DOCUMENT RESUME

ED 230 407 SE 041 607

AUTHOR	Klopping, Paul H.
TITLE	Flotation Thickening. Sludge Treatment and Disposal Course #166. Instructor's Guide [and] Student Workbook.
INSTITUTION	Envirotech Operating Services, San Mateo, CA.; Linn-Benton Community Coll., Albany, Oreg.
SPONS AGENCY	Office of Water Program Operations (EPA), Cincinnati, Ohio. National Training and Operational Technology Center.
PUB DATE	Aug 80
GRANT	EPA-900953010
NOTE	42p.
AVAILABLE FROM	Linn-Benton Community College, 6500 SW Pacific Blvd., Albany, OR 97321 ($1. student workbook, $2. instructor's guide, cost per entire set of slide-tape, 1 student workbook and 1 instructor's guide is $75. per unit); EPA/Instructional Resources Center, 1200 Chambers Rd., 3rd Floor, Columbus, OH 43212, prices from EPA are available upon request.
PUB TYPE	Guides - Classroom Use - Materials (For Learner) (051) -- Guides - Classroom Use - Guides (For Teachers) (052)
EDRS PRICE	MF01 Plus Postage. PC Not Available from EDRS.
DESCRIPTORS	Instructional Materials; Postsecondary Education; *Sludge; Teaching Guides; *Training Methods; *Waste Disposal; *Waste Water; *Water Treatment
IDENTIFIERS	*Flotation Thickening

ABSTRACT

This lesson describes the process of dissolved air flotation thickening. The material is intended to acquaint students with the fundamental principles of operation, components found on a typical thickener, factors that affect operation, a comparison with other thickening processes, and the calculations and laboratory tests required in establishing a normal operating routine. The lesson includes an instructor's guide and student workbook. The instructor's guide contains a description of the lesson, estimated presentation time, instructional materials list, suggested sequence of presentation, reading lists, objectives, lecture outline, narrative of the slide/tape program used with the lesson, and student worksheet (with answers). The student workbook contains plant flow diagrams, objectives, glossary, discussion material on flotation thickening, references, and worksheet. (JN)

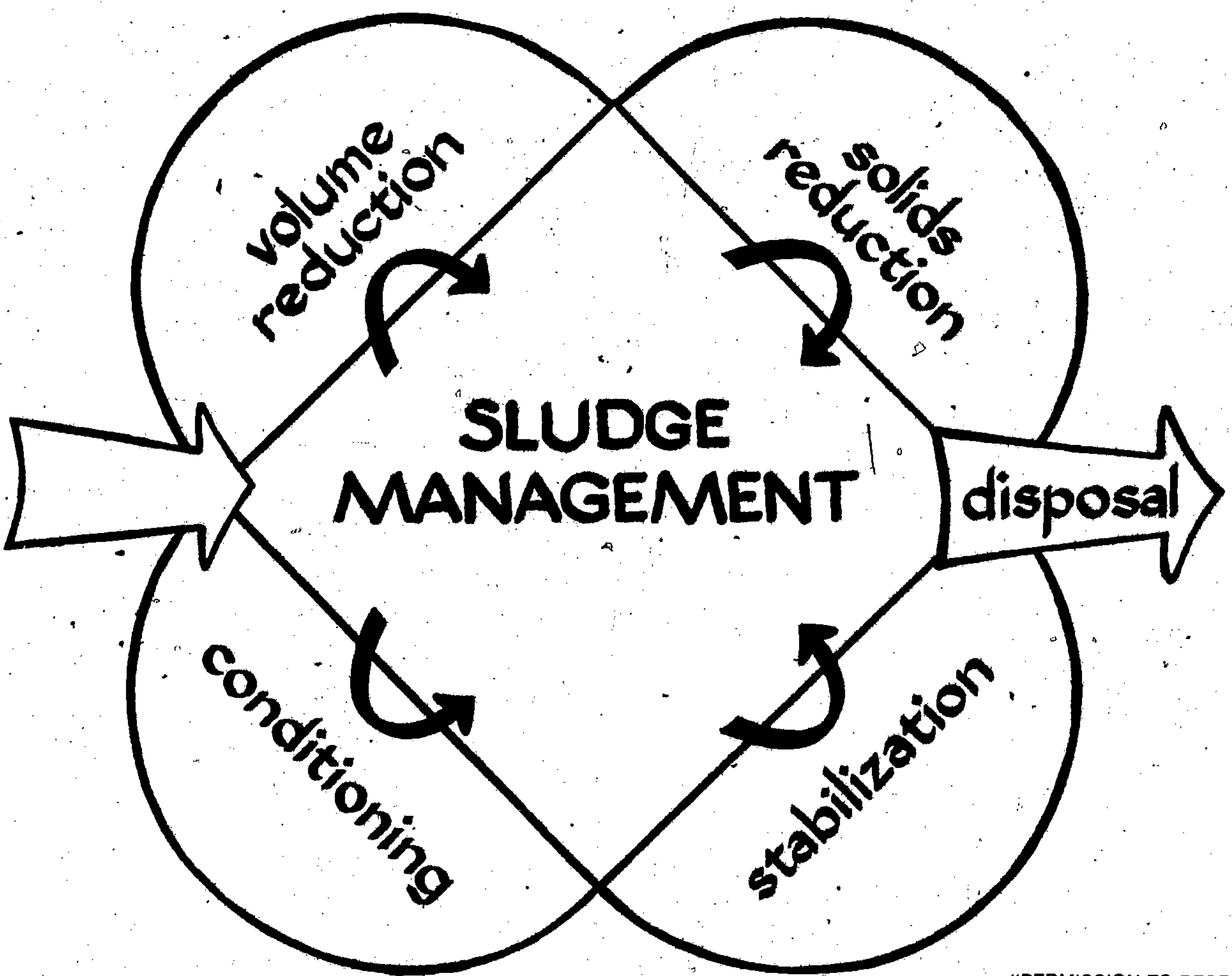
SLUDGE TREATMENT

and

DISPOSAL

COURSE # 166

FLOTATION THICKENING



INSTRUCTOR'S GUIDE

Prepared by
Linn-Benton Community College
and
Envirotech Operating Services

FLOTATION THICKENING

Written by:
Paul H. Klopping
Linn-Benton Community College
Albany, Oregon

Instructional Design:
Priscilla Hardin
Corvallis, Oregon

Technical Consultant:
Envirotech Operating Services
San Mateo, California

Project Director:
Paul H. Klopping
Linn-Benton Community College
Albany, Oregon

Project Officer:
Lynn S. Marshall
United States Environmental Protection Agency
National Training and Operational Technology Center
Cincinnati, Ohio

Developed Under:
EPA Grant #900953010
August, 1980

FLOTATION THICKENING

CONTENTS

FLOTATION THICKENING

Lesson Description

This lesson describes the process of dissolved air flotation thickening. It is a module which is intended to acquaint the student with the fundamental principles of operation, components found on a typical thickener, the factors that affect operation, a comparison with other thickening processes, and the calculations and lab tests required in establishing a normal operating routine. Prior to working with this module, the student should have a working knowledge of the information presented in "Sludge Characteristics" and "Sludge Conditioning". It may also be helpful to review the module on "Planning Considerations" prior to using this module so as to orient sludge thickening to other solids handling processes.

Estimated Time

Student preview	5-10 minutes
Presentation	30-45 minutes
Discussion	5-10 minutes
Worksheet and review	20-30 minutes

Instructional Materials List

1. Student Text "Flotation Thickening"
2. Slide Set "Flotation Thickening"
3. Slide projector and screen
4. Chalkboard & chalk or flipchart and marking pens
5. Samples of primary and secondary sludge, settleometer

Suggested Sequence of Presentation

1. Assign reading
2. Lecture and discussion using slide format and outline. This material may also be presented in a slide/tape mode using a Wollensak cassette player coupled to a 35 mm carousel projector. The tape is equipped with a non-audible cue to automatically advance and synchronize the slides.
3. Open discussion - handle any questions arising from lecture
4. Assign worksheet
5. Review worksheet

Required Reading

EPA Course # 166 "Flotation Thickening"

Reference Reading

EPA Course # 166 "Sludge Characteristics", "Sludge Conditioning", "Lab Procedures", "Planning Considerations".

Process Design Manual for Sludge Treatment and Disposal, U.S.E.P.A., September 1979, EPA 625/1-79-011

FLOTATION THICKENING

Objectives

Upon completion of this lesson, the student should be able to do the following:

1. When given a diagram and list of componenets, correctly (match) label a diagram of a typical Dissolved Air Flotation Thickener (DAFT).
2. State two methods of introducing air to a DAFT.
3. Describe, in general terms, how sludge is thickened in a DAFT.
4. List four of 7 factors which affect operation of a DAFT. The acceptable answers include:
   a. Type of sludge
   b. Age of feed sludge
   c. Solids and hydraulic loading
   d. Air/Solids
   e. Polymer conditioning
   f. Recycle rate
   g. Sludge blanket depth
5. State that a difficulty in flotation thickening primary sludge is it's tendency to settle due to heavy solids and grit.
6. Recall that bottom scrapers are needed on a DAFT to collect settled sludge solids.
7. Compare the importance of sludge age in gravity thickening and dissolved air flotation thickening operations.
8. Define the hydraulic loading on a DAFT in terms of GPM/ft^2.
9. Define the solids loading on a DAFT in terms of lbs/hr/ft^2.
10. Define and calculate air to solids ratio.
11. Recall that mixing the retention tank increases the amount of air which can be dissolved.
12. List the three variables in controlling air in a DAFT as:
    a. Air Rotameter
    b. Compressor
    c. Liquid level indicator
13. Given an air flow and solids loading, calculate A/S Ratio.
14. Define recycle rate.

7

15. Explain the function of the recycle stream on the operation of a DAFT.

16. Explain how sludge blanket thickness is controlled.

17. Recall the normal sludge blanket thickness to be 6-8".

FLOTATION THICKENING - LESSON OUTLINE

I. Objective

A. Separate solids from liquid in upward direction.

How: Attach air bubbles to particles of suspended solids.

II. 4 Methods

A. Dispersed air flotation - Bubbles produced by mixers or diffused aerators.

B. Biological flotation - Gases formed by biological activity.

C. Dissolved air (Vacuum) flotation - Water aerated under atmospheric pressure, released under vacuum.

D. Dissolved air (pressure) flotation - Water aerated under pressure, released under atmospheric pressure.

MOST COMMON

III. Components - Physical arrangement

A. Shape -

1. Circular or rectangular

B. Air supply

1. Compressed air supply
2. Aspirator - type air injection

C. Components

1. Air injection equipment
2. Pressurized retention tank
3. Recycle pump
4. Inlet or Distribution Assembly
5. Sludge scrapers
6. Effluent Baffle

IV. Operation

A. Preferred mode of operation

1. Recycle stream serves as air carrying medium.

a. Retention tank maintained at a pressure of 45-70 psig

b. Compressed air introduced to retention tank at an upstream point.

c. Aspirator assembly draws air into system (alternate method).

2. Pressurized air saturated liquid flows to inlet (distribution) assembly, released at atmospheric pressure through back-pressure relief valve.

3. Decrease in pressure -

a. Air comes out of solution in 1000's of minute air bubbles.

4. Bubbles contact sludge solids in distribution box and attach to solids

5. Solids float

6. Effluent baffle keeps solids from washing into effluent

a. Baffle - 12-18" below surface

b. Baffle - 2-3" above surface

V. Factors Affecting Performance

A. Performance dependent on:

1. Type of sludge
2. Age of feed sludge
3. Solids & Hydraulic loading
4. Air to Solids (A/S) Ratio
5. Recycle rate
6. Sludge blanket depth

B. Type and Age of Sludge

1. Primary sludges - heavier than biological sludges: Not as easy to treat by flotation.

a. Primary sludge will float with sufficient air

b. Gritty or heavy sludge (primary) - settles and must be removed therefore must have bottom scrapers for primary sludge

c. Sludge Age

(1) Usually doesn't affect flotation as drastically as gravity thickener

(2) Old Sludge--tends to gasify--very little effect on flotation thickener

C. Solids and Hydraulic Loading

1. Same calculations as gravity thickener's loading rates

2. Exceeding upper limits results in a degraded effluent

a. Hydraulic loading = GPM/ sq ft

b. Solids loading = lbs/hr/sq ft

D. Air to Solids Ratio

1. Quantity of Air-Critical

a. Enough air to cause flotation is necessary

2. Mix retention tank to increase amount of air that can be put into solution

a. unmixed = at least 50% saturation

b. mixed = 90% saturation

3. The greater the quantity of dissolved air, the greater the number of bubbles in the distribution assembly and more efficient the operation.

4. Amount of Air

a. Controlled by:

(1) Air rotameter

(2) Compressor

(3) Liquid level indicator in Retention Tank

b. Most important operational concern:

(1), (2), & (3) are in proper working order

5. .075 lb air/cubic foot of air = Conversion Factor

a. This changes with temperature and pressure

6. Quantity of Solids

a. Flow x conc x 8.34 lb/gal

7. Air/Solids Ratio = $\frac{\text{Air (lbs/min)}}{\text{Solids (lbs/min)}}$

Therefore, if: 100 GPM solids a 0.9%

$$100 \text{ gal/min} \times 8.34 \text{ lb/gal} \times \frac{0.9\%}{100\%}$$

$$= 7.5 \text{ lbs solids}$$

And also, if: 5 SCFM @ .075 lb/cubic foot

$$= 0.375 \text{ lbs air}$$

Then, the Air/Solids Ratio is:

$$\frac{0.375 \text{ lbs Air}}{7.5 \text{ lbs Solids}} = 0.05 \text{ lbs Air/lb Solids}$$

E. Recycle Rate and Sludge Blanket Depth
   1. Recycle Rate typically equals 100-200%
      a. 100% Recycle rate means:
         - For every gallon of influent sludge, 1 gallon of DAF effluent (subnatant) is recycled back to the DAF inlet.
   2. Recycle rate is plant dependent, unique
   3. The Point is:
      a. Recycle stream carries air to the inlet
      b. Increase recycle, the air carrying potential increases also

F. Sludge Blanket Thickness
   1. Varied by increasing or decreasing speed of surface sludge scrapers.
   2. Increase speed decreases thickness

VI. Normal Operating Principles

A. Flow through
   1. Ideally, constant flow, continuous operation

B. Monitoring
   1. Influent
   2. Effluent

3. Thickened Sludge Stream-Once per shift, samples composited.

C. Lab Results-Expected

1. Effluent-relatively free of solids, resembles secondary clarifier effluent

2. Thickened Sludge-resembles cottage cheese (brown)

a. Depth = 6-8 inches below water surface (6-8" thick)

VII. Typical Performance

	Without Polymer	With Polymer
Solids Loading (lbs/hr/sq ft)	1-2	2-6
Hydraulic loading (GPM/sq ft)	0.5-1.5	0.5-2.0
Recycle %	100-200	100-200
Air/Solids Ratio (lb/lb)	0.01-0.04	0.01-0.04
Minimum Influent Solids Concentration (mg/l)	5000	5000
Float Solids Conc (%)	2-4	3-5
Solids Recovery (%)	50-85	95-99

Narrative

Slide #

1. This module discusses Dissolved Air Flotation Thickening. It will present a description of the process, describe the typical components found in a thickener and will cover the fundamentals of process control.

2. This module was written by Paul Klopping. Instructional development was done by Pricilla Hardin. Envirotech Operating Services provided technical review of the material.

3. Many sludges encountered in wastewater treatment display poor settling characteristics due to specific gravities being close to 1.0. Flotation thickening is a process for concentrating these lighter sludges.

4. While gravity thickening works best for concentrating heavy sludges such as the raw sludge produced in a primary clarifier,

5. waste activated sludge is too light to compact to any great extent by gravity. Most sludges that don't concentrate well be gravity, however, can be successfully thickened in a flotation thickener. Waste activated sludge is commonly handled this way.

6. Flotation thickening works much like gravity thickening in reverse. Rather than encouraging sludge particles to settle to the bottom of a tank, flotation thickeners work by trapping tiny air bubbles in the sludge, floating it to the surface, where it is collected.

7. To produce the air bubbles needed in the process, air is introduced into a stream of recycled effluent in a pressurized retention tank.

8. This pressurized, air-saturated water is then mixed with feed sludge at the bottom of an open tank. Since the saturated mixture is now exposed to atmosphere, air bubbles readily come out of solution, rising to the surface.

9. This is much like removing the cork from a bottle of champagne--as soon as the bottle is opened at atmosphere, the decreased pressure allows gas bubbles to excape from solution.

10. The bouyant sludge blanket is known as the float.

11. Air can be introduced into a thickener by several methods. The most common is referred to as the dissolved air pressure method, where water is aerated under pressure and released under atmospheric pressure.

12. A second type is called the dissolved air vacuum method in which water is aerated at atmospheric pressure and released under vacuum. In either case, the effect is the same--air bubbles come out of solution as pressure around them is reduced. This module will discribe only dissolved air pressure flotation.

13. Thickeners are either circular or rectangular in shape.

14. A pressurized retention tank is used to hold recycled effluent under pressure as air is injected. A recycle pump moves water, through the pressurizing system, to the retention tank, and then into the thickener where the air bubbles are released. This water is recycled back to the pressurized tank for reuse.

15. Once the recycle stream is pressurized, it flows to the distribution box and circulates across the tank. A back-pressure relief valve is used to control this flow of pressurized water into the tank which is at atmospheric pressure.

16. In the distribution box, air comes out of solution releasing thousands of small bubbles, ideally ranging in size from 50 - 100 microns. Sludge is introduced adjacent to this point. The air and sludge mix, trapping gas bubbles in the sludge which then floats to the surface.

17. At the top of the tank chain driven skimmer blades drag the floating sludge to a pit. Particles that settle are collected by a similar mechanism scraping the bottom of the tank. Thickened sludge is removed from both the top and bottom of the flotation thickener.

18. Any effluent that is not recycled flows over a weir at the other end of the tank. An effluent baffle extends from several inches above the water surface downward several feet.

19. The effluent baffle prevents solids from washing into the effluent.

20. A number of factors affect the performance of the thickener. These are: Type of sludge, Age of feed sludge, Solids & Hydraulic loading, Air to Solids (A/S) Ratio, Polymer conditioning, Recycle Rate and Sludge blanket thickness.

21. The type and age of sludge is important in that secondary sludge is light and tends to float.

22. With sufficient air, primary sludge can be forced to float, but grit and other heavy particles which may be present will settle and must be removed. Consequently thickeners must have scrapers on the bottom, as well as on the top.

23. Biological sludges are lighter and tend to float, but bottom scrapers are still required for the small amount that settles.

24. Sludge age is not as important a consideration in flotation thickening as it is in gravity thickening.

25. As sludge gets older it has a tendency to gasify, giving it additional bouyancy. This is an aid to flotation thickening, since the goal is to produce a bouyant sludge.

26. But, if sludge age is too great, the solids may lose their ability to form a strong floc, in which case thickening efficiency may be impaired.

27. Thickeners are controlled by adjusting both solids and hydraulic loadings. The same calculations used to express loading on gravity thickeners apply to floatation thickeners.

28. Hydraulic loading is expressed as: gpm/ft^2, and solids loading is expressed as $lb/hr/ft^2$.

29. Hydraulic loading is calculated in terms of gpm/ft^2 of surface area. Flow to the thickener is measured in gallons per minute. This flow is the sum of both recycle flow and sludge feed. The surface area is expressed in square feet. Dividing the flow by the surface area is the method for figuring hydraulic loading.

30. Solids loading is expressed in terms of lbs/hr/sq. ft. To figure the lbs of dry solids, find the concentration of suspended solids in the feed in percent. Then find the rate of flow. Pounds can be calculated when concentration and flow are known.

31. When pounds of dry solids per hour being fed to the thickener have been determined, divide by the surface area in square feet.

32. Typically, flotation thickeners operate at hydraulic loadings ranging from 0.5 to 2.0 gpm/ft^2 and at solids loadings of from 2 to 6 $lb/hr/ft^2$.

33. The critical operational parameter is the Air to Solids Ratio, for there must be enough air to cause flotation, and this is proportional to the solids loading.

34. Recalling that the retention tank is where air is dissolved in the water, the efficiency with which this is accomplished depends on whether this tank is mechanically mixed or unmixed. An unmixed tank achieves at least 50% saturation of water with air, while a mixed tank may achieve 90% saturation.

35. As the quantity of dissolved air increases, the number of gas bubbles in the distribution assembly is increased, and more "lift" is provided to float the sludge being introduced at this point.

36. The air needed to the retention tank is provided by a compressor and monitored by an air rotameter and a liquid level indicator in the tank. From an operational standpoint, it is critical that these components are in proper working order.

37. One cubic foot of air is the quivalent of about 0.075 pounds.

38. The quanitity of air required to achieve satisfactory flotation is directly proportional to the quantity of solids entering the thickener.

39. For domestic sludges these values range from 0.01 - 0.4 lbs Air/lb Solids, while most operate at a value less than 0.1.

40. Since one cubic foot of air is the equivalent of about 0.075 pounds, air to solids ratio can easily be calculated if the air discharge (in cubic feet per minute) is known. Using the volume of air, in cubic feet per minute and its weight of 0.075 pounds per cubic foot, the weight of the air is determined.

41. This is divided by the pounds of solids applied per minute to the thickener, yielding the air to solids ratio.

42. Polymers have a significant impact on a thickener's performance. They also influence the acceptable solids and hydraulic loadings as well as the air/solids ratio.

43. Polymers are often effective in increasing particle size, thus improving operation. Small particles in sludge may not be big enough to trap air bubbles. Doubling the diameter of particles results in a fourfold increase in the rise rate at a given A/A ratio.

44. The major disadvantage of polymers is the cost of the polymer itself and the associated chemical feed equipment.

45. The required recycle rate is unique for each application, although rates of 100 - 200% are typical.

46. A 100% recycle rate means that for every gallon of influent sludge, 1 gallon of effluent is pressurized and recycled back to the inlet. This recycle stream adds air to the influent so the air- carrying potential is directly related to the recycle rate.

47. Sludge blanket thickness varies indirectly with the speed of the surface sludge scrapers.

48. As the speed increases the blanket thickness decreases. Normally, thickeners are operated to maintain a 6 - 8" blanket.

49. The best performance is usually seen when the thickener is operated continuously at a constant flow. To monitor the process, influent, effluent & thickened sludge streams should be sampled once per shift and composited. Polymer feed rate should also be recorded.

50. The effluent should be relatively free of solids, resembling secondary effluent, while the thickened sludge should have the consistency of cottage cheese.

51. In summary, the performance of Dissolved Air Flotation Thickeners can be affected by a number of factors. The type and age of sludge has some bearing on its tendency to sink or float.

52. Controllable operating parameters which affect performance are solids and hydraulic loading, A/S Ratio, polymer, recycle rate, and sludge blanket thickness.

53. The hydraulic loading governs the flow, in gallons per minute per square foot of surface area. The solids loading, regulates the lbs. of solids applied per hour per square foot of thickener surface area.

54. Recycle rate is adjusted as a percentage of the sludge flow to the thickener, the percentage being typically 100 - 200% of the sludge flow.

55. Air/Solids Ratio balances the weight of air with the weight of solids that must be lifted to the surface of the thickener.

56. The use of polymers has a significant effect on all of these parameters of control. Here is a comparison of performance with and without polymer.

57. Solids loadings of 1 - 2 lbs/hr/sq ft and hydraulic load of 0.5 - 1.5 gpm/ sq ft are typical for operations not utilizing polymers. When polymers are used, solids loading is increased by 2 - 3 times, while hydraulic loading is increased only slightly.

58. Ranges for recycle rate and Air/Solids Ratio are not significantly affected by polymer addition.

59. With a minimum influent solids concentration of 5,000 mg/l or 0.5%, float solids concentrations of 2 - 4% are expected without polymer, 3 - 5% with polymer. A substantial improvement in solids recovery is seen when polymer is used. 95 - 99% solids capture is possible with polymer, while 50 - 85% is typical without.

60. Dissolved air flotation is an importatnt sludge dewatering process. It can reduce or eliminate other plant operating costs.

61. The flotation thickening process is most effective for thickening aerobic biological sludges. When designed and operated to meet specific requirements, dissolved air flotation is an efficient and reliable process.

REFERENCES

Sludge Treatment and Disposal, Process Design Manual, U.S.E.P.A. September 1979, EPA 625/1-79-001

Manual of Practice No. 11, Operation of Wastewater Treatment Plants, Water Pollution Control Federation, 1978.

EPA Course #166, "Sludge Characteristics", "Sludge Conditioning", "Laboratory Procedures", "Planning Considerations", 1980.

FLOTATION THICKENING

WORKSHEET

1. Choose three factors which affect the operation of a flotation thickener.

   _____ a. Food/Microorganism Ratio

   __X__ b. Air/Solids Ratio

   __X__ c. Polymer conditioning

   __X__ d. Solids loading

   _____ e. Ambient Temperature

2. What characteristics about primary sludge affect its thickening by flotation?

   _____ a. It is lighter than secondary sludge.

   __X__ b. It is heavier than secondary sludge.

   __X__ c. It contains heavy solids and grit, causing it to settle.

   _____ d. It contains finely divided particles, causing it to float.

   _____ e. It is usually well nitrified.

3. Why are bottom scrapers present in a flotation thickener?

   _____ a. They mix the sludge to improve flocculation

   _____ b. They keep the tank homogeneously mixed.

   _____ c. They collect settled sludge solids.

   __X__ d. None of the above.

   _____ e. All of the above.

4. A treatment plant has a flotation thickener with a surface area of 400 square feet. If total flow to the thickener is 1000 GPM, what is the hydraulic loading in GPM/ft^2?

   _____ a. 1.0 GPM/sq. ft.

   _____ b. 1.5 GPM/sq. ft.

   _____ c. 2.0 GPM/sq. ft.

   __X__ d. 2.5 GPM/sq. ft.

   _____ e, None of the above.

5. If the thickener in Question #4 is loaded with 12,000 lbs of solids per day, what is the solids loading in lbs/hr/sq ft?

__X__ a. 1.25

_____ b. 2.50

_____ c. 3.75

_____ d. 5.00

_____ e. None of the above

6. How is the air to solids ratio calculated?

_____ a. D.O./MLSS

_____ b. F/M ÷ SVI

__X__ c. Lbs Air/ Lbs Solids

_____ d. SVI / Lbs Solids

_____ e. None of the above

7. What effect does mixing the retention tank have on the amount of air which can be dissolved?

__X__ a. Increases it

_____ b. Reduces it

_____ c. Has no effect

_____ d. The amount of air which will dissolve is only dependent on temperature and pressure.

_____ e. None of the above

8. What is meant by a 100% recycle rate on a flotation thickener?

_____ a. For every gallon of thickened sludge removed from the thickener, one gallon of subnatant is sent to the headworks.

__X__ b. For every 100 gallons of sludge fed to the thickener, 100 gallons of thickener effluent (subnatant) is recycled to the inlet.

_____ c. Clarifiers are pumping 100% of Q in the return sludge line.

_____ d. Water is 100% saturated with air

_____ e. None of the above.

9. How is sludge blanket thickness controlled on a flotation thickener?

____ a. Varying the rate of sludge feed.

__X__ b. Varying the rate of sludge surface scrapers.

____ c. Varying the rate of recycle.

____ d. Varying the rate of air discharge

____ e. None of the above.

10. What is the normal sludge blanket thickness on a flotation thickener?

____ a. 1-2 inches

____ b. 1-2 feet

____ c. 3-4 feet

__X__ d. 6-8 inches

____ e. None of the above

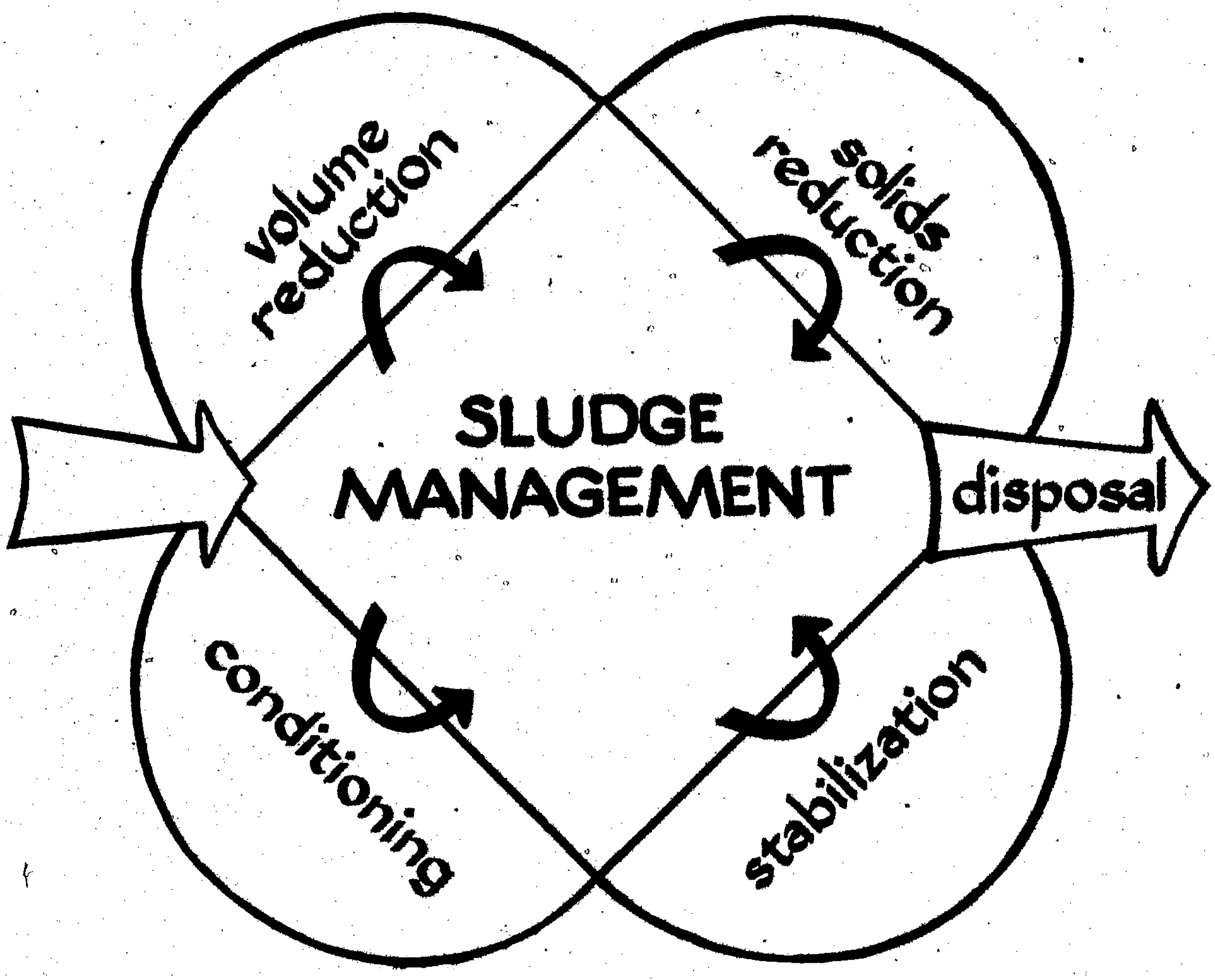
SLUDGE TREATMENT

and

DISPOSAL

COURSE # 166

FLOTATION THICKENING



STUDENT WORKBOOK

Prepared by
Linn-Benton Community College
and
Envirotech Operating Services

FLOTATION THICKENING

Written by:
Paul H. Klopping
Linn-Benton Community College
Albany, Oregon

Instructional Design:
Priscilla Hardin
Corvallis, Oregon

Technical Consultant:
Envirotech Operating Services
San Mateo, California

Project Director:
Paul H. Klopping
Linn-Benton Community College
Albany, Oregon

Project Officer:
Lynn S. Marshall
United States Environmental Protection Agency
National Training and Operational Technology Center
Cincinnati, Ohio

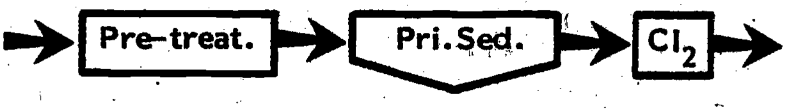
Developed Under:
EPA Grant #900953010
August, 1980

FLOTATION THICKENING

CONTENTS

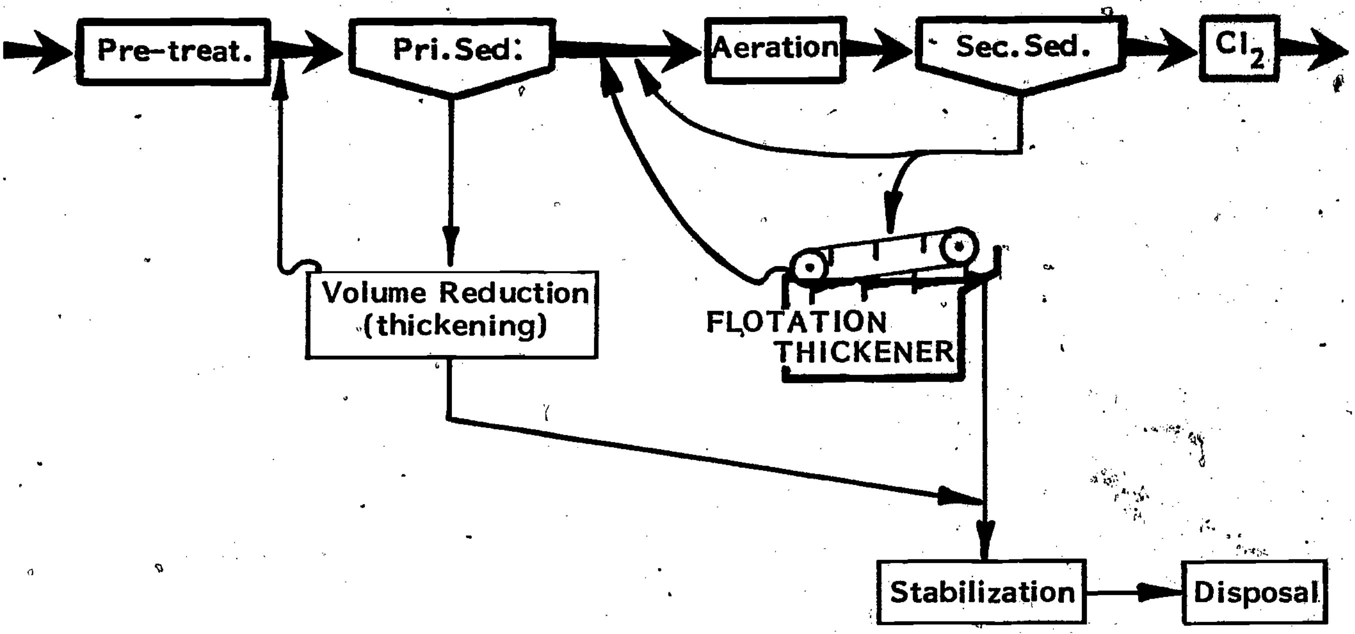
PLANT FLOW DIAGRAMS

PRIMARY PLANT



(Flotation Thickening is NOT NORMALLY USED in primary plants.)

SECONDARY PLANT



26

FLOTATION THICKENING

Objectives

Upon completion of this lesson, the student should be able to do the following:

1. When given a diagram and list of componenets, correctly (match) label a diagram of a typical Dissolved Air Flotation Thickener (DAFT).
2. State two methods of introducing air to a DAFT.
3. Describe, in general terms, how sludge is thickened in a DAFT.
4. List four of 7 factors which affect operation of a DAFT. The acceptable answers include:
   a. Type of sludge
   b. Age of feed sludge
   c. Solids and hydraulic loading
   d. Air/Solids
   e. Polymer conditioning
   f. Recycle rate
   g. Sludge blanket depth
5. State that a difficulty in flotation thickening primary sludge is it's tendency to settle due to heavy solids and grit.
6. Recall that bottom scrapers are needed on a DAFT to collect settled sludge solids.
7. Compare the importance of sludge age in gravity thickening and dissolved air flotation thickening operations.
8. Define the hydraulic loading on a DAFT in terms of GPM/ft^2.
9. Define the solids loading on a DAFT in terms of lbs/hr/ft^2.
10. Define and calculate air to solids ratio.
11. Recall that mixing the retention tank increases the amount of air which can be dissolved.
12. List the three variables in controlling air in a DAFT as:
    a. Air Rotameter
    b. Compressor
    c. Liquid level indicator
13. Given an air flow and solids loading, calculate A/S Ratio.
14. Define recycle rate.

15. Explain the function of the recycle stream on the operation of a DAFT.

16. Explain how sludge blanket thickness is controlled.

17. Recall the normal sludge blanket thickness to be 6-8".

GLOSSARY

Air/Solids Ratio - The weight of air (lbs) per minute in relationship to the weight of sludge (lbs) per minute to be thickened.

Float - Thickened sludge on the surface of a flotation thickener.

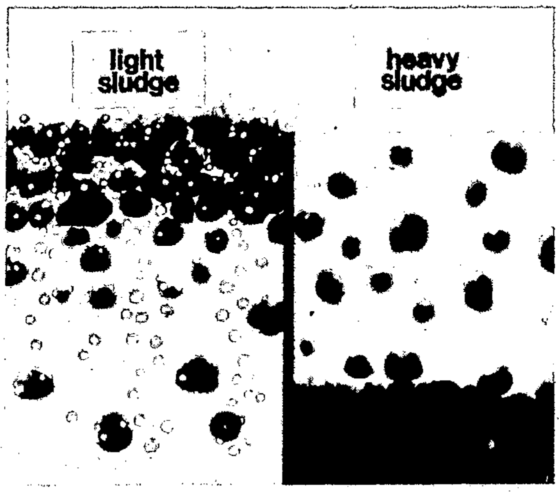
Specific Gravity - The weight of a substance in relation to an equivalent volume of water.

FLOTATION THICKENING

This module discusses Dissolved Air Flotation Thickening. It will present a description of the process, describe the typical components found in a thickener and will cover the fundamentals of process control.

This module was written by Paul Klopping. Instructional development was done by Priscilla Hardin. Envirotech Operating Services provided technical review of the material.

Many sludges encountered in wastewater treatment display poor settling characteristics due to specific gravities being close to 1.0. Flotation thickening is a process for concentrating these lighter sludges.



While gravity thickening works best for concentrating heavy sludges such as the raw sludge produced in a primary clarifier,

waste activated sludge is too light to compact to any great extent by gravity. Most sludges that don't concentrate well by gravity, however, can be successfully thickened in a flotation thickener. Waste activated sludge is commonly handled this way.

Flotation thickening works much like gravity thickening in reverse. Rather than encouraging sludge particles to settle to the bottom of a tank, flotation thickeners work by trapping tiny air bubbles in the sludge, causing it to float to the surface where it is collected.

To produce the air bubbles needed in the process, air is introduced into a stream of recycled effluent in a pressurized retention

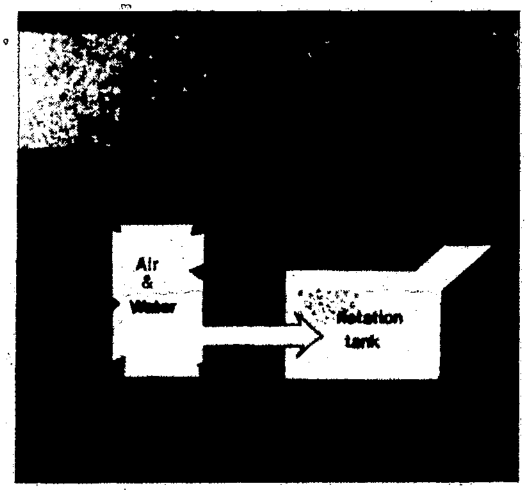
tank.

AIR SATURATION

This pressurized, air-saturated water is then mixed with feed sludge at the bottom of an open tank. Since the saturated mixture is now exposed to atmosphere, air bubbles readily come out of solution, rising to the surface.

This is much like removing the cork from a bottle of champagne--as soon as the bottle is opened to atmosphere, the decreased pressure allows gas bubbles to escape from solution.

The bouyant sludge blanket is known as the float.



Air can be introduced into a thickener by several methods. The most common is referred to as the dissolved air pressure method, where water is aerated under pressure and released under atmospheric pressure.

A second type is called the dissolved air vacuum method in which water is aerated at atmospheric pressure and released under vacuum. In either case, the effect is the same--air bubbles come out of solution as pressure around them is reduced. This module will describe only dissolved air pressure flotation.

COMPONENTS

Thickeners are either circular or rectangular in shape.

***Retention Tank**

A pressurized retention tank is used to hold recycled effluent under pressure as air is injected. A recycle pump moves water through

the pressurizing system, to the retention tank, and then into the thickener where the air bubbles are released. This water is recycled back to the pressurized tank for reuse.

*Recycle stream

Once the recycle stream is pressurized, it flows to the distribution box and circulates across the tank. A back-pressure relief valve is used to control this flow of pressurized water into the tank which is at atmospheric pressure.

In the distribution box, air comes out of solution releasing thousands of small bubbles, ideally ranging in size from 50 - 100 microns. Sludge is introduced adjacent to this point. The air and sludge mix, trapping gas bubbles in the sludge which then floats to the surface.

At the top of the tank chain driven skimmer blades drag the floating sludge to a pit. Particles that settle are collected by a similar mechanism scraping the bottom of the tank. Thickened sludge is removed from both the top and bottom of the flotation thickener.

Any effluent that is not recycled flows over a weir at the other end of the tank. An effluent baffle extends from several inches above the water surface downward several feet.

The effluent baffle prevents solids from washing into the effluent.

FACTORS AFFECTING PERFORMANCE

A number of factors affect the performance of the thickener. These are:

- Type of sludge
- Age of feed sludge
- Solids & Hydraulic loading
- Air to Solids (A/S) Ratio
- Polymer conditioning
- Recycle Rate
- Sludge blanket thickness

***Type of Sludge**

***Age of Sludge**

The type and age of sludge is important in that secondary sludge is light and tends to float.

With sufficient air, primary sludge can be forced to float, but grit and other heavy particles which may be present will settle and must be removed. Consequently thickeners must have scrapers on the bottom, as well as on the top.

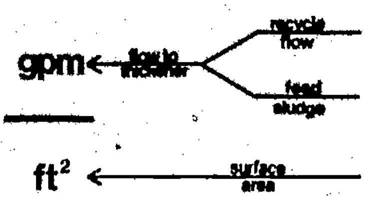
Biological sludges are lighter and tend to float, but bottom scrapers are still required for the small amount that settles.

Sludge age is not as important a consideration in flotation thickening as it is in gravity thickening.

As sludge gets older it has a tendency to gasify, giving it additional bouyancy. This is an aid to flotation thickening, since the goal is to produce a bouyant sludge.

But, if sludge age is too great, the solids may lose their ability to form a strong floc, in which case thickening efficiency may be impaired.

LOADING CALCULATIONS



Thickeners are controlled by adjusting both solids and hydraulic loadings. The same calculations used to express loading on gravity thickeners apply to flotation thickeners.

Hydraulic loading is expressed as: gpm/ft^2, and solids loading expressed as $lbs/hr/ft^2$.

Hydraulic loading is calculated in terms of gpm/ft^2 of surface area. Flow to the thickener is measured in gallons per minute. This flow is the sum of both recycle flow and sludge feed. The surface area is expressed in square feet. Dividing the flow by the surface area is the method for figuring hydraulic loading.

DRY SOLIDS WEIGHT

$$\text{lbs of dry solids per hr.} = \text{solids } (\%) \times \text{flow } (\text{gal/hr}) \times 8.34 \text{ lb/gal}$$

Solids loading is expressed in terms of lbs/hr/sq. ft. To figure the lbs of dry solids, find the concentration of suspended solids in the feed in percent. Then find the rate of flow. Pounds can be calculated when concentration and flow are known.

When pounds of dry solids per hour being fed to the thickener have been determined, divide by the surface area in square feet.

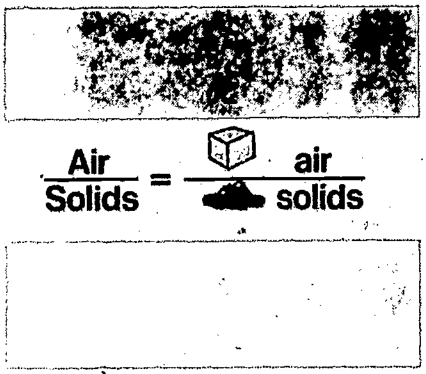
Typically, flotation thickeners operate at hydraulic loadings ranging from 0.5 to 2.0 gpm/ft^2 and at solids loadings of from 2 to 6 $lb/hr/ft^2$.

AIR TO SOLIDS RATIO

The critical operational parameter is the Air to Solids Ratio (A/S Ratio), for there must be enough air to cause flotation, and this is proportional to the solids loading.

Recalling that the retention tank is where air is dissolved in the water, the efficiency with which this is accomplished depends on whether this tank is mechanically mixed or unmixed. An unmixed tank achieves at least 50% saturation of water with air, while a mixed tank may achieve 90% saturation.

As the quantity of dissolved air increases, the number of gas bubbles in the distribution assembly is increased, and more "lift" is provided to float the sludge being introduced at this point.



The air added to the retention tank is provided by a compressor and monitored by an air rotameter and a liquid level indicator in the tank. From an operational standpoint, it is critical that these components are in proper working order.

One cubic foot of air is the equivalent of about 0.075 pounds.

The quantity of air required to achieve satisfactory flotation is directly proportional to the quantity of solids entering the thickener.

For domestic sludges these values range from 0.01 - 0.4 lbs Air/lb Solids, while most operate at a value less than 0.1.

Since one cubic foot of air is the equivalent of about 0.075 pounds, air to solids ratio can easily be calculated if the air discharge (in cubic feet per minute) is known. Using the volume of air, in cubic feet per minute and

its weight of 0.075 pounds per cubic foot, the weight of the air is determined.

This is divided by the pounds of solids applied per minute to the thickener, yielding the air to solids ratio.

POLYMERS Polymers have a significant impact on a thickener's performance. They also influence the acceptable solids and hydraulic loadings as well as the air/solids ratio.

Polymers are often effective in increasing particle size, thus improving operation. Small particles in sludge may not be big enough to trap air bubbles. Doubling the diameter of a particle results in a four-fold increase in the rise rate at a given A/S ratio.

The major disadvantage of polymers is the cost of the polymer itself and the associated chemical feed equipment.

RECYCLE RATE The required recycle rate is unique for each application, although rates of 100 - 200% are typical.

A 100% recycle rate means that for every gallon of influent sludge, 1 gallon of effluent is pressurized and recycled back to the inlet. This recycle stream adds air to the influent so the air-carrying potential is directly related to the recycle rate.

BLANKET THICKNESS

Sludge blanket thickness varies indirectly with the speed of the surface sludge scrapers.

As the speed increases the blanket thickness decreases. Normally, thickeners are operated to maintain a 6 - 8" blanket.

MONITORING THE PROCESS

*Influent
*Effluent
*Thickened Sludge
*Polymer feed

The best performance is usually seen when the thickener is operated continuously at a constant flow. To monitor the process, influent, effluent & thickened sludge streams should be sampled once per shift and composited. Polymer feed rate should also be recorded.

The effluent should be relatively free of solids, resembling secondary effluent, while the thickened sludge should have the consistency of cottage cheese.

In summary, the performance of Dissolved Air Flotation Thickeners can be affected by a number of factors. The type and age of sludge has some bearing on its tendency to sink or float.

CONTROLLABLE PARAMETERS

Controllable operating parameters which affect performance are solids and hydraulic loading, A/S Ratio, polymer, recycle rate, and sludge blanket thickness.

The hydraulic loading governs the flow, in gallons per minute per square foot of surface area. The solids loading, regulates the lbs. of solids applied per hour per square foot of thickener surface area.

Recycle rate is adjusted as a percentage of the sludge flow to the thickener, the percentage being typically 100 - 200% of the sludge flow.

Air/Solids Ratio balances the weight of air with the weight of solids that must be lifted to the surface of the thickener.

The use of polymers has a significant effect on all of these parameters of control. Here is a comparison of performance with and without polymer.

TYPICAL LOADINGS

Solids loadings of 1 - 2 lbs/hr/sq ft and hydraulic load of 0.5 - 1.5 gpm/sq ft are typical for operations not utilizing polymers. When polymers are used, solids loading is increased by 2 - 3 times, while hydraulic loading is increased only slightly.

Ranges for recycle rate and Air/Solids Ratio are not significantly affected by polymer addition.

EFFECT OF POLYMER

With a minimum influent solids concentration of 5,000 mg/l or 0.5%, float solids concentrations of 2 - 4% are expected without polymer, 3 - 5% with polymer. A substantial improvement in solids recovery is seen when polymer is used. 95 - 99% solids capture is possible with polymer, while 50 - 85% is typical without.

Dissolved air flotation is an important sludge dewatering process. It can reduce or eliminate other plant operating costs.

FLOTATION THICKENING
- *Volume reduction
- *Low density sludges
- *Efficient

The flotation thickening process is most effective for thickening aerobic biological sludges. When designed and operated to meet specific requirements, dissolved air flotation is an efficient and reliable process.

REFERENCES

Sludge Treatment and Disposal, Process Design Manual, U.S.E.P.A. September 1979, EPA 625/1-79-001

Manual of Practice No. 11, Operation of Wastewater Treatment Plants, Water Pollution Control Federation, 1978.

EPA Course #166, "Sludge Characteristics", "Sludge Conditioning", "Laboratory Procedures", "Planning Considerations", 1980.

FLOTATION THICKENING

WORKSHEET

1. Choose three factors which affect the operation of a flotation thickener.

_____ a. Food/Microorganism Ratio

_____ b. Air/Solids Ratio

_____ c. Polymer conditioning

_____ d. Solids loading

_____ e. Ambient Temperature

2. What characteristics about primary sludge affect its thickening by flotation?

_____ a. It is lighter than secondary sludge.

_____ b. It is heavier than secondary sludge.

_____ c. It contains heavy solids and grit, causing it to settle.

_____ d. It contains finely divided particles, causing it to float.

_____ e. It is usually well nitrified.

3. Why are bottom scrapers present in a flotation thickener?

_____ a. They mix the sludge to improve flocculation.

_____ b. They keep the tank homogeneously mixed.

_____ c. They collect settled sludge solids.

_____ d. None of the above.

_____ e. All of the above.

4. A treatment plant has a flotation thickener with a surface area of 400 square feet. If total flow to the thickener is 1000 GPM, what is the hydraulic loading in GPM/ft^2?

_____ a. 1.0 GPM/sq. ft.

_____ b. 1.5 GPM/sq. ft.

_____ c. 2.0 GPM/sq. ft.

_____ d. 2.5 GPM/sq. ft.

_____ e. None of the above.

5. If the thickener in Question #4 is loaded with 12,000 lbs of solids per day, what is the solids loading in lbs/hr/sq ft?

_____ a. 1.25

_____ b. 2.50

_____ c. 3.75

_____ d. 5.00

_____ e. None of the above

6. How is the air to solids ratio calculated?

_____ a. D.O./MLSS

_____ b. F/M ÷ SVI

_____ c. Lbs Air/ Lbs Solids

_____ d. SVI / Lbs Solids

_____ e. None of the above

7. What effect does mixing the retention tank have on the amount of air which can be dissolved?

_____ a. Increases it

_____ b. Reduces it

_____ c. Has no effect

_____ d. The amount of air which will dissolve is only dependent on temperature and pressure.

_____ e. None of the above

8. What is meant by a 100% recycle rate on a flotation thickener?

_____ a. For every gallon of thickened sludge removed from the thickener, one gallon of subnatant is sent to the headworks.

_____ b. For every 100 gallons of sludge fed to the thickener, 100 gallons of thickener effluent (subnatant) is recycled to the inlet.

_____ c. Clarifiers are pumping 100% of Q in the return sludge line.

_____ d. Water is 100% saturated with air

_____ e. None of the above.

9. How is sludge blanket thickness controlled on a flotation thickener?

_____ a. Varying the rate of sludge feed.

_____ b. Varying the rate of sludge surface scrapers.

_____ c. Varying the rate of recycle.

_____ d. Varying the rate of air discharge

_____ e. None of the above.

10. What is the normal sludge blanket thickness on a flotation thickener?

_____ a. 1-2 inches

_____ b. 1-2 feet

_____ c. 3-4 feet

_____ d. 6-8 inches

_____ e. None of the above