MISSOURI
DEPARTMENT OF
NATURAL RESOURCES

Title 10—DEPARTMENT OF NATURAL RESOURCES
Division 20—Clean Water Commission
Chapter 8—Minimum Design Standards

WORKING DOCUMENT
Strawman

The Department presents these draft materials for stakeholder review and discussion only.
Subject to the Red Tape Reduction review.

The Missouri Department of Natural Resources has identified 10 CSR 20-8, Minimum Design Standards, as a potential rulemaking amendment. This workgroup has been convened for the purpose of informal and voluntary public participation and discussions regarding the development of this rule prior to initiating formal rulemaking.

Under Governor Greitens' leadership, all state agencies are working to reduce regulations and other government processes that unnecessarily burden individuals and businesses while doing little to protect or improve public health, safety, and our natural resources. The Missouri Department of Natural Resources is committed to limiting regulation to what is necessary to protect Missouri's environment, implementing statutory mandates, and maintaining state control of programs. Any further proposed changes to rules discussed on this page are being developed with these goals in mind. We welcome your comments to help ensure that our regulations provide required protections but do not add unnecessary costs.

Title 10—DEPARTMENT OF NATURAL RESOURCES
Division 20—Clean Water Commission
Chapter 8—*[Design Guides]* Minimum Design Standards

10 CSR 20-8.180 Biological Treatment

[PURPOSE: The following criteria have been prepared as a guide for the design of biological treatment facilities. This rule is to be used with rules 10 CSR 20-8.110–10 CSR 20-8.220 for the planning and design of the complete treatment facility. This rule reflects the minimum requirements of the Missouri Clean Water Commission as regards adequacy of design, submission of plans, approval of plans and approval of completed sewage works. Deviation from these minimum requirements will be allowed where sufficient documentation is presented to justify the deviation. These criteria are taken largely from Great Lakes-Upper Mississippi River Board of State Sanitary Engineers Recommended Standards for Sewage Works and are based on the best information presently available. These criteria were originally filed as 10 CSR 20-8.030. It is anticipated that they will be subject to review and revision periodically as additional information and methods appear. Addenda or supplements to this publication will be furnished to consulting engineers and city engineers. If others desire to receive addenda or supplements, please advise the Clean Water Commission so that the name can be added to the mailing list.]

PURPOSE: The following minimum criteria have been prepared as a standard for the design of wastewater systems. This rule is to be used with rules 10 CSR 20-8.110 through 10 CSR 20-8.500 for the planning and design of a treatment facility. It is not reasonable or practical to include all aspects of design in these standards. The design engineer may use other appropriate reference materials for these design aspects not addressed in this rule, which include but are not limited to: copies of all ASTM International and American Water Works Association (AWWA) standards pertaining to wastewater systems and appurtenances, design manuals such as Water Environment Federation's Manuals of Practice, Department prepared guides and other wastewater design manuals containing principles of accepted engineering practice. This rule specifies minimum standards for the design and construction of wastewater systems, in addition to engineering experience and judgement in accordance with standards of practice.

[(1) Definitions. Definitions as set forth in the Clean Water Law and 10 CSR 20-2.010 shall apply to those terms when used in this rule, unless the context clearly requires otherwise. Where the terms shall and must are used, they are to mean a mandatory requirement insofar as approval by the Missouri Department of Natural Resources (department) is concerned, unless justification is presented for deviation from the requirements. Other terms, such as should, recommend preferred, and the like, indicate discretionary requirements on the part of the agency and deviations are subject to individual consideration.

(2) Exceptions. This rule shall not apply to facilities designed for twenty-two thousand five hundred gallons per day (22,500 gpd) (85.4m^3) or less (see 10 CSR 20-8.020 for the requirements for those facilities).]

(1) Applicability. Wastewater systems shall be designed based on criteria contained in this

rule, published standards, applicable federal and state requirements, standard textbooks, current technical literature and applicable safety standards. To the extent of any conflict between the above criteria, the requirement in this rule shall prevail.

(A) This rule shall not apply to animal waste management systems. Regulations for these facilities are found in 10 CSR 20-8.300.

(B) This rule shall not apply to agrichemical facilities. Regulations for these facilities are found in 10 CSR 20-8.500.

(2) Septic Tanks.

(A) A septic tank must have a minimum capacity of at least one thousand (1,000) gallons.

(B) The septic tank shall be baffled.

(3) Recirculating Media Filters.

(A) Location. Recirculating media filters following primary treatment shall be located a minimum of two hundred feet (200') from future or existing residences or other establishments.

(B) Filter Bed. A minimum of two (2) filter beds and a diversion box are required for all design flows.

(C) Dosing. Both timer and float switch controls are required; timers are the primary method of operation and the float switch control is a back-up.

(D) Loading. The hydraulic loading for media filters shall be less than three and half gallons per day per square foot (3.5 gpd/sqft).

(E) Media Characteristics. The media is any of a number of physical structures whose sole purpose is to provide a surface to support biological growth. Commonly used media includes rock, gravel, and sand of various sizes, textile media, and peat. Finely crushed limestone, dolomite, slag, any clay, limestone or appreciable amounts of organic material is not acceptable.

1. Rock, sand and gravel media, when used –

A. Shall be a total of at least thirty-three inches (33”) deep; and

B. Shall have at least twenty-four inches (24”) of fine filtering media.

(*[3]***4**) Trickling Filters.

(A) General. Trickling filters may be used for treatment of *[sewage]***wastewater** amenable to treatment by aerobic biologic processes. **Design filters so as to provide the reduction in carbonaceous and/or nitrogenous oxygen demand in accordance with 10 CSR 20-7.015, Effluent Regulations and 10 CSR 20-7.031, Water Quality Standards, or to properly condition the wastewater for subsequent treatment processes.** *[Trickling filters shall be preceded by effective settling tanks equipped with scum and grease collecting devices or other suitable pretreatment facilities. Filters shall be designed so as to provide the reduction in carbonaceous and/or nitrogenous oxygen demand in accordance with 10 CSR 20-7.015, Effluent Regulations and 10 CSR 20-7.031, Water Quality Standards, or to properly condition the sewage for subsequent treatment processes.*

(B) Hydraulics.

1. Distribution.

A. Uniformity. The sewage may be distributed over the filter by rotary distributors or other suitable devices which will ensure uniform distribution to the surface area. At design average flow, the deviation from a calculated uniformly distributed volume per square foot (m^2) of the filter surface shall not exceed plus or minus ten percent (±10%) at any point. All hydraulic factors involving proper distribution of sewage on the filters shall be submitted to the agency.
B. Head requirements. For reaction type distributions, a minimum head of twenty-four inches (24") (61 cm) between low water level in siphon chamber and center of arms is required. Similar allowance in design shall be provided for added pumping head requirements where pumping to the reaction type distributor is used.
C. Clearance. A minimum clearance of six inches (6") (15 cm) between media and distributor arms shall be provided. Greater clearance is essential where icing may occur.
2. Dosing. Sewage may be applied to the filters by siphons, pumps or by gravity discharge from preceding treatment units when suitable flow characteristics have been developed. Application of the sewage shall be practically continuous. The piping system shall be designed for recirculation.
3. Piping system. The piping system including dosing equipment and distributor shall be designed to provide capacity for the peak hourly flow rate including recirculation required under paragraph (3)(E)5. of this rule.
(C)] Media**.**
[1. Quality. The media may be crushed rock, slag or specially manufactured material. The media shall be durable, resistant to spalling or flaking and be relatively insoluble in sewage. The top eighteen inches (18") (46 cm) shall have a loss by the twenty (20)-cycle, sodium sulfate soundness test of not more than ten percent (10%), as prescribed by the ASCE Manual of Engineering Practice, Number 13; the balance is to pass a ten (10)-cycle test using the same criteria. Slag media shall be free from iron. Manufactured media shall be resistant to ultraviolet degradation, disintegration, erosion, aging, all common acids and alkalies, organic compounds and fungus and biological attack. Media shall be either structurally capable of supporting a man's weight or a suitable access walkway provided to allow for distributor maintenance.
2. Depth. Rock and/or slag filter media shall have]
1. Media depth shall:
A. Be a minimum depth of five feet (5') *[(1.5 m)]*above the underdrains*[.]* **for rock filter media;**
B. Be a minimum depth of ten feet (10') for *[M]***m**anufactured filter media *[should have a minimum depth of ten feet (10') (3m)]* to provide adequate contact time with the wastewater*[.]***; and**
C. *[Rock and/or slag filter media depths shall n]***N**ot exceed ten feet (10') **for rock filter media.** *[(3m) and manufactured filter media depths shall not exceed thirty feet (30') (9.1m) except where special construction is justified through extensive pilot studies.]*
*[3]***2**. Size and grading of *[media.*
A. R] **r**ock*[, slag]* and similar media *[. Rock, slag and similar media]***shall:**

A. *[n]***N**ot contain more than five percent (5%) by weight of pieces whose longest dimension is three (3) times the least dimension*[.]***;**
B. *[They shall b]***B**e free from thin elongated and flat pieces, dust, clay, sand or fine material**;** and*[shall]*
C. *[c]***C**onform to the following size and grading as shown in Table 180-*[3]***1**, included herein, when mechanically graded over vibrating screen with square openings.

Table 180-1 Particle Size Distribution:	
Screen Size	**Percent Passing by Weight**
4.5 inches	**100%**
3 inches	**0-95%**
2 inches	**0-0.2%**
1 inch	**0 to 0.1%**

*[B]***3**. Manufactured *[Media. Suitability will be evaluated on the basis of experience with installations handling similar wastes and loadings.]***and synthetic media material shall:**
A. Be used in accordance with all manufacturer's recommendations;
B. Be insoluble in wastewater and resistant to flaking, spalling, ultraviolet degradation, disintegration, erosion, aging, common acids and alkalis, organic compounds, and biological attack;
C. Be evaluated to determine the suitability based on experience with an installation treating wastewater under similar hydraulic and organic loading conditions. Include a relevant case history involving the use of the synthetic media;
D. Have a structure able to support the synthetic media, water flowing through or trapped in voids, and the maximum anticipated thickness of the wetted biofilm;
E. Support the maintenance activities, unless a separate provision is made for maintenance access to the entire top of the trickling filter media and to the distributor; and
F. Be placed with the edges matched as nearly as possible to provide consistent hydraulic conditions within the trickling filter.
[C. Handling and placing of media. Material delivered to the filter site shall be stored on wood planks or other approved clean hard surfaced areas. All material shall be rehandled at the filter site and no material shall be dumped directly into the filter. Crushed rock, slag and similar media shall be washed and rescreened or forked at the filter site to remove all fines. The material shall be placed by hand to a depth of twelve inches (12") (30 cm) above the tile underdrains and the remainder of material may be placed by means of belt conveyors or equally effective methods approved by the engineer. All material shall be carefully placed so as not to damage the underdrains. Manufactured media shall be handled and placed as approved by the engineer. Trucks, tractors or other heavy equipment shall not be driven over the filter during or after construction].
(*[D]***C**) Underdrainage System.

1. *[Arrangement. Underdrains with semicircular inverts or equivalent should be provided and the underdrainage system shall cover the entire floor of the filter. Inlet openings into the underdrains shall have an unsubmerged gross combined area equal to at least fifteen percent (15%) of the surface area of the filter.*
2.] Hydraulic capacity*[and ventilation]*. The underdrains shall *[have]***be designed with:**
A. *[a]* **A** minimum slope of one percent (1%)*[.]***;**
B. Effluent channels *[shall be designed to]* **that** produce a minimum velocity of two feet *[(2')]*per second (2 fps) *[(0.61m/s)]*at average daily rate of application to the filter*[.]***;**
C. The underdrainage system, effluent channels and effluent pipe *[shall be designed]*to permit free passage of air*[.]***;**
D. The size of drains, channels and pipe *[should be]* so that not more than fifty percent (50%) of their cross section area will be submerged under the design peak hydraulic loading, including proposed or possible future or recirculated flows*[. Consideration shall be given to the use of forced ventilation, particularly for covered filters and deep manufactured media filters.*
3. Flushing. Provision should be made for flushing the underdrains. In small filters, use of a peripheral head channel with vertical vents is acceptable for flushing purposes. Inspection facilities should be provided.
(E) Special Features.
1. Flooding. Appropriate valves, sluice gates or other structures shall be provided so as to enable flooding of filters comprised of rock or slag media for filter fly control.
2. Freeboard. A freeboard of four feet (4') (1.2 m) or more should be provided for tall, manufactured media filters to maximize the containment of windblown spray.
3. Maintenance. All distribution de-vices, underdrains, channels and pipes shall be installed so that they may be properly maintained, flushed or drained.
4. Winter protection. Adequate protection such as covers in severe climate or wind breaks in moderate climates shall be provided to maintain operation and treatment efficiencies when climatic conditions are expected to result in problems due to cold temperatures.
5. Recirculation. The piping system shall be designed for recirculation as required to achieve the design efficiency. The recirculation rate shall be variable and subject to plant operator control.
6. Recirculation measurement. Devices shall be provided to permit measurement of the recirculation rate. Time lapse meters and pump head recording devices are acceptable for facilities treating less than one million gallons per day (1 mgd) (3785m^3/d).
(F) Rotary Distributor Seals. Mercury seals shall not be permitted. Ease of seal replacement shall be considered in the design to ensure continuity of operation.
(G) Multi-Stage Filters. The foregoing standards also apply to all multi-stage filters.

(H) Unit Sizing. Required volumes of rock or slag media filters shall be based upon pilot testing with the particular wastewater or any of the various empirical design equations that have been verified through actual full scale experience. Calculations mustbe submitted if pilot testing is not utilized. Pilot testing is recommended to verify performance predictions based upon the various design equations, particularly when significant amounts of industrial wastes are present. Expected performance of filters packed with manufactured media shall be determined from documented full scale experience at similar installation or through actual use of a pilot plant on-site.

(I) Design Safety Factors. Trickling filters are affected by diurnal load conditions. The volume of media determined from either pilot plant studies or use of acceptable design equations shall be based upon the design peak hourly organic loading rate rather than the average rate. An alternative would be to provide flow equalization.]

(D) Forced Ventilation.

1. Forced ventilation for a trickling filter is required when:

A. Designed for nitrification;

B. Designed with a media depth in excess of six feet (6'); or

C. Seasonal or diurnal temperatures do not provide sufficient difference between the ambient air and wastewater temperatures to sustain passive ventilation.

2. Minimum design airflow rate for nitrifying rock, gravel, and sand trickling filter shall be the greater of:

A. Fifty pounds (50 lbs) of oxygen provided per pound of oxygen demand at average organic loading, based on stoichiometry; or

B. Thirty pounds (30 lbs) of oxygen provided per pound of oxygen demand at peak organic loading, based on stoichiometry.

[(4) Activated Sludge.

(A) General.

1. Applicability.

A. Biodegradable wastes. The activated sludge process and its various modifications may be used where sewage is amenable to biological treatment.

B. Operational requirement. This process requires close attention and competent operating supervision, including routine laboratory control. These requirements shall be considered when proposing this type of treatment.

C. Energy requirement. This process requires major energy usage to meet aeration demands. Energy costs and potential mandatory emergency public power reduction events in relation to critical water quality conditions must be carefully evaluated. Capability of energy usage phase down while still maintaining process viability, both under normal and emergency availability conditions, must be included in the activated sludge design.

2. Specific process selection. The activated sludge process and its several modifications may be employed to accomplish varied degrees of removal of suspended solids and reduction of carbonaceous and/or nitrogenous oxygen demand. Choice of the process most applicable will be influenced by the degree and consistency of treatment required, type of waste to be treated, proposed plant size, anticipated degree of operation and maintenance, and operating and capital costs. All designs shall provide for flexibility in operation. Plants over one (1) mgd (3785 m^3/d) shall be designed to facilitate easy conversion to various operation modes.

3. Winter protection. In severe climates, protection against freezing shall be provided to insure continuity of operation and performance.

(B) Pretreatment. Where primary settling tanks are not used, effective removal or exclusion of grit, debris, excessive oil or grease and comminution or screening of solids shall be accomplished prior to the activated sludge process. Where primary settling is used, provision shall be made for discharging raw sewage directly to the aeration tanks to facilitate plant start-up and operation during the initial stages of the plant's design life.

(C) Aeration.

1. Capacities and permissible loadings. The size of the aeration tank for any particular adaptation of the process shall be determined by full scale experience, plant pilot studies or rational calculations based mainly on food to microorganism ratio and mixed liquor suspended solids levels. Other factors such as size of treatment plant, diurnal load variations and degree of treatment required shall also be considered. In addition, temperature, pH and reactor dissolved oxygen shall be considered when designing for nitrification. Calculations should be submitted to justify the basis for design of aeration tank capacity. Calculations using values differing substantially from those in the accompanying table should reference actual operational plants. Mixed liquor suspended solids levels greater than five thousand (5000) mg/l may be allowed provided that adequate data is submitted that shows the aeration and clarification system is capable of supporting the levels. When process design calculations are not submitted, the aeration tank capacities and permissible loadings for the several adaptations of the processes shown in the following table shall be used. These values apply to plants receiving peak to average diurnal load ratios ranging from about two to one (2:1) to four to one (4:1). The utilization of flow equalization facilities to reduce the diurnal peak organic load may be considered by the agency as justification to approve organic loading rates that exceed those specified in the table.

Permissible Aeration Tank
Capacities and Loadings

(NOTE: For proper use of this table, see paragraph (4)(C)1. of this rule.)

Process	*Aeration Tank Organic Loading-lb. BOD_5/1,000 cu. ft./day*	*F/M Ratio-lb. BOD_5/lb. MLVSS/ day*	*MLSS* mg/liter*

Step Aeration, Complete Mix And Conventional	*40*	*0.2-0.5*	*1000-3000*
Contact Stabilization	*50***	*0.2-0.6*	*1000-3000*
Extended Aeration and Oxidation-Ditches	*15*	*0.05-0.1*	*3000-5000*

**MLSS values are dependent upon the surface area provided for sedimentation and the rate of sludge return as well as the aeration process.*
***Total aeration capacity, includes both contact and reaeration capacities. Normally the contact zone equals thirty to thirty-five percent (30%–35%) of the total aeration capacity.*

2. Arrangement of aeration tanks.

A. General tank configuration.

(I) Dimensions. The dimensions of each independent mixed liquor aeration tank or return sludge reaeration tank shall be so as to maintain effective mixing and utilization of air. Ordinarily, liquid depths should not be less than ten feet (10') (3 m) or more than thirty feet (30') (9 m) except in special design cases.

(II) Short-circuiting. For very small tanks or tanks with special configuration, the shape of the tank and the installation of aeration equipment should provide the positive control of short-circuiting through the tank.

B. Number of units. Total aeration tank volume required shall be divided among two (2) or more units, capable of independent operation, when required by the agency to meet applicable effluent limitations and reliability guidelines.

C. Inlets and outlets.

(I) Controls. Inlets and outlets for each aeration tank unit shall be suitably equipped with valves, gates, stop plates, weirs or other devices to permit controlling the flow to any unit and to maintain reasonably constant liquid level. The hydraulic properties of the system shall permit the maximum instantaneous hydraulic load to be carried with any single aeration tank unit out-of-service.

(II) Conduits. Channels and pipes carrying liquids with solids in suspension shall be designed to maintain self-cleansing velocities or shall be agitated to keep the solids in suspension at all rates of flow within the design limits. Adequate provisions should be made to drain segments of channels which are not being used due to alternate flow patterns.

D. Freeboard. All aeration tanks should have a freeboard of not less than eighteen inches (18") (46 cm). Additional freeboard or windbreak may be necessary to protect against freezing or wind blown spray.

3. Aeration equipment.

A. General. Oxygen requirements generally depend on maximum diurnal organic loading, degree of treatment and level of suspended solids concentration to be maintained in the aeration tank mixed liquor. Aeration equipment shall be capable of maintaining a minimum of two (2.0) mg/l of dissolved oxygen in the mixed liquor at all times and providing thorough mixing of the mixed liquor. In the absence of experimentally determined values, the design oxygen requirements for all activated sludge processes shall be 1.1 lbs. 0_2/lb. peak BOD_5 applied to the aeration tanks (1.1 kg 0_2/kg peak BOD_5) except the value of 1.8 shall be used for the extended aeration process. In the case of nitrification, the oxygen requirement for oxidizing ammonia mustbe added to the above requirement for carbonaceous BOD_5 removal. The nitrogen oxygen demand (NOD) shall be taken as 4.6 times the diurnal peak total kjeldahl nitrogen (TKN) content of the influent. In addition, the oxygen demands due to recycle flows—heat treatment supernatant, vacuum filtrate, elutriates, etc., mustbe considered due to the high concentration of BOD_5 and TKN associated with the flows. Careful consideration should be given to maximizing oxygen utilization per unit power input. Unless flow equalization is provided, the aeration system should be designed to match the diurnal organic load variation while economizing on power input.

B. Diffused air systems. The desire of the diffused air system to provide the oxygen requirements shall be done by either of the following two (2) methods.

(I) Having determined the oxygen requirements per subparagraph (4)(C)3.A. of this rule, air requirements for a diffused air system shall by use of any of the well known equations incorporate such factors as tank depth, alpha factor of waste, beta factor of waste, certified aeration device transfer efficiency, minimum aeration tank dissolved oxygen concentrations, critical wastewater temperature and altitude of plant. In the absence of experimentally determined alpha and beta factors, wastewater transfer efficiency shall be assumed to be fifty percent (50%) of clean water efficiency for plants treating primarily ninety percent (90%) or greater domestic sewage. Treatment plants where the waste contains higher percentages of industrial wastes shall use a correspondingly lower percentage of clean water efficiency and shall have calculations submitted to justify such a percentage.

(II) Normal air requirements for all activated sludge processes except extended aeration (assuming equipment capable of transmitting to the mixed liquor the amount of oxygen required in subparagraph (4)(C)3.A.) shall be considered to be fifteen hundred (1500) cu.ft. per pound of BOD_5 peak aeration tank loading (93.5 m^3/kg of BOD_5). For the extended-aeration process the value shall be two thousand (2000) cu. ft. (125 m).

(III) To the air requirements calculated in part (4)(C)3.B.(II) of this rule shall be added air required for channels, pumps, aerobic digesters or other air-use demand.

(IV) The specified capacity of blowers or air compressors, particularly centrifugal blowers, should take into account that the air intake temperature may reach forty degrees Celsius (40 °C) (one hundred four degrees Fahrenheit (104 °F)) or higher and the pressure may be less than normal. The specified capacity of the motor drive should also take into account that the intake air may be minus thirty degrees Celsius (-30 °C) (minus twenty-two degrees Fahrenheit (-22 °F)) or less and may require oversizing of the motor or a means of reducing the rate of air delivery to prevent overheating or damage to the motor.

(V) The blowers shall be so provided in multiple units, so arranged and in such capacities as to meet the maximum air demand with the single largest unit out-of-service. The design shall also provide for varying the volume of air delivered in proportion to the load demand of the plant. Aeration equipment shall be easily adjustable in increments and shall maintain solids suspension within these limits.

(VI) Diffuser systems shall be capable of providing for the diurnal peak oxygen demand or two hundred percent (200%) of the design average oxygen demand whichever is larger. The air diffusion piping and diffuser system shall be capable of delivering normal air requirements with minimal friction losses. Air piping systems should be designed such that total head loss from blower outlet (or silencer outlet where used) to the diffuser inlet does not exceed 0.5 pounds per square inch (psi) (0.04 kgf/cm^2) at average operating conditions. The spacing of diffusers should be in accordance with the oxygen requirements within the channel or tank, and should be designed to facilitate adjustment of their spacing without major revision to air header piping. All plants employing less than four (4) independent aeration tanks shall be designed to incorporate removable diffusers that can be serviced and/or replaced without de-watering the tank.

(VII) Individual assembly units of diffusers shall be equipped with control valves, preferably with indicator markings for throttling or for complete shutoff. Diffusers in any single assembly shall have substantially uniform pressure loss.

(VIII) Air filters shall be provided in numbers, arrangements and capacities to furnish at all times an air supply sufficiently free from dust to prevent damage to blowers and clogging of the diffuser system used.

C. Mechanical aeration systems.

(I) Oxygen transfer performance. The mechanism and drive unit shall be designed for the expected conditions in the aeration tank in terms of the power performance. Certified testing shall verify mechanical aerator performance.

(II) Design requirements. The design requirements of a mechanical aeration system shall accomplish the following: maintain a minimum of two (2.0) mg/l of dissolved oxygen in the mixed liquor at all times throughout the tank or basin; maintain all biological solids in suspension; meet maximum oxygen demand and maintain process performance with the largest unit out-of-service; and provide for varying the amount of oxygen transferred in proportion to the load demand on the plant.

(III) Winter protection. Due to high heat loss, the mechanism as well as subsequent treatment units shall be protected from freezing where extended cold weather conditions occur.

(D) Return Sludge Equipment.

1. Return sludge rate. The minimum permissible return sludge rate of withdrawal from the final settling tank is a function of the concentration of suspended solids in the mixed liquor entering it, the sludge volume index of these solids and the length of time these solids are retained in the settling tank. Since undue retention of solids in the final settling tanks may be deleterious to both the aeration and sedimentation phases of the activated sludge process, the rate of sludge return expressed as a percentage of the average design flow of sewage should generally be variable between the limits set forth as follows:

	Minimum	Maximum
Standard Rate	15	75
Carbonaceous Stage of Separate Stage Nitrificia-tion	15	75
Step Aeration	15	75
Contact Stabiliza-tion	50	150
Extended Aeration	50	150
Nitrification Stage of Separate Stage Nitrification	50	200

The rate of sludge return shall be varied by means of variable speed motors, drives or times (small plants) to pump sludge at the rates mentioned in the previous table.

2. Return sludge pumps. If motor driven return sludge pumps are used, the maximum return sludge capacity shall be obtained with the largest pump out-of-service. A positive head should be provided on pump suctions. Pumps should have at least three-inch (3") (7.6 cm) suction and discharge openings. If air lifts are used for returning sludge from each settling tank hopper, no standby unit will be required provided the design of the air lifts are so as to facilitate their rapid and easy cleaning and provided other suitable standby measures are provided. Air lifts should be at least three inches (3") (7.6 cm) in diameter.

3. Return sludge piping. Discharge piping should be at least four inches (4") (10 cm) in diameter and should be designed to maintain a velocity of not less than two feet (2') per second (0.61 m/s) when return sludge facilities are operating at normal return sludge rates. Suitable devices for observing, sampling and controlling return activated sludge flow from each settling tank hopper shall be provided.

4. Waste sludge facilities. Waste sludge control facilities should have a maximum capacity of not less than twenty-five percent (25%) of the average rate of sewage flow and function satisfactorily at rates of 0.5 percent of average sewage flow or a minimum of ten (10) gallons per minute (0.63 l/s), whichever may be the larger. Means for observing, measuring, sampling and controlling waste activated sludge flow shall be provided. Waste sludge may be discharged to the concentration or thickening tank, primary settling tank, sludge digestion tank, vacuum filters or any practical combination of these units.

(E) Measuring Devices. Devices should be installed in all plants for indicating flow rates of raw sewage or primary effluent, return sludge and air to each tank unit. For plants designed for sewage flows of 1 mgd (3785 m^3/d) or more, these devices should totalize and record, as well as, indicate flows. Where the design provides for all return sludge to be mixed with the raw sewage (or primary effluent) at one (1) location, then the mixed liquor flow rate to each aeration unit should be measured.]

[(5) Rotating Biological Contactors.

(A) General.

1. Applicability. The rotating biological contactor (RBC) process may be used where sewage is amenable to biological treatment. The process may be used to accomplish carbonaceous and/or nitrogenous oxygen demand reductions. Design standards, operating data and experience for this process are not well established. Therefore, expected performance of RBCs shall be based upon experience to similar full scale installations or thoroughly documented pilot testing with the particular wastewater.

2. Winter protection. Wastewater temperature affects rotating contactor performance. Year round operation in colder climates requires that rotating contactors be covered to protect the biological growth from cold temperatures and the excessive loss of heat from the wastewater with the resulting loss of performance. Enclosures shall be constructed of a suitable corrosion-resistant material. Windows or simple louvered mechanisms which can be opened in the summer and closed in the winter shall be installed to provide adequate ventilation. To minimize condensation, the enclosure should be adequately insulated and/or heated.

(B) Required Pretreatment. RBCs must be preceded by effective settling tanks equipped with scum and grease collecting devices unless substantial justification is submitted for other pretreatment devices which provide for effective removal of grit, debris and excessive oil or grease prior to the RBC units. Bar screening or comminution are not suitable as the sole means of pretreatment.

(C) Unit Sizing. Unit sizing shall be based on experience at similar full-scale installations or thoroughly documented pilot testing with the particular wastewater. In determining design loading rates, expressed in units of volume per day per unit area of media covered by biological growth, the following parameters must be considered: design flow rate and influent waste strength; percentage of BOD_5 to be removed; media arrangement including number of stages and unit area in each stage; rotational velocity of the media; retention time within the tank containing the media; and wastewater temperature; and the percentage of influent BOD_5 which is soluble. In addition to these parameters, loading rates for nitrification will depend upon influent TKN, pH and the allowable effluent ammonia nitrogen concentration.

(D) Design Safety Factor. Effluent concentrations of ammonia nitrogen from the RBC process designed for nitrification are affected by diurnal load variations. Therefore, it may be necessary to increase the design surface area proportional to the ammonia nitrogen diurnal peaking rates appropriately to meet effluent limitations. An alternative is to provide flow equalization sufficient to insure process performance within the required effluent limitations.]

[(6) Other Biological Systems. New biological treatment schemes with promising applicability in wastewater treatment may be considered if the required engineering data for new process evaluation is provided in accordance with 10 CSR 20-8.140(5)(B).]

(5) Activated Sludge.

(A) Basin lining. If using a synthetic liner, it shall be a minimum of 30 millimeters (30 mm) thick.

(B) Tank dimensions. Horizontally mixed aeration tanks shall have a depth of not less than five and a half feet (5.5').

(C) High purity oxygen, when used. An enclosed air-oxygen exhaust system shall be provided to collect and vent the reactor off-gases.

(6) Sequencing Batch Reactor (SBR). The minimum total basin volume shall be equal to the design daily influent flow volume and either upstream in-line or off-line storage is necessary to minimize influent flow during settling and decanting.

(7) Membrane Bioreactor (MBR).

(A) General.

1. For wastewater treatment plants with a flow equal to or greater than one hundred thousand gallons per day (100,000 gpd), the MBR process must be designed with a minimum of two (2) membrane trains capable of treating the daily average flow with one membrane cassette out of service.

2. Design flux criteria must be satisfied with one (1) membrane module out-of-service (e.g., for external clean in place, recovery cleaning, repair). For purposes of these criteria, a membrane module is the smallest membrane unit capable of separate removal from the tank while maintaining operation of other membrane units in the same tank; and

3. Membranes placed in the aeration basin(s) rather than a separate membrane tank shall have:

A. Individual modules and individual diffusers that can be removed separately for maintenance and repair; and

B. Aeration basin(s) volume sized for complete nitrification.

(B) Preliminary Treatment. Each system shall--

1. Be consistent with the membrane manufacturer recommendations;

2. Provide grit removal;

3. Provide oil and grease removal when the levels in the influent may cause damage to the membranes;

4. Provide a fine screen and high water alarm, designed to treat peak hourly flow. Coarse screens followed by fine screens may be used in larger facilities to minimize the complications of fine screening; and

5. Provide a duplicate fine screen and a high water alarm.

(C) Aeration. The aeration blowers must provide adequate air for membrane scour and process demands.

(D) Redundancy. The facility shall have one (1) of the following at a minimum:

1. The ability to run in full programmable logic control (PLC) or standby power mode in case of an automatic control failure;

2. An operational battery backup PLC if manual control is not possible; or
3. Sufficient standby power generating capabilities to provide continuous flow through the membranes during a power outage (e.g., preliminary screening, process aeration, recycle/RAS/permeate pumps, air scour, vacuum pumps) or an adequate method to handle flow for an indefinite period (e.g., private control of influent combined with contingency methods).

(E) Operations and Maintenance. The MBR design shall—
1. Include provisions to monitor membrane integrity;
2. Provide on-line continuous turbidity monitoring of filtrate or an equivalent for operational control and indirect membrane integrity monitoring for a treatment plant with design average flow greater than or equal to one hundred thousand gallons (100,000 gpd); and
3. Include provisions to remove membrane cassette for cleaning considering the membrane cassette wet weight plus additional weight of the solids accumulated on the membranes.

(8) Moving Bed Bioreactor (MBBR). A MBBR treatment system shall have upstream preliminary treatment units that are capable of:
(A) Screening to reduce pass-through and suspended solids;
(B) Grit removal;
(C) Oil and grease removal;
(D) Primary clarification;
(E) Control the release of hydrogen sulfide; and
(F) Should include corrosion protection.

(9) Nutrient Removal.
(A) A system designed for enhanced nutrient removal must;
1. Include an isolated tank or baffled zone for anoxic treatment, anaerobic treatment, or both.
2. Contain a deoxygenation basin, a larger anoxic basin, or another method of decreasing dissolved oxygen concentration, if the recycled activated sludge is returned to an anoxic or anaerobic basin.

(B) Aeration. The design oxygen concentration range used for sizing aeration systems for treatment zones shall be as follows:
1. Anoxic: not more than half a milligram per liter (0.5 mg/l);
2. Aerobic: at least one and half milligrams per liter but not more than three milligrams per liter (1.5-3.0 mg/L); and
3. Membranes: at least two milligrams per liter but not more than eight milligrams per liter (2.0-8.0 mg/L).