Advanced Preliminary and Primary Treatment Study Guide

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Subclass A

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

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

How to use this study guide with references

In preparation for the exams you should:

1. Read all of the key knowledges for each objective.

2. Use the resources listed at the end of the study guide for additional information.

3. Review all key knowledges until you fully understand them and know them by memory.

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

Choosing A Test Date

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

Acknowledgements

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Part 1 - Preliminary Treatment

Chapter 1 - Principle, Structure and Function

Section 1.1 - Principle of Preliminary Treatment

1.1.1 List the most important operational considerations in selecting a preliminary treatment system.

A. The type and strength of wastes that will be coming into the plant, especially industrial and commercial loadings.
B. The volume of flow to the plant.
C. If sewers are combined or separate.

1.1.2 List the reasons for pre-chlorination of wastewater influent.

A. It reduces decomposition.
B. It reduces odor (eliminates hydrogen sulfide gas).
C. It slightly reduces BOD.
D. It reduces corrosion of equipment.
E. It improves settling characteristics.

Dechlorination is particularly effective when clarifier detention times are long or sewage temperature is very high.

Section 1.2 - Structure and Function

1.2.1 Describe the types of equipment used in preliminary systems to control debris entering the treatment plant.

A. Comminutors - debris is screened and shredded at the same time using a rotary cutting device.
B. Barminutors - has a coarse bar screen ahead of this unit. A revolving cutter slides up and down the face of the screen.
C. Screening - there are various types of screening, including a traveling screen with high pressure spray wash, a static screen with manual removal, and rotating drum screens with either spray wash or mechanical removal of solids.

1.2.2 Discuss the purpose and methods of grit washing.

The purpose of grit washing is to remove volatile organic matter, reducing the odors associated with grit handling. There are various types of mechanical grit washing equipment used with cyclone type degritters and aerated grit chambers.

1.2.3 Discuss the reason for grinders and screening in preliminary treatment.

The function of grinders is to shred debris (hair, rags, food wastes, and other organic materials) into smaller size so as not to create problems in downstream treatment processes. There should be a rock sump or bar screen to catch larger rocks, sticks, and other debris ahead of the grinder. Various types of fine screening can also be used to remove debris to protect downstream treatment units.

Chapter 2 - Operation and Maintenance

Section 2.1 - Operation

2.1.1 Explain why the flow velocity in a horizontal grit chamber should be approximately one foot per second.

At a velocity of one foot per second, inorganic grit-type material will settle, while the organic suspended solids will stay in suspension and pass through the unit to downstream treatment processes.

2.1.2 Explain why flow rates in sewers should exceed two feet per second.

Flow rates in sewers are designed at a minimum of two feet per second to ensure that all materials in the sewage flow stays in suspension. Two feet per second is normally referred to as the "self-cleansing velocity". If lower velocities occur, deposition of suspended solids can cause anaerobic (septic) conditions. Septic conditions are favorable to the production of hydrogen sulfide which can cause corrosion in the collection system. In addition, septic sewage entering the treatment plant can cause odors, safety problems(hydrogen sulfide), corrosion problems, and increased difficulty in treating this type of wastewater.

2.1.3 Discuss the types of chemicals and their purpose that might be used for pretreatment.

Chemical additions at the beginning of treatment is normally done to change the raw wastewater characteristics to protect downstream equipment, prevent safety problems, and to ensure that the wastewater quality is suitable for the biologic secondary treatment process.
A. Acids and bases: acids and bases are used in special circumstances to adjust pH levels (the addition of an acid will lower the pH, while a base will raise the pH).
B. Chlorine or hydrogen peroxide: these chemicals are often used to control odors, especially when septic raw wastewater is encountered. The main odor problem in this situation is hydrogen sulfide. By controlling it, you reduce both safety concerns and corrosion problems. Chlorine is the most commonly used chemical for this purpose.
C. Polymers: these chemicals are not used often, but would be used if special settling problems occur requiring a settling aid.
D. Phosphorus removal chemicals: various chemicals may be added at the preliminary stage to precipitate phosphorus for removal in the primary clarifier.

Section 2.2 - Maintenance

2.2.1 Describe the maintenance needed for comminutors and barminutors.

The cutting surfaces need to be sharpened and adjusted. The equipment should be lubricated according to the manufacturer's specifications. Electric drive motors require normal maintenance as specified by the manufacturer.

2.2.2 Describe the impact on comminutor maintenance if it is located ahead of the screening and grit removal equipment.

If a comminutor is ahead of the plant's screening and grit removal units, the operator may need to check for wear on the teeth much more often than recommended in the O&M manuals. This is due to the wear caused by grit and the additional material that will be shredded.

Chapter 3 - Monitoring, Troubleshooting, and Safety

Section 3.1 - Monitoring

3.1.1 Identify the types of industries that might necessitate pH monitoring and control.

A. Dairies.
B. Metal finishing.
C. Printing.
D. Circuit board manufacturing.

3.1.2 Explain how to evaluate the organic content in grit removed from a treatment plant.

To determine the organic content of grit removed, it would be necessary to perform a volatile solids test.

Section 3.2 - Troubleshooting

3.2.1 Outline the causes and corrective actions to control odor problems in preliminary treatment plant systems.

A. Cause: there has been sewage in the collection system too long, or low flow velocities are causing septic conditions.
Correction: prechlorination and preaeration.

B. Cause: poor housekeeping practices.
Correction: develop regular housekeeping schedules.

C. Cause: infrequent grit removal.
Correction: remove the grit more often.

D. Cause: storage of grit and screenings too long.
Correction: promptly haul grit and screenings to the disposal site.

3.2.2 Discuss the uses, effectiveness, risks, and costs of chemical odor masking agents.

Chemical odor masking is used in wetwells, in sewage systems that have long detention times, or in emergency situations, to mask septic odors.
A masking agent's effectiveness is variable due to atmospheric conditions, types and dosages of chemicals, severity of the odor, and proper operation of equipment used to disperse the chemicals.
Risks would be minimal if the operator follows the directions of the manufacturer. The only risk would be to recognize that the odor masking agent could hide concentrations of gases that could be considered a safety hazard (e.g. hydrogen sulfide or digester gas).
Costs depend on the type of chemical used, the amount of chemical needed on a yearly basis, and the type of equipment required to dispense the chemical. The effectiveness of all odor masking chemicals is unpredictable, and should only be used in emergencies or special circumstances. Problem areas causing the odors should be located and corrected.

3.2.3 Explain how to make use on plant records of quantity of grit removed from the system.

The records of grit quantity can be useful to determine changes in the characteristics of the raw wastewater. If grit increases during normal flow periods, the cause should be determined (sewer cleaning, sewer construction, new industrial discharge, or from someone dumping illegally into the system). If grit increases during wet-weather flows, this should be checked for the possible cause (sewer or lateral damage, storm water cross-connections, flooded manholes, or open lines during sewer construction). If a significant decrease in grit occurs, sewer lines should be checked for possible blockage.

Section 3.3 - Safety

3.3.1 Describe the safety concerns associated with the following chemicals:

A. Sulfuric acid
B. Sodium hydroxide
C. Potassium permanganate
D. Hydrogen peroxide

A. Sulfuric acid: will cause severe burns if it comes in contact with the skin. Sulfuric acid should be stored in a shatter proof container. The operator should wear a face shield and rubber gloves when handling. Ventilation should be adequate in the area where it is being used.
B. Sodium hydroxide: this chemical is a very strong caustic (high pH), and like acid, it can cause severe burns. It should be stored in its original container and protected from physical abuse. When handling this material, an operator should wear protective clothing, a full face shield, and rubber gloves.
C. Potassium permanganate: this chemical is a strong oxidant sometimes used similar to chlorine to control odors. Protective clothing, gloves, and at least eye goggles, should be used when handling this chemical.
D. Hydrogen peroxide: this chemical is an oxidant and is used like chlorine to control odors. It is safer than a chlorine gas system because there is no safety problem from free chlorine gas. Protective clothing, gloves, and at least eye goggles should be used when handling this chemical.

Part 2 - Primary Treatment

Chapter 4 - Principle, Structure and Function

Section 4.1 - Principle of Primary Treatment

4.1.1 Describe the affect on the various types of secondary processes caused by poor quality primary effluent.

Poor quality primary effluent will cause problems with all secondary processes. The fixed film systems (RBC's and trickling filters) will be harmed the most because of their inability to correct for the situation. RBC units mainly have to accept the primary effluent as it is, and unless they have supplemental air there is no immediate process control changes available to the operator. Trickling filters can only change recirculation rates (if they have the ability to do so) to dilute the poor quality primary effluent. The dispensed growth systems (all the variations of activated sludge) have operational changes that can help in correcting this problem. The dispersed growth systems can normally increase dissolved oxygen and change return activated sludge flow rates to accommodate the effect of poor quality primary effluent.

4.1.2 Relate collection system management and enforcement of sewer use ordinances to the operation of the treatment plant.

Good collection system management and enforcement of sewer use ordinances should improve primary treatment by:

A. The elimination of inflow, infiltration, and other "clear" water sources to improve hydraulic detention time.

B. The control of oil and grease by proper operation of grease traps and oil skimmers.

C. Preventing the discharge of materials that can be detrimental to the treatment plant processes (pretreatment of toxic wastewater).

D. Eliminating the discharge of volatile explosive materials that could damage the collection system or treatment plant.

E. Pretreatment of high strength organic wastes to prevent shock loadings to the plant.

F. Pretreatment to eliminate or reduce inorganic suspended solids and reduce grit load.

G. Providing sewer system maintenance and cleaning to prevent problems with septic raw wastewater.

H. Control of septage haulers to prevent unauthorized dumping that could cause excessive primary sludge or plant upsets.

4.1.3 Describe two characteristics of influent wastewater that may inhibit settling.

The two influent wastewater concerns that inhibit settling are septic raw wastewater and low temperature wastewater.

Section 4.2 - Structure and Function

4.2.1 Describe the situations when construction or operation of primary clarifiers is not necessary or advisable.

The use of primary clarification prior to secondary biologic treatment is always necessary for fixed film systems (RBC's and trickling filters), and optional in the dispersed growth systems (all variations of activated sludge). Generally, the optional choice of not using or constructing primary clarifiers is based on the assumption of good preliminary treatment, including coarse screening, grit removal, and comminution. Provided good preliminary treatment is available, many activated sludge systems would not have to construct primary clarifiers. They would have to size aeration basins, all air equipment, and sludge handling equipment, to account for the increased organic loading caused by not having primary clarification. It would be necessary to ensure that the raw wastewater did not have a significant oil and grease problem, and that large amounts of septic tank sludge is not routinely received at the plant.

If primary clarifiers are already an existing part of the treatment plant, the non-use of these units should be considered under several circumstances. One situation where not to use them would be when the plant is extremely underloaded, has good preliminary treatment, does not have significant oil and grease problems, does not receive large amounts of septic tank sludge, and the aeration basins can handle the load. Another situation would be an underloaded plant with good preliminary treatment, but with very long detention times in the primary. This could cause anaerobic conditions to occur and cause the primary effluent to be of poor quality. A last situation where primary clarification might be discontinued, is if there is a change in loading that would preclude the need for that treatment (e.g. An industrial facility with a high organic loading to the plant that closes down its operation).

4.2.2 Compare metallic versus non-metallic chain for use in the sludge collection system of primary clarifiers.

A. Metallic:
1. Heavy to handle.
2. Harder to install.
3. Corrosion problems.
4. Stretches more.
5. Wears faster.

B. Non-metallic:
1. Lighter to handle.
2. Easily installed.
3. Corrosion resistant.
4. Stretches less.
5. Less affected by temperature.
6. Wears less.

4.2.3 Compare the discharge rate of piston pumps and centrifugal pumps at varying discharge heads.

A piston pump is a positive displacement type pump and will discharge a constant volume at varying discharge heads. A centrifugal pump relies on the forces generated by a rotating impeller and the discharge volume varies with the discharge pumping head. The higher the discharge head, the lower the discharge volume.

Chapter 5 - Operation and Maintenance

Section 5.1 - Operation

5.1.1 Describe the following types of circular clarifiers and the flow patterns used:
A. Center feed with rim overflow
B. Rim feed with rim overflow
C. Rim feed with center overflow

A. The vast majority of circular clarifiers are designed with center feed and rim overflow. This arrangement provides maximum length of weirs with easy access to the weirs for maintenance and adjustment. This would be the "standard" type circular clarifier.
B. A few installations use rim feed and rim overflow which has the advantage of easy access to both the influent channel and the overflow weirs.
C. A rare clarifier would be rim feed with center overflow. This type of clarifier has a problem with having enough weir length.

5.1.2 Explain the function of a torque limiter, and describe ways of checking to make sure it is not out of adjustment.

A torque limiter will prevent damage to sludge drive units and sludge collection equipment if they would happen to become jammed. It may be checked by holding the scum arm to see if it trips.

5.1.3 Explain how a fine screening system can be used instead of primary clarification.

Fine screening systems have been used in place of primary clarification. Fine screens have been operated as a traveling water screen, a static screen, or a rotating drum. Fine screens may be constructed from woven wire cloth, perforated plate, slots in drums, or closely spaced bars. The size of the debris collected is dependent on the size of the screen openings. The use of fine screens instead of primary clarification has had limited applications in recent times.

5.1.4 Discuss the importance of even flow splitting to several clarifiers.

Even flow splitting to several clarifiers is important from both the hydraulic and organic standpoint. Unequal flows will cause changes in detention times, weir overflow rates, sludge collection volumes, and the primary effluent quality. Higher flows to one clarifier could cause high BOD and suspended solids in the primary, while extremely low flows (long detention time) could cause a clarifier to go anaerobic. This would cause poor quality effluent and could make final effluent quality worse than normal.

5.1.5 Discuss the possible considerations when starting a clarifier's sludge collection mechanism after a prolonged shut-down.

Depending on the length of time that the sludge collection equipment has been shut-off, there is a possibility that excess sludge build-up could damage the equipment, shear pins, or trip the torque limiter. If it is suspected that excess sludge might be a problem, it would be appropriate to check with a sludge judge or a pole and pump sludge as necessary. Try to move equipment manually before turning on the drive motors. If pins are sheared or the torque limiter trips, it may be necessary to dewater the clarifier and clean-out the excess sludge.

5.1.6 Discuss the use of chemicals to aid sludge settling.

Although not used often in primary clarification, chemical additions can improve particulate settling. Coagulation chemicals that may be used include: lime, ferric chloride, alum (aluminum sulfate), and polymers. The coagulation process neutralizes electrical charges allowing particles to cling together to form larger flocs. Lime, ferric chloride, and alum also form chemical precipitates which aid settling, while polymers are just a settling aid. Lime, ferric chloride, alum, pickle liquor, and other chemicals may also be used in primary clarification for phosphorus removal.

5.1.7 Describe the methods used to determine that sufficient sludge is being pumped.

One method to determine sludge removal would be to use a sludge judge to measure sludge depths in the clarifier. A second method would be to visually observe sludge being withdrawn (telescopic valve sludge tank, visual sight glass, or sampling tap at the piston pump). A third method is visual observation of the clarifier to make sure there is minimal floating sludge and minimal gas bubbles. Calibration of sludge pumps and timing of pumping can be compared with observations using a sludge judge.

Section 5.2 - Maintenance

5.2.1 List the methods used to prevent or reduce wear on sludge collectors.

A. To protect and reduce wear on the entire sludge collector mechanism requires proper lubrication (per manufacturer's recommendations).
B. Correct the alignment of all parts.
C. Correct the tension on chain and belt drives.
D. Prevent interferences with stationary parts.
E. Make sure the right replacement equipment is used.
F. Prevent rust and corrosion.
G. Maintain proper clearances on moving equipment.
H. Maintain good security at the plant to prevent obstructing materials or debris from being deposited (accidentally or deliberately) in the clarifier.

5.2.2 List the items to consider in planning routine and long-term replacement part inventories.

The planning of a replacement parts inventory generally falls into two categories. The first, routine short-life items that need to be on hand, and second, the longer-term major items that require more planning. Items to consider in the inventory planning for preventive maintenance would include:

Routine: supplies on-hand for short-life equipment (lubricants, pump packing, shear pins, protective coatings, chain links and pins, wear shoes, belts and sheaves, tools,etc.), should be stocked at the plant and be immediately available. Experience will dictate the amount of individual items that are on-hand. As an example, lubricants should be in a volume necessary to meet preventive maintenance requirements as directed in the O & M manual or from manufacturer's recommendations.

Long-term: planning for longer-term items need to include a listing of major items (electric drive motors, gear boxes, sludge pumps, and other ancillary equipment). Information in the plan should include: availability of stand-by units in case of a major breakdown; expected life of major equipment; actual date equipment was installed (or running time since installation); a list of equipment suppliers and their ability to supply equipment on short notice. The plan should be maintained by either a manual card system or a computer program to track this information. The importance of this planning puts an operator into a preventive maintenance position rather than having to react to emergency breakdown situations.

Chapter 6 - Monitoring and Troubleshooting

Section 6.1 - Monitoring

6.1.1 Identify the range of sludge concentration that can be expected from a well-operated primary clarifier.

Good quality primary sludge should be in the 3-5% range.

6.1.2 Identify the range of values for the following:

A. Detention Time
B. Weir Overflow Rates
C. Surface Settling Rates

A. Detention time: 1 to 3 hours.
B. Weir overflow rates: should not exceed 10,000 gpd/linear foot of weir.
C. Surface settling rates: at average design flow, the rate should not exceed 1000 gallons per square foot per day, and not exceed 1500 gallons per square foot per day at maximum hourly flows.

6.1.3 Describe the concerns that can occur due to wastewater temperature changes.

The two changes that occur with rising temperature are: increased biological activity, and better settling (lower water viscosity). The increased biologic activity can lead to the need to pump sludge more often in summer to prevent the clarifier from becoming septic (odors, gasification, floating sludge ,and a drop in pH). This condition can be made worse if septic conditions develop in the sewer collection system. Another concern that could occur during low summer flows is that the clarifier temperature can be higher than the entering wastewater. This can cause density stratification to develop in the tank and can adversely affect settling performance.

6.1.4 Describe the factors to use in evaluating the operations of a primary clarifier.

Factors to evaluate the performance of a primary clarifier would be the:

A. Percent removal of BOD and suspended solids.
B. Detention time, actual (dye test) versus calculated.
C. Surface settling rates.

D. Weir overflow rates, including reviewing for short-circuiting (dye test or visual observations).
E. Sludge analysis for volatile and total suspended solids (if volatiles are considerably less than 70-75%, excess grit is entering the clarifier and the grit removal system must be checked).

6.1.5 Discuss the concerns that should be considered when accepting septage at a treatment plant.

The first consideration is overall organic loading of BOD and suspended solids to the plant, as compared to design loading. At no time, should septage be accepted if you will exceed the design organic loading. As a safety factor, it would be recommended that such loadings should not place the organic loading above 90% of design capacity.
A second consideration would be the type of septage being accepted. For example, holding tank wastes can be treated the same as raw sewage, while septic tank waste must be evaluated based on high organic loading. Other types of septage (industrial sources, leachate, or others) must be thoroughly evaluated for organic loads, the possibility of toxics that might interfere with biological treatment systems, and other items, including grease and oils. Consideration must also be given to the time of day that you are accepting septage. Low flow periods are best as it provides the added detention time and decreases loads on the secondary system. Ideally, provisions should be made to pretreat (screen) the septage and to provide a holding tank to allow the operator to "trickle" in these wastes at a controlled rate.

Section 6.2 - Troubleshooting

6.2.1 Discuss how a piston pumping system can be modified to prevent damage from pumping against a closed valve.

A. Install a softer shear pin.
B. Install a pressure switch for motor shut-off on the discharge side of the pump.

6.2.2 Identify the causes and corrective actions for the following:
A. Excess floating scum and grease
B. Floating solids
C. Frequent shearing of pins in collector mechanism or erratic movements
D. Excessive wear of primary chains
E. Hydraulic short circuiting
F. Sludge collector damaged due to excess load
G. Sludge collector jerks and/or jumps (no excess sludge blanket)
H. Sludge pump operating, but no sludge (or water) is being pumped

A. Excess floating scum and grease:
Cause: Incoming septic wastewater or failure to service the oil and grease pretreatment systems.
Correction: Correct septic wastewater with pre-aeration and check all oil and grease pretreatment facilities in the collection system.

B. Floating solids:

Cause: Septic conditions are occurring in the clarifier. This can be caused by septic conditions in the collection system, digester return flows, sludge pumping schedule, organic overloads, and return of well-nitrified waste activated sludge.
Correction: Improve hydraulics of the collection system or pre-aerate the incoming wastewater, improve the digester, pump sludge more frequently, operate sludge collection for longer periods, eliminate or pretreat high-strength organic wastes, and change sludge age of the waste activated sludge, or process the waste activated sludge in some other manner.

C. Frequent shearing of pins in collector mechanism or erratic movements:
Cause: Misalignment or debris.
Correction: Realign and lubricate. It could be caused by debris in the tank which would require dewatering of the clarifier and physically removing the cause of the blockage.

Cause: Worn parts (scrapers, shoes, flights, pins, chains, etc.).
Correction: Dewater the tank and replace or repair all defective parts.

Cause: Excessive load on sludge collection mechanism.
Correction: Check for excessive sludge caused by inadequate sludge pumping. Check for proper clearances between the collection equipment and the clarifier walls and tank bottom.

D. Excessive wear of primary chains:
Cause: Misalignment, faulty lubrication, or wrong equipment being used.
Correction: Realign, lubricate, and replace with correct equipment.

E. Hydraulic short circuiting:
Cause: Baffles improperly installed or misaligned, weirs not level or plugged with debris, poor design, and density currents.
Correction: Baffles should be correctly installed and aligned, weirs should be leveled and cleaned, possible design changes, and add additional baffles to control or stop density stratification.

F. Sludge collector damaged due to excess load:
Cause: There is a build-up of sludge or the possibility of excess grit in the clarifier.
Correction: Pump sludge more frequently, run collector mechanism longer, and improve grit removal practices.

G. Sludge collector jerks and/or jumps (no excess sludge blanket)
Cause: This has similar causes like frequent shearing of pins problem, except the excess sludge is not a cause. The possible causes would be misalignment, debris in the tank, or worn/broken parts.
Correction: To correct this situation, the tank will need to be dewatered to check the entire sludge collect or mechanism. Repair worn or damaged parts, remove debris, realign, and lubricate.

H. Sludge pump operating, but no sludge (or water) is being pumped:
Cause: (piston pump) Check if ball is being held-up by debris.

Correction: Close gate valves(inlet & outlet), release pressure carefully, and remove ball covers. Remove debris, reinstall ball and cover, and open gate.

Cause: (centrifugal pump) Loss of prime.
Correction: Prime the pump with water or use a vacuum pump to remove air to prime the pump. If problem continues, consider reducing negative suction head to a positive head.

Cause: (centrifugal pump) Sludge is too heavy.
Correction: Centrifugal pumps are generally not well adapted for pumping sludge (especially heavy sludge). They handle the sludges, provided sufficient velocity is maintained through the pump. If the sludge is too heavy, it should be diluted with water (if possible) or change sludge pumping frequency (more often with short cycles) to get thin sludge.

6.2.3 List the strategies to reduce the impact of flow surges from a nearby lift station on clarifier performance.

A. Place start and stop floats closer together so pump will pump more often, but will pump less gallons per cycle.
B. Install smaller pumps that pump less gallons per minute.
C. Install variable speed drive motors.
D. Consider installation of a flow equalization basin before the clarifier.

6.2.4 Describe the affect high strength organic waste can have on primary treatment and downstream processes.

High strength organic wastes can come from such industries as dairies, breweries, or food processing industries. These high strength wastes can cause the primary clarifier to become anaerobic, which will cause odors and floating sludge. These types of organic wastes can also cause excessive solids loading. If the facility is not designed for this type of loading, adequate pretreatment should be provided at the sources. Downstream processes that could be affected by such overloads would be the secondary treatment units which could cause a problem with poor final effluent. With high solids loading, the digestion system can be overloaded, resulting in poor quality supernatant return flows and an increase in waste sludge hauling.

6.2.5 Describe the potential symptoms and problems associated with inadequate industrial pretreatment of plating wastes.

The symptoms of receiving inadequately pretreated plating wastes would include color change, rapid pH variations, and an increase in heavy metals concentration. If the concentrations are high enough, the microorganisms in the secondary process can be killed off. In addition, the heavy metals that are precipitated in the primary clarifier will be transported to the digester, possibly causing digester microorganism die-off and loss of gas production.

6.2.6 Explain how denitrification (a problem usually associated with secondary clarifiers) can occur during primary clarification.

To have denitrification occur in a primary clarifier, it would be necessary to have a well nitrified waste activated sludge returned to the primary. The lower dissolved oxygen in the primary will allow denitrification to take place which releases free nitrogen bubbles, causing floating sludge.

6.2.7 Describe the possible modifications to eliminate or reduce problems caused by septic primary effluent.

To correct operational problems of septic primary effluent, the cause of the problem must be determined. For this overall problem, it is assumed that primary sludge pumping is being done correctly (covered in other objectives). The four main causes for this situation would be: 1) septic raw wastewater entering; 2) return of poor quality sidestream flows such as anaerobic digester supernatant; 3) high strength organic overloads; and 4) very long detention time in the clarifiers. This problem can also be caused by a combination of the above four. To eliminate or reduce this situation would require:

Septic raw wastewater: the cause of septic influent can be poor collection system hydraulics, such as, low flow flat sewers or excessive detention times in lift station wet wells. Corrections would include changes in the sewer system hydraulics, pumping modifications at lift stations to reduce detention time, and prechlorination and/or aeration.

Poor quality sidestreams: poor sidestream quality can cause organic overload to the primary clarifier. Correction would be to improve the quality of such flows with operational changes (better supernatant control or sludge hauling) or some form of inplant pretreatment (flow equalization, aeration, or chlorination).

High strength organic overloads: this normally would be caused by an industrial source within the collection system and the solution would be to obtain pretreatment at the source. Another organic overload could come from septage haulers which should be corrected by controlling the rate from its source ("trickle" it in or allow only during low flow periods) or if this does not correct the problem, completely discontinue accepting septage.

Long clarifier detention times: this problem would normally only occur with a significantly underloaded plant which could cause septic effluent due to very long primary clarifier detention times. If the plant has only one primary clarifier, it may be necessary to aerate the primary effluent if the secondary system is of the RBC or trickling filter type. If the secondary system is activated sludge, the single primary clarifier could be bypassed providing there is good preliminary treatment (screening, comminution, and grit removal). If the treatment plant is larger and has multiple primary clarifiers, consideration should be given to reducing the number of clarifiers being used to reduce detention time.

Chapter 7 - Safety and Calculations

Section 7.1 - Safety

7.1.1 Discuss the safety considerations in the prechlorination of influent.

Prechlorination with chlorine gas has all the safety problems associated with normal chlorination. Chlorine gas is toxic and heavier than air causing potential problems if in a closed space around preliminary treatment equipment. Concerns over gas leaks would include adequate ventilation, self-contained breathing apparatus, and repair kits. The use of hypochlorite solution is much safer, but even these solutions or powders are extremely strong oxidants. They can cause burns or irritation of mucus membranes and must be handled with care. Care must be exercised if a chlorine solution is mixed with ammonia as free chlorine gas can be released.

7.1.2 Discuss the safety hazards associated with septic influent in preliminary or primary treatment.

The safety hazards associated with septic influent would be the release of hydrogen sulfide and methane. The most dangerous health hazard would be the hydrogen sulfide.

7.1.3 Outline a safety and training program for employees working with preliminary and primary treatment processes.

An outline of safety training for preliminary and primary treatment would be:
A. Chemical handling: protective clothing, eye protection, and breathing apparatus.
B. Equipment operations: equipment safety devices(guards). Electrical tag/lock-out during repairs. Use proper equipment.
C. Confined spaces: recognize confined spaces. Take proper precautions -"DILHR" code governs such areas as: wet wells, manholes, digesters, etc.
D. Electrical equipment: electrical hazards. Do not attempt electrical repairs unless you are fully qualified for this work.
E. Health related: bacteria and viruses. Practice good personal hygiene.

Section 7.2 - Calculations

7.2.1 Given data, calculate the percent removal of BOD and suspended solids in a primary clarifier.

GIVEN:
Influent BOD = 200 mg/L
Influent SS = 180 mg/L
Effluent BOD = 140 mg/L
Effluent SS - 90 mg/L

FORMULA:
% Removal =
[(Concentration(IN) - Concentration(OUT))/Concentration(IN)] X 100

% BOD Removal =
[(200 mg/L - 140 mg/L) / 200 mg/L] X 100

= 30%

% SS Removal =
[(180 mg/L - 90 mg/L) / 180 mg/L] X 100

= 50%

7.2.2 Given data relating to flows, pump capacities and solids loading to the primary clarifier, calculate the running time needed to pump sludge.

GIVEN:
Raw Flow = 1 MGD
Raw Suspended Solids = 200 mg/L
Primary Effluent Suspended Solids = 100 mg/L
Waste Activated Sludge to Clarifier = 10,000 GPD @ 1% Solids
Primary Sludge = 4% Solids
Piston Pump = 2 Gallons per Stroke @ 25 Strokes per Minute

FORMULA:
Pounds = Flow (MGD) X Concentration(mg/L) X 8.34 lbs/MG/mg/L
Pounds From Raw = 1 MGD X (200 mg/L - 100 mg/L) X 8.34 lbs/MG/mg/L
= 834 Pounds

Pounds Waste Activated = .01 X 10,000 GPD X 8.34 lbs/gal
At 1% (10,000 mg/L) = 834 pounds

Volume of Pump At 4% (40,000 mg/L)
834 lbs + 834 lbs = 40,000 mg/L X 8.34 lbs/MG/mg/L

MGD = (834 lbs + 834 lbs) / (40,000 mg/L X 8.34 lbs/MG/mg/L)

= .005 MGD
= 5000 GPD

Pump Running Time (Minutes) = 5000 GPD / (2 gal/stroke X 25 strokes/min.)

= 100 minutes

7.2.3 Given data related to primary clarifier loading, calculate the gallons of sludge that need to be pumped daily.

GIVEN:
Flow = 2 MGD
Clarifier Influent Suspended Solids = 200 mg/L
Clarifier Effluent Suspended Solids = 100 mg/L
Primary Sludge = 5% Solids (50,000 mg/L)

FORMULA:
Pounds = Flow (MGD) X Concentration(mg/L) X 8.34 lbs/MG/mg/L
= 2 MGD X (200 mg/L - 100 mg/L) X 8.34 lbs/MG/mg/L

= 1668 pounds of Dry Solids

1668 lbs = MGD X 50,000 mg/L X 8.34 lbs/MG/mg/L

= .004 MGD

= 4000 Gallons per day

7.2.4 Given data, calculate the surface settling rate of a clarifier (rectangular and circular).

RECTANGULAR CLARIFIER
GIVEN:
Length = 20 Feet
Width = 10 Feet
Flow = 0.08 MGD

FORMULA:
Surface Settling Rate = Flow/Surface Area
= 80,000 GPD/ (20 ft x 10 ft)
= 400 GPD/Ft^2

CIRCULAR CLARIFIER
GIVEN:
Clarifier Diameter = 20 Feet
Flow = 0.10 MGD

FORMULA:
Area of Circle = 3.14 x r^2
Surface Settling Rate = 100,000 GPD/(3.14 x 10 ft x 10 ft)
= 318 GPD/Ft^2

7.2.5 Given data, calculate the detention time in a clarifier (rectangular and circular).

RECTANGULAR CLARIFIER
GIVEN:
Width = 20 Feet
Length = 40 Feet
Depth = 10 Feet
Flow = 370 GPM

FORMULA:
1 Cubic Foot = 7.5 Gallons
Volume Rectangle = Width x Length x Depth
Detention Time = Volume (gallons) / Flow Rate (GPM)

Detention Time = (20 ft X 40 ft X 10 ft X 7.5 gal/cubic foot) / 370 GPM
= 162.16 minutes
= 162.16 minutes/ 60 min/hr
= 2.7 Hours

CIRCULAR CLARIFIER
GIVEN:

Diameter = 20 Feet
Depth = 12 Feet
Flow = 300 GPM

FORMULA:
1 Cubic Foot = 7.5 gallons
Volume of a Cylinder = 3.14 x r^2 x depth
Detention Time = Volume (gallons) / Flow Rate (GPM)

Detention Time = (3.14 x 10 ft x 10 ft x 12 ft x 7.5 gal/cubic ft) / 300 GPM
= 94.2 minutes
= 94.2 minutes / 60 min/hr
= 1.57 Hours

7.2.6 Given data, calculate the change in volume of sludge with a change in percent solids.

Given:
5000 gallons of sludge at 5% solids thickened to 8% solids

Find: Volume at 8% solids

Formula:
$C_1V_1 = C_2V_2$
5% (5000 gal) = 8% V2
V2 = (5% x 5000 gal)/8%
V2 = 3125 gallons

References and Resources

1. **CONTROLLING WASTEWATER TREATMENT PROCESSES**

   (1984). Cortinovis, Dan. Ridgeline Press, 1136 Orchard Rd, Lafayette, CA 94549.

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