Class II Wastewater

Presented by
West Virginia Rural Water Association

Class II Wastewater

- Be Advised that the Content of the Certification Exams are continually changing and WV Rural Water Association is not always made aware of these changes so the Class is not all Inclusive!

Math

Lesson I

Math

- $Q = V \times A$
- Q = The Flow in CFS
- If you are given Flow in MGD, Gallons or other forms, It must be Converted to CFS

$Q = V \times A$

- V = Velocity in FPS
- Usually no Conversion with Velocity.
  - The Main thing on the Velocity part is to Make sure you do not Confuse FPS, which is velocity with CFS, which is Flow

$Q = V \times A$

- A = Area in Square Feet
- The Area will Normally be in Inches.
- It must be divided by 12 if it is in Inches
- It also must be ran through the area formula. (D x D x 0.785)

$Q = V \times A$

- To solve for Q

$$Q = V \times A$$

- To Solve for V

$$Q / A = V$$

- To Solve for A

$$Q / V = A$$

$Q = V \times A$

- Lets try one of each:

  You have a flow of 350 GPM flowing through a 8" pipe. Determine the Velocity in FPS.

Q = V x A

- Q = V x A
  350 x 1440 / 1,000,000 = 0.504 Mgd.
  0.504 x 1.545 = 0.778 CFS = Q
- A= 8/12 x 8/2 x 0.785 = 0.349 Sqft.

Q = V x A

- Q = V x A
- 0.778 x V = 0.349
- 0.778 / 0.349 = 2.23 FPS

Q = V x A

- Example 2
- You have a velocity of 3 fps and a flow of 0.31 MGD. find the area of the pipe.
- Q = V x A
- 0.31 x 1.545 = 0.479

0.479 / 3 = A

A = 0.16 Sqft.

Q = V x A

- You have a velocity of 5.1 fps and a 9" pipe. Find the flow in Mgd.
- Q = V x A
- Q = 5.1 x 9/12 x 9/12 x 0.785
- Q = 5.1 x 0.442
- Q = 2.254 CFS
- Q = 2.254 /1.545 =1.46 MGD

Pumping

- On the Class II Exam we have math problems where you are dealing with a Piston Pump. Important Information on this equation are the Diameter and length of stroke on the piston and the bore.
- Single Stage-Leave alone
- Duplex-Multiply by Two
- Triplex-Multiply by Three

Pumping

- Lets try a couple of these

- A triplex Piston Pump with a 9” bore and a 7” Stroke pumps 55 Cycles per Minute. How long must the pump be operated to 2000 gallons.

Pumping

- 9/12 = 0.75
- 7/12 = 0.583
- 0.75 x 0.75 x 0.785 x 7.48 = 1.926 Gal per Stroke
- 1.926 x 55 = 105.93 Gallons per Minute
- 2000 / 105.93 = 18.88 Minutes
- 18.88 / 3 = 6.35 Minutes

Pumping

- If a lift station Cycles 4 times per hour and the pump operates four minutes per cycle. It contains a duplex pump with a 5” bore and a 6” stroke. The pump puts out 30 strokes per minute. What is the pump capacity in GPM?

- 4 x 4 = 16 Minutes per Hour
- 2 x 5/12 x 5/12 x 0.785 x 6/12 x 7.48 x 30
- 30.58 GPM

Geometric Mean

- Lets say you were to run four fecal tests in a month.
- What do you report?
- Lets say your results were:
- 25, 31, 12, 3250
- Find the average of these

Geometric Mean

- 25 + 31+ 12 + 3250 = 3318
- 3318 ÷ 4 = 829.5 Counts per 100 Mls.

Geometric Mean

- Geometric Mean is used to Determine the results of Multiple Fecal Tests more accurately!
- You need four Tests to Make this Work!
- Lets Practice one:

- 25, 31, 12, 3250

Geometric Mean

- 25, 31, 12, 3250
- 25 x 31x 12x 3250 = 30,225,000
- 32,225,000 Hit the Square Root Key 2 Times
- 75.34 Counts per Hundred Mls.

Geometric Mean

- What if you Have numbers to large to run through your Calculator.
- Example:
- 9000, 7500, 28,000, 33,000
- You would divide each number by a number like 10, 100, or 1000. you can see how large the numbers are and determine what to divide by.

Geometric Mean

- In this case I will divide by 1000
- 9000/1000=9
- 7500/1000=7.5
- 28,000/1000=28
- 33,000/1000=33
- 9 x 7.5 x 28 x 33 =62,370
- Hit the Square root Key 2 Times
- 15.80315 Multiply the number you divided by back again

Geometric Mean

- 15.80315 x 1000 = 15,803.16 Counts per 100 mls

Trickling Filters

Operating Procedures

Trickling Filters

- Trickling Filter is Secondary Treatment Process
- Removes more than 90 % of TSS
- Three most common Secondary Treatment processes are RBC's Activated Sludge and Trickling filters

Basic Trickling Filter Parts

- Media or the Retaining Structure
- Underdrain System
- Distribution System

Media

- Media provides a area for the biological slime growth develops
- This is called the Zoogleal Film
- This contains the living organisms that break down the organic material

Media is Made of:

- Rock
- Slag
- Coal
- Brick
- Redwood Blocks
- Molded Plastic

Media Requirements

- Must be spaced to have empty spaces or voids so air can ventilate the filter
- Filter must stay aerobic
- Rock size is not very important but the rock should be uniform in size for adequate ventilation
- Depth 3'-8' Rock Media
- 15'-30' Synthetic Media

Media

- One of the Worst Problems with a Trickling Filter is the Deterioration of the Media and the Cost Burden this puts on the Owner.

Underdrain System

- Is Equipped with a slopped bottom
- This leads to a Center Channel which collects the Effluent
- The Underdrain Supports the Media and permits Air Flow

Distribution System

- Consists of two or more rotary pipes supported a few inches above the filter media by a Center Column
- The wastewater is feed through the pipes and is distributed over the media
- The water causes the pipes to rotate or sometimes they rotate by mechanical means

Distribution Arm

- Flow is adjusted with Guy or Stay Rods
- Arm Dump Gates are at the end of each arm to allow Flushing
- Two types of Distribution Systems
- Fixed Nozzle (Small Plants)
- Rotary (Most Common)

Operational Principles

- Protozoa are produced to use the Organic Matter in the Wastewater thus Treating it
- Some is oxidized to Carbon Dioxide
- Some is used for Food to produce new Cells
- Excess Matter which does the treatment is Sloughed off

Air

- Void spaces in the Filter Media Allow Ventilation
- They must be kept Open
- Ponding can be caused when the voids get Clogged
- Sometimes Trickling Filter Effluent is Recalculated

Recirculation

- Increases the Contact Time of the Wastewater with the Biological film
- This also allows for uniform and Continuous Sloughing of Growths
- This prevents ponding and improves ventilation
- This causes a increased hydraulic load which prevents snail and filter fly breeding
- Recirculation is the Best Operational Control of a Trickling Filter

Filter Classification

- Standard Rate
- High Rate
- Roughing filters

Inspection

- Ponding
- Filter Flies
- Odors
- Plugged Orifices
- Roughness or Vibration
- Leakage
- Splashing past the Media
- Clean up of
  slimes not on the Media (Very slick)

Operation

- Use the lowest Recirculation Rates that will
- Render Good Results
- Lower Recirculation Rates Save Energy and Costs
- Read Page 186 section 6.410 Ponding Volume 1
- Study Table 6.2 Page 191 Volume 1
- Study Chart Pages 192-194 Volume 1

RBC'S

Rotating Biological Contactors

Rotating Biological Contactors

- Secondary Treatment
- Treats Domestic and Industrial Waste
- They have a Rotating Shaft surrounded by a Disc Called the Media
- The Shaft and Media are called the Drum
- The Biological Slime grows on the Media

RBC'S

- The slime is Continuously Rotated into the Wastewater
- It is in then Rotated into the Atmosphere to provide Oxygen
- The Media is usually Made of Plastic, Usually about 12' Diameter Circular Plastic Sheets
- Spacing Between the Sheets Provides Voids for Air and Wastewater

RBC

- The Media is 40 % Submerged in Wastewater
- It Rotates fairly slow at 1.5 RPM
- The living in the slime use the Wastewater to acquire food and Dissolve Oxygen from the Air
- Some of the Slime is Sloughed off the Media as the process works and new grows

Staging

- The Wastewater Passes through RBC’s in *FOUR STAGES*
- The First Stage reduces a large amount of BOD and the amount becomes less as it goes through the stages because there is less to reduce
- The Water can flow Either Parallel or Perpendicular to the Shaft

Covering RBC

- Reasons they are Covered
- Control Odors
- Freezing
- Prevents Rain from Washing the Slime Away
- Prevents Direct Sunlight which would Cause Algae
- Protection of Operators when working on the Equipment

RBC Parts

- Page 220 Volume 1
- RBC's is a Suspended Growth System
- For Nutrient Removal you would need a High Density Media

Drive Assembly

- Motor with Chain Drive (Motor, Belt Drive, Gear or Speed Reducer and Chain Drive)
- Motor with Direct Drive
- Air Drive

Advantages

- Advantages over Trickling Filter
- No Distributor Arm (Maintenance Intensive)
- No Ponding
- No Filter Flies
- Even **Rotation** of the Media (More Efficient) More Uniform Biological Growth

Disadvantages

- Disadvantage Compared to Trickling Filters
- No Recirculation
- Recirculation is not needed but could sometimes improve treatment
- More Sensitive to Industrial Waste if they would enter the system

RBC's

- Look at Page 224 Volume 1
- Look at Page 230 Volume 1
- Look at Pages 232-233 Volume 1
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Inspection

- Bearing Housing (Feel for Heat)
- Listen for Motor and Bearing Noise
- Check for Hot Motors
- Check for Oil Leaks (This would tell if a Seal or Gaskets
- Inspect Chain and Belts for alignment and Tension
- Make sure Guards are in place
- Clean up Spills (Falling Hazard)

Media Appearance

- Use a Visual Observation to Inspect the Media
- They use Bacteria and Living Organisms on the Media
- Slime Growth should have a Brown to Gray Color
- No Algae
- Shaggy appearance with Uniform Coverage
- High Density Media is Made out of a Different Material Than Other Units

Media Appearance

- Very few if any Bare Spots
- No Offensive Odor
- No Rotten Egg (Hydrogen Sulfide) Smell
- If it Becomes Black you need to Increase DO by pre aeration usually

Snails

- Not a problem in RBC's used to remove Carbonaceous BOD
- Snails are a problem in others because they destroy the Bacteria that removes Nitrogen
- Snail Shells also often clog pipes and Pumps

RBC'S

- RBC'S Produce a Good Quality Effluent Even at High Flows

Math

Lesson 2

BOD Calculations

- Initial DO – Final DO ÷ ML Sample X 300
- Example :
- If your Initial DO is 9.55 and your DO if the 5 day incubation period is 4.51, Find the Final BOD on a 200 Ml sample.

- 9.55–4.51 ÷200 X 300 =7.56 Mg/l BOD

Composite Sampling

- In Wastewater one must usually take a 8 Hour Composite Sample for the Plant
- A Sample should be Collected once per Hour for 8 hours
- We have a Calculation to Determine how much Sample needs to be Collected each Hour

Composite Sampling

- One must also Know how many Total Mls. Of Sample you need to Collect
- This will either be Given in Mls. Or Liters
- If Given in Liters you must Multiply by 1000 to Convert to Mls.

Composite Sampling

- In this Calculation One Must determine the Total Flow during the 8 Hour Composite time.
- In the Field you would get the flow from your Flow Meter.
- For the Exam Purposes you are either given the flow for each hour and must add them up or you are Simply given a Total Flow

Composite Sampling

- Once the Total Flow and the Sample Size are Determined you will then Divide Sample Size in Mls. By Total Flow
- This will Equal the Factor
- Sample Size (Mls) ÷ Total Flow = Factor

Composite Sampling

- Once the Factor is Determined: you will Multiply the Flow in which you are to determine the amount for by the factor. This will tell you how Many Mls. of sample needs to be saved from each sample time

Composite Sampling

- Lets Try a Couple:
- Given a plant that requires a 3 liter sample with a total flow of 8 Mgd, Find how many Mls need to be saved from the 9:00 AM sample with a flow of 0.95 Mgd and the 1:00 PM sample with a flow of 1.5 Mgd.

Composite Sample

- Solution:
- 3 X 1000 = 3000 Mls.
- 3000 ÷ 8 = 375 Factor
- 0.95 X 375 = 356.25 Mls. For the 9:00 AM
- 1.5 X 375 = 562.5 Mls. For the 1:00 PM

Composite Sample

- Lets say you need a 3500 Ml. Sample and the flows in order they were taken were 0.88, 1.12, 1.55, 1.83, 1.85, 1.33, 1.22, 1.12.
- Find the Sample Volume for the last 3 Samples.

Composite Sampling

- 0.88 + 1.12 + 1.55 + 1.83 + 1.85 + 1.33 + 1.22 + 1.12 = 10.90 Total Flow
- 3500 ÷ 10.90 = 321.1 Factor
- 1.33 X 321.1 = 427.06 Mls.
- 1.22 X 321.1 =391.74 Mls.
- 1.12 X 321.1 = 359.63 Mls.

Billing

- The Class II Exam has a Equation on it in which one must figure out a costumers Sewer Bill
- On this problem it usually only wants the sewer bill
- You Usually do not go back and add the water portion on
- Pay close attention to how the question is worded in case you would need to add the water portion

Billing

Example: Your sewage rate structure is 133% of the water bill. The water bill is $ 25.00 for the first 2500 Gallons and $ 7.00 per 1000 Gallon after that. The costumer used 5000 Gallons. How much would the sewer bill be?

Gallons	Cost	Total
2500	25.00	25.00
2500	2.5 X 7 =	17.50

25 + 17.50 X 1.33 = $ 56.53

Billing

- Example: A costumer comes in with a bill of 105.00 for 5500 Gallon of water usage. The water rates are 3500 Gallon for $ 50.00 and $ 12.00 per thousand thereafter. Sewer rates are 125 % of the water rates. How much refund is he owed on his sewer bill?

Gallons	Cost	Total
3500	50.00	50.00
2000	12 X 2 =	24.00

50 + 24 = 74 x 1.25 = 92.5

105 – 92.5 = $ 12.50 Refund

Activated Sludge

Conventional Activated Sludge

Conventional Activated

- Have pretreatment to remove Grit and Screenings
- Most have Primary Clarifiers to remove Settleable and floatable Solids
- Normally this process treats settled wastewater but sometimes it is raw wastewater

Conventional Activated Sludge

- Activated Sludge Consists of Sludge Particles produced in raw or settled wastewater by the growth of organisms in the presence of DO

Activated Sludge Process

- Biological Wastewater Treatment Process
- Uses Microorganisms to speed up decomposition of wastes
- Need a study balance of food and oxygen to function properly

Process Description

- Secondary Treatment aimed at oxidation and the removal of finally divided particles
- Oxidation is the addition of oxygen, the removal of hydrogen and the removal of electrons

Process Description

- The solids are Stabilized after this
- Stabilized means to be in a form that if discharged will not cause a problem or odors in the receiving waters.
- The solids are changed to a form that can be settled out and removed as sludge.

Process Description

- After the aeration period the wastewater goes to a secondary settling tank
- The solids and water is separated
- The solids should be returned as quickly as possible due to lack of oxygen and food
- The water is usually disinfected and discharged

Process Description

- Wastewater entering the aeration tank is mixed to form a mixture of Sludge, Carrier Water and Influent Solids
- They use the incoming waste as food and a energy source and as a life source

Process Description

- The Water and Solids comes from the Discharges of:
- Homes
- Factories
- Business

Process Description

- Organisms will compete with each other for food
- The ratio of food to organisms is the main control
- The operator will waste to speed up and control the process
- A increase in organisms will require more oxygen

Oxygen

- DO is a essential control factor
- Lack of DO will Cause Filamentous Bacteria to thrive
- To much oxygen will cause pinpoint Floc
- The proper DO must be maintained so solids will settle properly

Process Description

- For the process to work properly the following must be Controlled.
- Number of Organisms
- The Aeration Tank DO
- Treatment Time
- Note: The RAS is Included in the Clarifier Loading Rate Calculation

Floc Mass

- Floc Mass includes:
- Bacteria
- Fungi
- Yeast
- Protozoa
- Annelids and Nematodes

Floc Mass

- Everything comes together
- Mixing causes the floc mass to come together and bump into each other
- They eventually become large enough to settle in the Clarifier
- Stable Treatment is Indicated by Stalked Ciliates

Solids Removal

- Some of the sludge is released into the air as gas
- This leaves water and solids
- Solids are returned to the aeration tank to treat incoming waste
- Some solids are wasted and removed from the process
- Water is Disinfected or sent to Advanced Waste Treatment

Sludge Age

- High Rate Activated Sludge 0.5-2 days

Conventional Activated sludge 3.5-7 Days

Extended Aeration Greater than 10 days

SBR have high Sludge Age and do not wash out easily

Aeration

- Serves a duel purpose of providing mixing and DO
- Two types of aerators:
- Mechanical
- Diffused Air

Aeration

- Mechanical Aeration Devices Agitate the water or cause spray and /or waves
- These devices are:
- Rotors
- Paddle Wheels
- Mixers
- Rotating Brushes
- The main thing is to splash water into the air where oxygen can be absorbed

Aeration

With surface aerators, the oxygen transfer rate increases as the submergence of the aerator is increased. Power cost also increase the deeper the aerator is submerged

Mechanical aerators tend to be less expensive in installation and maintenance cost

Aeration

- Diffused Air is the most common type of aerator
- The diffuser breaks up air from blowers into bubbles in the mixed liquor
- These are submerged
- The smaller the bubbles the more oxygen
- Down side is small bubbles tend to regroup into large bubbles, Fine Bubble Diffusers also Tend to Clog or Plug easier Then Medium or Course Bubble Diffusers

Aeration

- Diffusers are on the bottom of the aeration tank attached to headers
- This is a large pipe which a series of smaller pipes are attached to (also called a manifold)

Aeration

- Filters remove dust and dirt from the air so it will be clean when it is sent to the plant processes
- Filters are of fiber mesh or metal mesh

Blowers

- Positive Displacement
- Operate at low RPMs
- Centrifugal
- Operate at High RPMs
- Must Have a Butterfly Valve
- Check Valve Prevents a Blower from Running Backwards

Aeration

- Air Distribution System Consists of:
- Pipes
- Valves
- Metering Devices
- Diffusers
- Fine Bubble
- Medium Bubble
- Coarse Bubble

Safety Around Aeration Tanks

- Steel Toed Shoes
- Shanks
- Slip Retardant soles
- Wear A US Coast Guard Approved Safety Jacket when around a aeration tank without guard rails
- Wash up algae growths
- Keep area clear of spills of Oil and grease

Safety Around aeration Tanks

- Do not leave tools and equipment where they may cause a safety problem
- Have Adequate Lighting installed for Night Work
- Treat ice or have spiked shoes
- Remove only guard rail sections necessary to do the job and reinstall as soon as job is finished. This is part of the job

Pre start Check

- Before starting any piece of equipment read and understand the manufacturers manual
- Most upgrades get about 4 copies of the manual for each piece of equipment
- A new one can be obtained by writing the manufacturer
- Many are online now days

Three Areas of Concern for Activated Sludge Plant

- What Enters the Plant
- The Environment for Treating Wastes
- What Leaves the Plan

Influent Characteristics

- As the influent flows and waste Concentrations Change, the environment changes in the Aeration Tank and Secondary Clarifier

Aeration Tank

- Maintain a DO of 2-4 Mg/l
- Thorough mixing throughout the tank
- Adjust the MLSS by regulating waste
- If there is a white foam reduce sludge wasting
- If there is a dark foam increase sludge wasting

Effluent

- Turbidity Test is a quick way to determine the plant effluent
- Try to look at trends and see where the analysis are at when the plant is operating properly

Lab Results

- Volume 2 Page 54 Table 11.1

- To Measure 100 Ml. of MLSS, One would use the Buckner Funnel
- Primary Sludge Should be 60-80 % Volatile

Sludge Age

- Sludge Age is recommended for operational control because:
- TSS Easy to measure
- Measures Food entering the system
- Measures solids available to treat incoming wastes

Nitrification

- Complete Nitrification Converts Ammonia Nitrogen to Nitrate
- In a Complete Mix Vertical Loop Reactor the First Stage Should be Anoxic
-

Clarity

- In the Activated Sludge Process, the best, quickest, and most cost effective Indicator is the depth of Clarity in the Secondary Clarifier.
- The Secchi Disc is one way of Checking this

Wasting

- The amount of sludge wasted will very from 1–20 % of the total incoming flow
- Try not to Change the sludge wasting rate by more than 10–15 % from one day to the next
- You need to maintain a sludge age that produces the best effluent

Wasting

- Wasting is accomplished by diverting a portion of the return flow to a Primary Clarifier, gravity Thickener, Dissolved Air Flotation Thickener, Aerobic or Anaerobic Digester

F/M Ratio

- Food Provided each Day to the microorganism Mass in the aerator
- MCRT can also be used for Solids Control

Abnormal Operations

- A Activated Sludge Plant can take quite a shock load now and then. But not a continuous series of shock loads.

Abnormal Operation

- Only the Operator Depending on records can determine the problem and corrective action
- Has the flow went up or down
- Have air rates changed
- Have you received a toxic load
- Are your Return lines Clear
- Has the BOD Changed
- Has the MLSS

Abnormal Operation

- The hard decision after finding the cause is should a change be made and what?
- If you know the situation will only last a short time, minor changes may quickly improve things
- If it is long term, a total process change may be in order

Records

- Accurate and detailed records become very important when things go wrong
- MLSS may be anywhere from 1000-4000 mg/l
- BOD should be from 8-20 Mg/l
- High MLSS building up will cause turbid effluent

Bulking

- The MLSS settles very slow and their compaction is very limited
- The liquid that does separate has excellent Clarity but not enough time for all of it to separate
- The sludge blanket rises and starts to be released with the effluent

Bulking

- A quick and Accurate method of determining if your activated Sludge Plant is Bulking or has too many Solids is the Thirty Minute Diluted Settleability Test

Bulking

- A Few Long Filament are OK to Have in your Activated Sludge Operation

Bulking

- Bulking Causes:
- Bound Water (Water trapped in Jelly like water logged sludge)
- Filamentous Organisms (Spider like organisms in the sludge that web and prevent the sludge from settling. Often caused by low DO)

Bulking Causes

- Low PH
- Low DO
- High Food to Mass Loading Rates
- Low Sludge Ages

Bulking Helps

- Rain can Help
- Adding some pre-aerated digested sludge
- Polyelectrolyte Flocculent
- Decrease the load to the aeration tank
- Addition of Clay or Bentonite
- Main objective is to Increase Sludge Age
- Decrease Food

Rising Sludge

- Caused by being in a Secondary Clarifier to long
- Denitrification
- To solve reduce sludge age
- Increase F/M

Foaming/Frothing

- Some foams are caused by nutrient deficiencies
- Control these with water sprays
- Other foams are Filamentous or Nocardia
- Caused by high MCRT
- Control by Increasing MLSS
- Reduce Air during low flow but maintain DO
- Return Supernatant to aeration tank during low flow

Contact Stabilization

- 2 Tanks
- One for 4 hrs of reaeration time for the RASS
- One to mix the RASS with the Primary EFF
- In contact stabilization the organisms store large portions of influent waste load in a short time (30–90 Min.)
- Reaeration is used in this Process to prevent solids loss

Kraus Process

- Used when wastewater contains a excess of Carbon and Nitrogen than normal or has poor settling characteristics
- The RASS is sent to a reaeration basin to be mixed with digested sludge
- After they are mixed they are sent to a Mixed liquor aerator

Step-Feed Aeration

- In this process the return sludge is introduced separately from the primary effluent
- In many cases it gets a short reaeration period
- The Primary Effluent is introduced at several different locations
- This distributes the oxygen demand over the entire aerator instead at the beginning

Complete Mix

- In this system you want the waste load distributed over the entire tank
- Food, oxygen and organisms should be nearly the same in all parts of the tank
- This is accomplished by diffuser location and having Influent and RASS enter at several different locations throughout the tank

SBR'S

- Good for Towns
- Good for Fluctuating Flows
- Easy for a Skilled Operator to learn to Operate
- Continuous flow Process
- No Submergible Pumps

SBR'S

- Everything takes place in one tank
- The Sequences are:
- Fill the Tank
- React (Aerate)
- Settle (Clarification)
- Decant (Withdraw Clarified Effluent)

SBR'S

- The Complete Cycle usually occurs two-six times per game
- SBR Plants have a very high sludge age which makes them very Stable
- They Operate well at a high sludge age
- Storm flows are not as likely to cause problems like washouts at SBR Plants

SBR'S

- They Require at least two Reactors
- They Often have more than two
- One Reactor is filling and aerating
- The other is Settling and Decanting
- Most Operators that have SBR's Recommend at least three reactors incase one is having Maintenance or service

SBR'S

- Reactors are:
- Rectangular
- Circular
- Oval

SBR'S

- Depth Varies but is usually 11-20 feet
- Mixing is with Mechanical Mixers or Blowers
- Wasting is accomplished by:
- Sludge Draw Off Lines
- Submergible Pumps

SBR's

- Goes to Disinfection
- Most SBR Plants Operate in the Extended Aeration Mode
- The MLSS Should be Collected from the React Cycle
- They Should be wasted from the Decant Cycle
- Fixed Evacuation Submergible pump is not found in the Decant Cycle

VLR

- In a VLR, the first Complete Mix Basin is an Anoxic Zone
- Nitrification/Denitrication takes place in the anoxic Zone
- In the Final Tank of a VLR, 2 mg/l of DO is Necessary

Math

Lesson 3

Efficiency

- In-Out X 100
-       In

- Example: If you have a 312 Mg/l influent BOD and a 16 mg/l effluent BOD, what is the plant removal Efficiency?
- 312-16/312 = 0.9487 X 100 = 94.87%

Efficiency

- If your plant needs to meet a 15 Mg/l Effluent BOD and you have a 200 Mg/l Influent, what must the efficiency be to avoid a violation?

- 200-15/200 X 100 = 92.5 %

Weir Overflow Rate

- To Solve Weir Overflow Rate Equations, One will need to arrive at two find two Important Numbers.
- The First One is the Flow in Gallons Per Day
- As in Past Equations, Most of the Time Flow will need to be Converted to Get to Gallons per Day
- The Second Number Needed is the length of the Weir in Lineal Feet

Weir Overflow Rate

- This Number can be figured by Added up the Total Length of the Weirs
- Sometimes you may have several weirs to account for
- Sometimes you will have single sided weirs
- Most of the time the Weirs are Double Sided which means to DOUBLE the Length of that Weir

Weir Overflow Rate

- When Working these Equations, the dimensions of the tank are usually given
- If It Gives numbers for the Weir Length, Obviously that is what is Used
- If It does not give Numbers for the Weir Length, USE THE WIDTH OF THE TANK AS THE LENGTH OF THE WEIR
- One Still must account for how Many and how many sides they Have

Weir Overflow Rate

- Formula is:

$$\frac{\text{Flow GPD}}{\text{Length of Weir LF}}$$

This Equals Gallons Per LF Per Day

Weir Overflow Rate

- Lets Work a couple:
- Your Clarifier Receives a flow of 2.8 MGD and the Rectangular tank is 125’ Long 50, wide and 12’ deep. The Tank has two double sided weirs. What is the Weir Overflow Rate in Gal/LF/Day.

Weir Overflow Rate

- Solution:

- 2.8 X 1,000,000= 2,800,000
- 50 X 4 = 200
- $\frac{2,800,000}{200}$ = 14,000 Gal/LF/Day

Weir Overflow Rate

- Sometimes this Equation will need to be figured using a round Tank
- To accomplish this you would use Diameter X Pie (3.14) to get the Length of the Weir.

Weir Overflow Rate

- Lets Try One:
- A 55' diameter Clarifier has a Flow of 1800 GPM. Find the Weir Overflow Rate in Gal/LF/day.

- 1800 X1440 = 2,592,000 Gal
- 55 x 3.14 = 172.7 Ft of Weir
- <u>2,592,000</u>
- 172.7 = 15008.69 Gal/LF/Day

Weir Overflow

- Clarifier
- 1.5 MGD Flow
- 3 Double Sided Weirs 25' Long
- Determine Weir Overflow
- 1.5 X 1,000,000 = 1,500,000
- 25 X 3 X 2 = 150
- 1,500,000
- 150 = 10,000 Gal/LF/Day

Weir Overflow

- Clarifier
- 80’ Diameter
- Flow 3,333,000 Gal
- Calculate Weir Overflow
- 80 X 3.14 = 251.2

- 3,333,000
-     251.2   = 13,268.31 Gal/LF/Day
-

Surface Loading Rate

The formula for Surface Loading Rate is as Follows, This is sometimes called Surface Settling Rate.

Flow (GPG)

Ares in Sq. Ft. = Gal/Day/Sq. Ft.

Surface Loading Rate

- Lets Try One
- You have a tank that is 100' diameter and 18' deep. It takes on a flow of 1.75 MGD. find the Surface Loading rate in Gal/Square Foot/day.
- 1.75 X 1,000,000 = 1,750,000
- 100 x 100 x 0.785 = 7850 Sq. Ft.
- 1,750,000
- 7850 = 222.92 gal/Sq. Ft./day

Surface Loading

- You have two Identical tanks that are 50' Wide X 75' Long X 12' Deep with a Total flow of 2.25 MGD. find Surface Loading Rate.

- 50 X 75 X 2 = 7500
- 2.25 X 1,000,000 = 2,250,000
- <u>2,250,000</u>
- 7500 = 300 Gal/day/Sq. Ft.

Volume/Percentages

- $V_1 \times P_1 = V_2 \times P_2$
- Best Way to set this Up is:
- $\frac{V_1}{V_2} = \frac{P_2}{P_1}$
- Lets do a Couple:
- If you load 30000 gal of 6 % sludge to a drying bed and sludge removed from the drying bed is 2.5% How many Gallons will be removed?

Volume/Percentages

- Solution:
- $\frac{30,000}{6} = \frac{X}{6}$
- $\frac{30,000 \times 6}{2.5} = 72,000$ Gal

Sludge Volume Index

- Formula is:

- <u>30 min Settling test Volume X 1000</u>
- MLSS Mg/l
-
- Lets try a Couple

SVI

- On Wednesday Morning the results of the 30 min Settling test was 520 and the MLSS was 3890 Mg/l. Determine the SVI from these results.

- 520 X1000/ 3890 = 179.93 SVI

SVI

- If you have a MLSS of 3250 and the Settleometer settled to 480 Mg/l, What is the SVI?

- 480 X 1000 / 3250 = 147.7 SVI

Pounds

- A Aeration Basin must have 1500 Cubic feet of air per pound of BOD. If the Plant takes on a flow of 1.75 MGD, and a influent BOD of 225 Mg/l. How many CFM of air does the basin need?

- 1.75 X 225 X 8.34= 3283.88 LBS
- 3283.88 X 1500 = 4,925,820 Cubic Feet/day
- 4,925,820 /1440 = 3420.71 CFM

Activated Sludge

Package Plants and Oxidation Ditches

Activated Sludge

- Sludge Particles Produced in Raw or settled Wastewater by the growth of Organisms in Aeration Tanks in the presence of DO.

Activated Sludge Particles

- Team with
- Bacteria
- Protozoa
- Fungi

Activated Sludge Process

- Biological Waste Treatment Process
- Microorganisms speed up Decomposition of waste
- As the microorganisms grow and reproduce, more and more waste is removed cleaning the Wastewater

Food/Microorganism Ratio

- A measure of food provided to bacteria in the Aeration Tank

Process Description

- Secondary Treatment Process
- Uses Oxidation (Addition of Oxygen, Removal of hydrogen and electrons and it is changed to a more suitable substance)
- Creates a Stabilized Waste (A waste that if released will not do any harm or cause problems)

Process Description

- The remaining solids are changed to a form that can be sent to a clarifier and settled out

Process description

- After Aeration the water is sent to a settling tank for settling
- Settled organisms are in a deteriorating state in the Clarifier and should be returned as soon as possible
- They are not getting air in the Settling Tank
- The water is usually disinfected and discharged to the receiving water

Process Description

- Wastewater entering the Aeration Tank is mixed with Activated Sludge
- It forms a mixture of:
- Sludge
- Carrier Water
- Influent Solids

Process Description

- The Water and Solids come from Discharges of :
- Homes
- Factories
- Businesses

Process Description

- *The Organisms use the water and solids as food Thus treating the Water*
- *Floc is Clumps of Bacteria and particles that of come together to form a Clus*ter
- The Organisms will compete with each other for the food
- Wasting is important to remove organisms when to many exist

DO Control

- DO Must be Controlled in the System
- Filamentous Organisms will grow if DO is to Low
- Pinpoint Floc will develop if DO is too High

Package Plants

- Package Plants are usually one tank divided into 2 or 3 Compartments
- The large compartment is used for aeration and mixing
- The smaller compartment is used for sedimentation
- Some plants contain a third compartment used for digestion

Package Plants

- Package plants are most commonly Extended Aeration
- They also come in Complete Mix, Contact Stabilization, and Conventional Activated Sludge Package Plants

Extended Aeration

- Similar to Conventional Activated Sludge
- Bugs do not get as much food and stay in the aeration tank longer
- MLSS runs from 2000-6000 mg/l
- Extended Aeration does not produce as much waste as other processes but wasting is still necessary

Contact Stabilization

- Similar to Conventional Activated Sludge
- Capture of waste material and digestion is accomplished in different tanks in this process
- The bugs must digest their food in Contact Stabilization
- A additional tank or section called a stabilization or reaeration tank is provided for the digestion process

Contact stabilization

- From the stabilization tank the bugs are returned hungry to the original aeration tank to eat more
- MLSS Should be 1500-2000 Mg/l
- Uses Reaeration

Complete Mix

- In a ideal Complete Mix System the contents of the tank are uniformly mixed throughout the tank
- To help with this special arrangements are usually made to uniformly distribute the influent and withdraw the effluent from the aeration tank
- Tank shape is very important
- MLSS 2000-5000 mg/l

Aeration

- Two common aeration methods
- Mechanical
- Diffused Air
- Mechanical Aerators use a device such as Rotating Brushes, Paddle Wheels or Mixers to cause spray or waves
- Usually these are lower in Installation and Maintenance cost

Aeration

- Diffused Aeration uses a device called a diffuser to break up air from a blower into fine bubbles
- The smaller the bubble the greater the oxygen transfer
- Fine bubbles tend to group into large bubbles unless they are broken up by mixing and/or turbulence.

Sludge Wasting

- Waste about 5 % of the solids each week during summer operation

Oxidation Ditch

- Usually Extended Aeration
- Main Parts:
- Aeration Basin–Two side by side channels connected at the ends to form a continuous loop
- Brush Rotor–Mixing and aeration Device
- Settling Tank
- Return Sludge Pump
- Sludge Handling Facilities

Oxidation Ditch

- Usually no Primary Settling Tank
- Usually no grit Removal
- Grit is captured in the Oxidation Ditch and removed during wasting or cleaning operations
- The Rotors keep the ditch aerated, mixed and moving
- The Oxidation ditch must maintain a velocity of 1-1.5 fps to prevent solids settling

Oxidation Ditch

- The ends of the ditch are well rounded to prevent dead areas.
- Mixed liquor flows to a Secondary clarifier for solids separation
- Clean water passes over the clarifier weir and is disinfected then discharged
- Settled sludge is either returned to the ditch or wasted
- Scum is removed from the top and is either returned or buried

Oxidation Ditch

- The Oxygen Transfer Rate is Changed in a Rotor Type Oxidation Ditch by Adjusting the Level Control Weir or Sometimes Simply Referred to as Weir

Wasting

- Sludge must be removed by wasting
- This is your best control
- Wasting lowers the MLSS
- This keeps the microorganisms more active
- High reductions of this process is made possible by wasting

Oxidation Ditch

- Study Table 8.1 on Page 270 volume 1
- MLSS Concentration between 2000-6000 mg/l
- Cold weather does not effect this type of plant as much as other plants because of the large number of organisms in the ditch

Oxidation Ditches

- BOD Loading 10-50 lbs /day /1000 cubic feet of ditch space
- F/m 0.03-0.1
- MLSS 2000-6000 mg/l
- Sludge age 20-35 days
- Velocity Greater than 1 fps
- DO 0.5-3.0 mg/l(by Book)

Math

Lesson 4

Lab Math

- Weight of a crucible 19.3015
- Weight of Crucible + Ash 19.3375
- Weight of Crucible + Solids 19.3512
- 50 Ml Sample
- Find the % Solids and Mg/L Volatile Solids

Lab Math

- 19.3512-19.3375 = 0.0137
- 19.3512-19.3015 = 0.0497

- 0.0137
- 0.4975 = 0.275376 X 100= 27.54%
- 27.54% Volatile Solids

Lab Math

- 19.3512–19.3015 = 0.0497
- 0.0497 X 1,000,000 = 49,700
- 49,700/ 50 = 994 Mg/l TSS

Sludge Digestion

Solids Handling

Need for Digestion

- Digesters Receive:
- Sludge from the Bottom of Clarifiers
- Scum from the top of Clarifiers
- Sludge's from Clarifiers, Trickling Filters and Activated Sludge Process are often pumped to Digesters for Treatment

Need for Digesters

- Digesters can be Aerobic or Anerobic
- In either system the sludge is decomposed to a simpler form for disposal
- Sludge is called Biosolids after it is treated

Purpose of Anerobic Digesters

- Reduces Solids from a sticky, Smelly, Mixture to a pretty much odor free dewaterable mixture that can be disposed of without causing a nuisance
- You Want No D.O. in a Anaerobic Digester

Process Description

- Organic Solids in the Sludge are Liquefied, solids volume is reduced and valuable Methane Gas is Produced
- This is accomplished by two different Bacteria:
- Saprophytic Organisms (Acid Formers)
- Methane Fermenters

Process Description

- Methane Fermenters are not as abundant
- They only reproduce in a pH range of 6.6–7.6 su.
- The basis of good digester operation is for the environment to be such that the Acid Formers and Methane Fermenters can both thrive

Process Description

- To keep them where they should be you must Control:
- Food Supply or Loading Rate
- Volatile Acid/Alkalinity Relationship
- Mixing
- Temperature
- The Digester is doing a good job if you have a volatile solids Reduction between 50-60%

Process Description

- The Digester may require 5–120 days to get the Volatile Solids Reduction
- This Depends on:
- How much it must be Reduced
- Temperature
- Mixing
- Organic Loading Rate
- Better than 15 days is hard to obtain

Process Description

- You must keep the Acid Formers and the Methane Fermenters in Balance
- The most common imbalance is excessive Acid formers

Process Description

- Critical Components of the Anaerobic Digester Process are:
- Volatile Solids
- Total Solids
- Temperature

Mixing

- Most important factor in the High Rate Process and very important in any process
- Sludge Greater Than 12% Cannot be Mixed Properly

Mixing

- Mixing Accomplishes:
- Using as much of the Digester Space as Possible
- Quickly Distributes the Raw Sludge throughout the Tank
- Keeps the Food and Microorganisms in Contact with each other
- Prevents Coning and Scum in Secondary Digesters

Mixing Accomplishes

- Dilutes the inhibitory products
- Achieves good pH Control
- Keeps the heat distributed equally throughout the tank
- Keeps down on the grit and inorganic solids that settle or the scum floating on top

Three Temperature Zones

- Psychrophilic (50-68 Degrees) Digestion requires 50-180 days
- Mesophilic (68-113 degrees) 25-30 Days
- Thermophilic (Above 120-135 degrees must be above 113 to be in this range) 5-12 Days

Fixed Cover Tank

- Made of Concrete or Steel
- Roof does not move and may be Flat, Conical or Dome Shaped
- If water column of gas pressure is exceeded the water seal will be broken allowing air to enter the tank
- This can form a explosive mixture of gas and air if this happens

Fixed Cover Tank

- Explosive mixtures may be created when sludge is withdrawn
- Air can be drawn into the tank
- Study Table 12.1 Page 153 Volume 2

Floating Cover

- Floating covers move up and down with tank level and gas pressure
- They normally have a 8' travel span
- Corbels are stops that keeps the tank from traveling down to far

Floating Cover

- Floating covers have less danger of exploding, better control of supernatant withdraw and better control of scum blankets
- They are more expensive to build and maintain
- Tilting Covers are caused by Excessive Water in the Floatation Chamber

GAS

- Produces 8-12 Cubic feet of Gas for every pound of volatile matter added
- Produces 12-18 Cubic feet of gas for every pound of volatile matter destroyed
- Two Gases
- Methane (65-70%)
- Carbon)Dioxide(30-35%)
- About 2% is other gases

Gas

- Digester gas is used in many ways
- Heating Buildings
- Heating and Mixing the Digester
- Running engines and Blowers
- Running Activated Sludge Processes
- Electrical Power for the Plant

Gas

- Gas Dome–Point in the Digester Roof where the gas from the digester is removed
- Water Seal is also sometimes in the roof to protect from excessive positive pressure or vacuumed
- If gas pressure builds up to 11 inches of water column height it will escape to the atmosphere

Gas

- Keep it less than 8 inches of water column height
- Air in the digester between 85 and 95% creates a explosive mixture

Safety

- Pressure Relief Valve will Operate when the Waste Gas Burner Cannot Handle Excessive Gas Pressure
- The Vacuum Relief Valve will operate if sludge is withdrawn to fast to prevent the tank from collapsing

Safety

- Thermal Valve cuts off gas flow if there is to much heat
- The fusible element melts and drops the stem upon getting to hot
- Flame Arrester Prevents flame from getting into the tank
- Manometers–Give Gas Pressure
- The Floatation is a Confined Space

Sampling Well

- 2-10 inch pipe that is always submerged 1 foot or so into the sludge where one can collect a Representative Sample

Digester Heating

- Heat Exchanger
- Digester Gas to operate a Boiler
- Waste Gas Burner Burns the excess Gas
- Recalculating hot water through Coil pipes attached to the inside digester wall
- Other plants eject steam into the digester

Mixing

- Speeds up digestion Rate
- Mixed by gas or Mechanical means such as pumps, propellers or draft tube mixers

Floating Covers

- Provide a flexible space for gas storage
- Controls scum blank by keeping it down and moist and unable to dry out and harden
- This makes scum easier to treat
- Less apt to create a explosive condition by to fast sludge withdraw

Definitions

- Ballast blocks–Large concrete blocks on the top outside edge to provide stability
- Annular Space–Area full of Digesting sludge between the Sidewall of the digester and the Floating Cover

Definitions

- Access Hatches-They have two to four of these depending on size. This is to provide for cover access and Maintenance
- Floatation Chamber prevents the cover from sinking

Digester Operation

- Undesirable items that get in digesters:
- Petroleum Products
- Rubber Goods
- Plastics
- Hair Grit
- Filter tips from Cigarettes

Digester Operation

- Without great mixing these thing will accumulate in the digester
- Scum is sometimes pumped to the digester once a day or sometimes feed at a low rate all the time

Food

- Food is the raw sludge from the primary clarifier or secondary treatment process
- Pump as thick a sludge as possible
- Hold the sludge until it thickens but not long enough to go septic or start gassing

Feeding

- You get better operation if the digester is feed several time daily instead of once
- Never pump thin sludge
- Thin sludge is defined as less than 3.5 % Solids

Sour Digesters

- Sour Digesters can recover faster when a caustic naturalizing substance is added
- If Digester Volume is reduced, there will be a decrease in Volatile Solids Reduction

Gas

- Digester gas will burn at 56% methane
- Useable as fuel at 62%
- Methane should run 65–70%

Supernatant and Solids

- Some plants have two digesters or two sections within one tank
- The Primary is used for heating, mixing and solids breakdown
- The second tank is used for solids separation
- The sludge will settle to the Bottom and the Supernatant or clear water will remain on top

Sludge Withdraw

- Withdraw sludge no faster than the gas production is able to maintain a positive pressure

Sludge Withdraw

- If you have to much Supernatant draw off you must change the Draw off Level
- Anaerobic Digester Supernatant should be less than 0.5%

Temperature

- Temperature should be the same throughout the tank
- A temperature gage is installed on the line from the heat exchanger to the digester

- How much are you able to change the temperature in a digester per Day

Question

- How much are you able to change the temperature in a digester per Day?
- A 10 Degrees
- B 14 Degrees
- C 1 degrees
- D 4 degrees

Answer

- 1 Degrees per Day

- This gives the organisms time to adjust to the new temperature

Volatile Acid/Alkalinity Relationship

- This is the key to successful digester operation
- A Raise in this is the first indicator that problems are starting and action needs to be figured out and taken immediately
- The volatile Acids need to stay low and the alkalinity high

Volatile Acid/Alkalinity Relationship

- When Acids begin to increase:
- Increase mixing time
- Decrease raw sludge feed rates
- Control heat more evenly
- Decrease digested sludge withdraw rates

Study Over

- Table 12.44 Pages 206-211 volume 2
- An Anaerobic Digester Should Have no DO

Review

- Sludge pumping to the digester should be at frequent intervals and small quantities of sludge.

Aerobic Digestion

- Aerobic Digestion Does much Better on Secondary Sludge

Digester Cleaning

- Clean the Digester every 3-8 years
- Clean when the Digester is 1/3 full of inorganic material it is time to clean the digester
- The depth of heavy solids and scum should be measured every six months to one year
- Do not let the need for it to be cleaned catch you by surprise or wait until problems develop, Check it regularly

Math

Lesson 5

Cost Per 1000 Gallons

- Sometimes in the Wastewater Field, It Becomes Necessary to Calculate the cost of Treating 1000 Gallon of Wastewater

Cost Per 1000 Gallons

- Example:
- The Average Flow to the Plant for the Month of October (31 Days) is 0.5 MGD
- The Following Items were billed to the Wastewater Plants Account.
- Labor $22,000.00, Power $2000.00, Repairs $1700.00, Overhead $720.00, Amortization $50000.00 and Repair Account $1700.0. Determine the Cost per 1000 Gallon of Water.

Cost Per 1000 Gallons

- 0.5 X 1,000,000 X 31
- 1000
- 15,550
- 22,000 + 2000 + 1700 + 720 + 50,000 + 1700 = 78,120
- Cash/Gallons
- 78,120/15,550 = $5.04

Maintenance

Pumps

Maintenance

- A Good Maintenance Program Covers:
- Mechanical Equipment
- Pumps
- Motors
- Scrapers
- Valves
- Grounds
- Buildings
- Structures

Maintenance

- Always follow the Manufactures Manual on each piece of Equipment
- If you do not understand something most companies that make wastewater equipment have a service line you can call for help
- USE THEM

Maintenance

- Keep records of all the Maintenance and preventive Maintenance you perform
- Records will keep the warranty valid and you will not have to rely on memory to know what is due, when

Building Maintenance

- Always keep your buildings well maintained
- Keep them Clean, orderly, painted

Tanks

- Wastewater Tanks, Channels and Wet well's should be drained and inspected yearly
- Make sure the Ground Water is down far enough that a empty tank will not float or that the Relief Valves is open
- The Relief valve will let water come into the tank instead of the tank floating on the Water

Chlorine Leaks

- Check Daily for Chlorine Leaks
- A Green or Reddish deposit on Metal indicates a Chlorine leak
- You Can also detect them with ammonia on a rag, it will result in a white vapor
- A Chlorine leak in the presence of moisture will cause corrosion

Centrifugal Pumps

- Very simple Device
- A Impeller Rotating in a Casing
- The Impeller is supported on a Shaft
- The Shaft is supported by Bearings
- The Liquid enters at the eye (center of the Impeller)
- Liquid is picked up by Vanes and rotation of the impeller and is thrown to the discharge by Centrifugal Force

Centrifugal Pumps

- The Paddle Wheel part of the pump is the Impeller. The Impeller is the heart of the pump
- The Blades Curve out from the hub.
- As it spins liquid between the blades is impelled out with Centrifugal Force

Centrifugal Pumps

- The eye of the Impeller must be kept free of debris
- Install a Screen if plugging becomes a issue
- The Impeller is supported by a Heavy Shaft
- The Shaft must be protected by a sleeve
- The Sleeve Material depends on the Material being pumped
- It is commonly made of Bronze
- Sometimes Alloys, Ceramics, Glass or Rubber

Centrifugal Pumps

- Never Attempt to pump a liquid the pump was not designed to pump.
- If in doubt, Contact the Manufacturer

Centrifugal Pumps

- The Shaft is Mounted on Bearings
- These can be Sleeve, Ball or Roller Bearings
- To Prevent wear which will shorten the life of the pump, Grease according Manufacturing Recommendations

Centrifugal Pumps

- The Shaft is Connected to the Motor using a Coupling Flange
- When this Connection is made, Make sure of proper alignment using a straight edge or Dial Indicator
- Check the alignment from time to time after operation begins

Centrifugal Pumps

- The Pipe should have a slight up slope to prevent Trapped air from being drawn into the Pump
- Make sure the pipe puts no strain on the pump casing
- All piping should be in place and self supporting before the pipe and pump is connected

Centrifugal Pumps

- As water is drawn into the impeller, Centrifugal force causes it to flow outward
- This builds up high pressure on the outside of the pump which forces water out and low pressure inside the pump, which draws water in

Centrifugal Pumps

- We must use wearing rings to plug internal leaks
- The rings are used instead of making the gap almost non existent because they are replaceable
- To keep air from being drawn in we use a stuffing box

Centrifugal Pumps

- Never allow a pump to run dry
- Water is used as a lubricant between the rings and the impeller
- Replacing worn wear rings will greatly improve pump efficiency

Centrifugal Pumps

- We us stuffing in a stuffing box to seal out air
- We want the pump to pump water not air and Air leakage is apt to cause the Pump to lose suction
- In most cases a mechanical seal may used instead of stuffing

Centrifugal Pumps

- About 75 % of Centrifugal Pump problems trace to the discharge side of the pump
- Centrifugal Blowers have a Air Suction Line and a Butterfly Valve

Propeller Pumps

- Axial Flow Propeller Pump has flow parallel to the axis of the impeller
- Mixed Flow Propeller Pump is one having flow both Axial and Radial to the impeller

Vertical Wetwell Pump

- Vertical Shaft or diffuser type Centrifugal Pump
- The pumping element is suspended from the discharge piping
- Usually used to pump water from deep wells

Reciprocating or Piston Pump

- This moves water by a piston moving back and forth
- A check valve will open and close as the piston moves one way and then the other
- This will let water in and out as the piston moves
- This is a positive displacement pump so never operate it against a closed head

Incline Screw Pumps

- A Screw Operating at a constant speed in a casing or housing
- The Screw moves the water up the trough to a discharge point
- It is supported by two bearings one at each end

Pneumatic Ejectors

- Used for small flows
- They do not plug easily
- Centrifugal Pumps plug easily under small flows

Mechanical Seals

- Prevent Leakage
- Located in the Stuffing Box where the Shaft goes through the Volute
- The Seal has two faces held together by a Spring
- Higher Initial cost over packing but the cost is usually gained back over time

Blowers

- Running Backwards in Blowers is prevented by an Air Check Valve

Bearings

- Should last for years
- Free bearing drain hole before applying grease

Bearing Failure Causes

- Fatigue Failure
- Contamination
- Brinelling
- False Brinelling
- Thrust Failure
- Misalignment
- Electric arcing
- Lubrication Failure
- Cam Failure

Pump Driving Equipment

- Usually Electric Motors
- Internal Combustion Engines
- Turbine Engines

Electricity

- Most system do not do a lot of electrical Maintenance
- This is a highly specialized field
- You should no how your equipment works so you can explain more to the electrical professional that does the work

Electricity

- Volts is the electrical pressure available to push electricity or make it flow
- Direct Current is the electricity flowing in one direction only. This is not often used in our business. All batteries are direct Current
- Usually used in Automobiles sometimes in standby lighting

Electricity

- Periodic Current that goes from zero to Maximum and back to zero
- Usually 60 cycle which means 60 times per second (60 Hertz)
- Single Phase
- Two Phase
- Three Phase or Polyphase
- Two Phase is not real common

Single Phase

- Lights
- Small Pumps
- Small Motors
- Power Tools
- Only one Phase of Power is Supplied
- Two Leads with 120 volts
- One Lead Neutral usually Coded in White
- Many have a ground that should be Green

Three Phase

- Motors
- Transformers
- High Power Requirements is when this is used
- Most motors greater than 2 HP use 3 Phase
- Usually 3 Leads with Power on all Three

AMPS

- The Current Produced by a pressure of One Volt in a Circuit
- Ohm is the unit of Electrical Resistance
- Fuses are Checked with an Ohmmeter

Watts

- Watts are used to Rate Electric Motors or Power in a Electrical Circuit
- Multimeter is used to Measure Voltage
- Hold one Lead on the Ground and another on a power Lead you can tell if you are getting electricity and the intensity of the current
- They can also Measure Voltage, Current and Resistance

Megger and Ohmeter

- Megger or Megohmmeter is used to measure the insulation Resistance of Electricity
- Turn off Circuit Breaker Before Using
- Ohmeter is used to Check Fuses

Name Plate Data (Motor)

- Serial Number
- Type
- Model Number
- HP
- Frame
- Service Factor
- Amps

Volts

Name Plate (Motor)

- Class Of Insulation
- RPM
- Hertz
- Duty
- Ambient Temp
- Phase
- KVA Code
- Design
- Bearings
- Efficiency

Starters

- Connect Electrical Power to the Motor
- Read Over Tables, Pages 405-408 Volume 2

Laboratory

Waste Water Lab

Why is Analysis Performed

- Required by NPDES Permit
- Wastewater Plants Monitored by State Agencies such as WVDEP, Health Dept.
- Monitored by Federal Agency (USEPA)
- To see if equipment and process are working correctly
- To determine adjustments to the system

Why are Analysis Performed

- The Analysis need to be reported on the DMR
- If you have non compliant results,
- REPORT THEM ANYWAY

Why are analysis performed

- Do not falsify anything
- Analysis are necessary to see what the plant is doing
- Analysis are necessary for the operator to make adjustments

Definitions

- Aliquot–a portion or a part of a sample. If several grab samples is going to make up a composite sample, it is one of those grabs. It could also be the portion you take out to do a given analysis
- UG/L and ppb mean the same

Definitions

- Ambient Temperature–the temperature of the area surrounding the water.

- Buffer Capacity–the measure of a solutions ability to neutralize acids or bases

- Buret–Gives very accurate measures of liquid. Made of glass or plastic with measurement markings that have been calibrated

Definitions

- Preserving a Sample- Adding a chemical to prevent the sample from changing after it is collected. A Fixed Sample has Preparative

- Meniscus-The curve of the water

- Titration-adding a chemical to a end point such as a color change or a desired color or pH is reached.

Types of Samples

- Composite Sample-Several individual samples collected at regular intervals that give a representation of a large time frame
- Usually must be flow proportional
- What the flow is determines how much sample is collected that aliquot

Types of Samples

- Grab Sample–One sample collected and analyzed in 15 minutes or less. Tells conditions there and then only
- Instantaneous Maximum–Taken in the tank, water is not removed, a probe is dropped in to take the sample reading

Composite Tests

- BOD
- TKN
- Ammonia Nitrogen
- TSS (Needs no Preservation just temp. controlled)
- Most Metals

Grab Sample Tests

- Fecal
- Chlorine Residual
- DO
- pH

Instantaneous Maximum

- DO
- pH
- Chlorine Residual
- These are usually mentioned under grab samples also

Sample Frequency

- Refer to NPDES Permit for exact Intervals
- Daily:
- pH
- DO
- Flow
- Chlorine Residual
- Temp.

Sample Frequency

- Weekly, Monthly, Quarterly, 2/Year, Yearly
- NPDES Permit gives exact intervals.
- BOD
- TSS
- TKN
- Ammonia Nitrogen
- Most Metals

Laboratory Safety

- Always Pour Acid into Water, Never Pour Water into Acid
- Wear Proper safety Equipment in the Lab
- Never Eat, Drink or Smoke in the Lab
- Dispose of Broken or Chipped Glass Ware as soon as you discover it is broken

Laboratory Safety

- Make Sure you Know Where Fire Extinguishes are Located
- Make Sure to Know where Eye Wash Stations are Located
- Always wear gloves and wash your hands with as hot a water as you can take
- Use soap, Antibacterial Soap is not highly recommended

Laboratory

- Never mix Chemicals that you do not know what the reaction will be
- This can cause fire or explosions or give off toxic Fumes some of which may be odorless

Daily Tests

- pH–a expression of the acidic or basic condition of a liquid. Mathematically pH is the logarithm (base 10) of the reciprocal of the hydrogen Ion activity

pH

- The pH scale goes from 1-14
- Measured in su
- 7 is neutral
- Numbers below 7 are Acidic
- Numbers Above 7 are basic or Alkaline

pH

- Calibrate the Meter with at least to buffers
- Go by manufacturer requirements .
- Buffers have a known pH and the meter can be calibrated to read them correctly
- Sometimes 3 are required
- Rinse the probe with distilled water
- Store the probe in a buffer solution

Daily Tests

- Flow–The measurement of the amount of water entering or exiting a plant on a daily basis. Flow must be recorded on the DMR and ES–59. Usually Converted to MGD. Usually taken from a flow meter or totalizer.

Daily Tests

- Settleable Matter–a test that shows the amount of Settleable Matter present in wastewater

Daily Tests

- Chlorine Residual–shows the amount of Chlorine remaining after the Chlorine Demand of the Treated Waster has been satisfied. Usually needs to be 0.5 mg/l after chlorine contact but about 0.02 after dechlorination

Daily Tests

- Dissolved Oxygen-Measures the amount of oxygen present in water. Usually taken with a DO meter. Sometimes the Winkler Method is used. This is a titration Method, White floc indicates no DO. If using a meter, take the reading directly in the Tank if possible. Recorded on the DMR and ES-59

Weekly/Monthly Tests

- Fecal Coliform–analysis of the bacteria that may be in water and be harmful to humans. Fecal is present in the gut of all warm blooded animals. Fecal is a indicator that conditions are right for pathogens to be present. The Fecal test tells how effective your disinfection is

Weekly/Monthly Tests

- BOD–Measures the amount of oxygen used under controlled conditions.
- Test is for 5 days
- Considered Accurate at 55%
- 20 Degrees C
- Must be Dark in the Incubator

Weekly/Monthly Tests

- TKN or Ammonia Nitrogen– Measures the amount of Nitrogen or Ammonia as Nitrogen that is in water. To much Nitrogen can be fatal to infants and aquatic life

Weekly/Monthly Tests

- Total Suspended solids– Tells how much Suspended Matter is in Water

JJ1

Lab Equipment Temp.

- BOD Incubator 20 degrees
- Fecal Water Bath 44.5 degrees
- Drying Oven 103 degrees
- Muffler Furnace 550 degrees
- Sample Refrigerator 4 degrees
- Auto Clave 121 degrees
- All temp. are in Centigrade or Celsius

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BOD

- BOD should Dissolve about 55% of the DO
- BOD Samples should be collected before Chlorine is applied

Fecal Test/Bioessy

- Must be Run within 8 hrs. of Collection
- You want to get 20-60 Colonies per sample
- Bioessy refers to the toxicity of water
- It has to do with how minnows can live and reproduce

Math

- Find the Total Cost for Chlorine and Sulphur Dioxide in this Digester
- Feed Rate 1:1
- Chlorine is feed at 3.6 mg/l
- Chlorine has a 0.6 mg/l Residual
- Flow 0.9 MGD
- Chlorine is 25 Cents per pound
- Sulphur Dioxide is 32 Cents per Pound

Math

- 0.9 X 3.6 X 8.34 = 27.02 lbs. per day Chlorine

- 27.02 X 0.25 X 365 = 2465.57
- 27.02 X .32 X 365 = 3155.93
- 2465.57 + 3155.93 = 5621
- $5621.00

Math

- Try this one
- Find the Total cost of Chlorine and Sulphur Dioxide
- Feed Rate 1:1
- Chlorine Feed Rate 4.05 mg/l
- Chlorine Residual 0.5
- Flow 1.25 MGD
- Chlorine Cost 33 Cents per pound and Sulphur Dioxide Cost 39 Cents per pound

Math

- 1.25 X 4.05 X 8.34 = 42.22 Lbs. Chlorine per day
- 42.22 X .33 X 365 = 5085.39
- 42.22 X .39 X 365 = 6010.01

- 5085.39 + 6010.01 = 11095.40
- $11,095.40

Math

- 4000 Lbs. of 5.2% Sludge is Pumped to a Digester. The Flow for the Day is 4.1 MGD.
- The Influent TSS is 200 mg/l. What was the % of TSS Removal?
- 4.1 X 200 X 8.34 = 6838.8 lbs.
- 4000/6838.8 = 0.58
- 0.58 X 100 = 58%
- 58%

Math

- Try This One
- 3000 lbs. of 5.5 % Sludge is pumped to a Digester.
- 2.7 MGD Flow
- 222 mg/l Influent Suspended Solids.
- What % of Suspended Solids Removal Occurred?

Math

- 2.7 X 222 X 8.34 = 4998.99 lbs. TSS
- 3000/4998.99 = 0.60
- 0.60 X 100 = 60%
- 60%

Math

- Water Cost $14.00 for 3500 Gallon
- $5.75 for Each 1000 Gallon over 3500
- Sewer Cost 3.38/1000 Gallon of Water Used
- If a Costumer Used 5500 Gallon what would the Total Bill be?
- 3500 = $14.00 14 + 11.50 = 25.50
- 2000 = $11.50 Water
- 5.5 X 3.38 = $18.59 for Sewer
- 18.59 + 25.50 = $44.09 Total

Math

- Try One
- 3500 Gallon of Water was Used
- Water Costs $14 for 2000 Gallon
- 5.75 per 1000 Gallons over
- Sewer Cost $20.00/ 1000 Gallon
- Find the Total Bill

Math

- 2000 = 14.00
- 5.75 X 1.5 = 8.62
- 14 +8.62 = 22.62 for Water
- 3.5 X 20 = $70.00 for Sewer
- 70 + 22.62 = $92.62
- $92.62

Math

- A Polishing Pond is 100’ X 200’ X 3’ Deep
- Sodium Nitrate must be Added to the Pond Using the Following Assumption
- $NaNO_3$ is 50% Available Oxygen by Weight
- It is required to add 4 PPM of Oxygen by adding $NaNO_3$
- How Many Lbs. of $NaNO_3$ will be Required?

Math

- 200 X 100 X 3 X7.48/1,000,000 = .448 MGD.
- .448 X 4 X 8.34 = 14.95 LBS
- 14.95 X 2 = 29.9 Lbs.
- 29.9 Lbs.

Math

- Lets Try One
- A Polishing Pond is 150' X 225' X 5' Deep
- Sodium Nitrate must be Added to the Pond Using the Following Assumption
- $NaNO_3$ is 50% Available Oxygen by Weight
- It is required to add 5 PPM of Oxygen by adding $NaNO_3$
- How Many Lbs. of $NaNO_3$ will be Required?

Math

- 150 X 225 X 5 X 7.48 / 1,000,000 = 1.262 MGD
- 1.262 X 5 X8.34 =52.625 Lbs.
- 52.625 X 2 = 105.25 Lbs.
- 105.25 Lbs.

Math

- A Trickling Filter is 100’ in Diameter and 10’ Deep. It Received a Flow of 0.75 MGD with a 225 Mg/l BOD. What is the BOD loading Expressed in pounds per day per 1000 Cubic Feet of Filter Media?
- 0.75 X 225 X 8.34 = 1407.375 Lbs.
- 100 X 100 X 0.785 X 10 = 78,500 CF
- 78,500/1000 = 78.5
- 1407.375/78.5 = 17.93 Lbs.

Math

- Lets Try One
- A Trickling Filter is 75’ in Diameter and 10’ Deep. It Received a Flow of 0.5 MGD with a 180 Mg/l BOD. What is the BOD loading Expressed in pounds per day per 1000 Cubic Feet of Filter Media?

Math

- 0.5 X 180 X 8.34 = 750.6
- 75 X 75 X 0.785 X 10 = 44,156 CF
- 44,156/1000 = 44.156
- 750/44.156 = 16.985 Lbs.

Questions

- Questions