to a sedimentation unit.

a.

b.

25. Record keeping is

a. A waste of time since no one looks at them

b. Useful in operating a treatment plant

The information provided is to be used in calculating Problems 26, 27 and 28.

A circular clarifier has a diameter of 65 ft. and a depth of 18 ft. if the flow rate is 5 cubic feet per second.

26. Calculate the detention time in hours.

a. 13.2 hrs.

b. 3.3 hrs.

c. 6.6 hrs.

d. 2 hrs.

27. Calculate the surface settling rate to the closest gpd/ft^2

a. 54.127 gpd/ft^2

b. 243.6 gpd/ft^2

c. 405.9 gpd/ft^2

d. 972.6 gpd/ft^2

28. The weir diameters is also 65 feet. Calculate the weir overflow rate.

a. 2766

b. 63439

c. 15832

d. 881.

Nos. 29 & 30

Choose two of the three diagrams provided and match the component name with the number on the diagram.

Imhoff Tank

1.	A. Slot
2.	B. Sludge digestion compartment
3.	C. Settling compartment
4.	D. Gas vents
5.	E. Sludge withdrawal line
	F. Influent trough

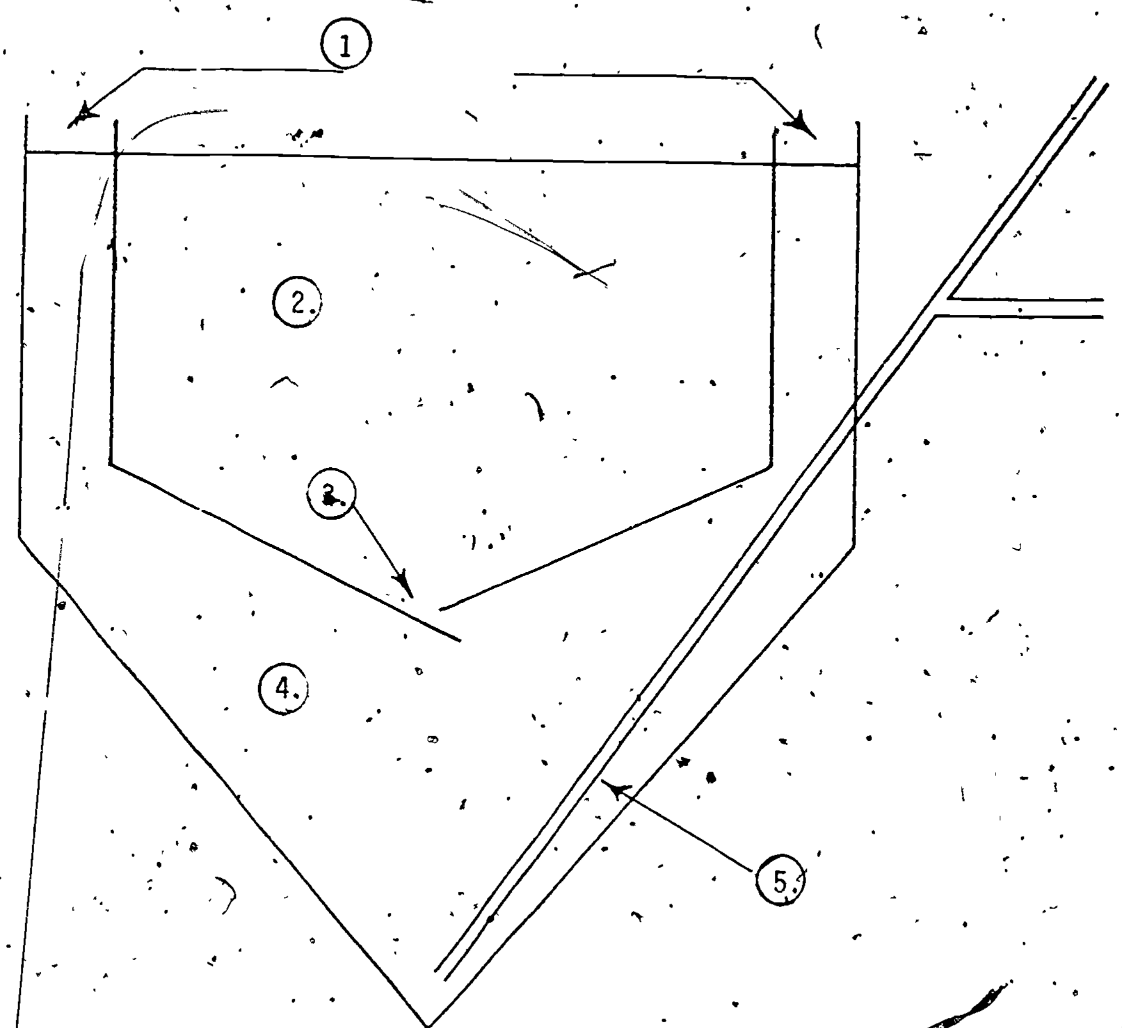
Circular Clarifier

1. A. Influent pipe
2. B. Scum trough
3. C. Sump
4. D. Effluent weir
5. E. Counter balance weights
6. F. Blades and scraper sources
7. G. Skimmer arm
8. H. Sludge withdrawal
9. I. Effluent trough

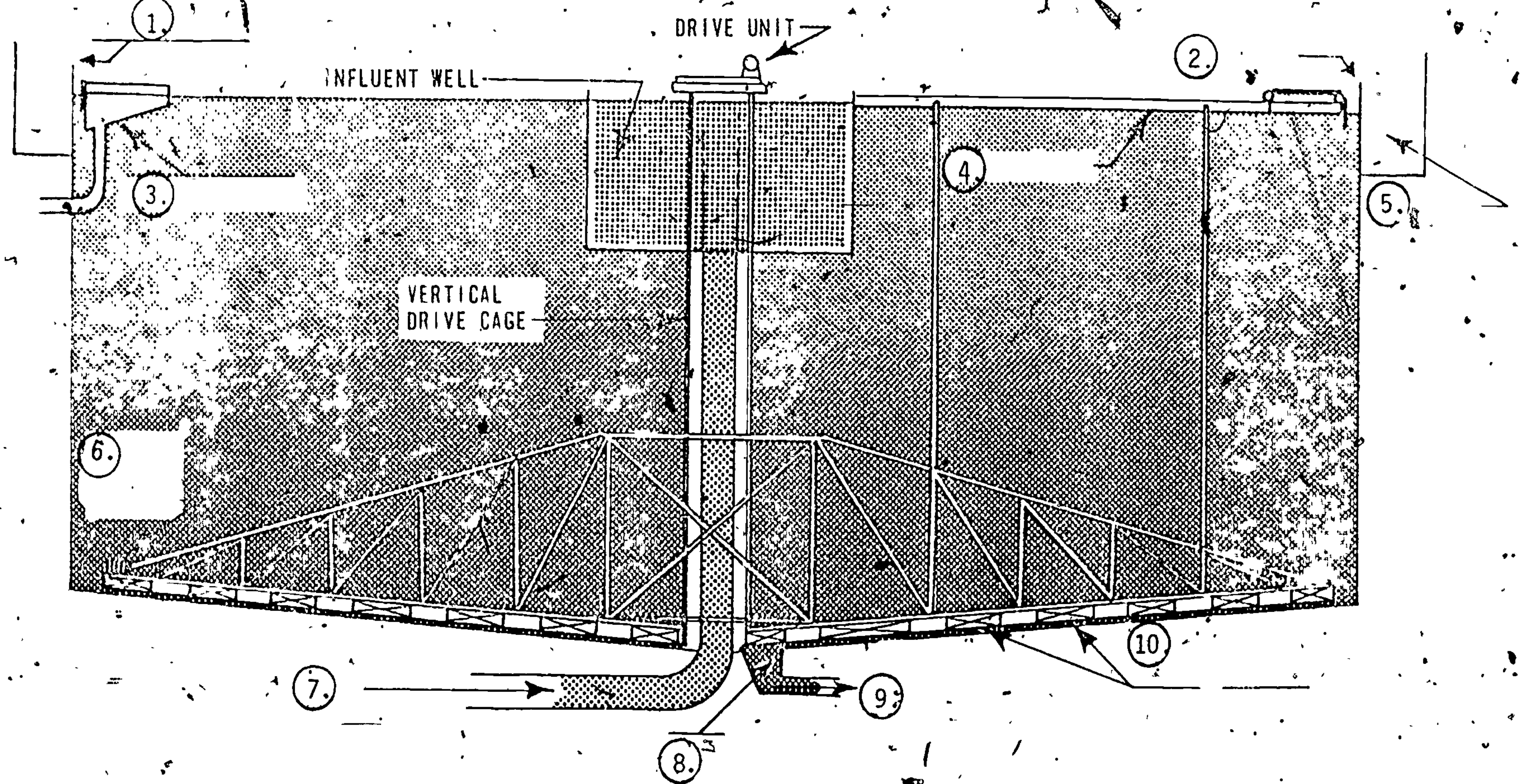
Rectangular Sedimentation Basin

1. A. Sludge sump
2. B. Sludge collector chain & flights
3. C. Influent baffle
4. D. Effluent trough
5. E. Scum baffle
6. F. Sludge withdrawal line
7. G. Scum trough
8. H. Effluent weirs

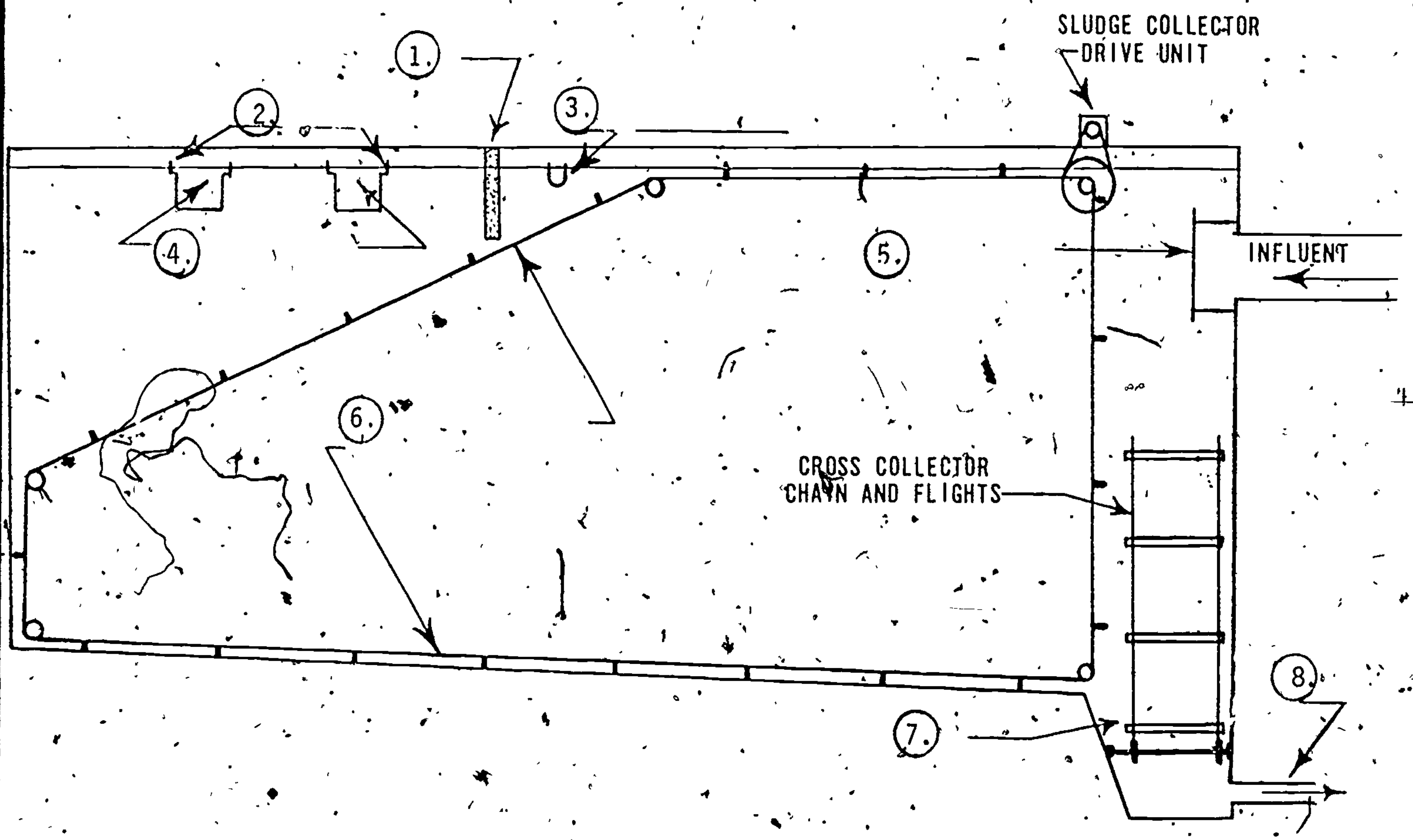
I. Sprockets



Imhoff tank



Circular clarifier



Rectangular sedimentation basin

Module No:	EVALUATION

Instructor Notes:	Instructor Outline:
1. Handout	1. Give 30 evaluation problems.

Answers

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

Answers to No. 24 are:

1. Removal of debris
2. All components functioning
3. All components in proper places

Answers to Nos. 29 & 30 are the diagrams of clarifiers provided.