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ABSTRACT

This lesson, an introduction to belt management, was developed for a course in sludge treatment and disposal. Fundamental principles of belt filter operation are described. Chemical conditioning and the effect on sludge characteristics are discussed, and a detailed description of the different zones of dewatering is presented. Information on typical components and their functions is followed by a discussion of process control parameters and safety considerations. The instructor's manual contains a brief description of the lesson, list of lessons students should review before starting belt filtration, estimated time, instructional materials list, suggested sequence of presentation, required reading list, reference reading list, lecture outline, narrative of the slide/tape program used with the lesson, and student worksheet (with answers). The student workbook contains objectives, plant flow diagrams, glossary, subject matter, references, and worksheet. The subject matter is presented under the following headings: theory, components, process stream characteristics, safety, and operational parameters. (Author/JN)

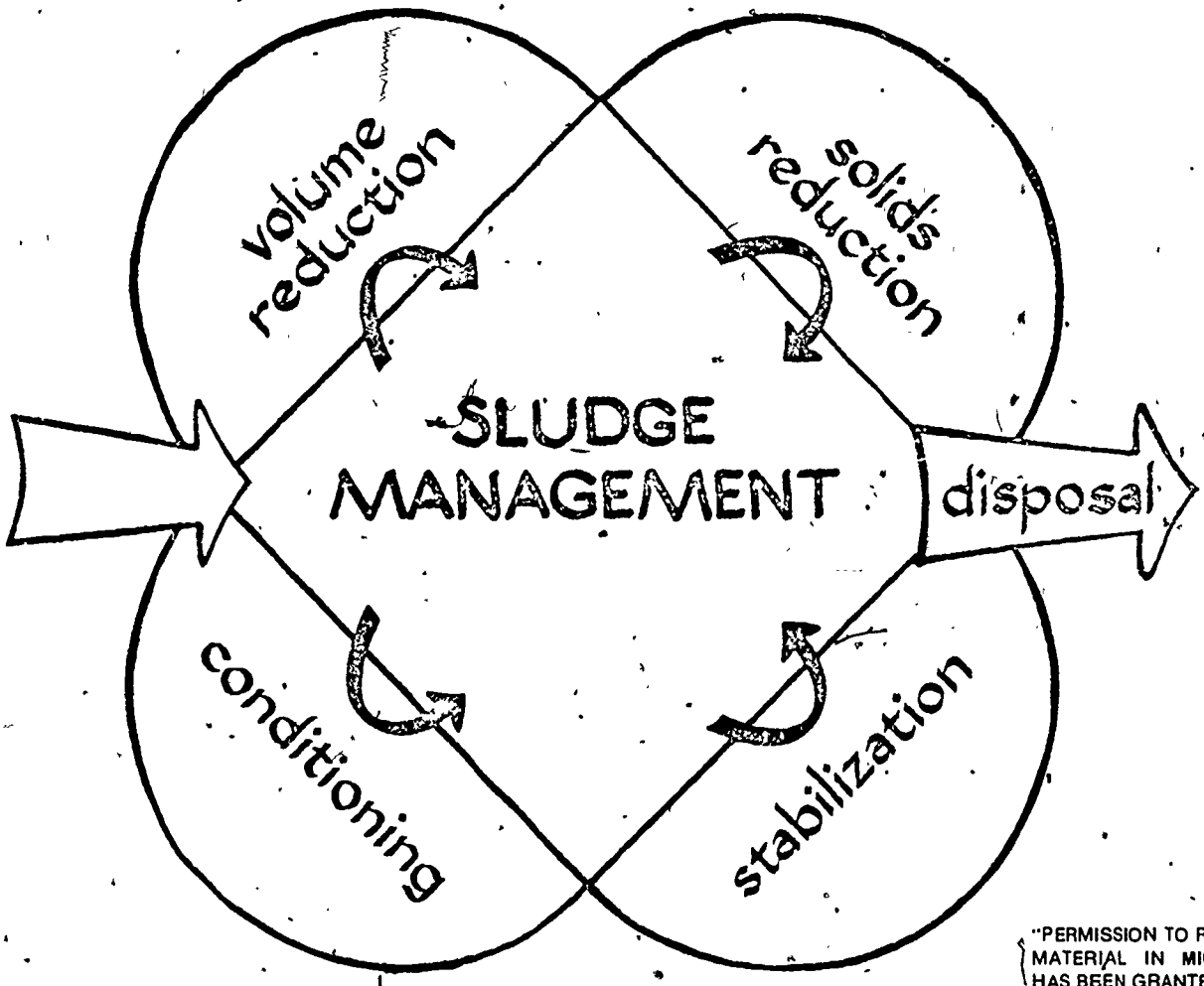
SLUDGE TREATMENT

and

DISPOSAL

COURSE # 166

BELT FILTRATION



INSTRUCTOR'S GUIDE

Prepared by
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and
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BELT FILTRATION

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BELT FILTRATION

CONTENTS

BELT FILTRATION

Lesson Description

This lesson is an introduction to belt filtration. It describes the fundamental principles of belt filter operation and discusses chemical conditioning and the effect on sludge characteristics. A detailed description of the different zones of dewatering is presented. Typical components and their function is followed by a discussion of process control parameters and safety considerations.

It is essential that the student review several lessons before studying Belt Filtration. Pre-requisites are: "Planning Considerations," "Sludge Characteristics," and "Sludge Conditioning." After learning the material in "Belt Filtration," the module entitled "Laboratory Procedures" may be needed to clarify references which are made to lab testing.

Estimated Time

Student preview of objectives	5-10 minutes
Presentation of Material	16 minutes
Worksheet	10-15 minutes
Correct worksheet and discussion	10-15 minutes

Instructional Materials List

1. Student text "Belt Filtration"
2. Slide set "Belt Filtration"
3. Slide Projector, 35 mm
4. Screen
5. Samples of polymers and coagulants
6. Pointer
7. Chalk and Chalkboard or Flipchart and marking pens

Suggested Sequence of Presentation

1. Assign review of objectives and glossary.
2. View slide/tape program or lecture from the lesson outline with support from slides.
3. Hold discussion and question/answer period.
4. Assign worksheet.
5. Correct worksheet and discuss questions that arise.

Required Reading

Student Text, Belt Filtration.

Reference Reading

Sludge Handling and Conditioning, E.P.A. 430/9-78-002, Washington, D.C., February, 1978.

Sludge Treatment and Disposal, Process Design Manual, E.P.A. 625/1-79-011, 1079.

BELT FILTRATION

OBJECTIVES

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

1. Recall that the main use of belt presses is to reduce the volume of sludge to be handled.

2. Recall five stages of processing in a belt press.

3. Recall that the effect of chemical conditioning is a destabilization of surface charges and particles linked together like spaghetti.

4. State what happens in each of the five stages of processing. Acceptable answers are:

    a) Conditioning - sludge becomes fibrous, forms mat.

    b) Gravity Drainage - sludge mat loosens free water for 1 - 2 minutes.

    c) Low Pressure Squeeze - Pressure is applied by top belt, floc water and free water removed, "wedge" zone.

    d) High Pressure Squeeze - "Shear" zone, particles forced out of shape, capillary water lost.

    e) Cake Release - belts separate and flex over discharge roll, doctor (scraper) blade removes sludge.

5. Recall that there are four areas of control of the belt and that they are:

    a) Spray washing

    b) Adjustable tension roller

    c) Tracking control - misalignment

    d) Speed of belt

6. Given a list of components for a typical belt filter, state their function. The list of components include:

    a) Flocculator

    b) Gravity drainage

    c) Low pressure zone

    d) High pressure zone

e) Edge sensors

f) Tracking rolls

g) Tensioning rolls

h) Drive rolls

i) Breast rolls

j) Feed regulator

k) Polymer feed system

l) Drainage tray

m) Wash spray header

n) Frame

o) Main belt

p) Pressure belt

q) Upper belt

r) Removable side panel

s) Doctor blade

t) Control panel

7. Describe the influent to a belt filter.

8. Describe the characteristics of the effluent "cake".

9. Identify the three sidestreams of the press.

10. List the operating changes which may be used to counteract the changes in influent quantity or quality.

11. Recall three reasons that the influent may change.

12. Recall where belt filtration is located in reference to other unit processes.

13. Recognize common safety considerations on a belt filter.

BELT FILTRATION

LECTURE OUTLINE

I. Belt Presses - Function

A. Belt presses squeeze water out of sludge solids.

1. Reduce water before burning or drying.

2. Reduce volume of sludge to be hauled away.

a. landfill

b. landspread

c. composting

B. Dewatering economics

1. Mechanical dewatering cheaper than heat.

2. Belt press - effective mechanical remover of water.

II. Fundamental Principles

A. Four stages of processing

1. Conditioning - chemicals added as flocculent aid.

a. Sludge becomes more fibrous, stringy.

b. Water released as sludge "curdles".

2. Gravity Drainage

a. Water released during flocculation drains away (free water)

b. Continuous porous belt drainage.

3. Low Pressure Squeeze

a. Remaining free water pressed out through belt.

b. Cake mat forms.

4. High Pressure Squeeze

a. Squeeze and Shear - "Washing your hands"

b. Particles compact - floc water forced out.

c. Particles shear - Capillary water squeezed out as particles change shape.

1) New surfaces exposed to porous belt.

B. Total System Overview

1. Conditioning and Processing

a. Chemical Addition, Gravity Drainage, Low and High Pressure Squeeze

2. Belt Control

a. Cleaning

b. Running True

3. Cake Discharge
4. Conveyor
   a. Removal

C. Critical Analysis of Each Area
1. Conditioning
   a. Chemical Effect
      (1) Charge destabilization
      (2) Particles link together - "spaghetti"
   b. Types of Chemicals
      (1) Polymer - polyelectrolyte
         (a) long chain - many reactive sites.
      (2) Lime
         (a) Alkaline powder, raise pH
      (3) Ferric chloride
         (a) yellow-brown liquid
         (b) links particles, they shed water
         (c) Effect of Chemicals
            (1) Sludge becomes fibrous, forms mat.
            (2) Must occur in drainage zone.
               (a) 1-2 minutes of drainage enroute to low pressure squeeze.
2. Gravity Drainage
   a. Mat loses water for 1-2 minutes.
   b. Travelling to low pressure squeeze zone.
3. Low Pressure Squeeze
   a. A second continuous belt meets top of sludge mat.
   b. Pressure is applied.
   c. More free and floc water squeezed out.
   d. Several rollers in low pressure zone.
      (1) Decreasing diameter = increasing pressure.
   e. Increase pressure gradually! = key to good dewatering.
   f. "Wedge Zone" - mat is getting thinner.
4. High Pressure Squeeze
   a. Particles forced out of shape and pressed tighter together.

b. "Shear Zone" - top belt moves at different rate than bottom belt, causing sludge to slip when travelling over roller.

5. Cake Release
   a. Belt flexes over discharge roll
   b. Doctor blade - Scraper rides against belt.
6. Belt Control
   a. After discharge, belt travels back to starting point.
   b. Washed by sprays.
   c. Adjustable tension roller.
   d. Tracking Control - corrects misalignment.
   e. Travel Speed

III. Practical Operation

A. Components and Function

1. Flocculator - Mixes sludge with diluted polymer to expose all electrical-charge areas on sludge surface to the binding and linking action of the conditioning chemical.
2. Gravity Drainage - Allows free water to leave the sludge mass, which compacts slightly and forms a matted structure. Conditioned particles entering this zone have a "cottage cheese" physical appearance (but they're sure not white).
3. Low pressure zone - applies squeeze to sludge mat contained between two porous belts or one porous and one impermeable belt (Carter). The gentle squeeze causes the mat to solidify as the water drains. Some designs do this by a tapered gap between belts.
4. High pressure section - here the maximum possible pressure is applied to compact the particles. This may be done by direct pressure or by "shear" as belts pass over rolls and knead the mat.
5. Edge sensors - a blade, wire, or lever which picks up contact with the belt when it drifts sideways and sends a signal to apply a counter-force. Good roller alignment and machining minimize drift.
6. Tracking rolls - These rolls align the cleaned belt in the return portion of travel by pivoting to push belt travel back into desired path.

7. Tensioning rolls - These rolls can tighten or loosen the belt and are positioned by screw jacks applied to the journal bearings.
8. Drive rolls - These rolls apply the torque of the adjustable speed drive motor to cause belt travel.
9. Breast rolls - These large diameter rolls aid in forming the initial low pressure mat by making a smooth transition from the gravity drainage zone.
10. Feed Regulator - This may be a variable speed Moyno-type pump, or a throttling valve or some other device to control the delivery of sludge to the flocculator. Ideally there will also be a magnetic flow meter for rate observation.
11. Polymer Feed System - Usually consists of a Moyno, gear, or piston pump with speed control, plus a rate meter, taking suction from a day tank in which the diluted polymer is prepared. The purpose is to provide accurate control of the expensive chemical flocculating agent.
12. Drainage Tray - Installed under the belt and roll system. This catches and routes filtrate and wash water. Sometimes it will have partitions to segregate streams, and a sump pump to recirculate clean filtrate to the wash spray nozzles.
13. Wash Spray Header - Applies high velocity water to belt to clean off accumulated sludge.
14. Frame - Basic skeleton of the press. Must be sturdy enough to retain bearings in position against the force of belt tension. Bearing drift would cause tracking trouble.
15. Main Belt - Porous continuous woven mesh of plastic strands, made in seamless style. Cake mat "rides" on this belt through the whole process.
16. Pressure Belt - A belt the same width as main belt, that applies squeeze in the travel path. May be porous and travel through both low and high pressure zones, or only the low pressure zones.
17. Upper Belt - A special short non-porous belt used by two manufacturers to apply squeeze in the low pressure zone.
18. Removable Side Panel - Sheet metal enclosure that helps retain odors within the press frame for easier venting. Also prevents side spray onto floor, but retards cleanup and observation of what is actually

occurring in the press.

19. Doctor Blade - A scraper that spans the width of the belt at the discharge point and assures removal of the cake.
20. Control Panel - Housing for the electrical functions of drive motor control and speed adjustment, flocculator rotation, polymer rate control, and possibly feed rate control. May also have readouts for operating variable instruments and alarms.

B. Characteristics

1. Influent
   a. Variable concentration 0.5-8% (watery to pea-soup)
   b. Heavy sludge - difficult to condition - better productivity of total tonnage.
   c. Biological Sludge
      (1) 3-6%
   d. Debris - fouls equipment
      (1) Sticks
      (2) Rags
      (3) Trash
   e. Odors
      (1) Aged sludge - nuisance
2. Effluent
   a. "Cake" - product of pressing sludge
      (1) Consistency of mud to broken, wet cardboard.
      (2) Depends on ratio of primary/secondary.
      (3) Similar to vacuum filter cake
      (4) Pathogenic
3. Sidestreams
   a. "Pressate" or "Filtrate"
   b. Belt washings
   c. Vented off-gas - foul air
      (1) offensive
      (2) corrosive
4. Process Characteristics
   a. If influent quantity and quality are stable, process is stable.

b. Changes in influent requires adjustment of
   (1) polymer dosage
   (2) belt speed
   (3) roll pressure
   (4) polymer formula
c. Causes of changes in influent
   (1) changing feed tank
   (2) added streams, such as scum
   (3) stratification of sludge in feed tank.

5. Interaction with other processes
   a. Second step in sludge processing.
   b. Follows thickening.
   c. Precedes incineration, drying, landfill, composting.

C. Safety Considerations
1. Overpressure - feed pump - causes rupture
   a. If discharge valve is shut off.
2. Polymer spills
   a. Difficult to sluice away
   b. Granulated salt = good "slip killer"
3. Moving parts - leave guards in place
   a. Pinching, crushing
4. Compression springs
   a. On roller journals - high tension
5. Motor control system
   a. High voltage
6. Belt
   a. Avoid tramp iron
   b. Alignment and tracking
7. Conveyor
   a. Don't stand on conveyor when doing maintenance.
   b. Use platforms, ladders.

OPERATIONAL PARAMETERS

Operating Parameter	Typical Range	Means of Diagnosis and Control
Sludge Feed Rate	20 to 200 GPM	Operator observation of width on belt or squeeze-out.
Polymer Dose	6 to 12 pounds (dry) per ton solids.	Meter by tank level drop, calculate dosage. Find optimum using CST, Buchner or leaf test.
Polymer Strength	0.05 to 0.25%	Lab test for solids. Follow dilution instructions verbatim.
Rotating Drum Mixer Speed(Flocculator)	30 to 90 RPM	Good floc formed. Keep slow as possible.
Belt Speed	$\frac{10}{2}$ to $\frac{16}{2}$ fpm	Operator observation of carry away from ponding area, cake thickness. Keep slow consistent with output target.
Belt Tension	$\frac{10}{2}$ to $\frac{30}{2}$ psi	Govern by cake appearance and stickiness.
Belt Cleanliness	Good to excellent.	Visual check on section past wash sprays. Raise pressure if dirty. Clean with detergent if grease fouled.
Filtrate Clarity	Varies with sludge and fabric.	Lab test or sample eyeball check - use to optimize polymer and fabric type.
Cake Dryness	16 to 28% (Range determined by sludge)	Ohaus balance test run hourly. Check samples sent to lab.

BELT FILTRATION

NARRATIVE

Slide #

1. This module deals with the process of belt filtration. The theory of operation, the components of the filters, and operational goals are all discussed.

2. The module was written by Dale Broste and edited by Dr. John W. Carnegie. Instructional design was done by Priscilla Hardin. Paul H. Klopping was project manager.

3. Belt filtration is used to reduce sludge volume. Belt filters are an economical method of sludge volume reduction prior to incineration, landfill, land application or composting.

4. The belt filter reduces sludge volume by squeezing water out of the sludge. This squeezing action is produced by mechanical means in much the same way that an old-time clothes wringer squeezes out the water.

5. Belt filters are produced by a number of manufacturers and vary somewhat in appearance. However, the theory and operation are quite similar, regardless of the brand. This module will describe the theory and operation of belt filtration, which can be applied to all belt filters. Some unique features of specific brands may not be covered.

6. The belt filter consists of two belts which sandwich the sludge between them as they pass through rollers. Water filters out through the porous belt material leaving a drier sludge cake trapped between the two belts.

7. These belts are continuous loops. The upper and lower belts come together to squeeze the sludge and move jointly over a system of common rollers. They then return over separate rollers to receive more sludge.

8. The lower belt is a porous material which picks up the feed sludge from a pool and carries it toward the first squeeze roller.

9. The upper belt moves thorugh the rollers, trapping the sludge solids in a sandwich. As the belts travel around the rollers, belt tension creates pressure, squeezing water out of the sludge.

10. Sludge falls off of the belts and leaves the filter in a form that resembles wet cardboard. It is usually removed by conveyor or auger to subsequent disposal processes.

11. The belt filter removes water from the sludge as it passes through 3 zones. These zones are called the drainage zone, the low pressure zone, and the high pressure zone.

12. The types of water that are removed in these three zones are free water, floc water, and capillary water. Bound water and intracellular water are not removed by belt filtration.

13. In the drainage zone, free water is removed from the sludge simply by gravity. This occurs on the lower feed belt as it moves toward the rollers, but before the upper belt starts to form the sandwich.

14. As the upper belt starts to squeeze, the sludge enters the low pressure zone where floc water is removed. The pressure applied to the sludge increases as the belts are pulled tighter and tighter by moving over progressively smaller rollers.

15. In the high pressure zone, capillary water is removed along with floc water. The upper and lower belts moving at different speeds produce a shearing action. This shearing action tears the sludge particles apart and aids in the release of capillary water.

16. We have looked briefly at the theory of belt filtration. Now let's discuss the typical belt filter components to see how the theory is applied.

17. The frame supports the rollers and the drainage system.

18. The belt itself is made of various types of material; depending on the brand and the application. A typical porous, plastic belt material is shown in this slide.

19. The baffle in front of the influent pipe distributes the sludge evenly to make a pool through which the lower belt passes. As the belt moves out of the pool the sludge is spread evenly over the entire width of the feed belt.

20. As the loaded belt passes through the drainage zone, water drips into one of several drainage trays. All of the drainage trays empty into the main catch basin under the belt filter.

21. The breast rolls are the first rollers that the belts encounter in the low pressure zone. These rollers provide for a smooth transition between the gravity drainage and low pressure zones.

22. Adjustable tension rolls loosen or tighten the upper and lower belts.

23. The drive roll is connected to a variable speed motor which provides the torque necessary to move the belts through the filter. The drive roll is a large roll carrying both belts.

24. The discharge rolls cause the dried sludge to crack and fall off the belt. Doctor blades, near the top and bottom discharge rolls, scrape the sludge off the belt.

25. Edge sensors make contact with the edge of the belt when it drifts out of line. They may be a wire, a lever or a blade, as shown here. The edge sensor sends an electric signal to tracking rolls to apply corrective force.

26. The tracking rolls respond to the edge sensor signal by pivoting slightly and causing the belt to move sideways back into proper alignment.

27. The belts pass through spray washers to remove accumulated sludge, as they make the loop back to the start. The fine, high-pressure spray covers the entire width of the belt.

28. So those are the components of the belt filter: the frame, the various rolls, the drive motor, the belts, the feed distribution system, the washers and drains.

29. The rolls include the breast rolls, the tension rolls, the drive roll, the tracking roll with the edge sensor and the discharge rolls.

30. The belt filter unit itself is only a part of the belt filter system which includes several supporting processes. These processes are grinding, blending, conditioning, filtrate and cake removal.

31. Sludge first passes through grinders that break up large pieces that might damage the belt. A sludge of small, uniform solids is more easily conditioned and dewatered.

32. Blend tanks are used to mix types of sludge prior to filtration. For example, primary sludge may be mixed with waste activated sludge to improve the dewaterability of the waste activated sludge.

33. Sludge is chemically conditioned by the addition of coagulants. Calibrated feed pumps control the chemical addition.

34. Flocculation of coagulated sludge solids takes place in mix tanks or conditioners just prior to entering the filter.

35. On the other side of the belt filter, two types of material leave the unit: the sludge cake discharge, and the filtrate sidestream.

36. The sludge cake drops onto a conveyor or auger and is removed for further treatment such as incineration, land application, landfill, or composting.

37. The filtrate sidestream is returned to the plant headworks where it can represent a significant hydraulic and organic load on the plant.

38. Operational control of the belt filter includes control of the conditioning process, sludge feed rate, belt speed, belt tension and wash down. Let's first consider conditioning.

39. Optimum conditioning assures good filter operation. Refer to lab tests and plant records of past performances to determine the type and amount of conditioning chemical necessary to bring about optimum coagulation and flocculation.

40. After the optimum chemical concentration is determined, the chemical feed rates are set. The point of chemical application will also have an influence on good floc formation.

41. The mixing speed in the conditioner is important. Mixing too vigorously may break up the floc or not allow it to form properly. The goal of conditioning is to create relatively large and strong floc particles that can stand the stress of the belt filter pressure and still allow water to escape.

42. Feed rate affects dewaterability. High feed rates mean heavy load and wet cake; lower feed rates mean lighter load and drier cake.

43. When adjusting the feed rate, the operator must consider the proper sludge blend and the conditioning chemical dosage.

44. Belt speed and belt tension also affect dewaterability.

45. Belt speed is controlled by adjusting the drive motor speed. If the belt moves fast, more sludge can be applied but the cake will be wet. If the belt moves slowly the cake may be dry but less sludge can be applied.

46. Belt tension is controlled by adjusting the hydraulic pressure to cylinders that control the tension roll position. This, in turn, increases or decreases the squeezing pressure on the sludge. Generally, higher belt tension means drier cake, but also increases belt wear.

47. Wash down is a preventive maintenance item that can save considerable down time.

48. Removing sludge from rollers and belts prevents plugging and build-up which can lead to misalignment and belt damage.

49. The operator must monitor cake quality and adjust the system to produce the best cake from the least cost.

50. The belt filter can be a dangerous place to work. Water, sludge, polymers, and lubricants can all contribute to spills. Move cautiously and keep the area clean.

51. The filter has many moving parts. Keep loose clothes and hair away from gears and rollers and keep protective shields in place.

52. Avoid electrical shocks by wearing rubber boots and using properly grounded electrical equipment.

53. Do not eat, drink, or smoke until you have left the area and cleaned up. Sludge contains pathogenic organisms.

54. In this module we have discussed dewatering sludge by belt filtration. Water is squeezed from the sludge as it is sandwiched between two belts and passes through a series of rolls.

55. The belt filter consists of two continuous belts passing over various rolls. Sludge feed troughs, washers, and drains complete the process components.

56. We saw that the belt filter system includes grinding, blending, and conditioning prior to the filter itself. Material leaves the filter as sludge cake or filtrate.

57. We outlined five important operational controls. The belt filter operation must be concerned about conditioning, feed rate, belt speed, belt tension, and wash down.

58. And finally, we summarized the fundamental goals of operation. The belt filter is an effective and useful method of sludge dewatering if operated correctly. The goals of proper operation are quality cake and filtrate, cost effectiveness, and safety.

BELT FILTRATION

WORKSHEET

Place an "X" next to the best answer(s), or place the appropriate letter in the space for multiple choice questions.

1. How are belt filters typically used in a treatment plant? (Choose two)

   __X__ a. They reduce the water content of sludge before burning.

   _____ b. They stabilize raw sludge so that it can be spread on land.

   _____ c. They thicken sludge prior to return to the aeration basin.

   __X__ d. They reduce the volume of sludge to be handled.

   _____ e. They filter suspended solids out of the final effluent.

2. There are five stages of processing sludge through a belt filter. Arrange the following stages in the proper sequence from beginning to end.

   __D__ 1st step
   __A__ 2nd step
   __B__ 3rd step
   __E__ 4th step
   __C__ 5th step

   a. Gravity Drainage
   b. Low Pressure Squeeze
   c. Cake Release
   _____ d. Conditioning
   e. High Pressure Squeeze

3. You are given a description of which occurs in each stage of belt filtration. Match the description with the stage.

   __E__ "Shear zone" - particles force out of shape, capillary water lost.

   __C__ Belts separate and flex over discharge roll, doctor blade.

   __A__ Sludge mat lose free water, 1 - 2 minutes.

   __B__ Pressure applied by top belt, floc water and free water removed, "wedge" zone.

   __D__ Sludge becomes fibrous; stringy

   a. Gravity Drainage
   b. Low Pressure Squeeze
   c. Cake Release
   d. Conditioning
   e. High Pressure Squeeze

4. There are four types of belt control required on a press when in operation. What are they?

   __X__ a. Tracking control to correct misalignment
   __X__ b. Speed of belt
   __X__ c. Spray washing
   __X__ d. Tension roller adjustment
   _____ e. Control pore size

5. Choose two characteristics that best describe the influent to a belt filter.

   X a. Watery to pea soup consistency, 0.5 - 8.0% solids.

   ___ b. Consistency of mud or wet cardboard, 10 - 25% solids.

   ___ c. Nonoffensive

   ___ d. Nonpathogenic

   X e. Potential for carrying debris.

6. Choose two characteristics that best describe the effluent "cake" of a belt filter.

   ___ a. Watery to pea soup consistency, 0.5 - 8.0% solids.

   X b. Consistency of mud or wet cardboard, 10 - 25% solids.

   X c. Dependent on ratio of primary to secondary sludge.

   ___ d. Nonpathogenic

   ___ e. Nonoffensive

7. What sidestreams are present in belt filtration?

   X a. Pressate or filtrate

   ___ b. Thickened sludge

   X c. Off-gas

   X d. Belt washings

   ___ e. Supernatant

8. On the following list, place an "X" by each item which may be changed by an operator in making normal process control decisions.

   X a. Polymer formula

   X b. Polymer dosage

   ___ c. Belt pore size

   ___ d. Belt area

   X e. Roll pressure

   X f. Belt speed

   X g. Feed rate

   X h. Blend ratio of primary/secondary

9. What are three reasons why the influent sludge stream to a belt filter may change?

___ a. Filter cloth plugs up (blinds).

_X_ b. Feed tank is not homogenous throughout.

_X_ c. Feed tank has been changed.

_X_ d. Another stream from elsewhere in the plant has been added.

___ e. Cake conveyor breaks down.

10. With the letter "A", mark the unit processes that follow belt filtration. Mark those that may logically precede it with a "B".

_B_ Bar screen

_A_ Incineration

_B_ Secondary treatment

_B_ Flotation thickener

_B_ Gravity thickener

_A_ Landfill

_A_ Composting

_B_ Primary treatment

_B_ Aerobic digestion

_B_ Anaerobic digestion

_B_ Grit chamber

_A_ Heat drying

11. With the letter "A", mark the operating parameters that would be checked and diagnosed with visual observations. With the letter "B", mark those that require lab testing for diagnosis. Where both diagnostic methods are used, mark a letter "C".

_C_ Sludge feed rate

_C_ Polymer dose/effectiveness

_A_ Mixer speed (flocculation)

_A_ Belt tension

_A_ Belt cleanliness

_C_ Filtrate quality and clarity

_C_ Cake dryness

_A_ Belt speed

_B_ mg/l of influent suspended solids

_B_ mg/l of pressate BOD

XT-154 (BF)

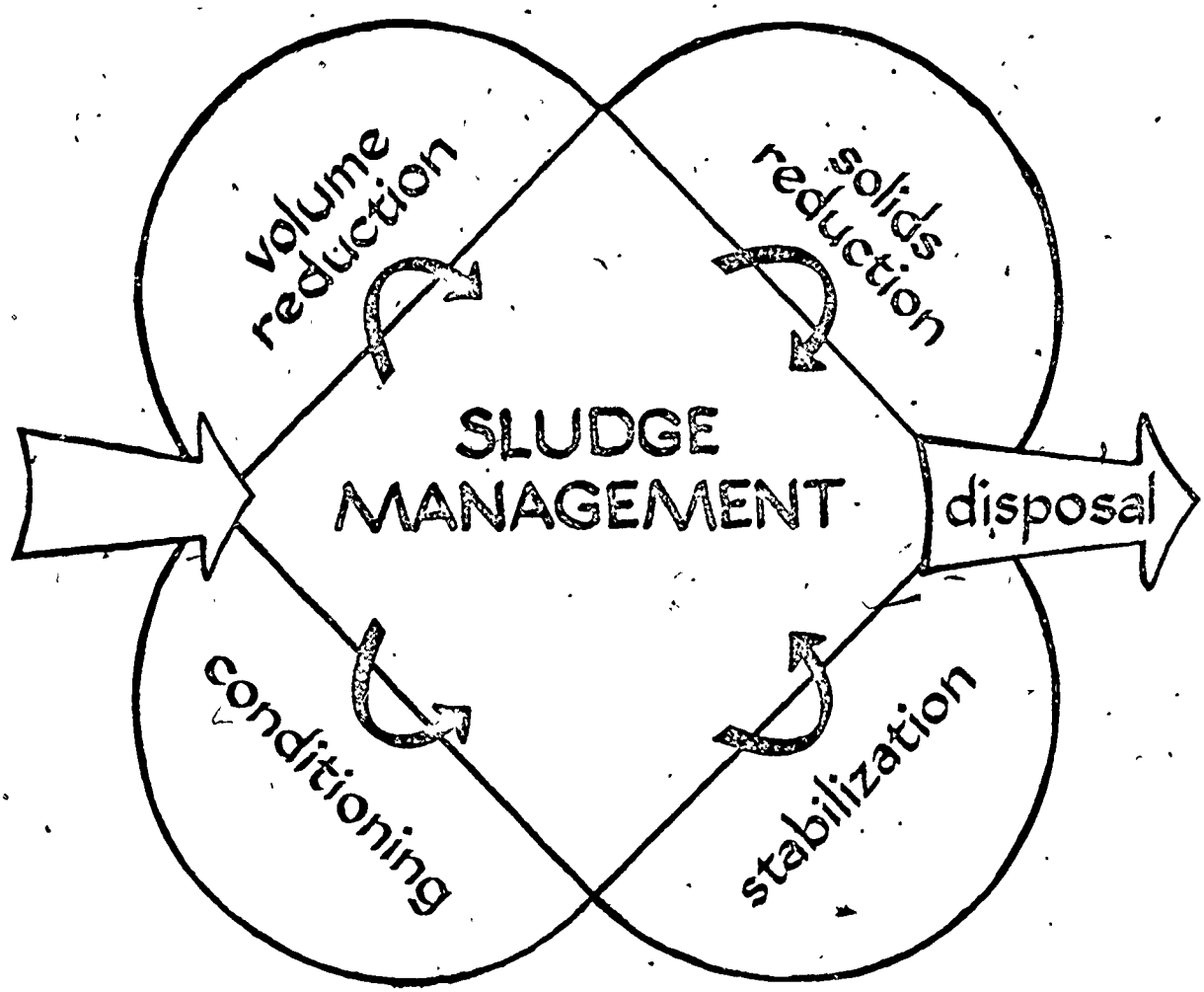
SLUDGE TREATMENT

and

DISPOSAL

COURSE # 166

BELT FILTRATION



STUDENT WORKBOOK

Prepared by
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BELT FILTRATION

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BELT FILTRATION

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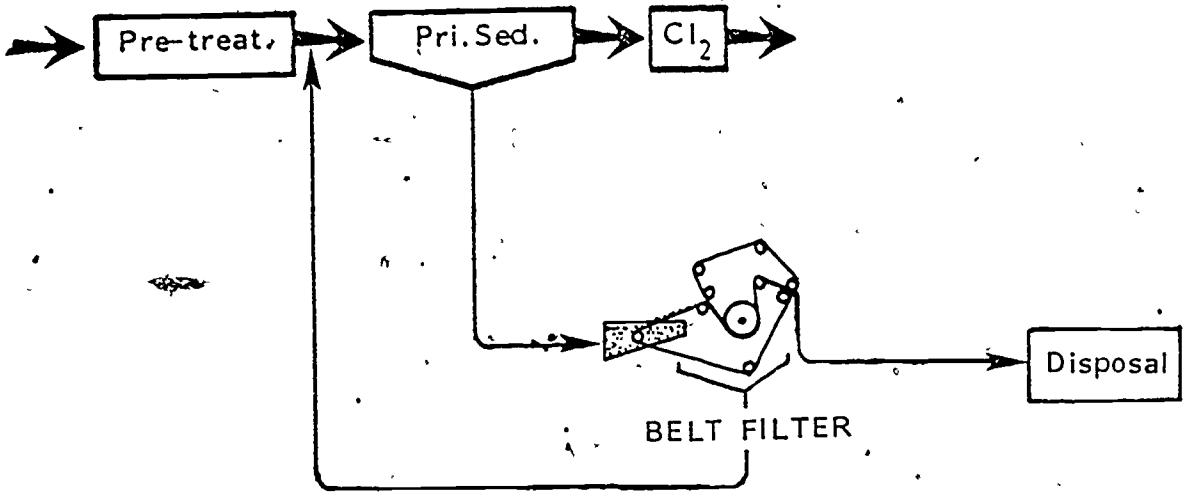
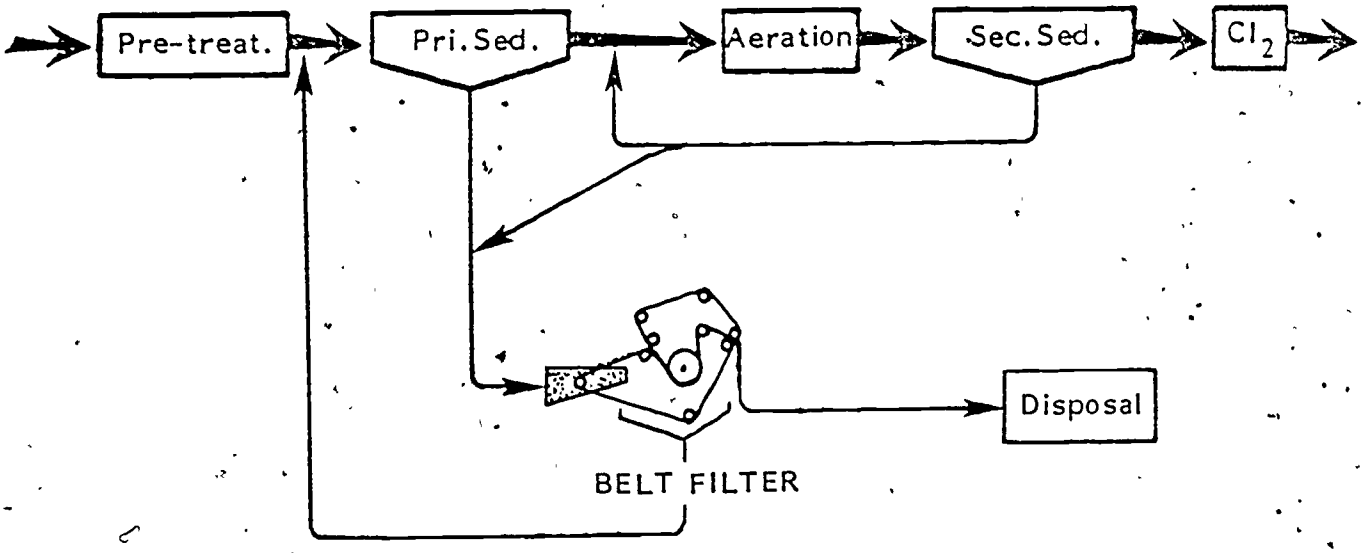
PLANT FLOW DIAGRAMS

PRIMARY PLANT



SECONDARY PLANT



BELT FILTRATION

OBJECTIVES

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

1. Recall that the main use of belt presses is to reduce the volume of sludge to be handled.

2. Recall five stages of processing in a belt press.

3. Recall that the effect of chemical conditioning is a destabilization of surface charges and particles linked together like spaghetti.

4. State what happens in each of the five stages of processing. Acceptable answers are:

    a) Conditioning - sludge becomes fibrous, forms mat.

    b) Gravity Drainage - sludge mat loosens free water for 1 - 2 minutes.

    c) Low Pressure Squeeze - Pressure is applied by top belt, floc water and free water removed, "wedge" zone.

    d) High Pressure Squeeze - "Shear" zone, particles forced out of shape, capillary water lost.

    e) Cake Release - belts separate and flex over discharge roll, doctor (scraper) blade removes sludge.

5. Recall that there are four areas of control of the belt and that they are:

    a) Spray washing

    b) Adjustable tension roller

    c) Tracking control - misalignment

    d) Speed of belt

6. Given a list of components for a typical belt filter, state their function. The list of components include:

    a) Flocculator

    b) Gravity drainage

    c) Low pressure zone

    d) High pressure zone

e) Edge sensors

f) Tracking rolls

g) Tensioning rolls

h) Drive rolls

i) Breast rolls

j) Feed regulator

k) Polymer feed system

l) Drainage tray

m) Wash spray header

n) Frame

o) Main belt

p) Pressure belt

q) Upper belt

r) Removable side panel

s) Doctor blade

t) Control panel

7. Describe the influent to a belt filter.

8. Describe the characteristics of the effluent "cake".

9. Identify the three sidestreams of the press.

10. List the operating changes which may be used to counteract the changes in influent quantity or quality.

11. Recall three reasons that the influent may change.

12. Recall where belt filtration is located in reference to other unit processes.

13. Recognize common safety considerations on a belt filter.

BELT FILTRATION

GLOSSARY

Belt Tension - The pressure, in psi, applied to the belts in the low and high pressure sections of a filter press.

Cake or Cake Mat - Sludge which has been partially dewatered by mechanical means. It has thus changed from a slurry to a fibrous mat, resembling wet carboard.

Doctor Blade - A scraper at the discharge end of a dewatering process which scrapes sludge cake free from the supporting surface.

Feed Rate - Rate that sludge is pumped to a processing device, usually expressed in gallons per minute (GPM).

Feed Tank - The tank containing the reservoir of sludge to be fed to the filter press.

Mixer Speed - Speed of the mixer blending sludge and conditioning chemicals prior to mechanical dewatering. Flocculation occurs during this mixing process. May be done in a rotating drum.

Pressate - The water which has been removed from sludge during belt filtration. This may occur through gravity drainage, squeezing or shear forces. Also called the filtrate.

Stratification - A layering of concentrations within one container - often refers to such a condition in the feed tank.

BELT FILTRATION

COST?

*handle solids or water?

EFFECTIVE DEWATERING

Belt presses squeeze water out of sludge solids. A belt press in a wastewater plant is an important contributor to economical operation. Water removal from sludge reduces costs regardless of whether the sludge solids are:

(a) burned or dried on-site, or

(b) Hauled away to landfill, landspread, or composting.

Mechanical removal of water usually costs less per ton removed than water removed by heat, so the most cost-effective dewatering system possible should be in service in each plant. Based on recent equipment development, this often calls for the belt press.

FUNDAMENTAL PRINCIPLES

The belt press applies several steps of processing to the sludge:

FILTRATION STEPS

*conditioning

*gravity drainage

*low pressure squeeze

*high pressure squeeze

(a) chemical conditioning, to flocculate the sludge into a fibrous network and strip adherent water from sludge particles.

(b) gravity drainage, to let the water loosened by the chemicals run free, through a continuous porous belt or similar drainage.

(c) low pressure squeeze, to further remove water loosened by conditioning and to form a cake mat on the porous belt.

(d) High pressure squeeze and shear (like washing your hands) to compact the sludge particles and cause more water to drain through the belt.

BELT CONTROL

The total system includes devices to carry out all these steps, plus devices to keep the belt clean, running true, and discharging cake efficiently onto a conveyor belt.

CONDITIONING

The principle of conditioning involves both chemical and physical effects. In the sludge particle surfaces there are sites that carry an electrical charge, something like the static electricity that builds up on a comb when used on a dry day. These electrical charges react with the conditioning chemical to form bonds that allow the chemical to link many thousands, maybe millions, of sludge particles together, making a network something like a plate of spaghetti. The chemicals most commonly used in belt presses are called "polymers" or more correctly, polyelectrolytes: each polymer molecule is an extremely long chain with electrical charge locations distributed along it's length.

In some cases, other chemicals may also be used for conditioning. Lime, an alkaline white powder, may be dispersed in water and mixed into the sludge to raise the pH if required. Ferric chloride, a yellow-brown liquid, is also sometimes used as a linking agent to hold sludge particles together, enabling them to shed water.

GRAVITY DRAINAGE

The linking of the sludge permits the development of a mat of fibrous structures in the first portion of the press. Here, the sludge is spread out on the belt and allowed to drain free for one to two minutes as the porous belt moves slowly into the low pressure squeeze

zone. Another continuous belt meets the top of the sludge mat. As rolls apply pressure to belts below and above the mat, more easily removed water is squeezed out. One design has a rotating porous drum to accomplish the gravity drainage.

LOW PRESSURE SQUEEZE

*"Wedge" zone

The low pressure roll system includes several rolls, sometimes with decreasing diameters for gradual increase of pressure. The key to good dewatering of wastewater sludge is to raise the squeeze at a gradual rate; otherwise, the soft material will be forced into the mesh of the belt instead of forming a tough mat. This zone is sometimes called the "wedge" zone because the cake mat gets thinner as it passes through.

HIGH PRESSURE SQUEEZE

*"Shear" zone

Water that remains between adjacent particles is squeezed out in the high pressure section, where the particles are forced out of shape and into each other. This shearing action removes some capillary water still clinging to the particles. Some designs use the decreasing-roll-diameter in the high pressure zone, which is called the "shear" zone. Shear is a term describing the action where one belt moves at a different rate than the other, causing a slip tendency in the sludge mat which helps release tightly held capillary water. The release of cake from the belt is aided by two features, (a) the flexing of the belt over the discharge roll, and (b) a scraper called a "doctor blade" which rides against the belt. After discharge the belt passes back to the start point, and in the process is washed by sprays, passes over an adjustable tension

CAKE RELEASE

roller, and is influenced by tracking control which senses mis-alignment and exerts a corrective push.

COMPONENTS

In the following section, the terms used by various manufacturers to describe the system's components are listed. Some presses do not have all of these items.

1. Flocculator - flocculation tank - conditioning tank mixing drum.
2. Gravity Drainage Section - Reactor - Stage 1.
3. Low Pressure Section - wedge zone - Stage 2 "S" or "P" Zone.
4. High Pressure Section - Shear Zone - Stage 3.
5. Edge sensors
6. Tracking Rolls
7. Tensioning Rolls and Adjustment
8. Drive Rolls
9. Breast Rolls
10. Feed Regulator
11. Polymer Feed System
12. Drainage Tray (pan)
13. Wash Spray Header
14. Frame with Bearings
15. Main Belt
16. Pressure Belt
17. Upper Belt
18. Removable Side Panel
19. Doctor Blade
20. Control Panel
    Belt Speed Control
    Flocculator Speed Control

BELT FILTER COMPONENTS

*What do they do?

Feed Rate Control

Polymer Rate Control

Now let's take a look at each component and describe what it does.

1. Flocculator - Mixes sludge with diluted polymer to expose all electrical-charge areas on sludge surface to the binding and linking action of the conditioning chemical.

2. Gravity Drainage - Allows free water to leave the sludge mass, which compacts slightly and forms a matted structure. Conditioned particles entering this zone have a "cottage cheese" physical appearance (but they're sure not white).

3. Low pressure zone - applies squeeze to sludge mat contained between two porous belts or one porous and one impermeable belt (Carter). The gentle squeeze causes the mat to solidify as the water drains. Some designs do this by a tapered gap between belts.

4. High pressure section - here the maximum possible pressure is applied to compact the particles. This may be done by direct pressure or by "shear" as belts pass over rolls and knead the mat.

5. Edge sensors - a blade, wire, or lever which picks up contact with the belt when it drifts sideways and sends a signal to apply a counter-force. Good roller alignment and machining minimize drift.

6. Tracking rolls - These rolls align the cleaned belt in the return portion of travel by pivoting to push belt travel back into desired path.

7. Tensioning rolls - These rolls can tighten or loosen the belt and are positioned by screw jacks applied to the journal bearings.

8. Drive rolls - These rolls apply the torque of the adjustable speed drive motor to cause belt travel.

9. Breast rolls - These large diameter rolls aid in forming the initial low pressure mat by making a smooth transition from the gravity drainage zone.

10. Feed Regulator - This may be a variable speed Moyno-type pump, or a throttling valve or some other device to control the delivery of sludge to the flocculator. Ideally there will also be a magnetic flow meter for rate observation.

11. Polymer Feed System - Usually consists of a Moyno, gear, or piston pump with speed control, plus a rate meter, taking suction from a day tank in which the diluted polymer is prepared. The purpose is to provide accurate control of the expensive chemical flocculating agent.

12. Drainage Tray - Installed under the belt and roll system. This catches and routes filtrate to the wash spray nozzles.

13. Wash Spray Header - Applies high velocity water to belt to clean off accumulated sludge.

14. Frame - Basic skeleton of the press. Must be sturdy enough to retain bearings in position against the force of belt tension. Bearing drift would cause tracking trouble.

15. Main Belt - Porous continuous woven mesh of plastic strands, made in seamless style. Cake mat "rides" on this belt through the whole process.

16. Pressure Belt - a belt the same width as main belt, that applies squeeze in the travel path. May be porous and travel through both and high pressure zones, or only the low pressure zones.

17. Upper Belt - A special short non-porous belt used by two manufacturers to apply squeeze in the low pressure zone.

18. Removable Side Panel - Sheet metal enclosure that helps retain odors within the press frame for easier venting. Also prevents side spray onto floor, but retards cleanup and observation of what is actually occurring in the press.

19. Doctor Blade - A scraper that spans the width of the belt at the discharge point and assures removal of the cake.

20. Control Panel - Housing for the electrical functions of drive motor control and speed adjustment, flocculator rotation, polymer rate control, and possibly feed rate control. May also have readouts for operating variable instruments and alarms.

PROCESS CHARACTERISTICS

PROCESS STREAM CHARACTERISTICS

INFLUENT

Sludge entering the system may vary in concentration from 0.5 to 8 percent solids, depending on its origin, and it will range from watery to pea-soup consistency. Heavier sludge generally means higher productivity (tonnage) but it increases the difficulty of getting good, uniform conditioning. Most sludges that have been influenced biologically, such as waste activated, digested, or aged, will be in the range 3 to 6%. The sludge may contain debris such as sticks,

rags, or other trash that fouls pumps and other handling equipment. Aged sludge may be very odorous, but the belt press permits capture of odors fairly readily.

Other input streams are polymer, a syrupy liquid diluted to 0.05 to 0.25% for thorough mixing, and wash water for belt sprays. Some designs re-use part of the clear filtrate for belt cleaning.

Effluent

The product of the press is called "cake", and it will typically range in consistency of mud to broken-up wet cardboard, depending on the ratio of secondary to primary sludge solids: It's handling properties are similar to vacuum filter cake, and it may cause disease. If stored it can develop offensive odors.

Sidestreams

The main output stream is filtrate, "pressate", to which may be added the belt washings.

From sludges containing odorous material there may be a vent gas stream of foul air that must be treated or dispersed. If confined, the gas will have moisture and corrosive content to be dealt with.

Process

1. This process runs very smoothly when influent sludge stays stable in quantity and quality. If sudden changes are made due to changing feed tanks; stratification of sludge in feed tank, or added streams such as scum, the polymer dosage must be readjusted to new optimum. Also, belt speed and roll pressure may have to.

be changed. Polymer formula may have to be changed. Polymer optimizing tests must be at the command of the operator.

2. The process is the second step in sludge disposal, following thickening, and usually precedes incineration or land disposal.

3. The process has little adverse impact on other parts of the plant during normal, rated operation. However, if it can't keep up with sludge production, a severe impact on effluent quality arises, because of solids back-up in the wet end.

SAFETY

The belt press is a relatively low hazard system relativeto some other treatment plant processes. Pressures and rotational speeds are moderate - however, certain unique hazards must be acknowledged and guarded against.

Overpressure in the feed pump delivery line can result if a downstream valve is shut off, assuming a positive displacement type pump, such as plunger or Moyno. Resultant rupture can injure people and equipment.

Polymer spilled on the floor is very slippery and can cause bone-breaking falls. It is hard to sluice away. Granulated salt is a good "slip killer" for many polymers.

The belt press has many working parts that can catch arms, hair, sleeves, fingers. Leave guards in place and don't service moving machinery.

Polymer cake, like sludge, is not sterile, so care should be taken that none enters mouth, eyes, etc. Wash hands before lunch.

Compression springs on roller journals pack a lot of wallop. Disassemble with care.

The motor control system has hazards similar to any of that voltage. Keep covers in place and have licensed electricians perform maintenance.

Prevent tramp iron from passing through, to avoid belt tears. Also, check alignment and tracking frequently to avoid belt damage.

Keep clear of cake conveyor working parts. Have adequate platforms, ladders, etc., to avoid standing on conveyor to do press maintenance.

Belt filtration can be an important contributor to economical operation. The efficient removal of water from sludge is essential in an economical sludge management program. When properly selected, built and operated, belt filters have performed well and represent a significant means of sludge dewatering.

OPERATIONAL PARAMETERS

Because this is a generalized discussion of various manufacturers' offerings, applied to various sludges, no specific numbers can be given for operating values. The following is intended, therefore, to present wide ranges within most municipal sludge installations will fall, to give the student a sense of magnitude.

Operating Parameter	Typical Range	Means of Diagnosis and Control
Sludge Feed Rate	20 to 200 GPM	Operator observation of width on belt or squeeze-out
Polymer Dose	6 to 12 pounds (dry) per ton solids.	Meter by tank level drop, calculate dosage. Find optimum using CST, Buchner or leaf test.
Polymer Strength	0.05 to 0.25%	Lab test for solids. Follow dilution instructions verbatim.
Rotating Drum Mixer Speed(Flocculator)	30 to 90 RPM	Good floc formed. Keep slow as possible.
Belt Speed	$\frac{10}{2}$ to $\frac{16}{2}$ fpm	Operator observation of carry away from ponding area, cake thickness. Keep slow consistent with output target.
Belt Tension	$\frac{10}{2}$ to $\frac{30}{2}$ psi	Govern by cake appearance and stickiness.
Belt Cleanliness	Good to excellent.	Visual check on section past wash sprays. Raise pressure if dirty. Clean with detergent if grease fouled.
Filtrate Clarity	Varies with sludge and fabric.	Lab test or sample eyeball check - use to optimize polymer and fabric type.
Cake Dryness	16 to 28% (Range determined by sludge)	Ohaus balance test run hourly. Check samples sent to lab.

BELT FILTRATION

References

Required Reading

Student Text, "Belt Filtration"

Reference Reading

Sludge Handling and Conditioning, EPA 430/9-78-002, Washington, D.C., February 1978.

Sludge Treatment and Disposal, Process Design Manual, EPA 625/1-79-011, 1979.

BELT FILTRATION

WORKSHEET

Place an "X" next to the best answer(s), or place the appropriate letter in the space for multiple choice questions.

1. How are belt filters typically used in a treatment plant? (Choose two)

   _____a. They reduce the water content of sludge before burning.

   _____b. They stabilize raw sludge so that it can be spread on land.

   _____c. They thicken sludge prior to return to the aeration basin.

   _____d. They reduce the volume of sludge to be handled.

   _____e. They filter suspended solids out of the final effluent.

2. There are five stages of processing sludge through a belt filter. Arrange the following stages in the proper sequence from beginning to end.

_____1st step	a. Gravity Drainage
_____2nd step	b. Low Pressure Squeeze
_____3rd step	c. Cake Release
_____4th step	d. Conditioning
_____5th step	e. High Pressure Squeeze

3. You are given a description of which occurs in each stage of belt filtration. Match the description with the stage.

_____"Shear zone" - particles force out of shape, capillary water lost.	a. Gravity Drainage
_____Belts separate and flex over discharge roll, doctor blade.	b. Low Pressure Squeeze
_____Sludge mat lose free water, 1 - 2 minutes.	c. Cake Release
_____Pressure applied by top belt, floc water and free water removed, "wedge" zone.	d. Conditioning
_____Sludge becomes fibrous, stringy	e. High Pressure Squeeze

4. There are four types of belt control required on a press when in operation. What are they?

   _____a. Tracking control to correct misalignment

   _____b. Speed of belt

   _____c. Spray washing

   _____d. Tension roller adjustment

   _____e. Control pore size

5. Choose two characteristics that best describe the influent to a belt filter.

_____a. Watery to pea soup consistency, 0.5 - 8.0% solids.

_____b. Consistency of mud or wet cardboard, 10 - 25% solids.

_____c. Nonoffensive

_____d. Nonpathogenic

_____e. Potential for carrying debris.

6. Choose two characteristics that best describe the effluent "cake" of a belt filter.

_____a. Watery to pea soup consistency, 0.5 - 8.0% solids.

_____b. Consistency of mud or wet cardboard, 10 - 25% solids.

_____c. Dependent on ratio of primary to secondary sludge.

_____d. Nonpathogenic

_____e. Nonoffensive

7. What sidestreams are present in belt filtration?

_____a. Pressate or filtrate

_____b. Thickened sludge

_____c. Off-gas

_____d. Belt washings

_____e. Supernatant

8. On the following list, place an "X" by each item which may be changed by an operator in making normal process control decisions.

_____a. Polymer formula

_____b. Polymer dosage

_____c. Belt pore size

_____d. Belt area

_____e. Roll pressure

_____f. Belt speed

_____g. Feed rate

_____h. Blend ratio of primary/secondary

9. What are three reasons why the influent sludge stream to a belt filter may change?

_____a. Filter cloth plugs up (blinds).

_____b. Feed tank is not homogenous throughout.

_____c. Feed tank has been changed.

_____d. Another stream from elsewhere in the plant has been added.

_____e. Cake conveyor breaks down.

10. With the letter "A", mark the unit processes that follow belt filtration. Mark those that may logically precede it with a "B".

_____Bar screen

_____Incineration

_____Secondary treatment

_____Flotation thickener

_____Gravity thickener

_____Landfill

_____Composting

_____Primary treatment

_____Aerobic digestion

_____Anaerobic digestion

_____Grit chamber

_____Heat drying

11. With the letter "A", mark the operating parameters that would be checked and diagnosed with visual observations. With the letter "B", mark those that require lab testing for diagnosis. Where both diagnostic methods are used, mark a letter "C".

_____Sludge feed rate

_____Polymer dose/effectiveness

_____Mixer speed (flocculation)

_____Belt tension

_____Belt cleanliness

_____Filtrate quality and clarity

_____Cake dryness

_____Belt speed

_____mg/l of influent suspended solids

_____mg/l of pressate BOD