phone line to a remote location is used as the means of alarm, the alarm shall be activated in the event of a failure in the telephone line.

(b) The alarm shall be either a suitable audible or visual alarm and shall be so located as to be readily seen or heard.

(6) EMERGENCY OPERATION. (a) Provisions for emergency operation of lift stations shall be provided to prevent the discharge of raw or partially treated sewage to a surface water or to the ground surface and to prevent sewage backup into basements.

(b) Power must be available from at least two independent sources or, in the alternative, emergency power generating equipment or portable pumping equipment must be available.

Note: It is recommended that a point of connection to the discharge force main be installed at a point where portable pumping units can be connected.

(7) FORCE MAINS. (a) *Velocity.* A velocity in excess of two feet per second shall be maintained in force mains.

(b) *Air relief valve.* An air relief valve shall be placed at high points in the force main to prevent air locking.

(c) *Termination.*

Note: The department recommends that force mains enter gravity sewer manholes at a point not more than 2 feet above the spring line of the outgoing sewer.

History: Cr. Register, November, 1974, No. 227, eff. 12-1-74.

NR 110.15 General requirements for sewage treatment works. (1) QUALITY OF EFFLUENT. (a) For purposes of design, the minimum allowable level of treatment shall be that level of treatment which results in the removal of 90% of the 5-day biochemical oxygen demand (BOD_5) and 90% of the suspended solids (SS).

Note: Higher levels of treatment may be required depending on the characteristic of the waste being treated, the low flow in the receiving stream or the water quality standards of the receiving stream.

(b) Existing treatment plants capable of removing at least 85% of the BOD, and SS and capable of producing an effluent quality of less than 30 mg/1 of BOD_5 and SS on a monthly average will be allowed to remain in service for the design life of the plant if water quality standards can be met in the receiving water.

(c) All effluents discharged to a receiving surface water, except from stabilization ponds, shall be properly disinfected in accordance with NR 111.23.

(2) DESIGN PERIOD. Sewage treatment plants shall be designed to provide for the estimated population 20 years hence.

Note: The department will waive this requirement upon a demonstration to its satisfaction that a lesser design period is more cost-effective.

(3) PLANT LOCATION. (a) Sewage treatment processes, except for lagoon systems, shall be located on sites not less than 500 feet from the nearest inhabited dwelling. Aerated lagoon treatment system shall be located not less than 750 feet from inhabited dwellings and stabilization ponds shall be located not less than 1,500 feet from inhabited dwellings.

(b) Existing treatment facilities which when constructed met the above distance requirement but which have since been encroached upon by residential, commercial or industrial development, shall be subjected to the above requirement at the time of expansion of the facility.

Note: The department may waive this requirement on a case-by-case basis. However, it is recommended that the municipality consider either the purchase of sufficient lands surrounding the plant site or the use of zoning to prevent encroachment of residential, commercial or industrial developments.

(c) All treatment plants and ponds shall be located such that they are not subject to flooding. No plant or pond shall be located in a floodway. If the plant or pond is located in a floodplain, it shall conform to chapter NR 116. The plant or pond shall be accessible at all times.

(4) NEW PROCESSES, METHODS AND EQUIPMENT.

Note: It is the policy of the department to encourage the development of new methods or equipment for treatment of sewage wastes. However, where new processes, methods or equipment are proposed and where limited data is available which demonstrates the performance of the equipment, the department may require the posting of a performance bond by the manufacturer.

(5) SEWAGE FLOW. Unless satisfactory justification is given for using a different value, new sewage treatment systems shall be designed for an average daily flow of 100 gallons per capita, and for anticipated daily flows from industrial waste contributors. Modifications or expansions of existing treatment systems shall be based on gaugings of the present sewage flow, plus allowance for estimated future increase.

(6) BOD_5 AND SS. Unless satisfactory justification is given for using different values, sewage treatment systems shall be designed based on a BOD_5 contribution of 0.17 pounds per capita per day and SS contribution of 0.20 pounds per capita per day and anticipated industrial waste contributions.

(7) DESIGN LOADING. The design of treatment units shall be based on an average rate of sewage flow per 24 hours except where significant deviation from normal diurnal flow pattern exists. Industrial waste design flows shall be determined from the observed rate of flow during the significant period of discharge. The following factors shall be evaluated in determining the design flow of the sewage treatment plant:

(a) Peak flow rates occurring over significant time periods;

(b) Data from similar municipalities in the case of new systems;

(c) Wet weather flows. Excessive clear water must be eliminated at its source and must not be included in the plant design;

(d) Recirculation.

(8) DESIGN OF CONDUITS. All piping and channels shall be designed to carry the maximum flows. The incoming sewer shall be designed to operate without surcharge. Pockets, corners and other dead areas where solids can accumulate must be eliminated.

(9) ARRANGEMENT OF UNITS. All treatment units shall be arranged to provide operating convenience and flexibility, and to facilitate installation of future units.

(10) BY-PASSES. Complete plant by-passes shall not be provided. Bypassing of individual units for maintenance purposes is permissible.

During periods of maintenance, the minimum degree of treatment shall be solids settling and effluent disinfection.

(11) TREATMENT DURING CONSTRUCTION. During construction of new facilities, treatment shall be maintained at the same level as that which existed prior to the start of construction.

(12) CONSTRUCTION MATERIALS. Materials shall be selected that are compatible with the characteristics of the sewage wastes.

Note: Dissimilar metals should be avoided to minimize galvanic action.

(13) PAINTING. (a) The use of paints containing lead is prohibited. In order to facilitate the identification of piping, the following color scheme shall be utilized:

1. Sludge line—brown;

2. Gas line—red;

3. Potable water line—blue;

4. Chlorine line—yellow;

5. Sewage line—gray;

6. Compressed air line—green;

7. Nonpotable water line—blue with 6-inch red bands spaced 30 inches apart.

(b) In addition to the color code, each pipe shall be adequately labeled with a minimum of 2 labels in each room, crawl space or compartment.

(14) OPERATING EQUIPMENT. All necessary tools and accessories for the plant operator's use shall be provided. Storage space and a work area shall also be provided.

(15) EMERGENCY POWER. A standby power source shall be provided at each sewage treatment plant in the form of connection to 2 independent power sources or by providing an emergency power generator. Sufficient emergency power shall be supplied to provide a minimum treatment equivalent to solids settling and effluent disinfection at all times.

(16) WATER SUPPLY. An adequate supply of potable water shall be provided for use in the laboratory. No connections shall be made which might cause contamination of a potable water supply.

(a) *Direct connections.* Potable water from a public supply may be used directly at points above grade for the following hot and cold supplies: lavatory sink, water closet, laboratory sink, shower, eyewash fountain and drinking fountain. Hot water for any of the above shall not be taken directly from a boiler used for supplying hot water to a sludge heat exchanger or digester heating coils.

(b) *Indirect connections.* Where a potable water supply is to be used for any other purpose than those listed in paragraph (a), a break tank, pressure pump and pressure tank or a backflow preventer shall be provided.

1. Break tank. Potable water shall be discharged to the break tank through an air gap at least 6 inches above the maximum flood line or the spill line of the tank, whichever is higher. A sign shall be permanently posted at every hose bib, faucet or sill cock located on the water system beyond the break tank to indicate that the water is not safe for drinking.

2. Backflow preventer. a. Backflow preventers may be used to protect the potable water supply provided that the following conditions are met:

i. Detailed plans and specifications covering the unit and its installation are approved by the department of health and social services, plumbing section, before installation.

ii. The installation is made above grade in a location accessible for testing, inspection and maintenance, and is protected from freezing and flooding.

iii. The unit is installed immediately downstream of the meter prior to any branches off the service line.

b. The following protective devices shall be installed where backflow preventers are used:

i. Chlorinator water supply. A vacuum breaker shall be installed downstream of the last water supply shutoff valve and at an elevation higher than the chlorinator.

ii. Hose bibs and approved yard hydrants. An approved combination backflow-siphon breaker shall be provided.

iii. Sinks or lavatories. A vacuum breaker located 6-7½ feet above the sink or, if located at sink elevation, an anti-hose connection on the faucet shall be required.

iv. Pump bearing lubrication. A vacuum breaker shall be provided downstream of the shutoff valve and above the elevation of the pumps. Additionally, a ⅛″ to ¼″ bleed line shall be installed that will allow free discharge to a storm sewer or to the ground surface.

(c) *Separate potable water supply.* Where it is not possible to provide potable water from a public water supply, a separate potable water supply must be provided.

Note: If a separate well is provided, the well specifications and usage must be approved by the private water supply section of the department.

(d) *Separate nonpotable water supply.* Where a separate nonpotable water supply is provided, a break tank or backflow preventer will not be necessary, but all water outlets must be posted with a permanent sign indicating the water is not safe for drinking.

(17) SANITARY FACILITIES.

Note: It is recommended that a toilet, shower and lavatory be provided.

(18) LABORATORY SPACE AND EQUIPMENT. All treatment works should include a laboratory for making the necessary analytical determinations and operating control tests. Equipment necessary for making the various determinations required by the department should be provided. In lieu of laboratory testing at the plant site, a suitable contract with a neighboring plant or independent laboratory is acceptable.

(19) FLOW MEASUREMENT. Equipment for flow measurement, totalizing and recording shall be provided for the total waste flow.

Note: It is recommended that measurement of other flow streams within the plant be done in aid of plant operation.

(20) FLOOR SLOPE. Floor surfaces shall be sloped adequately to a point of drainage.

(21) SAFETY.

Note: Although safety regulation is beyond the scope of these rules, the department recommends that adequate provision be made to effectively protect the operator and visitors from hazards. It is further recommended that the Safety and Health Rules set forth in Chapter IND 1000, Wisconsin Administrative Code, and the appropriate federal and local safety codes be adhered to in the operation of the plant. The following are specific measures which might be taken to enhance the safe operation of the plant:

(a) Enclosure of the plant site with a fence to discourage entrance of animals or unauthorized persons.

(b) Installation of hand rails and guards where necessary.

(c) Provision of first aid equipment.

(d) Posting of "No Smoking" signs in hazardous areas.

(e) Provision of protective clothing and equipment such as gas masks, goggles, gloves.

History: Cr. Register, November, 1974, No. 227, eff. 12-1-74; r. and recr. (1) (c), Register, March, 1978, No. 267, eff. 4-1-78.

NR 110.16 Screening devices. (1) APPLICABILITY. All sewage treatment plants shall provide protection for pumps and other equipment by installing coarse bar racks or screens, comminutors or mechanically cleaned bar screens. All equipment shall be readily accessible for maintenance. A screening device shall precede grit chambers.

(2) ACCESS. Screening devices shall be provided with convenient access, adequate lighting and ventilation, and convenient and adequate means for removing screenings when necessary.

(3) SEPARATION FROM OTHER EQUIPMENT IN BUILDING. Screening devices installed in a building where other equipment or offices are located shall be separated from the rest of the building, provided with separate outside entrances, and provided with adequate means of ventilation.

(4) DESIGN AND INSTALLATION. (a) *Nonmechanical screens.* Clear openings between bars shall not exceed two inches. Design and installation of bar screens shall be such that they can be conveniently cleaned.

(b) *Mechanical screens.* Clear openings for mechanically cleaned screens may be as small as adequate for conditions.

(c) *Velocities.* For hand raked bar screens the screen chamber should be designed to provide a velocity through the screen of approximately one foot per second at average rate of flow. For mechanically cleaned screens maximum velocities during wet weather periods shall not exceed 2.5 feet per second.

(d) *Invert.* The screen channel invert must be at least 3 inches below the invert of the incoming sewer.

(e) *Slope.* Hand-cleaned screens, except those for emergency use, must be placed on a slope of 30 to 45 degrees with the horizontal.

(5) CHANNELS. The channel preceding and following the screen shall be shaped to minimize settling of solids. Fillets shall be installed as necessary. Channels shall be equipped with the necessary gates to divert flow from any one screening unit. Methods for dewatering each unit must be provided.

(6) SAFETY DEVICES. All mechanical units which are operated by timing devices shall be provided with auxiliary controls which will activiate the cleaning mechanism at predetermined high-water marks or differentials in head.

(7) HANDLING SCREENINGS. Adequate facilities must be provided for removal, handling, storage, and disposal of screenings in a sanitary manner. Hand-cleaned screening facilities must include an accessible platform from which the operator may rake screenings. Suitable drainage facilities must be provided both for the platform and for storage areas.

(8) AUXILIARY SCREENS. Where mechanically operated screening or comminuting devices are used auxiliary hand-cleaned screens shall be provided. Plant design must provide for the automatic diversion of the entire sewage flow through the auxiliary screens should the regular units fail.

History: Cr. Register, November, 1974, No. 227, eff. 12-1-74.

NR 110.17 Grit removal facilities. (1) APPLICABILITY. Grit removal facilities are recommended for all sewage treatment plants, and are required for plants receiving sewage from combined sewers or from sewer systems receiving substantial amounts of grit.

(2) TYPE AND NUMBER OF UNITS. Grit removal facilities must have at least two hand-cleaned units, or a mechanically cleaned unit with a bypass. Where aerated grit chambers are proposed, detailed design information and necessary supporting documents shall be provided with the plans.

(3) DESIGN FACTORS. (a) *Inlet.* Inlet turbulence shall be minimized.

(b) *Velocity and detention.* Channel-type chambers shall be designed to provide controlled velocities of one foot per second. The detention period shall be based on the size of particle to be removed.

(c) *Grit washing.* All facilities not provided with positive velocity control shall include means for grit washing to further separate organic and inorganic materials.

(d) *Drains.* Drains or other means for dewatering each unit must be provided.

History: Cr. Register, November, 1974, No. 227, eff. 12-1-74.

NR 110.18 Settling tanks. (1) INLETS. Settling tank inlets shall be designed to dissipate the inlet velocity, to distribute the flow equally and to prevent short-circuiting. Channels shall be designed to maintain a velocity of at least one foot per second at one-half of design flow. Corner pockets and dead ends shall be eliminated and corner fillets or channeling used where necessary. Elimination or removal of floating materials in inlet structures having submerged ports shall be required.

(2) LENGTH OF FLOW. The minimum length of flow from inlet to outlet shall not be less than 10 feet unless special provision is made to prevent short-circuiting.

(3) SCUM BAFFLES. Scum baffles shall be provided ahead of outlet weirs on all primary and final settling tanks. Mechanical scum removal equipment shall be provided in all primary and final settling tanks.

Note: It is recommended that decanting tanks be used.

(4) WEIRS. Overflow weirs shall be adjustable. Weir loadings shall not exceed 10,000 gallons per day per linear foot for plants designed for average flows of 1.0 mgd or less.

Note: Weir loadings not in excess of 15,000 gallons per day per linear foot may be approved by the department for plants designed for flows in excess of 1.0 mgd.

(5) SUBMERGED SURFACES. The tops of troughs, beams, and similar construction features which are submerged shall have a minimum slope of 1.4 vertical to one horizontal.

Note: It is recommended that a slope of one to one on the underside of such features to prevent the accumulation of scum and solids be provided.

(6) MULTIPLE TANKS. Multiple units shall be provided at all plants with a design flow of greater than 0.5 mgd.

Note: The department may waive this requirement if it concludes that the facilities can be effectively operated for a short time with a single unit removed from service.

(7) SERVICING FACILITIES. All settling basins shall be provided with easy access for maintenance.

(8) SURFACE SETTLING RATES. (a) *Primary settling tanks.* Surface settling rates for primary tanks shall not exceed 600 gallons per day per square foot based on the design flow for plants where excess activated sludge or recirculated flows are returned to the primary settling tanks. In other cases, the surface settling rates shall not exceed 1,000 gallons per day per square foot based on the design flow.

(b) *Intermediate settling tanks.* Surface settling rates for intermediate settling tanks shall not exceed 1,000 gallons per day per square foot based on their design flow.

(c) *Final settling tanks.* Surface settling rates for final settling tanks based on their design flow, shall not exceed 600 gallons per day per square foot except as provided in NR 110.20 (5) (b), Wis. Adm. Code.

(9) SLUDGE REMOVAL. Direct pump suction to the sludge hoppers of primary settling tanks shall be provided. A sludge well shall be provided or appropriate equipment installed for viewing and sampling the sludge. Continuous sludge removal from final settling tanks shall be provided. Each sludge hopper shall have an individually valved sludge withdrawal line at least 6 inches in diameter. Head available for withdrawal of sludge shall be at least 30 inches for gravity withdrawal.

(10) DEPTH. The liquid depth of mechanically cleaned settling tanks shall be as shallow as practical but not less than 7 feet. Final clarifiers for activated sludge shall not be less than 10 feet in depth.

(11) SLUDGE HOPPERS. Hoppers shall be accessible for maintenance from the operating level. The minimum slope of the side walls of sludge

hoppers shall be 1.7 vertical to one horizontal. Clearance between the end of the sludge draw-off pipe and the hopper walls shall be sufficient to prevent "bridging" of solids. Hopper bottoms shall have a maximum dimension of two feet along the side.

(12) MECHANICAL SLUDGE COLLECTION EQUIPMENT. Suitable mechanical sludge collection equipment shall be provided in all settling tanks except for installations too small to warrant the use of mechanically equipped tanks.

(13) IMHOFF TANKS. Imhoff tanks are not acceptable.

Note: The department will waive this prohibition and approve Imhoff tanks only when plans are accompanied by sufficient justification and detailed design data.

History: Cr. Register, November, 1974, No. 227, eff. 12-1-74.

NR 110.19 Biological treatment; trickling filters. (1) APPLICABILITY. New trickling filters are not acceptable unless used in conjunction with other treatment units which will produce an overall level of treatment defined as acceptable in NR 110.15 (1). Existing trickling filters may be used as a treatment unit in plant expansion if the overall requirements of NR 110.15 (1) are met. Trickling filters shall be preceded by approved settling tanks equipped with scum collecting devices, or other suitable pretreatment facilities.

(2) DESIGN BASIS. Trickling filters shall be designed to accept an organic loading of less than 50 pounds of BOD, per 1,000 cubic feet of media. Filters using manufactured media shall be loaded at less than 75 pounds BOD, per 1,000 cubic feet of media.

Note: The department may approve a higher loading rate depending on the use of the filter with respect to other plant units.

(3) DOSING EQUIPMENT. (a) *Distribution.* The sewage shall be distributed over the filter by rotary distributors or other suitable devices which will permit reasonably uniform distribution to the surface area.

(b) *Dosing.* Sewage shall 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 continuous. A piping system which will permit recirculation shall be provided.

(c) *Clearance.* A minimum clearance of 6 inches between media and distributor arms shall be provided.

(4) MEDIA. (a) *Type.* The media shall be crushed rock, slag or any approved specially manufactured material.

(b) *Quality.* The media shall be durable, resistant to spalling or flaking, and be relatively insoluble in sewage. The top 18 inches of natural aggregate shall have a loss of not more than 10% as measured by the 20-cycle, sodium sulfate soundness test, with the balance passing a 10-cycle test. The test shall be done in accordance with A.S.C.E. Manual of Engineering Practice, Number 13 (October 13, 1935). Copies of the A.S.C.E. Manual of Engineering Practice, Number 13, are available for inspection at the office of the department of natural resources, secretary of state's office and the office of the revisor of statutes and may be obtained for personal use from the American Society of Civil Engineers, 33 West 39th

Street, New York, New York. Slag media shall be free from iron. Manufactured media shall be structurally stable and chemically and biologically inert.

(c) *Depth.* The filter media shall have a minimum depth of 5 feet above the underdrains and shall not exceed 7 feet in depth except where special construction is justified by studies.

(5) SIZE AND GRADING OF MEDIA. (a) *Rock, slag and similar media.* Rock, slag and similar media shall not contain more than 5% by weight of pieces whose longest dimension is 3 times the least dimension. They shall be free from thin elongated and flat pieces, dust, clay, sand, or fine material and shall conform to the following size and gradings when mechanically graded over vibrating screen with square openings:

1. Passing 4½-inch screen—100% by weight;

2. Retained on 3-inch screen—95-100% by weight;

3. Passing 2-inch screen—0-2% by weight;

4. Passing 1-inch screen—0.1% by weight;

(b) *Handling and placing of media.* Material delivered to the filter site shall be stored on wood planked 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 rescreened or forked at the filter site to removal all fines. Such material shall be placed by hand to a depth of 12 inches above the tile underdrains and all material shall be carefully placed so as not to damage the underdrains. The remainder of the material shall be placed by means of belt conveyors or equally effective methods. Trucks, tractors, or other heavy equipment shall not be driven over the filter during or after construction.

(6) UNDERDRAINAGE SYSTEM. (a) *Arrangement.* Underdrains with semi-circular 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 15 percent of the surface area of the filter.

(b) *Slope.* The underdrains shall have a minimum slope of 1%. Effluent channels shall be designed to produce a minimum velocity of 2 feet per second at average daily rate of application to the filter.

(c) *Flushing.* Provision shall 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 shall be provided.

(d) *Ventilation.* The underdrainage system, effluent channels, and effluent pipe shall be designed to permit free passage of air. The size of drains, channels, and pipe shall be such that not more than 50 percent of their cross-sectional area will be submerged under the design hydraulic loading.

Note: The design of the effluent channels should consider the possibility of increased hydraulic loading.

(7) PROTECTION FROM FREEZING. (a) *Covers.* Covers shall be provided on all filters to prevent icing and freezing during wintertime conditions

and to increase the efficiency of removal through the filter during cold weather.

Note: Where it can be demonstrated that freezing is not a problem and efficiencies are maintained at a high level during all weather conditions, the department may waive this requirement. Other means to prevent freezing and improve efficiency will also be considered by the department on their individual merits.

(b) *Ventilation of covered filters.* Adequate ventilation shall be provided to maintain the filter in an aerobic state at all times.

Note: Mechanical power ventilation at all installations is recommended.

(8) SPECIAL FEATURES. (a) *Flooding.*

Note: It is recommended that filter structures be so designed so that they may be flooded.

(b) *Seals.* Mercury seals shall not be used on trickling filter distributors.

(c) *Maintenance.* All distribution devices, underdrains, channels and pipes shall be installed so that they may be properly maintained, flushed or drained.

(d) *Flow measurement.* Devices shall be provided to permit measurement of flow to the filter, including the amount of recirculated flow.

History: Cr. Register, November, 1974, No. 227, eff. 12-1-74.

NR 110.20 Biological treatment; activated sludge. (1) APPLICABILITY.

Note: The activated sludge process, and its various modifications, may be used where sewage is amenable to biological treatment.

(2) PROCESS SELECTION. All designs shall provide for flexibility in operation.

Note: Choice of the activated sludge process most applicable will be influenced by the proposed plant size, type of waste to be treated, and degree and consistency of treatment required.

(3) WINTER PROTECTION. Measures shall be taken to insure against freezing.

(4) PRETREATMENT. Where primary settling tanks are not used, effective removal of grit, debris, excessive oil or grease, and comminution of solids shall be accomplished prior to the activated sludge process.

(5) SETTLING TANKS. The following requirements are in addition to those set forth in NR 110.18:

(a) *By-pass.* When a primary settling tanks is used, piping shall be provided to allow raw sewage to be discharged directly to the aeration tanks following pretreatment. When a primary settling tank is not used, piping shall be provided to allow raw sewage to be discharged to the final settling tanks to permit a minimum of primary treatment and effluent disinfection.

(b) *Final settling tanks.* 1. Inlets, sludge collection and sludge withdrawal facilities shall be designed as to minimize density currents and assure rapid return of sludge to the aeration tanks.

2. Multiple units capable of independent operation shall be provided in all plants where design flows exceed 500,000 gallons per day, unless other provision is made to assure continuity of treatment.

3. Effective baffling and mechanical scum removal equipment shall be provided for all final settling tanks.

Note: The department recommends that the following design parameters be observed in the design of final settling tanks for the following activated sludge processes, except that due consideration be given to the flow duration and the solids loading rate.

Type of Process	Average Design Flow, MGD	Average Detention Time-Hours	Surface Settling Rates (gal/day/sq.ft.)
Conventional or	to 0.5	3.0	600
Step	0.5 to 1.5	2.5	600
Aeration	1.5 up	2.0	600
Contact	to 0.5	3.6	500
Stabilitation	0.5 to 1.5	3.0	600
	1.5 up	2.5	600
Extended	to 0.05	4.0	300
Aeration	0.05 to 0.15	3.6	300
	0.15 up	3.0	400
Complete Mix	to 0.5	3.5	400
	0.5 to 1.5	3.0	500
	1.5 up	3.0	500

(6) AERATION TANKS. (a) *General.* The size of the aeration tank for any particular adaptation of the process shall be based on such factors as the size of the plant, degree of treatment desired, mixed liquor suspended solids concentration, BOD loading, and mixed liquor solids to BOD loading ratio. Calculations shall be submitted to justify the basis of design of the aeration tank capacity. Pilot plant studies may be considered as a basis for justification of the design of the system. When such calculations are not submitted to justify the capacity of the aeration tank, the minimum tank capacities set forth in paragraph (b) shall be required for the various modifications of the activated sludge process.

(b) Aeration tank capacities and permissible loadings.

Type of Process	Average Design Flow, MGD	Average Aeration Retention Period-Hours	Average Aerator Loading Lb. BOD,/1,000 cubic feet
Conventional or Step Aeration	to 1.5	7.5	30
	1.5 up	6.0	40
Contact Stabilitation	to 1.5	3.0 (in contact zone)	30
	1.5 up	2.0 (in contact zone)	40
Extended Aeration	All	24	12.5
Complete Mix	to 1.5	6.0	40
	1.5 up	4.5	50

Note: Contact Zone = 30-35% of total aeration tank volumes. Balance is in the reaeration zone.

(7) ARRANGEMENT OF AERATION TANKS. (a) *General.* The dimensions of each independent mixed liquor aeration tank or return sludge reaeration tank shall be such as to maintain effective mixing and utilization of air. For very small tanks or tanks with special configuration, the shape of the tank and the installation of aeration equipment shall provide for positive control of short-circuiting through the tank.

Note: The department recommends that liquid depths be not less than 10 feet nor more than 15 feet except in special design cases.

(b) *Number of units.* Duplicate units shall be provided where the design flow exceeds 500,000 gallons per day.

(c) *Inlets and outlets.* 1. Controls. Inlets and outlets for each aeration tank unit shall be 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.

2. Conduits. Channels and pipes carrying liquids with solids in suspension shall be designed to maintain self-cleansing velocities or shall be agitated to keep such solids in suspension at all rates of flow within the design limits.

(d) *Measuring devices.* Devices shall be installed for measuring and displaying flow rates of raw sewage or primary effluent, return sludge, and air to each tank unit. For plants designed for sewage flows of 1.5 mgd or more, these devices must 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 location, then the mixed liquor flow rate to each aeration unit shall be measured.

(e) *Freeboard.* All aeration tanks shall have a freeboard of not less than 18 inches.

(8) AERATION EQUIPMENT. (a) *General.* Aeration equipment shall be capable of maintaining a minumum of 2.0 mg/l of dissolved oxygen in the mixed liquor at all times and of providing thorough mixing of the mixed liquor.

(b) *Diffused air systems.* 1. Diffused air systems shall provide a minimum of 1,500 cubic feet of air per pound of BOD_5 applied to the aeration tank for all processes except extended aeration. For extended aeration, a minimum of 2,000 cubic feet of air per pound of BOD_5 shall be provided. In any case, the requirements of NR 110.20 (8) (a), Wis. Adm. Code, shall be met.

2. In addition to the requirements of NR 110.20 (8) (b) 1., Wis. Adm. Code, the diffused air system shall provide such additional quantities of air as are required for channels, pumps or other air-use demands.

3. The blowers shall be provided in multiple units, adequately housed and so arranged and with such capacities as to meet the maximum air demand with the single largest unit out of service. The design shall also provide the capability of varying the volume of air delivered in proportion to the load demand of the plant.

4. The air diffusion piping and diffuser system shall be capable of delivering 200% of the normal air requirements. The spacing of diffusers shall be in accordance with the oxygenation requirements through the length of the channel or tank. The arrangement of diffusers shall permit their removal for inspection, maintenance and replacement without dewatering the tank and without shutting off the air supply to other diffusers in the tank.

Note: In large systems, the department may waive the requirement of removable diffusers provided the efficiency of the system can be maintained with one unit out of service.

(c) *Mechanical aeration systems.* 1. A minimum of 1.0 pound of oxygen per pound of BOD_5 applied to the aeration tank shall be provided.

Note: A transfer rate of 2.0 pounds of oxygen per horsepower hour will be allowed. Higher transfer rates may be approved where adequate test data is provided.

2. Multiple mechanical aeration units shall be designed and located so as to meet the maximum air demand with the largest unit out of service. Spare equipment shall be provided at the treatment plant so that any unit can be returned to service with a minimum amount of down time.

(d) *Pure oxygen.* Where pure oxygen is proposed, supporting data from pilot plant installations or similar full-scale installations shall be submitted to justify the proposed aerator loading rate and the amount and type of aeration capacity and equipment proposed.

(9) RETURN SLUDGE EQUIPMENT. (a) *Return sludge rate.* The rate of sludge return expressed as a percentage of the average design flow of sewage must lie within the following limits:

	Minimum	Normal	Maximum
Conventional	15	30	75
Step aeration	20	50	75
Contact stabilization	50	100	150
Extended aeration	50	100	200
Complete mix	20	50	75

(b) *Return sludge pumps.* 1. If motor driven return sludge pumps are used, the maximum return sludge capacity must be met with the largest pump out of service. A positive head shall be provided on pump suctions. Pumps shall also have at least 3-inch suction and discharge openings.

2. If air lifts are used for returning sludge from each settling tank hopper, no standby unit is required provided the design of the air lifts are such as to facilitate their rapid and easy cleaning. Air lifts shall be at least 3 inches in diameter.

(c) *Return sludge piping.* Suction and discharge piping shall be at least 4 inches in diameter and must be designed to maintain a velocity of not less than 2 feet per second 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 shall be provided.

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

History: Cr. Register, November, 1974, No. 227, eff. 12-1-74.

NR 110.21 Biological treatment; fixed film contacters. Projects proposing to employ fixed film contacters as a means of treatment will be reviewed on their merits. The department may approve such devices if adequate substantiating design information is provided.

History: Cr. Register, November, 1974, No. 227, eff. 12-1-74.

NR 110.22 Physical-chemical treatment. Projects proposing to employ physical-chemical processes as a means of treatment will be reviewed on their merits. The department may approve such devices if adequate substantiating design information is provided.

History: Cr. Register, November, 1974, No. 227, eff. 12-1-74.

NR 110.23 Disinfection. (1) GENERAL. Continuous disinfection shall be provided to reduce the risk of a public health hazard. Exceptions to this requirement are as follows:

(a) Stabilization lagoon treatment systems as described in NR 110.28 are exempt from the disinfection requirement. However, where the department of natural resources determines that short circuiting within such a system might cause a potential risk to public health due to the lack of adequate detention time, requirements for disinfection may be imposed in specific cases. Aerated lagoon treatment systems as described in NR 110.28 are required to disinfect as required by this section.

(b) In areas where it can be shown that the costs exceed the benefits derived from the disinfection of secondary or higher level of treated effluent, the owner may request that the department waive or modify the

requirements for disinfection. The owner must submit to the department, for its review, specific data to justify any modification of the disinfection requirements.

(2) TYPES OF DISINFECTION. Chlorine is the most commonly used chemical. However, the department encourages the owner to evaluate the cost-effective application of ozone, bromine, bromine chloride, ultraviolet light, and other chemicals or methods or combinations of methods in individual cases. Where a disinfection process other than chlorine is proposed, supporting data from pilot plant installations or similar full-scale installations shall be submitted as a basis upon which the owner or the owner's representative may design the system.

(3) FEED EQUIPMENT — CHLORINE. (a) *Type.* Solution-feed vacuum type chlorinators or positive displacement type hypochlorite feeders are recommended.

(b) *Capacity.* Required capacity will vary, depending on the uses and points of application of the disinfectant. Caution should be used to not oversize the units.

(4) MEASUREMENT TECHNIQUES. (a) *Residual chlorine.* Residual chlorine concentrations shall be measured in accordance with chapter NR 219 Wis. Adm. Code.

(b) *Bacteriological measurements.* Coliform content of effluents shall be measured in accordance with chapter NR 219 Wis. Adm. Code.

(5) CHLORINE SUPPLY. (a) *Cylinders.* Cylinders must comply with department of transportation regulations concerning placards and labels. Furthermore, only chlorine institute approved valves can be used in this service.

Note: The department recommends consideration of one ton containers of chlorine where the average daily chlorine consumption is over 150 pounds. However, both monetary cost and potential residential exposure to chlorine should be evaluated when making a final decision. The department recommends that the cylinders be hydrostatically tested for integrity every 5 years.

(b) *Scales.* Scales or other means of determining chlorine usage must be provided at all plants using chlorine gas for disinfection. Scales shall be of corrosion-resistant material.

Note: At large plants, scales of the indicating and recording type ar recommended.

(c) *Evaporators.* Evaporators for converting liquid chlorine to a gas can be used where manifolding of ton units to increase gas flow is impractical or imprudent.

(d) *Leak detection and controls.* A bottle of 56% ammonium hydroxide solution shall be available for detecting chlorine leaks. Where ton containers are used, a leak repair kit approved by the chlorine institute shall be provided.

Note: The department recommends that caustic soda solution reaction tanks be installed where practical for absorbing the contents of leaking one ton cylinders where such cylinders are in use. At large installations the department recommends that automatic gas detection and related alarm equipment be installed.

(6) PIPING AND CONNECTIONS. (a) Only piping systems specifically manufactured for chlorine service are approvable. The specifications of the chlorine institute should be used as guidelines.

(b) Due to the corrosiveness of wet chlorine, all lines designed to handle dry chlorine must be protected from the entrance of water or air containing water.

(7) HOUSING. (a) *Separation.* If gas chlorination equipment and chlorine cylinders are to be in a building used for other purposes, a gas-tight partition shall separate this room from any other portion of the building. Doors to this room shall open only to the outside of the building, and shall be equipped with panic or emergency hardware. Such rooms shall be at least 6" above ground level, and must permit easy access to all equipment. Storage area shall be separated from the feed area where one ton or larger cylinders are used.

(b) *Inspection window.* A clear glass, gas-tight window shall be installed in an exterior door or interior wall of the chlorinator room to permit the chlorinator to be viewed without entering the room.

(c) *Temperature control.* Chlorinator rooms and cylinders in use shall be maintained at a temperature not less than 60°F and not greater than 140°F.

(d) *Ventilation.* Forced, mechanical ventilation shall be installed which will provide one complete air change per minute. The entrance to the air exhaust duct from the room shall be near the floor and the point of discharge shall be so located as not to contaminate the air inlet to any buildings or inhabited areas. Air inlets shall be so located as to provide cross ventilation and at such a temperature that will not adversely affect the chlorination equipment. The vent hose from the chlorinator shall discharge to the outside atmosphere above grade.

(e) *Electrical controls.* The controls for the fans and lights shall be such that the fans and lights will automatically operate when the door is opened and can also be manually operated from the outside without opening the door.

(8) SAFETY EQUIPMENT. Respiratory air-pack protection equipment, meeting the requirements of the national institute for occupational safety and health (NIOSH) shall be available where chlorine gas is handled, and shall be stored at a convenience location, but not inside any room where chlorine is used and stored. The units shall use compressed air or oxygen, have at least 30-minute capacity, and be compatible with the units used by the fire department responsible for the plant.

(9) APPLICATION OF CHLORINE. (a) *Initial mixing.* The chlorine shall be mixed as rapidly as possible. This may be accomplished by either the design of a turbulent flow regime or the use of a mechanical flash mixer.

(b) *Contact time.* After rapid mixing, a contact time of at least one hour at average design flow or 30 minutes at peak daily design flow shall be provided. The hydraulic characteristics of the contact zone must be equivalent to that achieved by a tank with a length to width ratio of 40:1 or more. A tank of this type could be expected to have a dispersion index of 0.02 and a Morril index of less than 2.0.

(c) *Characteristics.* The hydraulic characteristics of a contact zone with a length to width ratio less than 40:1 must be certified at the time of construction by the submission of the results of field test. It is recommended that the basin have provisions for cleaning which will not interrupt the disinfection process.

(10) CHLORINE CONTROL SYSTEMS. In all systems, with design flow of greater than 0.25 MGD the feed mechansim shall be provided with either an automatic flow proportional control or an automatic residual control. The department encourages the consideration of a "compound loop control" at plants with an average design flow of greater than one MGD.

(a) All sample lines should be designed to provide easy cleaning and to minimize biofouling. The department will inspect the chlorine control system on an annual basis to assure that it is being properly operated and maintained.

(11) DECHLORINATION. In instances where chlorine is used, the most practical method of lessening toxicity of residual chlorine present in the effluent will usually be dechlorination of the effluent by the use of sulfur dioxide, sodium biosulfite, sodium thiosulfate, or sodium metabisulfite. In instances where dechlorination of the effluent may be required, alternative forms of disinfection should be evaluated which may result in a lower total system cost. The most common chemical used to dechlorinate wastewater in large treatment plants (greater than one MGD) is sulfur dioxide and in smaller plants sodium metabisulfite. In both instances the following apply. (In certain individual cases, the use of activated carbon may be approved for the purposes of dechlorination.)

(a) *Feed equipment.* When using sulfur dioxide, the feed equipment is essentially the same as that used for the application of chlorine, and similar precautions must be observed. When using sodium metabisulfite, the chemical may be fed either in the dry form or as a solution and metered with a diaphragm pump. Although similar equipment is used, the same piece of equipment shall not be interchanged with the chlorine application equipment.

(b) *Mixing.* The chemical shall be mixed such that complete dispersion is achieved before the effluent reaches the receiving water.

(c) *Contact time.* When complete mixing has been achieved, no further contact time is necessary.

(d) *Control system.* At the present time it is not practical to continuously monitor the sulfite ion. The most practical method is to intermittently divert a portion of the final effluent to a chlorine residual analyzer (which is suggested for all chlorination-dechlorination systems) for a short period each one-two hours to allow the recorder to measure the residual chlorine. The residual should be essentially zero.

(e) *Sulfur dioxide supply.* The supply system should be designed similar to the chlorine system.

(f) *Safety.* Safety equipment is similar to that used for chlorine.

(g) *Reaeration.* Reaeration of the effluent may be necessary before the discharge to achieve an adequate dissolved oxygen level in the stream. The dissolved oxygen requirements as required in chapter NR 104 Wis. Adm. Code shall be used as a basis for the determination of the need for and capacity of reaeration facilities.

History: Cr. Register, November, 1974, No. 227, eff. 12-1-74; r. and recr. Register, March, 1978, No. 267, eff. 4-1-78.

NR 110.24 Phosphorus removal. (1) APPLICABILITY. (a) The department may require removal of excess amounts of phosphorus from any municipal waste discharge where such discharge is causing, or may cause, over-fertilization of surface waters.

(b) Phosphorus removal shall be provided at all municipal waste discharges serving a population equivalent of greater than 2,500 in the Lake Michigan and Lake Superior drainage basins.

(2) DEGREE OF TREATMENT. Phosphorus removal facilities shall be designed to achieve a monthly average phosphorus concentration in the effluent of not more than 1.0 mg/l of total phosphorus. In instances where it can be demonstrated that 1.0 mg/l phosphorus cannot be achieved on a monthly average, the system shall be operated to remove at least 85% of the influent phosphorus on an annual average.

(3) METHOD OF TREATMENT. Phosphorus removal shall be achieved by use of chemical precipitation or by any other method that has been proven effective by pilot plant testing.

(a) *Chemicals.* The following chemicals are considered acceptable for removing phosphorus: ferrous or ferric chloride, ferrous or ferric sulfate, aluminum sulfate, sodium aluminate, or other suitable metal salts.

Note: Selection of the chemical used should be based on the waste characteristics. Pilot plant work or jar testing is recommended.

(b) *Chemical feed equipment.* Feed equipment shall be selected which allows the use of various chemicals. Alternate points of chemical application within the flow scheme shall be provided for flexibility of operation and to maximize removal of phosphorus.

(c) *Polymers.* Polymers shall be used if necessary to meet the effluent concentration limits.

History: Cr. Register, November, 1974, No. 227, eff. 12-1-74.

NR 110.25 Hazardous chemical handling. (1) CONTAINMENT MATERIALS. The materials utilized for storage, piping, valves, pumping, metering, splash guards, and any other equipment used to contain or convey hazardous or corrosive chemicals shall be selected based on the physical and chemical characteristics of each such chemical used. Chlorine shall be handled separately in accordance with the requirements of NR 110.23.

(2) SECONDARY CONTAINMENT. Chemical storage areas shall be enclosed in dykes or curbs which will contain the stored volume until it can be either safely transferred to alternate storage areas or released to the wastewater at controlled rates which will not damage facilities, inhibit the treatment processes or contribute to stream pollution. Liquid polymer shall be similarly contained.

Note: Nonslip floor surfaces are desirable in polymer handling areas.

(3) EYE WASH FOUNTAINS AND SAFETY SHOWERS. (a) Eye wash fountains and safety showers utilizing potable water shall be provided in the laboratory and on each floor level or work location involving hazardous or corrosive chemical storage, mixing or slaking, pumping, metering, or transportation unloading. These facilities shall be as close as practical to possible chemical exposure sites and shall be fully useful during all weather conditions.

(b) The eye wash fountains shall be supplied with water of moderate temperature between 50°F and 90°F, separate from the hot water supply, suitable to provide 15 to 30 minutes of continuous irrigation of the eyes.

(c) The emergency showers shall be capable of discharging 30 to 50 gpm of water at moderate temperature at pressures of 20 to 50 psi.

Note: It is recommended that the eye wash fountains and showers be no more than 25 feet from points of caustic exposure.

(4) SPLASH GUARDS. All pumps or feeders for hazardous or corrosive chemicals shall have guards which will effectively prevent spray of chemicals into space occupied by personnel. The splash guards are in addition to guards to prevent injury from moving or rotating machinery parts.

(5) PIPING, LABELING, COUPLING GUARDS, LOCATION. All piping containing or transporting corrosive or hazardous chemicals shall be identified with labels every 10 feet and with at least 2 labels in each room, closet or pipe chase. Color coding may also be used but is not an adequate substitute for labeling. All connections except those adjacent to storage or fedder areas, shall have guards which will direct any leakage away from space occupied by personnel. Pipes

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