
Rules of
Department of Natural Resources
Division 20—Clean Water Commission
Chapter 8—Design Guides

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**Title 10—DEPARTMENT OF
NATURAL RESOURCES**

**Division 20—Clean Water Commission
Chapter 8—Design Guides**

**10 CSR 20-8.010 Design of Municipal
Waste Stabilization Lagoons in Missouri**
(Rescinded August 13, 1979)

AUTHORITY: section 204.026, RSMo Supp. 1973. Original rule filed July 17, 1961, effective July 27, 1961. Amended: Filed Oct. 3, 1962, effective Oct. 13, 1962. Amended: Filed Dec. 4, 1975, effective Dec. 14, 1975. Rescinded: Filed May 4, 1979, effective Aug. 13, 1979.

**10 CSR 20-8.020 Design of Small Sewage
Works**

PURPOSE: This rule sets out criteria as a guide in designing and constructing small sewage works. These criteria are not necessarily applicable to the design of works having daily flows in excess of 22,500 gallons per day. For works having larger flows, 10 CSR 20-8.110–10 CSR 20-8.220 reflect the minimum acceptable standards. This rule reflects the minimum requirements of the Missouri Department of Natural Resources for design, submission of plans, approval of plans and approval of completed small sewage works. These criteria are based on the best information presently available but they may be subject to periodic review and revision as additional information and methods appear. Deviation from minimum requirements will be allowed if sufficient documentation justifies the deviation. Addenda or supplements to this publication will be furnished to consulting engineers and city engineers. Others wanting to receive addenda or supplements should contact the Missouri Clean Water Commission to be added to the mailing list.

Editor's Note: The secretary of state has determined that the publication of this rule in its entirety would be unduly cumbersome or expensive. The entire text of the material referenced has been filed with the secretary of state. This material may be found at the Office of the Secretary of State or at the headquarters of the agency and is available to any interested person at a cost established by state law.

(1) Definitions. Definitions as set forth in the Missouri 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 used, the terms mean a mandatory requirement insofar as approval by

the department is concerned unless justification is presented for deviation from the requirements. Other terms, such as should, recommend and preferred, indicate discretionary department requirements. Deviations are subject to individual consideration.

(2) General.

(A) Before work on engineering documents has begun, it is recommended that inquiry be made to the appropriate department office as to what effluent limitations the proposed facility will probably be required to meet. The engineer and applicant should also be aware that if a geological evaluation of the receiving stream or lagoon site is required it will take thirty to forty-five (30–45) days to receive the geological evaluation. In general the final engineering documents will not be reviewed until the other elements of a complete application have been received in accordance with 10 CSR 20-6.010 Construction and Operating Permits. All reports, plans and specifications shall be submitted at least sixty (60) days prior to the date upon which approval of the engineering documents by the department is desired or in accordance with NPDES or other schedules. For unusual or complex projects, it is suggested that the engineer meet with the appropriate department office to discuss the project and that preliminary reports be submitted for review prior to preparation of final plans and specifications.

(B) One (1) set of engineering documents should be submitted for formal approval. It shall include the engineer's report, if required, general layout and detailed plans, specifications and summary of design data. All engineering documents shall be prepared by a registered professional engineer licensed to practice in Missouri and shall bear the imprint of his/her seal and signature. If the engineering documents contain known deviations from the criteria contained in this rule, documentation and justification for the deviation should be submitted with the summary of design data. If stamped, approved copies of plans and specifications are desired, additional copies should be submitted with the original documents along with a letter indicating disposition of the extra set of plans and specifications.

(3) Engineer's Report. An engineer's report shall be submitted whenever required by the department, and for sewage works serving subdivisions or other expandable projects, or for projects which might be connected to a comprehensive system at a future date. The engineer's report referenced in subsections

(2)(A) and (B) shall contain the information outlined in this section.

(A) Field Survey. The following items shall be determined and reported:

1. Nature and use of schools, resorts, subdivisions or establishments to be served by the proposed facilities;

2. Population to be served, present and ultimate, and in some cases, the twenty (20)-year population projection;

3. Character and quantity of wastes other than domestic sewage which will be discharged through the system, including present method of garbage disposal and the possibility of future disposal of garbage wastes with sewage. (Note: Method of garbage disposal is critical when designing treatment facilities to serve food service establishments.);

4. Existing sewage treatment facilities;

5. Consideration of the various sites available and the advantages of the one selected. The proximity of the site to buildings or developed areas and the possibilities of flooding of the plant site;

6. The proximity of wells, cisterns, supply lines or other water supply structures in relation to the sewage treatment facilities; and

7. The results of geological evaluations, detailed soils investigations and interpretation of any laboratory soils testing data taken from soil borings.

(B) Analysis of Field Survey Data. Review field findings to determine the best possible solution regarding location, type of treatment and population (present, twenty (20)-year projected and ultimate) to be served.

(C) Recommendations. Include recommendations in detail concerning the proposed treatment works and outline a plan for future extension of the works.

1. Alternate plans. Where two (2) or more solutions exist for a particular problem, each of which is feasible and practical, discuss the solutions and the reason for selecting the one (1) recommended.

2. Sewer system. Describe the drainage area and extent to which plans provide sewage facilities for future development.

3. Sewage treatment. Discuss the degree and type of treatment, reasons for adopting the proposed method and the provisions made for future needs.

4. Ownership and operation. State ownership and who will be responsible for the facility. Continuing authorities must be in accordance with 10 CSR 20-6.010(3).

(D) Industrial Wastewater Treatment Facilities. Industrial waste treatment facilities shall be designed based on a thorough evaluation of waste characteristics, waste treatability and

site characteristics. The content for engineering reports listed in 10 CSR 20-8.110 and the requirements in this rule should be considered. The engineering reports shall contain a detailed waste description, laboratory analyses and documentation of the treatability and potential environmental pathways for each constituent that may be present in the waste and wastewater. The engineering report shall include a discussion of any applicable effluent guidance documents by the United States Environmental Protection Agency. The engineering report shall also contain documentation as to whether the wastewater stream may be classified as a hazardous waste pursuant to 10 CSR 25-4.261. Industrial flows containing hazardous wastes shall comply with the requirements of the hazardous waste regulation in 10 CSR 25.

(4) General Layout. The general plans for sewage works shall show—

(A) Miscellaneous. A suitable title and the name of the school, resort, subdivision or institution, the scale in feet, a graphical scale, the north point, date, the name of the design engineer and the imprint of the engineer's professional seal. The scale for the plans should not be less than one hundred feet (100') or greater than three hundred (300') to the inch. The lettering and figures on the plans must be of appropriate size and of distinct outline. Datum used should be indicated.

(B) Existing or proposed buildings, roadways, recreation facilities and all water surfaces and streams shall be clearly shown. Contour lines at suitable intervals should be included on the general plan. Elevations should be referenced to United States Geological Survey datum. Elevations in flood plain areas shall be based on United States Geological data. The boundary line of the property or area to be served shall be shown.

(C) Existing Facilities. The location, size, length, slope and direction of flow of all existing sanitary and storm sewers affecting the proposed improvements shall be shown. A plot plan of the existing treatment works indicating the topography and arrangement of existing units shall be shown.

(D) Proposed Facilities. The location of all proposed sewers with size, grade, length and direction of flow shall be indicated. All manholes shall be numbered on the layout and subsequently numbered on the profile. The location of outlets, treatment units, manholes, lampholes, siphons, pumping stations and other accessories shall be shown. Suitable symbols appropriately referenced shall be shown in the title of all these works.

(E) Water Supply and Facilities. The location of all existing and proposed wells, cisterns, reservoirs or other sources of public, semi-public or private water supplies located within five hundred feet (500') of the proposed or existing sewerage works should be shown. The location of all existing or proposed pumps, distribution systems and any other water supply structures should be shown.

(5) Detailed Plans. All detailed plans shall be prepared on blue or white prints and shall be drawn to a suitable scale. Detailed plans for sewage works shall be shown.

(A) Sewers. A plan and profile of all sewers to be constructed shall be provided. Profiles should be on a horizontal scale of one hundred feet (100') to the inch and a vertical scale of ten feet (10') to the inch. Show all known structures above and below ground which might interfere with the construction. The manhole stationing, size of sewers, surface and invert manhole elevations and grade of all sewers between adjacent manholes must be shown on the profile. Construction details of all ordinary sewer appurtenances such as manholes, lampholes and inspection chambers must be shown.

(B) Sewage Pumping Stations. Complete details including elevations and provision for future pumps shall be shown.

(C) Sewage Treatment Works. Complete details including elevations shall be given for all treatment units.

(D) Location Map. The exact location of the project shall be shown on a United States Geologic Survey topographic map or other suitable map which provides the exact location.

(6) Specifications. Complete detailed specifications for the construction of sewers, sewage treatment plant and all appurtenances shall accompany the plans. Continuing authorities as described in 10 CSR 20-6.010 or private engineering firms may file for approval of their standard sanitary sewer construction specifications with this department. A minimum of two (2) copies of the proposed standard specifications shall be submitted. The standard specifications must contain the following:

(A) Certification statement by a registered professional engineer licensed to practice in Missouri including signature, number and date; and

(B) If the engineer preparing the specifications is not a permanent, full-time employee of the continuing authority submitting the specifications, then the governing body of the continuing authority submitting the specifications must also submit a resolution adopting the specifications submitted as the official

specifications of the continuing authority. Upon arrival and acceptance of standard specifications for sanitary sewer construction, the department will not require submission of specifications with the plans. However, the department will require that all plans contain a statement that all construction shall be in accordance with the approved standard specifications currently on file with the department. Additional special provisions for a particular project can also be utilized in conjunction with approved standard specifications. The applicant should submit copies of the special provisions properly certified by an engineer. When a revision to approved standard specifications is required by revision of departmental standards or governing continuing authority initiative, three (3) copies of the revision, properly certified and adopted, shall be submitted.

(7) Summary of Design Data. A summary of design data shall accompany the plans and specifications and contain the following:

(A) Flow and waste load projections, including estimated daily flow and types of wastes other than domestic;

(B) Type and size of individual process units along with hydraulic and organic loading to each individual unit. Show process diagrams, including flow diagram with capacities. Show the basic calculations and assumptions used to size each unit;

(C) Basic calculations for detention times in each process unit and the process as a whole. Discuss other considerations such as recycle, chemical additive control, physical control, flexibility and flow metering if applicable;

(D) Expected removals and expected effluent concentration of the permit limited contaminants in the discharge from the treatment facility; and

(E) Design calculations, tabulations and assumptions for the sewer lines and pump stations.

(8) Revisions to Approved Plans. Any deviations from approved plans or specifications affecting capacity, flow or operation of units must be approved in writing before these changes are made. Plans or specifications so revised should therefore be submitted well in advance of any construction work which will be affected by these changes to allow sufficient time for review and approval. Structural revisions or other minor changes not affecting capacities, flow or operation will be permitted during construction without approval. As-built plans clearly showing these alterations shall be placed on file with the department after the completion of the work.

(9) Sewers. Sewers serving subdivisions or other properties which might become incorporated into an existing or proposed comprehensive sewerage system at some future date shall be designed and constructed in accordance with 10 CSR 20-8.120 Design of Sewage Works. Privately-owned systems or collection systems for schools, resorts or establishments of similar nature shall meet the following requirements:

(A) General. In general the department will approve plans for new systems, extensions to new areas or replacement of sanitary sewers only when designed upon the separate plan in which rainwater from roofs, streets and other areas and groundwater from foundation drains and springs are excluded.

1. Design period. Sewers should be designed for the estimated ultimate tributary population.

2. Materials. Any generally accepted material for sewers will be given consideration but the materials selected should be adapted to local conditions, special care being given to possibilities of septicity, excessive external loadings, abrasions, soft foundations and similar problems. All sewer pipes shall be covered by an applicable American Society for Testing and Materials (ASTM) standard. All sewers shall be designed to prevent damage from superimposed loads. Proper allowance for loads on the sewer due to width and depth of trench shall be made. All pipe used shall comply with applicable ASTM standards. Thin-walled drain, waste and vent piping shall not be used for sewers.

3. Joints and infiltration. The method of making joints and the materials used shall be included in the specifications. Materials used in jointing shall have satisfactory records for preventing infiltration and the entrance of roots. Portland cement mortar joints are not acceptable. The amount of leakage under wet weather conditions shall not exceed two hundred (200) gallons per inch diameter per mile of sewer per day.

4. Water and sewer separation. There shall be no permanent physical connection between a potable water supply and any sewer, treatment device or appurtenances thereto which will permit the passage of sewage or contaminated water into the potable water supply. Whenever possible, sewers and manholes should be located at least ten feet (10') horizontally from any existing or proposed water line. Should local conditions prevent a lateral separation of ten feet (10'), a sewer may be laid closer than ten feet (10') from a water main if it is in a separate trench or if it is in the same trench with the waterline located at one (1) side on a bench of undisturbed earth. In either case the elevation of the

crowns of the sewer must be at least eighteen inches (18") below the invert of the water line. Whenever sewers must cross under water lines and the sewer cannot be buried to meet these requirements, the water line shall be relocated to provide this separation or the sewer line constructed of slip-on or mechanical joint cast iron pipe, asbestos cement pressure pipe or PVC pressure pipe for a distance of ten feet (10') on each side of the water line and be pressure tested to assure watertightness.

5. Sewers in relation to streams. The top of all sewers entering or crossing streams shall be at sufficient depth below the natural bottom of the stream bed to protect the sewer line. The top of the sewer pipe should be a minimum of three feet (3') below the natural stream bottom. Sewers crossing streams should be designed to cross the stream as nearly perpendicular to the stream flow as possible. Sewers entering or crossing streams shall be constructed of cast iron or ductile iron pipe with mechanical joints or shall be constructed so they will remain watertight and free from displacement. In stream beds consisting of loose or unconsolidated materials consideration must be given to the possible impeding effect the sewer line will have on water movement in the bed material. The sewer must be designed to present as little impedance as possible while maintaining structural integrity. Aerial sewer line crossing of streams shall be in accordance with 10 CSR 20-8.120.

(B) Sewer Design. The sewer must have sufficient capacity to carry one hundred gallons (100 gals.) per contributing person per day at the established grade with a peaking factor of four (4). Minimum allowable size of pipe for schools, resorts and similar establishments is six inches (6"). For subdivisions located in rural areas, the minimum allowable sewer size is six inches (6"). For subdivisions in metropolitan areas, or in rural areas adjacent to regional systems where incorporation into a regional system is feasible, the minimum allowable sewer size shall be eight inches (8"). In very small installations four-inch (4") diameter sewers may be used to carry raw sewage or settled sewage. No more than three (3) mobile homes or campsites or a four (4)-unit apartment house may be connected to a four-inch (4") line. The use of a four-inch (4") sewer line should be limited to one hundred fifty feet in length.

1. Depth. The sewer should be sufficiently deep to drain basements. Where cover of less than thirty inches (30") is necessary and justified, the sewer must be protected to prevent its being damaged from superimposed loads or freezing.

2. Velocity of flow. All sewers carrying raw sewage shall be so designed and constructed to give mean velocities when flowing full of not less than two feet (2') per second based on Manning's equation using an "n" value of 0.013. The following are the minimum slopes which should be provided:

Sewer Size (Raw Sewage)	Slope, feet/100 feet
4 inch	1.0
6 inch	0.60
8 inch	0.40

Sewer Size (Settled Sewage)	Slope, feet/100 feet
4 inch	0.5
6 inch	0.3
8 inch	0.2

3. Bedding. Concrete or well graded granular material (bedding classes A, B or C, as described in ASTM C12-74 or WPCF MOP No. 9) should be used for all rigid pipe provided the proper strength pipe is used with the specified bedding to support the anticipated load. Concrete or well graded granular material (bedding classes I, II or III, as described in ASTM D2321) should be used for all flexible pipe, provided the proper strength pipe is used with the specified bedding to support the anticipated load.

(C) Manholes. Manholes shall be installed at all changes in grade, size or alignment at all intersections and at distances of not greater than four hundred feet (400'). Cleanouts may be installed at the ends of laterals not exceeding one hundred fifty feet (150') in length.

1. Drop type. A drop pipe shall be provided for sewers entering a manhole at an elevation twenty-four inches (24") or more above the manhole invert. Where the difference in elevation between the incoming sewer and the manhole invert is less than twenty-four inches (24"), the invert shall be filleted to prevent solids deposition.

2. Diameter. The inside diameter of manholes shall not be less than forty-eight inches (48"). The manhole shall be sufficiently large to permit rodding and other maintenance work. Consideration should be given to larger diameters for shallow manholes under four feet (4'). Cleanouts shall be a minimum of eight inches (8") in diameter.

3. Flow channel. The flow channel through a manhole shall be made to conform in shape and slope to that of the sewer and shall be finished to provide a roughness coefficient as nearly as possible equal to that of

the sewer pipe. Where a bend occurs, the channel shall be curved uniformly from inlet to outlet. Changes in direction of flow should generally not exceed ninety degrees (90°). Where a junction of two (2) or more lines occurs, a separate channel shall be constructed for each incoming line with the channels gradually merging together ahead of the outlet using uniform curves. In general, the invert of any branch sewer should be slightly higher than the invert of the main sewer to avoid slack-water areas where solids may accumulate. The bench on either side of the flow channel should provide a secure footing for maintenance personnel and have enough slope to drain. A slope of one-half to one inch (.5—1.0") per foot is recommended.

4. Watertightness. Manholes shall be of the precast concrete or poured in place concrete type. Inlet and outlet pipes shall be joined to the manhole with a gasketed flexible watertight connection or any watertight connection arrangement that allows differential settlement of the pipe and manhole wall to take place. Watertight manhole covers are to be used wherever the manhole tops may be flooded by street runoff or high water. Locked manhole covers may be desirable in isolated locations where vandalism may be a problem.

5. Frame and cover. The frame and cover shall be of standard design with a minimum clear opening of twenty-two inches (22"). The frame and cover shall be designed as a unit. The cover shall be easily removable with the aid of ordinary hand tools, such as a pry bar. The cover shall be tight fitting and exclude surface water. The joint between the frame and manhole shall be watertight.

(D) Pressure Sewer Systems. A pressure sewer system is considered as two (2) or more individual pressurization units, such as grinder pumps, discharging into a common force main. Pressure sewer systems are not to be used in lieu of conventional gravity sewers but may be acceptable when it can be shown in the engineer's report that it is not feasible to provide conventional gravity sewers. When pressure sewer systems are utilized, the operating authority shall be responsible for the maintenance and operation of the individual pressurization units. When considering the use of a pressure sewer system, the problems of extreme flow variation and anaerobic conditions of the wastewater entering the treatment facility must be taken into consideration. Consideration shall also be given to the possible need for odor control facilities at receiving manholes or at the treatment facility. For pressure sewer systems to function as intended, all clear water from footing drains,

basement sumps, leaky house connections and any other sources must be eliminated.

1. Design factors. Pressure sewer systems shall be laid out in a branched or tree configuration to avoid flow-splitting at branches which cannot be accurately predicted. The required pipe size shall be determined on the basis of three (3) principal criteria:

A. Velocities adequate to assure scouring should be achieved. A velocity of two to five feet (2—5') per second must be achieved at least once and preferably several times per day based on design flow.

B. Design shall be for peak sewage flow rates and negligible infiltration. Design shall be based on cumulative flow within the system. Infiltration and inflow must be considered when systems are being designed for existing residences where there is a potential for leaky house connections or leaky septic tanks.

C. Head loss should not exceed the pumping pressure capabilities. Head loss determination should be based on total dynamic head under the maximum flow expected to occur infrequently. It is recommended that a Hazen-Williams coefficient of one hundred twenty (120) be used to determine frictional head loss.

2. System arrangement. All pressure sewer pipe shall be installed at a depth sufficient to protect against freezing and mechanical damage. Attention must be given to the necessity for providing automatic air release valves at changes in slope. Release devices are required when the liquid flow velocity is insufficient to purge bubbles of trapped air. Pressure and/or flow control valves shall be installed at the end of all critical surge pipe runs in order to maintain a full pipe system and eliminate lift station flooding or plant washout. Water/sewer line crossings shall be in accordance with paragraph (9)(A)4. of this section.

3. System pressures. Pressure sewer system operating pressures in general should be in the range of twenty to forty pounds per square inch (20—40 lbs. psi) and shall not exceed sixty pounds per square inch (60 lbs. psi) for any appreciable amount of time. Provisions shall be made in both the system and the grinder pumps to protect against the creation of any long-term high pressure situations.

4. Materials. Many types of pipe materials may be used for pressure sewers. However, maximum benefit from the pressure approach can usually be achieved with non-metallic materials such as polyethylene, fiberglass reinforced plastic and polyvinyl chloride. As a minimum the piping material

should be equivalent to SDR 21 PVC pressure pipe. The small diameter service lines may be required to be constructed of a heavier pipe than SDR 21 PVC pressure pipe. Other materials may be used.

5. Service connections. Building service connections from individual grinder pumps to the collectors should be of one and one-fourth inch (1 1/4") PVC pipe and should include a full-ported valve (such as a corporation stop or "u" valve) located in the service line to isolate the pump from the main. Check valves specifically suited to wastewater service should be provided in the pressure service line before it enters the main.

6. Cleanouts and fittings. In place of manholes normally provided in gravity systems, pressure systems shall have cleanouts at intervals of approximately four hundred to five hundred feet (400—500'), at major changes of direction and where one (1) collector main joins another main. These cleanouts shall include an isolating valve and capped Y-branch fitting located on either side of the isolating valve and pointed both upstream and downstream for access during maintenance procedures.

A. Access for cleaning shall be provided at the upstream end of each main branch.

B. All appurtenances and fittings shall be compatible with the piping system used and shall be full bore with smooth interior surfaces to eliminate obstruction and keep friction loss to a minimum.

7. Pumping equipment. Proper system design and installation shall assure that each grinder pump will be able to adequately discharge into the piping system during all normal flow situations including peak design flow. Combined static, friction and miscellaneous head losses during peak design flows for given paths of flow through the system shall be maintained below the recommended operating head of any unit on the given path. The equipment shall be designed and manufactured with materials appropriate to wastewater service and shall meet all applicable safety, fire and health requirements arising from its intended use in or near residential buildings. Inside installations must be examined for freedom from noise, odors and electrical hazards. Both free-standing and below-the-floor type installations are acceptable. Outside installations shall be provided with an access from the surface which is suitably graded to prevent the entrance of surface water and equipped with a vandal-proof cover for safety. Installation of nonsubmersible grinder/macerator pumps must be protected against entrance of surface water into the electrical portions of the equipment. This



may require that a motor breather be run from the interior of the motor and control compartment to a protected location higher than the maximum anticipated water or snow level. Waterproof factory-installed wiring and tamperproof access covers on wiring compartments are required.

A. The pumps shall have a head capability high enough to operate efficiently over the entire range of conditions anticipated in the system. Normally this will consist of a fixed static head component dependent on pump elevation with respect to the discharge point. The head capacity design point should be not more than eighty-five percent (85%) of the maximum attainable pressure. To insure proper operation, the units must be capable of operating under temporary loads above the normal recommended system design operating pressure without a serious reduction of flow or damage to the motor. The pump should be of flooded-suction design to assure that it will be positively primed. The pressure sewer system shall contain integral protection against back siphonage.

B. The grinder pumps shall operate at a noise level sufficiently low to be acceptable for installation inside a residential building. Generally this should be no louder than other motor-operated devices normally found in homes such as furnace blowers, sump pumps and similar equipment. The grinder pump equipment shall comply with National Electrical Code and applicable local building code requirements.

C. Both stable-curve centrifugal and progressing cavity semipositive displacement pumps may be used in pressure sewer systems. The stable-curve centrifugal, a pump having a maximum head at no flow, may be considered for its ability to compensate with reduced or zero delivery against excessive high pressures and the ability to deliver at a high rate during low flow situations in the system, thus enhancing scouring during low flow periods. The progressing cavity semipositive displacement pump may be considered for its relatively constant rate of delivery in situations in which this feature is considered necessary. The semipositive displacement pump has no significant increases in delivery against low-flow system conditions to enhance scour during minimum flow times.

D. The grinding pumping equipment must include an integral grinder capable of handling any reasonable quantity of foreign objects which customarily find their way into building drainage systems as a result of carelessness or accident on the part of building occupants. The particle size produced by the grinder must be small enough to insure that

the processed solids will not clog the grinder, the pump or any part of the discharge piping system. The grinder pump must be capable of processing these foreign objects without jamming, stalling, overloading or undue noise. The grinder shall be of a configuration to provide a positive flow of solids into the grinding zone. Open shafts shall not be exposed in the raw waste passageways since this will cause wrapping of cloth, string etc. around the blades or shaft.

E. The pump tank must be made of corrosion-resistant materials which are suitable for contact with sewage and direct burial below grade without deterioration over the projected lifetime (at least twenty (20) years). The tank shall be of a fifty (50)-gallon minimum capacity and be able to accommodate normal peak flows without exceeding its peak flow capacity. The volume between the on and off levels in the tank should be based on a sensible compromise between excessive unit operation and efficient removal of raw sewage into the system. In areas in which the groundwater table is high, tanks should be securely anchored to avoid floating. The geometry of the tank bottom and the pump suction currents generated when the grinder pump is in operation must be adequate to scour solids from the bottom of the tank so that there is no significant long-term accumulation of settleable solids on the tank bottom. The tank shall be vented so that air space above the wastewater is always at atmospheric pressure. Separate vents shall be provided if required by local codes but normally the fill piping connected to the building drain system will provide adequate venting. The tank shall be capable of accommodating connection to all normal building drainage piping systems. This would include three (3) and four (4)-inch sizes of PVC, cast iron, copper, vitreous clay and asbestos-cement pipe. The pump tank shall be furnished with integral level controls which reliably turn the pump on and off at appropriate and predictable levels. The level control shall be as trouble-free as possible with little care required for proper calibration. Mercury control, float type or pressure-type switches are acceptable. An alarm unit, visible or audible, shall be provided to indicate pump failure.

8. Power outages. Provisions must be made for periods of power failure. Alternatives are as follows:

A. Depend upon built-in storage of tank and associated gravity piping;

B. Provide additional storage capacity where power outages occur frequently (twenty-four (24)-hour storage capacity is recommended); or

C. Provide a mobile generator or pump to connect to each household for a short term during an extended outage.

9. Service. A twenty-four (24)-hour repair time either by replacement or repair must be assured. Spare grinder pump units should be stocked according to the following:

Installations	Spare Unit(s)
1—10	1
10—20	2
20—40	3

Installations	Spare Unit(s)
40—60	4
60—100	5
100—200	6
over 200	3% of installations

10. Instruction manuals. The equipment must be furnished complete with detailed wiring diagrams, suggested piping installations and detailed instructions for use by the contractor at the time of installation.

11. Construction factors. Granular bedding should be provided at least four inches (4") deep but not less than one (1) pipe diameter. The bedding should be smoothed prior to pipe installation. The excavation should be backfilled to a depth of eighteen inches (18") above the pipe with select backfill material. The bedding shall contain no rock greater than one inch (1") in diameter. Native materials may be used for the remainder of the backfill. Thrust blocks must be placed on all lines two inches (2") and larger at intersections and changes of direction of forty-five degrees (45°) or more.

12. Termination of force mains. Force mains and pressure trunks shall terminate in manholes using the following construction procedures:

A. The discharge shall be to the bottom of the manhole in line with the flow if possible;

B. Where piping must be installed to bring the discharge to the bottom of the manhole, the pipe shall be adequately braced to prevent movement, shall be vented on the top and shall allow access to the force main for cleaning purposes; and

C. Consideration shall be given for the possible need for odor control facilities at the termination of force mains and pressure sewer trunks.

13. Testing. Pressure tests shall be made only after the completion of backfilling operations and after the concrete thrust blocks have set for at least thirty-six (36) hours.

A. The duration of pressure tests shall be a minimum of one (1) hour unless otherwise directed by the engineer. Test pressure shall be fifty pounds per square inch (50 lbs. psi) minimum with a recommended pressure of two and one-half (2 1/2) times the maximum system operating pressure. All tests are to be conducted under the supervision of the engineer.

B. The pipe line shall be slowly filled with water. The specified pressure measured at the lowest point of elevation shall be applied by means of a pump connected to the pipe in a manner satisfactory to the engineer.

C. During filling of the pipe and before applying the specified pressure, all air shall be expelled from the pipeline by making taps at the point of highest elevation. After completion of the test the taps shall be tightly plugged at the main.

14. Septic tank effluent pump (STEP) systems. Septic tank effluent pump pressure sewer systems may be considered a similar application of the pressure sewer principle and the criteria contained in this rule may be used for these systems. Deviations from the criteria in this section when designing STEP systems will be judged on a case-by-case basis using substantiating information and material submitted with the design by the consulting engineer.

(10) Sewage Pumping Stations. Pumping stations serving subdivisions or other properties which might become incorporated into an existing or proposed comprehensive sewerage system at some future date shall be designed and constructed in accordance with 10 CSR 20-8.130 Sewage Pumping Stations.

(A) General. Every effort should be made to eliminate the necessity of pumping sewage in installations of the type covered in this rule.

1. Location. Sewage pumping stations should be located above the twenty-five (25)-year flood level and shall be readily accessible for maintenance. As a minimum, an unobstructed all-weather access road should be provided to the pump station.

2. Water supply protection. There shall be no physical interconnection between any potable water supply and a sewage pumping station or any of its components which under any conditions might cause contamination of a potable water supply. Sewage pumping stations shall be located at least one hundred feet (100') and preferably three hundred feet (300') from any potable water supply well.

3. Duplicate pumps required. At least two (2) pumps or pneumatic ejectors shall be provided. Each pump shall be capable of handling the design and maximum flows so that

each unit is a duplicate of the other. The pump installation shall be designed to handle as a maximum flow four (4) times the average daily flow. Single pump installations may be given consideration only for very small installations, where average daily flows are less than fifteen hundred (1500) gallons per day, and only if the station is designed to permit the installation of a future duplicate unit without structural change and satisfactory means are provided to detect malfunctions and take corrective actions before an overflow to waters of the state could occur.

(B) Design Considerations. All pumps except suction-lift types shall be placed so that under normal operating conditions they will operate under a positive suction head. Design of the sewage pumping stations shall consider the following:

1. Types of pumps. Sewage pumping units may be categorized as follows: submersible pumps, pneumatic ejectors, vertical pumps and suction-lift pumps.

A. Submersible pumps shall be readily removable and replaceable without dewatering the wet well and with continuity of operation of the other unit(s) maintained. Both standard and cutter/grinder pumps are acceptable. Submersible pump installations shall be equipped with check and shutoff valves on each discharge line located in a box outside of the wet well.

B. Pneumatic ejector station structures constructed of metal shall be coated with an acceptable corrosion-resistant material and shall be supplied with two (2) properly sized anodes for cathodic protection to be buried on opposite sides of the structure and securely connected to the structure by heavy copper or aluminum wire. The air storage chamber and sewage receiving chamber (wet well) shall be capable of withstanding one hundred fifty percent (150%) of the design working pressure.

C. Suction-lift pumps shall be of the self-priming type as demonstrated by a reliable record of satisfactory operation. The total suction lift should not exceed fifteen feet (15');

2. Pump openings. Pumps shall be capable of passing a two and one-half inch (2 1/2") sphere when pumping raw sewage. These pumps shall have suction and discharge openings of at least three inches (3") in diameter. Pumps handling settled sewage need not necessarily meet these requirements depending upon the outflow design from the settling device. If cutter/grinder pumps are used, the previously mentioned requirements may be modified;

3. Accessibility. Adequate openings and facilities to permit maintenance, cleaning and

removal of pumps and equipment shall be provided;

4. Protection of motors. Pump motors shall be so located to prevent damage by flooding or corrosion or otherwise satisfactorily protected from this damage;

5. Ventilation. Adequate ventilation shall be provided in all pump stations. Where the pump pit is below the ground surface, mechanical ventilation providing at least twelve (12) complete air changes per hour shall be provided. Portable ventilation equipment should be available when entrance to the wet well is required;

6. Wet wells. The wet well size and control setting shall be appropriate to avoid heat buildup in the pump motor due to frequent starting and to avoid septic conditions due to excessive detention time. The floor of the wet well shall have a minimum slope of one to one (1:1) to a hopper bottom. The horizontal area of the hopper bottom shall not be greater than necessary for proper installation and function of the inlet. The high water level in the wet well during normal operation shall be at least one foot (1') below the invert of the incoming sewer;

7. Controls. Control float bulbs, tubes, wires etc. should be located as not to be unduly affected by flows entering the wet well or by the turbulence created by the suction of the pumps. In stations with duplicate units, provision of automatic alternation of pump use shall be provided. Electrical equipment in enclosed places where hazardous gases may accumulate shall comply with the National Electrical Code for Class I Group D Division 1 locations;

8. Valves. Suitable shut-off valves shall be placed on the suction line of each pump except on submersible or suction-lift pumps. Suitable shut-off and check valves shall be placed on the discharge line of each pump. The check valve shall be located between the shut-off valve and the pump. Check valves shall not be placed on the vertical portion of discharge piping. No valves may be located in the wet well;

9. Overflows. Sewage pumping stations shall be designed to prevent bypassing of raw sewage to waters of the state and to prevent backups of sewage into buildings or property served by the sewerage system. A satisfactory method shall be provided to prevent or treat overflows. If a less preferred method is proposed, justification shall be provided for its choice. The following examples of some of the methods which will be considered are listed in order of their preference:

A. A holding basin with capacity for twenty-four (24)-hour retention of peak flows unless data justifies the use of a smaller



basin. The basin must be designed to drain back into the wet well or collection system as the influent flow recedes;

B. A portable pump capable of being connected to the pumping station or a portable generator; or

C. Storage of excess flow in trunk line sewers provided sufficient capacity for twenty-four (24)-hour storage of peak flows is available and flooding of basements will not occur; and

10. Alarm systems. Alarm systems shall be provided for all pumping stations. The alarm shall be activated in cases of power failure, pump failure or any cause of high water in the wet well. If possible, the alarm should be telemetered to a location that is manned twenty-four (24) hours per day. Audio-visual alarms with self-contained power supply shall be provided as a minimum. A sign shall be posted at each pump station in a clearly visible location, listing a telephone number to be called if the alarm is seen or heard; and

11. Instructions and equipment. Sewage pumping stations and their operators should be supplied with a complete set of operational instructions including emergency procedures, maintenance schedules, tools and spare parts as may be necessary.

(C) Force Mains. Design considerations for force mains are as follows:

1. Velocity. At design average flow, a cleansing velocity of at least two feet (2') per second shall be maintained;

2. Size. In general, three-inch (3") diameter pipe shall be the smallest used for raw sewage force mains. However, use of grinder pumps or similar equipment may allow use of smaller pipe. These instances will be reviewed on an individual basis. Piping materials may be pressure pipe normally used for conveying potable water, however the effects of surges and pressures within the system should be considered in the selection of the piping material. As a minimum SDR 21 PVC pressure pipe or its equivalent should be used. The force main and fittings including reaction blocking shall be designed to withstand normal pressure and pressure surges (water hammer);

3. Air relief valves. An automatic air relief valve shall be placed at high points in the force main to prevent air locking. However, consideration will be given to alternate proposals with proper substantiation;

4. Termination. Force mains should enter the gravity sewer system at a point no more than two feet (2') above the flow line of the receiving manhole; and

5. Water line and sewage force main separation. There shall be at least a ten-foot

(10') horizontal separation between water lines and sewage force mains. There shall be an eighteen-inch (18") vertical separation at crossings as required in paragraph (9)(A)4. of this rule. Only in extenuating circumstances will deviations be allowed to these minimum separation distances.

(11) Small Wastewater Treatment Works. Treatment the extent of which will depend on 10 CSR 20-7.015 Effluent Regulations and 10 CSR 20-7.031 Water Quality Standards shall be provided in connection with all installations. Secondary treatment shall be the minimum acceptable degree of treatment. Wastewater treatment plants should be designed to provide for the estimated population and flows to be fifteen (15) or twenty (20) years hence. The following items shall be taken into consideration in planning sewage treatment works:

(A) Plant Location. In general to avoid local objections, the wastewater treatment facilities should be located as far as is practical from any present built-up area or any area which will develop within a reasonable future period. No sewage treatment facility shall be located closer than fifty feet (50') to any dwelling or establishment.

1. The treatment facility shall be located above the twenty-five (25)-year flood level.

2. An all-weather access road shall be provided from a public right-of-way to every treatment facility. Sufficient room shall be provided at the site to permit turning vehicles around. In determining the type of roadway and method of construction, consideration shall be given to the types of vehicles and equipment necessary to maintain and operate the facility. If access is required for heavy sludge trucks, the road must be of more substantial construction than one (1) used only for access of mowing equipment or other light vehicles. Gravel roads to be used by heavy vehicles shall have a minimum depth of six inches (6") of crushed rock material with a bottom layer of four inches (4") of two to three inch (2-3") size material and a top layer two inches (2") thick of three-fourths inch (3/4") size material. In general, the grade of the access road shall not exceed twelve percent (12%).

3. Wastewater treatment facilities shall not be located within one hundred feet (100'), and preferably three hundred feet (300') of any well or water supply structure;

(B) Design.

1. Type of treatment. Careful consideration should be given to the type of treatment before making a final decision. A few of the important factors to consider are the location and topography of the plant site; character and quantity of the wastes to be treated; operating costs and the probable type of supervi-

sion and maintenance the plant will receive. Particular care must be used in choosing methods of treatment for seasonal use developments, such as parks and campgrounds, and for developments which produce waste loads which fluctuate between wide extremes from day-to-day. The use of activated sludge type plants is generally not recommended for these developments because a high degree of operating efficiency for these plants is dependent in part upon a relatively stable loading condition. Where all use of the development is confined to a specific season, consideration should be given to designing lagoon systems on the draw-and-fill concept, retaining all wastewaters generated during the season of use and discharging them after an appropriate period during the off season or utilizing the stored water for irrigation.

2. New processes, methods and equipment. The policy of the department is to encourage rather than obstruct the development of new methods and equipment for the treatment of sewage wastes. The lack of inclusion in these standards of some types of wastewater treatment processes or equipment should not be construed as precluding their use. The department may approve other types of wastewater treatment processes or equipment under the following conditions:

A. The operational reliability and effectiveness of the process or device shall have been demonstrated with a suitably sized prototype unit operating at its design load conditions to the extent required by the department; and

B. The department may require test results and engineering evaluations demonstrating the efficiency of the processes or equipment. The department may also require that appropriate testing be conducted and evaluations, other than those employed by the manufacturer or developer, be made under the supervision of a competent process engineer.

3. Sewage flow and strength. Minimum design loadings for all treatment processes shall be calculated using the following table unless the engineer can document the validity of lower per capita figures based on actual waste strength and/or flow data from the development to be served or from similar developments.

Table I

Type of Establishment	Pounds BOD per person (unless otherwise noted)	Gallons per day per person*
Employee Sanitary Waste	.05	15

Generally means eight (8)-hour shift employees at institutions, commercial establishments, factories and similar establishments. Total employee waste figure, if applicable, must be added to the appropriate patron or residential total from the following table:

Residential		
Single family dwellings	.17	75—100
Apartments or condominiums	.17	60—100
Rooming houses	.15	45
Boarding houses	.17	75
Mobile homes	.17	75—100

Food or Drink Establishments (wastes per patron)		
Tavern or bar (not serving food)	.01	2
Fast-food (paper service)	.02	3
Cafe or restaurant	.03	5
Restaurant serving alcoholic beverages	.04	5
Restaurant grinding garbage	.07	6

Schools (wastes per student)		
Day school, no cafeteria, gym or showers	.02	10
With cafeteria—ADD	.02	4
With garbage grinding—ADD	.02	1
With gym and showers—ADD	.01	10
Boarding schools	.17	75

Institutions		
Hospitals (per bed)	.22	125—200
Institutions other than hospitals	.17	100—150
Nursing homes	.17	100—125

Commercial and Recreational		
Public parks (toilets only)	.02	5
Public parks with bath house, showers, toilets	.06	15—25
Swimming pools and beaches	.06	15—25
Country clubs (per resident member)	.17	75—100
Country clubs (per member present)	.06	15—25
Service stations (wastes per customer)	.01	5
Laundromats (per machine)	1.25	580

Hotels	.15	50
Motels (without restaurants)	.10	40
Luxury resorts	.17	75
Camper trailers	.08	30
Work or construction camps	.15	60
Churches (per seat)	.01	5
Stores, malls or shopping centers (per one thousand (1000) square feet of floor area)	.34	200
Stadiums, auditoriums, theaters or drive-in (per seat)	.01	5

*Note: Gallons per person per day includes normal infiltration for residential systems.

4. Population to be served. Unless satisfactory justification can be given for using lower per-unit occupancies, the following numbers shall be used in determining the population for which to design the sewage works:

	Persons/ Unit
Residences	3.7
Apartments or condominiums (1 bedroom)	2.0
(2 bedroom)	3.0
(3 bedroom)	3.7
Mobile homes	3.0—3.7
Camper trailers without sewer hookup	2.5
Camper trailers with sewer hookup	3.0
Motels	3.0

5. Organic loading. Where sewage strengths are expected to be materially greater than normal domestic sewage (three hundred milligrams per liter (300 mg/l) biochemical oxygen demand), consideration shall be given to enlarging settling, digestion and secondary treatment units.

6. Conduits. All piping and channels should be designed to carry the maximum expected flows. The incoming sewer should be designed for free discharge. Pockets, corners and channels where solids can accumulate should be eliminated. Suitable gates should be placed in channels to seal off unused sections which might accumulate solids. Shear gates or stop-planks should be used in preference to gate valves or sluice gates.

7. Arrangement of units. Component parts of the facility should be arranged for greatest operating convenience, flexibility,

economy and so as to facilitate installation of future units.

(C) Facility Details.

1. Mechanical equipment. Mechanical equipment shall be used and installed in accordance with manufacturers' recommendations and specifications. Major mechanical units should be installed under the supervision of the manufacturers' representative.

2. Emergency operation. Facilities which enable removal of treatment units from service for cleaning, maintenance or mechanical breakdown without bypassing must be provided.

3. Drains. Means should be provided to dewater each unit. Pumping with portable pumps into a holding basin or other suitable disposal site will be considered a satisfactory means of dewatering. Due consideration shall be given to the possible need for hydrostatic pressure relief devices to prevent flotation of structures.

4. Construction materials. Due consideration should be given to the use of construction materials which are resistant to the action of hydrogen sulfide and other corrosive gases, greases, oils and similar constituents frequently present in sewage.

5. Operating equipment. Specifications should include a complete outfit of tools necessary for proper maintenance of the facility. If required by the department, an operation and maintenance manual shall be provided to explain the operating procedures at a level easily understood by the owner or operator of the facility. The manual, at a minimum, shall address maintenance of mechanical equipment, monitoring, recordkeeping and operating procedures including the amount, frequency and method of sludge disposal.

6. Grading and landscaping. Upon completion of the facility, the ground should be graded to prevent erosion and the entrance of surface water into any unit.

7. Treatment facilities outfalls. The outfall sewer shall be designed to discharge to the receiving stream in a manner acceptable to the department. In general the effluent from the final treatment process shall be conveyed to a defined stream channel via a closed pipe or a paved or rip-rapped open channel. Sheet or meandering drainage is not acceptable. The outfall sewer shall be so constructed and protected against the effects of floodwater, ice or other hazards as to reasonably insure its structural stability and freedom from stoppage. All outfalls shall be designed so that a sample of the effluent can be obtained at a point after the final treatment process and before discharge to or mixing with the receiving waters.

8. Potable water supply protection. No piping or other connections shall exist in any part of the treatment works which, under any conditions, might cause the contamination of a potable water supply. Potable water from a municipal or other supply may be used above grade for water closet, lavatory, drinking fountain or similar fixtures. A reduced pressure backflow preventer or break tank shall be used to isolate the potable system from all plant uses other than the ones provided for in this rule. Where a break tank is used, water shall be discharged to the break tank through an air-gap at least six inches (6") above the maximum flood line, ground level or the spill line of the tank, whichever is higher. Backflow preventers shall be located above the maximum flood line or ground level. A sign shall be permanently posted at every hose bib, faucet, hydrant or sill cock located on the water system beyond the break tank or backflow preventer to indicate that the water is not safe for drinking. Where a separate non-potable water system is to be provided, backflow prevention will not be necessary but all system outlets shall be posted with a permanent sign indicating that the water is not safe for drinking.

9. Sewage flow measurement. Flow measurement shall be provided for all wastewater treatment facilities. Flow measurement should not be less than pump calibration time clocks or calibrated flume or weir and stilling basins as required.

10. Protection from the elements. All sewage treatment facilities except those which operate only seasonally shall be designed to assure effective operation under all weather conditions. Protection from the elements must be given special consideration since small wastewater treatment facilities will frequently be located in remote areas and may not receive daily attention. Freezing temperatures affect most treatment facilities to some degree. Open sand filters and small extended aeration plants are likely to be affected the most. Provisions for covering exposed process areas with boards or insulating panels may be sufficient in many cases. The use of heat tapes around sludge and scum return piping may be helpful in addition to covering the tanks. Sufficient electrical outlets should be provided at the plant site for this purpose. Tanks which are not completely backfilled on all sides may require additional protective measures during freezing weather. Any such measures taken to comply with these provisions shall not present a hazard to the operator nor hinder the operation of the treatment facility.

11. Safety. Adequate provisions should be made to protect the operator and any visitors from unnecessary hazards.

A. All wastewater treatment facilities must be fenced sufficiently to restrict entry by children, livestock and unauthorized persons as well as to protect the facility from vandalism.

B. Fences shall be a minimum of five feet (5') in height and shall be constructed of durable materials appropriate to the site and nature of the treatment facilities. Posts shall be imbedded to a sufficient depth or otherwise securely anchored to prevent displacement and shall not be spaced more than twenty feet (20') apart. Barbed wire, woven wire fabric or chain link mesh shall be securely fastened to the posts with fasteners designed for the type of material used.

C. Fences shall be located far enough back from all process units to permit easy access for operation and maintenance and for access of mowing equipment, sludge trucks and similar equipment. A minimum four foot (4') clearance from all units is recommended.

D. Woven wire fabric will generally be acceptable for fencing lagoons and other small facilities having a minimum of mechanical equipment. The fabric should nearly touch the ground surface and should have small enough mesh in the lower two feet (2') to prevent passage of small animals. Larger and more complex treatment facilities should be provided with chain link or similar fencing.

E. At least two (2) strands of barbed wire shall be provided above the fence fabric spaced no more than six inches (6") apart.

F. At least one (1) gate shall be provided for access of maintenance equipment and vehicles and each gate shall be provided with a lock. Gates shall be constructed in a manner and of materials comparable to those used for the fence. Gates shall be designed to prohibit entry of the enclosure by crawling underneath. When sizing the gate, consideration must be given to the need for entry of mowing equipment, sludge trucks or other vehicles or equipment necessary for routine maintenance and operation.

G. At least one (1) warning sign shall be placed on each side of the facility enclosure in such positions as to be clearly visible from all directions of approach. A sign shall be placed on each gate. Minimum wording shall be SEWAGE TREATMENT FACILITY—KEEP OUT. Signs shall be made of durable materials with characters at least two inches (2") high and shall be securely fastened to the fence, equipment or other suitable locations.

(12) Primary Treatment. For general requirements applicable to all types of treatment facilities, refer to section (11) of this rule.

(A) Grease Traps. Grease traps shall be provided on kitchen drain lines from institutions, hotels, restaurants, school lunch rooms and other establishments from which relatively large amounts of grease may be discharged to the treatment facility.

1. Grease traps should be located as close to the fixtures being served as possible and should receive only the waste streams from grease-producing fixtures. Sanitary waste streams, garbage grinder waste streams and other waste streams which do not include grease should be excluded from passing through the grease traps. Grease traps must be cleaned on a regular basis and must be readily accessible for this purpose.

2. Sizing of grease traps is based on wastewater flow and can be calculated from the number and kind of sinks and fixtures discharging to the trap. In addition, a grease trap should be rated on its grease retention capacity, which is the amount of grease (in pounds) that the trap can hold before its average efficiency drops below ninety percent (90%). Current practice is that grease-retention capacity in pounds should equal at least twice the flow capacity in gallons per minute. The following two (2) equations may be used to determine the capacity of grease traps for restaurants and other types of commercial facilities:

A. Restaurants.

$$D \times GI \times Sc \times \frac{Hr}{2} \times Lf = \text{Size of grease trap in gallons, where:}$$

D = Number of seats in dining area;
 GI = Gallons of wastewater per meal, normally 5 gallons;
 Sc = Storage capacity factor, minimum of 1.7;
 Hr = Number of hours open; and
 Lf = Loading factor,
 1.25 interstate highways
 1.0 other freeways
 1.0 recreational areas
 0.8 main highways
 0.5 other highways.

B. Hospitals, nursing homes, other type commercial kitchens with varied seating capacity.

$$M \times GI \times Sc \times 2.5 \times Lf = \text{Size of grease trap in gallons, where:}$$

M = Meals per day;
 GI = Gallons of wastewater per meal, normally 4.5;
 Sc = Storage capacity factor, minimum of 1.7; and

Lf = Loading factor,

- 1.25 garbage disposal and dishwashing
- 1.0 without garbage disposal
- 0.75 without dishwashing
- 0.5 without dishwashing and garbage disposal.

3. Grease traps shall be provided with a manhole or opening of sufficient size to permit inspection and cleaning. When the grease trap is located below ground, the access opening shall be extended to grade. The opening shall be fitted with a tight fitting cover which will prevent the entrance of insects and vermin.

4. The grease trap should be constructed of materials similar to septic tanks and be properly baffled on both the inlet and outlet.

(B) Bar Screens. Bar screens should be provided before pumps, shredders or other mechanical equipment. Bar screens should precede imhoff tanks, primary settling basins and extended aeration plants.

1. Bar screens should be located to provide for easy cleaning and adequate drainage of screenings. Design must provide for removal and/or cleaning of bar screens or debris baskets located inside pump station wet wells without entering the wet well.

2. The invert of a bar screen channel or the bottom of a debris basket shall be a minimum of six inches (6") below the invert of the incoming sewer and a minimum of six inches (6") above the highest liquid level in the pump pit or treatment process tank. The channel preceding and following the screen should be filleted to prevent stranding and sedimentation of solids.

3. Clear openings between bars of hand cleaned screens should be from three-fourths to one and one-half inches (3/4-1 1/2"). Construction should be such that the screens can be conveniently raked.

4. The area of the screen openings should be sufficient to provide a velocity of one foot (1') per second through the vertical projection of the screen openings at average flow.

5. Hand cleaned screens should be placed on a slope of thirty to forty degrees (30-40°) with the horizontal.

6. Ample facilities must be provided for the removal, draining and deposit of screenings. Suitable storage facilities shall be provided where temporary storage of screenings is necessary. Screenings may be disposed of in an approved solid waste disposal facility.

(C) Septic Tanks. Septic tanks may be accepted as a satisfactory means of primary treatment for installations receiving flows not in excess of twenty-two thousand five hun-

dred (22,500) gallons per day. Minimum acceptable liquid capacity for septic tanks shall be seven hundred fifty (750) gallons. Septic tanks should be designed and constructed in accordance with 10 CSR 20-8.021(4).

(D) Comminutors. Comminutors may be used in conjunction with bar screens as a means of preliminary treatment upstream of extended aeration plants. A screened bypass channel to a bar screen shall be provided. The use of the bypass channel shall be automatic at depths of flow exceeding the design capacity for the comminutor. Each comminutor that is not preceded by grit removal equipment should be protected by a six-inch (6") deep gravel trap. Provisions shall be made to facilitate servicing units in place and removing units from their location for servicing. Electrical equipment in comminutor chambers where hazardous gases may accumulate shall be suitable for hazardous locations (National Electrical Code, Class 1, Group D, Division 1 location). Grinder pumps may be used in lieu of comminutors. Grinder pumps used for preliminary treatment must be sized to pump the maximum flow unless they are being used as part of flow equalization.

(13) Secondary Treatment. Criteria for design of secondary treatment processes are given for the most commonly used and recognized waste treatment processes applicable for small sewage treatment facilities. They include waste stabilization and aerated ponds, sand filters, extended aeration activated sludge and disinfection. Unit processes not covered by these criteria will be reviewed in accordance with paragraph (11)(B)2. The effluent quality that may be expected from a secondary treatment unit process or combination of processes is related not only to the engineering design but, most important, to the level of operation and maintenance that the units receive. The design criteria established in the rule for the various units are to reflect those features considered necessary for the unit to perform at its best efficiency, to ensure ease in operation and maintenance and to guide designers in selecting materials which will ensure the completed project will be durable. For other requirements applicable to all types of treatment facilities, refer to section (11).

(A) Wastewater Stabilization Ponds. Waste stabilization ponds provide treatment of primarily domestic wastewater by the unaided natural processes of biological activity. The wastewater stabilization pond process requires the least operational and maintenance skill of all processes considered in this

rule. The criteria contained in this rule is for facultative and aerated facultative ponds.

1. The summary of design data shall include pertinent information on location, geology, soil conditions, area for expansion and any other factors that will affect the feasibility and acceptability of the proposed project. The following information must be submitted in addition to that required by sections (4) and (7):

A. A layout showing the direction and distance of all cultural features within one fourth (1/4) mile of the proposed site. A seven and one-half (7.5) minute quadrangle map made by the United States Geological Survey of the area under consideration is acceptable, provided the map is field checked for accuracy in depicting present cultural features;

B. A geological evaluation of the proposed pond site prepared by the Missouri Department of Natural Resources, Division of Geology and Land Survey shall be submitted. To obtain this geological evaluation of the proposed site, the engineer shall submit the following information to the appropriate department office:

(I) A layout sheet showing the proposed location. The layout shall include the legal description, property boundaries, roads, streams and other geographical landmarks which will assist in locating the site;

(II) Size of the pond and/or approximate volume of waste to be treated;

(III) Maximum cuts to be made in the construction of the pond; and

(IV) Location and depth of cut for borrow area, if any;

C. A determination as to the compatibility of the proposed site with local zoning ordinances.

D. A description, including maps, showing elevations and contours of the site and adjacent area shall be provided;

E. Location of ponds in watersheds receiving significant amounts of stormwater runoff is discouraged. Adequate provisions must be made to divert stormwater runoff around the ponds and protect embankments from erosion;

F. Construction of ponds in close proximity to water supplies and other facilities subject to contamination should be avoided. A minimum separation of four feet (4') between the bottom of the pond and the maximum groundwater elevation should be maintained where feasible. The four-foot (4') separation distance does not necessarily apply to perched water tables due to impervious strata near the surface;

G. Proximity of ponds to water supplies located in areas of porous soils and fissured rock formation shall be evaluated to



avoid creation of health hazards or other undesirable conditions; and

H. In general, to avoid local objections, the wastewater stabilization pond should be located as far as is practical from any existing built-up areas or existing dwellings. In no case should the pond be located closer than two hundred feet (200') from an existing built-up area or existing dwelling. The pond should be located at least one hundred feet (100') from the building(s) that it serves.

2. Basis for design. A flow-through stabilization pond shall be considered capable of meeting effluent limitations of forty-five (45) mg/l BOD and seventy (70) mg/l suspended solids. Controlled discharge stabilization ponds shall be considered capable of producing an effluent of a quality that is much better than a flow-through stabilization pond when treating normal domestic type sewage.

A. In general, waste stabilization ponds shall be designed on the basis of thirty-four pounds (34 lbs) of applied BOD per day per acre of water surface area in the primary cell. Water surface area shall be computed as area at the three foot (3') operating level. A minimum of one hundred twenty (120) days' detention time should be provided in the total system. To achieve this detention time the use of secondary cells up to five feet (5') deep and the use of third cells up to eight feet (8') deep may be necessary.

B. For aerated wastewater stabilization ponds, the development of final design parameters, it is recommended that actual experimental data be developed. However, the aerated lagoon design for minimum detention time may be estimated using the following formula:

$$t = \frac{E}{2.3 k_1 \times (100 - E)}$$

where

t = detention time in the aeration cell in days;

E = percent of BOD₅ to be removed in an aerated pond; and

k₁ = reaction coefficient aerated pond, base 10.

For normal domestic sewage, the k₁ value may be assumed to be 0.12 at a temperature of twenty degrees Centigrade (20°C) and 0.06 at a temperature of one degree Centigrade (1°C). A temperature of one degree Centigrade (1°C) must be used for determining the detention time. Other k₁ values may be used to determine detention time when pilot test data is obtained by incubating anticipated wastes at critical operating temperatures. A temperature of twenty degrees Centi-

grade (20°C) may be used for determining aeration requirements. As a minimum, aerated facultative pond systems designed to treat a typical domestic waste (BOD≤300 milligrams per liter) shall consist of one (1) or more aerated cells and one (1) quiescent cell which provide the following minimum hydraulic detention times:

Minimum Detention Times for Aerated Pond Cells for Typical Domestic Waste (BOD ≤300 mg/l)

*No. of Aerated Cells	Days** for Treatment	Quiescent Cell, Days	Total Detention*** Time, Days
1	44	2-10	46-54
2	26	2-10	28-36
3	21	2-10	23-31

*For multiple aerated cells, the first two (2) cells shall be of equal size and no one (1) cell shall provide more than fifty percent (50%) of the total required volume.

**Includes three (3) days' detention time for sludge accumulation. Sludge volume is based upon 1.54 days detention time per one hundred milligrams per liter (100 mg/l) of suspended solids in the influent for a twenty (20)-year accumulation of sludge.

***Total detention time for all cells combined.

(I) The design minimum detention time of aerated cells treating domestic type waste of greater strength than three hundred (300) mg/l BOD should be determined utilizing the equation from subparagraph (13)(A)2.B. on a per-cell basis. For aerated facultative pond systems designed to treat greater strength waste with a BOD of four hundred (400) mg/l or more shall consist of two (2) or more aerated cells and one (1) quiescent cell. The first two (2) cells shall be of equal size and no one (1) cell shall provide more than fifty percent (50%) of the total required volume. The following minimum detention times are presented for illustration and result from use of the formula from subparagraph (13)(A)2.B. with provision of additional volume for sludge accumulation.

Minimum Detention Times for Aerated Pond Cells for Greater Strength Waste

Influent BOD mg/l	No. of Aerated Cells	Days for Treatment	Quiescent Cell, Days	Total Detention* Time, Days
400	2	46	2—10	48—56
400	3	37	2—10	39—47
400	4	32	2—10	34—42

1000	2	87	2—10	89—97
1000	3	67	2—10	69—77
1000	4	58	2—10	60—68

*Total detention time for all cells combined.

C. Where any wastes discharged to a stabilization pond are from a restaurant, institutional kitchen or similar establishment likely to produce large amounts of grease, grease traps shall be provided as discussed in subsection (12)(A) of this rule. If ground garbage is also introduced to the waste stream from these sources, a septic tank having a capacity equal to at least five (5) times the average daily flow of that waste stream shall be provided for primary treatment preceding unaerated pond systems. Septic tanks sized at one and one-half (1.5) times the average may be provided as primary treatment for other waste streams. No reduction in BOD applied to the stabilization pond shall be allowed where the only pretreatment is grease removal. Where complete primary treatment is provided for any waste stream entering the pond system, the BOD loading of that stream may be reduced by thirty-five percent (35%) when determining the required pond system surface area or detention time.

D. Consideration shall be given to the type and effect of industrial wastes contributed to the stabilization pond system. For high strength wastes where the required detention time exceeds nine (9) months for an unaerated stabilization pond, consideration should be given to other processes such as aerated ponds, land application of the effluent or activated sludge treatment plants.

E. A minimum of three (3) cells in series shall be provided for all flow-through pond systems. The second cell shall be three tenths (.3) times the area of the primary cell and the third cell shall be one tenth (.1) times the area of the primary cell. For facultative pond systems where the primary cell will be smaller than ten thousand (10,000) square feet, consideration should be given to the use of land application of the effluent. See section (15) of this rule. If the use of land application methods is not feasible or would present a nuisance, and the primary cell size is between three thousand (3000) and ten thousand (10,000) square feet, the third cell of the series shall have an area of at least one thousand (1000) square feet. Where the primary cell is less than three thousand (3000) square feet, only a secondary cell of one thousand (1000) square feet area is required.

F. A minimum of three (3) cells is required for all controlled discharge pond systems. The first and second cells shall be

sized as in subparagraph (13)(A)2.E. The third cell shall be a minimum of five tenths (.5) times the area of the primary cell. The third cell shall be placed at an elevation so that the primary and secondary cells may be lowered to the two-foot (2') operating level by gravity. Pumping from the secondary cell may be required to meet these criteria. Total detention time for the entire system shall be a minimum of one hundred sixty (160) days. Minimum storage above the two-foot (2') operating level in all the cells shall be one hundred (100) days.

G. Normal operating depths for flow through and controlled discharge pond systems shall be from two to five feet (2-5'). Depth in the third cell for flow-through and controlled discharge ponds shall be a minimum of five feet (5') but no greater than eight feet (8'). The minimum depth for aerated ponds shall be five feet (5'). Actual design depth for aerated ponds shall be based upon consideration of the type of aeration equipment used. Whenever possible each cell in a flow-through or aerated pond system should be designed with the water surface elevation at normal operating depth at least one foot (1') lower than the elevation in the preceding cell to facilitate independent variation of cell depths for maintenance and operational control procedures.

H. The shape of all pond cells should be such that there are no narrow or elongated portions. Round, square or rectangular ponds with a length not exceeding three (3) times the width are considered most desirable. No islands, peninsulas or coves shall be permitted. Dikes should be rounded at the corners to minimize accumulations of floating materials. Common dike construction, wherever possible, is strongly encouraged.

3. Pond construction details.

A. The design and construction of pond dikes is to ensure a stable, water tight structure, that can be easily and safely maintained. The dikes must be constructed of impervious materials and compacted sufficiently to form a stable, water tight structure. The engineering plans and specifications must indicate the type of soils to be used in the construction, the methods of compaction that will be used and the quality control tests, if any, that are required. Compaction methods which would achieve a standard proctor density of ninety percent (90%) of optimum throughout the dike are acceptable.

B. The minimum dike width shall be four feet (4'). If large farm type equipment is to be used for mowing, a top width of eight feet (8') shall be provided. The top of the dike must be at least two feet (2') above the maximum depth of the cell.

C. Inner and outer dike slopes shall not be steeper than three to one (3:1). Inner slopes shall not be flatter than four to one (4:1). Consideration may be given to steeper inner slopes provided special attention is given to stabilizing the slope with rip-rap, concrete or other rigid materials. These stabilization methods shall be specified. The flatness of the outer slope is of no concern provided surface water can be diverted around the lagoon. Long outer slopes should be flatter than three to one (3:1) to assist in safe mowing of vegetation.

D. The area on which the dike rests shall be stripped of all organic matter and all tree roots grubbed. Selected organic material should be stockpiled and spread on the outer surface of the completed dike to assist in establishing vegetation. Trees and brush must be removed from the immediate construction site. As a general rule, all trees within one hundred feet (100') of the water's edge of the pond shall be removed. Special consideration will be given to leaving selected trees if—

- (I) The trees' location will not result in shading of the pond's surface;
- (II) Roots from trees will not imperil the dike structure;
- (III) Felling of the tree from a storm or its natural death will not cause the tree to enter the pond; or
- (IV) Leaf litter from the tree will not have an adverse effect on the pond's effluent.

E. The pond dikes shall be sufficiently smoothed to allow the passage of mowing equipment without scalping or danger to the operator from tipping. The completed surface shall have all rocks removed which might endanger the mower operator or equipment.

F. Diversion terraces and ditches are required to prevent surface water intrusion into the lagoon. Diversion ditches shall be designed to minimize erosion by incorporation of ditch blocks, paved inverts, rip-rap or sodding as necessary. Long slopes of diversion ditches shall be avoided whenever possible and when necessary shall be protected from excessive erosion by sodding, mulching and terracing techniques. Diversion terraces and paved outlets are recommended whenever runoff from areas adjacent to the diversion ditch will contribute sheet runoff down the ditch slope. Point runoff should be conveyed to the ditch by a paved outlet.

G. The dikes, diversion ditches and terraces shall be seeded and a good vegetative cover established to minimize erosion and aid in weed control. The inner dikes should be seeded down to the normal water line of the structure. Where the structure is not anticipated to reach its normal operating level dur-

ing the first growing season, consideration should be given to further seeding on the dike slope. Long rooted grasses shall not be used for seeding of dikes. Fertilization needs, mulching and watering must be considered for all wastewater stabilization pond projects to ensure that a good growth of grass occurs rapidly and is sustained. Specifications shall detail specific amounts and variety of seeds to be used, mulching and fertilizer requirements as appropriate and the proper time period for application to be reasonably assured of success.

H. Rip-rap or some other acceptable method of erosion control is required as a minimum around all piping entrances and exits. For aerated cell(s), design should ensure erosion protection on the slopes and bottoms in the areas where turbulence will occur. Additional erosion control may also be necessary on the exterior dike slope(s) to protect the embankment(s) from erosion due to severe flooding of a water course.

4. Pond bottoms.

A. Soil used in constructing the pond bottom (not including seal) and dike cores shall be relatively incompressible, tight and compacted at or up to four percent (4%) above the optimum water content to at least ninety percent (90%) standard proctor density. Any soil borings and tests to determine characteristics of surface soil and subsoil shall be made part of the summary of design data. The bottom should be cleared of vegetation and debris.

B. All ponds shall be sealed so that seepage loss through the seal is as low as possible. The pond seal shall cover the bottom and extend up the inner dike slope to where the side slope intersects with the top of the dike. Seals consisting of soils, asphalt, soil cement or synthetic liners may be used provided the permeability, durability and integrity of the proposed materials can be satisfactorily demonstrated for anticipated conditions. Bentonite, soda ash or other sealing aids may be used to achieve an adequate seal in systems using soil.

(I) The design permeability of the pond seal shall not exceed five hundred (500) gallons per acre per day in areas where potable groundwater might become contaminated or when the wastewater contains industrial contributions of concern. Design seepage rates up to thirty-five hundred (3500) gallons per acre per day may be considered in other areas where potable groundwater contamination is not a problem, provided that the pond cells will maintain adequate water levels to provide treatment and avoid nuisance conditions.

(II) Soils having a permeability coefficient of 10^{-7} centimeters per second or less with a compacted thickness of twelve inches (12") will be acceptable as a pond seal for water depths up to five feet (5') and for seepage losses less than five hundred (500) gallons per acre per day. For permeability coefficients greater than 10^{-7} centimeters per second (cm/sec) or for heads over five feet

$$t = \frac{H \times K}{5.4 \times 10^{-7} \text{ cm/sec}}$$

(5') such as an aerated pond system, the following equation shall be used to determine minimum seal thickness:

where

K = the permeability coefficient of the soil in question;

H = the head of water in the pond; and

t = the thickness of the soil seal.

Units for H and t may be English or metric; however, they must be the same.

(III) Section (17) of this rule contains recommendations for seal design.

C. All ponds shall be prefilled to protect the liner, to prevent weed growth, to reduce odor, to allow measurement of percolation losses and to maintain moisture content of the seal. However, the dikes must be completely prepared as described in subparagraphs (13)(A)3.G. and H. of this rule before introduction of water.

D. If measurement of percolation losses is required by the department, the method of measurement shall be in accordance with section (16) of this rule. In no case shall measured percolation losses exceed thirty-five hundred (3500) gallons per acre per day. In areas where there is a significant potential for groundwater contamination, justification shall be provided before measured percolation losses will be allowed to exceed five hundred (500) gallons per acre per day and in no case shall percolation losses exceed seventeen hundred (1700) gallons per acre per day. Whenever industrial wastes are a significant part of the wastewater flow, the department may require more stringent seepage limitations and liner design considerations.

5. Inlet lines.

A. An effort should be made to locate and orient the lagoon and tributary sewers so as to have only one (1) inlet. When multiple inlets are necessary, they shall be located to minimize possibilities of short circuiting and uneven loading of the pond. The inlet line to the primary cell of an unaerated pond system shall terminate at the two-thirds (2/3) point farthest from the outlet on the longest axis of

the cell. The inlet line to an aerated pond cell shall discharge within the mixing zone of the aeration equipment.

B. Any type of piping generally used for transmitting sewage under pressure shall be used as the influent piping for a pond system. When plastic pipe or similar low density material is used, extra consideration must be given to anchoring or weighting the pipe to prevent flotation. Special consideration must also be given to the character of the waste, possibility of septicity, exceptionally heavy external loadings, abrasion, the necessity of reducing the number of joints, soft foundations and similar problems.

C. A manhole shall be installed prior to entrance of the influent line to the primary cell and shall be located as close to the dike as topography permits. Its invert shall be at least six inches (6") above the maximum operating level of the pond and provide sufficient hydraulic head without surcharging the manhole.

D. Inlet lines should slope on a uniform grade and straight line beginning at the inlet manhole to a point approximately at the lagoon floor elevation. From this point, the pipe is laid flat to the point of discharge. The pipe may be laid flat on the lagoon bottom and anchored, or a trench of one (1) pipe diameter depth may be constructed with the fill material serving as the anchor. The inlet should discharge into a saucer-shaped depression with depth equal to six inches (6") or the inlet pipe diameter, whichever is greatest. The depression will have an area of approximately one-sixteenth (1/16) of the pond surface area. The inlet shall terminate over a concrete apron with a minimum size of three foot (3') square.

6. Transfer piping between cells and final effluent piping.

A. Minimum piping size shall be four inches (4") in diameter. Any pipe material suitable for transmitting sewage under pressure will be satisfactory provided the pipe is capable of withstanding heavy external loads from mowing equipment, and is resistant to chemical and biological deterioration. Cast iron, ductile iron or steel is recommended.

B. Control of water depth provides a number of benefits including better treatment efficiency during the different seasons, the ability to effectively operate the system on a partial draw- and fill-basis (phase isolation) and the natural control of mosquitoes, midge larvae and weeds. Minimum transfer pipe requirements in the primary cell shall be a single pipe, with gate valve placed to withdraw one-foot (1') below the pond water surface. Second and final cells and primary cells of controlled discharge ponds shall be provided

with sufficient individual pipes and gate valves to raise and lower the pond levels in one-foot (1') increments from the two-foot (2') level upward. Final cells of flow through stabilization ponds in excess of five feet (5') deep shall level control piping in one foot (1') increments above five feet (5'). Final cells of controlled discharge ponds in excess of five feet (5') deep shall have level control piping in two-foot (2') increments above the two-foot (2') level. Overflow lines should discharge through anchored concrete structures at a point which will not cause dike erosion. Care shall be taken in location and design of transfer piping, valves and valve boxes to protect these appurtenances from damage by mowing equipment.

C. Transfer piping between aerated cells and from the quiescent cell shall consist of a single pipe equipped with a gate valve and located one foot (1') below the water surface.

D. The point of effluent draw-off from each cell shall be located as remotely as possible from the inlet to that cell.

7. Aeration requirements for aerated ponds.

A. Oxygen requirements generally will depend on the BOD loading, degree of treatment and the concentration of suspended solids to be maintained. Aeration equipment shall be capable of maintaining a minimum dissolved oxygen level of two milligrams per liter (2 mg/l) in the pond at all times. Suitable protection from the weather shall be provided for electrical controls. The aeration equipment shall be capable of providing one and three-tenths pounds (1.3 lbs.) of oxygen per pound of BOD removed. BOD removal shall be based on warm weather rates. Appropriate manufacturer's data on aeration equipment oxygen transfer capability may be requested for review when this information is not available to the department.

B. Aeration equipment shall have sufficient power and shall be located to provide dispersion of oxygen throughout the aerated basin. For an aerated pond utilizing mechanical surface aerators, a minimum of ten (10) horsepower per million gallons of wastewater in the aeration basin shall be provided for mixing. In addition, aeration equipment and aeration basins shall be designed and installed to ensure that mixing patterns are adequate to prevent dead spots within the basin.

C. Shore-mounted diffused aeration systems shall be provided with duplex blowers and motors, with each blower capable of providing air requirements during the critical design condition. Floating surface aeration systems shall be provided with one

(1) spare motor, shaft and impeller of the size equal to the largest as those used in the design.

8. Outfall structures. Materials and design shall be in accordance with paragraph (13)(A)6. of this rule. (For additional requirements refer to paragraph (11)(C)7. of this rule.)

9. Fencing and signs. Fencing and signs for pond systems shall be in accordance with paragraph (11)(C)11. of this rule. In general for pond systems the fence shall be located at the outer toe of the dikes. Consideration may be given to other locations under specific circumstances. In all cases the fence must not be located where it can interfere with access to and mowing of the dikes.

(B) Activated Sludge Treatment Plants. For the range of flows covered by this rule, the extended aeration process is the most commonly used and criteria for this process follows. Criteria for the design of systems using other variations of the activated sludge process may be found in 10 CSR 20-8.180 Design of Sewage Works, Biological Treatment. The extended aeration plant is of the activated sludge type in which primary settling tanks are omitted, where prolonged aeration consumes some of the sludge and produces a relatively stable effluent and where the wasting of sludge is mandatory at varying intervals. The extended aeration process or any activated sludge process should not be considered where there is not at least five (5) days per week of wastewater flow into the plant. It should be noted that daily operation and maintenance attention by experienced plant personnel is absolutely necessary for proper operation. The engineer should carefully evaluate the ability of the owner to provide effective operation before making a recommendation to use the extended aeration process.

1. Location. Plants should be located close enough to the building being served to optimize maintenance of the plant. They should be located to be the least objectionable to actual or potential surrounding land use. A housed treatment plant component shall be located at least fifty feet (50') from any existing or future residence. Exposed treatment plant components, protected by only a fence or open grating, shall be located at least one hundred fifty feet (150') from existing or future residences. Distances to commercial buildings, industrial buildings, schools and similar structures must be evaluated with respect to type of structure being served and the actual use made of that part of the structure adjacent to the sewage treatment plant.

2. General. The side walls of all tanks which are open at the top shall extend at least

six inches (6") above the adjacent ground surface with provision for erosion protection and drainage of the area surrounding the plant. All tanks shall have a minimum of ten inches (10") of freeboard above the maximum liquid operating level in each tank. Metal tanks shall be protected from corrosion by installation of anode packs. The location of the anode packs should be marked on the surface of the ground.

A. Riser sections may be used on plants where the invert of the influent sewer line has a maximum depth of four feet (4') below grade. Blower housing and electrical controls must be placed above the level of the riser section and above ground. All valve handles and cleanouts must be brought up to a minimum of one foot (1') from top of riser for easy maintenance. Where the invert of the influent sewer is deeper than four feet (4'), either a lift station should be provided and the plant be set at grade or a retaining wall or excavation with four feet (4') clear distance around the plant with free outfall of the drainage therefrom may be provided.

B. When phased development is proposed, one-half (1/2) the total ultimate capacity should be installed initially. Initial plans shall indicate all future phases of tributary development and ultimate plant capacity.

C. All treatment plant components shall be protected by one of the following methods:

(I) A rugged fence of chain-link, wood or block at least six feet (6') high with locked entrance gates. Plants located in areas where thrown objects or falling leaves might be a problem should be equipped with lightweight open grating over the tanks in addition to the fence described. Four foot (4') of working room must be provided around the plant;

(II) A building or housing constructed over the entire plant shall be provided with adequate means for gravity type ventilation by locating sufficient intake vents near the floor level and allowing the air to discharge out through large louvres or vents at ceiling height or by mechanical ventilation where gravity ventilation is not feasible. Housings over plants should provide at least seven feet (7') of headroom over the walkways. Adequate lighting shall be provided. Plants within buildings or housings shall be equipped with safe walkways providing access to all equipment and working areas housed therein. Access to the plant in a building should be by a door equipped with a lock. A minimum of four feet (4') of working room must be provided around the entire periphery of the plant;

D. The plant should always remain accessible. All-weather access roads are to be provided for all plants in accordance with paragraph (11)(A)2. of this rule; or

E. Plant equipment such as blowers, electrical controls and non-submersible pumps should be protected from foam and moisture. Equipment may be located either on top of the plant or in an adjacent enclosure. Guardrails with kickplates shall be provided at open tanks and along walkways, however, sturdy grating may be substituted over open tanks. Control valves shall be safely accessible from a position where firm footing is available. Motor shafts, pulleys, belts and the like shall be guarded. Above or below ground treatment units shall be accessible by sturdy stairways.

3. Pretreatment. Effective removal or exclusion of grit, debris, oil or grease and comminution or screening of solids shall be accomplished prior to the aeration tank. See section (12) of this rule for criteria applicable to preliminary and primary treatment devices. Stronger wastes from food service operations and wastes containing garbage or other organic matter increases both the hydraulic and BOD loadings and require special consideration. Excess organic materials, such as ground vegetables produced by supermarkets, should not be tributary to this type of plant. Garbage grinders should not be used in commercial facilities tributary to an extended aeration plant.

4. Flow equalization. Flow equalization facilities may be required for extended aeration treatment plants with flows greater than five thousand (5000) gallons per day. Equalization tanks must be located downstream of pretreatment facilities such as grease traps and bar screens.

A. A variety of methods may be employed to achieve flow equalization. Consideration may be given to on-line units, where all the flow passes through the equalization tanks and side-line units, where only that amount of flow above the maximum desired flow is diverted through the equalization tank(s). In addition, on-line treatment units may be utilized to dampen flow variations provided that the units are also capable of providing the required treatment efficiency throughout the entire range of operating wastewater depths.

B. Equalization tank size should be based upon a representative diurnal flow pattern derived from flow records or an acceptable approximation technique. The total equalization tank volume must be large enough to effectively reduce both flow and



load variations. Consideration should be given to dividing the flow equalization tank volume into two (2) compartments. The actual equalization tank volume must be greater than that obtained from the flow pattern in order to accommodate anticipated concentrated plant recycle streams such as supernatant from a digester or sand filter backwash. For new plants or where existing flows are not available to establish a representative diurnal flow pattern, Table I and the following criteria shall be used to approximate the required equalization tank volume.

C. Where existing flows are not available, the design peak flow factor shall be three and one-third (3 1/3) for all treatment plants. The peak daily flow for determining equalization tank volume shall be calculated as follows:

$$\text{Peak Daily Flow (gpd)} = 3 \frac{1}{3} \times \text{Average daily flow (gpd)} \times 24 \text{ (hrs.)}$$

Run-off period (hrs.)

Where the run-off period in hours is:

Subdivisions	16
Schools	8
Restaurants	12-16
Institutions	16
Commercial	12
Resorts	16
Motels	16

Table I

Recommended Flow Equalization Tank Volumes

As a Percent of the Average Daily Flow Q equ./Q avg.

Q max Q avg.	1.0	1.5	2.0	2.5	3.0
1.0	0	-	-	-	-
1.5	13	-	-	-	-
2.0	22	8	-	-	-
2.5	29	16	5	-	-
3.0	33	22	12	4	-
3.5	37	27	17	9	3
4.0	40	30	22	14	8
5.0	44	36	29	22	16
6.0	48	41	34	28	22
7.0	50	44	38	32	27
8.0	52	46	41	36	31
9.0	53	48	44	39	35
10.0	55	50	46	41	37

NOTE: Q max = Design peak daily flow rate tributary to the equalization tank including all backwash. See paragraph (13)(B)4. of this rule.

Q avg. = 24-hour average design flow rate.
Q equ. = Desired equalized flow rate.

D. When pumps are utilized, duplicate pumps shall be provided. With air-lift pumps, this requirement may be fulfilled by a standby air supply.

E. Aeration or mechanical mixing must be provided to prevent deposition of solids in the tank(s) and to maintain aerobic conditions. Normal air requirement is two (2) cubic feet per minute per one thousand (1000) gallons of storage. The air supply shall be independent of plant process aeration facilities to ensure proper control.

F. Corner fillets shall be provided to facilitate the periodic removal of any accumulated sludge or grit.

G. Equalization tanks shall be suitably equipped with accessible external valves, stop plates, weirs or other devices to permit flow control and ensure proper flow equalization. Devices to measure the equalized flow may also be required. The equalization tank shall be equipped with an overflow to ensure that all wastewater flow will pass through the secondary treatment facility before being discharged. The overflow shall be installed ten inches (10") above the normal maximum liquid level and shall interconnect the flow equalization tanks with the aeration chambers of the secondary treatment facility.

H. The equalization tanks should be designed to avoid varying pump rates with changing liquid levels in the tank. However, equalization tanks with varying outflow rates shall provide compensatory additional storage capacity.

5. Flow division. Flow division is required where parallel aeration unit arrangements are planned initially or as part of a future expansion. Proportionate distribution of incoming flow and return sludge shall be provided. The screening, comminuting device or bar screen must precede the flow division. Division of the total plant flow into more than two (2) parallel arrangements is generally unacceptable. If flow division is not accomplished in the equalization tanks, consideration should be given to pumping the flow into a diversion device to prevent deposition of solids where average flows are very low.

6. Aeration tanks. Aeration tanks shall be designed to allow for twenty-four (24) hours of detention time based on the expected twenty-four (24)-hour sewage flow of average strength, domestic sewage. For higher strength wastes, such as those from restaurants, the greater amount of BOD applied should be considered with the detention time increased. The design of tanks shall be based upon the following criteria:

A. The aeration tank shall be sized on the basis of an applied BOD load of fifteen

pounds (15 lbs) per one thousand (1000) cubic feet of aeration tank capacity per day. The design BOD loading rate shall include all recycle streams except return activated sludge;

B. Shape and design of the tank should maintain an effective mixture and utilization of air and prevent deposition of solids or short circuiting;

C. 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) 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 requirement for the extended aeration process shall be one and eight-tenths pounds (1.8 lbs) of oxygen dissolved per pound of diurnal peak carbonaceous BOD. In the case of nitrification the oxygen requirement for oxidizing ammonia shall be four and one-half pounds (4.5 lbs) of dissolved oxygen per pound of ammonia;

D. Twenty-six hundred (2600) cubic feet of air per pound of applied BOD shall be provided for diffused air plants. Additional capacity must be provided for channels, air-lifts, aerobic digesters and other air use demands. 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 greater;

E. Blowers shall be provided in duplicate units, with each blower being capable of supplying all of the air requirements listed in this section. All installed blowers must be operable;

F. Easily removed drop-pipes with shut-off valves should be provided on each tank. A pressure gauge shall be provided on the outlet of each blower;

G. A maximum of four (4) tanks in series or a maximum of two (2) parallel arrangements of two (2) tanks each in series. In parallel arrangements, passports must be provided between tanks to prevent liquid build-up within any tank. Means for balancing air supply to each header must be provided. Means for varying the amount of return sludge, as well as the location of the return sludge discharge, must be provided. Separate blowers and piping plus standby blower(s) must be provided for parallel series arrangements; and

H. Time clocks will generally be approved only if the plant is operating at less than seventy-five percent (75%) of design

load, will be operating with predictable variable loads or will be operating with light loading conditions which will significantly affect operations. Plants equipped with time clocks should be supervised by only trained, experienced personnel.

7. Final settling tanks. Final settling tanks following the aeration units shall be designed to give effective settling and continuous return of sludge. Detention time shall not be less than four (4) hours based on the average flow. Six to eight (6–8) hours may be required to handle peak flows. Design of the settling tanks shall be based on the following requirements:

A. The installation of multiple settling tanks in series is discouraged;

B. The area upstream of any part of the inlet baffle shall not be used in calculating the surface settling area. The maximum surface settling rate at peak rates of flow with flow equalization shall not exceed one thousand gallons (1000 gals.) per day per square foot for domestic type wastewater. For plants without flow equalization, the maximum surface settling rate shall not exceed one hundred fifty gallons (150 gals.) per day per square foot, at the twenty-four (24)-hour average design flow.

C. Tank hoppers should have a minimum side slope of sixty degrees (60°) to the horizontal and bottoms not in excess of one foot (1') square or one foot (1') in diameter. In computing detention capacity of non-mechanical hopper tanks, only the upper one third (1/3) (by height) of the hopper(s) may be included. Tank hoppers should be considered as commencing when two (2) or more sides have a side slope of sixty degrees (60°) to the horizontal. Dual hopped tanks should provide a minimum water depth of two feet (2') over the junction of sixty degree (60°) walls between hoppers. The installation of more than two (2) hoppers per settling tank will not be accepted.

D. A baffle shall be provided at the inlet to prevent turbulence and short circuiting and to entrap grease and floatable materials (surface skimmer shall be downstream of this baffle). The inlet baffle shall extend across the width of the settling tank and shall extend continuously from a minimum of six inches (6") above normal water level to a minimum depth of two feet (2') below the inlet part to the settling tank. The inlet baffle shall be located no less than twelve inches (12") from the tank end wall nor more than twenty inches (20") to allow an effective collecting area for floatable materials without infringing on the clear surface settling area of the settling tank;

E. A baffle shall be provided at the outlet, within six inches (6") of the effluent trough and extending four to eight inches (4–8") below and six inches (6") above the liquid level;

F. The outlet from the settling tank shall consist of an overflow trough equipped with an adjustable plate weir. The weir length shall be at least twice the narrow dimension of the settling tank and the weir overflow rate shall in no case exceed twenty-five hundred gallons (2500 gals.) per day per lineal foot at the twenty-four (24)-hour design flow nor seventy-five hundred gallons (7500 gals.) per day per lineal foot at peak flow. The overflow trough should be located a sufficient distance from the end wall of the final tank to offset the effect of end wall currents;

G. Sludge withdrawal shall be based on a return rate of fifty to two hundred percent (50–200%) of the average daily flow with variable control of the return rate provided. Positive visible return should be provided. Each hopper shall have separate sludge withdrawal and transfer equipment. Piping and valving shall be at least six inches (6") above the liquid level. Sludge return air-lifts shall be at least three inches (3") in diameter. Discharge piping should be at least four inches (4") in diameter and should be designed to maintain a velocity of not less than two feet (2') per second when operating at normal return rates. Suitable devices for observing, sampling and controlling return sludge flow from each settling tank hopper shall be provided;

H. Scum skimmers capable of continuously removing floating scum from the clarifier and returning it to the aeration zone shall be provided. The devices shall be easily adjustable. The design of air lift type scum removal devices must take into account the effect that the air lifts will have on the overflow rate in the settling tank. On food service operations, skimmers must discharge to a separate scum holding tank of no less than five percent (5%) of the food service daily hydraulic flow and be provided with a means of recirculating the subnatant to the aeration tank; and

I. Hosing facilities for routine flushing of walls and walkways at all facilities over five thousand gallons (5000 gals.) per day and at all food service operations shall be provided. Where water supply is not available, a pump with hose connection may be used. (See paragraph (11)(C)8. for requirement concerning potable water supply protection.)

8. Waste sludge facilities. An on-site sludge holding facility shall be provided at each extended aeration treatment plant

designed under this rule. For normal domestic type wastewater, the holding tank shall have a minimum capacity of three (3) cubic feet per population equivalent served. For higher strength wastes, the basis for design shall consider that sixty-five hundredths pounds (0.65 lbs) of solids per day must be wasted for every pound of influent BOD removed per day. Solids concentration in the holding tank may average two percent (2%) and a minimum of forty-five (45) days' storage must be provided. Suitable piping and valves shall be provided to allow wasting of excess activated sludge from the plant to the holding tank. The holding tank shall be provided with aeration at a minimum rate of four (4) cubic feet per minute per one thousand (1000)-gallon capacity. A means of returning supernatant from the sludge holding tank to the inlet end of the plant aeration zone or flow equalization tank shall be provided. A positive means for decanting the supernatant must be provided as an overflow port is not acceptable. Since all plants must waste sludge, the summary of design data shall indicate where waste sludge will be disposed. Sludge should be hauled to a municipal wastewater treatment facility or other suitable sludge disposal facility. Typically a twenty thousand gallon (20,000 gal.)-per day plant may produce from seven hundred to one thousand gallons (700–1000 gals.) of concentrated waste sludge per week. Failure to provide for proper handling of waste sludge may lead to plant failure and evidence of sludge in the receiving stream. For the size of facilities covered by this rule, on-site sludge disposal is not recommended. If on-site sludge disposal is proposed, an engineer's report shall be submitted which addresses the requirements of 10 CSR 20-8.170.

9. Filtration of effluent. All activated sludge treatment facilities that are required to produce effluents with less than ten (10) mg/l BOD and fifteen (15) mg/l suspended solids or remove ninety-five percent (95%) or more of the influent BOD shall have filtration of the effluent in accordance with subsection (13)(C) of this rule. Filtration is recommended for all activated sludge plants that must remove ninety percent (90%) or more of the influent BOD. These plants must be designed so that filtration, if required at a later date, can be added.

(C) Sand Filters. Sand filters are generally considered suitable for treatment of small flows or for flows which are highly intermittent or seasonal. Sand filters are considered capable of producing an effluent that meets advanced secondary treatment requirements. Sand filters may be used following a septic tank or activated sludge treatment facility.

The possibility of intermittent objectionable odors occurring during dosing of open filters should be considered when locating these systems. The criteria contained in this section is for buried, open and high rate backwashed type sand filters.

1. Location. Sand filters following activated sludge treatment plants shall be subject to the same setback distances as the treatment plant (see paragraph (13)(B)1. of this rule). Open sand filters following septic tanks shall be located a minimum of two hundred feet (200') from future or existing residences or other establishments. Buried sand filters shall be located a minimum of one hundred feet (100') from any water supply structure and fifty feet (50') from any residence or establishment. Siting of buried sand filters shall consider access needed for maintenance and repairs by construction equipment.

2. General. Sand filter bottoms are generally constructed of unfilled earth, however liners or poured concrete bottoms may be required in areas subject to potential groundwater contamination. All buried and open intermittent sand filters shall be dosed. Sand for sand filters may be either natural sand or manufactured sand. Manufactured sand shall be chat sand produced from flint chat in the Joplin area, fines manufactured from igneous rocks or chert gravel may be used. Finely crushed limestone or dolomite is not acceptable.

3. Buried sand filters. A buried sand filter shall consist of one filtering bed or two (2) or more filtering beds connected in series and separated by a minimum of six feet (6') of undisturbed earth. Two (2) or more filter beds are required where a high degree of treatment is required or where sand filter media with an effective size of one millimeter (1 mm) or greater is utilized. Each bed shall contain horizontal sets of distribution lines and collector lines. These lines shall be equivalent to schedule 40 PVC pipe or other suitable materials.

A. One (1) collector line shall be provided for each six feet (6') of width or fraction thereof. A minimum of two (2) collector lines shall be provided. The upper end of each collector line shall be sealed or plugged. The collector lines shall be laid to a grade of one inch (1") in ten feet (10'). The tops of open joints in the collector lines may be covered with tarred felt (tar paper) to prevent intrusion of the media.

B. Gravel three-fourths inch to two and one-half inches ($3/4$ "– $2\ 1/2$ ") in size shall be placed around and over the lower collector lines until there is a minimum of four inches (4") of gravel over the pipes. The gravel shall be overlain with a minimum of three

inches (3") of washed pea gravel one-eighth inch to three-eighth inch ($1/8$ – $3/8$ ") size interfacing with the filter media.

C. A minimum of twenty-four inches (24") of coarse washed sand shall be placed over the pea gravel. The sand shall have an effective size of one-half to two millimeters (.5–2 ml.) with a uniformity coefficient of less than three and one-half (3.5). Not more than one percent (1%) of the media shall be less than thirteen hundredths millimeters (.13 mm.) in size.

D. Six inches (6") of gravel three-fourths to two and one-half inches ($3/4$ – $2\ 1/2$ ") in size shall be placed upon the sand in the bed.

E. Distribution lines shall be level and shall be horizontally spaced a maximum of three feet (3') apart center to center. Enough gravel shall be carefully placed to cover the distributors.

F. Venting shall be placed on the downstream end of the distribution lines with each distribution line being vented or connected to a common vent. Vents shall extend at least twelve inches (12") above the ground surface with the outlet screened or provided with a perforated cap.

G. A layer of material such as unbacked, rolled three and one-half inches ($3\ 1/2$ ") thick fiberglass insulation, untreated building paper of forty to sixty pound (40–60 lb.) weight, synthetic drainage fabric or four to six inches (4–6") of straw shall be placed upon the top of the upper layer of gravel. A minimum of twelve inches (12") of backfill shall be provided over the beds.

H. A distribution box shall be provided for each filter bed. The distribution boxes shall be placed upon undisturbed earth outside the filter bed. Separate watertight lines shall be provided leading from the distribution boxes to each of the distributor lines in the beds.

I. All buried sand filters shall be dosed by use of either pumps or dosing siphons. The dosing system shall be designed to flood the entire filter during the dosing cycle. A dosing frequency of greater than two (2) times per day is recommended. The dosing volume should be sufficient to fill the voids in the gravel to a depth of at least four inches (4").

(I) A pump shall be installed when adequate elevation is not available for the system to operate by gravity. A pump is also required when two (2) filters are required in order to dose the effluent from the first filter to the second filter. The pump shall be of corrosion-resistant material. The pump shall be installed in a watertight pit.

(II) Dosing siphons may be used between the septic tank and first filter bed when elevation permits their use. Dosing siphons shall be installed with strict adherence to the manufacturer's instructions. The dosing tank shall be of such size that the siphon will flood the entire filter during the dosing cycle.

J. Septic tank effluent application rates for buried sand filters shall not exceed one gallon (1 gal.) per day per square foot for single bed filters using sand media with an effective size less than one millimeter (1 mm) and not more than one and one-half gallons ($1\ 1/2$ gals.) per day per square foot when using two (2) or more filters with sand that has an effective size of greater than one millimeter (1 mm). The maximum organic loading for a buried sand filter shall be one and seventy-five hundredths pounds ($1\ 7/5$ lbs.) of BOD per day per one thousand (1000) square feet. Extended aeration treatment plant effluent may be applied to buried sand filters at a rate of up to one and one-half gallons ($1\ 1/2$ gals.) per day per square foot. Total surface area for any sand filter shall not be less than two hundred (200) square feet.

K. There shall be no construction, such as buildings or concrete driveways, covering any part of a buried sand filter.

4. Open sand filters. Media characteristics and underdrain systems for open sand filters are similar to those for buried sand filters. Distribution is often provided through pipelines and directed on splash plates located at the center or corners of the sand surface. Occasionally troughs or spray nozzles are employed as well and ridge and furrow application has been successful during winter operation in severe climatic conditions. Dosing of the filter should provide for flooding the bed to a depth of approximately two inches (2") or one and one fourth gallons ($1\ 1/4$ gals.) per square foot. Dosing frequency is usually greater than two (2) times per day. For coarser media (greater than five tenths millimeters (0.5 mm)), a dosing frequency greater than four (4) times per day is desirable. Higher acceptable loadings on these filters as compared to buried filters relate primarily to the accessibility of the filter surface for maintenance. Gravel is not used on top of the sand media and the distribution pipes are normally exposed above the surface.

A. The media used in the filters should be from locally available sources, however, the effective size should be at least three-tenths millimeters (0.3 mm) and the uniformity coefficient must be less than three and one-half ($3\ 1/2$) and there shall be no more than one percent (1%) smaller than thirteen hundredths millimeters (.13 mm).

The media should have an effective size of less than one and two tenths millimeters (1.2 mm) or treatment efficiency will be impaired. The sand must be free of any clay, limestone or appreciable amounts of organic material. The operating authority or owner of the treatment facility should be aware that the smaller the effective size of the sand, the more maintenance of the filter bed will be required. No sand shall be used unless a sieve analysis has been performed on the material delivered to the site. A copy of the report on sieve analysis shall be submitted to the department with the final operating permit application.

B. Filter walls shall be of concrete or masonry. They shall extend at least six inches (6") above the top of the sand bed and at least six inches (6") above the adjacent ground surface. The filter surface should be protected from runoff and diversion ditches. Berms will be required as the need indicates.

C. Distribution to the filter may be by means of troughs laid on the surface, pipelines discharging to splash plates located at the center or corners of the filter or spray distributors. Care must be taken to insure that lines discharging directly to the filter surface do not erode the sand surface. The use of curbs around splash plates or large stones placed around the periphery of the plates will reduce the scour. When troughs or point discharges are used, they should be located so that the maximum lateral travel over the sand is not more than twenty feet (20'). The design of the distribution system shall assure that the effluent will be evenly distributed from each point discharge or trough or spray nozzle. Dosed distribution boxes may be appropriate in some situations. A layer of washed pea gravel placed over the filter media may also be employed to avoid surface erosion. This practice will create maintenance difficulties when it is time to rake or remove a portion of the media surface.

D. Open sand filters may be covered to protect against severe weather conditions and to avoid encroachment of weeds or animals. The cover also serves to reduce odor conditions. Covers may be constructed of treated wooden planks, galvanized metal or other suitable materials. Screens or hardware cloth mounted on wooden frames may also serve to protect filter surfaces. Where weather conditions dictate, covers should be insulated. A space of twelve to twenty-four inches (12–24") should be allowed between the insulated cover and sand surface.

E. The hydraulic loading for open sand filters shall be from two to five gallons (2–5 gals.) per day per square foot when treating septic tank effluent and less than eight gallons (8 gals.) per day per square foot

when treating the effluent from an extended aeration treatment plant. In choosing what loading rate to use, the engineer should consider effective size of the media and maintenance requirements. The maximum organic loading rate to open sand filters shall be five and thirteen hundredths pounds (5.13 lbs.) of applied BOD per day per one thousand (1000) square feet.

F. Dual filters each sized for the design flow are required for treating septic tank effluent. Single filters are adequate for extended aeration plant effluent except that plants receiving and treating wastewaters stronger than domestic type waste (less than three hundred (300) mg/l influent BOD) shall be provided with dual filters. A diversion box shall be provided where two (2) or more beds are used.

G. Open sand filters shall be fenced in accordance with subsection (11)(A) of this rule.

5. High rate sand filters. High rate sand filtration may be used following extended aeration type treatment plants with flow equalization. Design of high rate sand filters shall be in accordance with 10 CSR 20-8.210 Supplemental Treatment Processes, section (4).

(D) Disinfection. Disinfection shall be provided when required by 10 CSR 20-7.015 Effluent Regulations. Disinfection can be accomplished with chlorine gas, calcium hypochlorite, sodium hypochlorite, iodine, bromine, ozone, chlorine dioxide and ultraviolet irradiation. For the range of flows covered by this rule, calcium or sodium hypochlorite are the most commonly used. Criteria for their use follow:

1. Design capacity. Chlorinators shall be designed to have adequate capacity to produce a total chlorine residual of one-half milligram per liter (1/2) mg/l after fifteen (15) minutes of contact time at the peak rate of flow. For typical domestic wastewater the following dosing capacity is recommended:

Pond Effluent	Extended Aeration Effluent	Sand Filter Effluent
20—30	10—25 mg/l	1—5 mg/l

2. Contact tanks. The chlorine contact tank shall be constructed to provide a minimum of fifteen (15) minutes of contact at the peak flow rate. For slow rate sand filter effluent, consideration should be given to an orifice-controlled discharge to the chlorine contact tank in order to avoid excessive size tanks. No orifice shall be less than one and one-half inches (1 1/2") in diameter. Baffling for serpentine flow shall be provided to minimize short circuiting.

Baffles shall be designed to provide a length-to-width ratio of at least forty to one (40:1). Provisions shall be made for draining the tank to remove sludge with the sludge to be returned to either process or sludge holding facilities. Duplicate tanks are recommended.

3. Chlorinator housing. Chlorinators, with the exception of tablet type chlorinators, shall be housed in a separate enclosure which is properly ventilated and heated if winter operation is required. The chlorinator housings shall be equipped with mechanical ventilation with the inlet located near the floor. Ventilation equipment shall have sufficient capacity for providing a minimum of one (1) air change per minute; and

4. Dechlorination. Dechlorination shall be provided when required by 10 CSR 20-7.015 Effluent Regulations. Dechlorination chemicals shall be thoroughly mixed with the effluent, however no contact tank is required. Effluent reaeration may be required after dechlorination to insure adequate dissolved oxygen concentration. Special care should be taken not to allow calcium or sodium hypochlorite to mix with dechlorination chemicals during storage or handling. Dechlorinated effluent shall be monitored for chlorine residual and dissolved oxygen in accordance with discharge permit requirements.

(14) On-site Wastewater Treatment and Disposal. On-site wastewater treatment and disposal is a method of treatment involving pretreatment with a septic tank or extended aeration unit and further treatment and final disposal through soil adsorption. Soil adsorption is usually accomplished with the use of subsurface trenches, beds and elevated sand mounds. Land application of effluent from ponds is another method for a no-discharge system, however criteria for land application may be found in section (15) of this rule. This section also covers the criteria for engineering reports as required by 10 CSR 20-6.030 Disposal of Wastewater in Subdivisions.

(A) Engineer's Report—Single Family Wastewater Treatment Systems. An engineer's report required by 10 CSR 20-6.030 must demonstrate to the satisfaction of the department that the lot sizes, topography and soils in the subdivision are such that single family residence wastewater treatment systems may be used without causing a violation of the Missouri Clean Water Law and regulations. Also the design of the single family residence wastewater treatment systems will be in accordance with this rule. Criteria for an engineer's report that addresses these requirements are as follows:

1. General. A drawing or preliminary plat of the proposed subdivision that shows the individual lots and lot sizes must be submitted with the engineer's report. A copy of the geological evaluation, as required by 10 CSR 20-6.030, must be included with the report also. If county soils maps are available, the approximate soil boundaries must be shown on the plat or drawing.

A. The drawing or preliminary plat should show any existing water supplies or wastewater treatment systems. The proposed type of water supply must be indicated. If the development went from nonregulated to the number of lots to be regulated, the engineer should report on the method of wastewater treatment and disposal on the existing homes, whether or not the systems are surfacing and whether or not the effluent is crossing property lines. In areas of existing homes and potential groundwater contamination, the engineer should report on whether or not the wells serving the existing homes have had any history of contamination.

B. If no well records are available, the engineer should strive to have at least twenty-five percent (25%) of the wells tested. The wells should be tested for parameters recommended by the Missouri Department of Health. All information pertaining to failing systems or contaminated wells shall be shown on the plat or drawing. In these situations, the engineer should make recommendations for any deficiencies in the existing systems;

2. Lot sizes. The engineer's report must demonstrate that the lot sizes are large enough to satisfy the required set-back distances as required in 10 CSR 20-6.030 and 10 CSR 20-8.021. The lot size must be large enough for a soil adsorption system and repair area that is the same size as the original system in suitable soils;

3. Topography. The engineer's report must indicate that the areas where the soil adsorption systems will be sited are within the limits for slope as required in 10 CSR 20-8.021;

4. Soils. The location of all soil borings, percolation tests, backhoe pits or depth to bedrock determinations must be indicated on the drawing or plat. All these sites must be marked in the field by placing a lath at the hole or boring and writing on the lath whether the soil is suitable or unsuitable. The location of all these soils investigations must be at the most probable location of the sewage disposal area and based upon the most probable location of the residence.

A. There must be at least one (1) percolation test or soils investigation boring or pit on each lot in the subdivision. The soils investigation or percolation testing must con-

tinue on a lot until suitable conditions are found or the lot will not be considered for approval. Percolation tests and soils investigations must be in accordance with 10 CSR 20-8.021.

B. In some cases, where there are severe geological limitations for groundwater contamination, percolation tests and determination of soil morphological characteristics will not be sufficient. Particle size analysis or the percentage of rock fragments and depth to bedrock or seasonally high water table will be required in addition to the normal site evaluation. In some cases the additional requirements may apply when the geological limitations are moderate;

5. The proposed method of treatment and disposal, including soil loading rates and design, shall be in accordance with 10 CSR 20-8.021. The engineer's report must demonstrate that, based upon the site evaluations, there are sufficient suitable site conditions to design systems in accordance with 10 CSR 20-8.021. The report must also show the generic sizing of the different type of systems proposed;

6. The engineer's report must contain the name(s) and address(es) of the owner(s) and/or developer(s) with supporting documentation of the owner(s) and/or developer(s) approval of the report; and

7. The department may require provisions such as restricted covenants to assure that the proposed single family residence wastewater treatment systems will be constructed in accordance with 10 CSR 20-8.021 and the engineer's report unless other site evaluations by a person with the qualifications contained in this rule determines that the requirements of 10 CSR 20-8.021 can be met with a different design.

(B) On-site Systems Other Than Single Family Residences. On-site systems serving more than a single family residence or commercial establishment shall be designed in accordance with 10 CSR 20-8.021 provided that the design flow is less than fifteen hundred gallons (1500 gals.) per day. For on-site systems that are designed for more than fifteen hundred gallons (1500 gals.) per day, the criteria in this section shall be used in addition to the criteria contained in 10 CSR 20-8.021.

1. Engineer's report. An engineer's report is required for all on-site systems with design flows greater than fifteen hundred gallons (1500 gals.) per day. The engineer's report must contain the following in addition to the requirements of section (3) of this rule:

A. A geological evaluation of the proposed soil adsorption site must be performed by the Department of Natural Resources, Division of Geology and Land Survey;

B. For design flows greater than fifteen hundred gallons (1500 gals.) per day but less than three thousand gallons (3000 gals.) per day. The use of percolation tests at depths of three feet (3') in addition to soil pit observations to a depth of six feet (6') are the minimum site evaluation requirements. Analysis of the soil morphological characteristics may be used in place of percolation tests. Depth to bedrock from the bottom of the soil adsorption system must be six feet (6'). The following design parameters must be used:

(I) The slowest acceptable percolation rate is forty-five minutes (45 min.) per inch or a minimum permeability of six tenths to two inches (.6-2") per hour;

(II) Depth to seasonally high water table shall be a minimum of four feet (4') from the soil adsorption bottom. Depth from the soil adsorption system bottom to a restrictive layer or impermeable bedrock or mottling is six feet (6');

(III) The system shall be divided into a minimum of two (2) soil adsorption areas with each area sized for seventy-five percent (75%) of the design flow. The systems must be dosed with either a siphon or pump in order to achieve distribution between the lines or beds;

(IV) Slopes shall not exceed fifteen percent (15%). Linear loading rates and landscape drainage shall be sufficient to prevent oversaturation of the soil adsorption system at the lowest elevation in the system; and

(V) In areas of highly permeable bedrock and where there is groundwater contamination potential, the chert content must be less than forty percent (40%) for a depth of ten feet (10'). In areas where the chert content is less than sixty percent (60%) for ten feet (10') below the soil adsorption system and the total depth to bedrock is greater than thirty feet (30'), soil adsorption may be used. In these areas of potential groundwater contamination, groundwater monitoring wells may be required if recommended by the Division of Geology and Land Survey. In some cases where Karstification is well developed, monitoring of area springs may be required; and

C. For design flows greater than three thousand gallons (3000 gals.) per day, all requirements and limitations previously mentioned in this section shall apply and the following limitations shall apply:

(I) In general, sites will not be approved where the geological limitations are severe and in some cases where the geological limitations are moderate;

(II) Groundwater monitoring may be required in areas where potable drinking

water exists and there is a significant potential for contamination. The recommendations as to the number and construction details for groundwater monitoring wells from the Division of Geology and Land Survey will be followed;

(III) Soils shall be evaluated to a restrictive layer, bedrock or seasonally high perched water table. Calculations shall be submitted which show the predicted maximum height of the groundwater mound under the system or a perched groundwater mound. The minimum distance between the soil adsorption bottom and the maximum groundwater mound shall be four feet (4'); and

(IV) All hydraulic calculations on the pumps, siphons and distribution system shall be submitted.

(15) Land Application of Wastewater. This section applies to two (2) methods of land application which are slow rate (irrigation) and overland flow. The summary of design data and general layout shall contain pertinent information on the proposed site including location, geology, soil conditions, area for expansion, groundwater conditions and any other factors which may affect the feasibility and acceptability of the proposal. The summary of design data shall also include pretreatment and storage requirements, the design application rates and monitoring, application equipment, and operation and maintenance requirements. The source should be given for any information used by the consultant in design.

(A) Site Considerations. The following information concerning the site shall be provided:

1. Legal description of the disposal site;
2. The location of all existing and proposed residences, commercial or industrial developments, roads, ground or surface water supplies and wells within one-half (1/2) mile of the proposed site;
3. Available land area, both gross and net areas (excluding roads, right-of-way encroachments, stream channels and unusable soils);
4. Distance from the pretreatment and the storage facilities to the application site including elevation differential;
5. Proximity of site to industrial, commercial, residential developments, surface water streams, potable water wells, public use areas such as parks, cemeteries and wildlife sanctuaries;
6. Present and future land and groundwater uses;
7. A summary describing the existing vegetation of the area;

8. A description including maps showing elevations and contours of the site and adjacent areas which may be suitable for expansion. Specific information on the maximum and average slopes of the site must be provided; and

9. The department may require a geological evaluation of the proposed land application site prepared by the Department of Natural Resources, Division of Geology and Land Survey. A geologic report is not required for application rates that will not exceed twenty-four inches (24") of applied wastewater per year for typical domestic wastewater lagoon effluent.

(B) Wetted Application Area. The wetted application area is the land area which is normally wetted by wastewater application. The wetted application area must conform to the following criteria:

1. Flood-prone areas which flood at a frequency greater than once every ten (10) years should not be the sole source of land application;

2. The wetted application area shall be established at least one hundred fifty feet (150') from existing dwellings or public use areas, excluding roads or highways. In addition the wetted application area shall be at least fifty feet (50') inside the property line. Distances may be reduced depending upon the extent of pretreatment and operational techniques. One-half (1/2) the required distances may be used if the wastewater is disinfected in accordance with section (13) of this rule;

3. The wetted application area should be at least three hundred feet (300') from any sinkhole, losing stream or other structure or physiographic feature that may provide direct connection between the ground water table and the surface;

4. The wetted application area shall be at least three hundred feet (300') from any existing potable water supply well not located on the property. Adequate protection shall be provided for wells located on the application site; and

5. The application area should be fenced and posted along public roads and public use areas. Fencing is not required if the wastewater is disinfected prior to application or if other suitable barriers are provided or if the wetted application area is located in areas where access is limited. A minimum of one (1) sign should be placed on each side of the application area. The perimeter distance between any two (2) signs should not exceed five hundred feet (500'). Each sign should clearly identify the nature of the facility and advise against trespassing in letters not less than two inches (2") high.

(C) Soils Information. The department may require that the soil types and characteristics for the top five feet (5') of soil be investigated if applied wastewater will exceed twenty-four inches (24") per year. Unless required otherwise by the department, soils information shall include soil series name, soil texture, soil permeability and water-holding capacity. If a county soils map is available, the approximate boundaries of the different soils shall be shown. If a published soil survey is not available, the soils shall be classified by a professional soil scientist. In areas of soluble limestone and dolomite, where there is a potential for groundwater contamination, chert or stone content shall be determined to a depth of five feet (5'). Depth to restrictive layers such as fragipans or claypans shall be determined. Recommendations by the Division of Geology and Land Survey for further soils investigations shall be complied with.

1. The wetted application area should have a soil mantle of at least five feet (5') overlying any sand or gravel strata.

2. The topography of the site and adjacent land shall be evaluated for areas of potential erosion. The effects of both applied wastewater and storm runoff shall be considered. Special consideration should be given to the period of construction and system start-up when vegetative cover may be lacking or not fully developed.

(D) Preapplication Treatment. As a minimum, treatment prior to land application shall provide treatment equivalent to that obtained from a primary wastewater pond cell designed and constructed in accordance with section (13) of this rule, except that the pond depth may be increased to include wastewater storage on top of the primary volume. Separate storage cells may also be used. The maximum organic loading on the primary cell(s) at a water depth of three feet (3') shall not exceed thirty-four pounds (34 lbs.) of BOD per acre per day. The normal operating level for all ponds should be between the two-foot (2') level and the high water level. A permanent depth measurement gauge or marker shall be installed in the pond(s) and shall be easily readable at one-foot (1') increments or smaller. The gauge shall be placed in a suitable location where it is easily accessible during routine operations.

(E) Operation and Maintenance Plan. An operation and maintenance plan shall be provided to explain the key operating procedures at a level easily understood by the owner and the operator of the facility. An outline and brief summary of operations shall be provided as part of the engineering report. A detailed operation and maintenance plan shall

be included as part of the engineering plans and at a minimum shall address maintenance of mechanical equipment and vegetative cover, monitoring, recordkeeping, operating procedures, application scheduling and winterization of the system.

(F) Land Application Facility. This rule provides design criteria for a standardized conservative land application system. For the range of flows covered by this rule, the maximum application rate for typical domestic wastewater shall be forty to one hundred inches (40–100") of applied wastewater per year depending on soil characteristics. For higher application rates, additional soils and geologic information, detailed site specific design proposals and supporting documentation shall be submitted to justify the proposed design. These designs should follow the requirements in 10 CSR 20-8.220. For irrigation the recommended design procedures for domestic wastewaters may be found in the *U.S. Environmental Protection Agency Process Design Manual for Land Treatment of Municipal Wastewater* (EPA 625/1-81-013).

1. Crops and vegetation. A description of the crops or vegetation to be grown is required for all systems in which vegetation is to be an integral part of the treatment system. This includes all slow rate and overland flow systems. The use of wastewater for irrigation of truck farms growing vegetables will not be approved. The following information shall be provided:

A. Compatibility of the crop with site characteristics and design hydraulic loading rates;

B. Cultivation and harvesting requirements; and

C. Crop management.

2. Storage facility. Storage requirements shall be based on the design wastewater flows and net rainfall minus evaporation expected for a one (1) in ten (10) year return frequency for the storage period selected. The storage volume for wastewater stabilization ponds shall be calculated based on the useable volume above the two-foot (2') level. The minimum total days' storage required for no discharge ranges from sixty (60) days in southern Missouri to one hundred twenty (120) days in northern Missouri. These requirements assume that a permanent cover crop is in place and the primary purpose of the system is wastewater treatment. If the system uses row crops, or crop production is the primary goal, storage should be increased to correspond with crop planting and harvesting schedules. An exception to this is a system where flows are generated only during the application period. A storage capacity of forty-five (45) days or the flow generated dur-

ing the period of operation, whichever is less, must be provided.

3. Equipment. The following shall be considered in the design of the land application equipment:

A. Any spray application equipment specified shall minimize the formation of aerosols;

B. The pumping system and distribution system shall be sized for the flow and operating pressure requirements of the distribution equipment and the application restrictions of the soils and topography;

C. Provisions shall be made for draining the pipes to prevent freezing if pipes are located above the frost line;

D. A suitable structure shall be provided for either a portable pumping unit or a permanent pump installation. The intake to the pumping system shall provide the capability for varying the withdrawal depth. The intake elevation should be maintained twelve to twenty-four inches (12–24") below the wastewater elevation. The intake shall be screened so as to minimize clogging of the sprinkler nozzle or distribution system orifices. For use of a portable pump, a stable platform and flexible intake line with flotation device to control depth of intake will be acceptable;

E. Thrust blocking of pressure pipes shall be provided. For use of above ground risers for sprinklers, a concrete pad and support bracing should be considered; and

F. Automatic or semi-automatic controls should be considered for shut off of the system after a prescribed wastewater application period. Manual start-up of the application system is recommended.

4. Soil permeability. Soil permeability shall be based on the most restrictive layer in the top five feet (5') of soil. Soils having permeability rates of two tenths to two inches (.2–2") per hour are most suitable for irrigation. Values below two-tenths inch (.2") per hour may generally require special application equipment, reduced application rates or overland flow approach. Values above two inches (2") per hour will require reduced application rates to provide adequate residence time within the soil profile or will require additional soils and geologic information for depth to bedrock, depth to water table and recharge areas.

5. Slope. The maximum allowable slope of the wetted application area is twenty percent (20%).

6. Application rate. The application rate consists of an hourly application rate in inches per hour and daily, weekly and annual application rates in inches per acre. Application of wastewater will not be allowed during

periods of ground frost, frozen soil or during rainfalls. The following shall apply to design application rates:

A. The hourly application rate should not exceed the design sustained permeability rate except for short periods when initial soil moisture is significantly below field capacity. The hourly rate shall not exceed one-half (1/2) the design sustained permeability for slopes exceeding ten percent (10%). However, in no case should the application rate be greater than one-half inch (1/2") per hour. For soil permeability of less than two-tenths inch (.2") per hour, the designed maximum application rate should be as low as practicable and shall not exceed two-tenths inch (.2") per hour;

B. The daily and weekly application rates should be based on soil moisture holding capacity, antecedent rainfall and depth to the most restrictive soil permeability. The application rate shall in no case exceed one inch (1") per day and three inches (3") per week; and

C. The design maximum annual application rate shall not exceed a range from four percent to ten percent (4%–10%) of the design sustained soil permeability rate for the number of days per year when soils are not frozen. The following shall apply to typical domestic wastewater lagoon effluent:

(I) Soil permeability less than two-tenths inch (.2") per hour. The maximum application rate shall be forty inches (40") of applied wastewater per year. The department may require lower application rates when there is evidence of fragipans, claypans or zones of seasonal saturation within the top two feet (2') of the soil profile;

(II) Soil permeability range from two-tenths inch (.2") per hour to two inches (2") per hour. The maximum application rate shall be one hundred inches (100") of applied wastewater per year. Lower rates may be required if there is evidence of seasonal saturation in the top five feet (5') of the soil profile or if there is a significant potential for groundwater contamination;

(III) Soil permeability ranges from two inches (2") per hour to six inches (6") per hour. The maximum application rate shall be sixty inches (60") of applied wastewater per year. The department may require lower rates if there is a significant potential for groundwater contamination; and

(IV) Soil permeability over six inches (6") per hour. The maximum application rate shall be twenty-four inches (24") of applied wastewater per year.

D. In no case shall the application rate result in the runoff of applied wastewater during or immediately following application.

7. Nitrogen Loading. Nitrogen application rates shall not exceed the amount of nitrogen that can be utilized by the vegetation to be grown. Typical domestic wastewater after lagoon storage can be expected to contain from five to eight milligrams per liter (5–8 mg/l) of ammonia nitrogen as N and less than one (1) mg/l of nitrate nitrogen as N. Ammonia nitrogen can be adsorbed onto soil particles and retained in the soil for later use by plants and microorganisms. However, nitrate nitrogen is mobile and will readily leach through the soil profile if wastewater is applied faster than the vegetation or soil microbes can utilize the nitrates. If the applied wastewater is expected to provide more than one hundred fifty pounds (150 lbs.) of total nitrogen per acre annually or if the applied wastewater exceeds ten (10) mg/l of nitrate nitrogen as N, then calculations shall be submitted to show the amount of plant-available nitrogen provided and the amount of nitrogen that will be utilized by the vegetation to be grown.

8. Trace element loading. Consideration shall be given to the type and influence of any industrial wastes contributed to the wastewater stabilization pond. Typical domestic wastewater does not contain amounts of trace substances which are of concern for land application of wastewater under this rule. However, introduction of substances, such as excess sodium, chlorides, boron or other constituents, can have an adverse impact on soils and vegetation. Timber is more sensitive to these substances than grass or grain species. Wastewater suitable for general land application shall not exceed the trace element concentrations in Table 4-5 of the *U.S. Environmental Protection Agency Process Design Manual for Land Treatment of Municipal Wastewater* (EPA 625-1/81-013).

9. Public use areas. The following shall apply to the irrigation of public use areas with wastewater:

A. The wastewater shall be disinfected prior to land application (not storage) in accordance with section (13) of this rule. The wastewater shall contain as few of the indicator organisms as possible and in no case shall the irrigated wastewater contain more than two hundred (200) fecal coliform organisms per one hundred milliliters (100 ml);

B. The public shall not be allowed into an area when application is being conducted; and

C. For golf courses utilizing wastewater, all piping and sprinklers associated with the distribution or transmission of wastewater shall be color-coded and labeled or tagged to warn against the consumptive use of contents.

10. Grazing and harvesting deferment. Grazing of animals or harvesting of forage crops should be deferred for up to thirty (30) days following wastewater irrigation depending upon ambient air temperature and sunlight conditions. The following deferments shall be considered:

A. During the period from May 1 to October 30 of each year, the minimum deferment from grazing or forage harvesting shall be fourteen (14) days;

B. During the period from November 1 to April 30 of each year, the minimum deferment from grazing or forage harvesting shall be thirty (30) days;

C. Grazing of sewage irrigated land is generally not recommended for lactating dairy animals unless there has been a much longer deferment period. The recommendations of the State Milk Board shall be followed; and

D. Deferment may not be required for irrigation water that has been disinfected so that the water contains less than four hundred (400) fecal coliform organisms per one hundred milliliters (100 ml).

(G) Overland Flow. Overland flow distribution is accomplished by applying wastewater uniformly over relatively impermeable sloped surfaces which are vegetated. Part of the flow percolates into the ground, a portion is lost to evapotranspiration, while the remaining is collected and either discharged to a stream or reapplied on land.

1. Groundwater. The maximum groundwater elevation shall be at least two feet (2') below the application surface.

2. Slope. The land slope should be relatively uniform to prevent ponding and shall be in the range of two to eight percent (2–8%). For all overland flow systems, the slope must be nearly equal to a plane surface as possible and sloped in such a way as to prevent short-circuiting of the wastewater. No swales, depressions or gullies are permitted. The minimum length of slope for overland flow treatment is one hundred feet (100'). Two hundred feet (200') is the maximum length over which distribution of wastewater can be maintained.

3. Storage. The minimum amount of storage will range from forty-five (45) days in southern Missouri to ninety (90) days in northern Missouri. The applicant shall increase the storage facility to accommodate rainfall on the application site. This storage is then to be increased to accommodate any recirculation needed to comply with the discharge permit limitations.

4. Hydraulic loading. The recommended design hydraulic application rate is one and six-tenths inches (1.6") per day. The distribu-

tion system shall be designed to permit application on each field for eight to twelve (8–12) hours per day. Optimum wetting to drying cycle should range from a maximum of eight to twelve (8–12) hours on and a minimum of twelve to sixteen (12–16) hours off.

5. Distribution system. The system should be valved and manifolded to permit a portion of each application area to be taken out of service for grass mowing and/or harvesting. For facilities with flows less than fifteen thousand gallons (15,000 gals.) per day, the need to divide the overland flow plot into more than one (1) field is not necessarily required.

A. Sprinklers shall be placed down-slope from the highest point on the application area at a distance equal to the radius of the sprinkler.

B. For surface distribution methods, such as gated pipe or bubbling orifice, gravel may be necessary to dissipate energy and insure uniform distribution of water.

6. Vegetation. Grasses must be selected for their resistance to continuously wet root conditions. Their growth should not be in clumps as this will result in the formation of rivulets of flow rather than a uniform sheet flow. Common grasses for this purpose have been reed canary grass, Italian rye, red top, tall fescue and Bermuda grass. Application is not allowed until a full grass cover has been established.

A. Vegetation harvest and removal is recommended. The vegetation must be cut just prior to maturity (every four to six (4–6) weeks) and physically removed from the site. Harvesting should be conducted when the soil conditions are dry enough to avoid creating ruts that would short-circuit the flow.

7. Collection ditches. A network of ditches must be constructed to intercept the runoff and channel it to the point of discharge or storage. They must be graded to prevent erosion yet at the same time they shall have sufficient slope to prevent ponding in low spots. The collection system must be designed to accept the added flow from rainfall runoff. If the collection ditch discharges to a stream, the effluent must meet the limitations and monitoring required in the discharge operating permit.

(16) Appendix I. This water balance study criteria is specific to newly-constructed ponds and to existing ponds when required by the department to perform a water balance. New ponds must be prefilled to at least the two-foot (2') level with clear water and this test conducted prior to the introduction of sewage to the ponds. The water level in the ponds must always remain above the two-foot

(2') riser during the test period to insure the measurement of pond level in the control structure will be accurate. It is advised to begin the test with a pond level several inches above the two-foot (2') riser level. Existing ponds must have at least three feet (3') of water in them for the test period. The study shall contain pertinent information that will be sufficient to establish the seepage rate of each cell within the pond system. All raw data should be presented along with the calculations used to formulate the conclusion.

(A) Two (2) methods for conducting this study are offered here. One method utilizes a Class A Weather Pan to measure evaporation. Standard procedures for setup and data gathering must be practiced when using a Class A Pan. The other technique, referred to as the Barrel Method, uses a simpler data gathering task and reduced calculations. Either method may be used to perform the water balance study. Due to the ease of data gathering and calculation, the Barrel Method is recommended. The following information must be generated and used in the calculation of the seepage rate of each cell individually within the pond system. The procedures identify data needed for using the Barrel Method or the Class A Weather Pan:

1. An accurate determination of the square footage of the cell must be made. Dimensions from the as built plans, if available, should be used to calculate this area at the height of the water level used during the water balance study. Pond floor measurements are usually given inside toe of dike to inside toe. Therefore, use the side slope ratio to calculate the added horizontal distance from the toe of slope to the dike at the water level used for the study;

2. No sewage inflow to the pond should be allowed until the test has been completed and approved. Inflow to the pond during the test period should be zero (0) and the inflow factor F will have a zero (0) value. If an unavoidable discharge or transfer of water to a cell must occur during the study period, that inflow must be accurately measured by either a flow recorder or by time clocks on pumps that have been calibrated at least twice during the study period. If an accurate measurement of flow cannot be made the test must be redone. If control structure slide gates or valves leak, they must be plugged for the duration of the test;

3. Rainfall measurement must be taken from a reliable rain gauge installed at the pond system. This data will be used directly in the seepage calculation when using the Class A Weather Pan or will be used as substantiation data if the Barrel Method is used. Rainfall measurements must be used to

account for runoff from the top of the berms and side slopes. An appropriate runoff coefficient shall be used. The runoff coefficient should consider the antecedent conditions, amount of rainfall and duration of rainfall. Rainfall shall be measured daily during the normal work week;

4. Water losses through evaporation must be incorporated into the seepage calculation either by the use of a United States Weather Bureau Class A Land Evaporation Pan or by the use of barrels. Standard methods for use and placement of a Class A Weather Pan must be followed. The Barrel Method does not directly calculate the value of evaporation but gives a joint value for rainfall and evaporation. If a Class A Pan is used, an evaporation pan factor (to obtain a realistic value for actual pond evaporation) should be used;

5. In order to provide the highest degree of accuracy for the water balance test, no discharges should be made from the cells during the test period. Therefore, the outflow factor O in the seepage calculation should be zero (0). If discharge transfer from a cell is unavoidable during the test period, accurate flow measurements must be made by either flow recorder, time clocks or pumps (that have been calibrated at least twice during the discharge period) or some other form of accurate measurement; and

6. The water level of each cell should be recorded to the nearest one-sixteenth (1/16) of an inch. The measurements should be made within the manhole control structure from a fixed measuring device. This fixed device may be a temporarily fixed ruler installed for the test period only. Water level measurements shall be taken daily during a normal five (5)-day work week.

(B) A large (approximately fifty-five gallon (55 gal.)), clean (no oil or grease film), light-colored (inside and outside) barrel can be used to measure the rainfall and evaporation on a pond cell. At least three (3) barrels must be strategically located within the pond system with a surrounding baffle on each to avoid possible splash over. Barrels should be placed all in one (1) cell if only that cell is being tested at the time. If more than one (1) cell is being tested during the test period, the barrels should be arranged throughout the cells with a minimum of one (1) barrel per cell. Place the barrels where they are accessible for reading the water depths. The top of the barrel should extend at least one foot (1') but not more than two feet (2') above the water level in the cell. The barrel top should be cut (if necessary) to within these dimensions to accurately reflect the evaporation and rainfall changes to the pond contents. A mea-

suring device should be fixed to the inside of the barrel to facilitate accurate water depth measurement to the nearest one-sixteenth (1/16) of an inch. In case splash over or overturning of a barrel occurs, the close results of the other two (2) barrels will validate the test. If one (1) barrel provides invalid data, that data should be presented but not included in the calculation. If all sets of data are reasonable to use, the data from the three (3) barrels should be averaged for the final calculation of the individual seepage rate for each cell.

1. The barrel must be on a firm footing with the bottom of the barrel on the bottom of the pond. The top of the barrel should always remain level.

2. The water level in the barrel should be initially set as close as possible to the water level outside the barrel. At the daily readings this water level in the barrel may need to be adjusted up or down to again be as close as possible to the outside water level. These resettings of the water levels in the barrel should be closely measured and recorded so that they are not included in the overall increase or drop of the barrel water elevation for the length of the study. Keeping the water level inside the barrel close to the water level outside the barrel will increase the reliability that the evaporation inside the barrel will match that of the rest of the pond. However, do not adjust the water level in the barrel during the test unless it varies from the water level outside the barrel by more than five inches (5").

(C) The necessary data should be obtained on a daily basis for a period of thirty (30) days during a period of time when no freezing can occur or when air temperatures go above ninety to ninety-five degrees Fahrenheit (90–95°F). If realistic estimates of surface runoff into the pond cannot be made, the data taken on days with rainfall should not be used in the calculations. In any case there must be thirty (30) days of data.

1. The net seepage rate should be given in gallons per acre per day calculated for each cell over the cell bottom and dike areas by using the following equation:

$$S = F + R - E - O - WL$$

Where:

WL = change in height of water level in a pond cell given in inches after taking rainfall and evaporation into account. WL will be a positive number for an increase in pond depth and will be a negative number for a decrease in pond depth. Reading will be taken in the control structure. When using the Barrel Method, WL will be calculated in the following manner:

$$WL = Hp - Hb$$

Where:

WL = the pond water elevation change accounting for rainfall and evaporation. A positive number indicates an increase in the pond level and a negative number will indicate a drop in the pond water level;

Hp = the change in the water level within the pond. A positive number is an increase in the water level and a negative number equals the drop of water level. This measurement should be made in the control structure;

Hb = the change of water level measured in the barrel. A positive number is an increase in water level and a negative number equals a drop in the water level. This measurement should be made in the barrel;

S = net seepage rate from a cell calculated to inches of water elevation and converted to gallons per acre per day. A positive number equals the amount of seepage the pond experiences; a negative number would indicate a negative seepage rate which is a net gain of water in the pond system;

F = wastewater flow into the cell during the study period should be zero (0). If there is an inflow, however, it would be given in gallons and should be converted to inches of water elevation over the cell;

R = rainfall directly on pond system calculated in inches during the study period. When the Barrel Method is used, this factor will not be included in the seepage calculations as it is automatically accounted for in the barrel measurement. However, runoff from the berms must be accounted for and calculated as inches of water in the pond;

E = evaporation from the pond surface measured in inches over the duration of the study period. When the Barrel Method is used, this factor will not be included in the calculation as it is automatically accounted for in the barrel measurement; and

O = outflow from the pond cell and/or transfer of contents from a cell should not occur during the study period. If a discharge does occur, however, it should be given in gallons and converted to inches of water elevation over the cell.

Note: When data taken on rainfall days is eliminated, the days between rainfall events essentially become short separate water balance studies. In this case the seepage rate will become the average of the studies.

(17) Appendix II. This appendix contains additional criteria for design and construction of liners in wastewater stabilization ponds.

(A) Site Evaluation. A preliminary investigation for a pond site should be undertaken to screen a study area for potential sites before a detailed site investigation, if required, is

undertaken. The purpose of the investigation is to assemble available information to determine if soil borings and soil tests are required to design a pond which will meet the seepage requirements. The investigation should be done using data such as Soil Conservation Service (SCS) County Soil Surveys, U.S. Geological Survey topographic maps and the required geological evaluation from the Department of Natural Resources, Division of Geology and Land Survey. Visual inspection of the area noting topography, wet areas, vegetation and ditching is useful and may be necessary, particularly if maps are not detailed and/or soil maps do not exist. Information gathered from this investigation should be particularly useful in evaluation of the site with regard to estimating possible soil variability and suitability.

1. All potential pond sites will receive a rating from the geological evaluation. The rating will infer the relative geological limitations for designing and constructing a pond at the site in question. Whenever the geological evaluation indicates that a site has slight limitations, the requirements for additional site investigation as set forth in subsection (17)(B) of this rule, may not be required by the department. The department may require that the results of density tests, taken on the finished pond liner, be submitted and approved prior to putting the pond into operation.

2. Whenever a site has moderate geological limitations, the department may require one (1) or all of the requirements for a detailed site investigation as set forth in subsection (17)(B) of this rule. The department may require density tests, taken on the finished pond liner, be submitted and approved prior to putting the pond into operation.

3. Sites that have severe geological limitations for construction of wastewater stabilization ponds will be reviewed on a case-by-case basis. The department may require artificial liners in these situations. In general, where there is high collapse potential due to bedrock and soil conditions, the use of ponds will not be allowed. Exceptions may be granted dependent upon the type of liner proposed and where the geological considerations have been thoroughly evaluated so that the risk of groundwater contamination is minimized.

4. Where liners are used in storage or treatment basins for wastewaters of an industrial nature, the summary of design data shall document that the liner or storage structure material is capable of containing the wastewater for at least twenty (20) years and shall specify repair or replacement procedures in the event of leakage or damage to the seal.

Secondary containment or leakage detection and collection devices shall be considered for corrosive or reactive wastewaters and for toxic materials. The department may require leakage testing in accordance with section (16) of this rule and submittal of density tests and/or coefficient of permeability on the finished liner prior to placing the structure into operation.

(B) Detailed Soils Investigation. If a detailed site investigation is needed to substantiate feasibility and design of a project at a selected site with regard to design requirements, the quantity and quality of soil materials on site (and borrow) must be identified and evaluated for use in the pond and/or liner construction. The design concepts and objectives of the investigation should be made clear by the consulting engineer to the qualified soil engineering party doing the field work so that an investigation strategy can be developed and sufficient data collected. Most important, an identification of the volume of the soil needed for the liner must be determined. The department may require the following to be included in the soils investigation:

1. Exploration shall be sufficient to identify and define the quantities and quality of the soil liner materials. The use of test pits, split barrel or thin wall sampling or a combination of these techniques may be used depending on the total area of investigation and the depth to which exploration is needed. The following information, in whole or in part, may be required by the department:

- A. Atterburg limits;
- B. Standard Proctor density (moisture/density relationships);
- C. Coefficient of permeability (undisturbed and remolded);
- D. Depth to bedrock;
- E. Particle size analysis; and
- F. Depth to seasonal high groundwater table; and

2. Information gathered from the investigation should be presented on a base map drawn to scale and referenced to U.S. Geological Survey datum. Slope, landscape position and other surface features should also be included. Stratigraphy of soils should be shown using cross sections or fence diagrams when soil liner material is to be identified. Copies of original boring and other soil test logs shall also be included. An interpretation of the collected data shall be incorporated into the report. Any site constraints and how they will be dealt with should be discussed.

(C) Design. The following criteria are for design and construction of soil liners. Engineering reports, plans and specifications should address these criteria.



1. The soils used for construction of a wastewater stabilization pond liner should meet the following minimum specifications:

A. Be classified under the Unified Soil Classification Systems as Cl, Ch, Gc or Sc;

B. Allow more than fifty percent (50%) passage through a No. 200 sieve;

C. Have a liquid limit equal to or greater than thirty (30);

D. Have a plasticity index equal to or greater than twenty (20); and

E. Have a coefficient of permeability equal to or less than 1×10^{-7} centimeters per second when compacted to ninety percent (90%) of standard proctor density with the moisture content between two percent (2%) below and four percent (4%) above the optimum moisture content;

2. The minimum thickness of the liner is twelve inches (12"). For soils which have a coefficient of permeability greater than 1×10^{-7} centimeter per second, liner thickness of more than twelve inches (12") may be required as set forth in subparagraph (13)(A)4.B. of this rule;

3. Normal construction methods will include scarification and compaction of base material to ninety percent (90%) standard proctor density at a moisture content that allows the material to be plastic. Construction of the liner material should be at a moisture content between two percent (2%) below and four percent (4%) above optimum and compaction of lifts generally not exceeding six inches (6") to greater than ninety percent (90%) standard proctor density. Maximum rock size should not exceed one-half (1/2) of the thickness of the compacted lift. The completed seal shall be maintained at or above the optimum water content until the pond is pre-filled in accordance with subparagraph (13)(A)4.C. of this rule; and

4. If bentonite is proposed to be part of the liner construction, the following must be considered:

A. The bentonite should be high swelling and free flowing for uniform application. The application rate should be a minimum of two pounds (2 lbs.) per square foot. The water content of the soil-bentonite mixture should be at or up to four percent (4%) above the optimum for maximum compaction;

B. The bentonite should be spread with equipment that provides uniform application and minimizes wind drift. The application shall be split, so that one-half (1/2) is applied in one direction and the remaining half in a perpendicular direction on the pond floor and dikes. The bentonite shall be mixed into the soil to a uniform depth of at least four

inches (4") and the liner should be compacted to at least ninety percent (90%) standard proctor density without the use of a sheepsfoot roller. The completed liner shall be covered with at least four inches (4") of fine textured soil and the liner shall be hydrated with fresh water prior to introduction of wastewater and kept at or above optimum water content until the pond is pre-filled; and

C. At sites where the soils are considered to be aggregated cherty clays, the pond bottom below the bentonite seal should be either constructed as embankment or scarified to a depth of twelve inches (12") and compacted in six-inch (6") lifts to at least ninety percent (90%) standard proctor density. At least four inches (4") of fine soil shall be placed on top of the compacted pond bottom for mixing with the bentonite. The maximum size of rocks in the fine soil used for covering the soil-bentonite liner and in the soil-bentonite mixture should be one inch (1").

(D) Synthetic Liners. Requirements for thickness of synthetic seals may vary due to liner material but the liner thickness shall be no less than two hundredths inch (.02") or twenty (20) mil. Consideration should also be given to liners containing reinforcement in appropriate situations, such as sidewall slopes steeper than one to three (1:3) or pond depths greater than six feet (6'). Also in areas of cherty or gravelly soils, consideration should be given to using a geotextile under the liner or very thick polyethylene (80 mil) liners. Special care must be taken to select the appropriate material to perform under existing conditions.

1. Proper site preparations for synthetic liners are essential. The subsoil bed shall be sufficiently prepared to insure that all holes, rocks, stumps and other debris are eliminated. The subsoil shall be sieved or the area raked after grading to provide a smooth, flat surface free of stones and other sharp objects. A bedding of two to four inches (2-4") of sand or clean soil free of stones greater than three-eighths inch (3/8") or other sharp objects shall be provided. Soil shall be well compacted and sterilized to kill vegetation. If gas generation from decaying organic material or air pumping from a fluctuating groundwater table is a potential problem, a method of gas venting must be proposed. The method utilized will be dependent on the existing conditions at the site.

2. Liner panels should be laid out to minimize seams with an overlap of four to six inches (4-6"). Careful application of the seaming method is essential. The anchor trench should have a minimum six-inch (6") depth and be placed at least nine to twelve

inches (9-12") beyond the slope break at the dike. Care must be exercised in the backfilling of the anchor trench to insure the liner is not damaged. To prevent erosion, mechanical damage to the liner and hydraulic uplifting of the liner, a minimum backfill of twelve inches (12") of sand or finely textured soils on the top of the liner is recommended on the pond floor. On the side slopes this should consist of a minimum twelve-inch (12") primary fill of finely textured soil and possibly a minimum six-inch (6") secondary fill of rip-rap.

3. All seams should be inspected and the inspection reports should be submitted to the department prior to seepage testing if required. It is recommended that installation be done by contractors familiar with potential problems which can be encountered.

(E) Asphalt Liners. Asphalt liners have not been tried extensively in Missouri and may be approved on a case-by-case basis. If proposed, the following hydraulic asphalt mix conditions will apply at a minimum. Other conditions may be indicated as requirements based on the project specific review. Due to the potential of the seal lifting and cracking from groundwater and/or from the frost cycles, the groundwater depth and subsurface drainage in the dikes must be carefully considered in the design phase for the asphalt liner to be successful:

1. The aggregate for the mixture shall meet the quality requirements of *Missouri Standard Specification for Highway Construction*, Missouri Highway and Transportation Commission, 1986, section 1002 and shall meet the following gradation requirements of (The Asphalt Institute) Hydraulic Mixtures A and B:

Sieve Size	Percent Passing	
	A	B
3/4"		100
1/2"	100	95-100
3/8"	95-100	84-94
#4	70-84	63-93
#8	52-69	46-65
#16	38-56	34-53
#30	27-44	25-42
#50	19-33	17-32
#100	13-24	12-23
#200	8-15*	8-15*

*Mineral filler may be required to meet the gradation requirements on the No. 200 sieve.

2. The asphalt incorporated into the mixture shall meet the requirements of AC-20, Table 2 of AASHTO designating M226, viscosity graded asphalt cement, except that the minimum penetration shall be eighty (80) rather than sixty (60).

3. Mix design criteria shall be as follows (Marshall Method ASTM D 1559):

- A. Marshall Stability (35 blows/side) five hundred pounds (500 lbs.) minimum;
- B. V.M.A., % 15 minimum;
- C. Air Voids, % 0-2 (target value—1%);

and
D. Asphalt Cement, %
(wt. of total mix) 6.5-9.5.

4. The liner should be constructed in accordance with the requirements specified in *Missouri Standard Specification for Highway Construction*, Missouri Highway and Transportation Commission, section 403, Asphaltic Concrete Pavement, except as modified or supplemented by the following:

- A. The liner shall be four inches (4") thick at a minimum;
- B. The liner shall be constructed in two (2) lifts, with each lift being approximately equal to one-half (1/2) the total surface thickness to within plus or minus one-half inch (1/2") tolerance;

C. Longitudinal joints between paver passes for the second layer should be offset from the joints in the lower layer by three feet (3');

D. Transverse joints in the second layer shall be offset from joints in the lower layer by at least three feet (3');

E. A tack coat of an emulsion such as CSS-1 or CSS-1h diluted one to one (1:1) with water and applied at an approximate rate of ten hundredths gallons (.10 gals.) per square yard should be applied between asphaltic lifts and on all vertical joints prior to placement of the next and/or adjacent lift. The tack coat between two (2) lifts should be uniformly distributed. All tacking should be done in accordance with MSSHC section 407, except as modified as described here; and

F. Placement of the hot-mix asphalt mixture shall be accomplished when the ambient temperature is above and fifty degrees Fahrenheit (50°F);

5. Upon completion of the construction of the hot-mix asphalt concrete liner and prior to filling of the basin with water or sewage, a surface treatment of asphalt cement should be applied to the entire basin to ensure a watertight basin and to reduce the rate of oxidation of the surface of the lining. An AC-20 should be used and applied at a rate of about twenty-five hundredths gallons (.25 gals.) per square yard. Two (2) applications may be necessary to achieve this rate. The surface should be clean, dry and free from loose material prior to the application;

6. The sides of the basin should be designed so that paving equipment may oper-

ate or on a four to one (4:1) slope (horizontal to vertical). The asphaltic surface should be extended up and onto the berm of the basin for a distance of at least three feet (3') beyond the point of intersection of the berm and side slope. This asphalt cap should be constructed around the basin; and

7. The subgrade or base for the slopes and bottom shall be constructed of MSSHC type 2 base material and shall be a minimum of one and one-half inches (1 1/2") and compacted to ninety-five percent (95%) standard proctor density. Prior to construction of the asphaltic concrete liner, the subgrade soil (type 2 base) on all side slopes should be treated with soil sterilants to prevent weed growth through the lining.

AUTHORITY: section 644.026, RSMo Supp. 1988.* Original rule filed July 17, 1961, effective July 27, 1961. Amended: Filed Oct. 3, 1962, effective Oct. 13, 1962. Amended: Filed Dec. 4, 1975, effective Dec. 14, 1975. Rescinded and readopted: Filed Nov. 4, 1988, effective April 15, 1989.

*Original authority 1972, amended 1973, 1987, 1993.

10 CSR 20-8.021 Individual Sewage Treatment Systems Standards
(Rescinded March 30, 1999)

AUTHORITY: section 644.026, RSMo 1986. Original rule filed Nov. 14, 1988, effective April 15, 1989. Rescinded: Filed July 13, 1998, effective March 30, 1999.

10 CSR 20-8.030 Design of Sewage Works
(Rescinded August 13, 1979)

AUTHORITY: section 204.026, RSMo Supp. 1973. Original rule filed July 17, 1961, effective July 27, 1961. Amended: Filed Oct. 3, 1962, effective Oct. 13, 1962. Amended: Filed Dec. 4, 1975, effective Dec. 14, 1975. Rescinded: Filed May 4, 1979, effective Aug. 13, 1979.

Op. Atty. Gen. No. 92, Bockenkamp (3-24-75). The City of Farmington may impose user charges pursuant to section 204.026(18), RSMo (Supp. 1973), to cover costs of operation and/or future expansion of a public sewer treatment facility constructed pursuant to a grant of federal funds under 33 USC, Sections 1281-1292, without the necessity of an election as provided in section 71.715, RSMo (1969).

Op. Atty. Gen. No. 229, Smith (8-20-73). Municipalities and sewer districts have

authority to make the user charges to industries required by the Federal Water Pollution Control Act amendments of 1972 and to establish the reserves for future expansion or reconstruction.

10 CSR 20-8.110 Engineering—Reports, Plans and Specifications

PURPOSE: The following criteria have been prepared as a guide for the preparation of engineering reports or facility plans and detail plans and specifications. This rule is to be used with rules 10 CSR 20-8.120—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 names can be added to the mailing list.

Editor's Note: The secretary of state has determined that the publication of this rule in its entirety would be unduly cumbersome or expensive. The entire text of the material referenced has been filed with the secretary of state. This material may be found at the Office of the Secretary of State or at the headquarters of the agency and is available to any interested person at a cost established by state law.

(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 agency 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 (22,500) gallons (85.4m³) per day or less (see 10 CSR 20-8.020 for the requirements for those facilities).

(3) Engineering services are performed in three (3) steps—engineering report or facilities plan; preparation of construction plans, specifications and contractual documents; and construction compliance, inspection, administration and acceptance. These services are generally performed by engineering firms in private practice but may be executed by municipal, state or federal agencies. All reports, plans and specifications should be submitted at least sixty (60) days prior to the date upon which action by the agency is desired, or in accordance with NPDES or other schedules. The documents, at the appropriate times, should be submitted for formal approval and should include the engineer's report (facilities plan) and design drawings and specifications. For nongrant projects which are unusual or complex, it is suggested that the engineer meet with the appropriate regional office to discuss the project and that preliminary reports be submitted for review prior to the preparation of final plans and specifications. These documents are used by the owner in programming future action, by the agency to evaluate probable compliance with statutes and regulations, by bond attorneys and investment houses to develop and evaluate financing and by the news media. Preliminary reports and plans shall broadly describe existing problems; consider methods for alternate solutions including site and/or route selection; estimate capital and annual costs; and outline steps for further project implementation, including financing and approval by regulatory agencies. No approval for construction can be issued until final, detailed plans and specifications have been submitted to the agency and found to be satisfactory.

(4) Engineering Report or Facility Plan. For construction grant projects the federal regulations describe requirements for the facility plan which must be met. The engineering report, for nongrant projects, assembles basic information; presents design criteria and assumptions; examines alternate projects with preliminary layouts and cost estimates; describes financing methods giving anticipated charges for users; reviews organizational and staffing requirements; offers a conclusion

with a proposed project for client consideration; and outlines official actions and procedures to implement the project. The concept, including process description and sizing, factual data and controlling assumptions and considerations for the functional planning of sewerage facilities are presented for each process unit and for the whole system. These data form the continuing technical basis for detail design and preparation of construction plans and specifications. Architectural, structural, mechanical and electrical designs are usually excluded. Sketches may be desirable to aid in presentation of a project. Outline specifications of process units, special equipment, etc., are occasionally included.

(A) Format for Content and Presentation. It is urged that the following paragraphs be utilized as a guideline for content and presentation of the project engineering report to the agency for review and approval.

1. Title. The wastewater facilities report—collection, conveyance, processing and discharge of wastewater.

2. Letter of transmittal. A one (1) page letter typed on the firm's letterhead and bound into report should include submission of report to the client, statement of feasibility of recommended project, acknowledgment to those giving assistance and reference to project as outgrowth of approved area-wide wastewater management plans.

3. Title page. Title of project; municipality, county or other sponsoring agency; names of officials, managers, superintendents; name and address of firm preparing report; seal and signature of the professional engineer in charge of project.

4. Table of contents. (Number all pages; cross-reference by page number.) Section heading, chapter heading and sub-headings; maps; graphs; illustrations, exhibits; diagrams; appendices.

5. Summary. Highlight, very briefly, what was found from the study.

A. Findings. Population—present, design (when), ultimate; land use and zoning—portion per residential, commercial, industrial, greenbelt, etc.; wastewater characteristics and concentrations—portions of total hydraulic, organic and solids loading attributed to residential, commercial and industrial fractions; collection system projects—immediate needs to implement recommended project, deferred needs to complete recommended project and pump stations, force mains, appurtenances, etc.; selected process and site—characteristics of process expected for effluent quality and description of site, environmental assessment of selected process; receiving waters—existing water quality and quantity, classifications and downstream

water uses and impact of project on receiving water; proposed project—total project costs, total annual expense requirements for debt service; operation, personnel and operation and nonpersonnel; finances—indicate financing requirements and typical annual charges; organization—administrative control necessary to implement project, carry through to completion, operate and maintain wastewater facility and system; and changes—alert client to situations that could alter recommended project.

B. Conclusions. Project(s) recommended to client for immediate construction, suggested financing program and other.

C. Recommendations. Summarized, step-by-step actions, for client to follow to implement conclusions—official acceptance of report; adoption of recommended project; submission of report to agency for review and approval; authorization of engineering services for approved project (construction plans, specifications, contract documents, etc.); legal services; enabling ordinances, resolutions, etc., required; adoption of sewer-use ordinance; adoption of operating rules; financing program requirements; organization and administration (structure, personnel, employment, etc.); time schedules—implementation, construction, completion dates, reflecting applicable hearings, stipulations, abatement orders.

6. Introduction. Purpose—reasons for report and circumstances leading up to report; scope—coordination of recommended project with approved comprehensive master plan and guideline for developing the report.

7. Existing conditions and projections.

A. Planning period. Total period of time for which program is to be studied.

B. Land use. Existing area, expansion, annexation, intermunicipal service, ultimate planning area; drainage basin, portion covered; and residential, commercial and industrial land use, zoning, population densities, industrial types and concentrations.

C. Demographic and economic data. Population growth, trends, increase during design of life of facility (graph); assessed valuation, tax structure, tax rates, portions for residential, commercial, industrial property; employment, from within and outside service area; transportation systems, effect on commuter influx, exempt property (schools, colleges, churches, foundations, governmental agencies, etc.) and effect on project; and costs of present water and wastewater services.

D. General. Topography, general geology and effect on project; and meteorology, precipitation, runoff, flooding, etc. and effect on project.

E. Forecasts of flow and waste loads. Water consumption (total, unit, industrial); wastewater flow pattern, peaks, total design flow; physical, chemical and biological characteristics and concentrations; residential, commercial, industrial, infiltration/inflow fractions, considering organic, solids, toxic, aggressive, etc. substances; tabulate each fraction separately and summarize.

F. Local regulations. Existing ordinances and rules including defects and deficiencies, etc.; recommended amendments, revisions or cancellation and replacement; sewer-use ordinance (toxic, aggressive, volatile, etc. substances) surcharge based on volumes and concentration for industrial wastewaters; existing contracts and agreements (intermunicipal, etc.); and enforcement provisions including inspection, sampling, detection, penalties, etc.

8. Existing facilities evaluation.

A. Existing collection system. Inventory of existing sewers; isolation from water supply wells; adequacy to meet project needs (structural condition, hydraulic capacity tabulation); gauging and infiltration/inflow analysis; overflows and required maintenance, repairs, improvements and methods for control; outline repair, replacement and storm-water separation requirements; evaluation of costs for treating infiltration/inflow versus cost for rehabilitation of system; establish renovation priorities, if selected; present recommended annual program to renovate sewers; and indicate required annual expenditure.

B. Existing treatment plant site. Area for expansion, terrain, subsurface conditions; isolation from habitation; isolation from water supply structures; enclosures of units, odor control, landscaping, etc.; and flooding (predict elevation of twenty-five (25) and one hundred (100)-year flood stage).

C. Existing facilities. Tabulate capacities and adequacy of units (wastewater treatment, sludge processing and sludge disposal); relationship and/or applicability to proposed project; age and condition; adaptability to different usages; structures to be retained, modified or demolished; and outfall.

D. Existing wastewater characteristics. Water consumption from records (total, unit, industrial); wastewater flow pattern, peaks, total design flow (verify accuracy of installed metering equipment); physical, chemical and biological characteristics and concentrations; residential, commercial, industrial, infiltration/inflow fractions, considering organic solids, toxic, aggressive, etc. substances; tabulate each fraction separately and summarize.

E. Evaluation of unsewered communities. Types of existing residential systems and

their construction of deficiencies, operational problems and number of residents served.

9. Basic project development.

A. Proposed collection system. Inventory of proposed additions, isolation from water supply wells, reservoirs, facilities, etc.; area of service; unusual construction problems; utility interruption and traffic interference; restoration of pavements, lawns, etc.

B. Design wastewater characteristics. Character of wastewater necessary to insure amenability to process selected; need to pretreat industrial wastewater before discharge to sewers; portion of residential, commercial, industrial wastewater fractions to comprise projected growth.

C. Receiving water considerations. Upstream wastewater discharges; receiving water base flow; characteristics (concentrations) of receiving waters; downstream water uses including water supply, recreation, agricultural, industrial, etc.; impact of proposed discharge on receiving waters; tabulation of plant performance versus receiving water requirements; listing of effluent characteristics; and correlation of plant performance versus receiving water requirements. A determination from the Department of Natural Resources, Division of Geology and Land Survey, of whether the receiving stream is losing or gaining shall be included in the engineering report (facility plan).

D. Effluent limitations. Allowable concentration of pollutants in the effluent based on 10 CSR 20-7.015 Effluent Regulations.

E. Treatment plant site requirements. Compare advantages and disadvantages relative to cost, hydraulic requirements, flood control, accessibility, enclosure of units, odor control, landscaping, etc. and isolation with respect to potential nuisances and protection of water supply facilities.

F. Alternatives. Consider such items as regional solutions, optimum operation of existing facilities, flow and waste reduction, location of facilities, phased construction, necessary flexibility and reliability, sludge disposal, alternative treatment sites, alternative collection and treatment processes and institutional arrangements.

G. Alternative process and sites. Describe and delineate (line diagrams); preliminary design for cost estimates; estimates of total project cost (dated, keyed to construction cost index, escalated, etc.); advantages and disadvantages of each; individual differences, requirements, limitations; characteristics of process output; comparison of process performances; environmental assessment of each (including both primary and secondary impacts); operation and maintenance

expense and energy requirements; and annual expense requirements (tabulation of annual operation, maintenance, personnel, debt obligation for each alternate).

H. Selected process and site. Identify and justify process and site selected; adaptability to meet initial and future needs; environmental assessment; outfall location; and describe immediate and deferred construction.

I. Project financing. Review applicable, financing methods; effect of state and federal assistance; assessment (a combination of methods should most probably be applied to distribute cost and expenses as equitably as possible in relation to benefit received) by valuation, front foot, area unit or other benefit; charges (a combination of methods should most probably be applied to distribute cost and expenses as equitably as possible in relation to benefit received) by connection, occupancy, readiness-to-serve, water consumption, industrial wastewater discharge, etc.; existing debt service requirements; bond retirement schedule; tabulate all expenses; show how representative properties and users are to be affected; and show anticipated typical annual charge to user and nonuser.

J. Legal and other considerations. Needed enabling legislation, ordinances, rules; statutory requirements and limitations, contractual considerations for intermunicipal cooperation; and public information and education.

(B) Appendices. Technical Information and Design Criteria.

1. Collection system. Design tabulation—flow, size, velocities, etc.; regulator or overflow design; pump station calculations including energy requirements; special appurtenances; stream crossings; and system map (report size).

2. Process facilities. Criteria selection and basis; hydraulic and organic loadings—minimum, average, maximum and effect (wastewater and sludge processes); unit dimensions; rates and velocities; detentions concentrations; recycle; chemical additive control; physical control and flow metering; removals; effluent concentrations, etc. (include a separate tabulation for each unit to handle solid and liquid fractions); energy requirement; and flexibility.

3. Process diagrams. Process configuration, interconnecting piping, processing, flexibility, etc.; hydraulic profile; organic loading profile; solids profile; solids control system; and flow diagram with capacities, etc.

4. Laboratory. Physical and chemical tests and frequency to control process; time for testing; space and equipment requirements; and personnel requirements—number,

type, qualifications, salaries, benefits (tabulate).

5. Operation and maintenance. Routine special maintenance duties; time requirements; tools, spare parts, equipment, vehicles, safety, etc.; maintenance workspace and storage; and personnel requirements—number, type, qualifications, training, salaries, benefits (tabulate).

6. Office space for administrative personnel and records.

7. Personnel services. Locker rooms and lunch rooms.

8. Chemical control. Processes needing chemical addition; chemicals and feed equipment; tabulation of amounts and unit and total costs.

9. Collection systems control. Cleaning and maintenance; regulator and overflow inspection and repair; flow gauging; industrial sampling and surveillance; ordinance enforcement; equipment requirements; trouble-call investigation; and personnel requirements—number, type, qualifications, salaries, benefits, training (tabulate).

10. Control summary. Personnel; equipment; chemicals, utilities, list power requirements of major units; and summation.

11. Support data. Outline unusual specifications, construction materials and construction methods; maps, photographs, diagrams; and other.

(5) Preliminary Design Review. On all grant projects the consulting engineer shall submit the project for review at approximately a twenty percent (20%) design stage. The design information to be submitted shall include a layout of the study area delineating all proposed improvements, including subareas, with contributing flows and design populations. All calculations regarding sizing of lift stations and treatment plant units shall also be included. A conference between the consultant and the review engineer may be arranged to discuss the project.

(6) Plans.

(A) General. All plans for sewage works shall bear a suitable title showing the name of the municipality, sewer district or institution; and shall show the scale in feet, a graphical scale, the north point, data and the name of the engineer, certificate number and imprint of his/her registration seal. A space should be provided for signature and/or approval stamp of the appropriate reviewing and approving officials and/or agencies. The plans shall be clear and legible (suitable for microfilming). They shall be drawn to a scale which will permit all necessary information to be plainly shown. The size of the plans generally

should not be larger than thirty by forty-two inches (30" × 42") (76 cm × 107 cm). Datum used should be indicated. Locations and logs of test borings, when made, shall be shown on the plans. Blueprints shall not be submitted. Detail plans shall consist of plan views, elevations, sections and supplementary views which, together with the specifications and general layouts, provide the working information for the contract and construction of the works. Include dimensions and relative elevations of structures, the location and outline form of equipment, location and size of piping, water levels and ground elevations.

(B) Plans of Sewers.

1. General plan. A comprehensive plan of the existing and proposed sewers shall be submitted for projects involving new sewer systems and substantial additions to existing systems. This plan shall show the following:

A. Geographical features. Existing or proposed streets and all streams or water surfaces shall be clearly shown. Contour lines at suitable intervals should be included. The direction of flow in all streams and high and low water elevations of all water surfaces at sewer outlets and overflows shall be shown. The boundary lines of the municipality and the sewer district or area to be sewered shall be shown.

B. Sewers. The plan shall show the location, size and direction of flow of all existing and proposed sanitary and combined sewers draining to the treatment works concerned.

2. Detail plans. Detail plans shall be submitted. Profiles should have a horizontal scale of not more than one hundred feet (100') to the inch (12 m to the cm) and a vertical scale of not more than ten feet (10') to the inch (12 dm to the cm). Plan view should be drawn to a corresponding horizontal scale. Plans and profiles shall show—

A. Location of streets and sewers;

B. Line of ground surface, pipe size, length between manholes, invert and surface elevation at each manhole, grade of sewer between each two (2) adjacent manholes and pipe material and type where special construction features are required. All manholes shall be numbered on the plan and correspondingly numbered on the profile. Where there is any question of the sewer being sufficiently deep to serve any residence, the elevation and location of the basement floor shall be plotted on the profile of the sewer which is to serve the house in question. The engineer shall state that all sewers are sufficiently deep to serve adjacent basements except where otherwise noted on the plans;

C. Locations of all special features such as inverted siphons, concrete encasements, elevated sewers, etc.;

D. All known existing structures and utilities both above and below ground which might interfere with the proposed construction, particularly water mains, gas mains and storm drains; and

E. Special detail drawings, made to a scale to clearly show the nature of the design and the following particulars: all stream crossings and sewer outlets, with elevations of the stream bed and of normal and extreme high and low water levels; details of all special sewer joints and cross sections; details of all sewer appurtenances such as manholes, lampholes, inspection chambers, inverted siphons, regulators, tide gates and elevated sewers.

(C) Plans of Sewage Pumping Stations.

1. Location plan. A plan shall be submitted for projects involving construction or revision of pumping stations. This plan shall show the following: the location and extent of the tributary area; any municipal boundaries with the tributary area; the location of the pumping station and force main; and pertinent elevations.

2. Detail plans. Detail plans shall be submitted showing the following, where applicable:

A. Topography of the site;

B. Existing pumping station;

C. Proposed pumping station, including provisions for installation of future pumps or ejectors;

D. Elevation of high water at the site and maximum elevation of sewage in the collection system upon occasion of power failure;

E. Maximum hydraulic gradient in downstream gravity sewers when all installed pumps are in operation; and

F. Test boring and groundwater elevations.

(D) Plans of Sewage Treatment Plants.

1. Location plan. A plan shall be submitted showing the sewage treatment plant in relation to the remainder of the system. Sufficient topographic features shall be included to indicate its location with relation to streams and the point of discharge of treated effluent.

2. General layout. Layouts of the proposed sewage treatment plant shall be submitted showing topography of the site; size and location of plant structures; schematic flow diagram showing the flow through various plant units and for the various utility systems serving the plant processes; piping, including any arrangement for bypassing individual units; materials handled and direction

of flow through pipes; hydraulic profiles showing the flow of sewage, supernatant liquid and sludge; test borings; and groundwater elevations shall be provided.

3. Detail plans shall show the following, unless otherwise covered by the specifications or engineer's reports—location, dimensions and elevations of all existing and proposed plant facilities; elevation of high and low water level of the body of water to which the plant effluent is to be discharged; type, size, pertinent features and operating capacity of all pumps, blowers, motors and other mechanical devices; minimum, average and maximum hydraulic flow in profile; and adequate description of any other features pertinent to the design.

(7) Specifications. Complete technical specifications for the construction of sewers, sewage pumping stations, sewage treatment plants and all appurtenances shall accompany the plans. The specifications accompanying construction drawings shall include, but not be limited to, all construction information not shown on the drawings which is necessary to inform the builder in detail of the design requirements as to the quality of materials and workmanship and fabrication of the project and the type, size, strength, operating characteristics and rating of equipment; allowable infiltration; the complete requirements for all mechanical and electrical equipment, including machinery, valves, piping and jointing of pipe; electrical apparatus, wiring, instrumentation and meters; laboratory fixtures and equipment; operating tools; construction materials; special filter materials such as stone, sand, gravel or slag; miscellaneous appurtenances; chemicals when used; instructions for testing materials and equipment as necessary to meet design standards; and performance tests for the completed works and component units. It is suggested that these performance tests be conducted at design load conditions wherever practical.

(8) Revisions to Approved Plans. Any deviations from approved plans or specifications affecting capacity, flow, operation of units or point of discharge shall be approved in writing before such changes are made. Plans or specifications so revised should be submitted therefore, well in advance of any construction work which will be affected by the changes, to permit sufficient time for review and approval. Structural revisions or other minor changes not affecting capacities, flows or operation will be permitted during construction without approval. As-built plans clearly showing the alterations shall be submitted to the agency at the completion of the work.

(9) Operation During Construction. Specifications shall contain a program for keeping existing treatment plant units in operation during construction of plant additions. Should it be necessary to take plant units out of operation, a shutdown schedule which will minimize pollutional effects on the receiving stream shall be reviewed and approved in advance by the agency and shall be adhered to.

*AUTHORITY: section 644.026, RSMo 1986. * Original rule filed Aug. 10, 1978, effective March 11, 1979.*

**Original authority 1972, amended 1973, 1987, 1993.*

10 CSR 20-8.120 Design of Sewers

PURPOSE: The following criteria have been prepared as a guide for the design of sewers. 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 names can be added to the mailing list.

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(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 agency 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 (22,500) gallons per day (85.4m³) or less (see 10 CSR 20-8.020 for the requirements for those facilities).

(3) Approval of Sewers. In general, the agency will approve plans for new systems, extensions to new areas or replacement sanitary sewers only when designed upon the separate plan, in which rainwater from roofs, streets and other areas and groundwater from foundation drains are excluded.

(4) Design Capacity. In general, sewer capacities should be designed for the estimated ultimate tributary population, except in considering parts of the systems that can be readily increased in capacity. Similarly, consideration should be given to the maximum anticipated capacity of institutions, industrial parks, etc. Where future relief sewers are programmed, economic analysis of alternatives should accompany initial permit applications. In determining the required capacities of sanitary sewers, the following factors should be considered: maximum hourly domestic sewage flow; additional maximum sewage or waste flow from industrial plants; inflow and groundwater infiltration; topography of area; location of sewage treatment plant; depth of excavation; and pumping requirements. The basis of design for all sewer projects shall accompany the plan documents. More detailed computations may be required by the agency for critical projects.

(5) Design Flow.

(A) Per Capita Flow. New sewer systems shall be designed on the basis of an average daily per capita flow of sewage of not less than one hundred (100) gallons per day (.38m³/day). This figure is assumed to cover normal infiltration but an additional allowance should be made where conditions are unfavorable. For existing sewer systems an additional per capita allowance shall be made where the average annual flow exceeds this value and immediate remedial measures are not proposed.

(B) Peak Design Flow. Sanitary sewers shall be designed on a peak design flow basis

using one (1) of the following methods: the ratio of peak to average daily flow as determined from the quotient of eighteen (18) plus the square root of the population in thousands divided by four (4) plus the square root of population in thousands or values established from an infiltration/inflow study acceptable to the agency. Use of other values for peak design flow will be considered if justified on the basis of extensive documentation.

(C) Combined Sewer Interceptors. In addition to the requirements in subsection (5)(B) of this rule, interceptor sewers that will receive combined sewage shall have sufficient additional capacity to insure attainment of the appropriate state and federal water quality standards.

(6) Details of Design and Construction.

(A) Minimum Size. Gravity collector sewers conveying raw sewage shall be no less than eight inches (8") (20 cm) in diameter, except in unusual circumstances where smaller diameter pipe can be justified.

(B) Depth. In general, sewers should be sufficiently deep so as to receive sewage from basements and to prevent freezing and to protect them from superimposed loads. Insulation shall be provided for sewers that cannot be placed at a depth sufficient to prevent freezing.

(C) Slope.

1. All sewers shall be so designed and constructed to give mean velocities, when flowing full, of not less than two feet (2') per second (0.61m/s), based on Kutter's formula using an "n" value of 0.013. The following are the minimum slopes which should be provided; however, slopes greater than this are desirable:

Sewer Size	Minimum Slope in Feet Per 100 Feet (m/100 m)
8 in. (20 cm)	0.40
9 in. (23 cm)	0.33
10 in. (25 cm)	0.28
12 in. (30 cm)	0.22
14 in. (36 cm)	0.17
15 in. (38 cm)	0.15
16 in. (41 cm)	0.14
18 in. (46 cm)	0.12
21 in. (53 cm)	0.10
24 in. (61 cm)	0.08
27 in. (69 cm)	0.067
30 in. (76 cm)	0.058
36 in. (91 cm)	0.046

2. The pipe diameter and slope shall be selected to obtain the greatest practical velocities to minimize settling problems. Slopes slightly less than those required for the 2.0 feet per second (0.61m/s) velocity when

flowing full may be permitted. Decreased slopes will only be considered where the depth of flow will be 0.3 of the diameter or greater and the velocity from partial flow determination will be 0.9 feet per second (27.4 cm/s) or greater based on design average flow. These reduced slopes may result in better flow characteristics at design flow than minimum slope in a larger pipe. Whenever the decreased slopes are selected, the design engineer must furnish with his/her report computations of the anticipated flow velocities of average and daily or weekly peak flow rates. The operating authority of the sewer system will give written assurance to the agency that any additional sewer maintenance required by reduced slopes will be provided.

3. Sewers shall be laid with uniform slope between manholes.

4. Where velocities greater than fifteen feet (15') per second (4.6m/s) are attained, special provision shall be made to protect against displacement by erosion and shock.

5. Sewers on twenty percent (20%) slope or greater shall be anchored securely with concrete anchors or equal, spaced as follows: not over thirty-six feet (36') (11m) center-to-center on grades twenty percent (20%) and up to thirty-five percent (35%); not over twenty-four feet (24') (7.3m) center-to-center on grades thirty-five percent (35%) and up to fifty percent (50%); and not over sixteen feet (16') (4.9m) center-to-center on grades fifty percent (50%) and over.

(D) Alignment. Sewers twenty-four inches (24") (61 cm) or less shall be laid with straight alignment between manholes. The alignment shall be checked by either using a laser beam or lamping.

(E) Changes in Pipe Size. When a smaller sewer joins a larger one, the invert of the larger sewer should be lowered sufficiently to maintain the same energy gradient. An approximate method for securing these results is to place the 0.8 depth point of both sewers at the same elevation. Sewer extensions should be designed for projected flows even when the diameter of the receiving sewer is less than the diameter of the proposed extension. The agency may require a schedule for future downstream sewer relief.

(F) Materials. Any generally accepted material for sewers will be given consideration but the material selected should be adapted to local conditions, such as character of industrial wastes, possibility of septicity, soil characteristics, exceptionally heavy external loadings, abrasion and similar problems. All sewers shall be designed to prevent damage from superimposed loads. Proper allowance for loads on the sewer shall be made because of the width and depth of the

trench. Where necessary to withstand extraordinary superimposed loading, special bedding, concrete cradle or special construction may be used.

(G) Installation.

1. Standards. Installation specifications shall contain appropriate requirements based on the criteria, standards and requirements established by industry in its technical publications. Requirements shall be set forth in the specifications for the pipe and methods of bedding and backfilling thereof so as not to damage the pipe or its joints, impede cleaning operations and future tapping nor create excessive side fill pressures or ovalation of the pipe nor seriously impair flow capacity.

2. Trenching.

A. The width of the trench shall be ample to allow the pipe to be laid and jointed properly and to allow the backfill to be placed and compacted as needed. The trench sides shall be kept as nearly vertical as possible. When wider trenches are dug, appropriate bedding class and pipe strength shall be used.

B. Ledge rock, boulders and large stones shall be removed to provide a minimum clearance of four inches (4") (10 cm) below and on each side of all pipe.

3. Bedding.

A. Concrete or well-graded granular material (bedding classes A, B or C as described in ASTM C12-74 or WPCP MOP No. 9) shall be used for all rigid pipe provided the proper strength pipe is used with the specified bedding to support the anticipated load.

B. Concrete or well-graded granular material (bedding classes I, II or III as described in ASTM D2321-74) shall be used for all flexible pipe provided the proper strength pipe is used with the specified bedding to support the anticipated load.

4. Backfill.

A. Backfill shall be of a suitable material removed from excavation except where other material is specified. Debris, frozen material, large clods or stones, organic matter or other unstable materials shall not be used for backfill within two feet (2') (0.61 m) of the top of the pipe.

B. Backfill shall be placed in a manner as not to disturb the alignment of the pipe.

5. Deflection test.

A. Deflection tests shall be performed on all flexible pipe. The test shall be run not less than thirty (30) days after final backfill has been placed.

B. No pipe shall extend a deflection of five percent (5%).

C. If the deflection test is to be run using a rigid ball or mandrels, they shall have diameters equal to ninety-five percent (95%) of the inside diameter of the pipe and the tests shall be performed without mechanical pulling devices.

(H) Joints and Infiltration.

1. Joints. The installation of joints and the materials used shall be included in the specifications. Sewer joints shall be designed to minimize infiltration and to prevent the entrance of roots throughout the life of the system.

2. Leakage tests. Leakage tests shall be specified. This may include appropriate water or low pressure air testing. The leakage outward or inward (exfiltration or infiltration) shall not exceed two hundred (200) gallons per inch of pipe diameter per mile per day (0.19m³/cm of pipe dia./km/day) for any section of the system. An exfiltration or infiltration test shall be performed with a minimum positive head of two feet (2') (0.61m). The air test, if used, as a minimum shall conform to the test procedure described in ASTM C-828-76T, entitled *Tentative Recommended Practice for Low-Pressure Air Test of Vitrified Clay Pipe Lines*. The testing methods selected should take into consideration the range in groundwater elevations projected and the situation during the test. For the purpose of leakage tests, manholes shall be considered pipe of equivalent diameter and shall be tested by an appropriate test method.

(7) Manholes.

(A) Location. Manholes shall be installed at the end of each line; at all changes in grade, size or alignment; at all intersections; and at distances not greater than four hundred feet (400') (120 m) for sewers fifteen inches (15") (38 cm) or less and five hundred feet (500') (150m) for sewers eighteen inches to thirty inches (18"—30") (46 cm—76 cm), except that distances up to six hundred feet (600') (180m) may be approved in cases where adequate modern cleaning equipment for such spacing is provided. Greater spacing may be permitted in larger sewers. Cleanouts may be used only for special conditions and shall not be substituted for manholes nor installed at the end of laterals greater than one hundred fifty feet (150') (46m) in length.

(B) Drop Type. A drop pipe should be provided for a sewer entering a manhole at an elevation of twenty-four inches (24") (61 cm) or more above the manhole invert. Where the difference in elevation between the incoming sewer and the manhole invert is less than twenty-four inches (24") (61 cm), the invert should be filleted to prevent solids deposition. Drop manholes should be constructed

with outside drop connection. Inside drop connections (when necessary) shall be secured to the interior wall of the manhole and provide access for cleaning. Due to the unequal earth pressures that would result from the backfilling operation in the vicinity of the manhole, the entire outside drop connection shall be encased in concrete.

(C) Diameter. The minimum interior diameter of manholes shall be forty-two inches (42") (1.07m) on eight-inch (8") (20 cm) diameter gravity sewer lines and forty-eight inches (48") (1.22m) on all sewer lines larger than eight inches (8") (20 cm) in diameter. Larger diameter manholes are necessary for large diameter sewers in order to maintain structural integrity. A minimum access diameter of twenty-two inches (22") (56 cm) shall be provided.

(D) Flow Channel. The flow channel through manholes should be made to conform in shape and slope to that of the sewers.

(E) Watertightness. Manholes shall be of the precast concrete or poured in place concrete type. Manholes shall be waterproofed on the exterior. Inlet and outlet pipes shall be joined to the manhole with a gasketed flexible watertight connection or any watertight connection arrangement that allows differential settlement of the pipe and manhole wall to take place. Watertight manhole covers are to be used wherever the manhole tops may be flooded by street runoff or high water. Locked manhole covers may be desirable in isolated easement locations or where vandalism may be a problem.

(F) Electrical. Electrical equipment installed or used in manholes shall conform to 10 CSR 20-8.130(4)(C)5.

(8) Inverted Siphons. Inverted siphons should have not less than two (2) barrels, with a minimum pipe size of six inches (6") (15 cm) and shall be provided with necessary appurtenances for convenient flushing and maintenance; the manholes shall have adequate clearances for rodding; and in general, sufficient head shall be provided and pipe sizes selected to secure velocities of at least 3.0 feet per second (0.92m/s) for average flows. The inlet and outlet details shall be arranged so that the normal flow is diverted to one (1) barrel and so that either barrel may be cut out-of-service for cleaning. The vertical alignment should permit cleaning and maintenance.

(9) Sewers in Relation to Streams.

(A) Location of Sewers on Streams.

1. Cover depth. The top of all sewers entering or crossing streams shall be at a sufficient depth below the natural bottom of the

stream bed to protect the sewer line. In general, the following cover requirements must be met: one foot (1') (0.3m) of cover is required where the sewer is located in rock; three feet (3') (0.9m) of cover is required in other material (in major streams, more than three feet (3') (0.9m) of cover may be required); in paved stream channels, the top of the sewer line should be placed below the bottom of the channel pavement. Less cover will be approved only if the proposed sewer crossing will not interfere with the future improvements to the stream channel. Reasons for requesting less cover should be given in the project proposal.

2. Horizontal location. Sewers located along streams shall be located outside of the stream bed and sufficiently removed therefrom to provide for future possible stream widening and to prevent pollution by siltation during construction.

3. Structures. The sewer outfalls, head walls, manholes, gateboxes or other structures shall be so located that they do not interfere with the free discharge of flood flows of the streams.

4. Alignment. Sewers crossing streams should be designed to cross the stream as nearly perpendicular to the stream flow as possible and shall be free from change in grade. Sewer systems shall be designed to minimize the number of stream crossings.

(B) Construction.

1. Materials. Sewers entering or crossing streams shall be constructed of cast- or ductile-iron pipe with mechanical joints or shall be so otherwise constructed that they will remain watertight and free from changes in alignment or grade. Material used to backfill the trench shall be stone, coarse aggregate, washed gravel or other materials which will not cause siltation.

2. Siltation and erosion. Construction methods that will minimize siltation and erosion shall be employed. The design engineer shall include in the project specifications the method(s) to be employed in the construction of sewers in or near streams to provide adequate control of siltation and erosion. Specifications shall require that clean-up, grading, seeding, planting or restoration of all work areas shall begin immediately and exposed areas shall not remain unprotected for more than seven (7) days.

(10) Aerial Crossings. Support shall be provided for all joints in pipes utilized for aerial crossings. The supports shall be designed to prevent frost heave, overturning and settlement. Precautions against freezing, such as insulation and increased slope, shall be provided. Expansion jointing shall be provided

between above-ground and below-ground sewers. For aerial stream crossings, the impact of flood waters and debris shall be considered. The bottom of the pipe should be placed no lower than the elevation of the fifty (50)-year flood.

(11) Protection of Water Supplies.

(A) Water Supply Interconnections. There shall be no physical connections between a public or private potable water supply system and a sewer, or appurtenance thereto which would permit the passage of any sewage or polluted water into the potable supply. No water pipe shall pass through or come in contact with any part of a sewer manhole.

(B) Relation to Water Works Structures. While no general statement can be made to cover all conditions, it is generally recognized that sewers shall meet the requirements of 10 CSR 60-2.010 with respect to minimum distances from public water supply wells or other water supply sources and structures.

(C) Relation to Water Mains.

1. Horizontal separation. Sewer mains shall be laid at least ten feet (10') (3.0m) horizontally from any existing or proposed water main. The distances shall be measured edge-to-edge. In cases where it is not practical to maintain a ten foot (10')-separation, the agency may allow deviation on a case-by-case basis, if supported by data from the design engineer. This deviation may allow installation of the sewer closer to a water main, provided that the water main is in a separate trench or on an undisturbed earth shelf located on one (1) side of the sewer at an elevation that the bottom of the water main is at least eighteen inches (18") (46 cm) above the top of the sewer.

2. Crossings. Sewers crossing water mains shall be laid to provide a minimum vertical distance of eighteen inches (18") (46 cm) between the outside of the water main and the outside of the sewer. This shall be the case where the water main is either above or below the sewer. The crossing shall be arranged so that the sewer joints will be equidistant and as far as possible from the water main joints. When a water main crosses under a sewer, adequate structural support shall be provided for the sewer to prevent damage to the water main.

3. Special conditions. When it is impossible to obtain proper horizontal and vertical separation as stipulated previously, the sewer shall be designed and constructed equal to water pipe and shall be pressure tested to assure watertightness prior to backfilling.

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**Original authority 1972, amended 1973, 1987, 1993.*

10 CSR 20-8.130 Sewage Pumping Stations

PURPOSE: The following criteria have been prepared as a guide for the design of sewage pumping stations. 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 names can be added to the mailing list.

Editor's Note: The secretary of state has determined that the publication of this rule in its entirety would be unduly cumbersome or expensive. The entire text of the material referenced has been filed with the secretary of state. This material may be found at the Office of the Secretary of State or at the headquarters of the agency and is available to any interested person at a cost established by state law.

(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 agency 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 (22,500) gallons per day (85.4m³) or less, see 10 CSR 20-8.020 for the requirements for those facilities.

(3) General.

(A) Flooding. Sewage pumping station structures and electrical and mechanical equipment shall be protected from physical damage by the one hundred (100)-year flood. Sewage pumping stations should remain fully operational and accessible during the twenty-five (25)-year flood.

(B) Accessibility. The pumping station shall be readily accessible by maintenance vehicles during all weather conditions. The facility should be located off the traffic way of streets and alleys.

(C) Grit. Where it is necessary to pump sewage prior to grit removal, the design of the wet well and pump station piping shall receive special consideration to avoid operational problems from the accumulation of grit.

(4) Design.

(A) Type. Sewage pumping stations should be of the wet/dry well type. Other types as set forth under sections (5) and (6) of this rule may be approved where circumstances justify their use.

(B) Structures.

1. Separation. Dry wells, including their superstructure, shall be completely separated from the wet well.

2. Equipment removal. Provision shall be made to facilitate removing pumps, motors and other mechanical and electrical equipment.

3. Access. Suitable and safe means of access shall be provided to dry wells and to wet wells containing either bar screens or mechanical equipment requiring inspection or maintenance. For built-in-place pump stations, a stairway with rest landings shall be provided at vertical intervals not to exceed twelve feet (12') (3.7m). For factory-built pump stations over fifteen feet (15') (4.6m) deep, a rigidly fixed landing shall be provided at vertical intervals not to exceed ten feet (10') (3.0m). Where a landing is used, a suitable and rigidly fixed barrier shall be provided to prevent an individual from falling past the intermediate landing to a lower level. Where approved by the agency, a manlift or elevator may be used in lieu of landings in a factory-built station, provided emergency access is included in the design. Reference should be made to local, state and federal safety codes and, if they are more stringent, they shall govern (also see 10 CSR 20-8.140(8)(F)).

4. Construction materials. Due consideration shall be given to the selection of materials because of the presence of hydrogen sulfide and other corrosive gases, greases, oils and other constituents frequently present in sewage.

(C) Pumps and Pneumatic Ejectors.

1. Multiple units. At least two (2) pumps or pneumatic ejectors shall be provided. A minimum of three (3) pumps should be provided for stations handling flows greater than one (1) mgd (3800m³/d). If only two (2) units are provided, they should have the same capacity. Each shall be capable of handling flows in excess of the expected maximum flow. Where three (3) or more units are provided, they should be designed to fit actual flow conditions and must be of a capacity that with any one (1) unit out-of-service the remaining units will have capacity to handle maximum sewage flows.

2. Protection against clogging. Pumps handling combined sewage shall be preceded by readily accessible bar racks to protect the pumps from clogging or damage. Bar racks should have clear openings not exceeding two and one-half inches (2 1/2") (6.4 cm). Where a bar rack is provided, a mechanical hoist shall also be provided. Where the size of the installation warrants, mechanically cleaned and/or duplicate bar racks shall be provided. Pumps handling separate sanitary sewage from thirty inches (30") (76 cm) or larger diameter sewers shall be protected by bar racks meeting these requirements. Appropriate protection from clogging shall also be considered for small pumping stations.

3. Pump openings. Except where grinder pumps are used, pumps shall be capable of passing spheres of at least three inches (3") (7.6 cm) in diameter and pump suction and discharge piping shall be at least four inches (4") (10.2 cm) in diameter.

4. Priming. The pump shall be so placed that under normal operating conditions it will operate under a positive suction head, except as specified in section (5) of this rule.

5. Electrical equipment. Electrical systems and components (for example, motors, lights, cables, conduits, switchboxes, control circuits, etc.) in enclosed or partially enclosed spaces where hazardous concentrations of flammable gases or vapors may be present, including raw sewage wet wells, shall be suitable for hazardous locations (National Electrical Code, Class I, Group D, Division 1 location). In addition, equipment located in the wet well shall be suitable for use under corrosive conditions. Each flexible cable shall be provided with watertight seal and separate strain relief. A fused disconnect switch located above ground shall be provided

for all pumping stations. When the equipment is exposed to weather, it shall meet the requirements of weather proof equipment (NEMA 3R).

6. Intake. Each pump should have an additional individual intake. Wet well design should be such as to avoid turbulence near the intake. Intake piping should be as straight and short as possible.

7. Dry well de-watering. A separate sump pump equipped with dual check valves shall be provided in the dry wells to remove leakage or drainage with the discharge located as high as possible. A connection to the pump suction is also recommended as an auxiliary feature. Water ejectors connected to a potable water supply will not be approved. All floor and walkway surfaces should have an adequate slope to a point of drainage. Pump seal water shall be piped to the sump.

8. Pumping rates. The pumps and controls of main pumping stations and especially pumping stations pumping to the treatment works or operated as part of the treatment works should be selected to operate at varying delivery rates to permit discharging sewage at approximately its rate of delivery to the pump station. Design pumping rates should be established in accordance with 10 CSR 20-8.120(5) or 10 CSR 20-8.140(5)(C)1. as appropriate.

(D) Controls.

1. Type. Control systems shall be of the air bubbler type, the encapsulated float type or the flow measuring type. Float tube control systems on existing stations being upgraded may be approved. The electrical equipment shall be suitable for hazardous locations (National Electrical Code, Class I, Group D, Division 1 location).

2. Location. The control system shall be located away from the turbulence of incoming flow and pump suction.

3. Alternation. In small stations, provisions should be made to automatically alternate the pumps in use.

(E) Valves.

1. Suitable shutoff valves shall be placed on the suction line of each pump except on submersible and vacuum primed pumps.

2. Suitable shutoff and check valves shall be placed on the discharge line of each pump. The check valve shall be located between the shutoff valve and the pump. Check valves shall be suitable for the material being handled. Check valves shall not be placed on the vertical portion of discharge piping. Valves shall be capable of withstanding normal pressure and water hammer. Where limited pump backspin will not damage the pump and low discharge head conditions exist, short individual force mains for

each pump may be considered in lieu of discharge valves.

3. Valves shall not be located in the wet well.

(F) Wet Wells.

1. Divided wells. Consideration should be given to dividing the wet well into multiple sections, properly interconnected, to facilitate repairs and cleaning.

2. Size. The wet well size and control setting shall be appropriate to avoid heat buildup in the pump motor due to frequent starting and to avoid septic conditions due to excessive detention time.

3. Floor slope. The wet well floor shall have a minimum slope of one to one (1:1) to the hopper bottom. The horizontal area of the hopper bottom shall not be greater than necessary for proper installation and function of the inlet.

(G) Ventilation. Adequate ventilation shall be provided for all pump stations. Where the pump pit is below the ground surface, mechanical ventilation is required, so arranged as to independently ventilate the dry well and the wet well if screens or mechanical equipment requiring maintenance or inspection are located in the wet well. There shall be no interconnection between the wet well and dry well ventilation systems. In pits over fifteen feet (15') (4.6m) deep, multiple inlets and outlets are desirable. Dampers should not be used on exhaust or fresh air ducts and fine screens or other obstructions in air ducts should be avoided to prevent clogging. Switches for operation of ventilation equipment should be marked and located conveniently. All intermittently operated ventilating equipment shall be interconnected with the respective pit lighting system. Consideration should be given also to automatic controls where intermittent operation is used. The fan wheel should be fabricated from non-sparking material. Consideration should be given to installation of automatic heating and/or dehumidification equipment.

1. Wet wells. Ventilation may be either continuous or intermittent. Ventilation, if continuous, shall provide at least twelve (12) complete air changes per hour, if intermittent, at least thirty (30) complete air changes per hour. Air shall be forced into the wet well rather than exhausted from the wet well.

2. Dry wells. Ventilation may be either continuous or intermittent. Ventilation, if continuous, shall provide at least six (6) complete air changes per hour, if intermittent, at least thirty (30) complete air changes per hour.

(H) Flow Measurement. Suitable devices for measuring sewage flow should be considered at all pumping stations.

(I) Water Supply. There shall be no physical connection between any potable water supply and a sewage pumping station which under any conditions might cause contamination of the potable water supply. If a potable water supply is brought to the station, it should comply with conditions stipulated under 10 CSR 20-8.140(8)(B).

(5) Suction Lift Pumps. Suction lift pumps shall be of the self priming or vacuum priming type and shall meet the applicable requirements under section (4) of this rule. Suction lift pump stations using dynamic suction lifts exceeding the limits outlined in the following subsections may be approved by the agency upon submission of factory certification of pump performance and detail calculations indicating satisfactory performance under the proposed operating conditions. Detail calculations must include static suction lift as measured from “lead pump off” elevation to center line of pump suction, friction and other hydraulic losses of the suction piping, vapor pressure of the liquid, altitude correction, required net positive suction head and a safety factor of at least six feet (6') (1.8m). The pump equipment compartment shall be above grade or offset and shall be effectively isolated from the wet well to prevent the humid and corrosive sewer atmosphere from entering the equipment compartment. Wet well access shall not be through the equipment compartment. Valving shall not be located in the wet well.

(A) Self-Priming Pumps. Self-priming pumps shall be capable of rapid priming and repriming at the “lead pump on” elevation. This self-priming and repriming shall be accomplished automatically under design operating conditions. Suction piping should not exceed the size of the pump suction and shall not exceed twenty-five feet (25') (7.6m) in total length. Priming lift at the “lead pump on” elevation shall include a safety factor of at least four feet (4') (1.2m) from the maximum allowable priming lift for the specific equipment at design operating conditions. The combined total of dynamic suction lift at the “pump off” elevation and required net positive suction head at design operating conditions shall not exceed twenty-two feet (22') (6.7m).

(B) Vacuum Priming Pumps. Vacuum priming pump stations shall be equipped with dual vacuum pumps capable of automatically and completely removing air from the suction lift pump. The vacuum pumps shall be adequately protected from damage due to sewage. The combined total of dynamic suction lift at the “pump off” elevation and required net positive suction head at design

operating conditions shall not exceed twenty-two feet (22') (6.7m).

(6) Submersible Pump Stations. Submersible pump stations shall meet the applicable requirements under section (4) of this rule, except as modified in this section.

(A) Construction. Submersible pumps and motors shall be designed specifically for raw sewage use, including totally submerged operation during a portion of each pumping cycle. An effective method to detect shaft seal failure or potential seal failure shall be provided and the motor shall be of squirrel-cage type design without brushes or other arc-producing mechanisms.

(B) Pump Removal. Submersible pumps shall be readily removable and replaceable without de-watering the wet well or disconnecting any piping in the wet well.

(C) Electrical.

1. Power supply and control. Electrical supply and control circuits shall be designed to allow disconnection at a junction box located or accessible from outside the wet well. Terminals and connectors shall be protected from corrosion by location outside of the wet well or by watertight seals.

2. Controls. The motor control center shall be located outside the wet well and be protected by a conduit seal to prevent the atmosphere in the wet well from gaining access to the control center. The seal shall be located so that the motor may be removed and electrically disconnected without disturbing the seal.

3. Power cord. Pump motor power cords shall be designed for flexibility and serviceability under conditions of extra hard usage and shall meet the requirements of the Mine Safety and Health Administration for trailing cables. Ground fault interruption protection shall be used to de-energize the circuit in the event of any failure in the electrical integrity of the cable. Power cord terminal fittings shall be corrosion resistant and be constructed in a manner to prevent the entry of moisture into the cable, shall be provided with strain relief appurtenances and shall be designed to facilitate field connecting.

(D) Valves. Valves required under subsection (4)(E) of this rule shall be located in a separate valve pit. Accumulated water shall be drained to the wet well or to the soil. If the valve pit is drained to the wet well, an effective method shall be provided to prevent sewage from entering the pit during surcharged wet well conditions.

(7) Alarm Systems. Alarm systems shall be provided for pumping stations. The alarm shall be activated in cases of power failure,

pump failure, use of the lag pump, unauthorized entry or any cause of pump station malfunction. Pumping station alarms shall be telemetered, including identification of the alarm condition, to a municipal facility that is manned twenty-four (24) hours a day. If such a facility is not available and twenty-four (24)-hour holding capacity is not provided, the alarm shall be telemetered to city offices during normal working hours and to the home of the person(s) responsible in charge of the lift station during off-duty hours. Audiovisual alarm systems with a self-contained power supply may be acceptable in some cases in lieu of the telemetering system outlined in this section, depending upon location, station holding capacity and inspection frequency.

(8) Emergency Operation. Pumping stations and collection systems shall be designed to prevent or minimize bypassing of raw sewage. For use during possible periods of extensive power outages, mandatory power reductions or uncontrolled storm events, consideration should be given to providing a controlled, high-level wet well overflow to supplement alarm systems and emergency power generation in order to prevent backup of sewage into basements, or other discharges which may cause severe adverse impacts on public interests, including public health and property damage. Where a controlled diversion is utilized, consideration shall also be given to the installation of storage-detention tanks or basins, which will be made to drain to the station wet well. Where overflows affect public water supplies, shellfish production or waters used for culinary or food processing purposes, a storage-detention basin or tank, shall be provided having two (2)-hour detention capacity at the anticipated overflow rate.

(A) Overflow Prevention Methods. A satisfactory method shall be provided to prevent or minimize overflows. The following methods should be evaluated on an individual basis. The choice should be based on least cost and least operational problems of the methods providing an acceptable degree of reliability. The methods are—

1. Storage capacity including trunk sewers for retention of wet weather flows. Storage basins must be designed to drain back into the wet well or collection system after the flow recedes;

2. An in-place or portable pump, driven by an internal combustion engine meeting the requirements of subsection (8)(B) of this rule, capable of pumping from the wet well to the discharge side of the station; and

3. Two (2) independent public utility sources or engine-driven generating equipment meeting the requirements of subsection (8)(B) of this rule.

(B) Equipment Requirements.

1. General. The following general requirements shall apply to all internal combustion engines used to drive auxiliary pumps, service pumps through special drives or electrical generating equipment.

A. Engine protection. The engine must be protected from operating conditions that would result in damage to equipment. Unless continuous manual supervision is planned, protective equipment shall be capable of shutting down the engine and activating an alarm on-site and as provided in section (7) of this rule. Protective equipment shall monitor for conditions of low oil pressure and overheating, except oil pressure monitoring will not be required for engines with splash lubrication.

B. Size. The engine shall have adequate rated power to start and continuously operate all connected loads.

C. Fuel type. Reliability and ease of starting, especially during cold weather conditions should be considered in the selection of the type of fuel.

D. Engine ventilation. The engine shall be located above grade with adequate ventilation of fuel vapors and exhaust gases.

E. Routine start-up. All emergency equipment shall be provided with instructions indicating the need for regular starting and running of the units at full loads.

F. Protection of equipment. Emergency equipment shall be protected from damage at the restoration of regular electrical power.

2. Engine-driven pumping equipment. Where permanently installed or portable engine-driven pumps are used, the following requirements in addition to general requirements shall apply:

A. Pumping capacity. Engine-driven pump(s) shall meet the design pumping requirements unless storage capacity is available for flows in excess of pump capacity. Pumps shall be designed for anticipated operating conditions, including suction lift if applicable;

B. Operation. The engine and pump shall be equipped to provide automatic start-up and operation of pumping equipment. Provisions shall also be made for manual start-up. Where manual start-up and operation is justified, storage capacity and alarm system must meet the requirements of subparagraph (8)(B)2.C. of this rule; and

C. Portable pumping systems. Where part or all of the engine-driven pumping equipment is portable, sufficient storage

capacity to allow time for detection of pump station failure and transportation and hookup of the portable equipment shall be provided. A riser from the force main with quick-connect coupling and appropriate valving shall be provided to hookup portable pumps.

3. Engine-driven generating equipment. Where permanently installed or portable engine-driven generating equipment is used, the following requirements in addition to general requirements shall apply:

A. Generating capacity. Generating unit size shall be adequate to provide power for pump motor starting current and for lighting, ventilation and other auxiliary equipment necessary for safety and proper operation of the lift station. The operation of only one (1) pump during periods of auxiliary power supply must be justified. Justification may be made on the basis of maximum anticipated flows relative to single pump capacity, anticipated length of power outage and storage capacity. Special sequencing controls shall be provided to start pump motors unless the generating equipment has capacity to start all pumps simultaneously with auxiliary equipment operating;

B. Operation. Provisions shall be made for automatic and manual start-up and load transfer. The generator must be protected from operating conditions that would result in damage to equipment. Provisions should be considered to allow the engine to start and stabilize at operating speed before assuming the load. Where manual start-up and transfer is justified, storage capacity and alarm system must meet the requirements of subparagraph (8)(B)3.C. of this rule; and

C. Portable generating equipment. Where portable generating equipment or manual transfer is provided, sufficient storage capacity to allow time for detection of pump station failure and transportation and connection of generating equipment shall be provided. The use of special electrical connections and double throw switches are recommended for connecting portable generating equipment.

(9) Grinder Pumps in Pressure Sewer Systems. A pressure sewer system is defined as two (2) or more grinder pump units at different locations discharging into a common force main. Grinder pump units and pressure systems are not to be used in lieu of conventional gravity collection systems; however, grinder pumps may be used where it is not feasible to provide conventional gravity sewer service, such as where the topography makes it difficult for the users to be served by a conventional system, groundwater conditions make construction and maintenance of a

conventional system difficult or excessive rock excavation makes a conventional system impractical. The operating authority shall be responsible for the entire system which shall include the force mains, grinder pump units and appurtenances.

(A) Pump Openings. The grinder unit must be capable of reducing any material which enters the grinder unit to a size that the materials will pass through the pump unit and force main without plugging or clogging. No screens or other devices requiring regular maintenance may be used to keep trashy or stringy material out of the grinder pump or force main. This requirement shall be in lieu of the requirements in paragraph (4)(C)3. of this rule.

(B) Storage Capacity. The minimum storage capacity of the grinder pump unit shall be fifty (50) gallons (189 l). The unit shall be capable of accommodating normal peak flows for periods of eight to twelve (8—12) hours.

(C) Alarm System. For grinder pump units serving a single home, an audiovisual alarm capable of alerting the resident and operating personnel in the area may be used in lieu of the alarm system specified in section (7) of this rule.

(D) Valves. A gate valve must be provided on the service line near the common force main.

(E) Force Main Velocity. The velocity shall meet the requirements of subsection (11)(A) of this rule based on the most probable number of pump units expected to operate simultaneously or on some other acceptable method of computing the peak pumpage rate.

(F) Cleaning. Consideration should be given to providing a suitable method of cleaning the force main whenever the velocity in the force main may be less than two feet (2') per second (0.61m/s) before ultimate development is reached.

(G) Electrical. Units must be serviceable and replaceable under wet conditions without electrical hazard to repair personnel. Electrical equipment shall be suitable for hazardous locations (National Electrical Code, Class I, Group D, Division 1 location).

(H) Standby Units. One (1) standby unit for each fifty (50) units or fraction thereof must be provided for each model installed.

(I) Service Interruptions. Provisions shall be made to avoid interruption of service due to mechanical or power failure by providing standby power, storage capacity or interconnection with another disposal system.

(10) Instructions and Equipment. Sewage pumping stations and their operators should be supplied with a complete set of operational

instructions, including emergency procedures, maintenance schedules, special tools and spare parts as may be necessary.

(11) Force Mains.

(A) Velocity. At design average flow a velocity of at least two feet (2') per second (0.61m/s) shall be maintained.

(B) Air Relief Valve. An air relief valve shall be placed at high points in the force main to prevent air locking. When accumulation of air or decomposition gases are likely, an automatic air relief valve suitable for use on sewage force mains shall be used.

(C) Termination. Force mains should enter the gravity sewer system at a point not more than two feet (2") (30 cm) above the flow line of the receiving manhole.

(D) Design Pressure. The force main and fittings including reaction blocking shall be designed to withstand normal pressure and pressure surges (water hammer).

(E) Special Construction. Force main construction near streams or used for aerial crossings shall meet applicable requirements of 10 CSR 20-8.120(9) and (10).

(F) Design Friction Losses. Friction losses through force mains shall be based on the Hazen and Williams formula or other acceptable method. When the Hazen and Williams formula is used, the following values for "C" shall be used for design; unlined iron or steel—one hundred (100) and all other—one hundred twenty (120). When initially installed, force mains will have a significantly higher "C" factor. The higher "C" factor should be considered only in calculating maximum power requirements.

(G) Separation from Water Mains. There shall be at least a ten-foot (10') (3.0m) horizontal separation between water mains and sanitary sewer force mains. Force mains crossing water mains shall be laid to provide a minimum vertical distance of eighteen inches (18") (46 cm) between the outside of the force main and the outside of the water main. This shall be the case where the water main is either above or below the force main. At crossings, one (1) full length of water pipe shall be located so both joints will be as far from the force main as possible. Special structural support for the water main and force main may be required.

(H) Identification of Force Mains. Where force mains are constructed of material which might cause the force main to be confused with potable water mains, the force main should be appropriately identified.

AUTHORITY: section 644.026, RSMo Supp. 1988. Original rule filed Aug. 10, 1978, effective March 11, 1979.*

**Original authority 1972, amended 1973, 1987, 1993.*

10 CSR 20-8.140 Sewage Treatment Works

PURPOSE: The following criteria have been prepared as a guide for the general design requirements for sewage treatment works. 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 names can be added to the mailing list.

Editor's Note: The secretary of state has determined that the publication of this rule in its entirety would be unduly cumbersome or expensive. The entire text of the material referenced has been filed with the secretary of state. This material may be found at the Office of the Secretary of State or at the headquarters of the agency and is available to any interested person at a cost established by state law.

(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 agency 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) (85.4 m³) or less (see 10 CSR 20-8.020 for the requirements for those facilities).

(3) Plant Location. The following items shall be considered when selecting a plant site: proximity to residential areas; direction of prevailing winds; accessibility by all-weather roads; area available for expansion; local zoning requirements; local soil characteristics, geology, hydrology and topography available to minimize pumping; access to receiving stream; downstream uses of the receiving stream and compatibility of treatment process with the present and planned future land use, including noise, potential odors, air quality and anticipated sludge processing and disposal techniques. Where a site must be used which is critical with respect to these items, appropriate measures shall be taken to minimize adverse impacts.

(A) Flood Protection. The treatment works structures, electrical and mechanical equipment shall be protected from physical damage by the one hundred (100)-year flood. Treatment works should remain fully operational and accessible during the twenty-five (25)-year flood. This applies to new construction and to existing facilities undergoing major modification.

(4) Quality of Effluent. The required degree of wastewater treatment shall be based on 10 CSR 20-7.015, Effluent Regulations and 10 CSR 20-7.031, Water Quality Standards.

(5) Design.

(A) Type of Treatment. As a minimum, the following items shall be considered in the selection of the type of treatment: present and future effluent requirements; location of and local topography of the plant site; space available for future plant construction; the effects of industrial wastes likely to be encountered; ultimate disposal of sludge; system capital costs; system operating and maintenance costs, including basic energy requirements; process complexity governing operating personnel requirements; and environmental impact on present and future adjacent land use.

(B) Required Engineering Data for New Process Evaluation. The policy of the agency is to encourage rather than obstruct the development of any methods or equipment for treatment of wastewater. The lack of inclusion in these standards of some types of wastewater treatment processes or equipment should not be construed as precluding their use. The agency may approve other types of wastewater treatment processes and equipment under the following conditions: the operational reliability and effectiveness of the process or device shall have been demonstrated with a suitably sized prototype unit operating at its design load conditions to the extent required

by the agency; the agency may require monitoring observations, including test results and engineering evaluations, demonstrating the efficiency of the processes, detailed description of the test methods; testing, including appropriately composited samples, under various ranges of strength and flow rates (including diurnal) and waste temperature over a sufficient length of time to demonstrate performance under climatic and other conditions which may be encountered in the area of the proposed installations and other appropriate information; the agency may require that appropriate testing be conducted and evaluations be made under the supervision of a competent process engineer other than those employed by the manufacturer or developer.

(C) Design Loads.

1. Hydraulic design.

A. New systems.

(I) Undeveloped areas. The design for sewage treatment plants to serve new sewerage systems being built in currently undeveloped areas shall be based on an average daily flow of one hundred (100) gallons per capita (378 l/cap), unless water use data or other justification upon which to better estimate flow is provided.

(II) Existing developed areas. Consideration shall be given in the designs for sewage treatment plants to serve a new sewerage system for a municipality or sewer district for higher flow rates if a large percentage of older buildings are likely to contribute significant infiltration/inflow to the new sanitary sewer system through basement floor drains.

B. Existing systems. Where there is an existing system, the volume and strength of existing flows shall be determined. The determination shall include both dry weather and wet weather conditions. Samples shall be taken and composited so as to be accurately representative of the strength of the wastewater. At least one (1) year's flow data should be taken as the basis for the preparation of hydrographs for analysis to determine the following types of flow conditions of the system: the annual average daily flow—as determined by averaging flows over one (1) year, exclusive of inflow due to rainfall; the minimum daily flow—as determined by observing twenty-four (24)-hour flows during dry weather (low rainfall period) when infiltration/inflow are at a minimum; wet weather peak flows—as determined by observing twenty-four (24)-hour flows during a period of one (1) year when infiltration/inflow are at a maximum; wet weather flows of seven (7)-day duration—as determined by observing for a period of one (1) year the daily flows during the immediate seven (7)-day period following rainfall

sufficient to cause ground surface runoff; peak hourly flows—as determined by observing the maximum hydraulic load to the plant; and industrial waste flows—as determined by flow data, including water use records, for each of the industries tributary to the sewer system. The plant design flow selected shall meet the appropriate effluent and water quality standards in 10 CSR 20-7.015 and 10 CSR 20-7.031.

C. Flow equalization. Facilities for the equalization of flows and organic shock load shall be considered at all plants which are critically affected by surge loadings. The sizing of the flow equalization facilities should be based on data obtained from paragraph (5)(C)1. of this rule and 10 CSR 20-8.120(5)(B).

2. Organic design.

A. New system minimum design.

Domestic waste treatment design shall be on the basis of at least 0.17 pounds (0.08 kg) of biochemical oxygen demand (BOD) per capita per day and 0.20 pounds (0.09 kg) of suspended solids per capita per day, unless information is submitted to justify alternate designs; when garbage grinders are used in areas tributary to a domestic treatment plant, the design basis should be increased to 0.22 pounds (0.10 kg) of BOD per capita per day and 0.25 pounds (0.11 kg) of suspended solids per capita per day; domestic waste treatment plants that will receive industrial wastewater flows shall be designed to include these industrial waste loads.

B. Existing systems. When an existing treatment works is to be upgraded or expanded, the organic design shall be based upon the actual strength of the wastewater as determined from the measurements taken in accordance with subparagraph (5)(C)1.B. of this rule, with an appropriate increment for growth.

3. Shock effects. The shock effects of high concentrations and diurnal peaks for short periods of time on the treatment process, particularly for small treatment plants, shall be considered.

4. Design by analogy. Data from similar municipalities may be utilized in the case of new systems; however, thorough investigation that is adequately documented shall be provided to the agency to establish the reliability and applicability of the data.

(D) Conduits. All piping and channels should be designed to carry the maximum expected flows. The incoming sewer should be designed for unrestricted flow. Bottom corners of the channels must be filleted. Conduits shall be designed to avoid creation of pockets and corners where solids can accumulate. Suitable gates should be placed in the

channels to seal off unused sections which might accumulate solids. The use of shear gates or stop planks is permitted where they can be used in place of gate valves or sluice gates. Noncorrosive materials shall be used for these control gates.

(E) Arrangement of Units. Component parts of the plant should be arranged for greatest operating and maintenance convenience, flexibility, economy, continuity of maximum effluent quality so as to facilitate installation of future units.

(F) Flow Division Control. Flow division control facilities shall be provided as necessary to insure organic and hydraulic loading control to plant process units and shall be designed for easy operator access, change, observation and maintenance. Appropriate flow measurement shall be incorporated in the flow division control design.

(6) Plant Details.

(A) Installation of Mechanical Equipment. The specifications should be so written that the installation and initial operation of major items of mechanical equipment will be supervised by a representative of the manufacturer.

(B) Unit Isolation. Properly located and arranged structures and piping shall be provided so that each unit of the plant can be removed from service independently. The design shall facilitate plant operation during unit maintenance and emergency repair so as to minimize deterioration of effluent quality and insure rapid process recovery upon return to normal operational mode.

1. Continuity during construction. Final plan documents shall include construction requirements as deemed necessary by the agency to avoid unacceptable temporary water quality degradation.

(C) Drains. Means shall be provided to de-water each unit to an appropriate point in the process. Due consideration shall be given to the possible need for hydrostatic pressure relief devices to prevent flotation of structures. Pipes subject to clogging shall be provided with means for mechanical cleaning or flushing.

(D) Construction Materials. Due consideration should be given to the selection of materials which are to be used in sewage treatment works because of the possible presence of hydrogen sulfide and other corrosive gases, greases, oils or similar constituents frequently present in sewage. This is particularly important in the selection of metals and paints. Contact between dissimilar metals should be avoided to minimize galvanic action.

(E) Painting. The use of paints containing lead or mercury should be avoided. In order

to facilitate identification of piping, particularly in the large plants, it is suggested that different lines be color coded. The following color scheme is recommended for purposes of standardization: sludge line—brown; gas line—orange; potable water line—blue; chlorine line—yellow; sewage line—gray; compressed air line—green; and water lines for heating digesters or buildings—blue with a six inch (6") (15 cm) red band spaced thirty inches (30") (76 cm) apart. The contents shall be stenciled on the piping in contrasting color.

(F) Operating Equipment. A complete outfit of tools, accessories and spare parts necessary for the plant operator's use shall be provided. Readily accessible storage space and workbench facilities shall be provided and consideration be given to provision of a garage storage area for large equipment, maintenance and repair.

(G) Erosion Control During Construction. Effective site erosion control shall be provided during construction.

(H) Grading and Landscaping. Upon completion of the plant, the ground should be graded. Concrete or gravel walkways should be provided for access to all units. Where possible, steep slopes should be avoided to prevent erosion. Surface water shall not be permitted to drain into any unit. Particular care shall be taken to protect trickling filter beds, sludge beds and intermittent sand filters from stormwater runoff. Provision should be made for landscaping, particularly when a plant must be located near residential areas.

(7) Plant Outfalls.

(A) Entrance Impact Control. The outfall sewer shall be designed to discharge to the receiving stream in a manner acceptable to the agency. Consideration should be given in each case to the following: preference for free fall or submerged discharge at the site selected; utilization of cascade aeration of effluent discharge to increase dissolved oxygen; limited or complete across stream dispersion as needed to protect aquatic life movement and growth in the immediate reaches of the receiving stream; appropriate effluent sampling in accordance with subsection (7)(C) of this rule.

(B) Protection and Maintenance. The outfall sewer shall be so constructed and protected against the effects of flood water, ice or other hazards as to reasonably insure its structural stability and freedom from stoppage. A manhole should be provided at the shore end of all gravity sewers extending into the receiving waters. Hazards to navigation shall be considered in designing outfall sewers.

(C) Sampling Provisions. All outfalls shall be designed so that a sample of the effluent can be obtained at a point after the final treatment process and before discharge to or mixing with the receiving waters.

(8) Essential Facilities.

(A) Emergency Power Facilities. All plants shall be provided with an alternate source of electric power to allow continuity of operation during power failures, except as noted in this subsection. Methods of providing alternates include the connection of at least two (2) independent public utility sources, such as substations; a power line from each substation is recommended and will be required unless, documentation is received and approved by the agency verifying that duplicate line is not necessary to minimize water quality violations; portable or inplace internal combustion engine equipment which will generate electrical or mechanical energy; and portable pumping equipment when only emergency pumping is required.

1. Standby generating capacity normally is not required for aeration equipment used in the activated sludge process. In cases where a history of long-term (four (4) hours or more) power outages have occurred, auxiliary power for minimum aeration of the activated sludge will be required. Full power generating capacity may be required by the agency on certain stream segments.

2. Continuous disinfection, where required, shall be provided during all power outages.

(B) Water Supply.

1. General. An adequate supply of potable water under pressure should be provided for use in the laboratory and for general cleanliness around the plant. No piping or other connections shall exist in any part of the treatment works which, under any conditions, might cause the contamination of a potable water supply. The chemical quality should be checked for suitability for its intended uses, such as heat exchangers, chlorinators, etc.

2. Direct connections. Potable water from a municipal or separate supply may be used directly at points above grade for the following hot and cold supplies: lavatory; water closet; laboratory sink (with vacuum breaker); shower; drinking fountain; eye wash fountain; and safety shower. Hot water for any of these units shall not be taken directly from a boiler used for supplying hot water to a sludge heat exchanger or digester heating coils.

3. Indirect connections. A reduced pressure backflow preventer or a break tank shall be used to isolate the potable system from all other plant uses other than those listed in

paragraph (8)(B)2. of this rule. Where permanent connections are to be made to uses other than those listed in paragraph (8)(B)2. of this rule, a break tank shall be used. Where a break tank is used, water shall be discharged to the break tank through an air-gap at least six inches (6") above the maximum flood line, ground level or the spill line of the tank, whichever is higher. Backflow preventers shall be located above the maximum flood line or ground level. A sign shall be permanently posted at every hose bib, faucet, hydrant or sill cock located on the water system beyond the break tank or backflow preventer to indicate that the water is not safe for drinking.

4. Separate potable water supply. Where it is not possible to provide potable water from a public water supply, a separate well may be provided. Location and construction of the well should comply with requirements of 10 CSR 60-2.010. Requirements governing the use of the supply are those contained in paragraphs (8)(B)2. and 3. of this rule.

5. Separate nonpotable water supply. Where a separate nonpotable water supply is to be provided, a break tank will not be necessary, but all system outlets shall be posted with a permanent sign indicating the water is not safe for drinking.

(C) Sanitary Facilities. Toilet, shower, lavatory and locker facilities should be provided in sufficient numbers and convenient locations to serve the expected plant personnel.

(D) Laboratory. All treatment works shall include a laboratory for making the necessary analytical determinations and operating control tests, except in individual situations where other arrangements are approved by the agency. The laboratory shall have sufficient size, bench space, equipment and supplies to perform all self-monitoring analytical work required by discharge permits and to perform the process control tests necessary for good management of each treatment process included in the design. The facilities and supplies necessary to perform analytical work to support industrial waste control programs will normally be included in the same laboratory. The laboratory size and arrangement must be sufficiently flexible and adaptable to accomplish these assignments. The layout should consider future needs for expansion in the event that more analytical work is needed.

1. Location and space. The laboratory should be located on ground level, easily accessible to all sampling points, with environmental control as an important consideration. It shall be located away from vibrating machinery or equipment which might have

adverse effects on the performance of laboratory instruments or the analyst or design or to prevent adverse effects from vibration. A minimum of four hundred (400) square feet (37m³) of floor space should be allocated for the laboratory. If more than two (2) persons will be working in the laboratory at any given time, one hundred (100) square feet (9.3m³) of additional space should be provided for each additional person. Bench top working surface should occupy at least thirty-five percent (35%) of the total floor space. Minimum ceiling height should be eight feet six inches (8'6") (2m). If possible this height should be increased to provide for installation of wall-mounted water stills, distillation racks and other equipment with extended height requirements.

2. Materials.

A. Ceilings. Acoustical tile should be used for ceiling except in high humidity areas where they should be constructed of plaster.

B. Walls. For easy maintenance and a pleasant working environment, light colored ceramic tile should be used from floor to ceiling for all interior walls.

C. Floors. Floor surfaces should be either vinyl asbestos or rubber, fire-resistant and highly resistant to acids, alkalies, solvents and salts.

D. Doors. Two (2) exit doors should be located to permit a straight egress from the laboratory preferably at least one (1) to outside the building. Panic hardware should be used. They should have large glass windows for easy visibility of approaching or departing personnel. Automatic door closers should be installed; swinging doors should not be used. Flush hardware should be provided doors if cart traffic is anticipated. Kick plates are also recommended.

3. Cabinets and bench tops. Wall hung cabinets are useful for dust-free storage of instruments and glassware. Units with sliding doors are preferable. They should be hung so the top shelf is easily accessible to the analyst. Thirty inches (30") (76 cm) from the bench top is recommended. One (1) or more cupboard style base cabinets should be provided for storing large items; however, drawer units are preferred for the remaining cabinets. Drawers should slide out so that entire contents are easily visible. They should be provided with rubber bumpers and with stops which prevent accidental removal. Drawers should be supported on ball bearings or nylon rollers which pull easily in adjustable steel channels. All metal drawer fronts should be of double wall construction. All cabinet shelving should be acid resistant and adjustable from inside the cabinet. Water, gas, air and vacuum service fixtures; traps,

strainers, overflows, plugs and tailpieces; and all electrical service fixtures shall be supplied with the laboratory furniture. Generally, bench top height should be thirty-six inches (36") (91 cm). However, areas to be used exclusively for sit-down type operations should be thirty inches (30") (76 cm) high and include knee hole space. One-inch (1") (2.54 cm) overhangs and drip grooves should be provided to keep liquid spills from running along the face of the cabinet. Tops should be furnished in large sections one and one-fourth inches (1 1/4") (3.18 cm) thick. They should be field joined into a continuous surface with acid, alkali and solvent resistant cements which are at least as strong as the material of which the top is made.

4. Hoods. Fume hoods to promote safety and canopy hoods over heat releasing equipment shall be installed.

A. Fume hoods.

(I) Location. Fume hoods should be located where air disturbance at the face of the hood is minimal. Air disturbance may be created by persons walking past the hood, supply in diffusers, drafts from opening or closing a door, etc. Safety factors should be considered in locating a hood. If a hood is situated near a doorway, a secondary means of egress must be provided. Bench surfaces should be available next to the hood so that chemicals need not be carried long distances.

(II) Design and materials. The selection of fume hoods, their design and materials of construction must be made considering the variety of analytical work to be performed and the characteristics of the fumes, chemicals, gases or vapors that will or may be released by the activities therein. Special design and construction is necessary if perchloric acid use is anticipated. Consideration should be given for providing more than one (1) fume hood to minimize potential hazardous conditions throughout the laboratory. Fume hoods are not appropriate for operation of heat releasing equipment, that does not contribute to hazards, unless they are provided in addition to those needed to perform hazardous tasks.

(III) Fixtures. A cup sink should be provided inside each fume hood. All switches, electrical outlets, utility and baffle adjustment handles should be located outside the hood. Light fixtures should be explosion proof.

(IV) Exhaust. Twenty-four (24)-hour continuous exhaust capability should be provided. Exhaust fans should be explosion proof. Exhaust velocities should be checked when fume hoods are installed.

(V) Alarms. A buzzer for indicating exhaust fan failure and a static pressure

gauge should be placed in the exhaust duct. A high temperature sensing device located inside the hood should be connected to the buzzer.

(VI) Canopy hoods. Canopy hoods should be installed over the bench top areas where hot plate, steam bath or other heating equipment or heat releasing instruments are used. The canopies should be constructed of steel, plastic or equivalent material and finished with enamel to blend with other laboratory furnishings.

5. Sinks. The laboratory shall be equipped with at least one (1) double-wall sink with drainboards. Additional sinks should be provided in separate work areas as needed and identified for the use intended. Sinks should be made of epoxy resin or plastic material with all appropriate characteristics for laboratory applications. Waste openings should be located toward the back so that a standing overflow will not interfere. All water fixtures on which hoses may be used should be provided with reduced zone pressure backflow preventers to prevent contamination of water lines. The sinks should be constructed of material highly resistant to acids, alkalies, solvents and salts, should be abrasion and heat resistant, nonabsorbent and light in weight. Traps should be made of glass, plastic or lead and easily accessible for cleaning.

6. Ventilation and lighting. Laboratories should be separately air conditioned with external air supply for one hundred percent (100%) makeup volume. In addition, separate exhaust ventilation should be provided. Ventilation outlet locations should be remote from ventilation inlets. Good lighting, free from shadows, is important for reading dials, meniscuses, etc., in the laboratory.

7. Gas and vacuum. Natural gas should be supplied to the laboratory. Digester gas should not be used. An adequately sized line source of vacuum should be provided with outlets available throughout the laboratory.

8. Balance and table. An analytical balance of the automatic, digital readout, single pan 0.1 milligram sensitivity type shall be provided. A heavy special design balance table which will minimize vibration of the balance shall be provided. It shall be located as remote as possible from windows, doors or other sources of drafts or air movements, so as to minimize undesirable impacts from these sources upon the balance.

9. Equipment, supplies and reagents. The laboratory shall be provided with all of the equipment, supplies and reagents that are needed to carry out all of the facility's analytical testing requirements. Discharge permit requirements, process control requirements

and industrial waste monitoring requirements should be considered when specifying equipment needs.

(E) Floor Slope. Floor surfaces shall be sloped adequately to a point of drainage.

(F) Stairways. Stairways shall be installed wherever possible in lieu of ladders. Spiral or winding stairs are permitted only for secondary access where dual means of egress are provided. Stairways shall have slopes between fifty degrees (50°) and thirty degrees (30°) (preferably nearer the latter) from the horizontal to facilitate carrying samples, tools, etc. Each tread and riser shall be of uniform dimension in each flight. Minimum tread run shall not be less than eight inches (8") (20.3 cm). The sum of the tread run and riser shall not be less than seventeen inches (17") (43 cm) nor more than eighteen inches (18") (46 cm). A flight of stairs shall consist of not more than a twelve-foot (12') (3.7m) continuous rise without a platform.

(G) Flow Measurement. Flow measurement facilities shall be provided at all plants. Indicating, totalizing and recording flow measurement devices shall be provided for all mechanical plants. Flow measurement facilities for lagoon systems shall not be less than pump calibration time clocks or calibrated flume and shall be provided on both the influent and effluent.

(9) Safety. Adequate provision shall be made to effectively protect the operator and visitors from hazards, the following shall be provided to fulfill the particular needs of each plant: enclosure of the plant site with a fence designed to discourage the entrance of unauthorized persons and animals; installation of hand rails and guards around tanks, trenches, pits, stairwells and other hazardous structures; provision of first-aid equipment; posting of "No Smoking" signs in hazardous areas; provision of protective clothing and equipment such as air pacs, goggles, gloves, hard hats, safety harnesses, etc.; provision of portable blower and sufficient hose; portable lighting equipment approved by the United States Bureau of Mines; and appropriately placed warning signs for slippery areas, non-potable water fixtures, low head clearance areas, open service manhole, hazardous chemical storage areas, flammable fuel storage areas, etc.

(A) Hazardous Chemical Handling.

1. Containment materials. The materials utilized for storage, piping, valves, pumping, metering, splash guards, etc., shall be specially selected considering the physical and chemical characteristics of each hazardous or corrosive chemical.

2. Secondary containment. Chemical storage areas shall be enclosed in dikes or curbs which will contain the stored volume until it can be safely transferred to alternate storage or released to the wastewater at controlled rates which will not damage the facilities, inhibit the treatment process or contribute to stream pollution. Liquid polymer should be similarly contained to reduce areas with slippery floors, especially to protect travelways. Nonslip floor surfaces are desirable in polymer-handling areas.

3. Eye wash fountains and safety showers. 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 are to be as close as practicable to possible chemical exposure sites and are to be fully useful during all weather conditions. The eye wash fountains shall be supplied with water of moderate temperature—fifty degrees to ninety degrees Fahrenheit (50°–90°F) (ten degrees to thirty-two degrees Celsius (10°–32°C)), separate from the hot water supply, suitable to provide fifteen to thirty (15–30) minutes of continuous irrigation of the eyes. The emergency showers shall be capable of discharging thirty to fifty gallons per day (30–50 gpm) (1.9–3.2 l/s) of water at moderate temperature at pressures of twenty to fifty pounds per square inch (20–50 psi) (1.41–3.52 kgf/cm²). The eye wash fountains and showers shall be no more than twenty-five feet (25') (7.6 m) from points of hazardous chemical 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 ten feet (10') (3.0m) and with at least two (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 (flanged or other type), except adjacent to storage or feeder areas, shall have guards which will direct any leakage away from space occupied by personnel. Pipes containing hazardous or corrosive chemicals should not be located above shoulder level except where continuous drip collection trays and coupling guards will eliminate spray or dripping onto personnel.

6. Protective clothing and equipment. The following items of protective clothing or equipment shall be available and utilized for all operations or procedures where their use will minimize injury hazard to personnel: respirators, air supply type recommended for protection against chlorine; chemical workers' goggles or other suitable goggles (safety glasses are insufficient); face masks or shields for use over goggles; rubber gloves, rubber aprons with leg straps; rubber boots (leather and wool clothing should be avoided near caustics); and safety harness and line.

7. Warning system and signs. Facilities shall be provided for automatic shutdown of pumps and sounding of alarms when failure occurs in a pressurized chemical discharge line. Warning signs requiring use of goggles shall be located near chemical unloading stations, pumps and other points of frequent hazard.

8. Dust collection. Dust collection equipment shall be provided to protect personnel from dusts injurious to the lungs or skin and to prevent polymer dust from settling on walkways. The latter is to minimize slick floors which result when a polymer-covered floor becomes wet.

9. Container identification. The identification and hazard warning data included on shipping containers, when received shall appear on all containers (regardless of size or type) used to store, carry or use a hazardous substance. Sewage and sludge sample containers should be adequately labeled. Following is a suitable label for a sewage sample:

RAW SEWAGE

Sample point No.

Contains Harmful Bacteria.

May contain hazardous or toxic material.

Do not drink or swallow.

Avoid contact with openings or breaks in the skin.

AUTHORITY: section 644.026, RSMo Supp. 1989. Original rule filed Aug. 10, 1978, effective March 11, 1979.*

**Original authority 1972, amended 1973, 1987, 1993.*

10 CSR 20-8.150 Screening, Grit Removal and Flow Equalization

PURPOSE: The following criteria have been prepared as a guide for the design of screening, grit removal and flow equalization 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 names can be added to the mailing list.

Editor's Note: The secretary of state has determined that the publication of this rule in its entirety would be unduly cumbersome or expensive. The entire text of the material referenced has been filed with the secretary of state. This material may be found at the Office of the Secretary of State or at the headquarters of the agency and is available to any interested person at a cost established by state law.

(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 agency 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 (22,500) gallons per day (85.4m³) or less (see 10 CSR 20-8.020 for the requirements for those facilities).

(3) Screening Devices.

(A) Bar Racks and Screens.

1. When required. Protection for pumps and other equipment shall be provided by either coarse bar racks or bar screens. Pro-

tection for comminutors should be provided by coarse bar racks.

2. Location.

A. Indoors. Screening devices, installed in a building where other equipment or offices are located, should be accessible only through a separate outside entrance.

B. Outdoors. Screening devices installed outside shall be protected from freezing.

C. Access. Screening areas shall be provided with stairway access, adequate lighting and ventilation and a convenient and adequate means for removing the screenings.

3. Design and installation.

A. Bar spacing. Clear opening between bars should be no less than one inch (1") (2.54 cm) for manually cleaned screens. Clear openings for mechanically cleaned screens may be as small as five-eighths of an inch (5/8") (1.50 cm). Maximum clear openings should be one and three-fourths inches (1 3/4") (4.45 cm).

B. Slope. Manually cleaned screens, except those for emergency use, should be placed on a slope of thirty to forty-five degrees (35°-45°) on the horizontal.

C. Velocities. At normal operating flow conditions, approach velocities should be no less than 1.25 feet per second (38.1 cm/sec), to prevent settling; and no greater than 3.0 fps (91.4 cm/sec) to prevent forcing material through the openings.

D. Channels. Dual channels shall be provided and equipped with the necessary gates to isolate flow from any screening unit. Provisions shall also be made to facilitate dewatering each unit. The channel preceding and following the screen shall be shaped to eliminate stranding and settling of solids.

E. Invert. The screen channel invert should be three to six inches (3-6") (7.6-15.2 cm) below the invert of the incoming sewer.

F. Flow distribution. Entrance channels should be designed to provide equal and uniform distribution of flow to the screens.

G. Flow measurement. Flow measurement devices should be selected for reliability and accuracy. The effect of changes in backwater elevations, due to intermittent cleaning of screens, should be considered in locations of flow measurement equipment.

4. Safety.

A. Railings and gratings. Manually cleaned screen channels shall be protected by guard railings and deck gratings with adequate provisions for removal or opening to facilitate raking. Mechanically cleaned screen channels shall be protected by guard railings and deck gratings. Consideration should also

be given to temporary access arrangements to facilitate maintenance and repair.

B. Mechanical devices. Mechanical screening equipment shall have adequate removal enclosures to protect personnel against accidental contact with moving parts and to prevent dripping in multi-level installations. A positive means of locking out each mechanical device shall be provided.

5. Control systems.

A. Timing devices. All mechanical units which are operated by timing devices shall be provided with auxiliary controls which will set the cleaning mechanism in operation at a pre-set high water elevation.

B. Electrical fixtures and controls. Electrical fixtures and controls in screening areas where hazardous gases may accumulate shall be suitable for hazardous locations (National Electrical Code, Class I, Group D, Division 1 location).

C. Manual override. Automatic controls shall be supplemented by a manual override.

6. Disposal of screenings. Facilities must be provided for removal, handling, storage and disposal of screenings in a sanitary manner. Separate grinding of screenings and return to the sewage flow is unacceptable. Manually cleaned screening facilities should include an accessible platform from which the operator may rake screenings easily and safely. Suitable drainage facilities shall be provided for both the platform and storage areas.

7. Auxiliary screens. Where a single mechanically cleaned screen is used, an auxiliary manually cleaned screen shall be provided. Where two (2) or more mechanically cleaned screens are used, the design shall provide for taking any unit out-of-service without sacrificing the capability to handle the peak design flow.

(B) Fine Screens.

1. General. Fine screens may be used in lieu of primary sedimentation providing that subsequent treatment units are designed on the basis of anticipated screen performance. Fine screens should not be considered equivalent to primary sedimentation. Where fine screens are used, additional provisions for the removal of floatable oils and greases shall be considered.

2. Design. Tests should be conducted to determine BOD₅ and suspended solids removal efficiencies at the design peak hydraulic and peak organic loadings. A minimum of two (2) fine screens shall be provided; each unit being capable of independent operation. Capacity shall be provided to treat peak design flows with one (1) unit out-of-service. Fine screens shall be preceded by a

mechanically cleaned bar screen or other protective device. Comminuting devices shall not be used ahead of fine screens.

3. Electrical fixtures and controls. Electrical fixtures and controls in screening areas where hazardous gases may accumulate shall be suitable for hazardous locations (National Electrical Code, Class I, Group D, Division 1 location).

4. Servicing. Hosing equipment shall be provided to facilitate cleaning. Provisions shall be made for isolating or removing units from their location for servicing.

(4) Comminutors.

(A) General. Provisions for location shall be in accordance with screening devices, paragraph (3)(A)2. of this rule.

(B) When Required. Comminutors shall be used in plants that do not have primary sedimentation or fine screens and should be provided in cases where mechanically cleaned bar screens will not be used.

(C) Design Considerations.

1. Location. Comminutors should be located downstream of any grit removal equipment.

2. Size. Comminutor capacity shall be adequate to handle peak flows.

3. Installation. A screened bypass channel shall be provided. The use of the bypass channel should be automatic at depths of flow exceeding the design capacity for the comminutor. Each comminutor that is not preceded by grit removal equipment should be protected by a six inch (6.0") (15.2 cm) deep gravel trap. Gates shall be provided in accordance with subparagraph (3)(A)3.D. of this rule.

4. Servicing. Provisions shall be made to facilitate servicing units in place and removing units from their location for servicing.

5. Electrical controls and motors. Electrical equipment in comminutor chambers where hazardous gases may accumulate shall be suitable for hazardous locations (National Electrical Code, Class I, Group D, Division 1 location). Motors in areas not governed by this requirement may need protection against accidental submergence.

(5) Grit Removal Facilities.

(A) When Required. Grit removal facilities should be provided for all sewage treatment plants; and are required for plants receiving sewage from combined sewers or from sewer systems receiving substantial amounts of grit. If a plant serving a separate sewer system is designed without grit facilities, the design shall include provisions for future installation. Consideration shall be given to possible

damaging effects on pumps, comminutors and other preceding equipment and the need for additional storage capacity in treatment units where grit is likely to accumulate.

(B) Location.

1. General. Grit removal facilities should be located ahead of pumps and comminuting devices. Coarse bar racks should be placed ahead of grit removal facilities.

2. Housed facilities.

A. Ventilation. Uncontaminated air shall be introduced continuously at a rate of twelve (12) air changes per hour or intermittently at a rate of thirty (30) air changes per hour. Odor control facilities may also be warranted.

B. Access. Adequate stairway access to above or below grade facilities shall be provided.

C. Electrical. All electrical work in enclosed grit removal areas where hazardous gases may accumulate shall be suitable for hazardous locations (National Electrical Code, Class I, Group D, Division 1 location).

3. Outside facilities. Grit removal facilities located outside shall be protected from freezing.

(C) Type and Number of Units. Plants treating wastes from combined sewers should have at least two (2) mechanically cleaned grit removal units with provisions for bypassing. A single manually cleaned or mechanically cleaned grit chamber with bypass is acceptable for small sewage treatment plants serving separate sanitary sewer systems. Minimum facilities for larger plants serving separate sanitary sewers should be at least one (1) mechanically cleaned unit with a bypass. Facilities other than channel-type are acceptable if provided with adequate and flexible controls for agitation and/or air supply devices and with grit collection and removal equipment.

(D) Design Factors.

1. General. The design effectiveness of a grit removal system shall be commensurate with the requirements of the subsequent process units.

2. Inlet. Inlet turbulence shall be minimized.

3. Velocity and detention. Channel-type chambers shall be designed to control velocities during normal variations in flow as close as possible to one foot (1') per second (30 cm/sec). The detention period shall be based on the size of particle to be removed. All grit removal facilities should be provided with adequate automatic control devices to regulate detention time, agitation or air supply.

4. Grit washing. The need for grit washing should be determined by the method of final grit disposal.

5. Drains. Provisions shall be made for isolating and de-watering each unit.

6. Water. An adequate supply of water under pressure shall be provided for cleanup.

7. Grit handling. Grit removal facilities located in deep pits should be provided with mechanical equipment for hoisting or transporting grit to ground level. Impervious non-slip working surfaces with adequate drainage shall be provided for grit handling areas. Grit transporting facilities shall be provided with protection against freezing and loss of material.

(6) Pre-aeration of sewage to reduce septicity may be required in special cases.

(7) Flow Equalization.

(A) General. Flow equalization can reduce the dry weather variations in organic and hydraulic loadings at any wastewater treatment plant. It should be provided where large diurnal variations are expected.

(B) Location. Equalization basins should be located downstream of pretreatment facilities such as bar screens, comminutors and grit chambers.

(C) Type. Flow equalization can be provided by using separate basins or on-line treatment units such as aeration tanks. Equalization basins may be designed as either in-line or side-line units. Unused treatment units, such as sedimentation or aeration tanks, may be utilized as equalization basins during the early period of design life.

(D) Size. Equalization basin capacity should be sufficient to effectively reduce expected flow and load variations to the extent deemed to be economically advantageous. With a diurnal flow pattern, the volume required to achieve the desired degree of equalization can be determined from a cumulative flow plot over the representative twenty-four (24)-hour period.

(E) Operation.

1. Mixing. Aeration or mechanical equipment shall be provided to maintain adequate mixing. Corner fillets and hopper bottoms with draw-offs should be provided to alleviate the accumulation of sludge and grit.

2. Aeration. Aeration equipment shall be sufficient to maintain a minimum of 1.0 mg/l of dissolved oxygen in the mixed basin contents at all times. Air supply rates should be a minimum of 1.25 cfm per one thousand gallons (1000 gal) (9 l/min/m³) of storage capacity. The air supply should be isolated from other treatment plant aeration requirements to facilitate process aeration control.

Standard process aeration supply equipment may be utilized as a source of standby aeration.

3. Controls. Inlets and outlets for all basin compartments shall be suitably equipped with accessible external valves, stop plates, weirs or other devices to permit flow control and the removal of an individual unit from service. Facilities shall also be provided to measure and indicate liquid levels and flow rates.

(F) Electrical. All electrical work in housed equalization basins shall be suitable for hazardous locations (National Electrical Code, Class I, Group D, Division 1 location).

(G) Access. Suitable access shall be provided to facilitate the maintenance of equipment and cleaning.

AUTHORITY: section 644.026, RSMo Supp. 1988. Original rule filed Aug. 10, 1978, effective March 11, 1979.*

**Original authority 1972, amended 1973, 1987, 1993.*

10 CSR 20-8.160 Settling

PURPOSE: The following criteria have been prepared as a guide for the design of settling tanks. 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 names can be added to the mailing list.

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erenced has been filed with the secretary of state. This material may be found at the Office of the Secretary of State or at the headquarters of the agency and is available to any interested person at a cost established by state law.

(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 agency is concerned, unless justification is presented for deviation from the requirements. Other terms, such as should, recommend, referred 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) (85.4m³) or less (see 10 CSR 20-8.020 for the requirements for those facilities).

(3) General Considerations.

(A) Number of Units. Multiple units capable of independent operation are desirable and shall be provided in all plants where design flows exceed one hundred thousand (100,000) gpd (379m³/d). Plants not having multiple units shall include other provisions to assure continuity of treatment.

(B) Arrangement. Settling tanks shall be arranged in accordance with subsection 10 CSR 20-8.140(5)(E).

(C) Flow Distribution. Effective flow measurement devices and control appurtenances (that is, valves, gates, splitter boxes, etc.) shall be provided to permit proper proportion of flow to each unit.

(D) Tank Configuration. Consideration should be given to the probable flow pattern in the selection of tank size and shape, and inlet and outlet type and location.

(4) Design Considerations.

(A) Dimensions. The minimum length of flow from inlet to outlet should be ten feet (10') (3m) unless special provisions are made to prevent short-circuiting. The sidewater depth for primary clarifiers shall be as shallow as practicable, but not less than seven feet (7') (2.1m). Clarifiers following the activated sludge process shall have sidewater depths of at least twelve feet (12') (3.7m) to provide adequate separation zone between the sludge blanket and the overflow weirs. Clarifiers following fixed film reactors shall have

sidewater depth of at least seven feet (7') (2.1m).

(B) Surface Settling Rates (Overflow Rates).

1. Primary settling tanks. Surface settling rates for primary tanks should not exceed one thousand (1000) gpd per square foot (41m³/m²/day) at design average flows or one thousand five hundred (1500) gpd per square foot (61m³/m²/day) for peak hourly flows. Clarifier sizing shall be calculated for both flow conditions and the larger surface area determined shall be used. Primary settling of normal domestic sewage can be expected to remove thirty to fifty percent (30–50%) of the influent BOD. However, anticipated BOD removal for sewage containing appreciable quantities of industrial wastes (or chemical additions to be used) should be determined by laboratory tests and consideration of the quantity and character of the wastes.

2. Intermediate settling tanks. Surface settling rates for intermediate settling tanks following series units of fixed film reactor processes shall not exceed one thousand five hundred (1500) gpd per square foot (61m³/m²/day) based on peak hourly flow.

3. Final settling tanks. Settling tests should be conducted wherever pilot study of biological treatment is warranted by unusual waste characteristics or treatment requirements. Testing shall be done where proposed loadings go beyond the limits set forth in this section. Surface settling rates for settling tanks following trickling filters or rotating biological contractors shall not exceed one thousand two hundred (1200) gpd per square foot (49m³/m²/day) based on peak hourly flow. Final settling tanks following activated sludge processes must be designed to meet thickening as well as solids separation requirements. Since the rate of recirculation of return sludge from the final settling tanks to the aeration or re-aeration tanks is quite high in activated sludge processes, surface settling rate and weir overflow rate should be adjusted for the various processes to minimize the problems with sludge loadings, density currents, inlet hydraulic turbulence and occasional poor sludge settleability. The hydraulic design of intermediate and final settling tanks following activated sludge processes shall be based upon the anticipated peak hourly rate for the area downstream of the inlet baffle. The hydraulic loadings shall not exceed—one thousand two hundred (1200) gpd per square foot (49m³/m²/day) for conventional, step aeration, contact stabilization and the carbonaceous stage of separate-stage nitrification; one thousand (1000) gpd

per square foot ($41\text{m}^3/\text{m}^2/\text{day}$) for extended aeration; and eight hundred (800) gpd per square foot ($33\text{m}^3/\text{m}^2/\text{day}$) for the separate nitrification stage. The solids loading for all activated sludge processes shall not exceed fifty pounds (50 lbs.) solids per day per square foot ($244\text{ kg}/\text{m}^2/\text{day}$) at the peak rate. Consideration should be given to flow equalization.

(C) Inlet Structures. Inlets should be designed to dissipate the inlet velocity, to distribute the flow equally both horizontally and vertically and to prevent short-circuiting. Channels should be designed to maintain a velocity of at least one foot (1') per second (0.3m/s) at one-half (1/2) the design flow. Corner pockets and dead ends should be eliminated and corner fillets or channeling used where necessary. Provisions shall be made for elimination or removal of floating materials in inlet structures.

(D) Weirs.

1. General. Overflow weirs shall be adjustable for leveling.

2. Location. Overflow weirs shall be located to optimize actual hydraulic detention time, and minimize short-circuiting.

3. Design rates. Weir loadings should not exceed ten thousand (10,000) gpd per lineal foot ($124\text{m}^3/\text{m}/\text{day}$) for plants designed for average flows of 1.0 mgd ($3,785\text{m}^3/\text{day}$) or less. Higher weir loadings may be used for plants designed for larger average flows but should not exceed fifteen thousand (15,000) gpd per lineal foot ($186\text{m}^3/\text{m}/\text{day}$). If pumping is required, weir loadings should be related to pump delivery rates to avoid short-circuiting.

4. Weir troughs. Weir troughs shall be designed to prevent submergence at maximum design flow and to maintain a velocity of at least one foot (1') per second (0.3m/s) at one-half (1/2) the design flow.

(E) Submerged Surfaces. The tops of troughs, beams and similar submerged construction elements shall have a minimum slope of 1.4:1; the underside of the elements should have a slope of one to one (1:1) to prevent the accumulation of scum and solids.

(F) Unit De-watering. Unit de-watering features shall conform to the provisions outlined in 10 CSR 20-8.140(6). The unit isolation design should also provide for redistribution of the plant flow to the remaining units.

(G) Freeboard. Walls of settling tanks shall extend at least six inches (6") (15 cm) above the surrounding ground surface and shall provide not less than twelve inches (12") (30 cm) freeboard. Additional freeboard or the use of wind screens is recommended where larger

settling tanks are subject to high velocity wind currents that would cause tank surface waves and inhibit effective scum removal.

(5) Sludge and Scum Removal.

(A) Scum Removal. Effective scum collection and removal facilities, including baffling, shall be provided for all settling tanks. The unusual characteristics of scum which may adversely affect pumping, piping, sludge handling and disposal should be recognized in design. Provisions may be made for the discharge of scum with the sludge; however, other special provisions for disposal may be necessary.

(B) Sludge Removal. Sludge collection and withdrawal facilities shall be so designed as to assure rapid removal of the sludge. Suction withdrawal should be provided for activated sludge plants designed for reduction of the nitrogenous oxygen demand and is encouraged for those plants designed for carbonaceous oxygen demand reduction.

1. Sludge hopper. The minimum slope of the side walls shall be 1.7:1. Hopper wall surfaces should be made smooth with rounded corners to aid in sludge removal. Hopper bottoms shall have a maximum dimension of two feet (2') (0.6m). Extra depth sludge hoppers for sludge thickening are not acceptable.

2. Cross-collectors. Cross-collectors serving one (1) or more settling tanks may be useful in place of multiple sludge hoppers.

3. Sludge removal piping. Each hopper shall have an individually-valved sludge withdrawal line at least six inches (6") (15 cm) in diameter. The static head available for withdrawal of sludge shall be thirty inches (30") (76 cm) or greater as necessary to maintain a three-foot (3') per second (0.9m/s) velocity in the withdrawal pipe. Clearance between the end of the withdrawal line and the hopper walls shall be sufficient to prevent bridging of the sludge. Adequate provisions shall be made for rodding or back-flushing individual pipe runs. Piping shall also be provided to return waste sludge to primary clarifiers.

4. Sludge removal control. Sludge wells equipped with telescoping valves or other appropriate equipment shall be provided for viewing, sampling and controlling the rate of sludge withdrawal. The use of easily maintained sight glass and sampling valves may be appropriate. A means of measuring the sludge removal rate shall be provided. Air lift type of sludge removal will not be approved for removal of primary sludges. Sludge pump motor control system shall include time clocks and valve activators for regulating the duration and sequencing of sludge removal.

(6) Protective and Service Facilities.

(A) Operator Protection. All settling tanks shall be equipped to enhance safety for operators. These features shall appropriately include machinery covers, life lines, stairways, walkways, hand rails and slip-resistant surfaces.

(B) Mechanical Maintenance Access. The design shall provide for convenient and safe access to routine maintenance items such as gear boxes, scum removal, mechanism and baffles, weirs, inlet stilling baffle area and effluent channels.

(C) Electrical Fixtures and Controls. Electrical fixtures and controls in enclosed settling basins shall be suitable for hazardous locations (National Electrical Code for Class I, Group D, Division 1 location). The fixtures and controls shall be located so as to provide convenient and safe access for operation and maintenance. Adequate area lighting shall be provided.

AUTHORITY: section 644.026, RSMo Supp. 1988. Original rule filed Aug. 10, 1978, effective March 11, 1979.*

**Original authority 1972, amended 1973, 1987, 1993.*

10 CSR 20-8.170 Sludge Handling and Disposal

*PURPOSE: The following criteria have been prepared as a guide for the design of sludge handling and disposal 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 names can be added to the mailing list.*

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(2) Exceptions. This rule shall not apply to facilities designed for twenty-two thousand five hundred gallons per day (22,500 gpd) (85.4m³) or less (see 10 CSR 20-8.020) for the requirements for those facilities.

(3) Design Considerations. The selection of sludge handling and disposal methods should include the following considerations: energy requirements; efficacy of sludge thickening; complexity of equipment; staffing requirements; toxic effects of heavy metals and other substances on sludge stabilization and disposal; treatment of side-stream flow such as digester and thickener supernatant; a back-up method of sludge handling and disposal; and methods of ultimate sludge disposal.

(4) Sludge Thickeners. As the first step of sludge handling, the need for sludge thickeners to reduce the volume of sludge should be considered. The design of thickeners (gravity, dissolved air flotation, centrifuge and others) should consider the type and concentration of sludge, the sludge stabilization processes, the method of ultimate sludge disposal, chemical needs and the cost of operation. Particular attention should be given to the pumping and piping of the concentrated sludge and possible onset of anaerobic conditions. Sludge should be thickened to at least five percent (5%) solids prior to transmission to digesters.

(5) Anaerobic Sludge Digestion.

(A) General.

1. Multiple units. Multiple tanks are recommended. Where a single digestion tank is used, an alternate method of sludge processing or emergency storage to maintain continuity of service shall be provided.

2. Depth. For those units proposed to serve as supernatant separation tanks, the depth should be sufficient to allow for the formation of a reasonable depth of supernatant liquor. A minimum sidewater depth of twenty feet (20') (6.10m) is recommended.

3. Maintenance provisions. To facilitate draining, cleaning and maintenance, the following features are desirable:

A. Slope. The tank bottom should slope to drain toward the withdrawal pipe. For tanks equipped with a suction mechanism for withdrawal of sludge, a bottom slope of one to twelve (1:12) or greater is recommended. Where the sludge is to be removed by gravity alone, one to four (1:4) slope is recommended.

B. Access manholes. At least two (2) thirty-six inch (36") (91 cm) diameter access manholes should be provided in the top of the tank in addition to the gas dome. There should be stairways to reach the access manholes. A separate sidewall manhole shall be provided. The opening should be large enough to permit the use of mechanical equipment to remove grit and sand.

C. Safety. Nonsparking tools, safety lights, rubber-soled shoes, safety harness, gas detectors for inflammable and toxic gases, and at least two (2) self-contained breathing units shall be provided for emergency use.

(B) Sludge Inlets and Outlets. Multiple recirculation withdrawal and return points should be provided to enhance flexible operation and effective mixing, unless mixing facilities are incorporated within the digester. The returns, in order to assist in scum breakup, should discharge above the liquid level and be located near the center of the tank. Raw sludge discharge to the digester should be through the sludge heater and recirculation return piping or directly to the tank if internal mixing facilities are provided. Sludge withdrawal to disposal should be from the bottom of the tank. This pipe should be interconnected with the recirculation piping to increase versatility in mixing the tank contents, if the piping is provided. Sludge withdrawal should be at the bottom of the tank.

(C) Tank Capacity. The total digestion tank capacity should be determined by rational calculations based upon such factors as volume of sludge added, its percent solids and character, the temperature to be maintained in the digesters, the degree or extent of mixing to be obtained and the degree of volatile solids reduction required. Calculations should be submitted to justify the basis of design. When the calculations are not based on these factors, the minimum combined digestion tank capacity outlined in paragraphs (5)(C)1. and 2. will be required. The

requirements assume that a raw sludge is derived from ordinary domestic wastewater, that a digestion temperature is to be maintained in the range of ninety degrees to one hundred degrees Fahrenheit (90°–100°F) (32.2°C–37.8°C), that forty to fifty percent (40–50%) volatile matter will be maintained in the digested sludge, and that the digested sludge will be removed frequently from the system (see also paragraph (5)(A)1. of this rule).

1. Completely-mixed systems. Completely-mixed systems shall provide for intimate and effective mixing to prevent stratification and to assure homogeneity of digester content. The system may be loaded at a rate up to eighty pounds (80 lbs.) of volatile solids per one thousand (1000) cubic feet of volume per day (1.28 kg/m³/day) in the active digestion units. When grit removal facilities are not provided, the reduction of digester volume due to grit accumulation should be considered. Complete mixing can be accomplished only with substantial energy input.

2. Moderately-mixed systems. For digestion systems where mixing is accomplished only by circulating sludge through an external heat exchanger, the system may be loaded at a rate up to forty pounds (40 lbs.) of volatile solids per one thousand (1000) cubic feet of volume per day (0.64 kg/m³/day) in the active digestion units. This loading may be modified upward or downward depending upon the degree of mixing provided. Provisions for mixing scum shall be included.

(D) Gas Collection, Piping and Appurtenances.

1. General. All portions of the gas system, including the space above the tank liquor, storage facilities and piping, shall be so designed that under all normal operating conditions, including sludge withdrawal, the gas will be maintained under positive pressure. All enclosed areas where any gas leakage might occur shall be adequately ventilated.

2. Safety equipment. All necessary safety facilities shall be included where gas is produced. Pressure and vacuum relief valves and flame traps, together with automatic safety shutoff valves, shall be provided. Water seal equipment shall not be installed. Gas safety equipment and gas compressors should be housed in a separate room with an exterior entrance.

3. Gas piping and condensate. Gas piping shall be of adequate diameter and shall slope to condensate traps at low points. The use of float-controlled condensate traps is not permitted.

4. Gas utilization equipment. Gas-fired boilers for heating digesters shall be located in a separate room not connected to the digester gallery. The separated room would not ordinarily be classified as hazardous location. Gas lines to these units shall be provided with suitable flame traps.

5. Electrical fixtures. Electrical fixtures and controls in places enclosing anaerobic digestive appurtenances where hazardous gases are normally contained in the tanks and/or piping shall comply with the National Electrical Code, Class I, Group D, Division 2 locations. Digester galleries should be isolated from normal operating areas to avoid an extension of the hazardous location in accordance with paragraph (5)(D)7. of this rule.

6. Waste gas. Waste gas burners shall be readily accessible and should be located at least twenty-five feet (25') (7.6m) away from any plant structure if placed at ground level or may be located on the roof of the control building if sufficiently removed from the tank. All waste gas burners shall be equipped with automatic ignition, such as pilot light or a device using a photoelectric cell sensor. Consideration should be given to the use of natural or propane gas to insure reliability of the pilot light. In remote locations it may be permissible to discharge the gas to the atmosphere through a return-bend screened vent terminating at least ten feet (10') (3m) above the ground surface, provided that the assembly incorporates a flame trap.

7. Ventilation. Any underground enclosures connecting with digestion tanks or containing sludge or gas piping or equipment shall be provided with forced ventilation in accordance with 10 CSR 20-8.130(4)(G) and 10 CSR 20-8.130(4)(G)2. The piping gallery for digesters should not be connected to other passages. Where used, tightly fitting, self-closing doors should be provided at connecting passageways and tunnels to minimize the spread of gas.

8. Meter. A gas meter with bypass shall be provided to meter total gas production.

(E) Digester Heating.

1. Insulation. Wherever possible digestion tanks should be constructed above groundwater level and should be suitably insulated to minimize heat loss.

2. Heating facilities. Sludge may be heated by circulating the sludge through external heaters or by heating units located inside the digestion tank.

A. External heating. Piping shall be designed to provide for the preheating of feed sludge before introduction to the digesters. Provisions shall be made in the layout of the piping and valving to facilitate cleaning of these lines. Heat exchanger sludge piping

should be sized for heat transfer requirements.

B. Other heating methods. Other types of heating facilities will also be considered on their own merits.

3. Heating capacity. Heating capacity sufficient to consistently maintain the design sludge temperature shall be provided. Where digester tank gas is used for sludge heating, an auxiliary fuel supply is required.

4. Hot water internal heating controls.

A. Mixing valves. A suitable automatic mixing valve shall be provided to temper the boiler water with return water so that the inlet water to the heat jacket can be held below a temperature at which caking will be accentuated. Manual control should also be provided by suitable bypass valves.

B. Boiler controls. The boiler should be provided with suitable automatic controls to maintain the boiler temperature at approximately one hundred eighty degrees Fahrenheit (180°F) (82°C) to minimize corrosion and to shut off the main gas supply in the event of pilot burner or electrical failure, low boiler water level or excessive temperature.

C. Thermometers shall be provided to show temperatures of the sludge, hot water feed, hot water return and boiler water.

(F) Supernatant Withdrawal.

1. Piping size. Supernatant piping should not be less than six inches (6") (15 cm) in diameter.

2. Withdrawal arrangements.

A. Withdrawal levels. Piping should be arranged so that withdrawal can be made from three (3) or more levels in the digester. A positive unvalved vented overflow shall be provided.

B. Supernatant selector. If a supernatant selector is provided, provisions shall be made for at least one (1) other draw-off level located in the supernatant zone of the tank in addition to the unvalved emergency supernatant draw-off pipe. High pressure backwash facilities shall be provided.

3. Sampling. Provisions should be made for sampling at each supernatant draw-off level. Sampling pipes should be at least one and one-half inches (1 1/2") (3.8 cm) in diameter and should terminate at a suitably-sized sampling sink or basin.

4. Alternate supernatant disposal. Consideration should be given to supernatant conditioning where appropriate in relation to its effect on plant performance and effluent quality.

(6) Aerobic Sludge Digestion.

(A) General. Aerobic digestion can be used to stabilize primary sludge, secondary sludge or a combination of the two. Digestion is

accomplished in single or multiple tanks designed to provide effective air mixing, reduction of the organic matter, supernatant separation and sludge concentration under controlled conditions.

1. Digestion tanks. Multiple tanks are recommended. A single sludge digestion tank may be used in the case of small treatment plants or where adequate provision is made for sludge handling where a single unit will not adversely affect normal plant operations.

(B) Mixing and Air Requirements. Aerobic sludge digestion tanks shall be designed for effective mixing by satisfactory aeration equipment. Sufficient air shall be provided to keep the solids in suspension and maintain dissolved oxygen between one and two (1–2) mg/l. A minimum mixing and oxygen requirement of thirty (30) cfm per one thousand (1000) cubic feet of tank volume (30 l/min/m³) shall be provided with the largest blower out-of-service. If diffusers are used, the nonclog type is recommended, and they should be designed to permit continuity of service. If mechanical aerators are utilized, a minimum of 1.0 horsepower per one thousand (1000) cubic feet (28.3m³) should be provided. Use of mechanical equipment is discouraged where freezing temperatures are normally expected.

(C) Tank Capacity. The determination of tank capacities shall be based on rational calculations, including such factors as quantity of sludge produced, sludge characteristics, time of aeration and sludge temperature.

1. Volatile solids loading. It is recommended that the volatile suspended solids loading not exceed one hundred pounds per one thousand cubic feet (100 lb/1000 ft³) of volume per day (1.60 kg/m³/day) in the digestion units. Lower loading rates may be necessary depending on temperature, type of sludge and other factors.

2. Solids retention time. Required minimum solids retention time for stabilization of biological sludges vary depending on type of sludge. Normally, a minimum of fifteen (15) days' retention should be provided for waste activated sludge and twenty (20) days for combination of primary and waste activated sludge, or primary sludge alone. Where sludge temperature is lower than fifty degrees Fahrenheit (50°F) (10°C), additional detention time should be considered.

(D) Supernatant Separation. Facilities shall be provided for effective separation and withdrawal of supernatant and for effective collection and removal of scum and grease.

(7) Sludge Pumps and Piping.

(A) Sludge Pumps.

1. Capacity. Pump capacities should be adequate but not excessive. Provision for varying pump capacity is desirable.

2. Duplicate units. Duplicate units shall be provided where failure of one (1) unit would seriously hamper plant operation.

3. Type. Plunger pumps, screw feed pumps, recessed impeller type centrifugal pumps, progressive cavity pumps or other types of pumps with demonstrated solids handling capability shall be provided for handling raw sludge. Where centrifugal pumps are used, a parallel plunger type pump should be provided as an alternate to increase reliability of the centrifugal pump.

4. Minimum head. A minimum positive head of twenty-four inches (24") (61 cm) shall be provided at the suction side of centrifugal type pumps and is desirable for all types of sludge pumps. Maximum suction lifts should not exceed ten feet (10') (3m) for plunger pumps.

5. Sampling facilities. Unless sludge sampling facilities are otherwise provided, quick closing sampling valves shall be installed at the sludge pumps. The size of valve and piping should be at least one and one-half inches (1 1/2") (3.8 cm).

(B) Sludge Piping.

1. Size and head. Sludge withdrawal piping should have a minimum diameter of eight inches (8") (20.3 cm) for gravity withdrawal and six inches (6") (15.2 cm) for pump suction and discharge lines. Where withdrawal is by gravity the available head on the discharge pipe should be adequate to provide at least three feet (3') per second (0.9m/sec) velocity.

2. Slope. Gravity piping should be laid on uniform grade and alignment. The slope of gravity discharge piping should not be less than three percent (3%). Provisions should be made for cleaning, draining and flushing discharge lines.

3. Supports. Special consideration should be given to the corrosion resistance and continuing stability of supporting systems located inside the digestion tank.

(8) Sludge De-watering.

(A) Sludge Drying Beds.

1. Area. In determining the area of sludge drying beds, consideration shall be given to climatic conditions, the character and volume of the sludge to be de-watered, the method and schedule of sludge removal and other methods of sludge disposal. (It should be recognized that, in northern areas of the country, the drying season is only six (6) months a year.) In general, the sizing of the drying bed may be estimated on the basis of 2.0 ft²/capita (0.2m²/capita) when the dry-

ing bed is the primary method of de-watering, and 1.0 ft²/capita (0.1m²/capita) if it is to be used as a back-up de-watering unit. An increase of bed area by twenty-five percent (25%) is recommended for paved-type bed.

2. Percolation type. The lower course of gravel around the underdrains should be properly graded and should be twelve inches (12") (30 cm) in depth, extending at least six inches (6") (15.2 cm) above the top of the under drains. It is desirable to place this in two (2) or more layers. The top layer of at least three inches (3") (7.6 cm) should consist of gravel one-eighth inch (1/8") to one-fourth inch (1/4") (3.2–6.4 mm) in size.

A. Sand. The top course should consist of at least six to nine inches (6"–9") (15–23 cm) of clean coarse sand. The finished sand surface should be level.

B. Underdrains. Underdrains should be clay pipe or concrete drain tile at least four inches (4") (10 cm) in diameter laid with open joints. Underdrains should be spaced not more than twenty feet (20') (6m) apart. As to the discharge of the underdrain filtrate, refer to subsection (8)(C) of this rule.

3. Partially paved type. The partially paved type drying bed should be designed with consideration for space requirement to operate mechanical equipment for removing the dried sludge.

4. Walls. Walls should be watertight and extend fifteen to eighteen inches (15"–18") (38 cm–46 cm) above and at least six inches (6") (15 cm) below the surface. Outer walls should be curbed to prevent soil from washing onto the beds.

5. Sludge removal. Not less than two (2) beds should be provided and they should be arranged to facilitate sludge removal. Concrete truck tracks should be provided for all percolation type sludge beds. Pairs of tracks for percolation type should be on twenty-foot (20') (6m) centers.

6. Sludge influent. The sludge pipe to the drying beds should terminate at least twelve inches (12") (30 cm) above the surface and be so arranged that it will drain. Concrete splash plates for percolation type should be provided at sludge discharge points.

7. Protective enclosure. A protective enclosure shall be provided if winter operation is required.

(B) Mechanical De-watering Facilities. Provision shall be made to maintain sufficient continuity of service so that sludge may be de-watered without accumulation beyond storage capacity. The number of vacuum filters, centrifuges, filter presses, belt filters or other mechanical de-watering facilities should be sufficient to de-water the sludge produced with one (1) largest unit out-of-ser-

vice. Unless other standby facilities are available, adequate storage facilities shall be provided. The storage capacity should be sufficient to handle at least a three (3)-month sludge production.

1. Auxiliary facilities per vacuum filters. There shall be a back-up vacuum pump and filtrate pump installed for each vacuum filter. It is permissible to have an uninstalled back-up vacuum pump or filtrate pump for every three (3) or less vacuum filters, provided that the installed unit can easily be removed and replaced.

2. Ventilation. Adequate facilities shall be provided for ventilation of de-watering area. The exhaust air should be properly conditioned to avoid odor nuisance.

3. Chemical handling enclosures. Lime-mixing facilities should be completely enclosed to prevent the escape of lime dust. Chemical handling equipment should be automated to eliminate the manual lifting requirement.

(C) Drainage and Filtrate Disposal. Drainage from beds or filtrate from de-watering units shall be returned to the sewage treatment process at appropriate points.

(D) Other De-watering Facilities. If it is proposed to de-water or dispose of sludge by other methods, a detailed description of the process and design data shall accompany the plans.

(9) Municipal Sludge Disposal on Land. The program of land spreading of sludge must be evaluated as an integral system which include stabilization, storage, transportation, application, soil, crop and groundwater. The following guidelines were formulated to provide the criteria of municipal sludge disposal on land. Sewage sludge is useful to crop and soil by providing nutrients and organic matter. Sewage sludge contains heavy metals and other substances which could affect soil productivity and the quality of food. Sufficient information is not available to completely evaluate the deleterious effects. The purpose of the guidelines is to indicate the acceptable method of sludge disposal on land surface based on current knowledge. It is recognized that these guidelines should be revised as more information becomes available.

(A) General Limitations to be Observed.

1. Stabilized sludge. Only stabilized sludge shall be surface applied to farmland or pasture. Stabilized sludge is defined as processed sludge in which the organic and bacterial contents of raw sludge are reduced to levels deemed necessary by the agency to prevent nuisance odors and public health hazards. Any process which produces sludge equivalent in quality to the above in terms of

public health factors and odor potential may be accepted. Additional treatment would be required to further reduce pathogens when the sludge is to be spread on dairy pastures and other crops which are in the human food chain.

2. Raw vegetables. Sludge should not be applied to land which is used for growing food crops to be eaten raw, such as leafed vegetables and root crops.

3. Minimum pH. No sludge shall be applied on land if the soil pH is less than 6.5 when sludge is applied and pH shall be maintained above 6.5 for at least two (2) years following end of sludge application.

4. Persistent organic chemicals. At present time, sufficient information is not available to establish criteria of sludge spreading in regard to persistent organic chemicals, such as pesticides and polychlorinated biphenyls (PCB). However, if there is a known source in the sewer service area which discharges or discharged in the past such chemicals, the sludge should be analyzed for chemicals and the agency shall be consulted for recommendations concerning sludge spreading.

(B) Site Selection. By proper selection of the sludge application site, the nuisance potential and public health hazard should be minimized. The following items should be considered and the agency should be consulted for specific limits: land ownership information; groundwater table and bedrock location; location of dwellings, road and public access; location of wells, springs, creeks, streams and flood plains; slope of land surface; soil characteristics; climatological information and periods of ground freezing; land use plan; and road weight restrictions.

(C) Sludge Application on Farmland. Heavy metal loading to land should be limited in order to avoid reduction of soil productivity. A detailed chemical analysis of the sludge shall be made and the application rate shall be based on characteristics of the application site and crop uptake. The agency shall be contacted for specific limits.

(D) Sludge Application on Forested Land. Disposal of sludge on forested land is considerably less hazardous than on cropland in terms of heavy metal toxicity unless the land is to be converted to cropland. For the allowable sludge loading the agency should be consulted.

(E) Management of Spreading Operation.

1. Hauling equipment. The sludge hauling equipment should be designed to prevent spillage, odor and other public nuisance.

2. Valve control. The spreading tank truck should be provided with a control so that the discharge valve can be opened and

closed by the driver while the vehicle is in motion. The spreading valve should be of the fail-safe type (that is, self-closing) or an additional manual standby valve should be employed to prevent uncontrolled spreading or spillage.

3. Sludge storage. Sufficient sludge storage capacity shall be provided for periods of inclement weather and equipment failure. The storage facilities shall be designed, located and operated so as to avoid nuisance conditions.

4. Spreading methods. The selection of spreading methods depends on the sludge characteristics, environmental factor and others. When control of odor nuisance and runoff is required, immediate incorporation of sludge after spreading or subsurface injection should be considered. When the a method is utilized, an adjustment in the reduced rate of ammonia loss into the atmosphere should be considered in the computation for nitrogen balance. The sewage sludge should be spread uniformly over the surface when tank truck spreading, ridge and furrow irrigation or other methods are used. Proposals for subsurface application of sludge shall include for review a description of the equipment and program for application. Spray systems except for downward directed types will not ordinarily be approved.

5. Boundary demarcation. The boundaries of the site shall be marked (for example, with stakes at corners) so as to avoid confusion regarding the location of the site during the sludge application. The markers should be maintained until the end of the current growing season.

6. Public access. Public access of the disposal site must be controlled by either positive barriers or remoteness of the site.

(F) Monitoring and Reporting. The requirement of the agency on the monitoring and reporting of sludge spreading operation should be followed. As a minimum, the producer of sludge should regularly collect and record information on the sludge and soil characteristics and volume of sludge spread to a particular site.

(10) Other Sludge Disposal Methods. When other sludge disposal methods, such as incineration and landfill, are considered, pertinent requirements from the agency shall be followed.

AUTHORITY: section 644.026, RSMo Supp. 1988. Original rule filed Aug. 10, 1978, effective March 11, 1979.*

**Original authority 1972, amended 1973, 1987, 1993.*

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.*

Editor's Note: The secretary of state has determined that the publication of this rule in its entirety would be unduly cumbersome or expensive. The entire text of the material referenced has been filed with the secretary of state. This material may be found at the Office of the Secretary of State or at the headquarters of the agency and is available to any interested person at a cost established by state law.

(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 agency 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) (85.4m³) or less (see 10 CSR 20-8.020 for the requirements for those facilities).

(3) Trickling Filters.

(A) General. Trickling filters may be used for treatment of sewage amenable to treatment by aerobic biologic 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 (m²) 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*, Num-

ber 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 a minimum depth of five feet (5') (1.5m) above the underdrains. Manufactured filter media should have a minimum depth of ten feet (10') (3m) to provide adequate contact time with the wastewater. Rock and/or slag filter media depths shall not exceed ten feet (10') (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. Size and grading of media.

A. Rock, slag and similar media. Rock, slag and similar media shall not contain more than five percent (5%) by weight of pieces whose longest dimension is three (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 grading when mechanically graded over vibrating screen with square openings.

Passing 4 1/2-inch (4 1/2") screen (11.4 cm)—one hundred percent (100%) by weight.

Retained on 3-inch (3") screen (7.6 cm)—ninety-five to one hundred percent (95–100%) by weight.

Passing 2-inch (2") screen (5.1 cm)—0.2% by weight.

Passing 1-inch (1") screen (2.5 cm)—0.1% by weight.

B. Manufactured Media. Suitability will be evaluated on the basis of experience with installations handling similar wastes and loadings.

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) 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 a minimum slope of one percent (1%). Effluent channels shall be designed to produce a minimum velocity of two feet (2') per second (0.61m/s) at average daily rate of application to the filter. The underdrainage system, effluent channels and effluent pipe shall be designed to permit free passage of air. 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 devices, 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) (3785m³/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 must be 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.

(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 (3785m³/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
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') (3m) or more than thirty feet (30') (9m) 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. O₂/lb. peak BOD₅ applied to the aeration tanks (1.1 kg O₂/kg peak BOD₅) 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 must be added to the above requirement for carbonaceous BOD₅ 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., must be considered due to the high concentration of BOD₅ 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 BOD₅ peak aeration tank loading (93.5m³/kg of BOD₅). For the extended-aeration process the value shall be two thousand (2000) cu. ft. (125m).

(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/cm²) 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:

	<u>Minimum</u>	<u>Maximum</u>
Standard Rate	15	75
Carbonaceous Stage of Separate Stage Nitrification	15	75
Step Aeration Contact Stabilization	15	75
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 suction. 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 (0.61m/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 (3785m³/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. RBC's 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 BOD₅ 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 BOD₅ 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).

AUTHORITY: section 644.026, RSMo Supp. 1988. Original rule filed Aug. 10, 1978, effective March 11, 1979.*

**Original authority 1972, amended 1973, 1987, 1993.*

10 CSR 20-8.190 Disinfection

PURPOSE: The following criteria have been prepared as a guide for the design of disinfection 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 names can be added to the mailing list.

Editor's Note: The secretary of state has determined that the publication of this rule in its entirety would be unduly cumbersome or expensive. The entire text of the material referenced has been filed with the secretary of state. This material may be found at the Office of the Secretary of State or at the headquarters of the agency and is available to any interested person at a cost established by state law.

(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 agency 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) (85.4m³) or less (see 10 CSR 20-8.020 for the requirements for those facilities).

(3) Forms of Disinfection. Chlorine is the most commonly used chemical for wastewater disinfection. The forms most often used are liquid chlorine and calcium or sodium hypochlorite. Other disinfectants, including chlorine dioxide, ozone or bromine, may be accepted by the agency in individual cases. The chemical should be selected after due consideration of waste flow rates, application and demand rates, pH of the wastewater, cost of equipment, chemical availability and maintenance problems. If chlorination is utilized, it may be necessary to dechlorinate if the chlorine level in the effluent would impair the natural aquatic habitat of the receiving stream.

(4) Feed Equipment.

(A) Type. Solution-feed vacuum-type chlorinators are generally preferred for large chlorination installations. The use of hypochlorite feeders of the positive displacement type may be considered and are generally preferred when intermittent disinfection is required. The preferred method of genera-

tion of chlorine dioxide is the injection of a sodium chlorite solution into the discharge line of a solution-feed gas-type chlorinator with subsequent formation of the chlorine dioxide in a reaction chamber at a pH of four (4.0) or less. Ozone dissolution is accomplished through the use of conventional gas diffusion equipment, with appropriate consideration of materials. If ozone is being produced from air, gas preparation equipment (driers, filters, compressors) is required. If ozone is being produced from oxygen, this equipment may not be needed as a clean dry pressurized gas supply will be available.

(B) Control.

1. Chlorination without dechlorination. Facilities with design flows of one million gallons per day (1.0mgd) (3785m³/d) or greater shall be equipped with a chlorine rate control to feed the chlorine proportional to the flow of wastewater and the chlorine residual. Facilities with design flows between one (1.0) mgd (3785m³/d) and twenty-two thousand five hundred (22,500) gpd (85.4m³) shall be equipped with a control system to feed the chlorine proportional to the flow of wastewater.

2. Chlorination with dechlorination. All facilities designed for dechlorination must be equipped to feed the chlorine proportional to the flow of wastewater and the chlorine residual. Dechlorination equipment shall be equipped to feed in proportion to the flow of wastewater.

3. Ozone. Facilities for disinfection with ozone should be equipped to feed the ozone in proportion to the flow of wastewater.

(C) Capacity. Required disinfection capacity will vary, depending on the uses and points of application of the disinfecting chemical. For disinfection, the capacity should be adequate to produce an effluent that will meet the coliform limits specified by the agency. For normal domestic sewage, the following may be used as a guide in sizing chlorination facilities.

Type of Treatment	Dosage
Trickling filter plant	10 mg/l
Activated sludge plant effluent	8 mg/l
Tertiary filtration effluent	6 mg/l
Nitrified effluent	6 mg/l

(D) Standby Equipment and Spare Parts. Standby equipment of sufficient capacity should be available to replace the largest unit during shutdowns. Spare parts shall be available for all disinfection equipment to replace parts which are subject to wear and breakage.

(E) Water Supply. An ample supply of water shall be available for operating the

chlorinator. Where a booster pump is required, duplicate equipment should be provided and when necessary, standby power as well. Protection of a potable water supply shall conform to the requirements of 10 CSR 20-8.140(8)(B).

(5) Chlorine Supply.

(A) General. The type of chlorine supply should be carefully evaluated during the planning process. Large quantities of chlorine are contained in ton cylinders and tank cars can present a considerable hazard to plant personnel and to the surrounding area should the containers develop leaks.

(B) Containers. The use of ton containers should be considered where the average daily chlorine consumption is over one hundred fifty pounds (150 lbs.) (68 kg). Both monetary cost and the potential residential exposure to chlorine should be considered when making the final determination.

(C) Tank Cars. At large chlorination installations consideration should be given to the use of tank cars, generally accompanied by gas evaporators. Both monetary cost and the potential residential exposure to chlorine should be considered when making the final determination. Liquid chlorine lines from tank cars to evaporators shall be buried and installed in a conduit and shall not enter below grade spaces. Systems shall be designed for the shortest possible pipe transportation of liquid chlorine.

(D) Scales. Scales for weighing cylinders shall be provided at all plants using chlorine gas. At large plants, scales of the indicating and recording type are recommended. At least a platform scale shall be provided. Scales shall be of corrosion-resistant material.

(E) Evaporators. Where manifolding of several cylinders or ton containers will be required to evaporate sufficient chlorine, consideration should be given to the installation of evaporators, to produce the quantity of gas required.

(F) Leak Detection and Controls. A bottle of fifty-six percent (56%) ammonium hydroxide solution shall be available for detecting chlorine leaks. Where ton containers or tankcars are used, a leak repair kit approved by the Chlorine Institute shall be provided. Consideration should be given to the provision of caustic soda solution reaction tanks for absorbing the contents of leaking ton containers where the containers are in use. At large chlorination installations, consideration should be given to the installation of automatic gas detection and related alarm equipment. For ozone installations, similar purpose equipment shall be provided.

(6) Ozone Generation. Ozone may be produced from either an air or an oxygen gas source. Generation units shall be automatically controlled to adjust ozone production to meet disinfection requirements.

(7) Piping and Connections. Piping systems should be as simple as possible, specifically selected and manufactured to be suitable for chlorine or ozone service, with a minimum number of joints. Piping should be well supported and protected against temperature extremes. The correct weight or thickness of steel is suitable for use with dry chlorine liquid or gas. Even minute traces of water added to chlorine results in a corrosive attack that can only be resisted by pressure piping utilizing materials such as silver, gold, platinum or Hasteloy C. Low pressure lines made of hard rubber, saran-lined, rubber-lined, polyethylene, polyvinylchloride (PVC) or Uscolite materials are satisfactory for wet chlorine or aqueous solutions of chlorine. Due to the corrosiveness of wet chlorine, all lines designed to handle dry chlorine should be protected from the entrance of water or air containing water. For ozonation systems, the selection of material should be made with due consideration for ozone's corrosive nature. Copper or aluminum alloy should be avoided. Stainless steel with a corrosion resistance of at least equal to grade 304 L should be specified for piping containing ozone in nonsubmerged applications. Unplasticized PVC, Type 1, may be used in submerged piping, provided the gas temperature is below one hundred forty degrees Fahrenheit (140°F) (60°C) and the gas pressure is low.

(8) Housing.

(A) Separation. If gas chlorination equipment, chlorine cylinders or ozone generation equipment are to be in a building used for other purposes, a gas-tight room shall separate this equipment from any other portion of the building. Floor drains from the chlorine room should not be connected to floor drains from other rooms. Doors to this room shall open only to the outside of the building and shall be equipped with panic hardware. The rooms shall be at ground level and should permit easy access to all equipment. Storage area should be separate from the feed area. Chlorination equipment should be situated as close to the application point as reasonably possible.

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

(C) Heat. Rooms containing disinfection equipment shall be provided with a means of heating so that a temperature of at least sixty degrees Fahrenheit (60°F) (16°C) can be maintained but the room should be protected from excess heat. Cylinders shall be kept at essentially room temperature. The room containing the ozone generation units shall be maintained above thirty-five degrees Fahrenheit (35°F) (2°C) at all times.

(D) Ventilation. With chlorination systems, forced, mechanical ventilation shall be installed which will provide one (1) complete air change per minute when the room is occupied. For ozonation systems, continuous ventilation to provide at least six (6) complete air changes per hour should be installed. 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 with air and at a temperature that will not adversely affect the chlorination of ozone generation equipment. The vent hose from the chlorinator shall discharge to the outside atmosphere above grade.

(E) Electrical Controls. Switches for fans and lights shall be outside of the room at the entrance. A labeled signal light indicating fan operation should be provided at each entrance, if the fan can be controlled from more than more one (1) point.

(9) Respiratory Protection. Respiratory air-pac 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 convenient location but not inside any room where chlorine is used or stored. Instructions for using, testing and replacing mask parts including canisters, shall be posted adjacent to the equipment. The units shall use compressed air, have at least thirty (30)-minute capacity and be compatible with the units used by the fire department responsible for the plant.

(10) Application of Chlorine or Ozone.

(A) Mixing. The disinfectant shall be positively mixed as rapidly as possible, with a complete mix being effected in three (3) seconds. This may be accomplished by either the use of turbulent flow regime or a mechanical flash mixer.

(B) Contact Period. For a chlorination system, a minimum contact period of fifteen (15) minutes at peak hourly flow or maximum rate of pumpage shall be provided after thorough mixing. Consideration should be

given to running a field tracer study to assure adequate contact time. If dechlorination is required after complete mixing of the effluent with the chemical, no further contact time is necessary. The required contact time for an ozonation unit varies with the type of dissolution equipment used. Certain high rate devices require contact times less than one (1) minute to achieve disinfection while conventional dissolution equipment may require contact times similar to chlorination systems.

(C) Contact Tank. The chlorine or ozone contact tank shall be constructed so as to reduce short-circuiting of flow to a practical minimum. Baffles shall be parallel to the longitudinal axis of the chamber with a minimum length to width ratio of forty to one (40:1) (the total length of the channel created by the baffles should be forty (40) times the distance between the baffles). The tank should be designed to facilitate maintenance and cleaning without reducing effectiveness of disinfection. Duplicate tanks, mechanical scrapers or portable deck level vacuum cleaning equipment shall be provided. Consideration should be given to providing skimming devices on all contact tanks. Covered tanks are discouraged.

(11) Evaluation of Effectiveness.

(A) Sampling. Facilities shall be included for sampling the disinfected effluent after contact. In large installations, or where stream conditions warrant, provisions should be made for continuous monitoring of effluent chlorine residual.

(B) Testing. Equipment shall be provided for measuring chlorine residuals using accepted test procedures. Automatic equipment required by subsection (4)(C) of this rule may be used to meet the requirements of this subsection. Equipment shall also be required for measuring fecal coliform using accepted test procedures as required by 10 CSR 20-9.010.

AUTHORITY: section 644.026, RSMo Supp. 1988. Original rule filed Aug. 10, 1978, effective March II, 1979.*

**Original authority 1972, amended 1973, 1987, 1993.*

10 CSR 20-8.200 Wastewater Treatment Ponds (Lagoons)

PURPOSE: The following criteria have been prepared as a guide for the design of wastewater treatment ponds (lagoons). 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 names can be added to the mailing list.

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(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 agency 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 (22,500) gallons per day (85.4m³) or less (see 10 CSR 20-8.020 for the requirements for those facilities).

(3) General. This rule deals with generally used variations of treatment ponds to achieve secondary treatment including controlled discharge pond systems, flow-through pond systems and aerate pond systems. Ponds utilized for equalization, percolation, evaporation and sludge storage will not be discussed in this rule.

(4) Supplement to Engineer's Report. The engineer's report shall contain pertinent information on location, geology, soil conditions, area for expansion and any other factors that will affect the feasibility and acceptability of the proposed project. The following information must be submitted in addition to that required in 10 CSR 20-8.110.

(A) Supplementary Field Survey Data.

1. The location and direction of all residences, commercial developments, parks, recreational areas and water supplies, including a log of each well if available within one-half (1/2) mile (0.8 km) of the proposed pond shall be included in the engineer's report.

2. Land use zoning adjacent to the proposed pond site shall be included.

3. A description, including maps showing elevations and contours, of the site and adjacent area shall be provided. Due consideration shall be given to additional treatment units and/or increased waste loadings in determining land requirements. Current United States Geological Survey and Soil Conservation Service maps may be considered adequate for preliminary evaluation of the proposed site.

4. The location, depth and discharge point(s) of any field tile in the immediate area of the proposed site shall be identified.

5. A geological evaluation of the proposed lagoon site prepared by the Division of Geology and Land Survey (DGLS) shall be submitted. To obtain this geological evaluation of the proposed site, the engineer shall submit the following information to the Department of Natural Resources, Division of Geology and Land Survey, P.O. Box 250, Rolla, MO 65401:

A. A layout sheet showing the proposed location. The layout shall include the legal description, property boundaries, roads, streams and other geographical landmarks which will assist in locating the site;

B. Size of the lagoon and/or approximate volume of waste to be treated;

C. Maximum cuts to be made in the construction of the lagoon; and

D. Location and depth of cut for borrow area, if any.

6. Sulfate content of the primary water supply shall be determined.

7. Data from all soil borings conducted by a professional soil testing laboratory to determine subsurface soil characteristics and groundwater characteristics, including elevation, at the proposed site and their effect on the construction and operation of a pond shall also be provided. All boring holes shall be filled and sealed. The permeability characteristics of the pond bottom and pond seal material shall also be studied. At the facility plan

stage particle size analysis, Atterburg limits, standard Procter density (moisture-density relations) or permeability coefficient may be required on a case-by-case basis to reflect soil characteristics. At the twenty percent (20%) design stage, soil analysis of each representative soil material including particle size analysis, Atterburg limits, standard Procter density (moisture-density relations) and permeability coefficient of the compacted soil as measured in a falling head permeameter or other test procedure acceptable to the agency may be required. Soil borings may be required in each geological area to determine depth to piezometric surface and to bedrock. Recommendations of the DGLS will be used to establish the required tests at the facility plan and twenty percent (20%) design stages.

(B) Site Information.

1. Distance from habitation. Lagoon sites should be as far as practicable from habitation or any area which may be built up within a reasonable future period. The agency does not attempt to set any minimum distance from habitation since each case must be judged upon its own merits.

2. Prevailing winds. If practicable, ponds should be located so that local prevailing winds will be in the direction of uninhabited areas.

3. Surface runoff. Location of ponds in watersheds receiving significant amounts of stormwater runoff is discouraged. Adequate provisions must be made to divert stormwater runoff around the ponds and protect embankments from erosion.

4. Hydrology. Construction of ponds in close proximity to water supplies and other facilities subject to contamination should be avoided. A minimum separation of four feet (4') (1.2m) between the bottom of the pond and the maximum groundwater elevation should be maintained where feasible.

5. Groundwater pollution. Proximity of lagoons to water supply located in areas of porous soils and fissured rock formation shall be elevated to avoid creation of health hazards or other undesirable conditions. If the geological report from DGLS makes suggestions for remedial treatment of the site, the engineer shall comply with the suggestions. In some cases, the engineering geologist requests to visit the site during or after construction. When a request is made, the consulting engineer shall comply with the request.

(5) Basis of Design.

(A) Quality of Effluent. A controlled discharge stabilization pond (four (4)-cell) will be considered capable of meeting effluent limitations of thirty (30) mg/l biochemical

oxygen demand (BOD₅) and thirty (30) mg/l suspended solids. Flow-through stabilization ponds (three (3)-cell), and aerated lagoon systems will be considered capable of meeting effluent limitations of thirty (30) mg/l BOD₅ and eighty (80) mg/l suspended solids. Flow-through lagoon systems and aerated lagoon systems followed by submerged sand filters will be considered capable of meeting effluent limitations of twenty (20) mg/l BOD₅ and twenty (20) mg/l suspended solids. Lagoons may be incorporated into irrigation systems or systems utilizing chemical coagulation and filtration to meet the requirements of 10 CSR 20-7.015(3)(A)3. Please refer to 10 CSR 20-7.015 Effluent Regulation for discharge requirements.

(B) Area and Loadings for Controlled Discharge Stabilization Ponds (four (4)-cell). Pond design for BOD₅ loadings shall not exceed thirty-four (34) lbs./acre/day (38 km per hectare per day) at the three-foot (3'-1.9m) operating depth in the primary cells. The primary cell shall be followed by a secondary cell having 0.3 the area of the primary cell and by two (2) storage cells. The two (2) storage cells shall have a volume above the two-foot (2'-0.6m) level for one (1) month's storage of average daily flow in each cell. At least one hundred twenty (120) days' detention time between the two-foot (2') level (0.6m) and the maximum operating depth shall be provided in the entire pond system. Flow can be based on one hundred (100) gallons per capita per day (38m³/cap/d) or other values if data is presented to justify the rate. Primary and secondary cells shall be designed for water depths up to a maximum of five feet (5') (1.5m). The storage cell should be made as deep as possible up to a maximum depth of eight feet (8') (2.4m).

(C) Area and Loadings for Flow-through Stabilization Ponds (three (3) cell). Pond design for BOD₅ loadings shall not exceed thirty-four (34) pounds per acre per day (38 km per hectare per day). The second cell must be at least 0.3 the area of the first cell and the third cell 0.1 the area of the first cell. The first and second cells must have a variable operating level of between two feet (2') (0.6m) and five feet (5') (1.5m). The third cell must have a variable operating level of between two feet (2') (0.6m) and eight feet (8') (2.4m). Detention time of at least one hundred twenty (120) days must be provided. Flows of less than one hundred (100) gallons per capita per day (.38m³/cap/d) may be used if data is presented to justify the lower rate.

(D) Aerated Lagoons. For the development of final design parameters it is recommended that actual experimental data be developed; however, the aerated lagoon design for minimum detention time may be estimated using the following formula:

$$t = \frac{E}{2.3 K_1 \times (100-E)}$$

where:

t = detention time in the aeration cell in days;

E = percent of BOD₅ to be removed in an aerated pond; and

K₁ = reaction coefficient aerated lagoon, base 10.

For normal domestic sewage the K₁ value may be assumed to be .15 per day for Missouri conditions. The reaction rate coefficient for domestic sewage which includes some industrial waste, other waste or partially treated sewage must be determined experimentally for various conditions which might be encountered in the aerated ponds. Conversion of the reaction coefficient at other temperatures shall be based on experimental data. Raw sewage strength should also consider the effect of any return sludges. Also, additional storage volume should be considered for sludge and in northern climates, ice cover. Oxygen requirements generally will depend on the BOD₅ loading, the degree of treatment and the concentration of suspended solids to be maintained. Aeration equipment shall be capable of maintaining a minimum dissolved oxygen level of two (2) mg/l in the ponds at all times. Suitable protection from weather shall be provided for electrical controls. The aeration equipment shall be capable of providing 1.3 pounds of oxygen per pound of BOD₅(1.3 kg/kg BOD₅) removed. BOD₅ removal shall be based on warm weather rates. Aerated cells shall be followed by a polishing cell with a volume of 0.3 of the volume of the aerated cell (see 10 CSR 20-8.180 for details on aeration equipment).

(E) Multiple Units. Parallel cells should be considered for large installations. The maximum size of any cell should be forty (40) acres (16 ha). The system should be designed to permit isolation of any cell without disrupting service of the other cells.

(F) Pond Shape. The shape of all cells should be so that there are no narrow or elongated portions. Round, square or rectangular ponds with a length not exceeding three (3) times the width are considered most desirable. No islands, peninsulas or coves shall be permitted. Dikes should be rounded at corners to minimize accumulation of floating materials. Common dike construction, wherever possible, is strongly encouraged.

(G) Industrial Wastes. Consideration shall be given to the type and effects of industrial wastes on the treatment process. In some cases it may be necessary to pretreat industrial or other discharges. Industrial wastes shall not be discharged to ponds without assessment of the effects the substances may have

upon the treatment processor discharge requirements in accordance with state and federal laws.

(H) Additional Treatment. Consideration should be given in the design stage to the utilization of additional treatment units as may be necessary to meet applicable discharge standards (see paragraph (4)(A)3. of this rule).

(6) Pond Construction Details.

(A) Embankments and Dikes.

1. Material. Dikes shall be constructed of relatively impervious material and compacted to at least ninety-five percent (95%) standard Procter density to form a stable structure. Vegetation and other unsuitable materials shall be removed from the area where the embankment is to be placed.

2. Top width. The minimum dike width shall be eight feet (8') (2.4m) to permit access of maintenance vehicles.

3. Maximum slopes. Inner and outer dike slopes shall not be steeper than three horizontal to one vertical (3:1).

4. Minimum slopes. Inner slopes should not be flatter than four horizontal to one vertical (4:1). Flatter slopes can be specified for larger installations because of wave action but have the disadvantage of added shallow areas being conducive to emergent vegetation. Outer slopes shall be sufficient to prevent surface runoff from entering the ponds.

5. Freeboard. Minimum freeboard shall be two feet (2') (0.6m). For very large cells, three feet (3') (1.0m) should be considered.

6. Design depth. The minimum operating depth should be sufficient to prevent growth of aquatic plants and damage to the dikes, bottom, control structures, aeration equipment and other appurtenances. In no case should pond depths be less than two feet (2') (0.6m). The design water depth for aerated lagoons should be ten to fifteen feet (10-15') (3-4.5m). This depth limitation may be altered depending on the aeration equipment, waste strength, climatic conditions and geologic conditions.

7. Erosion control. A justification and detailed discussion of the method of erosion control which encompasses all relative factors such as pond location and size, variations in operating depths, seal material, topography, prevailing winds, cost breakdown, application procedures, etc., shall be provided.

A. Seeding. The dikes shall have a cover layer of fertile topsoil with a minimum thickness of four inches (4") (10 cm) to promote establishment of an adequate vegetative cover wherever riprap is not utilized. Prior to prefilling (in accordance with paragraph (6)(C)3. of this rule), adequate vegetation

shall be established on dikes from the outside toe to one foot (1') above the water line measured on the slope. Perennial-type, low growing, spreading grasses that minimize erosion and can be mowed are most satisfactory for seeding of dikes. In general, alfalfa and other long-rooted crops should not be used for seeding since the roots of this type are apt to impair the water holding efficiency of the dikes. Alternate dike stabilization practices may be considered if vegetative cover cannot be established prior to refilling.

B. Additional erosion protection. Riprap or some other acceptable method of erosion control is required as a minimum around all piping entrances and exits. For aerated cell(s) design should ensure erosion protection on the slopes and bottoms in the areas where turbulence will occur. Additional erosion control may also be necessary on the exterior dike slope(s) to protect the embankment(s) from erosion due to severe flooding of a water course.

C. Alternate erosion protection. Alternate erosion control on the interior dike slopes may be necessary for ponds which are subject to severe wave action. In these cases riprap or an acceptable equal shall be placed from one foot (1') (.3m) above the high water mark to two feet (2') (0.6m) below the low water mark (measured on the vertical). This protection should also be provided in the storage cells of a controlled discharge (four (4)-cell) pond and the third cell of a flow-through pond (three (3)-cell) where large fluctuations in operating depths will occur.

(B) Pond Bottom.

1. Soil. Soil used in constructing the pond bottom (not including the seal) and dike cores shall be selected to avoid settlement. Soil shall be compacted with the moisture content between two percent (2%) below and four percent (4%) above the optimum water content and to the specified standard Procter density but no less than ninety-five percent (95%) standard Procter density.

(C) Seal.

1. Design. Ponds shall be sealed so that seepage loss through the seal is as low as practicably possible. Seals consisting of soils or synthetic liners may be used provided the permeability, durability, integrity and cost effectiveness of the proposed materials can be satisfactorily demonstrated for anticipated conditions. Bentonite, soda ash or other sealing aids may be used to achieve an adequate seal in systems using soil. Results of a testing program which substantiates the adequacy of the proposed seal must be incorporated into and/or accompany the engineering report. Standard ASTM procedures or other acceptable methods shall be used for all tests. Soils

having a permeability coefficient of 10-cm/sec or less with a compacted thickness of twelve inches (12") (30.5 cm) will be acceptable as a lagoon seal for water depths up to five feet (5') (1.5m). For permeability coefficients greater than 10-cm/sec or for heads over five feet (5') (1.5m) such as an aerated lagoon system, the following formula shall be used to determine minimum seal thickness:

$$t = \frac{H \times K}{5.4 \times 10^{-7} \text{ cm/sec}}$$

where:

K = the permeability coefficient of the soil in question;

H = the head of water in the lagoon; and

t = the thickness of the soil seal.

Units for H and t may be English or metric; however, they must be the same. For a seal consisting of an artificial liner, seepage loss shall not exceed the equivalent of the rate expressed in this paragraph.

2. Normal construction methods will include over-excavation below grade level of twelve inches (12") (30.5 cm), scarification and compaction of base material to ninety-five percent (95%) standard Procter density at moisture content between two percent (2%) below and four percent (4%) above optimum, and compaction of lifts generally not exceeding six inches (6") (15.2 cm) to ninety-five percent (95%) standard Procter density at moisture content between two percent (2%) below and four percent (4%) above optimum. Maximum rock size should not exceed one-half (1/2) of the thickness of the compacted lift. The cut face of dikes must also be over-excavated and compacted in lifts not to exceed six inches (6") (15.2 cm) per lift. Soils containing plastic clay may be excluded from this construction requirement on a case-by-case basis based on particle size analysis and Atterburg limits. In fact, with some clay soils, satisfactory construction cannot be obtained by over-excavation and recompaction. Construction control must include field density. A minimum of two (2) density tests per acre or not less than three (3) tests must be performed for the base and each lift. Permeability tests of field compacted material may be performed at the option of the consulting engineer.

3. Prefilling. The pond shall be prefilled in order to protect the liner, to prevent weed growth, to reduce odor, to allow measurement of percolation losses and to maintain moisture content of the seal. However, the dikes must be completely prepared as described in subparagraphs (6)(A)7.A. and/or B. of this rule before the introduction

of water. If the lagoon bottom is allowed to dry, the seal must be recompacted as required in paragraph (6)(C)2.

4. Percolation losses. Measurement of percolation losses shall consider flow into and out of the lagoon, rainfall and evaporation, and changes in water level. Measured percolation losses in excess of one-sixteenth inch (1/16") (1.6 mm) per day will be considered excessive.

(D) Influent Lines.

Material. Cast- or ductile-iron pipe should be used for the influent line to the pond. Unlined corrugated metal pipe should be avoided due to corrosion problems. Other materials selected shall be suited to local conditions. In material selection, consideration must be given to the quality of the wastes, exceptionally heavy external loadings, abrasion, soft foundations and similar problems.

2. Manhole. A manhole shall be installed prior to entrance of the influent line into the primary cell(s) and shall be located as close to the dike as topography permits. Its invert shall be at least six inches (6") (15 cm) above the maximum operating level of the pond and provide sufficient hydraulic head without surcharging the manhole.

3. Flow distribution. Flow distribution structures shall be designed to effectively split hydraulic and organic loads equally to the primary cells.

4. Influent line(s). The influent line(s) shall be located along the bottom of the pond so that the top of the pipe is just below the average elevation of the pond seal; however, the pipe shall have adequate seal below it.

5. Point of discharge. All primary cells shall have individual influent line(s) which terminate at approximately the center of the cell so as to minimize short-circuiting. Consideration should be given to multi-influent discharge points for primary cells of twenty (20) acres (8 hectares) or larger to enhance distribution of the waste load on the cell. All aerated cells shall have influent lines which distribute the load within the mixing zone of the aeration equipment. Consideration of multi-inlets should be closely evaluated for any diffused aeration systems.

6. Influent discharge apron. The influent line(s) shall discharge horizontally into the shallow saucer-shaped depression. The end of the discharge line(s) shall rest on a suitable concrete apron large enough so that the terminal influent velocity at the end of the apron does not cause soil erosion. A minimum size apron of two feet (2') (0.6m) square shall be provided.

(E) Control Structures and Interconnecting Piping.

1. Structure. Facilities design shall consider the use of multipurpose control structures, where possible, to facilitate normal operational functions such as drawdown and flow distribution, flow and depth measurement, sampling, pumps for recirculation, chemical additions and mixing and to minimize the number of construction sites within the dikes. As a minimum, control structures shall be accessible for maintenance and adjustment of controls; adequately ventilated for safety and to minimize corrosion; locked to discourage vandalism; contain controls to allow water level and flow rate control, complete shut off and complete draining; constructed of noncorrosive materials (metal on metal contact in controls should be of like alloys to discourage electrochemical reactions); and located to minimize short-circuiting within the cell and avoid freezing and ice damage. Recommended devices to regulate the water level are valves, slide tubes or dual slide gates. Regulators should be designed so that they can be preset to stop flows at any pond elevation.

2. Piping. All piping shall be of cast-iron or other acceptable materials. The piping should not be located within the seal. Seep collars shall be provided on drain pipes where they pass through the pond seal. Backfill around the drain pipe shall be placed and compacted in the same manner as the pond seal. Pipes should be anchored with adequate erosion control.

A. Drawdown structure piping.

(I) Multilevel outlets. The outlet structure on each pond cell, except aerated cells, shall be designed to permit overflow at one-foot (1') (30.5 cm) increments between the two foot (2'-61 cm) level and the maximum operating level. Suitable baffling shall be provided to prevent discharge of scum or other floating materials. Means must be provided to prevent unauthorized variance of the lagoon depth. A flap valve shall be provided at the outlet end of the final cell overflow or drain pipe to prevent entrance of animals or backwater from flooding.

(II) Pond drain. All ponds shall have emergency drawdown piping to allow complete draining for maintenance. These should be incorporated into the previously described structures. Sufficient pumps and appurtenances shall be made available to facilitate draining of individual ponds if ponds cannot be drained by gravity.

(III) Emergency overflow. To prevent overtopping of dikes, emergency overflow should be provided.

B. Hydraulic Capacity. The hydraulic capacity for constant discharge structures and piping shall allow for a minimum of two hun-

dred fifty percent (250%) of the design flow of the system. The hydraulic capacity for controlled discharge systems shall permit transfer of water at a minimum rate of six inches (6") (15.2 cm) of pond water depth per day at the available head.

(7) Submerged Sand Filters.

(A) Applications. Submerged sand filters may be used for solids and BOD₅ removal following waste stabilization ponds and are considered to be both a third lagoon cell and solids removal facility when designed according to the parameters in subsection (7)(B) of this rule.

(B) Design Details.

1. Following nonaerated waste stabilization ponds, the loading shall not exceed five (5) gallons per day per square foot (.2m³/m²/day) of sand. Following aerated waste stabilization ponds, the loading shall not exceed fifteen (15) gallons per day per square foot (.6m³/m²/day) of sand.

2. Clean graded gravel, preferably placed in at least three (3) layers should be placed around the underdrains and to a depth of at least six inches (6") (15 cm) over the top of the underdrains. Suggested gradings for the three (3) layers are: one and one-half inches to three-fourths inch (1 1/2"-3/4") (3.8 cm-1.9 cm), three-fourths inch to one-fourth inch (3/4"-1/4") (1.9 cm-.6 cm) and one-fourth inch to one-eighth inch (1/4"-1/8") (.6 cm-.3 cm).

3. At least twenty-four inches (24") (0.6m) of clean washed sand should be provided. The sand should have an effective size of 0.3-1.0 mm and a uniformity coefficient of 3.5 or less.

4. Open-joint or perforated pipe underdrains may be used. They should be spaced not to exceed ten-foot (10') (3.0m) center-to-center.

5. The earth base of the filters should be sloped to the underdrains or the underdrains may simply be placed in the gravel base on the flat bottom of the basin.

6. The depth of liquid above the sand must be adjustable from one to five feet (1-5') (.3m-1.5m).

7. At least two (2) cells must be provided with the combined capacity equal to that necessary for the design loading.

8. A vehicle access ramp from the top of the embankment down to the sand surface and running along one (1) side of the filter is a desirable feature for periodic maintenance of the filter.

(8) Miscellaneous.

(A) Fencing. The pond area shall be enclosed with an adequate fence to discour-

age trespassing and prevent entering of livestock. Minimum fence height shall be five feet (5') (1.5m). The fence may be of the chain link or woven type. Fencing shall not obstruct vehicle traffic or mowing operations on the dike. A vehicle access gate of sufficient width to accommodate mowing equipment shall be provided. All access gates shall be provided with locks.

(B) Access. An all-weather access road shall be provided to the pond site to allow year-round maintenance of the facility.

(C) Warning Signs. Appropriate permanent signs shall be provided along the fence around the pond to designate the nature of the facility and advise against trespassing. At least one (1) sign shall be provided on each side of the site and one (1) for every five hundred feet (500') (150m) of its perimeter.

(D) Flow Measurement. Refer to 10 CSR 20-8.140(8)(G).

(E) Groundwater Monitoring. An approved system of groundwater monitoring wells or lysimeters may be required around the perimeter of the pond site to facilitate groundwater monitoring. The use of wells and/or lysimeters will be determined on a case-by-case basis.

(F) Laboratory Equipment. Refer to 10 CSR 20-8.140(8)(D).

(G) Pond Level Gauges. Pond level gauges shall be provided.

(H) Service Building. Consideration in design should be given to a service building for laboratory and maintenance equipment.

AUTHORITY: section 644.026, RSMo Supp. 1988. Original rule filed Aug. 10, 1978, effective March 11, 1979.*

**Original authority 1972, amended 1973, 1987, 1993.*

10 CSR 20-8.210 Supplemental Treatment Processes

PURPOSE: The following criteria have been prepared as a guide for the design of supplemental treatment processes. 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 names can be added to the mailing list.

Editor's Note: The secretary of state has determined that the publication of this rule in its entirety would be unduly cumbersome or expensive. The entire text of the material referenced has been filed with the secretary of state. This material may be found at the Office of the Secretary of State or at the headquarters of the agency and is available to any interested person at a cost established by state law.

(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 agency 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 (22,500) gallons per day (85.4m³) or less (see 10 CSR 20-8.020 for the requirements for those facilities).

(3) Phosphorus Removal by Chemical Treatment.

(A) General.

1. Method. Addition of lime or the salts of aluminum or iron may be used for the chemical removal of soluble phosphorus. The phosphorus reacts with the calcium, aluminum or iron ions to form insoluble compounds. These insoluble compounds may be coagulated with or without the addition of a coagulant aid such as polyelectrolyte to facilitate separation by sedimentation.

2. Design basis. Laboratory, pilot or full scale trial of various chemical feed systems and treatment processes are recommended to determine the performance level achievable, cost-effective design criteria and ranges of chemical dosages required. Systems shall be designed with sufficient flexibility to allow

for several operational adjustments in chemical feed point location, chemical feed rates and for feeding alternate chemical compounds.

(B) Process Requirements.

1. Dosage. The chemical dosage required shall include the amount needed to react with the phosphorous in the wastewater, the amount required to drive the chemical reaction to the desired state of completion and the amount required due to inefficiencies in mixing or dispersion. Excessive chemical dosage should be avoided.

2. Chemical selection. The choice of lime or the salts of aluminum or iron should be based on the wastewater characteristics and the economics of the total system. When lime is used it may be necessary to neutralize the high pH prior to subsequent treatment in secondary biological systems or prior to discharge in those flow schemes where lime treatment is the final step in the treatment process.

3. Chemical feed points. Selection of chemical feed points shall include consideration of the type of chemicals used in the process, necessary reaction times between chemical and polyelectrolyte additions, and the type of wastewater treatment processes and components utilized. Considerable flexibility in feed point location should be provided, and multiple feed points are recommended.

4. Flash mixing. Each chemical must be mixed rapidly and uniformly with the flow stream. Where separate mixing basins are provided, they should be equipped with mechanical mixing devices. The detention period should be at least thirty (30) seconds.

5. Flocculation. The particle size of the precipitate formed by chemical treatment may be very small. Consideration should be given in the process design to the addition of synthetic polyelectrolytes to aid settling. The flocculation equipment should be adjustable in order to obtain optimum flow growth, control deposition of solids and prevent floc destruction.

6. Liquid—solids separation. The velocity through pipes or conduits from flocculation basins to settling basins should not exceed 1.5 feet per second (0.46m/s) in order to minimize floc destruction. Entrance works to settling basins should also be designed to minimize floc shear. Settling basin design shall be in accordance with criteria outlined in 10 CSR 20-8.160. For the design of a sludge handling system, special consideration should be given to the type and volume of sludge generated in the phosphorus removal process.

7. Filtration. Effluent filtration shall be considered where effluent phosphorus con-

centrations of less than one (1) mg/l must be achieved.

(C) Feed Systems.

1. Location. All liquid chemical mixing and feed installations should be installed in corrosion-resistant pedestals and elevated above the highest liquid level anticipated during emergency conditions. Lime feed equipment should be located so as to minimize the length of slurry conduits. All slurry conduits shall be accessible for cleaning.

2. Liquid chemical feed system. Liquid chemical feed pumps should be of the positive displacement type with variable feed rate control. Pumps shall be selected to feed the full range of chemical quantities required for the phosphorus mass loading conditions anticipated with the largest unit out-of-service. Screens and valves shall be provided on the chemical feed pump suction lines. An air break or antisiphon device shall be provided where the chemical solution discharges to the transport water stream to prevent an induction effect resulting in overfeed. Consideration shall be given to providing pacing equipment to optimize chemical feed rates.

3. Dry chemical feed system. Each dry chemical feeder shall be equipped with a dissolver which is capable of providing a minimum five (5)-minute retention at the maximum feed rate. Polyelectrolyte feed installations should be equipped with two (2) solution vessels and transfer piping for solution makeup and daily operation. Makeup tanks shall be provided with an eductor funnel or other appropriate arrangement for wetting the polymer during the preparation of the stock feed solution. Adequate mixing should be provided by a large diameter, low-speed mixer.

(D) Storage Facilities.

1. Size. Storage facilities shall be sufficient to insure that an adequate supply of the chemical is available at all times. Exact size required will depend on size of shipment, length of delivery time and process requirements. Storage for a minimum of ten (10) days' supply should be provided.

2. Location. The liquid chemical storage tanks and tank fill connections shall be located within a containment structure having a capacity exceeding the total volume of all storage vessels. Valves on discharge lines shall be located adjacent to the storage tank and within the containment structure. Auxiliary facilities, including pumps and controls, within the containment area shall be located above the highest anticipated liquid level. Containment areas shall be sloped to a sump area and shall not contain floor drains. Bag storage should be located near the solution

makeup point to avoid unnecessary transportation and housekeeping problems.

3. Accessories. Platforms, ladders and railings should be provided as necessary to afford convenient, safe access to all filling connections, storage tank entries and measuring devices. Storage tanks shall have reasonable access provided to facilitate cleaning.

(E) Other Requirements.

1. Materials. All chemical feed equipment and storage facilities shall be constructed of materials resistant to chemical attack by all chemicals normally used for phosphorous treatment.

2. Temperature/humidity and dust control. Precautions shall be taken to prevent chemical storage tanks and feed lines from reaching temperatures likely to result in freezing or chemical crystallization at the concentrations employed. A heated enclosure or insulation may be required. Consideration should be given to temperature, humidity and dust control in all chemical feed room areas.

3. Cleaning. Consideration shall be given to the accessibility of piping. Piping should be installed with plugged wyes, tees or crosses at changes in direction to facilitate cleaning.

4. Drains and drawoff. Above-bottom drawoff from chemical storage or feed tanks shall be provided to avoid withdrawal of settled solids into the feed system. A bottom drain shall also be installed for periodic removal of accumulated settled solids.

(F) Hazardous Chemical Handling. The requirements of 10 CSR 20-8.140(9)(A) shall be met.

(G) Sludge Handling.

1. General. Consideration shall be given to the type and additional capacity of the sludge handling facilities needed when chemicals are used.

2. De-watering. Design of de-watering systems should be based, where possible, on an analysis of the characteristics of the sludge to be handled. Consideration should be given to the ease of operation, effect of recycle streams generated, production rate, moisture content, de-waterability, final disposal and operating costs.

(4) High Rate Effluent Filtration.

(A) General.

1. Applicability. Granular media filters may be used as a tertiary treatment device for the removal of residual suspended solids from secondary effluents. Where effluent suspended solids requirements are less than ten (10) mg/l, where secondary effluent quality can be expected to fluctuate significantly or where filters follow a treatment process where significant amounts of algae will be

present, a pretreatment process such as chemical coagulation and sedimentation or other acceptable process should precede the filter units. Pretreatment units shall meet the applicable requirements of section (3) of this rule.

2. Design consideration. Care should be given in the selection of pumping equipment ahead of filter units to minimize shearing of floc particles. Consideration should be given in the plant design to providing flow equalization facilities to moderate filter influent quality and quantity.

(B) Filter Types. Filters may be of the gravity-type or pressure-type. Pressure filters shall be provided with ready and convenient access to the media for treatment or cleaning. Where greases or similar solids which result in filter plugging are expected, filters should be of the gravity-type.

(C) Filtration Rates.

1. Allowable rates. Filtration rates shall not exceed five (5) gallons per minute per square foot based on the maximum hydraulic flow rate applied to the filter units.

2. Number of units. Total filter area shall be provided in two (2) or more units, and the filtration rate shall be calculated on the total available filter area with one (1) unit out-of-service.

(D) Backwash.

1. Backwash rate. The backwash rate shall be adequate to fluidize and expand each media layer a minimum of twenty percent (20%) based on the media selected. The backwash system shall be capable of providing a variable backwash rate having a maximum of at least twenty (20) gpm/sq. ft. (13.6 l/m²/s) and a minimum backwash period of ten (10) minutes.

2. Backwash. Pumps for backwashing filter units shall be sized and interconnected to provide the required rate to any filter with the largest pump out-of-service. Filtered water should be used as the source of backwash water. Waste filter backwash water shall be adequately treated.

(E) Filter Media.

1. Selection. Selection of proper media size will depend on the filtration rate selected, the type of treatment provided prior to filtration, filter configuration and effluent quality objectives. In dual or multi-media filters, media size selection must consider compatibility among media.

2. Media specifications. The following table provides a listing of the normal acceptable range of media sizes and minimum media depths. The designer has the responsibility for selection of media to meet specific conditions and treatment requirements relative to the project under consideration.

**Media Sizes, mm
and Minimum Depths, (in)**

	Single Media	Dual Media	Multi Media
Anthracite	—	1.0–2.0 (20")	1.0–2.0 (20")
Sand	1.0–4.0 (48")	0.5–1.0 (12")	0.6–0.8 (10")
Garnet or Similar Material	—	—	0.3–0.6 (2")

Uniformity Coefficient shall be 1.7 or less.

(F) Filter Appurtenances. The filters shall be equipped with washwater troughs, surface wash or air scouring equipment, means of measurement and positive control of the backwash rate, equipment for measuring filter head loss, positive means of shutting off flow to a filter being backwashed and filter influent and effluent sampling points. If automatic controls are provided, there shall be a manual override for operating equipment, including each individual valve essential to the filter operation. The underdrain system shall be designed for uniform distribution of backwash water (and air, if provided) without danger of clogging from solids in the backwash water. Provision shall be made to allow periodic chlorination of the filter influent or backwash water to control slime growths.

(G) Reliability. Each filter unit shall be designed and installed so that there is ready and convenient access to all components and the media surface for inspection and maintenance without taking other units out-of-service. The need for housing of filter units shall depend on expected extreme climatic conditions at the treatment plant site. As minimum, all controls shall be enclosed. The structure housing filter controls and equipment shall be provided with adequate heating and ventilation equipment to minimize problems with excess humidity.

(H) Backwash Surge Control. The rate of return of waste filter backwash water to treatment units shall be controlled so that the rate does not exceed fifteen percent (15%) of the design average daily flow rate to the treatment units. The hydraulic and organic load from waste backwash water shall be considered in the overall design of the treatment plant. Surge tanks shall have a minimum capacity of two (2) backwash volumes, although additional capacity should be considered to allow for operational flexibility. Where waste backwash water is returned for treatment by pumping, adequate pumping capacity shall be provided with the largest unit out-of-service.

(I) Backwash Water Storage. Total backwash water storage capacity provided in an

effluent clearwell or other unit shall equal or exceed the volume required for two (2) complete backwash cycles.

(J) Proprietary Equipment. Where proprietary filtration equipment not conforming to the preceding requirements is proposed, data which supports the capability of the equipment to meet effluent requirements under design conditions shall be provided. The equipment will be reviewed on a case-by-case basis at the discretion of the agency.

(5) Microscreening.

(A) General.

1. Applicability. Microscreening units may be used following a biological treatment process for the removal of residual suspended solids. Selection of this unit process should consider final effluent requirements, the preceding biological treatment process and anticipated consistency of biological process to provide a high quality effluent.

2. Design considerations. Pilot plant testing on existing secondary effluent is encouraged. Where pilot studies so indicate, where microscreens follow trickling filters or lagoons, or where effluent suspended solids requirements are less than ten (10) mg/l, a pretreatment process such as chemical coagulation and sedimentation shall be provided. Care should be taken in the selection of pumping equipment ahead of microscreens to minimize shearing of floc particles. The process design shall include flow equalization facilities to moderate microscreen influent quality and quantity.

(B) Screen Material. The microfabric shall be a material demonstrated to be durable through long-term performance data. The aperture size must be selected considering required removal efficiencies, normally ranging from twenty to thirty-five (20–35) microns. The use of pilot plant testing for aperture size selection is recommended.

(C) Screening Rate. The screening rate shall be selected to be compatible with available pilot plant test results and selected screen aperture size, but shall not exceed five (5) gallons per minute per square foot (3.40 l/m²/s) of effective screen area based on the maximum hydraulic flow rate applied to the units. The effective screen area shall be considered the submerged screen surface area less the area of screen blocked by structural supports and fasteners. The screening rate shall be that applied to the units with one (1) unit out-of-service.

(D) Backwash. All waste backwash water generated by the microscreening operation shall be recycled for treatment. The backwash volume and pressure shall be adequate to assure maintenance of fabric cleanliness and

flow capacity. Equipment for backwash of at least eight (8) gallons per minute per linear foot (1.66 l/m/s) of screen length and sixty (60) pounds per square inch (4.22 kgf/cm²), respectively, shall be provided. Backwash water shall be supplied continuously by multiple pumps, including one (1) standby and should be obtained from microscreened effluent. The rate of return of waste backwash water to treatment units shall be controlled so that the rate does not exceed fifteen percent (15%) of the design average daily flow rate to the treatment plant. The hydraulic and organic load from waste backwash water shall be considered in the overall design of the treatment plant. Where waste backwash water is returned for treatment by pumping, adequate pumping capacity shall be provided with the largest unit out-of-service. Provisions should be made for measuring backwash flow.

(E) Appurtenances. Each microscreen unit shall be provided with automatic drum speed controls with provisions for manual override, a bypass weir with an alarm for use when the screen becomes blinded to prevent excessive head development and means for de-watering the unit for inspection and maintenance. Bypassed flows must be segregated from water used for backwashing. Equipment for control of biological slime growths shall be provided. The use of chlorine should be restricted to those installations where the screen material is not subject to damage by the chlorine.

(F) Reliability. A minimum of two (2) microscreen units shall be provided, each unit being capable of independent operation. A supply of critical spare parts shall be provided and maintained. All units and controls shall be enclosed in a heated and ventilated structure with adequate working space to provide for ease of maintenance.

*AUTHORITY: section 644.026, RSMo 1986. * Original rule filed Aug. 10, 1978, effective March 11, 1979.*

**Original authority 1972, amended 1973, 1987, 1993.*

10 CSR 20-8.220 Land Treatment

PURPOSE: The following criteria have been prepared as a guide for the design of land treatment systems. 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 names can be added to the mailing list.

Editor's Note: The secretary of state has determined that the publication of this rule in its entirety would be unduly cumbersome or expensive. The entire text of the material referenced has been filed with the secretary of state. This material may be found at the Office of the Secretary of State or at the headquarters of the agency and is available to any interested person at a cost established by state law.

(1) Definitions.

(A) 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 agency 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.

(B) Land treatment is the application of wastewater at rates up to the maximum amount which can be renovated by the soil—plant filter without detrimental effects to surface or groundwater soils or crops.

(C) Wastewater reuse is the application of wastewater for maximum economic return from the cropping system. Application rates will approximate the irrigation deficit and normally will not exceed twelve inches (12") (30 cm) per year.

(2) Exceptions.

(A) This rule shall not apply to facilities designed for twenty-two thousand five hundred (22,500) gallons per day (85.4m³) or less (see 10 CSR 20-8.020 for the requirements for those facilities).

(B) This rule shall not apply to land application systems designed for wastewater reuse. Due to the low application rates, little need for regulation exists at this time.

(3) Preliminary Considerations. Land treatment is the application of wastewater at rates not to exceed the maximum which can be renovated by the soil and vegetation without detrimental effects to surface or groundwater, soils or crops. Land treatment installations are to be used where the waste contains pollutants which can be successfully renovated through organic decomposition and the adsorptive, physical and chemical reactions in the soil and vegetation. The land treatment of wastewater may recharge the local groundwater or reemerge into streams; therefore, the quality, direction and rate of movement and local use of the groundwater, present and future, are important considerations in evaluating a proposed site. It is essential to maintain an aerated zone in the soil to provide good vegetative growth and removal of nutrients. A groundwater mound may develop after the system is in use. Major factors in the design of land treatment systems are topography, soils, geology, hydrology, weather, agricultural practice, crop, use of crop, adjacent land use, equipment selection and installation.

(4) Design Report. The design report shall include maps and diagrams as noted in the following. It shall also include any additional material that is pertinent about the location, geology, topography, hydrology, soils, areas for future expansion and adjacent land use.

(A) Location.

1. A copy of the USGS topographic map of the area (seven and one-half (7 1/2)-minute series where published), similar map or aerial photograph showing the exact boundaries of the spray field.

2. A topographic map of the total area under consideration by the applicant at a scale of approximately one inch to fifty feet (1":50') (2.54:15.2cm) with appropriate contour interval. It should show all buildings, the waste disposal system, the spray field boundaries and buffer zone. An additional map should show the spray field topography in detail with a contour interval of two feet (2') (61 cm) and include buildings and land use on adjacent lands within one-fourth (1/4) mile of the project boundary.

3. Water supply wells which might be affected shall be located and identified as to uses—for example, potable, industrial, agricultural and class of ownership; for example, public, private, etc.

4. All abandoned wells, shafts, etc., where possible, should be located and identified. Pertinent information thereon shall be furnished.

(B) Geology.

1. Geologic formation's name and the rock types at the site.

2. Degree of weathering of the bedrock.

3. Character and thickness of the surficial deposits.

4. Local bedrock structure including the presence of faults, fractures and joints.

5. The presence of any solution openings and sinkholes in carbonate terrain.

6. The source of the information in (4)(B)1.—5. must be indicated.

(C) Hydrology.

1. The depth to seasonal and permanent highwater tables (perched and/or regional) must be given, including an indication of seasonal variations.

2. The direction of groundwater movement and the point(s) of discharge must be shown on one (1) of the attached maps.

3. Chemical analyses indicating the quality of groundwater at the site must be included.

4. Indicate the source of the data in (4)(C)1.—3.

5. The following information shall be provided from existing wells and from the test wells as may be necessary:

A. Construction details—where available. Depth, well log, pump capacity, static levels, pumping water levels, casing, grout material and the other information as may be pertinent; and

B. Groundwater quality. For example, nitrates, total nitrogen, chlorides, sulfates, pH, alkalinities, total hardness, coliform bacteria and metal ions.

6. A minimum of one (1) groundwater monitoring well, where deemed necessary by the DGLS, must be drilled in each dominant direction of groundwater movement and between the project site and public well(s) and/or high capacity private wells with provision for sampling at the surface of the water table and at five feet (5') (1.5m) below the water table at each monitoring site. The location and construction of the monitoring well(s) must be approved by the agency. These may include one (1) or more of the test wells where appropriate.

(D) Evaluation of Effluent to be Applied. Representative samples are essential to properly evaluate the effluent. Where the discharge is from a sewage treatment plant, twenty-four (24)-hour samples proportioned to the rate of flow will be needed to obtain a representative sample. In cases where the effluent is stored for several days or longer, a

single sample of the effluent will suffice. Analyses which will be of major importance will be for total suspended solid (TTS), a volatile suspended solid (VSS), sodium, calcium, magnesium, electrical conductivity (EC), nitrogen, phosphorous, metal ions and fluoride. The sodium absorption ratio (SAR) should be calculated from sodium, calcium and magnesium determination.

(E) Soils. All soils investigation should be performed by a qualified soil scientist.

1. A soils map should be furnished of the spray field, indicating the various soil types. This may be included on the large-scale topographic map. Soils information can normally be secured through the USDA Soil Conservation Service.

2. The soils should be named and their texture described.

3. Slopes and agricultural practice on the spray field are closely related. Slopes on cultivated fields should be limited to four percent (4%) or less. Slopes on sodded fields should be limited to eight percent (8%) or less. Forested slopes should be limited to eight percent (8%) for year-round operation but some seasonal operation slopes up to fourteen percent (14%) may be acceptable.

4. The thickness of soils should be indicated. Indicate how determined.

5. Data should be furnished on the exchange capacity of the soils. In cases of industrial wastes particularly, this information must be related to special characteristics of the wastes.

6. Information must be furnished on the internal and surface drainage characteristics of the soil materials. Location and depths to impermeable or restricted horizons should be indicated.

7. Proposed application rates should take into consideration the drainage and permeability of the soils and the distance to the water table.

(F) Agricultural Practice.

1. The present and intended soil-crop management practices, including forestation, shall be stated.

2. Pertinent information shall be furnished on existing drainage systems.

3. When cultivated crops are anticipated, a cropping and harvesting program by a qualified agronomist shall be included.

(G) Adjacent Land Use.

1. Present and anticipated use of the adjoining lands must be indicated. This information can be provided on one (1) of the maps and may be supplemented with notes.

2. The plan shall show existing and proposed screens, barriers or buffer zones to prevent blowing spray from entering adjacent land areas.

3. If expansion of the facility is anticipated, the lands which are likely to be used for expanded spray fields must be shown on the map.

(5) System Design.

(A) Treatment Before Land Application. The treatment of wastewater prior to application shall be adequate to prevent nuisance conditions from occurring in the treatment facility, in the storage basins or on the application site. When spray application is to be used, the system must also minimize the aerosol spread of pathogen. A primary lagoon cell loaded at a rate not to exceed thirty-four pounds (34 lbs.) BOD₅/acre/day (38 kilograms BOD₅/hectare/day) will be considered adequate to avoid nuisance conditions. Detention time of sixty (60) days or greater will be considered adequate to achieve pathogen reduction to acceptable levels. Other treatment methods may be used to meet these requirements and will be reviewed on a case-by-case basis.

(B) Storage Requirements. Storage shall be provided for the maximum capacity required to accommodate wastewater flows in excess of quantities which can be irrigated during the wettest year in ten (10). Computations for storage shall consider possible increases in wastewater flow during wet weather. If discharge to surface waters is permitted during portions of the year, storage facilities should be adequate to store excess wastewater flow during the period when discharge is not permitted. National Weather Service records should be used to estimate the number of days that weather will prevent the application of wastewater to the land.

(C) Application Rates. Application rates shall be determined for each individual site based on topography, soils, geology, hydrology, weather, agricultural practice, adjacent land use and application method. A balance calculation for water and each significant parameter should be prepared to show that the system performance meets the requirements of 10 CSR 20-7.031 Water Quality Standards. The agency will consider comments from the Division of Geology and Land Survey, the Soil Conservation Service and University of Missouri-Extension Division in evaluating the proposed application rate.

(6) System Monitoring. An appropriate monitoring system shall be provided to determine the quality of water leaving the land treatment site and entering surface and/or ground water. Analysis of soil and plant tissue samples may be required to monitor the effect of the wastewater on the soil and crop.

(7) Fencing. The project area shall be enclosed with a suitable fence to preclude livestock and discourage trespassing. A vehicle access gate of sufficient width to accommodate mowing equipment should be provided. All access gates should be provided with locks.

(8) Warning Signs. Appropriate signs should be provided along the fence around the project boundaries to designate the nature of the facility and advise against trespassing.

AUTHORITY: section 644.026, RSMo Supp. 1988. Original rule filed Aug. 10, 1978, effective March 11, 1979.*

**Original authority 1972, amended 1973, 1987, 1993.*

10 CSR 20-8.500 Secondary Containment for Agrichemical Facilities

PURPOSE: The following criteria have been prepared as a guide for the design, construction and operation of secondary and operational area containment structures at bulk agrichemical 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 storage and containment facility. This rule reflects the minimum requirements of the Missouri Clean Water Commission regarding adequacy of design, submission of plans, approval of plans and approval of completed storage and containment facility. Deviation from these minimum requirements will be allowed where sufficient documentation is presented to justify the deviation. A facility need only to comply with these rules when it comes within the definition of an agrichemical facility. Any new agrichemical facility shall be in compliance with all of these rules before the commencement of any operational activities or any storage or use of agrichemicals. Upon adoption of these rules, all existing agrichemical facilities shall be in compliance with them as follows: secondary and operational area containment for pesticides—five (5) years from the date the rule is adopted; and secondary and operational area containment for fertilizers—five (5) years from the date the rule is adopted. Any facility that has a discharge of agrichemicals or process generated wastewater which results in damage to the environment may be required to take immediate steps to implement the secondary and operational containment requirements contained in this rule. All agrichemical facilities shall be registered and issued a general operating permit from the department on forms furnished by the department. Registration shall be valid for the life of the permit,

terminated by the department or voluntarily withdrawn by the applicant. These criteria are based on the best information presently available and are similar to secondary containment regulations that have been implemented in other states. 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 the regulated community. If others desire to receive addenda or supplements, please advise the Clean Water Commission so that your name can be added to the mailing list.

Editor's Note: The secretary of state has determined that the publication of this rule in its entirety would be unduly cumbersome or expensive. The entire text of the material referenced has been filed with the secretary of state. This material may be found at the Office of the Secretary of State or at the headquarters of the agency and is available to any interested person at a cost established by state law.

(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 agency 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) General. A facility need only to comply with these rules when they come within the definition of an agrichemical facility. Any new agrichemical facility shall be in compliance with all of these rules before the commencement of any operational activities or any storage or use of agrichemicals. All existing agrichemical facilities shall be in compliance with these rules as follows: secondary and operational area containment for pesticides—five (5) years from the date the rule is adopted; and secondary and operational area containment for fertilizers—five (5) years from the date the rule is adopted. Any existing agrichemical facility that has a discharge of agrichemicals or process generated wastewater to the environment will be required to take immediate steps to implement the secondary and operational containment requirements contained in this rule. All agrichemical facilities shall apply for an operating permit on forms furnished by the

department. Storage of bulk liquid fertilizer in a mobile container for more than thirty (30) days is prohibited unless the mobile storage container is located within a secondary containment or operational containment area. Deviation from the requirements contained in this rule will be considered by the department on a case-by-case basis. Sufficient documentation shall be submitted justifying the need for the deviation.

(3) Exceptions. The following exceptions shall apply to agrichemical facilities:

(A) This rule shall not apply to agrichemical facilities storing or handling less than the regulated quantities of agrichemicals unless an on-site evaluation by the department determines that compliance with the regulations is necessary to protect the environment.

(B) Liquid fertilizer storage tanks, that are in use when this rule is adopted, having a storage capacity greater than forty thousand (40,000) gallons shall be exempt from the requirement of installing a liner underneath the tank itself. Spill containment diking is required around these tanks. These facilities shall submit to the department for approval a program outlining the monitoring, tank testing and recordkeeping that will be done at the facility to document that a release of agrichemicals from these tanks has not occurred either to surface or subsurface waters of the state.

(C) The prohibition of storing bulk liquid fertilizer in a mobile container for more than thirty (30) days shall not apply to barges and rail cars used solely for transporting liquid fertilizer from chemical production facilities to retail or wholesale facilities.

(D) The prohibition of burying pipes used for transferring full strength agrichemicals shall not apply to piping used solely for the loading and unloading of liquid fertilizer from barges and rail cars. These pipes shall be pressure tested on a yearly basis to certify the integrity of the pipes. Records of the pressure testing shall be kept on file at the facility and made available to department personnel upon request.

(4) Engineering services are performed in three (3) steps: engineering report or facilities plan, preparation of construction plans, specifications and contractual documents and construction compliance, inspection, administration and acceptance. These services are generally performed by engineering firms in private practice but may be performed by state or federal agencies. All reports, plans and specifications should be submitted at least sixty (60) days prior to the date upon which action by the agency is desired or in

accordance with the National Pollutant Discharge Elimination System (NPDES) or other schedules. The documents should be submitted for formal approval at the appropriate times and should include the engineer's report (facilities plan) and design drawings and specifications. For unusual or complex projects, it is suggested that the engineer meet with the appropriate department staff to discuss the project and that preliminary reports be submitted for review prior to the preparation of final plans and specifications. These documents are used by the owner in programming future action and by the agency to evaluate probable compliance with statutes and regulations. The preliminary reports and plans shall broadly describe existing problems, consider methods for alternate solutions including site and/or facility relocation estimate capital and annual costs and outline steps for further project implementation including approval by regulatory agencies. No approval for construction can be issued until final, detailed plans and specifications have been submitted to the agency and found to be satisfactory.

(5) Engineering Report. The engineering report assembles basic information, presents design criteria and assumptions, examines alternate projects with preliminary layouts and cost estimates, offers a conclusion with a proposed project for client consideration and outlines official actions and procedures to implement the project. The concept, including process description and sizing, factual data and controlling assumptions and considerations for the functional planning of secondary and operational containment facilities are presented for each process at the facility as well as the overall operation of the agrichemical facility as a whole system. These data form the continuing technical basis for detail design and preparation of construction plans and specifications. Architectural, structural, mechanical and electrical designs are usually excluded. Sketches may be desirable to aid in presentation of a project. Outline specifications of process units, special equipment, etc. are occasionally included.

(A) Engineering Report Content. It is urged that the following paragraphs be utilized as a guideline for the content of the project engineering report to be submitted to the agency for review and approval:

1. Letter of transmittal. A one (1)-page letter typed on design engineer's letterhead should be included in the submission of the report to the client;

2. Title page. Title of project, agrichemical facility name and address, name and address of firm preparing the report, seal and

signature of the professional engineer in charge of project;

3. Table of contents shall include section headings, chapter headings and subheadings, maps, graphs, illustrations, exhibits, diagrams and appendices. Number all pages and cross-reference by page number;

4. Introduction. Purpose—reasons for the report and circumstances leading up to the report;

5. Existing conditions at the agrichemical facility and discussion about proposed expansions or modifications to the facility;

6. Technical information and design criteria—

A. Process facilities. The process by which bulk chemicals are received, unloaded and transferred within the facility should be discussed. The mixing, loading and unloading of spreading or spraying equipment should be discussed. Design and sizing of secondary and operational containment structures should be discussed. All cleaning of chemical handling equipment, spraying or spreading vehicles, nurse vehicles and containment areas should be discussed. Collection, storage and disposal of rinsates, process generated wastewaters and collected precipitation should be discussed. Collection, treatment and disposal of all domestic wastewater flows associated with the facility should be discussed; and

B. Process diagrams. A process configuration showing the interconnection of all pumps, piping and storage tanks associated with the operation of the agrichemical facility should be shown; and

7. Summary. Highlight very briefly what was found from the evaluation of the facility and what the proposed recommendations are for the facility—

A. Findings. Method of operation, estimation of the number of cropping programs for which agrichemical services will be provided, sources of wastewater, proposed disposal or treatment practices;

B. Conclusions. Project recommended to client for construction; and

C. Recommendations. Summarized, step-by-step actions for client to follow to implement conclusions and submission of the report to the agency for review and approval.

(6) Primary Containment for Bulk Agrichemicals. Containers and appurtenances used as the primary containment in the storage and handling of bulk agrichemicals shall be constructed, installed and maintained to prevent a discharge and shall be of materials and construction compatible with the specifications of the product stored.

(A) In the event of a discharge or accumulation of storm water in the secondary containment area storage containers subject to flotation shall be anchored or placed on a raised stand to prevent flotation of the container in the event of a discharge or accumulation of storm water in the secondary containment area. The anchoring devices used to secure the storage container as well as any support structure for the storage container shall not compromise the structural integrity of the containment area or the ability of the containment area to adequately contain liquids that have accumulated in the containment area.

(B) All containers and appurtenances shall be designed to handle all operating stresses, taking into account hydrostatic head, pressure buildup from pumps and compressors and any other mechanical stresses to which the containers and appurtenances may be subject to in the foreseeable course of operation.

(C) External sight gauges shall not be used with bulk pesticide storage containers.

(D) External sight gauges may be used for bulk liquid fertilizer containers, but the gauge shall have a lockable valve located between the sight gauge and the storage container so that if the sight gauge is damaged, the contents of the storage container will not leak out.

(E) The main discharge valve from the storage container shall be lockable.

(F) All appurtenances shall be protected against damage from operating personnel and moving vehicles. All appurtenances shall be located within the secondary containment or operational containment area.

(G) Storage of bulk liquid pesticides or bulk liquid fertilizers in an underground storage tank as defined by 10 CSR 20-10.010 is prohibited. This prohibition does not apply to a water-tight catch basin used for the temporary collection of runoff or rinsate from transfer and loading areas.

(H) All filling of containers acting as the primary containment vessel shall be done in a manner that the individual handling the transfer hose has both feet on the floor of the containment structure or a working platform adjacent to the container. The transfer hose used in the filling process shall be securely connected to the storage container by appropriate plumbing connections.

(7) Secondary Containment for Bulk Agrichemicals. Secondary containment for nonmobile bulk pesticides and nonmobile bulk fertilizers shall be designed to contain any spilled product from the primary containers or rainfall from the operational containment area and secondary containment area for the

amount of time required for proper cleanup and recovery.

(A) Nonmobile Bulk Liquid Pesticides.

1. The volume of the secondary containment area when not protected from precipitation shall have a minimum volume of one hundred twenty-five percent (125%) of the volume of the largest storage container located within the containment area plus the space occupied by any other tanks located within the containment area.

2. The volume of the secondary containment when protected from precipitation shall have a minimum volume of one hundred ten percent (110%) of the volume of the largest storage container located within the containment area plus the space occupied by any other tanks located within the containment area.

3. The secondary containment structure shall not have a discharge outlet or gravity drain through the wall or floor of the containment structure.

4. The walls and floors of the secondary containment structure for nonmobile bulk liquid pesticide containers shall be constructed of suitable material that is compatible with the specifications of the product being stored. The walls and floors shall be resistant to penetration by moisture and agrichemicals. The walls and floors shall be designed to support the gravity load of the storage containers and any hydrostatic loads that would result from a massive spill within the containment structure.

5. For concrete floors and walls, expansion joints shall be spaced to prevent cracks from forming. The joints shall be sealed with a material resistant to agrichemicals. Water stops shall be installed between the containment walls and floor.

6. A collection sump may be included in the secondary containment area. The structure shall not be more than two feet (2') deep or hold more than one hundred fifty (150) gallons of liquid. The sump shall be constructed of materials that resist penetration by moisture and agrichemicals. The connection point between the containment area floor and the sump shall be sealed to prevent leakage of liquids from the containment area. The secondary containment structure floor should be sloped to the collection sump to allow for removal of liquids accumulating in the containment area.

7. No piping shall be installed through the walls or floor of the secondary containment structure except for interconnecting more than one (1) bulk liquid pesticide containment structure to another having a common wall. All piping entering and leaving the secondary containment structure shall go up and over the containment walls.

8. Piping used for transferring full strength agrichemicals, process wastewaters and rinsates shall not be buried underground.

9. Secondary containment for bulk liquid pesticides and bulk liquid fertilizers shall be separated at a minimum with a common wall. There shall be no interconnection of piping through a common wall between a bulk liquid pesticide secondary containment structure and a bulk liquid fertilizer secondary containment structure.

10. Auxiliary tanks for storage of rinsate or precipitation collected in the secondary or operational containment area shall be located within a secondary containment structure.

(B) Nonmobile Bulk Liquid Fertilizer.

1. The volume of the secondary containment area when not protected from precipitation shall have a minimum volume of one hundred twenty-five percent (125%) of the volume of the largest storage container located within the containment area plus the space occupied by any other tanks located within the containment area.

2. The volume of secondary containment area when protected from precipitation shall have a minimum volume of one hundred ten percent (110%) of the volume of the largest storage container located within the containment area plus the space occupied by any other tanks located within the containment area.

3. The secondary containment structure shall not have a discharge outlet or gravity drain through the wall or floor of the containment structure.

4. The walls and floors of the secondary containment area for nonmobile bulk liquid fertilizer containers shall be constructed of suitable material compatible with the specifications of the product being stored. The walls and floors shall be designed to support the gravity load of the storage tanks and the hydrostatic loads of a massive spill within the containment structure.

A. Floors and walls may be covered by a synthetic liner installed according to the manufacturer's written directions and repaired and maintained according to the manufacturer's recommendations. The liner shall have an in-place permeability of 1×10^{-7} cm/sec. or less. The liner material shall be compatible with the chemicals being stored and the liner shall be resistant to punctures, abrasion, cracking and weathering.

B. Floors and walls may be constructed of suitable soil so that the finished compacted permeability rate of the floor and berm walls shall be 1×10^{-7} cm/sec. or less.

C. Soils used in the construction of the walls and floors of the secondary containment structure may be treated with bentonite

clay so that the finished compacted permeability rate of the floor and berm walls shall be 1×10^{-7} cm/sec. or less.

D. The inner and outer slope and floors of an earthen secondary containment structure should be protected against erosion (for example, top soil placed over the seal with sodding or seeding, a compacted layer of washed river gravel or riprap material of a suitable size). If the inner side slope and floors of the containment structure are seeded or sodded, a six inch (6")-layer of top soil shall be placed over the floor and side slope prior to seeding or sodding to prevent the roots of the cover material from penetrating the earthen liner. Long rooted grasses shall not be used for seeding the side slopes and floors. If gravel or riprap is used inside the containment structure, the depth of the gravel or riprap layer shall be at least six inches (6") in depth. Side slopes of the earthen containment structure should not be steeper than a three to one (3:1) ratio of horizontal to vertical. The top width of earthen walls should not be less than two and one-half feet (2 1/2').

E. Floors and walls may be constructed of concrete or steel provided the material is protected from corrosion or deterioration from the materials being stored.

5. For concrete floors and walls, expansion joints shall be spaced to prevent cracks from forming. The joints shall be sealed with a material resistant to agrichemicals. Water stops shall be installed between the containment walls and floor.

6. A collection sump may be included in the secondary containment area. The structure shall not be more than two feet (2') deep or hold more than one hundred fifty (150) gallons of liquid. The sump shall be constructed of materials that resist penetration by moisture and agrichemicals. The connection point between the containment area floor and the sump shall be sealed to prevent leakage of liquids from the containment area. The secondary containment structure floor should be sloped to the collection sump to allow for removal of liquids accumulating in the containment area.

7. No piping shall be installed through the walls or floor of the secondary containment structure except for interconnecting more than one (1) bulk liquid fertilizer containment structure to another and piping exempted in subsection (3)(D). All piping entering and leaving the secondary containment structure shall go up and over the containment walls.

8. Piping used for transferring full strength agrichemicals, process wastewaters and rinsates shall not be buried.

9. Auxiliary tanks to hold rinsate or precipitation collected in the secondary or operational containment area shall be located within a secondary containment area.

(C) Nonmobile Bulk Dry Fertilizer Storage.

1. Dry fertilizer shall be stored inside a sound structure to prevent contact with precipitation. All surface water runoff shall be diverted away from the storage structure.

2. All unloading, loading, mixing and handling of dry bulk fertilizers should be done on an operational containment area.

3. Pesticide impregnation of dry fertilizer shall take place within an operational containment area adequate in size to hold the volume of pesticides used and impregnation equipment.

4. Unloading of bulk dry fertilizers may be satisfied by individual catchment basins.

5. Daily cleanup of the dry fertilizer loading, unloading, mixing and handling areas shall take place.

6. Whenever feasible, dry fertilizer spreading equipment should be cleaned in the field to minimize containment and disposal requirements at the operational containment area.

7. The floors of the bulk dry fertilizer storage area shall be paved with concrete or other approved materials that will prevent the downward movement of fertilizer materials and moisture through the floor. For concrete floors and walls, expansion joints shall be placed on a close enough spacing to prevent cracks from forming. The expansion joints shall be sealed with a material resistant to agrichemicals. Cracks that occur in the floors and walls shall be sealed to prevent the downward or lateral movement of fertilizer materials and moisture.

(D) Nonmobile Bulk Dry Pesticide Storage.

1. Dry pesticides shall be stored inside a sound structure to prevent contact with precipitation. All surface water runoff shall be diverted away from the storage structure.

2. All loading, mixing and handling of bulk dry pesticides should be done on an operational containment area.

3. Unloading of bulk dry pesticides may be satisfied by individual catchment basins.

4. Daily cleanup of the bulk dry pesticide loading, unloading, mixing and handling areas shall take place.

5. Whenever feasible, bulk dry pesticide spreading equipment should be cleaned in the field to minimize containment and disposal requirements at the operational containment area.

6. The floors of the bulk dry pesticide storage area shall be paved with concrete or

other approved materials that will prevent the downward movement of pesticide materials and moisture through the floor. For concrete floors and walls, expansion joints shall be placed on a close enough spacing to prevent cracks from forming. The expansion joints shall be sealed with a material resistant to agrichemicals. Cracks that occur in the floors and walls shall be sealed to prevent the downward or lateral movement of pesticide materials and moisture.

(8) The operational containment area for bulk liquid pesticides and bulk liquid fertilizers shall be designed to contain any product discharged or collected precipitation for the amount of time required for proper cleanup and recovery.

(A) Wherever feasible, application equipment should be rinsed in the field to minimize containment and disposal requirements at the operational containment area.

(B) Precipitation should be diverted away from the operational containment area.

(C) The volume of the operational containment area shall be one hundred ten percent (110%) of the volume of the largest application vehicle that will be loaded or unloaded in the operational containment area. This volume may be achieved through the use of above ground tank(s) located within the secondary containment area connected to an automatic sump pump in the operational containment area.

(D) A sediment trap and sump may be designed in the operational containment area. The structure shall not be more than two feet (2') deep or hold more than one hundred fifty (150) gallons of liquid. The sump shall be constructed of materials that resist penetration by moisture and agrichemicals. The connection point between the operational containment area floor and the sump shall be sealed to prevent leakage of liquids from the containment area.

(E) Unloading containment may be satisfied by the operational containment area or with individual catchment basins or portable pans/containers. The individual basins or portable containers shall be placed to catch or recover spillage and leakage from transfer connections and pumps.

(F) Bulk repackaging containment of agrichemicals may be satisfied by the operational containment area.

(9) The operational containment area for bulk dry pesticides and bulk dry fertilizers. The operational containment area for bulk dry pesticides and bulk dry fertilizers shall be sized and designed to contain any spillage or leakage of dry materials that occurs from the

loading and unloading of hauling or spreading equipment and from the mixing and blending equipment or precipitation that comes in contact with the operational containment area for the amount of time required for proper cleanup and recovery.

(A) Wherever feasible, spreading equipment should be cleaned in the field to minimize containment and disposal requirements at the operational containment area.

(B) Precipitation should be diverted away from the operational containment area.

(C) Unloading containment may be satisfied by the operational containment area or with individual catchment basins or portable pans/containers. The individual basins or portable containers shall be placed to catch or recover spillage and leakage from transfer connections and conveyors.

(10) Connection to Water Supplies. An air gap separation or reduced pressure principle backflow prevention assembly shall be installed in the water supply line that serves an agrichemical facility. The air gap or backflow prevention assembly shall be constructed, installed and inspected in accordance with 10 CSR 60-11.010 Prevention of Backflow.

(11) Protection from Flooding. All agrichemical facilities shall be located so that the agrichemicals being stored are protected from a one hundred (100)-year flood event.

(12) Operation and Management of Agrichemical Facilities. Bulk agrichemicals shall be stored, handled, transported, loaded and unloaded in a manner to prevent discharge that may result in unreasonable adverse affects to humans or the environment. All applicable hazards of the pesticide shall be considered in the handling and loading practices to ensure proper protection of facility personnel and the environment.

(A) Discharges occurring to the secondary containment and operational containment area shall be recovered promptly. All waste and wastewater associated with the recovery process shall be disposed of in accordance with the permit for the facility and the product labeling.

(B) Precipitation collected in the secondary containment and operational containment area shall be disposed of in accordance with the permit for the facility.

(C) Field application of rinsate and collected precipitation is acceptable and recommended.

(D) Appropriate security measures at the agrichemical facility, such as lighting or security fencing to discourage ready access by

unauthorized personnel to the facility when unattended, are encouraged.

(E) Agrichemical rinsates or collected precipitation shall not be disposed through storm sewers, sanitary sewer systems or waters of the state without an approved permit.

(F) Prior to repackaging or refilling bulk containers, the containers must be thoroughly cleaned and inspected except when a dedicated pesticide container is refilled and the tamper indicator is otherwise intact.

(13) Emergency and Discharge Response Plan. The operator of a bulk agrichemical facility shall prepare a written emergency and discharge response plan for the storage facility. The plan shall comply with Superfund Amendments and Reauthorization Act of 1986 (SARA) Title III requirements.

(14) Plans.

(A) General. All plans for secondary containment structures at agrichemical facilities shall bear the name of the agrichemical facility and shall show the scale in feet, a graphic scale, the north point, data and the name of the engineer, certificate number and imprint of his/her registration seal. The plans shall be clear and legible. They shall be drawn to a scale which will permit all necessary information to be plainly shown. The size of the plans generally should not be larger than thirty inches by forty-two inches (30" × 42") (76 cm × 107 cm). Datum used should be indicated. Locations and logs of test borings and when made shall be shown on the plans. Blueprints shall not be submitted. Detail plans shall consist of plan views, elevations, sections and supplementary views which, together with the specifications and general layouts, provide the working information for the contract and construction of the containment facilities. Include dimensions and relative elevations of structures, the location and outline form of equipment, storage tanks, location and size of piping and ground elevations.

(B) Plans of Agrichemical Facilities.

1. Location plan. A plan shall be submitted showing the location of the agrichemical facility in relation to streams, roads, water supply systems, property lines and any dwellings or structures not owned by the agrichemical facility in the immediate area of the facility.

2. General layout. Layouts of the proposed agrichemical containment facility shall be submitted showing topography of the site, size and location of storage tanks and containment structures, schematic flow diagram showing the flow through the various agrichemical mixing and handling systems, pip-

ing including any arrangements for bypassing individual systems, agrichemical handled and direction of flow through pipes, pumps and valves used for handling agrichemicals, storage areas for waste materials that cannot be reused (mud and sediment from sumps, dry fertilizer and pesticide materials accumulated during clean up processes, etc.), any test borings showing soil and rock elevations and composition at the proposed site and information showing existing groundwater elevations in relation to proposed liner installation and containment area floors shall be provided.

3. Detail plans. Unless otherwise covered by the specifications or engineer's report, detail plans shall show location, dimensions and elevations of all existing and proposed facilities; elevations of high and low groundwater level; size, pertinent features and operating capacity of all pumps, tanks, containment areas and other mechanical devices associated with the operation of the agrichemical facility and adequate description of any other features pertinent to the design and operation of the agrichemical containment facility.

(15) Specifications. Complete technical specifications for the construction of the agrichemical containment facility shall accompany the plans. The specifications accompanying construction drawings shall include, but not be limited to, all construction information not shown on the drawings which is necessary to inform the builder in detail of the design requirements as to the quality of materials and workmanship and fabrication of the project and type, size, strength, operating characteristics and rating of equipment; the complete requirements for all mechanical and electrical equipment, including machinery, valves, piping and jointing of pipe; electrical apparatus, wiring and instrumentation; operating tools; construction materials; special construction materials such as clay, sand, concrete or steel; miscellaneous appurtenances; instructions for testing materials and equipment as necessary to meet design standards and performance tests for the completed works and component units. It is suggested that these performance tests be conducted at the design conditions for the operation of the agrichemical facility whenever practical.

(16) Modifications During Construction. Any deviations or changes from the approved plans or specifications affecting capacity or operation of the agrichemical facility shall be noted on a set of as-built plans clearly showing the alternations. The as-built plans shall

be submitted to the department at the completion of the project along with an application for issuance of an operating permit for the facility.

AUTHORITY: sections 644.026, RSMo Supp. 1990 and 644.036, RSMo 1986. Original rule filed July 15, 1991, effective Jan. 13, 1992.*

**Original authority 1972, amended 1973, 1987, 1993.*