Minnesota Pollution Control Agency

Water Quality

Wastewater Technical Review and Guidance

# BIOLOGICAL TREATMENT CHECKLIST – SUSPENDED GROWTH – ACTIVATED SLUDGE, OXIDATION DITCHES

Water/Wastewater/#5.10, April, 2001

FACILITY NAME

DATE

CONSULTING ENGINEER

SITE INSPECTION (DATE & INSPECTOR)

PLANNING OR DESIGN PHASE

## INTRODUCTION

The activated sludge process is an aerobic biological process, which uses the metabolic reactions of microorganisms to attain an acceptable effluent quality by removing substances exerting an oxygen demand. There are many modifications of activated sludge that can be used to meet specific treatment requirements. These modifications consist of and are defined as follows:

**Conventional Activated Sludge -** The conventional activated sludge process consists of an aeration tank, a secondary clarifier and a sludge recycle line. Both influent sewage and recycled sludge enter the tank at the head end, move through the tank in plug flow and are aerated for a period of time.

**Step Feed Activated Sludge -** The Step feed process (sometimes called Step Aeration) is a modification of the activated sludge process in which sewage is introduced at two or more points in the aeration tank while return sludge is introduced only at the head end of the aeration tank. In this modification, the oxygen demand is more uniformly spread over the length of the aeration tank.

**Tapered Aeration Activated Sludge -** The tapered aeration activated sludge process is a modification of the conventional activated sludge process. Tapered aeration affects only the arrangement of the aeration devices in the aeration tank. In tapered aeration the diffusers or aeration devices are spaced closer together at the head end of the tank to match the oxygen demand.

**Contents:**



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**Complete Mix Activated Sludge -** The complete mix activated sludge process is characterized by distributing the influent sewage, return sludge and air equally throughout the aeration tank to form a nearly homogeneous mixture in the tank. The organic load and thus oxygen demand is uniform from one end of the tank to the other.

**Contact Stabilization Activated Sludge -** The contact stabilization activated sludge process utilizes two aeration compartments to divide the two phases of BOD removal. The first phase, adsorption, takes place in the first aeration tank (contact tank). Mixed liquor from the contact tank then flows to the clarifier. Return sludge flows to the second aeration tank (reaeration tank) where the second phase, absorption, occurs. The reaeration tank provides detention time before flowing into the contact tank.

**Extended Aeration Activated Sludge -** The extended aeration activated sludge process operates in the indigenous respiration phase of the growth curve, which necessitates a relatively low organic loading (low F/M) and long aeration time.

**Oxidation Ditch Activated Sludge -** The oxidation ditch activated sludge process is an extended aeration process utilizing a ring-shaped channel and aeration than provides continuous flow around the channel.

**Pure Oxygen Activated Sludge -** Pure oxygen activated sludge is characterized by the use of high purity oxygen instead of air for aeration. 30

## I. **DESCRIPTION OF FACILITY –** Provide a short description of the proposed facility:

______________________________
______________________________
______________________________

**Hydraulic and Organic Loading / Design Flow**

| | | |
|---|---|---|
| Average Wet Weather (AWW) | ____________ | gals/day |
| Peak Hourly Wet Weather (PHWW) | ____________ | gals/day |
| Peak Instantaneous Wet Weather (PIWW) | ____________ | gals/day |
| Organic Loading, CBOD5 | ____________ | lbs/day |
| Explain Primary modification of activated sludge | ____________ | |
| Type of activated sludge process chosen | ____________ | |
| Type of Aeration | ____________ | |

| | | |
|---|---|---|
| Tank Dimensions and Volume | ____________ | |
| Detention time in aeration basin | | hrs |
| Aeration tank organic loading (CBOD/day/1000ft$^3$) | ____________ | |
| Design F/M ratio | ____________ | |
| Design MLSS | ____________ | |
| Process Preceded by (specify process) | ____________ | |
| Process Followed by (specify process) | ____________ | |

Final effluent limitation ____________ mg/L CBOD5
____________ mg/L TSS
____________ mg/L Ammonia (min. concentration)
____________ mg/L Phosphorus

**GENERAL**

Calculations and/or documentation shall be submitted to justify the basis of design for the following:

a. Process efficiency. ____________
b. Aeration tanks. ____________
c. Aeration equipment (including oxygen and mixing requirements) ____________
d. Secondary clarifiers ____________
e. Return sludge equipment ____________
f. Waste sludge equipment ____________
g. Sludge handling facilities ____________

Wastewater must be amenable to biological treatment. Check for industrial discharges that may cause a nutrient imbalance, variable pH or temperature, or toxic or slug discharge. Certain dairy wastes, paper wastes, potato wastes particularly should be examined for nutrient deficiencies. ____________

City has sufficient equipment, trained perator, financial resources, etc. to properly operate and mange this system: ____________

**Efficient use of energy is provided?**
Particular attention should be given to initial operation when oxygen demands may be significantly less than the design oxygen demand. The design should always maintain the minimum mixing levels; mixing may control power requirements at low oxygen demands. Energy conservation measures should be considered in design of aeration systems. For diffused aeration systems, the following should be considered: ____________

a. Use of smaller compressors and more units. ____________
b. Variable-speed drives on positive-displacement compressors. ____________
c. Intake throttling on centrifugal compressors. ____________
d. Use of high-efficiency diffusers. ____________

For mechanical aeration systems, the following should be considered:

a. Use of smaller aerators. ____________________
b. Variable aeration tank weirs. ____________________
c. Multiple speed motors. ____________________
d. Use of timers. ____________________

Duplication of critical units (pumps, aerators, motors) as well as standby units (tanks etc.) have been provided. See "Reliability Guidelines." ____________________

Standby or auxiliary power is provided for aeration and pumping equipment. TYPE ____________________

Flexibility allows for at least three modes of operation (two for extended aeration). Flexibility refers to providing several modification, series and parallel operation, munerous return and waste sludge flow options, etc. If feasible, aeration tank systems, except extended aeration, should be designed to accommodate at least three (3) modes of operation (such as plug flow, complete mix, contact-stabilization, step feed etc.). Two (2) modes of operation for extended aeration systems larger than 1893 m3/day (0.5 MGD) should be considered. Design of aeration systems should provide adequate flexibility to vary the oxygen transfer capability and power consumption in relation to oxygen demands. MODES ____________________

Protection of aeration tanks, clarifiers and equipment from freezing. Winter protection for the aeration tanks may consist of windwalls, earthen bank insulation, and extra freeboard, etc. Other equipment such as blowers, pumps, etc. should also be protected. Secondary clarifiers and aerobic digesters should be covered under certain conditions. TYPE ____________________

**PRETREATMENT**

Grit removal, scum and comminution or screening ____________________

**AERATION**

Number of Units – The requirements for dual aeration tanks shall be as listed in MPCA's Reliability for Mechanical Wastewater Treatment Plants Guidelines.

a. Additional aeration tanks designed specifically for nitrogen removal shall not be used for satisfying the requirement of dual aeration tanks for secondary treatment activated sludge.

b. Plants with initial flows of less than one-half design should have at least two (2) aeration basins. All flow splitting devices shall have vertical inlet into the splitter and split by overflowing horizontal surfaces at the same elevation.

c. When two (2) or more tanks are installed, both series and parallel flow schemes should be available. In addition each train of aeration tank(s) and clarifier(s) shall have its own separate return and waste sludge pumping facilities, as well as intergroup return and wasting sludge capabilities.

**ARRANGEMENT OF AERATION TANKS**

a. **Dimensions –** Deep aeration tanks utilizing surface aeration should be avoided without assurance of adequate mixing. Spiral flow refers to the circular flow pattern that results what the diffusers are located along one wall of the aeration tank. Fillets should be provided around the bottom of aeration tanks where the wall and bottom meet to eliminate dead spots.

Do any unusual factors exist that will affect design such as excessive diurnal load (>4:1, <2:1) variations, stricter degree of treatment than 25 mg/1 BOD, 30 mg/l TSS, temperatures, pH, etc. Wastes with high concentrations of BOD diurnal load ratios or peak hourly BOD5 to average BOD5 of greater than 4:1. may be handled best by complete mix activated sludge because BOD is dispersed completely through tank and makes maximum use of dilution. Contact Stabilization may not be practical for wastewater with a high soluble BOD such as dairy waste. Lab tests should be performed on mixtures of industrial and domestic wastes. Conventional activated sludge may be designed for slightly higher organic loadings if the system also has the capability to operate in a mode that can handle higher loadings. For step feed plants, influent hydraulic design should permit all flow to enter any single pass. The flow to each pass must be controllable.

**CRITERIA**

Liquid depth in aeration tank, should not be less than 10 or more than 30 feet. Horizontally mixed aeration tanks shall have a depth of not less than 5.5 (as an exception). FT

Shape of tank and installation of aeration equipment shall avoid short-circuiting.

Access must be available to allow for observing aeration tank contents, mixing pattern, sampling, etc., in aeration tank and settling, scum collection, level weirs, etc., in clarifier. ____________________

Each compartment has load-bearing walls for individual compartment dewatering. Slope bottom to assure complete drainage. Aeration tank drainage should be discharged upstream of the activated sludge process.

Piping for bypassing and dewatering each individual compartment is provided? ____________________

Pressure relief valves in each compartment provided? Tanks with freeboard greater than 18' shall provide rails, steps or other means of egress from each aeration tank. Additional freeboard or windbreak may be necessary to protect against freezing or windblown spray. Walkways should be located and/or designed to preclude spray and foam from freezing on their surfaces. Locating walkways away from or sufficiently elevated, above water levels and using grated walkways are examples of methods used to prevent ice build up. ____________________

Aeration Tank freeboard, minimum 18 inches. _____ IN _______________

If a mechanical surface aerator is used, the freeboard should not be less than 3 feet to protect against windblown spray freezing on walkways, etc. ____________________

**AERATION EQUIPMENT-DIFFUSED AIR**

In diffused air systems, a minimum air flow volume of 20-30 scfm/1000 $ft^3$ than volume is required for adequate mixing velocities and to avoid depositing of solids. For a grid aeration system, mixing rates of 10 to 15 $ft^3/min/1000ft^3$ is sufficient. ____________________

A bypass to the atmosphere should be installed avoid surging. The bypass should be arranged to be open at starting and at all times when the airflow is less than that at the surge point. ____________________

Aluminum pipe should be avoided due to corrosion problems. ____________________

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|---|---|
| Centrifugal blowers should and rotary positive displacement blowers must be provided with both inlet and discharge silencers to reduce the high pitched whine that is transmitted to the piping. | |
| Surging will result If the blower is throttled on the discharge side or by adjustment of the air valves at the aeration thanks to capacity equal to or less than that at the peak of the head-capacity curve. | |
| Total aeration tank volume shall be divided between two or more units, capable of independent operation, for reliability. | |
| Both parallel and series operation are available when two or more aeration tanks exist. | |
| Inlets and outlets of aeration tank shall be equipped with valves, gates, plats, weirs or other devices to control flow to any unit and to maintain constant liquid level. | |
| The effluent weir for a horizontally mixed aeration tank system must be easily adjustable by mechanical means and shall be sized based on the design peak instantaneous flow plus the maximum return sludge flow. | |
| Design peak instantaneous flow can be carried with any single aeration tank unit out of service. | |
| All channels and pipes designed to maintain self-cleansing velocities. Min.2'/Sec | FT/SEC |
| Channels not being used during alternate flow patterns can be drained | |
| Minimum dissolved oxygen concentration that can be maintained by aeration equipment. Should be at least 2 mg/l D.O. | Mg/l |
| Design oxygen requirements in lbs. $O_2$/lb. Peak BOD5 applied to aeration tanks (Minimum 1.1 lbs. $O_2$/lb. $BOD_5$, except extended aeration the value shall be 1.5). | LBS $0_2$ DAY |
| For **nitrification** oxygen demand of recycle flow must be added to determine $0_2$ requirement | LBS $0_2$ |
| Total oxygen requirement, BOD recycle plus **nitrification** in lbs. $0_2$/lbs. BOD. | LBS $0_2$ DAY |

| | |
|---|---|
| Alpha and Beta factor (50% of clean water efficiency where 90 % + waste is domestic sewage, higher industrial percentages should use less that 50 % of clean water efficiencies and calculations need be submitted to justify) | ALPHA<br>BETA |
| Certified aeration device transfer efficiency. | |
| Air requirements for diffused air systems, $ft^3$/lb BOD peak aeration tank loading. (500 $ft^3$/lb BOD except extended aeration which shall be 2050 $ft^3$/lb BOD.) | CUBIC FT/LB BOD |
| Air requirements for additional air for channels, pumps, digesters, etc. | CUBIC FEET/MIN |
| Total air requirements, $ft^3$/Min. | CUBIC FEET/MIN |
| High air intake temperature for blower (should be designed for 115ºF (45ºC)). | Fº |
| Low air intake temperature for motor drive (should be designed for -20ºF (-29ºC)) | Fº |
| Blowers in multiple units and can meet maximum air demand with single largest unit out of service | |
| Air rate shall be variable or adjustable. For energy conservation | |
| Adequate workspace shall be provided around each blower and other equipment (2' minimum). For easy maintenance access. | FT |
| Diffuser systems designed for diurnal peak oxygen demand or 200% of design average oxygen demand, whichever is greater. | PEAK OR 200% |
| Total head loss from blower outlet of silencer to diffuser inlet (should not exceed 0.5 psi at average operating conditions. | psi |
| Spacing of diffusers should be in accordance with oxygen requirements through length of tank and designed to facilitate adjustment of aeration throughout tank. | |
| Diffusers are removable without dewatering aeration tank. | |
| Hoist provided to raise diffusers. | |

Individual diffusers are equipped with control valves with indicator markings for throttling, or for complete shutoff. ______________________

Air filters with easy access provided for blowers. ______________________

Soundproofing provided between blower room and other work areas. ______________________

Airflow rate meters provided for each aeration compartment in addition to a total air flow rate meter. ______________________

**AERATION EQUIPMENT – MECHANICAL**

Design Requirements – Provide mixing with use of a draft tube. Mixing requirements vary from .75 to 1.5 hp/1000$ft^3$ tank volume for complete mixing. Adjustable aeration tank outlet weirs are desirable with mechanical aerators for varying submergence of the aerator. Aeration devices in small plants may have time minute increments.
Reliability – An additional motor (and bearings for brush aerator systems) shall be provided for single mechanical aerator systems.

Oxygen requirements, lbs. 92/Hr. ______ DAY ______________

Certified testing of mechanical aerator and drive unit shall verify lbs. $0_2$/Hr. ______________________

In the absence of specific design information, the oxygen requirements shall be calculated using a transfer rate not to exceed 2 lbs. Of oxygen per horsepower per hour in clean water under standard test conditions. ______________________

Minimum D.O. maintained by mechanical aeration system (2 mg/l). ______ mg/l ______________

Mechanical aeration system can maintain all biological solids in suspension (for a horizontally mixed aeration tank system an average velocity of 1 ft. per second must be maintained). ______________________

Can mechanical aeration system meet maximum oxygen demand and maintain process performance with largest unit out of service. ______________________

Provide for varying the amount of oxygen transferred (adjustable mechanism, adjustable aeration tank outlet weirs, time clocks for smaller facilities, etc.) ______________________

Provide that motors, gear housing, bearings, grease fittings, etc., and be easily accessible and protected from inundation and spray as necessary for proper functioning of the unit. Aerators shall be removable without dewatering tanks on shutting off air supply to other tanks. ____________________

Protection from freezing and excessive ice build up. ____________________

**RETURN SLUDGE EQUIPMENT**

Return Sludge Rate – Timers should be considered only as a last resort. Timers should allow for operation in five (5) minute increments. Airlift pumps used for return sludge and waste sludge shall have air flow regulators with gauged handles for control of return sludge and waste sludge rates.
Return Sludge Pumps - Air lifts commonly plug up at top, so access must be provided at top of airlift to remove accumulated debris.

Return Sludge Piping - Observation and sampling of waste sludge, as well as return sludge, should be provided from a safe vantage point. Return sludge should be added to the influent wastewater prior to entering the aeration tank or added to the aeration tank in a manner and location that assures adequate mixing with the influent waste.

Minimum return sludge rate as percentage of design average flow (DAF). ______ % ______

Maximum return sludge rate (%) ______ % ______

Method of varying rate of sludge return (variable speed motors, drives or timers; timers for small facilities and as a last resort only) obtained with largest return pump. ______ TYPE ______

Can maximum return sludge capacity be obtained with largest return pump blower out of service? ____________________

Size of suction and discharge openings on return sludge pumps (three-inch minimum). ______ IN ______

Do airlifts allow rapid and easy cleaning? ____________________

Diameter of airlift (minimum three inches). ______ IN ______

Diameter of return sludge discharge (four-inch minimum). ______ IN ______

Design velocity of return sludge piping at normal return sludge rtes (minimum two feet per second). FPS

Devices provided for observing, sampling, measuring and controlling return sludge flow from each settling tank
OBS.
SAMP.
MEAS.
CONT. ______

Type of waste sludge handling. ____________________

Type of waste sludge control (manual, timer, % of return sludge, etc.) ____________________

Maximum capacity of waste sludge control facilities as percentage of average rate of sewage flow (not less than 25%). ____ %

Minimum capacity of waste sludge control facilities as percentage of average rate of sewage flow (0.5 % or 10 gal/min, whichever is larger). ____ %

Devices provided for observing, sampling, controlling and measuring waste activated sludge flow (list type separately).
OBS.
SAMP.
MEAS.
CONT

Where is waste sludge discharge? ____________________

**MEASURING DEVICES**

Measurement devices should be located to measure flows to each tank unit. This means if flow splitting is utilized, measurement should be located downstream of the flow splitting device to measure flows after splitting. When a totalizer and recorder are available to measure flows prior to flow spilling, a weir may be sufficient to satisfy flow measurement after splitting.

**For facilities over 1 MGD, can measuring devices for return and waste sludge also total and record?** ____________________

**OXIDATION DITCHES**

In addition to the above criteria concerning activated sludge facilities, oxidation ditches should conform to the following recommendation.

**Sidewalls and bottoms of oxidation ditch channels are tied together with reinforcing bar or are poured as on slab to eliminate frost heave?**
There must be something holding the walls and bottom together to prevent frost heaving causing separation. The weight sufficient to prevent this separation. ____________________

Type of backfill for oxidation ditch channel (should be sand with drainage).

Type of cover ground between channels.
The areas between the channels should be covered with an impermeable material to prevent rainwater from entering the ground between the channels. TYPE ____________________

Location of influent and return sludge lines with respect to rotor (lines should be upstream for best mixing). ______________________

Location of ditch discharge to final clarifier with respect to rotor (should be upstream of rotor and far enough upstream of influent and return sludge to prevent short-circuiting). The discharge weir shall be designed to withdraw mixed liquor from below the channel water surface such as through the use of a baffle in front of the weir. A baffle in front of the ditch overflow weir will prevent decanting clear liquid from the ditch. A floating draw off weir should be encouraged. ______________________

Water level control in aeration channel (should be adjustable weir). ______________________

Weir length of channel discharge (use maximum raw flow plus maximum recirculated flow to determine weir length to prevent excessive rotor immersions. ________ FT

Type of access to rotor for maintenance (should be at least walkways located upstream of rotor and located to prevent spray from rotor on walkway). ______________________

Horizontal baffles should be located within 15 feet downstream of brush aeration in channels with water depth over six feet. This provides proper mixing of the entire depth of the basin. Channels using jet aeration may be deeper and should have a water depth as recommended by the manufacturer. ______________________

In a single channel, rotor drive assembly should be on outboard side. ______________________

Drive and gear assembly elevated out of water for safe and easy access. ______________________

Equipment requiring normal maintenance should be housed and /or heated. ______________________

**PROTECTIVE AND SERVICE FACILITIES**

Ladders, hoists and walkways provided for easy access to equipment, pipes and valves for normal operation, routine maintenance or repair.
Tanks with freeboard greater than 18" shall provide rails, steps or other means of egress from each aeration tank. Additional freeboard or windbreak may be necessary to protect against freezing or windblown spray. Walkways should be located and /or designed to preclude spray and foam from freezing on their surfaces. Locating walkways away from or sufficiently elevated, above water levels and sing grated walkways are examples of methods used to prevent ice build up. ________________________________________

Hoisting equipment available for blowers, pumps and other heavy equipment ________________________________________

Adequate remote and local controls provided for mechanical equipment, especially waste sludge pump, return sludge control, sludge loadout, etc. ________________________________________

Chlorination flexibility provided for chlorination of return sludge. ________________________________________

Laboratory equipment to be provided, should be MLSS, settlemeter, settleabilty and dissolved oxygen. Consider minimum "Process Control" Tests. ________________________________________

Railings or other protective walls shall be placed around all aeration tanks. ________________________________________

List safety equipment to be provided near aeration tanks and clarifiers. Should include safety vests, lifelines, and rings and safety poles. ________________________________________

Sufficient lighting should be provided to permit safe working conditions near aeration tanks and clarifiers at night. ________________________________________