RECOMMENDED STANDARDS
for
WASTEWATER FACILITIES

POLICIES FOR THE DESIGN, REVIEW, AND APPROVAL OF PLANS AND SPECIFICATIONS

FOR WASTEWATER COLLECTION AND TREATMENT FACILITIES

2014 EDITION

A REPORT OF THE WASTEWATER COMMITTEE

OF THE

GREAT LAKES - UPPER MISSISSIPPI RIVER

BOARD OF STATE AND PROVINCIAL PUBLIC HEALTH AND ENVIRONMENTAL MANAGERS

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FOREWORD

In 1947, a "Committee on Development of Uniform Standards for Sewage Works" was created by the group now known as the Great Lakes - Upper Mississippi River Board of State and Provincial Public Health and Environmental Managers. This Committee, composed of a representative from each of the ten states, was assigned the responsibility to review existing standards for sewage works, to investigate the possibility of preparing joint standards to be adopted by the states represented, and to report its findings to the Board.

Based on this initial report, the Board authorized the Committee to prepare sewage works design standards, which were first published in 1951. They subsequently were revised and published again in 1960, 1968, 1971, 1973, 1978, 1990, 1997, and 2004. In 1977, the Province of Ontario was invited, as a Great Lakes participant, to serve on the Committee.

These standards have again been revised and are published herein as the 2014 edition. They are intended for use as a guide in the design and preparation of plans and specifications for wastewater facilities insofar as these standards are applicable to normal situations for an individual project.

The design criteria in these standards are intended for the more conventional municipal wastewater collection and treatment systems. Innovative approaches to collection and treatment, particularly for the very small municipal systems, are not included. The individual reviewing authority should be contacted for design guidance and criteria where such systems are being considered.

Lack of description or criteria for a unit process or equipment in these standards does not suggest it should not be used, but only that consideration by the reviewing authority will be on the basis of information submitted with the design. Engineering data that may be required for new process and application evaluation is included in Paragraph 53.2 of these standards. The contingency planning requirement in Paragraph 11.28(j) is intended to help users determine potential risk in meeting standards of performance on a long term basis, and to help determine the stage of development for technologies satisfying the criteria of Paragraph 53.2.

These standards are intended to suggest limiting values for items upon which an evaluation of the plans and specifications will be made by the reviewing authority; and to establish, as far as practicable, uniformity of practice among the several states and province. Statutory requirements, regulations, and guidelines among the states and province are not uniform and use of the standards must adjust itself to these variations. Users also should be cognizant of locally adopted regulations or standards and applicable federal requirements.

The term "shall" is used where practices are sufficiently standardized to permit specific delineation of requirements or where safeguarding of the public health or protection of water quality justifies such definite action. Other terms, such as "should," "recommended," and "preferred," indicate desirable procedures or methods, with deviations subject to individual consideration.

Definition of terms and their use in these standards is intended to be in accordance with GLOSSARY -- WATER AND WASTEWATER CONTROL ENGINEERING, jointly prepared by APHA, ASCE, AWWA and WPCF. The International Standard Units are in accordance with those recommended in National Institute of Standards and Technology (NIST) Guide for the Use of the International System of Units (SI). The customary units of expression used are generally in accordance with Manual of Practice No. 6, INTERNATIONAL STANDARD UNITS FOR WATER AND WASTEWATER PROCESSES, jointly prepared by AWWA, IWA and WEF.

CHAPTER 10
ENGINEERING REPORTS AND FACILITY PLANS

10. GENERAL

10.1 Engineering Services

Engineering services are performed in three steps:

a. Engineering Report or Facility Plan;

b. Preparation of construction plans, specifications, and contractual documents; and

c. Construction compliance, inspection, administration, and acceptance.

Chapter 10, Engineering Reports and Facility Plans, covers only item (a) above.

10.2 Preliminary Project Submittal

A preliminary project submittal may be necessary prior to the preparation of an Engineering Report or Facility Plan. This submittal needs to include:

a. A description of problems or developments which have resulted in consideration of a wastewater facilities project;

b. Identification of governmental and consultant representatives authorized to provide information and seek regulatory agency approvals and decisions regarding the project; and

c. Identification of potential treated wastewater discharge locations and flows for the purpose of regulatory agency determinations of suitable effluent quality requirements.

No approval for construction can be issued until final, detailed plans and specifications have been submitted and approved by the appropriate reviewing authority. Refer to Chapter 20.

11. ENGINEERING REPORT OR FACILITY PLAN

An Engineering Report or Facility Plan identifies and evaluates wastewater related problems; assembles basic information; presents criteria and assumptions; examines alternate projects (with preliminary layouts and cost estimates); describes system reliability for each unit operation with the largest unit out of service; describes financing methods; sets forth anticipated charges for users; reviews organizational and staffing requirements; offers a conclusion with a proposed project for client consideration; and outlines official actions, time schedules and procedures to implement the project. The document shall include sufficient detail to demonstrate that the proposed project meets applicable criteria.

The concept (including process description and sizing), factual data, and controlling assumptions and considerations for the functional planning of wastewater facilities are presented for each process unit and for the whole system. These data form the continuing technical basis for the detailed 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.

Engineering Reports shall be completed for minor collection system, pump station, and interceptor projects. Facility Plans shall be completed or have been completed for projects involving new, expanded, upgraded, or rehabilitated wastewater treatment facilities and major collection, interceptor sewer, and pump station projects. The determination of classification as major or minor collection interceptor sewer and pump station projects will be made by the reviewing authority based on review of recommended classification by the owner.

For federal, provincial, or state financed grant or loan projects, additional requirements may apply.

11.1 Engineering Reports

Engineering reports shall contain the following and any other pertinent information as required by the reviewing authority.

11.11 Problem Definition

Description of the existing system should include an evaluation of the conditions and problems needing correction.

11.12 Flows and Organic Loads

The anticipated design average and design peak flows and waste loads for the existing and ultimate conditions shall be established. The basis of the projection of initial and future flows and waste loads shall be included and shall reflect the existing or initial service area, and the anticipated future service area. More detail on flow and organic load information and the data needed for new collection systems are included in Paragraphs 11.24 and 11.25.

11.13 Impact on Existing Wastewater Facilities

The impact of the proposed project on all existing wastewater facilities (including gravity sewers, lift stations, and treatment facilities) shall be evaluated.

11.14 Project Description

A written description of the project is required.

11.15 Location Drawings

Drawings identifying the site of the project and the anticipated location and alignment of proposed facilities are required.

11.16 Engineering Criteria

Engineering criteria to be used in design of the project shall be included.

11.17 Site Information

Project site information should include topography, soils, geologic conditions, depth to bedrock, groundwater level, floodway or floodplain considerations, and any other pertinent site information.

11.18 Alternative Selection

The reasons for selection of the proposed alternative, including any lift station sites, feasibility, and how the project fits into a long term plan, should be discussed.

11.19 Environmental Review

Consideration should be given to minimizing any potential adverse environmental effects of the proposed project. Compliance with the planning requirements of federal, provincial, state, and local regulatory agencies shall be documented, if appropriate.

11.2 Facility Plans

Facility Plans shall contain the following and any other pertinent information as required by the reviewing authority.

11.21 Problem Evaluation and Existing Facility Review

a. Descriptions of existing system including condition and evaluation of problems needing correction.

b. Summary of existing and previous local and regional wastewater facility and related planning documents.

11.22 Planning and Service Area

A description of the planning area and existing and potential future service areas shall be included.

11.23 Population Projection and Planning Period

Present and predicted population shall be based on a 20 year planning period. Phased construction of wastewater facilities should be considered in rapid growth areas. Sewers and other facilities with a design life in excess of 20 years should be designed for the extended period.

11.24 Hydraulic Capacity

11.241 Flow Definitions and Identification

The following flows for the design year shall be identified and used as a basis of design for sewers, lift stations, wastewater treatment plants, treatment units, and other wastewater handling facilities. Where any of the terms defined in this Paragraph are used in these design standards, the definition contained in this Paragraph applies.

a. Design Average Flow

The design average flow is the average of the daily volumes to be received for a continuous 12 month period expressed as a volume per unit time. However, the design average flow for facilities having critical seasonal high hydraulic loading periods (e.g., recreational areas, campuses, industrial facilities) shall be based on the average of the daily volumes to be received during the seasonal period.

b. Design Maximum Day Flow

The design maximum day flow is the largest volume of flow to be received during a continuous 24 hour period expressed as a volume per unit time.

c. Design Peak Hourly Flow

The design peak hourly flow is the largest volume of flow to be received during a one hour period expressed as a volume per unit time.

d. Design Peak Instantaneous Flow

The design peak instantaneous flow is the instantaneous maximum flow rate to be received.

11.242 Hydraulic Capacity for Wastewater Facilities to Serve Existing Collection Systems

a. Projections shall be made from actual flow data to the extent possible.

b. The probable degree of accuracy of data and projections for all critical design flow conditions shall be evaluated. This reliability estimation should include an evaluation of the accuracy of existing data, and an evaluation of the reliability of estimates of flow reduction anticipated due to infiltration/inflow (I/I) reduction, or flow increases due to elimination of sewer bypasses and backups or hydraulic restrictions. To ensure a higher degree of accuracy, estimates of I/I reduction shall consider design precipitation events with representative runoff characteristics and groundwater elevations.

c. Critical data and methodology used shall be included. Graphical displays of critical peak wet weather flow data [refer to Paragraphs 11.241(b), 11.241(c) and 11.241(d)] should be included for a sustained wet weather flow period of significance to the project.

11.243 Hydraulic Capacity for Wastewater Facilities to Serve New Collection Systems

a. The sizing of wastewater facilities receiving flows from new wastewater collection systems shall be based on an average daily flow of 100 gallons (380 L) per capita plus wastewater flow from industrial plants and major institutional and commercial facilities unless water use data or other justification upon which to better estimate flow is provided.

b. The 100 gal/cap/d [380 L/(capita·d)] value shall be used in conjunction with a peaking factor from Figure 1 to cover normal infiltration for systems built with modern construction techniques. Refer to Section 31. However, an additional allowance should be made where conditions are unfavorable.

c. If the new collection system is to serve existing development the likelihood of I/I contributions from existing service lines and non-wastewater connections to those service lines shall be evaluated and wastewater facilities designed accordingly.

11.244 Combined Sewer Interceptors

In addition to the above requirements, interceptors for combined sewers shall have capacity to receive a sufficient quantity of combined wastewater for transport to treatment facilities to ensure attainment of the appropriate water quality standards.

11.25 Organic Capacity

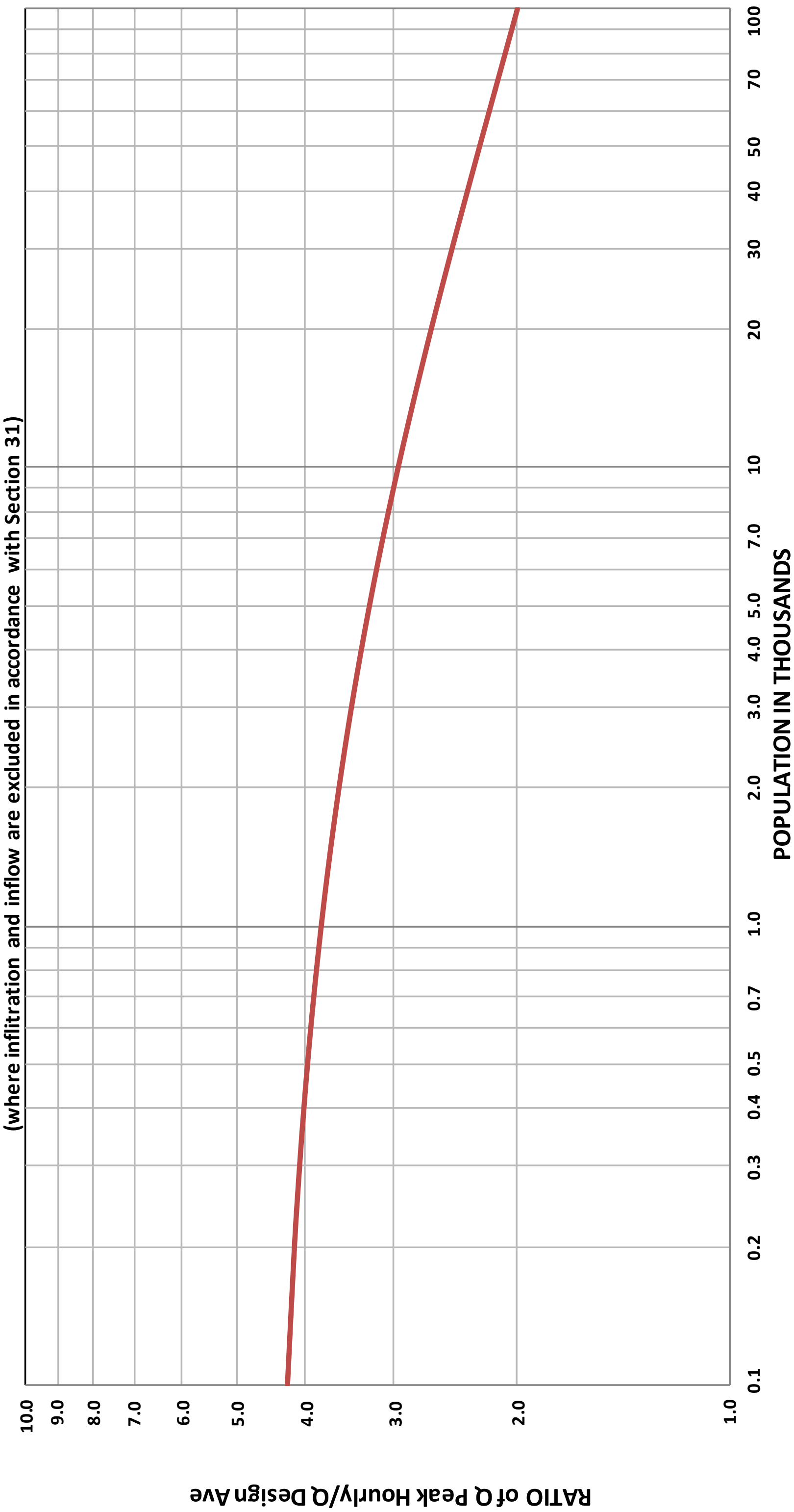
11.251 Organic Load Definitions and Identification

The following organic loads for the design year shall be identified and used as a basis for design of wastewater treatment facilities. Where any of the terms defined in this Paragraph are used in these design standards, the definition contained in this Paragraph applies.

FIGURE 1

RATIO OF PEAK HOURLY FLOW TO DESIGN AVERAGE FLOW

(where infiltration and inflow are excluded in accordance with Section 31)



Q peak hourly: Maximum Rate of Wastewater Flow (Peak Hourly Flow)
Q design ave: Design Average Daily Wastewater Flow

$$\text{Q Peak Hourly/Q Design Ave} = \frac{18+\sqrt{P}}{4+\sqrt{P}}$$

(P= population in thousands)

Source: Fair, G. M. and Geyer, J. C., "Water Supply and Waste-water Disposal" 1st Ed., John Wiley & Sons, Inc., New York (1954), p. 136

a. Biochemical Oxygen Demand Defined

The 5-day Biochemical Oxygen Demand (BOD_5) is defined as the amount of oxygen required to stabilize biodegradable organic matter under aerobic conditions within a five day period in accordance with Standard Methods for the Examination of Water and Wastewater. Total 5-day Biochemical Oxygen Demand ($TBOD_5$) is equivalent to BOD_5 and is sometimes used in order to differentiate carbonaceous plus nitrogenous oxygen demand from strictly carbonaceous oxygen demand.

The Carbonaceous 5-day Biochemical Oxygen Demand ($CBOD_5$) is defined as BOD_5 less the nitrogenous oxygen demand of the wastewater. See Standard Methods for the Examination of Water and Wastewater.

b. Design Average BOD_5

The design average BOD_5 is generally the average of the organic load to be received for a continuous 12 month period for the design year expressed as weight per day. However, the design average BOD_5 for facilities having critical seasonal high loading periods (e.g., recreational areas, campuses, industrial facilities) shall be based on the average organic load to be received during the seasonal period.

c. Design Maximum Day BOD_5

The design maximum day BOD_5 is the largest amount of organic load to be received during a continuous 24 hour period expressed as weight per day.

d. Design Peak Hourly BOD_5

The design peak hourly BOD_5 is the largest amount of organic load to be received during a one hour period expressed as weight per day.

11.252 Design of Organic Capacity of Wastewater Treatment Facilities to Serve Existing Collection Systems

a. Projections shall be made from actual waste load data to the extent possible.

b. Projections shall be compared to those described in Paragraph 11.253 and an accounting made for significant variations from those values.

c. Impact of industrial sources shall be documented. For projects with significant industrial contributions, evidence of adequate pretreatment strategies shall be included along with documentation that industries are aware of the pretreatment limitations and user costs associated with the project. Documentation of the individual industrial participation in the project plan including user charges shall be provided.

d. Septage and leachate may contribute significant organic load and other materials which can cause operational problems and non-compliance with National Pollutant Discharge Elimination System (NPDES) permit limitations. If septage or leachate is to be discharged to the wastewater treatment facility, consult the state regulatory agency and the Appendix, Handling and Treatment of Septage at a Wastewater Treatment Plant.

11.253 Design of Organic Capacity of Wastewater Treatment Facilities to Serve New Collection Systems

a. Domestic wastewater treatment design shall be on the basis of at least 0.17 pounds (0.08 kg) of BOD_5 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. If nitrification is required, 0.036 pounds (0.016 kg) TKN per capita per day may be used.

b. Where garbage grinders are commonly used in areas tributary to a domestic treatment plant, the design basis should be increased to 0.22 pounds (0.10 kg) of BOD_5 per capita per day, and 0.25 pounds (0.11 kg) of suspended solids per capita per day. If nitrification is required, 0.046 pounds (0.021 kg) TKN per capita per day may be used.

c. Industrial contributions. Refer to Paragraph 11.252(c).

d. Septage and Leachate. Refer to Paragraph 11.252(d).

e. 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 reviewing authority to establish the reliability and applicability of such data.

11.26 Wastewater Treatment Facility Design Capacity

The wastewater treatment facility design capacity is the design average flow at the design average BOD_5. Refer to Paragraphs 11.24 and 11.25 for definitions and required peaking factors.

11.27 Initial Alternative Development

The process of selection of wastewater treatment alternatives for detailed evaluation should be discussed. All wastewater management alternatives considered, including no action, and the basis for the engineering judgment for selection of the alternatives chosen for detailed evaluation, should be included.

11.28 Detailed Alternative Evaluation

The following shall be included for the alternatives to be evaluated in detail.

a. Sewer System Revisions

Proposed revisions to the existing sewer system including adequacy of portions not being changed by the project shall be evaluated.

b. Wet Weather Flows

Facilities to transport and treat wet weather flows in a manner that complies with federal, state and local regulations shall be provided.

c. Wet Weather Flow Equalization

If the ratio of design peak hourly flow to design average flow is 3:1 or more, flow equalization shall be considered. This may be accomplished by either building a wet weather retention basin and gradually returning the excess flow to the treatment plant during off-peak periods or by providing a plant large enough to handle all flows.

d. Site Evaluation

Site evaluation shall consider the following criteria. When a site must be used which is critical with respect to the following items, appropriate measures shall be taken to minimize adverse impacts.

1. Compatibility of the treatment process with the present and planned future land use, including noise, potential odors, air quality, and anticipated sludge processing and disposal techniques, shall be considered.

Non-aerated lagoons should not be used if excessive sulfate is present in the wastewater.

Wastewater treatment facilities should be separate from habitation or any area likely to be built up within a reasonable future period and shall be separated in accordance with state and local requirements.

2. Zoning and other land use restrictions shall be identified.

3. The accessibility and topography of the site shall be evaluated.

4. Area for future plant expansion shall be identified.

5. Direction of prevailing wind shall be identified.

6. Flood considerations, including the 25 and 100 year flood levels, impact on floodplain and floodway, and compliance with applicable regulations regarding construction in flood-prone areas, shall be evaluated. Paragraph 51.2 contains requirements for protection from flooding.

7. Geologic information, depth to bedrock, karst features, or other geologic considerations of significance to the project shall be included. Lagoons shall not be located in karst areas unless the specific geologic and construction details are acceptable.

8. Protection of groundwater including public and private wells is of utmost importance. Demonstration that protection will be provided shall be included. The regulatory agency shall be contacted for required separation.

9. Soil type and suitability for construction and depth to normal and seasonal high groundwater shall be determined.

10. The location, depth, and discharge point of any field tile in the immediate area of the proposed site shall be identified.

11. Present and known future effluent quality requirements as determined by the regulatory agency shall be included.

12. Access to receiving stream for the outfall line shall be discussed and displayed.

13. A preliminary assessment of site availability shall be included.

e. Unit Sizing

Unit operation and unit process sizing and basis shall be provided.

f. Flow Diagram

Flow diagram of treatment facilities including all recycle flows shall be included.

g. Flexibility

Compliance with requirements of Paragraph 53.6 Arrangement of Units shall be assured.

h. Removal Efficiencies

Loadings to and removal efficiencies through each unit operation shall be provided in addition to total removal efficiency and effluent quality (both concentrations and mass).

i. Emergency Operation

Emergency operation requirements as outlined in Section 47 and Paragraph 56.1 shall be provided. State or local regulatory agencies may have more stringent requirements.

j. Technology Not Included In These Standards

Paragraph 53.2 outlines procedures for introducing and obtaining approval to use technology not included in these standards. Proposals to use technology not included in these standards shall address the requirements of Paragraph 53.2.

A contingency plan, in the event that such new technology fails to meet the expected performance, may be required by the reviewing authority in the absence of three separate and representative full scale installations successfully using the same technology. Each representative full scale installation should have sufficient monitoring and appropriate testing results that demonstrate reliable and effective compliance with the design performance criteria and have been operated for not less than three years at or near design capacity without major failure of either the process or equipment.

k. Sludge

The solids disposal options considered and method selected shall be included. This is critical to completion of a successful project. Compliance with requirements of Chapter 80, Sludge Processing, Storage, and Disposal shall be assured.

l. Treatment During Construction

A plan for the method and level of treatment (including sludge processing, storage and disposal) to be achieved during construction shall be developed and included in the Facility Plan submitted to the regulatory agency for review and approval. This approved treatment plan shall be implemented by inclusion in the plans and specifications to be bid for the project. Refer to Paragraph 20.15 and Section 21.

m. Operation and Maintenance

Portions of the project which involve complex operation or maintenance requirements shall be identified including laboratory requirements for operation, industrial sampling, and self-monitoring.

n. Cost Estimates

Cost estimates for capital and operation and maintenance (including basis), shall be included.

o. Environmental Review

Consideration shall be given to minimizing any potential adverse environmental effects of the proposed project. Compliance with planning requirements of federal, provincial, state, and local regulatory agencies shall be documented.

11.29 Final Project Selection

The project selected from the alternatives considered under Paragraph 11.28, including the financing considerations and recommendations for implementation of the plan, shall be set forth in the final Facility Plan document to be forwarded to the reviewing authority for review and approval.

12.0 PRE-DESIGN MEETING

A pre-design meeting is recommended for plant projects with the applicant, design engineer and reviewing authority in attendance to discuss subsequent changes to the engineering report or facilities plan approval, deviations from design standards, schedule of submittal and review, and applicable reliability guidelines. Significant changes may require a Preliminary Project Submittal in accordance with Paragraph 10.2 and preparation of an Engineering Report or Facility Plan for review and approval.

CHAPTER 20
ENGINEERING PLANS AND SPECIFICATIONS

20. PLANS AND SUPPORT DOCUMENTS

Submissions to the reviewing authority shall include sealed plans, design criteria, the appropriate construction permit applications, review forms, and permit fee if required.

20.1 General

20.11 Plan Title

All plans for wastewater facilities shall bear a suitable title showing the name of the municipality, sewer district, or institution. They shall show the scale in feet or meters, a graphical scale, the north point, date, and the name and signature of the engineer, with the certificate number and imprint of the professional engineering seal. A space should be provided for signature and/or approval stamp of the appropriate reviewing authority.

20.12 Plan Format

The plans shall be clear and legible (suitable for microfilming). They shall be drawn to a scale that will permit all necessary information to be plainly shown. Generally, the size of the plans should not be larger than 30 inches x 42 inches (760 mm x 1070 mm). Datum used should be indicated. Locations and logs of test borings, when required, shall be shown on the plans. Blueprints shall not be submitted.

20.13 Plan Contents

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 facilities. They also shall include dimensions and relative elevations of structures, the location and outline form of equipment, location and size of piping, water levels, and ground elevations.

20.14 Design Criteria

Design criteria shall be included with all plans and specifications and a hydraulic profile shall be included for all wastewater treatment facilities. For sewer and lift station projects, information shall be submitted to verify adequate downstream sewer, pump station and treatment plant capacity.

20.15 Operation During Construction

Project construction documents shall specify the procedure for operation during construction that complies with the plan required by Paragraph 11.28(l), Treatment During Construction.

20.2 Plans of Sewers

20.21 General Plan

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

20.211 Geographical Features

a. Topography and elevations - Existing or proposed streets and all streams or water surfaces shall be clearly shown. Contour lines at suitable intervals should be included.

b. Streams - The direction of flow in all streams and the high and low water elevations of all water surfaces at sewer outlets and overflows shall be shown.

c. Boundaries - The boundary lines of the municipality or the sewer district and the area to be sewered shall be shown.

20.212 Sewers

The plan shall show the location, size, and direction of flow of relevant existing and proposed sanitary and combined sewers draining to the treatment facility concerned.

20.22 Detail Plans

Detail plans shall be submitted. Profiles should have a horizontal scale of not more than 100 feet to the inch (1200:1) and a vertical scale of not more than 10 feet to the inch (120:1). Plan views should be drawn to a corresponding horizontal scale and shall be shown on the same sheet. Plans and profiles shall show:

a. Location of streets and sewers;

b. Line of ground surface; size, material, and type of pipe; length between manholes; invert and surface elevation at each manhole; and grade of sewer between each two adjacent manholes (all manholes shall be 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 residence 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 or require isolation setback, particularly water mains and water supply structures (i.e., wells, clear wells, basins, etc.), gas mains, storm drains, and telephone and power conduits; and

e. Special detail drawings, made to a scale to clearly show the nature of the design, shall be furnished to show the following particulars:

All stream crossings and sewer outlets, with elevations of the stream bed and high, normal, and low water levels;

Details of all special sewer joints and cross-sections; and

Details of all sewer appurtenances, such as manholes, lampholes, inspection chambers, inverted siphons, regulators, tide gates, and elevated sewers.

20.3 Plans of Wastewater Pumping Stations

20.31 Location Plan

A location plan shall be submitted for projects involving construction or revision of pumping stations. This plan shall show the following:

a. The location and extent of the tributary area;

b. Any municipal boundaries within the tributary area; and

c. The location of the pumping station and force main, and pertinent elevations.

20.32 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;

d. Elevation of high water at the site, and maximum elevation of wastewater 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 borings and groundwater elevations.

20.4 Plans of Wastewater Treatment Plants

20.41 Location Plan

A location plan shall be submitted showing the wastewater 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.

20.42 General Layout

Layouts of the proposed wastewater treatment plant shall be submitted, showing:

a. Topography of the site;

b. Size and location of plant structures;

c. Schematic flow diagram(s) showing the flow through various plant units, and showing utility systems serving the plant processes;

d. Piping, including any arrangements for bypassing individual units (materials handled and direction of flow through pipes shall be shown);

e. Hydraulic profiles showing the flow of wastewater, supernatant liquor, recycle streams, and sludge; and

f. Test borings and groundwater elevations.

20.43 Detail Plans

Detail plans shall show the following, where applicable:

a. Location, dimensions, and elevations of all existing and proposed plant facilities;

b. Elevations of high and low water level of the body of water to which the plant effluent is to be discharged;

c. Type, size, pertinent features, and operating capacity of all pumps, blowers, motors, and other mechanical devices;

d. Minimum, design average, and peak hourly hydraulic flow in profile;

e. Existing and design sludge storage volumes in plan and profile; and

f. Adequate description of any features not otherwise covered by the specifications or engineer's report.

21. SPECIFICATIONS

Complete signed and sealed technical specifications (see Paragraph 20.11) shall be submitted for the construction of sewers, wastewater pumping stations, wastewater treatment plants, and all other appurtenances, and shall accompany the plans.

The technical specifications accompanying construction drawings shall include, but not be limited to, specifications for the approved procedures for operation during construction in accordance with Paragraphs 11.28(l) and 20.15, and all construction information not shown on the drawings which is necessary to inform the builder in detail of the design requirements for the quality of materials, workmanship, and fabrication of the project.

The specifications shall also include the type, size, strength, operating characteristics, and rating of equipment; allowable infiltration; 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 facilities and component units. It is suggested that these performance tests be conducted at design load conditions wherever practical.

22. 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 well in advance of any construction work which will be affected by such 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 such alterations shall be submitted to the reviewing authority at the completion of the work.

CHAPTER 30
DESIGN OF SEWERS

31. APPROVAL OF SEWERS

In general, the appropriate reviewing authority will approve plans for new systems, extensions to new areas, or replacement sanitary sewers only when designed upon the separate basis, where rain water from roofs, streets, and other areas and groundwater from foundation drains are excluded.

32. DESIGN CAPACITY AND DESIGN FLOW

In general, sewer capacities should be designed for the estimated ultimate tributary population, except when considering parts of the system 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 planned, economic analysis of alternatives should accompany initial permit applications. See Paragraph 11.24.

33. DETAILS OF DESIGN AND CONSTRUCTION

33.1 Minimum Size

A public gravity sewer conveying raw wastewater shall not be less than 8 inches (200 mm) in diameter.

33.2 Depth

In general, sewers should be sufficiently deep to receive wastewater from basements and to prevent freezing. Insulation shall be provided for sewers that cannot be placed at a depth sufficient to prevent freezing.

33.3 Buoyancy

Buoyancy of sewers shall be considered. Flotation of the pipe shall be prevented with appropriate construction where high groundwater conditions are anticipated.

33.4 Slope

33.41 Recommended Minimum Slopes

All sewers shall be designed and constructed to give mean velocities, when flowing full, of not less than 2.0 feet per second (0.6 m/s), based on Manning's formula using an "n" value of 0.013. The following are the recommended minimum slopes that should be provided for sewers 42 inches (1050 mm) or less. However, slopes greater than these may be desirable for construction, to control sewer gases or to maintain self-cleansing velocities at all rates of flow within the design limits.

Nominal Sewer Size	Minimum Slope in Feet Per 100 Feet (m/100 m)
8 inch (200 mm)	0.40
10 inch (250 mm)	0.28
12 inch (300 mm)	0.22
15 inch (375 mm)	0.15
18 inch (450 mm)	0.12
21 inch (525 mm)	0.10
24 inch (600 mm)	0.08
27 inch (675 mm)	0.067
30 inch (750 mm)	0.058
33 inch (825 mm)	0.052
36 inch (900 mm)	0.046
39 inch (975 mm)	0.041
42 inch (1050 mm)	0.037

Sewers 48 inches (1200 mm) or larger should be designed and constructed to give mean velocities, when flowing full, of not less than 3.0 feet per second (0.9 m/s), based on Manning's formula using an "n" value of 0.013.

33.42 Minimum Flow Depths

Slopes that are slightly less than the recommended minimum slopes may be permitted. Such decreased slopes may be considered where the depth of flow will be 0.3 of the diameter or greater for the design average flow. The operating authority of a sewer system considering decreased slopes shall furnish the appropriate reviewing authority written assurance that any additional sewer maintenance required by reduced slopes will be provided.

33.43 Minimization of Solids Deposition

The pipe diameter and slope shall be selected to obtain the greatest practical velocities so as to minimize settling problems. Flatter slopes shall not be justified with oversize sewers. If the proposed slope is less than the minimum slope of the smallest pipe that can accommodate the design peak hourly flow, the actual depths and velocities at minimum, average, and design maximum day and peak hourly flow for each design section of the sewer shall be calculated by the design engineer and be included with the plans.

33.44 Slope Between Manholes

Sewers shall be laid with uniform slope between manholes.

33.45 High Velocity Protection

Where velocities greater than 10 feet per second (3 m/s) are attained, special provisions as necessary shall be made to avoid scour and protect against displacement caused by erosion or impact.

33.46 Steep Slope Protection

Sewers on 20 percent slopes or greater shall be anchored securely with concrete, or equal, anchors spaced as follows:

a. Not over 36 feet (11 m) center to center on grades of 20 percent up to 35 percent;

b. Not over 24 feet (7.3 m) center to center on grades of 35 percent up to 50 percent; and

c. Not over 16 feet (4.9 m) center to center on grades of 50 percent or greater.

33.5 Alignment

In general, sewers 24 inches (600 mm) or less shall be laid with straight alignment between manholes. Straight alignment shall be checked by either using a laser beam or lamping.

Curvilinear alignment of sewers larger than 24 inches (600 mm) may be considered on a case by case basis provided compression joints are specified and ASTM or specific pipe manufacturers' maximum allowable pipe joint deflection limits are not exceeded. Curvilinear sewers shall be limited to simple curves that start and end at manholes. When curvilinear sewers are proposed, the recommended minimum slopes indicated in Paragraph 33.41 shall be increased accordingly to provide a minimum velocity of 2.0 feet per second (0.6 m/s) when flowing full.

33.6 Changes in Pipe Size

When a smaller sewer joins a large 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 at a manhole constructed in accordance with Section 34. However, special consideration shall be given to an appropriate flow channel to minimize turbulence when there is a change in sewer size. The appropriate reviewing authority may require a schedule for construction of future downstream sewer relief.

33.7 Materials

Any generally accepted material for sewers may 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, corrosion, or similar problems.

Suitable couplings complying with ASTM specifications shall be used for joining dissimilar materials. The leakage limitations on these joints shall be in accordance with Paragraphs 33.94 or 33.95.

All sewers shall be designed to prevent damage from superimposed live, dead, and frost induced loads. Proper allowance for loads on the sewer shall be made because of soil and potential groundwater conditions, as well as the width and depth of trench. Where necessary, special bedding, haunching and initial backfill, concrete cradle, or other special construction shall be used to withstand anticipated superimposed loading or loss of trench wall stability. See ASTM D-2321 or ASTM C-12 as appropriate.

For new pipe materials for which ASTM standards have not been established, the design engineer shall provide complete pipe specifications and installation specifications developed on the basis of criteria adequately documented and certified in writing by the pipe manufacturer to be satisfactory for the specific detailed plans.

33.8 Installation

33.81 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 so as not to damage the pipe or its joints, impede cleaning operations and future tapping, create excessive side fill pressures and ovalation of the pipe, nor seriously impair flow capacity.

33.82 Trenching

a. The width of the trench shall be ample to allow the pipe to be laid and jointed properly and to allow the bedding and haunching to be placed and compacted to adequately support the pipe. The trench sides shall be kept as nearly vertical as possible. When wider trenches are specified, appropriate bedding class and pipe strength shall be used.

In unsupported, unstable soil the size and stiffness of the pipe, stiffness of the embedment and insitu soil and depth of cover shall be considered in determining the minimum trench width necessary to adequately support the pipe.

b. Ledge rock, boulders, and large stones shall be removed to provide a minimum clearance of 4 inches (100 mm) below and on each side of all pipe(s).

33.83 Bedding, Haunching, and Initial Backfill

a. Bedding Classes A, B, C, or crushed stone as described in ASTM C-12 shall be used and carefully compacted for all rigid pipe provided the proper strength pipe is used with the specified bedding to support the anticipated load, based on the type soil encountered and potential ground water conditions.

b. Embedment materials for bedding, haunching and initial backfill, Classes I, II, or III, as described in ASTM D-2321, shall be used provided the proper strength pipe is used with the specified bedding to support the anticipated load, based on the type soil encountered and potential groundwater conditions. The embedment materials shall be carefully compacted for all flexible pipe.

c. All water entering the excavations or other parts of the work shall be removed. No sanitary sewer shall be used for the disposal of trench water, unless specifically approved by the engineer, and then only if the trench water does not ultimately arrive at existing pumping or wastewater treatment facilities.

33.84 Final Backfill

a. Final 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 final backfill within 2 feet (0.6 m) of the top of the pipe.

b. Final backfill shall be placed in such a manner so as not to disturb the alignment of the pipe.

33.85 Deflection Test

a. Deflection tests shall be performed on all flexible pipe. The tests shall be conducted after the final backfill has been in place at least 30 days to permit stabilization of the soil-pipe system.

b. No pipe shall exceed a deflection of 5 percent of the inside diameter. If deflection exceeds 5 percent, the pipe shall be excavated. Replacement or correction shall be accomplished in accordance with the requirements in the approved specifications.

c. The rigid ball or mandrel used for the deflection test shall have a diameter not less than 95 percent of the base inside diameter or average inside diameter of the pipe depending on which is specified in the ASTM Specification, including the appendix, to which the pipe is manufactured. The tests shall be performed without mechanical pulling devices.

33.9 Joints and Infiltration

33.91 Joints

The joint installation requirements 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.

33.92 Service Connections

Service connections to the sewer main shall be water tight and shall not protrude into the sewer. If a saddle type connection is used, it shall be a device designed to join with the types of pipe which are to be connected. All materials used to make service connections shall be compatible with each other and with the pipe materials to be joined and shall be corrosion proof.

33.93 Leakage Tests

Leakage tests shall be specified. This may include appropriate water or low pressure air testing. The testing methods selected should take into consideration the range in groundwater elevations during the testing and those anticipated during the design life of the sewer.

33.94 Water (Hydrostatic) Test

The leakage exfiltration or infiltration shall not exceed 100 gallons per inch of pipe diameter per mile per day [9 L/(mm of pipe diameter·km·d)] for any section of the system. An exfiltration or infiltration test shall be performed with a minimum positive head of 2 feet (0.6 m).

33.95 Air test

The air test shall, as a minimum, conform to the test procedure described in ASTM C-828 for clay pipe, ASTM C-924 for concrete pipe, and ASTM F-1417 for plastic pipe. For other materials, test procedures shall be approved by the regulatory agency.

34. MANHOLES

34.1 Location

Manholes shall be installed at the end of each line; at all changes in grade, size, or alignment; at all intersections; at distances not greater than 400 feet (120 m) for sewers that are 15 inches (375 mm) or less, and at 500 feet (150 m) for sewers that are 18 inches (450 mm) to 30 inches (750 mm). Distances up to 600 feet (185 m) 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 150 feet (45 m) in length.

34.2 Drop Type

A drop pipe shall be provided for a sewer entering a manhole at an elevation of 24 inches (610 mm) or more above the manhole invert. Where the difference in elevation between the incoming sewer and the manhole invert is less than 24 inches (610 mm), the invert shall be filleted to prevent solids deposition.

Drop manholes should be constructed with an outside drop connection. Inside drop connections (when necessary) shall be secured to the interior wall of the manhole and shall 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.

34.3 Diameter

The minimum diameter of manholes shall be 48 inches (1,200 mm). Larger diameters are required for manholes with inside drops, and may be necessary for manholes with large diameter sewers or multiple pipes connecting at the manhole. A minimum access diameter of 24 inches (610 mm) shall be provided.

34.4 Flow Channel

The flow channel straight through a manhole should be made to conform as closely as possible in shape and slope to that of the connecting sewers. The channel walls should be formed or shaped to the full height of the crown of the outlet sewer in such a manner as to not obstruct maintenance, inspection, or flow in the sewers.

When curved flow channels are specified in manholes, including branch inlets, the minimum slopes indicated in Paragraph 33.41 should be increased to maintain acceptable velocities.

34.5 Bench

A bench shall be provided on each side of any manhole channel when the pipe diameter(s) are less than the manhole diameter. The bench should be sloped no less than ½ inch per foot (40 mm/m) (4 percent). No lateral sewer, service connection, or drop manhole pipe shall discharge onto the surface of the bench.

34.6 Watertightness

Manholes shall be of the pre-cast concrete (as prescribed by ASTM C-478) or poured-in-place concrete type. Manhole lift holes and grade adjustment rings shall be sealed with non-shrinking mortar or other material approved by the regulatory agency.

Inlet and outlet pipes shall be joined to the manhole with a gasketed flexible watertight connection or another watertight connection arrangement that allows differential settlement of the pipe and manhole wall to take place.

Watertight manhole covers shall 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.

34.7 Inspection and Testing

The specifications shall include a requirement for manhole inspection and testing for watertightness or damage prior to placing into service. Air testing, if specified for concrete sewer manholes, shall conform to the test procedures described in ASTM C-1244.

34.8 Corrosion Protection For Manholes

Where corrosive conditions due to septicity or other causes are anticipated, corrosion protection on the interior of the manholes shall be provided.

34.9 Electrical

Electrical equipment installed or used in manholes shall conform to Paragraph 42.35.

35. INVERTED SIPHONS

Inverted siphons shall have not less than two barrels, with a minimum pipe size of 6 inches (150 mm). They shall be provided with necessary appurtenances for maintenance, convenient flushing, and cleaning equipment. The inlet and discharge structures shall also have adequate clearances for cleaning equipment, inspection, and flushing. Design shall provide sufficient head and appropriate pipe sizes to secure velocities of at least 3.0 feet per second (0.9 m/s) for design average flows. The inlet and outlet details shall be so arranged that the design average flow is diverted to one barrel, and so that either barrel may be removed from service for cleaning. The vertical alignment should permit cleaning and maintenance.

36. SEWERS IN RELATION TO STREAMS

36.1 Location of Sewers in Streams

36.11 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 shall be met:

a. One foot (0.3 m) of cover where the sewer is located in rock;

b. Three feet (0.9 m) of cover in other material. In major streams, more than 3 feet (0.9 m) of cover may be required; and

c. In paved stream channels, the top of the sewer line should be placed below the bottom of the channel pavement.

Less cover may be approved only if the proposed sewer crossing will not interfere with future modifications to the stream channel. Justification for requesting less cover shall be provided to the reviewing authority.

36.12 Horizontal Location

Sewers located along streams shall be located outside of the stream bed and at a sufficient distance to provide for future possible stream widening and to prevent pollution by siltation during construction.

36.13 Structures

The sewer outfalls, headwalls, manholes, gate boxes, or other structures shall be located so they do not interfere with the free discharge of flood flows of the stream.

36.14 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.

36.2 Construction

36.21 Materials

Sewers entering or crossing streams shall be constructed of ductile iron pipe with mechanical joints; otherwise they shall be constructed so 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 readily erode, cause siltation, damage the pipe during placement, or corrode the pipe.

36.22 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. Such methods shall provide adequate control of siltation and erosion by limiting unnecessary excavation, disturbing or uprooting trees and vegetation, dumping of soil or debris, or pumping silt-laden water into the stream. Specifications shall require that cleanup, grading, seeding, planting and/or restoration of all work areas shall begin immediately. Exposed areas shall not remain unprotected for more than seven days.

36.23 Alternative Construction Methods

When the alignment of a sewer crosses a stream, consideration shall be given to trenchless construction technologies as an alternative to open trench construction. Such designs may be approved by the reviewing authority on a case by case basis under the provisions of Paragraph 53.2.

37. 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. Where buried sewers change to aerial sewers, special construction techniques shall be used to minimize frost heaving.

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 50 year flood. Ductile iron pipe with mechanical joints is recommended.

38. PROTECTION OF WATER SUPPLIES

When wastewater sewers are proposed in the vicinity of any water supply facilities, requirements of the GLUMRB "Recommended Standards for Water Works" should be used to confirm acceptable isolation distances in addition to the following requirements.

38.1 Cross Connections Prohibited

There shall be no physical connections between a public or private potable water supply system and a sewer or appurtenance which would permit the passage of any wastewater or polluted water into the potable supply. No water pipe shall pass through or come into contact with any part of a sewer manhole.

38.2 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 the appropriate reviewing agency with respect to minimum distances from public water supply wells and other water supply sources or structures.

All existing waterworks units, such as basins, wells, or other treatment units, within 200 feet (60 m) of the proposed sewer shall be shown on the engineering plans.

Soil conditions in the vicinity of the proposed sewer within 200 feet (60 m) of waterworks units shall be determined and shown on the engineering plans.

38.3 Relation to Water Mains

38.31 Horizontal and Vertical Separation

Sewers shall be laid at least 10 feet (3 m) horizontally from any existing or proposed water main. The distance shall be measured edge to edge. For gravity sewers where it is not practical to maintain a 10 foot (3 m) separation, the appropriate reviewing agency may allow deviation on a case-by-case basis, if supported by data from the design engineer. Such deviation may allow installation of the gravity 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 side of the gravity sewer and at an elevation so the bottom of the water main is at least 18 inches (460 mm) above the top of the sewer.

If it is impossible to obtain proper horizontal and vertical separation as described above for gravity sewers, both the water main and gravity sewer shall be constructed of slip-on or mechanical joint pipe complying with Section 8.1 and Section 8.7 of the "Recommended Standards for Water Works – 2012 Edition" and shall be pressure rated to at least 150 psi (1034 kPa) and pressure tested to ensure watertightness.

38.32 Crossings

Sewers crossing water mains shall be laid to provide a minimum vertical distance of 18 inches (460 mm) 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. Where a water main crosses under a sewer, adequate structural support shall be provided for the sewer to maintain line and grade.

When it is impossible to obtain proper horizontal and vertical separation as stipulated above, one of the following methods shall be specified:

a. The sewer shall be designed and constructed equal to water pipe, as described in Paragraph 38.31.

b. Either the water main or the sewer line may be encased in a watertight carrier pipe that extends 10 feet (3 m) on both sides of the crossing, measured perpendicular to the water main. The carrier pipe shall be made of materials approved by the regulatory agency for use in water main construction.

CHAPTER 40
WASTEWATER PUMPING STATIONS

41. GENERAL

41.1 Flooding

Wastewater pumping station structures and electrical and mechanical equipment shall be protected from physical damage by the 100 year flood. Wastewater pumping stations should remain fully operational and accessible during the 25 year flood. Regulations of state, provincial and federal agencies regarding flood plain obstructions shall be considered.

41.2 Accessibility and Security

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. It is recommended that security fencing and access hatches with locks be provided.

41.3 Grit

Where it is necessary to pump wastewater 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.

41.4 Safety

Adequate provision shall be made to effectively protect maintenance personnel from hazards. Equipment for confined space entry in accordance with OSHA and regulatory agency requirements shall be provided for all wastewater pumping stations. Also refer to Section 57.

42. DESIGN

The following items should be given consideration in the design of wastewater pumping stations:

42.1 Type

Wastewater pumping stations in general use fall into four types: wet well/dry well, submersible, suction lift, and screw pump.

42.2 Structures

42.21 Separation

Dry wells, including their superstructure, shall be completely separated from the wet well. Common walls shall be gas tight.

42.22 Equipment Removal

Provisions shall be made to facilitate removing pumps, motors, and other mechanical and electrical equipment. Individual pump and motor removal shall not interfere with the continued operation of remaining pumps.

42.23 Access and Safety Landings

42.231 Access

Suitable and safe means of access for persons wearing self-contained breathing apparatus shall be provided to dry wells, and to wet wells. Access to wet wells containing either bar screens or mechanical equipment requiring inspection or maintenance shall conform to Paragraph 61.13. Also refer to Section 57.

42.232 Safety Landings

For built-in-place pump stations, a stairway to the dry well shall be provided with rest landings at vertical intervals not to exceed 12 feet (3.7 m). For factory-built pump stations over 15 feet (4.6 m) deep, a rigidly fixed landing shall be provided at vertical intervals not to exceed 10 feet (3 m). Where a landing is used, a suitable and rigidly fixed barrier shall be provided to prevent individuals from falling past the intermediate landing to a lower level. A manlift or elevator may be used in lieu of landings in a factory-built station, provided emergency access is included in the design.

42.24 Buoyancy

Where high groundwater conditions are anticipated, buoyancy of the wastewater pumping station structures shall be considered and, if necessary, adequate provisions shall be made for protection.

42.25 Construction Materials

Materials shall be selected that are appropriate under conditions of exposure to hydrogen sulfide and other corrosive gases, greases, oils, and other constituents frequently present in wastewater. This is particularly important in the selection of metals and paints. Contact between dissimilar metals should be avoided or other provisions made to minimize galvanic action.

42.3 Pumps

42.31 Multiple Units

Multiple pumps shall be provided. Where only two units are provided, they shall be of the same size. Units shall have capacity such that, with any unit out of service, the remaining units will have capacity to handle the design peak hourly flow. All pumps should be tested by the manufacturer. These tests should include a hydrostatic test and an operating test.

42.32 Protection Against Clogging

42.321 Combined Wastewater

Pumps handling combined wastewater shall be preceded by readily accessible bar racks to protect the pumps from clogging or damage. Bar racks should have clear openings as provided in Paragraph 61.121. 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. Refer to Paragraphs 42.23 and 61.13.

42.322 Separate Sanitary Wastewater

Pumps handling separate sanitary wastewater from 30 inch (750 mm) diameter or larger sewers shall be protected with bar racks meeting the above requirements. Appropriate protection from clogging shall also be considered for small pumping stations. Refer to Paragraphs 42.23 and 61.13.

42.33 Pump Openings

Pumps handling raw wastewater shall be capable of passing solid spheres of at least 3 inches (80 mm) in diameter. Pump suction and discharge openings shall be at least 4 inches (100 mm) in diameter. An exception to the requirement for passing solid spheres of at least 3 inches (80 mm) in diameter may be made on a case by case basis when the design includes equivalent protection from clogging or damage (i.e., grinder pumps, etc.).

42.34 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 43.

42.35 Electrical Equipment

Electrical systems and components (e.g., motors, lights, cables, conduits, switch boxes, control circuits, etc.) in raw wastewater wet wells, or in enclosed or partially enclosed spaces where hazardous concentrations of flammable gases or vapors may be present, shall comply with the National Electrical Code requirements for Class I, Division 1, Group D locations. Equipment located in the wet well shall be suitable for use under corrosive conditions. Each flexible cable shall be provided with a watertight seal and separate strain relief. A fused disconnect switch located above ground shall be provided for the main power feed for all pumping stations. When such equipment is exposed to weather, it shall meet the requirements of weatherproof equipment NEMA 3R or 4, at a minimum. Lightning and surge protection systems should be considered. Lift station control panels located outdoors shall be provided with a 110 volt power receptacle inside the control panel to facilitate maintenance. Ground Fault Circuit Interruption (GFCI) protection shall be provided for all outdoor outlets.

42.36 Intake

Each pump shall have an individual intake. Wet well and intake design should be such as to avoid turbulence near the intake and to prevent vortex formation.

42.37 Dry Well Dewatering

A sump pump equipped with dual check valves shall be provided in the dry well to remove leakage or drainage with discharge above the maximum high water level of the wet well. 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 leakage shall be piped or channeled directly to the sump. The sump pump shall be sized to remove the maximum pump seal water discharge that could occur in the event of a pump seal failure. Refer to Section 46.

42.38 Pumping Rates

The pumps and controls of main pumping stations, especially pumping stations operated as part of treatment facilities, should be selected to operate at varying delivery rates. Such stations should be designed to deliver as uniform a flow as practicable in order to minimize hydraulic surges. The station design capacity shall be based on the peak hourly flow determined in accordance with Paragraph 11.24 and should be adequate to maintain a minimum velocity of 2 feet per second (0.6 m/s) in the force main. Refer to Paragraph 49.1.

42.4 Controls

Water level control sensing devices should be located to prevent undue affects from turbulent flows entering the well or by the turbulent suction of the pumps. Bubbler type level monitoring systems shall include dual air compressors. Provision shall be made to automatically alternate the pumps in use. Suction lift stations should be designed to alternate pumps daily instead of each pumping cycle to extend the life of the priming equipment.

42.5 Valves

42.51 Suction Line

Suitable shutoff valves shall be placed on the suction line of dry pit pumps.

42.52 Discharge Line

Suitable shutoff and check valves shall be placed on the discharge line of each pump (except on screw pumps). The check valve shall be located between the shutoff valve and the pump. Check valves shall be suitable for the material being handled and shall be placed on the horizontal portion of discharge piping except for ball checks, which may be placed in the vertical run. Valves shall be capable of withstanding normal pressures and water hammer.

All shutoff and check valves shall be operable from floor level and accessible for maintenance. Outside levers are recommended on swing check valves.

42.6 Wet Wells

42.61 Divided Wells

Where continuity of pumping station operation is critical, consideration should be given to dividing the wet well into two interconnected sections to facilitate repairs and cleaning.

42.62 Size

The design fill time and minimum pump cycle time shall be considered in sizing the wet well. The effective volume of the wet well shall be based on the design average flow determined in accordance with Paragraph 11.24 and a filling time not to exceed 30 minutes, unless the facility is designed to provide flow equalization. The pump manufacturer's duty cycle recommendations shall be utilized in selecting the minimum cycle time. When the anticipated initial flow tributary to the pumping station is less than the design average flow, provisions should be made so that the fill time indicated is not exceeded for initial flows. When the wet well is designed for flow equalization as part of a treatment plant, provisions should be made to prevent septicity.

42.63 Floor Slope

The wet well floor shall have a minimum slope of 1 to 1 to the hopper bottom. The horizontal area of the hopper bottom shall be no greater than necessary for proper installation and function of the inlet.

42.64 Air Displacement

Covered wet wells shall have provisions for air displacement to the atmosphere, such as an inverted "j" tube or other means.

42.7 Safety Ventilation

42.71 General

Adequate ventilation shall be provided for all pump stations. Mechanical ventilation shall be provided for dry wells that are located below the ground surface. If screens or mechanical equipment requiring maintenance or inspection are located in the wet well, permanently installed ventilation is required. There shall be no interconnection between the wet well and dry well ventilation systems.

42.72 Air Inlets and Outlets

In dry wells over 15 feet (4.6 m) deep, multiple inlets and outlets are desirable. Dampers should not be used on exhaust or fresh air ducts. Fine screens or other obstructions in air ducts should be avoided to prevent clogging.

42.73 Electrical Controls

Switches for operation of ventilation equipment should be clearly marked and conveniently located. All intermittently operated ventilation equipment shall be interconnected with the respective pit lighting system. Consideration should be given to automatic controls where intermittent operation is used. The manual lighting/ventilation switch shall override the automatic controls. For a two speed ventilation system with automatic switch over where gas detection equipment is installed, consideration should be given to increasing the ventilation rate automatically in response to the detection of hazardous concentrations of gases or vapors.

42.74 Fans, Heating, and Dehumidification

The fan wheel shall be fabricated from non-sparking material. Automatic heating and dehumidification equipment shall be provided in all dry wells. The electrical equipment and components shall meet the requirements in Paragraph 42.35.

42.75 Wet Wells

Wet well ventilation may be either continuous or intermittent. Ventilation, if continuous, shall provide at least 12 complete air changes per hour; if intermittent, at least 30 complete air changes per hour. Air shall be forced into the wet well by mechanical means rather than solely exhausted from the wet well. The air change requirements shall be based on 100 percent fresh air. Portable ventilation equipment shall be provided for use at submersible pump stations and wet wells with no permanently installed ventilation equipment.

42.76 Dry Wells

Dry well ventilation may be either continuous or intermittent. Ventilation, if continuous, shall provide at least 6 complete air changes per hour; if intermittent, at least 30 complete air changes per hour. A system of two speed ventilation with an initial ventilation rate of 30 changes per hour for 10 minutes and automatic switch over to 6 changes per hour may be used to conserve heat. The air change requirements shall be based on 100 percent fresh air.

42.8 Flow Measurement

Suitable devices for measuring wastewater flow shall be provided at all pumping stations. Indicating, totalizing, and recording flow measurement shall be provided at pumping stations with a 350 gpm (22 L/s) or greater design peak hourly flow, determined in accordance with Paragraph 11.24, or pumping stations with variable frequency drives or screw pumps. Elapsed time meters, used in conjunction with annual pumping rate tests, may be acceptable for pump stations with constant output pumps and a design peak hourly flow up to 350 gpm (22 L/s), provided sufficient metering is configured to measure the duration of individual and simultaneous pump operation.

42.9 Water Supply

There shall be no physical connection between any potable water supply and a wastewater 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 shall comply with conditions stipulated under Paragraph 56.23.

43. SUCTION-LIFT PUMP STATIONS

Suction-lift pumps shall meet the applicable requirements of Section 42.

43.1 Pump Priming and Lift Requirements

Suction-lift pumps shall be of the self-priming or vacuum-priming type. Suction-lift pump stations using dynamic suction lifts exceeding the limits outlined in the following sections may be approved upon submission of factory certification of pump performance and detailed calculations indicating satisfactory performance under the proposed operating conditions. Such detailed calculations shall 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 6 feet (1.8 m).

43.11 Self-Priming Pumps

Self-priming pumps shall be capable of rapid priming and repriming at the "lead pump on" elevation. Such 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 25 feet (7.6 m) in total length. Priming lift at the "lead pump on" elevation shall include a safety factor of at least 4 feet (1.2 m) from the maximum allowable priming lift for the specific equipment at design operating conditions. The combined total of the dynamic suction-lift at the "pump off" elevation and the required net positive suction head at design operating conditions shall not exceed 22 feet (6.7 m).

43.12 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 wastewater. The combined total of the dynamic suction-lift at the "pump off" elevation and the required net positive suction head at design operating conditions shall not exceed 22 feet (6.7 m).

43.2 Equipment, Wet Well Access, and Valve Location

The pump equipment compartment shall be above grade or offset and shall be effectively isolated from the wet well to prevent a hazardous and corrosive sewer atmosphere from entering the equipment compartment. Wet well access shall not be through the equipment compartment and shall be at least 24 inches (610 mm) in diameter. Gasketed replacement plates shall be provided to cover the opening to the wet well for pump units removed for servicing. Valves shall not be located in the wet well.

44. SUBMERSIBLE PUMP STATIONS - SPECIAL CONSIDERATIONS

Submersible pump stations shall meet the applicable requirements under Section 42, except as modified in this Section.

44.1 Construction

Submersible pumps and motors shall be designed specifically for raw wastewater use, including totally submerged operation during a portion of each pumping cycle, and shall meet the requirements of the National Electrical Code for such units. An effective method to detect shaft seal failure or potential seal failure shall be provided.

44.2 Pump Removal

Submersible pumps shall be readily removable and replaceable without personnel entering or dewatering the wet well or disconnecting any piping in the wet well.

44.3 Electrical Equipment

44.31 Power Supply and Control Circuitry

Electrical supply, control, and alarm circuits shall be designed to provide strain relief and to allow disconnection from outside the wet well. Terminals and connectors shall be protected from corrosion by location outside the wet well or through use of watertight seals.

44.32 Controls

The motor control center shall be located outside the wet well, be readily accessible, and be protected by a conduit seal or other appropriate measures meeting the requirements of the National Electrical Code, to prevent the atmosphere of the wet well from gaining access to the control center. The seal shall be located so that the motor can be removed and electrically disconnected without disturbing the seal. When such equipment is exposed to weather, it shall meet the requirements of weatherproof equipment NEMA 3R or 4, at a minimum.

44.33 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 National Electrical Code standards for flexible cords in wastewater pump stations. 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 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.

44.4 Valves

Valves required under Paragraph 42.5 shall be located in a separate valve chamber. Provisions shall be made to remove or drain accumulated water from the valve chamber. The valve chamber may be dewatered to the wet well through a drain line with a gas and water tight valve. Check valves that are integral to the pump need not be located in a separate valve chamber provided that the valve can be removed from the wet well in accordance with Paragraph 44.2. Access shall be provided in accordance with Paragraph 42.231.

45. SCREW PUMP STATIONS - SPECIAL CONSIDERATIONS

Screw pumps shall meet the applicable requirements of Section 42.

45.1 Covers

Covers or other means of excluding direct sunlight shall be provided as necessary to eliminate adverse effects caused by temperature changes.

45.2 Pump Wells

A positive means of isolating individual screw pump wells shall be provided.

45.3 Bearings

Submerged bearings shall be lubricated by an automated system without pump well dewatering.

46. ALARM SYSTEMS

Alarm systems with a backup power source shall be provided for pumping stations. The alarm shall be activated in cases of power failure, dry well sump and wet well high water levels, pump failure, unauthorized entry, or any other cause of pump station malfunction. Pumping station alarm systems shall transmit and identify alarm conditions to a municipal facility that is staffed 24 hours a day. If such a facility is not available and a 24-hour holding capacity is not provided, the alarm shall be transmitted to municipal offices during normal working hours and to the home of the responsible person(s) in charge of the lift station during off-duty hours. Audio-visual alarm systems may be acceptable in some cases in lieu of a transmitting system depending upon location, station holding capacity and inspection frequency.

47. EMERGENCY OPERATION

47.1 Objective

The objective of emergency operation is to prevent the discharge of raw or partially treated wastewater to any waters and to protect public health by preventing back-up of wastewater and subsequent discharge to basements, streets, and other public and private property.

47.2 Emergency Pumping Capability

Emergency pumping capability is required unless on-system overflow prevention is provided by adequate storage capacity. Emergency pumping capability shall be accomplished by connection of the station to at least two independent utility substations, by provision of portable or in-place internal combustion engine equipment to generate electrical or mechanical energy, or by the provision of portable pumping equipment. Emergency pumping shall comply with the conditions stipulated in Paragraph 56.1. Such emergency standby systems shall have sufficient capacity to start up and maintain the total rated running capacity of the station. Regardless of the type of emergency standby system provided, a portable pump connection to the force main with rapid connection capabilities and appropriate valves shall be provided outside the dry well and wet well.

47.3 Emergency High Level Overflows

For use during possible periods of extensive power outages, mandatory power reductions, or uncontrollable emergency conditions, consideration should be given to providing a controlled, high-level wet well overflow to supplement alarm systems and emergency pumping capability in order to prevent backup of wastewater into basements, or other discharges that could cause severe adverse impacts on public interests, including public health and property damage. Where a high level overflow is utilized, consideration shall also be given to the installation of storage/detention tanks or basins, which shall drain back to the station wet well. All structures capable of bypassing shall be controlled by a lockable, manually operated valve. Where such overflows are considered, the regulatory agency shall be contacted for the necessary treatment or storage requirements.

47.4 Equipment Requirements

47.41 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:

47.411 Engine Protection

The engine shall 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 as required in Section 46. Protective equipment shall monitor for conditions of low oil pressure and overheating. Oil pressure monitoring will not be required for engines with splash lubrication.

47.412 Size

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

47.413 Fuel Type

Reliability and ease of starting, especially during cold weather conditions, should be considered in the selection of the type of fuel. Where public utility gas is selected, consideration shall be given to a generator design that may be operated with an alternate fuel supply system in accordance with National Electric Code (701.11, 2008 Edition.)

47.414 Underground Fuel Storage

Underground fuel storage and piping facilities shall be constructed in accordance with applicable state, provincial, and federal regulations.

47.415 Engine Ventilation

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

47.416 Routine Start-up

All emergency equipment shall be provided with instructions indicating the need for regular starting and running of such units at full loads.

47.417 Protection of Equipment

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

47.418 Air Quality

Regulations of state, provincial and federal agencies regarding air quality shall be considered.

47.419 Silencer

Noise control should be considered.

47.42 Engine-Driven Pumping Equipment

In addition to the general requirements of Paragraph 47.41, the following requirements shall apply to permanently-installed or portable engine-driven pumping equipment:

47.421 Pumping Capacity

Engine-driven pumps 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.

47.422 Operation

The engine and pump shall be equipped for automatic start-up and operation of pumping equipment unless manual start-up and operation is justified. Provisions shall also be made for manual start-up. Where manual start-up and operation is justified, the storage capacity and the alarm system shall meet the requirements of Paragraphs 46 and 47.423.

47.423 Portable Pumping Equipment

Where part or all of the engine-driven pumping equipment is portable, sufficient storage capacity with an alarm system shall be provided to allow time for the detection of pump station failure and the transportation and hookup of the portable equipment.

47.43 Engine-Driven Generating Equipment

In addition to the general requirements of Paragraph 47.41, the following requirements shall apply to permanently-installed or portable engine-driven generating equipment:

47.431 Generating Capacity

a. 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 the proper operation of the lift station.

b. The operation of only one pump during periods of auxiliary power supply shall be justified. Such justification may be made on the basis of the design peak hourly flows relative to single-pump capacity, the anticipated length of power outages, and the storage capacity.

c. 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.

47.432 Operation

Provisions shall be made for automatic and manual start-up and load transfer unless only manual start-up and operation is justified. The generator shall be protected from operating conditions that could 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, the storage capacity and the alarm system shall meet the requirements of Paragraphs 46 and 47.433.

47.433 Portable Generating Equipment

Where portable generating equipment or manual transfer is provided, sufficient storage capacity, with an alarm system, shall be provided to allow time for the detection of pump station failure and the transportation and connection of generating equipment. Special electrical connections and double throw switches should be used to connect the portable generating equipment.

47.44 Independent Utility Substations

Where independent substations are used for emergency power, each separate substation and its associated distribution lines shall be capable of starting and operating the pump station at its rated capacity.

48. INSTRUCTIONS AND EQUIPMENT

Wastewater pumping stations and portable equipment shall be supplied with a complete set of operational instructions, including emergency procedures and maintenance schedules. Tools and spare parts shall be supplied as necessary.

49. FORCE MAINS

49.1 Velocity and Diameter

At design pumping rates, a cleansing velocity of at least 2 feet per second (0.6 m/s) should be maintained. A maximum velocity of 8 feet per second (2.4 m/s) is recommended to avoid high head loss and protect valves. The minimum force main diameter for raw wastewater shall not be less than 4 inches (100 mm).

49.2 Air and Vacuum Relief Valve

Air relief valves shall be placed at high points in the force main to prevent air locking. Vacuum relief valves may be necessary to relieve negative pressures on force mains. The force main configuration and head conditions should be evaluated as to the need for and placement of vacuum relief valves.

49.3 Termination

The force main shall enter the receiving manhole with a smooth flow transition to the gravity sewer system at a point not more than 1 foot (0.3 m) above the flow line. Corrosion protection for the receiving manhole shall be provided in accordance with Paragraph 34.8.

49.4 Pipe and Design Pressure

Pipe and joints shall be equal to water main strength materials suitable for design conditions. The force main, reaction blocking, and station piping shall be designed to withstand water hammer pressures and associated cyclic reversal of stresses that are expected with the cycling of wastewater lift stations. The use of surge valves, surge tanks or other suitable means to protect the force main against severe pressure changes shall be evaluated.

49.5 Special Construction

Force main construction near streams or water works structures and at water main crossings shall meet the applicable provisions of Sections 36, 37, and 38. There shall be at least a 10 foot (3 m) horizontal separation between water mains and sewer force mains.

49.6 Design Friction Losses

49.61 Friction Coefficient

Friction losses through force mains shall be based on the Hazen-

Williams formula or other acceptable methods. When the Hazen-Williams formula is used, the value for "C" shall be 100 for unlined iron or steel pipe for design. For other smooth pipe materials such as PVC, polyethylene, lined ductile iron, etc., a higher "C" value, not to exceed 120, may be allowed for design.

49.62 Maximum Power Requirements

When initially installed, force mains will have a significantly higher "C" factor. The effect of the higher "C" factor should be considered when calculating maximum power requirements and duty cycle time to prevent damage to the motor. The effects of higher discharge rates on selected pumps and downstream facilities should also be considered.

49.7 Identification

Where force mains are constructed of a material that might cause the forcemain to be confused with potable water mains, the force main shall be appropriately identified.

49.8 Leakage Testing

Leakage tests shall be specified including testing methods and leakage limits.

49.9 Maintenance Considerations

Isolation valves should be considered where force mains connect into a common force main. Cleanouts at low points and chambers for pig launching and catching should be considered for any force main to facilitate maintenance.

49.10 Cover

Force mains shall be covered with sufficient earth or other insulation to prevent freezing.

CHAPTER 50
WASTEWATER TREATMENT FACILITIES

51. PLANT LOCATION

51.1 General

Items to be considered when selecting a plant site are listed in Chapter 10.

51.2 Flood Protection

The treatment plant structures, electrical, and mechanical equipment shall be protected from physical damage by the one hundred (100) year flood. Treatment plants should remain fully operational and accessible during the twenty-five (25) year flood. This requirement applies to new construction and to existing facilities undergoing major modification. Flood plain regulations of state, province, and federal agencies shall be considered.

52. QUALITY OF EFFLUENT

The required degree of wastewater treatment shall be based on the effluent requirements and water quality standards established by the responsible province, state agency and/or appropriate federal regulations including discharge permit requirements.

53. DESIGN

53.1 Type of Treatment

Items to be considered in selection of the appropriate type of treatment are presented in Chapter 10.

The plant design shall provide the necessary flexibility to perform satisfactorily within the expected range of waste characteristics and volumes.

53.2 Required Engineering Data for New Process and Application Evaluation

The policy of the reviewing authority 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 reviewing authority may approve other types of wastewater treatment processes and equipment under the condition that the operational reliability and effectiveness of the process or device shall have been demonstrated with one or more suitably-sized prototype units operating at their design load conditions, to the extent required.

To determine that such new processes and equipment or applications have a reasonable and substantial chance of success, the reviewing authority may require the following:

a. Monitoring observations, including test results and engineering evaluations, demonstrating the efficiency of such processes.

b. Detailed description of the test methods.

c. Testing, including appropriately-composited samples, under various ranges of strength and flow rates (including diurnal variations) and waste temperatures over a sufficient length of time to demonstrate performance under the range of climatic and other conditions which may be encountered in the area of the proposed installations.

d. Other appropriate information.

The reviewing authority 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, patent holder or developer.

53.3 Design Period

The design period shall be clearly identified in the engineering report or facilities plan as required in Chapter 10.

53.4 Design Loads

53.41 Hydraulic Design

53.411 Critical Flow Conditions

Flow conditions critical to the design of the treatment plant are described in Chapter 10.

Initial low flow conditions shall be evaluated in the design to minimize operational problems with freezing, septicity, flow measurements and solids dropout. The design peak hourly flow shall be used to evaluate the effect of hydraulic peaks on unit processes, pumping, piping, settling tanks, etc.

53.412 Treatment Plant Design Capacity

The treatment plant design capacity shall be as described in Chapter 10. The plant design flow selected shall meet the appropriate effluent and water quality standards that are set forth in the discharge permit. The design of treatment units that are not subject to peak hourly flow requirements shall be based on the design average flow. For plants subject to high wet weather flows or overflow detention pumpback flows, the design maximum day flows that the plant is to treat on a sustained basis should be specified.

53.413 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 herein and from Chapter 10.

53.42 Organic Design

Organic loadings for wastewater treatment plant design shall be based on the information given in Chapter 10. The effects of septage flow which may be accepted at the plant shall be given consideration and appropriate facilities shall be included in the design. Refer to the Appendix.

53.43 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 and batch processes, shall be considered.

53.5 Conduits

All piping and channels shall be designed to carry the maximum expected flows. The incoming sewer should be designed for unrestricted flow. Bottom corners of the channels, except final effluent channels, shall be filleted. Conduits shall be designed to avoid creation of pockets and corners where solids can accumulate.

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

53.6 Arrangement of Units

Component parts of the plant should be arranged for greatest operating and maintenance convenience, flexibility, continuity of optimum effluent quality for water quality protection, economy of function, and ease of installation of future units.

Where duplicate units are provided, a central collection and distribution point including proportional flow splitting shall be provided for the wastewater flow before each unit operation. Exceptions to this central collection and distribution point requirement may be made on a case-by-case basis when the design incorporates more than one unit process in the same physical structure.

53.7 Flow Division Control

Flow division control facilities shall be provided as necessary to ensure organic and hydraulic loading control to plant process units and shall be designed for easy operator access, change, observation, and maintenance. The use of upflow division boxes equipped with adjustable sharp-crested weirs or similar devices is recommended. The use of valves for flow splitting is not acceptable. Appropriate flow measurement facilities shall be incorporated in the flow division control design.

54. PLANT DETAILS

54.1 Installation of Mechanical Equipment

The specifications should be written to ensure that the installation and initial operation of major items of mechanical equipment will be inspected and approved by a representative of the manufacturer.

54.2 Unit Bypasses

54.21 Removal from Service

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

Bypassing may be accomplished through the use of duplicate or multiple treatment units in any stage if the design peak instantaneous flow can be handled hydraulically with the largest unit out of service.

The actuation of all bypasses shall require manual action by operating personnel. All power-actuated bypasses shall be designed to permit manual operation in the event of power failure and shall be designed so that the valve will fail as is, upon failure of the power operator.

A fixed high water level bypass overflow should be provided in addition to a manually or power actuated bypass.

54.22 Unit Bypass During Construction

Unit bypassing during construction shall be in accordance with the requirements in Paragraphs 11.28(l), 20.15 and Section 21.

54.3 Unit Dewatering, Flotation Protection, and Plugging

Means such as drains or sumps shall be provided to completely dewater 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 plugging shall be provided with means for mechanical cleaning or flushing.

54.4 Construction Materials

Materials shall be selected that are appropriate under conditions of exposure to hydrogen sulfide and other corrosive gases, greases, oils, and other constituents frequently present in wastewater. This is particularly important in the selection of metals and paints. Contact between dissimilar materials should be avoided or other provisions made to minimize galvanic action.

54.5 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 the different lines be color-coded. The following color scheme is recommended for purposes of standardization.

Raw sludge line - gray
Sludge recirculation suction line - brown with yellow bands
Sludge draw off line - brown with orange bands
Sludge recirculation discharge line - brown
Digested sludge line - black
Sludge gas line - red
Natural gas line - red
Nonpotable water line - purple
Potable water line - blue
Fire main - red
Chlorine line - yellow
Sulfur Dioxide - yellow with red bands
Sewage (wastewater) line - gray
Compressed air line - dark green
Process air line - light green
Water lines for heating digesters or buildings - blue with a 6-inch (150 mm) red band spaced 30 inches (760 mm) apart
Fuel oil/diesel - red
Plumbing drains and vents - black
Ferric Chloride - orange
Polymer - unpainted PVC

The contents and direction of flow shall be stenciled on the piping in a contrasting color.

54.6 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. Consideration shall be given to provision of a garage for large equipment storage, maintenance, and repair.

54.7 Erosion Control During Construction

Effective site erosion control shall be provided during construction.

54.8 Grading and Landscaping

Upon completion of the plant, the ground shall be graded and sodded or seeded. All-weather 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.

55. PLANT OUTFALLS

55.1 Discharge Impact Control

The outfall sewer shall be designed to discharge to the receiving stream in a manner acceptable to the reviewing authority. Consideration should be given in each case to the following:

a. Preference for free fall or submerged discharge at the site selected;

b. Utilization of cascade aeration of effluent discharge to increase dissolved oxygen; and

c. Limited or complete across-stream dispersion as needed to protect aquatic life movement and growth in the immediate reaches of the receiving stream.

55.2 Protection and Maintenance

The outfall sewer shall be so constructed and protected against the effects of floodwater, tide, ice, or other hazards as to reasonably ensure its structural stability and freedom from stoppage. A manhole should be provided at the shore end of all gravity sewers that extend into the receiving waters. Hazards to navigation shall be considered in designing outfall sewers.

55.3 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. If disinfection is provided, a sampling point also should be located immediately prior to disinfection.

56. ESSENTIAL FACILITIES

56.1 Emergency Power Facilities

56.11 General

All plants shall be provided with an alternate source of electric power or pumping capability to allow continuity of operation during power failures, except as noted below. Refer to Paragraph 47.4 for design details. Methods of providing alternate sources include:

a. The connection of at least two independent power sources such as substations able to supply power without interruption. A power line from each substation and separate routes are recommended, and will be required unless documentation is received and approved by the reviewing authority verifying that a duplicate line is not necessary;

b. Portable or in-place internal combustion engine equipment which will generate electrical or mechanical energy; and

c. Portable pumping equipment when only emergency pumping is required.

56.12 Power for Aeration

Standby generating capacity normally is not required for aeration equipment used in the activated sludge process. In cases where a history of long-term (4 hours or more) power outages or reduced voltage have occurred, auxiliary power for minimum aeration of the activated sludge is required. Full power generating capacity may be required by the reviewing authority for waste discharges to certain critical stream segments such as upstream of bathing beaches, upstream of a public water supply intake or other similar situations.

56.13 Power for Disinfection

Continuous disinfection, where required, shall be provided during all power outages. Continuous dechlorination is required for systems that dechlorinate.

56.14 Power for Data Loggers

Computers configured to log data shall be supplied with an uninterruptable power supply (UPS). Each UPS shall monitor its own battery condition and issue alarms on low battery. UPSs configured to supply computers shall cause the computer to save all open files and data logging files, without overwriting existing files, at the time of primary power failure and again when a low battery condition occurs.

56.2 Water Supply

56.21 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 plant 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 in heat exchangers, chlorinators, etc.

56.22 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:

a. Lavatory;
b. Water closet;
c. Laboratory sink (with vacuum breaker);
d. Shower;
e. Drinking fountain;
f. Eye wash fountain; and
g. Safety shower.

Hot water for any of the above units shall not be taken directly from a boiler used for supplying hot water to a sludge heat exchanger or digester heating unit.

56.23 Indirect Connections

Where a potable water supply is to be used for any purpose in a plant other than those listed in Paragraph 56.22, a break tank, pressure pump, and pressure tank shall be provided. Water shall be discharged to the tank through an air gap at least 6 inches (150 mm) above the maximum flood line or the spill line of the tank, whichever is higher.

A sign shall be permanently posted at every hose bib, faucet, hydrant, or sill cock located on the water system beyond the break tank to indicate that the water is not safe for drinking.

56.24 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 shall comply with requirements of the governing state or province and local regulations. Requirements governing the use of the potable water supply are those contained in Paragraphs 56.22 and 56.23.

56.25 Separate Non-Potable Water Supply

Where a separate non-potable 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.

56.3 Sanitary Facilities

Toilet, shower, lavatory, and locker facilities should be provided in sufficient numbers and at convenient locations to serve the expected plant personnel.

56.4 Floor Slope

Floor surfaces shall be sloped adequately to a point of drainage.

56.5 Stairways

Stairways shall be installed in lieu of ladders for access to units requiring routine inspection and maintenance, such as digesters, trickling filters, aeration tanks, clarifiers, tertiary filters, etc. Spiral or winding stairs are permitted only for secondary access where dual means of egress are provided.

Stairways shall have slopes between 30 and 40 degrees 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 9 inches (230 mm). The sum of the tread run and riser shall not be less than 17 inches (430 mm) nor more than 18 inches (460 mm). A stairway shall not have more than a 12-foot (3.7 m) continuous rise without a platform.

56.6 Flow Measurement

56.61 Location

Flow measurement facilities shall be provided to measure the following flows:

a. Plant influent or effluent flow;

b. Plant influent and effluent flows. If influent flow is significantly different from effluent flow, both shall be measured. This applies to installations such as lagoons, sequencing batch reactors, and plants with excess flow storage or flow equalization;

c. Excess flow treatment facility discharges;

d. Other flows required to be monitored under the provisions of the discharge permit; and

e. Other flows such as return activated sludge, waste activated sludge, recirculation, and recycle required for plant operational control.

56.62 Facilities

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 elapsed time meters used in conjunction with pumping rate tests or shall be calibrated weirs. All flow measurement equipment shall be sized to function effectively over the full range of flows expected and shall be protected against freezing.

See Paragraph 42.35 for the requirements concerning electrical systems and components located in enclosed or partially enclosed spaces where hazardous concentrations of flammable gases or vapors may be present.

56.63 Hydraulic Conditions

Flow measurement equipment including approach and discharge conduit configuration and critical control elevations shall be designed to ensure that the required hydraulic conditions necessary for accurate measurement are provided. Turbulence, eddy currents, air entrainment or any other aspect that upsets the normal hydraulic conditions that are necessary for accurate flow measurement shall be avoided.

56.7 Sampling Equipment

Effluent composite sampling equipment shall be provided at all mechanical plants with a design average flow of 0.1 mgd (380 m^3/d) or greater and at other facilities where it is necessary to meet discharge permit monitoring requirements. Composite sampling equipment shall also be provided as needed for influent sampling and for monitoring plant operations. The influent sampling point should be located prior to any process return flows.

Refer to Paragraph 42.35 for the requirements concerning electrical systems and components located in enclosed or partially enclosed spaces where hazardous concentrations of flammable gases or vapors may be present. This Paragraph shall be considered in the design and location of influent composite sampling equipment.

57. SAFETY

57.1 General

Adequate provision shall be made to effectively protect plant personnel and visitors from hazards. The following shall be provided to fulfill the particular needs of each plant:

a. Enclosure of the plant site with a fence and signs designed to discourage the entrance of unauthorized persons and animals;

b. Hand rails with toe-boards where appropriate and guards around tanks, trenches, pits, stairwells, and other hazardous structures where the top of the wall is less than 42 inches (1070 mm) above the surrounding ground level;

c. Gratings over appropriate areas of treatment units where access for maintenance is required;

d. First aid equipment;

e. "No Smoking" signs in hazardous areas;

f. Protective clothing and equipment as needed, such as self-contained breathing apparatus, gas detection equipment, goggles, gloves, hard hats, safety harnesses, hearing protectors, etc.;

g. Portable blowers and sufficient hose;

h. Portable lighting equipment complying with the National Electrical Code requirements;

i. Gas detectors listed and labeled for use in Class I, Division 1, Group D locations;

j. Appropriately-placed warning signs for slippery areas, non-potable water fixtures, low head clearance areas, open service manholes, hazardous chemical storage areas, flammable fuel storage areas, high noise areas, etc.;

k. Adequate ventilation in pump station areas in accordance with Paragraph 42.7;

l. Provisions for local lockout on stop motor controls;

m. Provisions for confined space entry and laboratory safety in accordance with OSHA and regulatory agency requirements; and

n. Adequate vector control.

57.2 Hazardous Chemical Handling

57.21 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.

57.22 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 facilities, inhibit the treatment processes, or contribute to stream pollution. Liquid polymer should be similarly contained to reduce areas with slippery floors, especially to protect travelways. Non-slip floor surfaces are desirable in polymer-handling areas.

57.23 Liquefied Gas Chemicals

Areas intended for storage and handling of chlorine and sulfur dioxide and other hazardous gases shall be properly designed and isolated. Gas detection kits, alarms, controls, safety devices, and emergency repair kits shall be provided.

57.24 Splash Guards

All pumps or feeders for hazardous or corrosive chemicals shall have guards that 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.

57.25 Piping, Labeling, Coupling Guards, Location

All piping containing or transporting corrosive or hazardous chemicals shall be identified with labels every 10 feet (3 m) and with at least two 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 those 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 chemical spray or dripping onto personnel.

57.26 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:

a. Self-contained breathing apparatus recommended for protection against chlorine;

b. Chemical worker's goggles or other suitable goggles (safety glasses are insufficient);

c. Face masks or shields for use over goggles;

d. Dust masks to protect the lungs in dry chemical areas;

e. Rubber gloves;

f. Rubber aprons with leg straps;

g. Rubber boots (leather and wool clothing should be avoided near caustics); and

h. Safety harness and line.

57.27 Warning System and Signs

Facilities shall be provided for the automatic shutdown of pumps and sounding of alarms when failure occurs in a pressurized chemical discharge line.

Warning signs requiring the use of goggles shall be located near chemical stations, pumps, and other points of frequent hazard.

57.28 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 that can become slick when wet.

57.29 Eyewash Fountains and Safety Showers

Eyewash fountains and safety showers utilizing potable water shall be provided on each floor level or work location involving hazardous or corrosive chemical storage, mixing (or slaking), pumping, metering, or transportation unloading. These facilities shall be as close as practical to points of chemical exposure and shall be fully operable during all weather conditions.

Each eyewash fountain shall be supplied with water of moderate temperature 50°F to 90°F (10 °C to 32 °C) suitable to provide 15 to 30 minutes of continuous irrigation of the eyes. Each emergency shower shall be capable of discharging at least 20 gpm (1.3 L/s) of water at moderate temperature and should be at pressures of 30 psi to 50 psi (210 kPa to 345 kPa).

57.3 Hazardous Chemical 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. Wastewater and sludge sample containers should be adequately labeled. Below is an example of a suitable label to identify a wastewater sample as a hazardous substance:

RAW SEWAGE WASTEWATER

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.

58. LABORATORY

58.1 General

All treatment plants shall include a laboratory for making the necessary analytical determinations and operating control tests, except for plants utilizing only processes not requiring laboratory testing for plant control where satisfactory off-site laboratory provisions are made to meet the permit monitoring requirements. For plants where a fully equipped laboratory is not required, the requirements for utilities, fume hoods, etc., may be reduced. 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 arrangement should be sufficiently flexible to allow future expansion should more analytical work be needed. Laboratory instrumentation and size should reflect treatment plant size, staffing requirements, process complexity, and applicable certification requirements. Experience and training of plant operators should also be assessed when determining treatment plant laboratory needs.

Treatment plant laboratory needs may be divided into the following three general categories:

I. Plants performing only basic operational testing; this typically includes pH, temperature, and dissolved oxygen;

II. Plants performing more complex operational and permit laboratory tests including biochemical oxygen demand, suspended solids, and bacterial analysis, and;

III. Plants performing more complex operational, permit, industrial pretreatment, and multiple plant laboratory testing.

Expected minimum laboratory needs for these three plant classifications are outlined in this Section. However, in specific cases, laboratory needs may have to be modified or increased due to industrial monitoring needs or special process control requirements.

58.2 Category I: Plants performing only basic operational testing

58.21 Location and Space

A floor area up to 150 square feet (14 m^2) should be adequate. It is recommended that this be at the treatment site. Another location in the community utilizing space in an existing structure owned by the involved wastewater authority may be acceptable.

58.22 Design and Materials

The facility shall provide for electricity, water, heat, sufficient storage space, a sink, and a bench top. The lab components need not be of industrial grade materials. Laboratory equipment and glassware shall be of types recommended by Standard Methods for the Examination of Water and Wastewater and the reviewing authority.

58.3 Category II: Plants performing more complex operational and permit laboratory tests including biochemical oxygen demand, suspended solids, and bacterial analysis

58.31 Location and Space

The laboratory size should be based on providing adequate room for the equipment to be used. In general, the laboratories for this category of plant should provide a minimum of approximately 300 square feet (28 m^2) of floor space. Adequate bench space for each analyst shall be provided. The laboratory should be located at the treatment site on ground level. It shall be isolated from vibrating, noisy, or high-temperature machinery or equipment which might have adverse effects on the performance of laboratory staff or instruments.

58.32 Floors

Floor surfaces should be fire resistant and highly resistant to acids, alkalies, solvents, and salts.

58.33 Cabinets and Bench Tops

Laboratories in this category usually perform both discharge permit testing and operational control monitoring utilizing "acids" and "bases" in small quantities, such that laboratory grade metal cabinets and shelves are not mandatory. The cabinets and shelves selected may be of wood or other durable materials. Bench tops should be of acid resistant laboratory grade materials for protection of the underlying cabinets. Glass doors on wall-hung cabinets are recommended. One or more cupboard style base cabinets should be provided. Cabinets with drawers should be provided with rubber bumpers and stops to prevent accidental removal. Cabinets for Category II laboratories are not required to have gas, air, vacuum, and electrical service fixtures. Built-in shelves should be adjustable.

58.34 Fume Hoods, Sinks, and Ventilation

58.341 Fume Hoods

Fume hoods shall be provided for laboratories where required analytical work results in the production of noxious fumes. Air intake should be balanced against all exhaust ventilation to maintain an overall positive pressure relative to atmospheric in the laboratory.

58.342 Sinks

A laboratory grade sink and drain trap shall be provided.

58.343 Ventilation

Laboratories should be air conditioned. In addition, separate exhaust ventilation should be provided.

58.35 Balance and Table

An analytical balance of the automated 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 is recommended. This table shall be located as far 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.

58.36 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. If any required analytical testing produces malodorous or noxious fumes, the engineer should verify that the in-house analysis is more cost-effective than use of an independent off-site laboratory. Discharge permit, process control, and industrial waste monitoring requirements should be considered when specifying equipment needs. Composite samplers may be required to satisfy permit sampling requirements. References such as Standard Methods for the Examination of Water and Wastewater and the U.S.E.P.A. Analytical Procedures Manual should be consulted prior to specifying equipment items.

58.37 Utilities

58.371 Power Supply

Consideration should be given to providing line voltage regulation for the power supplied to laboratories using delicate instruments.

58.372 Laboratory Water

Reagent water of a purity suitable for analytical requirements shall be supplied to the laboratory. In general, reagent water prepared using an all glass distillation system is adequate. However, some analyses require deionization of the distilled water. Consideration should be given to softening the feed water to the still.

58.38 Safety

58.381 Equipment

Laboratories shall provide, as a minimum, the following: first aid equipment; protective clothing (including goggles, gloves, lab aprons, etc.); and a fire extinguisher.

58.382 Eyewash Fountains and Safety Showers

Eyewash fountains and safety showers utilizing potable water shall be provided in the laboratory. These should be as close as practical to work locations and shall be no more than 25 feet (7.6 m) from points of hazardous chemical exposure.

Each eyewash fountain shall be supplied with water of moderate temperature 50°F to 90°F (10 °C to 32 °C) suitable to provide 15 to 30 minutes of continuous irrigation of the eyes. Each emergency shower shall be capable of discharging at least 20 gpm (1.3 L/s) of water at a moderate temperature and should be at pressures of 30 psi to 50 psi (210 kPa to 345 kPa).

58.4 Category III: Plants performing more complex operational, permit, industrial pretreatment and multiple plant laboratory testing

58.41. Location and Space

The laboratory should be located at the treatment site on ground level, with environmental control as an important consideration. It shall be isolated from vibrating, noisy, or high temperature machinery or equipment which might have adverse effects on the performance of laboratory staff or instruments.

The laboratory facility needs for Category III plants should be described in the Engineering Report or Facility Plan. The laboratory floor space and facility layout should be based on an evaluation of the complexity, volume, and variety of sample analyses expected during the design life of the plant including testing for process control, industrial pretreatment control, user charge monitoring, and discharge permit monitoring requirements.

Consideration shall be given to the necessity to provide separate (and possibly isolated) areas for some special laboratory equipment, glassware, and chemical storage. The analytical and sample storage areas should be isolated from all potential sources of contamination. It is recommended that the organic chemical facilities be isolated from other facilities. Adequate security shall be provided for sample storage areas. Provisions for the proper storage and disposal of chemical wastes shall be made. At large plants, office and administrative space needs should be considered.

For less complicated laboratory needs bench-top working surface should occupy at least 35 percent of the total laboratory floor space. Additional floor and bench space should be provided to facilitate the performance of analysis of industrial wastes, as required by the discharge permit and the utility's industrial waste pretreatment program. Ceiling height should be adequate to allow for the installation of wall mounted water stills, deionizers, distillation racks, hoods, and other equipment with extended height requirements.

58.42 Floors and Doors

58.421 Floors

Floor surfaces should be fire resistant and highly resistant to acids, alkalis, solvents, and salts.

Floor surfaces should be a single color for ease of locating dropped items. The structural floor shall be concrete with no basement.

58.422 Doors

Two exit doors should be located to permit straight egress from the laboratory, preferably at least one to outside the building. Doors should have a minimum width of 36 inches (915 mm) and shall open in the direction of exit traffic. 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 on doors if cart traffic is anticipated. Kick plates are also recommended.

58.43 Cabinets and Bench Tops

58.431 Cabinets

Wall-hung cabinets are recommended for dust-free storage of instruments and glassware. Units with sliding glass doors are recommended. A reasonable proportion of cupboard style base cabinets and drawer units should be provided. All cabinet shelving should be acid resistant and adjustable.

Drawers should slide out so that entire contents are easily visible. They should be provided with rubber bumpers and stops to 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 double-wall construction.

The laboratory furniture shall be supplied with adequate water, gas, air, and vacuum service fixtures; traps, strainers, plugs, and tailpieces, and electrical service fixtures.

58.432 Bench Tops

Bench tops should be constructed of materials resistant to attacks from normally used laboratory reagents. Generally, bench-top height should be 36 inches (915 mm). However, areas to be used exclusively for sit-down type operations should be 30 inches (760 mm) high and include kneehole space. One-inch (25 mm) 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, 1¼ inches (32 mm) 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.

58.44 Hoods

58.441 General

Fume hoods to promote safety shall be provided for laboratories where required analytical work results in the production of noxious fumes. Canopy hoods over heat-releasing equipment shall be provided.

58.442 Fume Hoods

a. 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; by heating, ventilating, or air-conditioning systems; by 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 shall be provided. Bench surfaces should be available next to the hood so that chemicals need not be carried long distances.

b. Design and Materials

The selection, design, and materials of construction of fume hoods and their appropriate safety alarms shall be made by considering the variety of analytical work to be performed. The characteristics of the fumes, chemicals, gases, or vapors that will or may be released by the activities therein should be considered. Special design and construction is necessary if perchloric acid use is anticipated. Consideration should be given to providing more than one fume hood to minimize potential hazardous conditions throughout the laboratory. Air intake should be balanced against all exhaust ventilation to maintain an overall positive pressure relative to atmospheric in 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.

c. Fixtures

One sink should be provided inside each fume hood. A cup sink is usually adequate.

All switches, electrical outlets, and utility and baffle adjustment handles should be located outside the hood. Light fixtures should be explosion-proof.

d. Exhaust

Twenty-four hour continuous exhaust capability should be provided. Exhaust fans should be explosion-proof. Exhaust velocities should be checked when fume hoods are installed.

58.443 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 canopy should be constructed of heat and corrosion resistant material.

58.45 Sinks, Ventilation, and Lighting

58.451 Sinks

The laboratory should have a minimum of two sinks (not including cup sinks). At least one of them should be a double-well sink with drainboards. A sink dedicated to hand washing should be provided. Additional sinks should be provided in separate work areas as needed, and identified for the use intended.

Sinks and traps should be made of epoxy resin or plastic materials highly resistant to acids, alkalies, solvents, and salts, and should be abrasion and heat resistant, non-absorbent, and lightweight. Traps should be made of glass, plastic, or lead when appropriate and easily accessible for cleaning. 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.

58.452 Ventilation

Laboratories should be separately air conditioned, with external air supply for one hundred percent make-up volume. In addition, separate exhaust ventilation should be provided. Ventilation outlet locations should be remote from ventilation inlets. Consideration should be given to providing dehumidifiers. Air intake should be balanced against all supply air that is exhausted to maintain an overall positive pressure in the laboratory relative to atmospheric and other pressurized areas of the building which could be the source of airborne contaminants.

58.453 Lighting

Good lighting, free from shadows, shall be provided for reading dials, meniscuses, etc., throughout the laboratory.

Consideration shall be given to the effects of radio frequency interference when selecting luminary ballasts for laboratories using delicate instruments.

58.46 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. The table shall be located as far as practical from windows, doors, or other sources of drafts or air movements, so as to minimize undesirable impacts from these sources upon the balance.

58.47 Microscope

A binocular or trinocular microscope with a 20 watt halogen light source, phase contrast condenser, mechanical stage, 10x, 40x and 100x phase contrast objectives, wastewater reticule eyepiece and centering telescope is recommended for process control at activated sludge plants.

58.48 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, process control, and industrial waste monitoring requirements should be considered when specifying equipment needs. Composite samplers may be required to satisfy permit sampling requirements. References such as Standard Methods for the Examination of Water and Wastewater and the U.S.E.P.A. Analytical Procedures Manual should be consulted prior to specifying equipment items.

58.49 Utilities and Services

58.491 Power Supply

Consideration should be given to providing line voltage regulation for power supplied to laboratories using delicate instruments.

58.492 Laboratory Water

Reagent water of a purity suitable for analytical requirements shall be supplied to the laboratory. In general, reagent water prepared using an all glass distillation system is adequate. However, some analyses require deionization of the distilled water. Consideration should be given to softening and/or deionizing the feed water to the still.

58.493 Gas and Vacuum

Natural or LP gas should be supplied to the laboratory. Digester gas should not be used.

An adequately-sized line source of vacuum with outlets available throughout the laboratory should be provided.

58.50 Safety

58.501 Equipment

Laboratories shall provide, as a minimum, the following: first aid equipment; protective clothing and equipment (such as goggles, safety glasses, full face shields, gloves, etc.); fire extinguishers; chemical spill kits; "No Smoking" signs in hazardous areas; and appropriately placed warning signs for slippery areas, non-potable water fixtures, hazardous chemical storage areas, flammable fuel storage areas, etc.

58.502 Eyewash Fountains and Safety Showers

Eyewash fountains and safety showers utilizing potable water shall be provided in the laboratory. These facilities are to be as close as practical to work locations and shall be no more than 25 feet (7.6 m) from points of hazardous chemical exposure.

Each eyewash fountain shall be supplied with water of moderate temperature 50°F to 90°F (10 °C to 32 °C), suitable to provide 15 to 30 minutes of continuous irrigation of the eyes. Each emergency shower shall be capable of discharging at least 20 gpm (1.3 L/s) of water at moderate temperature and should be at pressures of 30 psi to 50 psi (210 kPa to 345 kPa).

CHAPTER 60
SCREENING, GRIT REMOVAL, AND FLOW EQUALIZATION

61. SCREENING DEVICES

61.1 Coarse Screens

61.11 Where Required

Protection for pumps and other equipment shall be provided by trash racks, coarse bar racks, or coarse screens.

61.12 Design and Installation

61.121 Bar Spacing

Clear openings between bars should be no less than 1 inch (25 mm) for manually cleaned screens. Clear openings for mechanically cleaned screens may be smaller. Maximum clear openings should be 1¾ inches (45 mm).

61.122 Slope and Velocity

Manually cleaned screens should be placed on a slope of 30 to 45 degrees from the horizontal. Mechanically cleaned screens should be placed on a slope of 45 to 90 degrees from the horizontal.

At design average flow conditions, approach velocities should be no less than 1.25 feet per second (0.4 m/s), to prevent settling; and no greater than 3.0 fps (0.9 m/s) to prevent forcing material through the openings.

61.123 Channels

Dual channels shall be provided and equipped with the necessary gates to isolate flow from any screening unit. Provisions shall be made to facilitate dewatering each unit. The channel preceding and following the screen shall be shaped to eliminate stranding and settling of solids.

61.124 Auxiliary Screens

Where a single mechanically cleaned screen is used, an auxiliary manually cleaned screen shall be provided. Where two 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 design peak instantaneous flows.

61.125 Invert

The screen channel invert should be 3 to 6 inches (75 mm to 150 mm) below the invert of the incoming sewer.

61.126 Flow Distribution

Entrance channels should be designed to provide equal and uniform distribution of flow to the screens.

61.127 Backwater Effect on Flow Metering

Flow measurement devices should be selected for reliability and accuracy. The effect of changes in backwater elevation due to intermittent cleaning of screens should be considered in locations of flow measurement equipment.

61.128 Freeze Protection

Screening devices and screening storage areas shall be protected from freezing.

61.129 Screenings Removal and Disposal

A convenient and adequate means for removing screenings shall be provided. Hoisting or lifting equipment may be necessary depending on the depth of pit and amount of screenings or equipment to be lifted.

Facilities shall be provided for handling, storage, and disposal of screenings in a manner acceptable to the regulatory agency. Separate grinding of screenings and return to the wastewater flow is unacceptable.

Manually cleaned screening facilities shall 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 the screenings storage area.

61.13 Access and Ventilation

Screens located in pits more than 4 feet (1.2 m) deep shall be provided with stairway access. Access ladders are acceptable for pits less than 4 feet (1.2 m) deep, in lieu of stairways.

Screening devices, installed in a building where other equipment or offices are located, shall be isolated from the rest of the building, be provided with separate outside entrances, and be provided with separate and independent fresh air supply.

Fresh air shall be forced into enclosed screening device areas or open pits more than 4 feet (1.2 m) deep. Dampers should not be used on exhaust or fresh air ducts and fine screens or other obstructions should be avoided to prevent clogging. Where continuous ventilation is required, at least 12 complete air changes per hour shall be provided. Where continuous ventilation would cause excessive heat loss, intermittent ventilation of at least 30 complete air changes per hour shall be provided when personnel enter the area. The air change requirements shall be based on 100 percent fresh air.

Switches for operation of ventilation equipment should be marked and conveniently located. All intermittently operated ventilation equipment shall be interconnected with the respective pit lighting system. The fan wheel shall be fabricated from non-sparking material. Explosion proof gas detectors shall be provided in accordance with Section 57.

61.14 Safety and Shields

61.141 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.

61.142 Mechanical Devices

Mechanical screening equipment shall have adequate removable 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 and temporary access for use during maintenance shall be provided.

61.143 Drainage

Floor design and drainage shall be provided to prevent slippery areas.

61.144 Lighting

Suitable lighting shall be provided in all work and access areas. Refer to Paragraph 61.152.

61.15 Electrical Equipment and Control Systems

61.151 Timing Devices

All mechanical units that are operated by timing devices shall be provided with auxiliary controls that will set the cleaning mechanism in operation at a preset high water elevation. If the cleaning mechanism fails to lower the high water, a warning should be signaled.

61.152 Electrical Equipment, Fixtures and Controls

Electrical equipment, fixtures and controls in the screening area where hazardous gases may accumulate shall meet the requirements of the National Electrical Code for Class I, Division 1, Group D locations.

61.153 Manual Override

Automatic controls shall be supplemented by a manual override.

61.2 Fine Screens

61.21 General

Fine screens, as discussed in this Paragraph, have openings of approximately 1/16 inch (2 mm). The amount of material removed by fine screens is dependent on the waste stream being treated and screen opening size.

Fine screens should not be considered equivalent to primary sedimentation. However, they may be used in lieu of primary sedimentation where subsequent treatment units are designed on the basis of anticipated screen performance. Selection of screen capacity should consider flow restriction due to retained solids, gummy materials, frequency of cleaning, and extent of cleaning. Where fine screens are used, additional provision for removal of floatable oils and greases shall be considered.

61.22 Design

Tests should be conducted to determine BOD_5 and suspended solids removal efficiencies at the design maximum day flow and design maximum day BOD_5 loadings. Pilot testing for an extended time is preferred.

A minimum of two fine screens shall be provided with each unit being capable of independent operation. Capacity shall be provided to treat design peak instantaneous flow with one unit out of service.

Fine screens shall be preceded by a coarse bar screening device, shall be protected from freezing, and shall be located to facilitate maintenance.

61.23 Electrical Equipment, Fixtures and Control

Electrical equipment, fixtures and controls in the screening area where hazardous gases may accumulate shall meet the requirements of the National Electrical Code for Class I, Division 1, Group D locations.

61.24 Servicing

Hosing equipment shall be provided to facilitate cleaning. Provision shall be made for isolating and removing units from their location for servicing.

62. COMMINUTORS

62.1 General

Provisions for access, ventilation, shields, and safety shall be in accordance with Paragraphs 61.13, 61.14, and 61.15.

62.2 When Used

Comminutors may be used in lieu of screening devices to protect equipment where stringy substance accumulation on downstream equipment will not be a substantial problem.

62.3 Design Considerations

62.31 Location

Comminutors should be located downstream of grit removal equipment and be protected by a coarse screening device. Comminutors not preceded by grit removal equipment shall be protected by a 6 inch (150 mm) deep gravel trap.

62.32 Size

Comminutor capacity shall be adequate to handle design peak hourly flow.

62.33 Installation

A screened bypass channel shall be provided. The use of the bypass channel should be automatic for all comminutor failures.

Gates shall be provided in accordance with Paragraphs 61.123 and 61.124.

62.34 Servicing

Provisions shall be made to facilitate servicing units in place and to remove units from their location for servicing.

62.35 Electrical Controls and Motors

Electrical equipment in comminutor chambers where hazardous gases may accumulate shall meet the requirements of the National Electrical Code for Class I, Division 1, Group D locations. Motors shall be protected against accidental submergence.

63 GRIT REMOVAL FACILITIES

63.1 When Required

Grit removal facilities should be provided for all wastewater treatment plants, and are required for plants receiving wastewater from either combined sewers or from sewer systems receiving substantial amounts of grit. If a plant serving a separate sewer system is designed without grit removal facilities, the design shall include provision 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.

63.2 Location

63.21 General

Grit removal facilities should be located ahead of pumps and comminuting devices. Coarse bar racks should be placed ahead of grit removal facilities.

63.22 Housed Facilities

63.221 Ventilation

Refer to Paragraph 61.13. Fresh air shall be introduced continuously at a rate of at least 12 air changes per hour, or intermittently at a rate of at least 30 air changes per hour. Odor control facilities may also be warranted.

63.222 Access

Adequate stairway access to above or below grade facilities shall be provided.

63.223 Electrical

Electrical equipment in enclosed grit removal areas where hazardous gases may accumulate shall meet the requirements of the National Electrical Code for Class I, Division 1, Group D locations. Explosion proof gas detectors shall be provided in accordance with Section 57.

63.23 Outside Facilities

Grit removal facilities located outside shall be protected from freezing.

63.3 Type and Number of Units

Plants treating waste from combined sewers should have at least two mechanically cleaned grit removal units, with provisions for bypassing. A single manually cleaned or mechanically cleaned grit chamber with bypass is acceptable for small wastewater treatment plants serving separate sanitary sewer systems. Facilities for larger plants serving separate sanitary sewers should have at least one mechanically cleaned unit with a bypass.

Facilities other than channel-type shall be provided with adequate and flexible controls for velocity and/or air supply devices and with grit collection and removal equipment. Aerated grit chambers should have air rates adjustable in the range of 3 to 8 cubic feet per minute per foot [4.7 L/(m·s) to 12.4 L/(m·s)] of tank length. Detention time in the tank should be in the range of 3 to 5 minutes at design peak hourly flows. Vortex-type grit chambers may also be considered.

63.4 Design Factors

63.41 General

The design effectiveness of a grit removal system shall be commensurate with the requirements of the subsequent process units.

63.42 Inlet

Inlet turbulence shall be minimized in channel-type units.

63.43 Velocity and Detention

Channel-type chambers shall be designed to control velocities during normal variations in flow as close as possible to 1 foot per second (0.3 m/s). The detention period shall be based on the size of particle to be removed. All aerated grit removal facilities should be provided with adequate control devices to regulate air supply and agitation.

63.44 Grit Washing

The need for grit washing should be determined by the method of grit handling and final disposal.

63.45 Dewatering

Provision shall be made for isolating and dewatering each unit. The design shall provide for complete draining and cleaning by means of a sloped bottom equipped with a drain sump.

63.46 Water

An adequate supply of water under pressure shall be provided for cleanup.

63.47 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.

64. PREAERATION

Preaeration of wastewater to reduce septicity may be required in special cases.

65. FLOW EQUALIZATION

65.1 General

The use of flow equalization should be considered where significant variations in organic and hydraulic loadings are expected. The reviewing authority should be contacted for design requirements when wet weather storage facilities are considered. See also Paragraph 53.413.

65.2 Location

Equalization basins should be located downstream of pretreatment facilities such as bar screens, comminutors, and grit chambers.

65.3 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.

65.4 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 a representative 24-hour period.

65.5 Operation

65.51 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.

65.52 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/1000 gal [0.16 L/($m^3 \cdot s$)] of storage capacity. The air supply should be isolated from other treatment plant aeration requirements to facilitate process aeration control, although process air supply equipment may be utilized as a source of standby aeration.

65.53 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.

65.6 Electrical

All electrical work in housed equalization basins, where hazardous concentrations of flammable gases or vapors may accumulate, shall meet the requirements of the National Electrical Code for Class I, Division 1, Group D locations.

65.7 Access

Suitable access shall be provided to facilitate cleaning and the maintenance of equipment.

CHAPTER 70
SETTLING

71. GENERAL

71.1 Number of Units

Multiple settling units capable of independent operation are desirable and shall be provided in all plants where design average flows exceed 100,000 gallons/day (380 m^3/d). Plants not having multiple settling units shall include other provisions to assure continuity of treatment.

71.2 Flow Distribution

Effective flow splitting devices and control appurtenances (i.e., gates, splitter boxes, etc.) shall be provided to permit proper proportioning of flow and solids loading to each settling unit, throughout the expected range of flows. Refer to Paragraph 53.7.

72. DESIGN CONSIDERATIONS

72.1 Dimensions

The minimum length of flow from inlet to outlet shall be 10 feet (3 m) unless special provisions are made to prevent short circuiting. The vertical side water depths shall be designed to provide an adequate separation zone between the sludge blanket and the overflow weirs. The minimum side water depths shall be as follows:

Type of Settling Tank	Minimum Side Water Depth ft (m)
Primary	10 (3.0)
Secondary tank following activated sludge process*	12 (3.7)
Secondary tank following attached growth biological reactor*	10 (3.0)

* Greater side water depths are recommended for secondary clarifiers in excess of 4,000 square feet (372 m^2) surface area [equivalent to 70 feet (21 m) diameter]. Side water depths less than 12 feet (3.7 m) may be permitted for package plants with a design average flow less than 25,000 gallons per day (95 m^3/d), if justified based on successful operating experience.

72.2 Surface Overflow Rates

72.21 Primary Settling Tanks

Primary settling tank sizing should reflect the degree of solids removal needed and the need to avoid septic conditions during low flow periods. Sizing shall be calculated for both the design average and design peak hourly flow conditions, and the larger surface area determined shall be used. The following surface overflow rates should not be exceeded in the design:

	Surface Overflow Rates at: *	
Type of Primary Settling Tank	Design Average Flow gpd/ft^2 [$m^3/(m^2 \cdot d)$]	Design Peak Hourly Flow gpd/ft^2 [$m^3/(m^2 \cdot d)$]
Tanks not receiving waste activated sludge **	1,000 (41)	1,500 - 2,000 (61-81)
Tanks receiving waste activated sludge	700 (29)	1,200 (49)

* Surface overflow rates shall be calculated with all flows received at the settling tanks. Primary settling of normal domestic wastewater can be expected to remove approximately one-third of the influent BOD when operating at an overflow rate of 1,000 gallons per day/square foot [41 $m^3/(m^2 \cdot d)$].

** Anticipated BOD removal should be determined by laboratory tests and should consider the character of the wastes. Significant reduction in BOD removal efficiency will result when the peak hourly overflow rate exceeds 1,500 gallons per day/square foot [61 $m^3/(m^2 \cdot d)$].

72.22 Intermediate Settling Tanks

Surface overflow rates for intermediate settling tanks following series units of fixed film reactor processes should not exceed 1,200 gallons per day per square foot [49 $m^3/(m^2 \cdot d)$] based on the design peak hourly flow. Higher surface settling rates to 1,500 gallons per day per square foot [61 $m^3/(m^2 \cdot d)$] based on the design peak hourly flow may be permitted if such rates are shown to have no adverse effects on subsequent treatment units.

72.23 Final Settling Tanks

Settling tests shall be conducted wherever a pilot study of biological treatment is warranted by unusual waste characteristics, treatment requirements, or where proposed loadings go beyond the limits set forth in this Section.

72.231 Final Settling Tanks - Attached Growth Biological Reactors

Surface overflow rates for settling tanks following trickling filters or rotating biological contactors shall not exceed 1,200 gallons per day per square foot [49 $m^3/(m^2 \cdot d)$] based on the design peak hourly flow.

72.232 Final Settling Tanks - Activated Sludge

To perform properly while producing a concentrated return flow, activated sludge settling tanks shall be designed to meet thickening and solids separation requirements. Since the rate of recirculation of return sludge from the final settling tanks to the aeration or reaeration tanks is quite high in activated sludge processes, the surface and weir overflow rates 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 size of the settling tank shall be based on the larger of the surface areas determined for surface overflow rate and solids loading rate. The following design criteria shall not be exceeded:

Treatment Process	Surface Overflow Rate at Design Peak Hourly Flow* gpd/ft^2 [$m^3/(m^2 \cdot d)$]	Peak Solids Loading Rate*** lb/day/ft^2 [$kg/(m^2 \cdot d)$]
Conventional, Step Aeration, Complete Mix, Contact Stabilization, Carbonaceous Stage of Separate Stage Nitrification	1,200** (49)	40 (195)
Extended Aeration Single Stage Nitrification	1,000 (41)	35 (171)
2 Stage Nitrification	800 (33)	35 (171)
Activated Sludge with Chemical addition to Mixed Liquor for Phosphorus Removal	900**** (37)	As Above

* Based on influent flow only.

** Plants needing to meet 20 mg/L suspended solids should reduce the surface overflow rate to 1,000 gallons per day per square foot [41 $m^3/(m^2 \cdot d)$].

*** The clarifier peak solids loading rate shall be calculated based on the design maximum day flow rate plus the design maximum return sludge rate requirement and the design MLSS under aeration.

**** When phosphorus removal to a concentration of less than 1.0 mg/L is required.

72.3 Inlet Structures

Inlets and baffling shall be designed to dissipate the inlet velocity, to distribute the flow equally, both horizontally and vertically, and to prevent short circuiting. Provision of flocculation zones shall be considered for secondary settling tanks. Channels shall be designed to maintain a velocity of at least 1 foot per second (0.3 m/s) at one-half of the design average flow. Corner pockets and dead ends shall be eliminated and corner fillets or channeling shall be used where necessary. Provisions shall be made for the elimination or removal of floating materials that may accumulate in inlet structures.

72.4 Weirs

72.41 General

Overflow weirs shall be readily adjustable over the life of the structure to correct for differential settlement of the tank.

72.42 Location

Overflow weirs shall be located to optimize actual hydraulic detention time, and minimize short circuiting. Peripheral weirs shall be placed at least 1 foot (0.3 m) from the wall.

72.43 Design Rates

Weir loadings shall not exceed:

Average Plant Capacity	Loading Rate at Design Peak Hourly Flow gpd/lin ft [$m^3/(m \cdot d)$]
equal to or less than 1 mgd (3785 m^3/d)	20,000 (250)
greater than 1 mgd (3785 m^3/d)	30,000 (375)

If pumping is required, the pumps shall be operated as continuously as possible. Also, weir loadings should be related to pump delivery rates to avoid short circuiting.

72.44 Weir Troughs

Weir troughs shall be designed to prevent submergence at design peak hourly flow, and to maintain a velocity of at least 1 foot per second (0.3 m/s) at one-half design average flow.

72.5 Submerged Surface

The tops of troughs, beams, and similar submerged construction elements shall have a minimum slope of 1.4 vertical to 1 horizontal. The underside of such elements shall have a slope of 1 to 1 to prevent the accumulation of scum and solids.

72.6 Unit Dewatering

Unit dewatering features shall conform to the provisions outlined in Paragraph 54.3. The bypass design shall provide for distribution of the plant flow to the remaining settling units.

72.7 Freeboard

Walls of settling tanks shall extend at least 6 inches (150 mm) above the surrounding ground surface and shall provide not less than 12 inches (300 mm) of 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.

73. SLUDGE AND SCUM REMOVAL

73.1 Scum Removal

Full surface mechanical scum collection and removal facilities, including baffling, shall be provided for all settling tanks. The unusual characteristics of scum that may adversely affect pumping, piping, sludge handling and disposal shall be recognized in the design. Provisions shall be made to remove scum from the wastewater treatment process and direct it to either a scum concentrator or to the sludge treatment process. Other special provisions for scum disposal may be necessary.

73.2 Sludge Removal

Mechanical sludge collection and withdrawal facilities shall be designed to assure rapid removal of the sludge. Suction withdrawal should be provided for activated sludge clarifiers over 60 feet (18 m) in diameter, especially for activated sludge plants that nitrify.

Each settling tank shall have independent sludge withdrawal lines to ensure adequate control of sludge wasting rates for each tank.

73.21 Sludge Hopper

The minimum slope of the side walls shall be 1.7 vertical to 1 horizontal. Hopper wall surfaces should be made smooth with rounded corners to aid in sludge removal. Hopper bottoms shall have a maximum dimension of 2 feet (0.6 m). Sludge hoppers with extra depth for sludge thickening are not acceptable.

73.22 Cross-Collectors

Cross-collectors serving one or more settling tanks may be useful in place of multiple sludge hoppers.

73.23 Sludge Removal Pipeline

Each sludge hopper shall have an individually valved sludge withdrawal line at least 6 inches (150 mm) in diameter. The static head available for the withdrawal of sludge shall be 30 inches (760 mm) or greater as necessary to maintain a 3 foot per second (0.9 m/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. Provisions shall be made to allow for visual confirmation of return sludge. Piping shall be provided to return sludge for further processing.

73.24 Sludge Removal Control

Separate settling tank sludge lines may drain to a common sludge well.

Sludge wells equipped with telescoping valves or other appropriate equipment shall be provided for viewing, sampling, and controlling the rate of sludge withdrawal. A means of measuring the sludge removal rate shall be provided. Air-lift sludge removal will not be approved for the removal of primary sludges.

74. PROTECTIVE AND SERVICE FACILITIES

74.1 Operator Protection

All settling tanks shall be equipped to enhance safety for operators. Safety features shall appropriately include machinery covers, life lines, stairways, walkways, handrails, and slip resistant surfaces.

74.2 Mechanical Maintenance Access

The design shall provide for convenient and safe access to routine maintenance items such as gear boxes, scum removal mechanisms, baffles, weirs, inlet stilling baffle areas, and effluent channels.

74.3 Electrical Equipment, Fixtures and Controls

Electrical equipment, fixtures and controls in enclosed settling basins and scum tanks, where hazardous concentrations of flammable gases or vapors may accumulate, shall meet the requirements of the National Electrical Code for Class I, Division 1, Group D locations.

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.

CHAPTER 80
SLUDGE PROCESSING, STORAGE, AND DISPOSAL

81. GENERAL

Facilities for processing sludge shall be provided at all mechanical wastewater treatment plants. Handling equipment shall be capable of processing sludge to a form suitable for ultimate disposal unless provisions acceptable to the regulatory agency are made for processing the sludge at an alternate location.

The reviewing authority should be contacted if sludge unit processes not described in this Chapter are being considered or are necessary to meet state, provincial, or federal sludge disposal requirements.

82. PROCESS SELECTION

The selection of sludge handling unit processes should be based, at a minimum, upon the following considerations:

a. Local land use;

b. System energy requirements;

c. Cost effectiveness of sludge thickening and dewatering;

d. Equipment complexity and staffing requirements;

e. Adverse effects of heavy metals and other sludge components upon the unit processes;

f. Sludge digestion or stabilization requirements, including appropriate pathogen and vector attraction reduction;

g. Side stream or return flow treatment requirements (e.g., digester or sludge storage facilities supernatant, dewatering unit filtrate, wet oxidation return flows);

h. Sludge storage requirements;

i. Methods of ultimate disposal; and

j. Back-up techniques of sludge handling and disposal.

83. SLUDGE THICKENERS

83.1 Design Considerations

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, storage requirements, the method of ultimate sludge disposal, chemical needs, and the cost of operation.

The use of gravity thickening tanks for unstabilized sludges is not recommended because of problems due to septicity unless provisions are made for adequate control of process operational problems and odors at the gravity thickener and any following unit processes.

Particular attention should be given to the pumping and piping of the concentrated sludge and possible onset of anaerobic conditions.

83.2 Prototype Studies

Process selection and unit process design parameters should be based on prototype studies. The reviewing authority will require such studies where the sizing of other plant units is dependent on thickener performance. Refer to Paragraph 53.2 for any new process determination.

84. ANAEROBIC SLUDGE DIGESTION

84.1 General

84.11 Multiple Units

Multiple units or alternate methods of sludge processing shall be provided. Facilities for sludge storage and supernatant separation in an additional unit may be required, depending on raw sludge concentration and disposal methods for sludge and supernatant.

84.12 Depth

If process design provides for supernatant withdrawal, the proportion of depth to diameter should allow for the formation of a reasonable depth of supernatant liquor. A minimum side water depth of 20 feet (6.1 m) is recommended.

84.13 Design Maintenance Provisions

To facilitate emptying, cleaning, and maintenance, the following features are desirable:

84.131 Slope

The tank bottom shall slope to drain toward the withdrawal pipe. For tanks equipped with a suction mechanism for sludge withdrawal, a bottom slope not less than 1 to 12 should be provided. Where the sludge is to be removed by gravity alone, the slope should be 1 to 4.

84.132 Access Manholes

At least 2 access manholes not less than 30 inches (760 mm) in diameter should be provided in the top of the tank, in addition to the gas dome. Stairways to reach the access manholes should be provided.

A separate side wall manhole shall be provided that is large enough to permit the use of mechanical equipment to remove grit and sand. The side wall access manhole should be low enough to facilitate heavy equipment handling and may be buried in the earthen bank insulation.

84.133 Safety

Non-sparking tools, rubber-soled shoes, safety harness, gas detectors for flammable and toxic gases, and at least two self-contained breathing units, as described in Paragraph 102.56, shall be provided for emergency use. Refer to other safety items as appropriate in Section 57.

84.14 Toxic Materials

If the anaerobic digestion process is proposed, the basis of design shall be supported by wastewater analyses to determine the presence of undesirable materials, such as high concentrations of sulfates or inhibitory concentrations of heavy metals.

84.2 Sludge Inlets, Outlets, Recirculation, and High Level Overflow

84.21 Multiple Inlets and Draw-Offs

Multiple sludge inlets and draw-offs and, where used, multiple recirculation suction and discharge points to facilitate flexible operation and effective mixing of the digester contents shall be provided unless adequate mixing facilities are provided within the digester.

84.22 Inlet Configurations

One inlet should discharge above the liquid level and be located at approximately the center of the tank to assist in scum breakup. The second inlet should be opposite to the suction line at approximately the 2/3 diameter point across the digester.

84.23 Inlet Discharge Location

Raw sludge inlet discharge points should be so located as to minimize short circuiting to the digested sludge or supernatant draw-offs.

84.24 Sludge Withdrawal

Sludge withdrawal to disposal should be from the bottom of the tank. The bottom withdrawal pipe should be interconnected with the necessary valving to the recirculation piping to increase operational flexibility when mixing the tank contents.

84.25 Emergency Overflow

An unvalved vented overflow shall be provided to prevent damage to the digestion tank and cover in case of accidental overfilling. This emergency overflow shall be piped to an appropriate point and at an appropriate rate in the treatment process or sidestream treatment facilities to minimize the impact on process units.

84.3 Tank Capacity

84.31 Rational Design

The total digestion tank capacity shall be determined by rational calculations based upon factors such as: volume of sludge added, percent solids, and character; the temperature to be maintained in the digesters; the degree or extent of mixing to be obtained; the degree of volatile solids reduction required; the solids retention time at peak loadings; method of sludge disposal; and the size of the installation with appropriate allowances for gas, scum, supernatant, and digested sludge storage. Secondary digesters of two-stage series digestion systems which are utilized for digested sludge storage and concentration shall not be credited in the calculations for volumes required for sludge digestion. Calculations should be submitted to justify the basis of design.

84.32 Standard Design

When such calculations are not submitted to justify the design based on the above factors, the minimum digestion tank capacity shall be as outlined below. These requirements assume that the raw sludge is derived from ordinary domestic wastewater, a digestion temperature is to be maintained in the range of 85°F to 95°F (29 °C to 35 °C), 40 to 50 percent volatile matter in the digested sludge, and that the digested sludge will be removed frequently from the process. (See also Paragraphs 84.11 and 89.11.)

84.321 Completely Mixed Systems

For digestion systems providing for intimate and effective mixing of the digester contents, the system may be loaded up to 80 pounds of volatile solids per 1000 cubic feet of volume per day [1.3 kg/(m^3·d)] in the active digestion units.

84.322 Moderately Mixed Systems

For digestion systems where mixing is accomplished only by circulating sludge through an external heat exchanger, the system may be loaded up to 40 pounds of volatile solids per 1000 cubic feet of volume per day [0.65 kg/(m^3·d)] in the active digestion units. This loading may be modified upward or downward depending upon the degree of mixing provided.

84.323 Multistage Systems

For digestion systems utilizing two stages (primary and secondary units), the first stage (primary) may be either completely mixed or moderately mixed and loaded in accordance with Paragraphs 84.321 or 84.322. The second stage (secondary) shall be designed for sludge storage, concentration, and gas collection and shall not be credited in the calculations for volumes required for sludge digestion.

84.324 Digester Mixing

Facilities for mixing the digester contents shall be provided where required for proper digestion by reason of loading rates or other features of the system. Where sludge recirculation pumps are used for mixing they shall be provided in accordance with appropriate requirements of Paragraph 87.1.

84.4 Gas Collection, Piping, and Appurtenances

84.41 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 pressure. All enclosed areas where any gas leakage might occur shall be adequately ventilated.

84.42 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 shut off valves shall be provided and shall be protected from freezing. Water seal equipment shall not be installed. Safety equipment and gas compressors should be housed in a separate room with an exterior door.

84.43 Gas Piping and Condensate

Gas piping shall have a minimum diameter of 4 inches (100 mm). A smaller diameter pipe at the gas production meter is acceptable. Gas piping shall slope to condensation traps at low points. Float-controlled condensate traps shall not be used. Condensation traps shall be protected from freezing.

Tightly fitted self-closing doors should be provided at connecting passageways and tunnels that connect digestion facilities to other facilities to minimize the spread of gas. Piping galleries shall be ventilated in accordance with Paragraph 84.47.

84.44 Gas Utilization Equipment

Gas burning boilers, engines, etc., shall be located in well-ventilated rooms. Such rooms would not ordinarily be classified as a hazardous location if isolated from the digestion gallery. Gas lines to these units shall be provided with suitable flame traps.

84.45 Electrical Equipment, Fixtures, and Controls

Electrical equipment, fixtures and controls, in places enclosing and adjacent to anaerobic digestion appurtenances, where hazardous gases may accumulate shall comply with the National Electric Code for Class I, Division 1, Group D locations.

84.46 Waste Gas

84.461 Location

Waste gas burners shall be readily accessible and should be located at least 50 feet (15 m) away from any plant structure. Waste gas burners shall be of sufficient height and so located to prevent injury to personnel due to wind or downdraft conditions.

84.462 Pilot Light

All waste gas burners shall be equipped with automatic ignition such as a pilot light or a device using a photoelectric cell sensor. Consideration should be given to the use of natural or propane gas to ensure reliability of the pilot.

84.463 Gas Piping Slope

Gas piping shall be sloped at a minimum of 2 percent up to the waste gas burner with a condensate trap provided in a location not subject to freezing.

84.47 Ventilation

Any underground enclosures connecting with digestion tanks or containing sludge or gas piping or equipment shall be provided with forced ventilation for dry wells in accordance with Paragraphs 42.71 through 42.74 and 42.76. The ventilation rate for Class I, Division 2, Group D locations including enclosed areas without a gas tight partition from the digestion tank or areas containing gas compressors, sediment traps, drip traps, gas scrubbers, or pressure regulating and control valves, if continuous, shall be at least 12 complete air changes per hour.

84.48 Meter

A gas meter with bypass shall be provided to meter total gas production for each active digestion unit. Total gas production for two-stage digestion systems operated in series may be measured by a single gas meter with proper interconnected gas piping.

Where multiple primary digestion units are utilized with a single secondary digestion unit, a gas meter shall be provided for each primary digestion unit. The secondary digestion unit may be interconnected with the gas measurement unit of one of the primary units. Interconnected gas piping shall be properly valved with gas tight gate valves to allow measurement of gas production from either digestion unit and maintenance of either digestion unit.

Gas meters may be of the orifice plate, turbine or vortex type. Positive displacement meters should not be utilized. The meter shall be specifically designed for contact with corrosive and dirty gases.

84.5 Digestion Tank Heating

84.51 Insulation

Wherever possible digestion tanks should be constructed above groundwater level and shall be suitably insulated to minimize heat loss. Maximum utilization of earthen bank insulation should be used.

84.52 Heating Facilities

Sludge may be heated by circulating the sludge through external heaters or by units located inside the digestion tank. Refer to Paragraph 84.522.

84.521 External Heating

Piping shall be designed to provide for the preheating of feed sludge before introduction into the digesters. Provisions shall be made in the layout of the piping and valving to facilitate heat exchanger tube removal and cleaning of the lines. Heat exchanger sludge piping should be sized for peak heat transfer requirements. Heat exchangers should have a heating capacity of 130 percent of the calculated peak heating requirement to account for the occurrence of sludge tube fouling.

84.522 Other Heating Methods

a. Hot water heating coils affixed to the walls of the digester or other types of internal heating equipment that require emptying the digester contents for repair shall not be used.

b. Other systems and devices have been developed recently to provide both mixing and heating of anaerobic digester contents. These systems will be reviewed on their own merits. Operating data detailing their reliability, operation, and maintenance characteristics will be required. Refer to Paragraph 53.2.

84.53 Heating Capacity

84.531 Capacity

Sufficient heating capacity shall be provided to consistently maintain the design sludge temperature, considering insulation provisions and ambient cold weather conditions. Where digestion tank gas is used for other purposes, an auxiliary fuel may be required. The design operating temperature should be in the range of 85°F to 100°F (29 °C to 38 °C) where optimum mesophilic digestion is required.

84.532 Standby Requirements

The provision of standby heating capacity or the use of multiple units sized to provide the heating requirements shall be considered, unless acceptable alternative means of handling raw sludge are provided for the extended period that a digestion process outage is experienced due to heat loss.

84.54 Hot Water Internal Heating Controls

84.541 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 removable heat jacket or coil in the digester can be held below a temperature at which caking will be accentuated. Manual control should also be provided by suitable bypass valves.

84.542 Boiler Controls

The boiler should be provided with suitable automatic controls to maintain the boiler temperature at approximately 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, low gas pressure, or excessive boiler water temperature or pressure.

84.543 Boiler Water Pumps

Boiler water pumps shall be sealed and sized to meet the operating conditions of temperature, operating head, and flow rate. Duplicate units shall be provided.

84.544 Thermometers

Thermometers shall be provided to show inlet and outlet temperatures of the sludge, hot water feed, hot water return, and boiler water.

84.545 Water Supply

The chemical quality should be checked for suitability for use as a water supply. Refer to Paragraph 56.23 for required break tank for indirect water supply connections.

84.55 External Heater Operating Controls

All controls necessary to ensure effective and safe operation are required. Provision for duplicate units in critical elements should be considered.

84.6 Supernatant Withdrawal

Where supernatant separation is to be used to concentrate sludge in the digester units and increase digester solids retention time, the design shall provide for ease of operation and positive control of supernatant quality.

84.61 Piping Size

Supernatant piping should not be less than 6 inches (150 mm) in diameter.

84.62 Withdrawal Arrangements

84.621 Withdrawal Levels

Supernatant withdrawal piping should be arranged so that withdrawal can be made from three or more levels in the tank. An unvalved vented overflow shall be provided. The emergency overflow shall be piped to an appropriate point and at an appropriate rate in the treatment process or side stream treatment units to minimize the impact on process units.

84.622 Withdrawal Selection

On fixed cover tanks, the supernatant withdrawal level should be selected by means of interchangeable extensions at the discharge end of the piping.

84.623 Supernatant Selector

A fixed screen supernatant selector or similar type device shall be limited for use in an unmixed secondary digestion unit. If such a supernatant selector is provided, provisions shall be made for at least one other draw-off level located in the supernatant zone of the tank, in addition to the unvalved emergency supernatant draw-off pipe. High pressure back-wash facilities shall be provided.

84.63 Sampling

Provision shall be made for sampling at each supernatant draw-off level. Sampling pipes should be at least 1½ inches (40 mm) in diameter and should terminate at a suitably sized sampling sink or basin.

84.64 Supernatant Disposal

Supernatant return and disposal facilities should be designed to alleviate adverse hydraulic and organic effects on plant operations. If nutrient removal (e.g., phosphorus, ammonia nitrogen) must be accomplished at a plant, a separate supernatant side stream treatment system should be provided.

84.7 Anaerobic Digestion Sludge Production

For calculating design sludge handling and disposal needs, sludge production values from a two-stage anaerobic digestion process shall be based on a maximum solids concentration of 5 percent without additional thickening. The solids production values on a dry weight basis shall be based on the following for the listed processes:

Primary plus waste activated sludge - at least 0.12 lb/P.E./day [0.05 kg/(P.E.·d)].

Primary plus fixed film sludge - at least 0.09 lb/P.E./day [0.04 kg/(P.E.·d)].

85. AEROBIC SLUDGE DIGESTION

85.1 General

An aerobic sludge digestion system shall include provisions for digestion, supernatant separation, sludge concentration, and any necessary sludge storage. These provisions may be accomplished by separate tanks or processes or in the digestion tanks.

85.2 Multiple Units

Multiple digestion units capable of independent operation are desirable and shall be provided in all plants where the design average flow exceeds 100,000 gallons per day (380 m^3/d). All plants not having multiple units shall provide alternate sludge handling and disposal methods.

85.3 Tank Capacity

85.31 Volume Required

The following digestion tank capacities are based on a solids concentration of 2 percent with supernatant separation performed in a separate tank. If supernatant separation is performed in the digestion tank, a minimum of 25 percent additional volume shall be provided. These capacities shall be provided unless sludge thickening facilities (refer to Section 83) are utilized to thicken the feed solids concentration to greater than 2 percent. If such thickening is provided, the digestion volumes may be decreased proportionally.

Sludge Source	Volume/Population Equivalent ft^3/P.E. (m^3/P.E.)
Waste activated sludge -- no primary settling	4.5 (0.13)*
Primary plus waste activated sludge	4.0 (0.11)*
Waste activated sludge exclusive of primary sludge	2.0 (0.06)*
Extended aeration activated sludge	3.0 (0.09)
Primary plus attached growth biological reactor sludge	3.0 (0.09)

* These volumes also apply to waste activated sludge from single stage nitrification facilities with less than 24 hours detention time based on design average flow.

85.32 Effect of Temperature on Volume

The volumes in Paragraph 85.31 are based on digester temperatures of 59°F (15 °C) and a solids retention time of 27 days. Aerobic digesters should be covered to minimize heat loss for colder temperature applications. Additional volume or supplemental heat may be required if the land application disposal method is used in order to meet the applicable U.S. EPA requirements. Refer to Paragraph 85.9 for necessary sludge storage.

85.4 Mixing

Aerobic digesters shall be provided with mixing equipment that can maintain solids in suspension and ensure complete mixing of the digester contents. Refer to Paragraph 85.5.

85.5 Air Requirements

Sufficient air shall be provided to keep the solids in suspension and maintain dissolved oxygen between 1 mg/L and 2 mg/L. For minimum mixing and oxygen requirements, an air supply of 30 cfm/1000 ft^3 [0.5 $L/(m^3 \cdot s)$] of tank volume shall be provided with the largest blower out of service. If diffusers are used, the nonclog type should be provided, and they should be designed to permit continuity of service. If mechanical turbine aerators are utilized, at least two turbine aerators per tank shall be provided to permit continuity of service. Mechanical aerators are not recommended for use in aerobic digesters where freezing conditions will cause ice build-up on the aerator and support structures.

85.6 Supernatant Separation and Scum and Grease Removal

85.61 Supernatant Separation

Facilities shall be provided for effective separation or decanting of supernatant. Separate facilities are recommended; however, supernatant separation may be accomplished in the digestion tank if additional volume is provided per Paragraph 85.3. The supernatant drawoff unit shall be designed to prevent recycle of scum and grease back to plant process units. Provision should be made to withdraw supernatant from multiple levels of the supernatant withdrawal zone.

85.62 Scum and Grease Removal

Facilities shall be provided for the effective collection of scum and grease from the aerobic digester for final disposal, to prevent its recycle back to the plant process, and to prevent long term accumulation and potential discharge in the effluent.

85.7 High Level Emergency Overflow

An unvalved high level overflow and any necessary piping shall be provided to return digester overflow back to the head of the plant or to the aeration process in case of accidental overfilling. Design considerations related to the digester overflow shall include waste sludge rate and duration during the period the plant is unattended, potential effects on plant process units, discharge location of the emergency overflow, and potential discharge of suspended solids in the plant effluent.

85.8 Aerobic Digestion Sludge Production

For calculating design sludge handling and disposal needs, sludge production values from aerobic digesters shall be based on a maximum solids concentration of 2 percent without additional thickening. The solids production values on a dry weight basis shall be based on the following for the listed processes:

Primary plus waste activated sludge - at least 0.16 lb/P.E./day [0.07 kg/(P.E.·d)].

Primary plus fixed film sludge - at least 0.12 lb/P.E./day [0.05 kg/(P.E.·d)].

85.9 Digested Sludge Storage Volume

85.91 Sludge Storage Volume

Sludge storage shall be provided in accordance with Section 89 to accommodate daily sludge production volumes and as an operational buffer for unit outage and adverse weather conditions. Designs shall not utilize increased sludge age in the activated sludge system as a means of storage.

85.92 Liquid Sludge Storage

Liquid sludge storage facilities shall be based on the following values unless digested sludge thickening facilities are utilized (refer to Section 83) to provide solids concentrations of greater than 2 percent.

Sludge Source	Volume/Population Equivalent
	ft^3/P.E./day [m^3/(P.E.·d)]
Waste activated sludge -- no primary settling, primary plus waste activated sludge, and extended aeration activated sludge	0.13 (0.004)
Waste activated sludge exclusive of primary sludge	0.06 (0.002)
Primary plus attached growth biological reactor sludge	0.10 (0.003)

85.10 Autothermal Thermophilic Aerobic Digestion

Thermophilic digestion temperature should be maintained between 122°F and 158°F (50 °C and 70 °C). Systems may be either single or multiple stage. The sludge should be thickened prior to treatment in the digestion tanks. The digestion tanks should be suitably insulated to minimize heat loss.

86. HIGH pH STABILIZATION

86.1 General

Alkaline material may be added to liquid primary or secondary sludges for sludge stabilization in lieu of digestion facilities; to supplement existing digestion facilities; or for interim sludge handling. There is no direct reduction of organic matter or sludge solids with the high pH stabilization process. There is an increase in the mass of dry sludge solids. Without supplemental dewatering, additional volumes of sludge will be generated.

The design shall account for the increased sludge quantities for storage, handling, transportation, and disposal methods and associated costs.

86.2 Operational Criteria

Sufficient alkaline material shall be added to liquid sludge in order to produce a homogeneous mixture with a minimum pH of 12 after two hours of vigorous mixing. Facilities for adding supplemental alkaline material shall be provided to maintain the pH of the sludge during interim sludge storage periods.

86.3 Odor Control and Ventilation

Odor control facilities shall be provided for sludge mixing and treated sludge storage tanks when located within 1/2 mile (0.8 km) of residential or commercial areas. The reviewing authority should be contacted for design and air pollution control objectives to be met for various types of air scrubber units. Ventilation shall be provided for indoor sludge mixing, storage or processing facilities in accordance with Paragraph 42.75.

86.4 Mixing Tanks and Equipment

86.41 Tanks

Mixing tanks may be designed to operate as either a batch or continuous flow process. A minimum of two tanks shall be provided. The tanks shall provide a minimum of two hours contact time in each tank. The following items shall also be considered in determining the number and size of tanks:

a. peak sludge flow rates;

b. storage between batches;

c. dewatering or thickening performed in tanks;

d. repeating sludge treatment due to pH decay of stored sludge;

e. sludge thickening prior to sludge treatment; and

f. type of mixing device used and its associated maintenance or repair requirements.

86.42 Equipment

Mixing equipment shall be designed to provide vigorous agitation within the mixing tank, maintain solids in suspension, and provide for a homogeneous mixture of the sludge solids and alkaline material. Mixing may be accomplished either by diffused air or mechanical mixers. If diffused aeration is used, an air supply of 30 cfm/1000 ft^3 [0.5 $L/(m^3 \cdot s)$] of mixing tank volume shall be provided with the largest blower out of service. When diffusers are used, the nonclog type should be provided, and they should be designed to permit continuity of service. If mechanical mixers are used, the impellers shall be designed to minimize fouling with debris in the sludge and consideration shall be made to provide continuity of service during freezing weather conditions.

86.5 Chemical Feed and Storage Equipment

86.51 General

Alkaline material is caustic in nature and can cause eye and tissue injury. Equipment for handling or storing alkaline material shall be designed for adequate operator safety. Refer to Section 57 for proper safety precautions. Storage, slaking, and feed equipment should be sealed as airtight as practical to prevent contact of alkaline material with atmospheric carbon dioxide and water vapor and to prevent the escape of dust material. All equipment and associated transfer lines or piping shall be accessible for cleaning.

86.52 Feed and Slaking Equipment

The design of the feeding equipment shall be determined by the treatment plant size, type of alkaline material used, slaking required, and operator requirements. Equipment may be either of batch or automated type. Automated feeders may be of the volumetric or gravimetric type depending on accuracy, reliability, and maintenance requirements. Manually operated batch slaking of quicklime (CaO) should be avoided unless adequate protective clothing and equipment are provided. At small plants, hydrated lime [$Ca(OH)_2$] should be used instead of quicklime due to safety and labor-saving reasons. Feed and slaking equipment shall be sized to handle a minimum of 150% of the peak sludge flow rate including sludge that may need to be retreated due to pH decay. Duplicate units shall be provided.

86.53 Chemical Storage Facilities

Alkaline materials may be delivered either in bag or bulk form depending upon the amount of material used. Material delivered in bags shall be stored indoors and elevated above floor level. Bags should be of the multi-wall moisture-proof type. Dry bulk storage containers shall be as airtight as practical and shall contain a mechanical agitation mechanism. Storage facilities shall be sized to provide a minimum of a 30-day supply.

86.6 Sludge Storage

Refer to Section 89 for general design considerations for sludge storage facilities. The design shall incorporate the following considerations for the storage of high pH stabilized sludge:

86.61 Liquid Sludge

Liquid high pH stabilized sludge shall not be stored in a lagoon. Said sludge shall be stored in a tank or vessel equipped with rapid sludge withdrawal mechanisms for sludge disposal or retreatment.

Provisions shall be made for adding alkaline material in the storage tank. Mixing equipment in accordance with Paragraph 86.42 above shall be provided in all storage tanks.

86.62 Dewatered Sludge

On-site storage of dewatered high pH stabilized sludge should be limited to 30 days. Provisions for rapid retreatment or disposal of dewatered sludge stored on-site shall be made in case of sludge pH decay.

86.63 Off-Site Storage

There shall be no off-site storage of high pH stabilized sludge unless specifically allowed by the regulatory agency.

86.7 Disposal

Immediate sludge disposal methods and options are recommended to be utilized in order to reduce the sludge inventory on the treatment plant site and the amount of sludge that may need to be retreated to prevent odors if sludge pH decay occurs. If the land application disposal option is utilized for high pH stabilized sludge, said sludge should be incorporated into the soil during the same day of delivery to the site.

87. SLUDGE PUMPS AND PIPING

87.1 Sludge Pumps

87.11 Capacity

Pump capacities shall be adequate but not excessive. Provisions for varying pump capacity should be made. A rational basis of design shall be provided with the plan documents.

87.12 Duplicate Units

Duplicate units shall be provided at all installations.

87.13 Type

Plunger pumps, screw feed 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 positive displacement pump shall be provided as an alternate to pump heavy sludge concentrations, such as primary or thickened sludge, that may exceed the pumping head of the centrifugal pump.

87.14 Minimum Head

A minimum positive head of 24 inches (610 mm) shall be provided at the suction side of centrifugal type pumps and should be provided for all types of sludge pumps. Maximum suction lifts should not exceed 10 feet (3 m) for plunger pumps.

87.15 Sampling Facilities

Unless sludge sampling facilities are provided, quick-closing sampling valves shall be installed at the sludge pumps. The size of valve and piping should be at least 1½ inches (40 mm) and terminate at a suitably sized sampling sink or floor drain.

87.2 Sludge Piping

87.21 Size and Head

Digested sludge withdrawal piping should have a minimum diameter of 8 inches (200 mm) for gravity withdrawal and 6 inches (150 mm) for pump suction and discharge lines. Where withdrawal is by gravity, the available head on the discharge pipe should be at least 4 feet (1.2 m), preferably more. Undigested sludge withdrawal piping shall be sized in accordance with Paragraph 73.23.

87.22 Slope and Flushing Requirements

Gravity piping should be laid on uniform grade and alignment. Slope on gravity discharge piping should not be less than 3 percent for primary sludges and all sludges thickened to greater than 2 percent solids. Slope on gravity discharge piping should not be less than 2 percent for aerobically digested sludge or waste activated sludge with less than 2 percent solids. Cleanouts shall be provided for all gravity sludge piping. Provisions shall be made for draining and flushing discharge lines. All sludge piping shall be suitably located or otherwise adequately protected to prevent freezing.

87.23 Supports

Special consideration shall be given to the corrosion resistance and permanence of supporting systems for piping located inside the digestion tank.

88. SLUDGE DEWATERING

88.1 General

On-site sludge dewatering facilities shall be provided for all plants, although the following requirements may be reduced with on-site liquid sludge storage facilities or approved off-site sludge disposal.

For calculating design sludge handling and disposal needs for sludge stabilization processes other than described in Paragraphs 84.7 for anaerobic digestion and 85.8 for aerobic digestion, a rational basis of design for sludge production values shall be developed and provided to the reviewing authority for approval on a case-by-case basis.

88.2 Sludge Drying Beds

88.21 Applicability

Sludge drying beds may be used for dewatering well digested sludge from either the anaerobic or aerobic process. Due to the large volume of sludge produced by the aerobic digestion process, consideration should be given to using a combination of dewatering systems or other means of ultimate sludge disposal.

88.22 Unit Sizing

Sludge drying bed area shall be calculated on a rational basis with the following items considered:

a. The volume of wet sludge produced by existing and proposed processes.

b. Depth of wet sludge drawn to the drying beds. For design calculation purposes, a maximum depth of 8 inches (200 mm) shall be utilized. For operational purposes, the depth of sludge placed on the drying bed may increase or decrease from the design depth based on the percent solids content and type of digestion utilized.

c. Total digester volume and other wet sludge storage facilities.

d. Degree of sludge thickening provided after digestion.

e. The maximum drawing depth of sludge which can be removed from the digester or other sludge storage facilities without causing process or structural problems.

f. The time required on the bed to produce a removable cake. Adequate provision shall be made for sludge dewatering and/or sludge disposal facilities for those periods of time during which outside drying of sludge on beds is hindered by weather.

g. Capacities of auxiliary dewatering facilities.

88.23 Percolation Type Bed Components

88.231 Gravel

The lower course of gravel around the underdrains should be properly graded, should be at least 12 inches (300 mm) in depth, extending at least 6 inches (150 mm) above the top of the underdrains, and should be placed in two or more layers. The top layer of at least 3 inches (80 mm) should consist of gravel 1/8 to 1/4 inch (3 mm to 6 mm) in size.

88.232 Sand

The top course should consist of at least 9 to 12 inches (230 mm to 300 mm) of clean, hard, and washed coarse sand. The effective size of the sand should be in the range of 0.8 mm to 1.5 mm. The finished sand surface should be level.

88.233 Underdrains

Underdrains should be at least 4 inches (100 mm) in diameter laid with open joints. Perforated pipe may also be used. Underdrains should be spaced not more than 20 feet (6.1 m) apart and sloped at a minimum of 1 percent. Lateral tiles should be spaced at 8 to 10 feet (2.4 m to 3.0 m). Various pipe materials may be selected provided the pipe is corrosion resistant and appropriately bedded to ensure that the underdrains are not damaged by sludge removal equipment.

88.234 Additional Dewatering Provisions

Consideration shall be given to provide a means of decanting the supernatant of sludge placed on the sludge drying beds. More effective decanting of supernatant may be accomplished with polymer treatment of sludge.

88.235 Seal

The bottom of the percolation bed shall be sealed in a manner approved by the reviewing authority.

88.24 Walls

Walls should extend 18 inches (460 mm) above and at least 9 inches (230 mm) below the surface of the sludge drying bed. Outer walls shall be water tight down to the bottom of the bed and extend at least 4 inches (100 mm) above the outside grade elevation to prevent soil from washing into the beds.

88.25 Sludge Removal

Each sludge drying bed shall be constructed so as to be readily and completely accessible to mechanical equipment for cleaning and sand replacement. Concrete runways spaced to accommodate mechanical equipment shall be provided. Special attention should be given to assure adequate access to the areas adjacent to the sidewalls. Entrance ramps down to the level of the sand bed shall be provided. These ramps should be high enough to eliminate the need for an entrance end wall for the sludge bed.

88.3 Mechanical Dewatering Facilities

88.31 General

Provision shall be made to maintain sufficient continuity of service so that sludge may be dewatered without accumulation beyond storage capacity. The number of vacuum filters, centrifuges, filter presses, belt filters, other mechanical dewatering facilities, or combinations thereof should be sufficient to dewater the sludge produced with the largest unit out of service. Unless other standby wet sludge facilities are available, adequate storage facilities of at least 4 days production volume, in addition to any other sludge storage needs, shall be provided. Documentation shall be submitted justifying the basis of design of mechanical dewatering facilities.

88.32 Water Supply Protection

Provisions for water supply to mechanical dewatering facilities shall be in accordance with Paragraph 56.23.

88.33 Auxiliary Facilities for Vacuum Filters

Back-up vacuum and filtrate pumps shall be provided. It is permissible to have uninstalled back-up vacuum and filtrate pumps for every three or less vacuum filters, provided that the installed units can easily be removed and replaced. At least one filter media replacement unit shall be provided.

88.34 Ventilation

Adequate facilities shall be provided for ventilation of the dewatering area in accordance with Paragraph 42.75. The exhaust air should be properly conditioned to avoid odor nuisance.

88.35 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. Refer to Section 57.

88.4 Drainage and Filtrate Disposal

Drainage from sludge drying beds or filtrate from other dewatering units shall be returned to the wastewater treatment process at appropriate points and rates. Sampling equipment shall be provided as needed to monitor drainage and filtrate waste streams. See also Paragraphs 56.7 and 84.64.

88.5 Other Dewatering Facilities

If other methods of sludge dewatering are proposed, a detailed description of the process and design data shall accompany the plans. Refer to Paragraph 53.2 for any new process determinations.

89. SLUDGE STORAGE AND DISPOSAL

89.1 Storage

89.11 General

Sludge storage facilities shall be provided at all mechanical treatment plants. Appropriate storage facilities may consist of any combination of drying beds, lagoons, separate tanks, additional volume in sludge stabilization units, pad areas or other means to store either liquid or dried sludge. Refer to Paragraphs 88.2 and 89.2 for drying bed and lagoon design criteria, respectively.

The design shall provide for odor control in sludge storage tanks and sludge lagoons including aeration, covering, or other appropriate means.

89.12 Volume

Rational calculations justifying the number of days of storage to be provided shall be submitted and shall be based on the total sludge handling and disposal system. Refer to Paragraphs 84.7 and 85.8 for anaerobically and aerobically digested sludge production values. Sludge production values for other stabilization processes should be justified in the basis of design. If the land application method of sludge disposal is the only means of disposal utilized at a treatment plant, storage shall be provided based on the following considerations, at a minimum:

a. Inclement weather effects on access to the application land;

b. Temperatures including frozen ground and stored sludge cake conditions;

c. Haul road restrictions including spring thawing conditions;

d. Area seasonal rainfall patterns;

e. Cropping practices on available land;

f. Potential for increased sludge volumes from industrial sources during the design life of the plant;

g. Available area for expanding sludge storage; and

h. Appropriate pathogen reduction and vector attraction reduction requirements.

A minimum range of 120 to 180 days storage should be provided for the design life of the plant unless a different period is approved by the reviewing authority. Refer to Paragraph 89.33 for other sludge land application considerations.

89.2 Sludge Storage Lagoons

89.21 General

Sludge storage lagoons may be permitted only upon proof that the character of the digested sludge and the design mode of operation are such that offensive odors will not result. Where sludge lagoons are permitted, adequate provisions shall be made for other acceptable sludge handling methods in the event of upset or failure of the sludge digestion process.

89.22 Location

Sludge lagoons shall be located as far as practicable from inhabited areas or areas likely to be inhabited during the lifetime of the structures. Siting of sludge lagoons shall comply with the requirements of the reviewing authority.

89.23 Seal

Adequate provisions shall be made to seal the sludge lagoon bottoms and embankments in accordance with the requirements of Paragraph 93.422 to prevent leaching into adjacent soils or ground water. The seal shall be protected to prevent damage from sludge removal activities. Groundwater monitoring may be required by the reviewing authority in accordance with Paragraph 93.65.

89.24 Access

Provisions shall be made for pumping or heavy equipment access for sludge removal from the sludge lagoon on a routine basis.

89.25 Supernatant Disposal

Lagoon supernatant shall be returned to the wastewater treatment process at appropriate points and rates. Sampling equipment shall be provided as needed to monitor supernatant waste streams. See also Paragraphs 56.7 and 84.64.

89.3 Disposal

89.31 General

Drainage facilities for sludge vehicle transfer stations shall be provided to allow any spillage or washdown material to be collected and returned to the wastewater treatment plant or sludge storage facility.

89.32 Sanitary Landfilling

Sludge and sludge residues may be disposed of in approved sanitary landfills under the terms and conditions of the regulatory agency.

89.33 Land Application

The reviewing authority should be contacted for specific design and approval requirements governing the land application of municipal sludges. Additional operating criteria may be obtained from applicable federal regulations. Sludge may be utilized as a soil conditioner for agricultural, horticultural, or reclamation purposes. Important design considerations include, but are not necessarily limited to: sludge stabilization process, appropriate pathogen and vector attraction reduction, sludge characteristics including the presence of inorganic and organic chemicals, application site characteristics (soils, groundwater elevations, setback distance requirements, etc.), local topography and hydrology, cropping practices, spreading and incorporation techniques, population density and odor control, and local groundwater quality and usage.

Sludge mixing equipment or other provisions to assist in the monitoring of land applied sludge should be considered in the design of sludge handling and storage facilities.

Due to inclement weather and cropping practices, alternative sludge disposal options are recommended to ensure the sludge is properly managed.

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.

89.34 Sludge Lagoons for Disposal

Sludge lagoons should not be used for ultimate disposal of sludge due to odor potential, area and volume required, and possible long term problems from groundwater contamination. The regulatory agency shall be contacted for the acceptability of lagoons for final disposal.

89.35 Other Disposal Methods

If other methods of sludge disposal are proposed, a detailed description of the technique and design data shall accompany the plans. Refer to Paragraph 53.2 for any new process determinations.

CHAPTER 90
BIOLOGICAL TREATMENT

91. TRICKLING FILTERS

91.1 General

Trickling filters may be used for treatment of wastewater amenable to treatment by aerobic biological processes. The trickling filter is a non-submerged attached-growth process. Trickling filters shall be preceded by effective settling tanks equipped with scum and grease collecting devices, or other suitable pretreatment facilities. Trickling filters shall be designed to provide for reduction in carbonaceous and/or nitrogenous oxygen demand in accordance with water quality standards and objectives for the receiving waters as established by the appropriate reviewing authority, or to properly condition the wastewater for subsequent treatment processes. Multi-stage filters should be considered if needed to meet more stringent effluent standards.

91.2 Hydraulics

91.21 Distribution

91.211 Uniformity

The wastewater may be distributed over the filter by rotary distributors or other suitable devices that will ensure uniform distribution to the surface area. At design average flow, the deviation from a calculated uniformly distributed volume per square foot of the filter surface shall not exceed plus or minus 10 percent at any point. All hydraulic factors involving proper distribution of wastewater on the filters shall be carefully calculated. Such calculations shall be submitted to the appropriate reviewing authority.

Reverse reaction nozzles, hydraulic brakes or motor-driven distributor arms shall be provided for rotary distributors to ensure that the maximum speed recommended by the distributor manufacturer is not exceeded and to attain the desired media dosing rate.

91.212 Head Requirements

For reaction type distributors, a minimum head of 24 inches (610 mm) between low water level in the siphon chamber and center of the arms is required. Similar allowance in design shall be provided for added pumping head requirements where pumping to the reaction type distributor is used.

91.213 Clearance

A minimum clearance of 12 inches (305 mm) between filter media and the bottom of the distributor arms shall be provided.

91.22 Dosing

Wastewater may be applied to the filter by siphons, pumps or gravity discharge from preceding treatment units when suitable flow characteristics have been developed. Application of the wastewater shall be practically continuous. The piping system shall be designed for recirculation.

91.23 Piping System

The piping system, including dosing equipment and distributor, shall be designed to provide capacity for the design peak hourly flow, including recirculation required under Paragraph 91.55.

91.3 Media

91.31 Quality

The trickling filter media may be crushed rock, slag, or manufactured material. The media shall be durable, resistant to spalling or flaking, and relatively insoluble in wastewater. The top 18 inches (460 mm) shall have a loss of not more than 10 percent according to the 20-cycle, sodium sulfate soundness test, as prescribed by ASCE Manual of Engineering Practice, Number 13. The balance is to pass a 10-cycle sodium sulfate soundness test using the ASCE Manual criteria. Slag media shall be free from iron or other leachable materials that will adversely affect the process or effluent quality. Manufactured media shall be resistant to ultraviolet degradation, disintegration, erosion, aging, all common acids and alkalis, organic compounds, and fungus or biological attack. Such media shall be structurally capable of supporting a person's weight or a suitable access walkway shall be provided to allow for distributor maintenance.

91.32 Depth

Trickling filter media shall have a minimum depth of 6 feet (1.8 m) above the underdrains. Rock and/or slag filter media depths shall not exceed 10 feet (3 m). Manufactured filter media depths should not exceed the recommendations of the manufacturer. Forced ventilation should be considered in accordance with Paragraph 91.43.

91.33 Size, Grading, and Handling of Media

91.331 Rock, Slag, and Similar Media

Rock, slag, and similar media shall not contain more than 5 percent by weight of pieces whose longest dimension is three times the least dimension. The media 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 a vibrating screen with square openings.

Passing 4½ inch (115 mm) screen - 100% by weight
Retained on 3 inch (75 mm) screen - 95-100% by weight
Passing 2 inch (50 mm) screen - 0-2% by weight
Passing 1 inch (25 mm) screen - 0-1% by weight

91.332 Manufactured Media

Media suitability shall be evaluated on the basis of experience with installations handling similar wastes and loadings. To ensure sufficient void clearances, media with specific surface areas of no more than 30 square feet per cubic foot (100 m^2/m^3) are acceptable for filters employed for carbonaceous reduction, and 45 square feet per cubic foot (150 m^2/m^3) for second stage ammonia reduction.

91.333 Handling and Placing of Media

Material delivered to the filter site shall be stored on wood-planked or other approved clean, hard-surfaced areas. All material shall be rehandled at the filter site and no material shall be dumped directly into the filter. Crushed rock, slag, and similar media shall be washed and rescreened or forked at the filter site to remove all fines. Such material shall be placed by hand to a depth of 12 inches (305 mm) above the tile underdrains. The remainder of the 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, and other heavy equipment shall not be driven over the filter during or after construction.

91.4 Underdrainage System

91.41 Arrangement

Underdrains with semicircular inverts or equivalent should be provided. The underdrainage system shall cover the entire floor of the filter. Inlet openings into the underdrains shall have an unsubmerged gross combined area equal to at least 15 percent of the surface area of the filter.

91.42 Hydraulic Capacity

The underdrains shall have a minimum slope of 1 percent. Effluent channels shall be designed to produce a minimum velocity of 2 feet per second (0.6 m/s) at design average flow rates of application to the filter, including recirculated flows. Refer to Paragraph 91.43.

91.43 Ventilation

The underdrainage system, effluent channels, and effluent pipe shall be designed to permit free passage of air. The size of drains, channels, and pipe should be such that not more than 50 percent of their cross-sectional area will be submerged under the design peak instantaneous flow, including proposed or possible future recirculated flows.

Forced ventilation should be provided for covered trickling filters to ensure adequate oxygen for process requirements. Windows or simple louvered mechanisms so arranged to ensure air distribution throughout the enclosure shall be provided. The design of the ventilation facilities shall provide for operator control of air flow in accordance with outside seasonal temperature. Design computations showing the adequacy of air flow to satisfy process oxygen requirements shall be submitted.

91.44 Flushing

Provision should be made for flushing the underdrains unless high rate recirculation is utilized. In small rock and slag filters, use of a peripheral head channel with vertical vents is acceptable for flushing purposes. Inspection facilities should be provided.

91.5 Special Features

91.51 Flooding

Appropriate valves, sluice gates, or other structures shall be provided to enable flooding of filters comprised of rock or slag media for filter fly control.

91.52 Freeboard

A freeboard of 4 feet (1.2 m) or more should be provided for tall, manufactured filters to contain windblown spray. At least 6 foot (1.8 m) headroom for distributor maintenance should be provided for covered filters.

91.53 Maintenance

All distribution devices, underdrains, channels, and pipes shall be installed so that they may be properly maintained, flushed and/or drained.

91.54 Winter Protection

Covers shall be provided to maintain operation and treatment efficiencies when climatic conditions are expected to result in problems due to cold temperatures.

91.55 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 at the range of 0.5:1 up to 4:1 (ratio of recirculation rate versus design average flow). A minimum of two recirculation pumps shall be provided.

91.56 Recirculation Measurement

Devices shall be provided to permit measurement of the filter recirculation rate. Elapsed time meters and pump head recording devices are acceptable for facilities treating less than 1 mgd (3,785 m^3/d). The design of the recirculation facilities shall provide for both continuity of service and the range of recirculation ratios. Reduced recirculation rates for periods of brief pump outages may be acceptable depending on water quality requirements.

91.57 Ventilation Ports

The underdrainage ventilation ports shall be designed to ensure that the interior flow will be retained inside the trickling filter.

91.6 Rotary Distributor Seals

Mercury seals shall not be permitted. Ease of seal replacement shall be considered in the design to ensure continuity of operation.

91.7 Unit Sizing

Required volumes of filter media shall be based on pilot testing with the particular wastewater or any of the various empirical design equations that have been verified through actual full scale experience. Such calculations shall be submitted if pilot testing is not utilized. Pilot testing is recommended to verify performance predictions based on the various design equations, particularly when significant amounts of industrial wastes are present.

Trickling filter design shall consider peak organic load conditions including the oxygen demands due to recycle flows (i.e., sludge dewatering filtrate, anaerobic digester supernatant, etc.) resulting from high concentrations of BOD_5 and TKN associated with such flows. The volume of media determined from either pilot plant studies or the use of acceptable design equations shall be based on the design maximum day BOD_5 loading rate rather than the design average BOD_5 rate. Refer to Paragraph 11.251.

92. ACTIVATED SLUDGE

92.1 General

92.11 Applicability

92.111 Biodegradable Wastewaters

The activated sludge process and its various modifications may be used where wastewater is amenable to biological treatment and the biological solids are separated from the treated water. It is a suspended growth type process that relies on secondary clarification for removal of effluent suspended solids while producing a concentrated return activated sludge flow.

92.112 Operational Requirement

The activated sludge process requires close attention and competent operating supervision, including routine laboratory testing for monitoring and process control. These requirements shall be considered when proposing this type of treatment.

92.113 Energy Requirements

The activated sludge 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 shall be carefully evaluated. Capability of energy usage phasedown while still maintaining process viability, both under normal and emergency energy availability conditions, shall be included in the activated sludge process design.

92.12 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 wastewater 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 and should provide for operation in various modes, if feasible.

92.13 Winter Protection

In severe climates, protection against freezing shall be provided to ensure continuity of operation and performance. Insulation of the tanks by earthen banks should be considered.

92.2 Pretreatment

Where primary settling tanks are not used, effective removal or exclusion of grit, debris, excessive oil or grease, and screening of solids shall be accomplished prior to the activated sludge process. Screening devices with clear openings of 1/4 inch (6 mm) or less shall be provided.

Where primary settling is used, provision shall be made for discharging raw wastewater directly to the aeration tanks to facilitate plant start-up and operation during the initial stages of the plant's design life.

92.3 Aeration

92.31 Capacities and Permissible Loadings

The size of the aeration tank for any particular adaptation of the process shall be determined by full scale experience, pilot plant studies, or rational calculations based mainly on solids retention time, food to microorganism (F/M) 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. When designing for nitrification, temperature, alkalinity, pH, and reactor dissolved oxygen shall be considered.

Calculations should be submitted to justify the basis of the aeration tank capacity design. Calculations using process design values differing substantially from those in the accompanying table should reference actual operational plants. Mixed liquor suspended solids levels greater than 5,000 mg/L may be allowed providing adequate data is submitted showing the aeration and clarification systems are capable of supporting such levels.

When process design calculations are not submitted, the aeration tank capacities and permissible loadings shown in the following table shall be used for the several adaptations of the processes. These values apply to plants receiving diurnal load ratios of design peak hourly BOD_5 to design average BOD_5 ranging from about 2:1 to 4:1. The utilization of flow equalization facilities to reduce the diurnal design peak hourly BOD_5 organic load may be considered by the appropriate reviewing authority as justification to approve organic loading rates that exceed those specified in the table.

PERMISSIBLE AERATION TANK CAPACITIES AND LOADINGS

Process	*Aeration Tank Organic Loading lb BOD_5/d/1000 ft^3 [kg BOD_5/ ($m^3 \cdot d$)]**	F/M Ratio lb BOD_5/d/lb MLVSS [kg BOD_5/(kg MLVSS·d)]**	MLSS*** mg/L
Conventional Step Aeration Complete Mix	40 (0.64)	0.2-0.5	1,000-3,000
Contact Stabilization	50****(0.80)	0.2-0.6	1,000-3,000
Extended Aeration Single Stage Nitrification	15 (0.24)	0.05-0.1	3,000-5,000

* Volumetric loadings are based on the influent organic load to the aeration tank at plant design average BOD_5.

** Refer to 11.251(a) for definition of BOD_5.

*** Maximum MLSS values are dependent upon the surface area provided for final sedimentation, the rate of sludge return, and the aeration process.

**** Total aeration capacity includes both contact and reaeration capacities. Normally the contact zone equals 30 to 35% of the total aeration capacity.

92.32 Arrangement of Aeration Tanks

a. Dimensions

The dimensions of each independent mixed liquor aeration tank or return sludge reaeration tank shall be such as to maintain effective mixing and utilization of air. Liquid depths should not be less than 10 feet (3 m) or more than 30 feet (9 m) except in special design cases. Horizontally mixed aeration tanks shall have a depth of not less than 5.5 feet (1.7 m).

b. Short-circuiting

For very small tanks or tanks with a special configuration, the shape of the tank, the location of the influent and sludge return, and the installation of aeration equipment should provide for positive control to prevent short-circuiting of the wastewater through the tank.

92.321 Number of Units

Total aeration tank volume shall be divided among two or more units, capable of independent operation, when required by the appropriate reviewing authority to meet applicable effluent limitations and reliability guidelines.

92.322 Inlets and Outlets

a. Controls

Inlets and outlets for each aeration tank unit shall be suitably equipped with valves, gates, stop plates, weirs, or other devices that allow for flow control to any unit and to maintain a reasonably constant liquid level. The effluent weir for a horizontally mixed aeration tank system shall be easily adjustable by mechanical means and shall be sized based on the design peak instantaneous flow plus the maximum return sludge flow. Refer to Paragraph 92.41. The hydraulic properties of the system shall permit the design peak instantaneous flow to be carried with any single aeration tank unit out of service.

b. Conduits

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

92.323 Freeboard

All aeration tanks should have a freeboard of not less than 18 inches (460 mm). However, if a mechanical surface aerator is used, the freeboard should be not less than 3 feet (0.9 m) to protect against windblown spray freezing on walkways, etc.

92.33 Aeration Equipment

92.331 General

Oxygen requirements generally depend on maximum diurnal organic loading (design peak hourly BOD_5 as described in Paragraph 11.251), 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 2.0 mg/L of dissolved oxygen in the mixed liquor at all times and provide 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 lb O_2/lb design peak hourly BOD_5 (1.1 kg

O_2/kg design peak hourly BOD_5) applied to the aeration tanks, with the exception of the extended aeration process, for which the value shall be 1.5 lb O_2/lb design peak hourly BOD_5 (1.5 kg O_2/kg design peak hourly BOD_5) to include endogenous respiration requirements.

Where nitrification is required or will occur, such as within the extended aeration process, the oxygen requirement for oxidizing ammonia shall be added to the above design oxygen requirements for carbonaceous BOD_5 removal and, where applicable, endogenous respiration requirements. The nitrogenous oxygen demand (NOD) shall be taken as 4.6 times the diurnal peak hourly TKN content of the influent. In addition, the oxygen demands due to recycle flows (i.e., sludge dewatering filtrate, anaerobic digester supernatant, etc.) shall be considered due to the high concentrations of BOD_5 and TKN associated with such flows.

Careful consideration should be given to maximizing oxygen utilization per unit of 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. Refer to Paragraph 92.31.

92.332 Diffused Air Systems

The diffused air system shall be designed according to either of the two methods described below in (a) and (b), augmented as required by consideration of items (c) through (h):

a. Having determined the oxygen requirements per Paragraph 92.331, air requirements for a diffused air system shall be determined using any of the well known equations and incorporating such factors as:

   1. Tank depth;
   2. Alpha factor of wastewater;
   3. Beta factor of wastewater;
   4. Certified aeration device oxygen transfer efficiency;
   5. Minimum aeration tank dissolved oxygen concentration;
   6. Critical wastewater temperature; and
   7. Altitude of plant.

   In the absence of experimentally determined alpha and beta factors, wastewater oxygen transfer efficiency shall be assumed to be not greater than 50 percent of clean water oxygen transfer efficiency for plants treating primarily (90% or greater) domestic wastewater. Treatment plants where the wastewater 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. The design oxygen transfer efficiency should be included in the specifications.

b. 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 Paragraph 92.331) shall be considered to be 1,500 cubic feet at standard conditions of pressure, temperature, and humidity per pound of BOD_5 aeration tank loading (94 m^3/kg BOD_5). For the extended aeration process, the value shall be 2,050 cubic feet per pound of BOD_5 (128 m^3/kg of BOD_5).

c. The air required for channels, pumps, aerobic digesters or other air-use demand and to satisfy oxygen demands due to recycle flows (e.g., sludge dewatering filtrate, anaerobic digester supernatant) shall be added to the air requirements calculated above.

d. The specified capacity of blowers or air compressors, particularly centrifugal blowers, should take into account that the air intake temperature may reach 115°F (46 °C) or higher and that 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 -20°F (-29 °C) 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.

e. The blowers shall be 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 in suspension within these limits.

f. Diffuser systems shall be capable of providing for 200 percent of the design average day oxygen demand. 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 psi (3.4 kPa) at average operating conditions.

The spacing of diffusers should be in accordance with the oxygen requirements through the length of the channel or tank, and should be designed to facilitate adjustment of their spacing without major revisions to air header piping.

All plants employing less than four independent aeration tanks shall be designed to incorporate removable diffusers that can be serviced and/or replaced without dewatering the tank.

g. 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.

h. 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.

92.333 Mechanical Aeration Systems

a. 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 be provided to verify mechanical aerator performance. Refer to applicable provisions of Paragraph 92.332. In the absence of specific design information, the oxygen requirements shall be calculated using a transfer rate not to exceed 2 pounds of oxygen per horsepower per hour [1.22 kg O_2/(kW·h)] in clean water under standard test conditions. Design transfer efficiencies shall be included in the specifications.

b. Design Requirements

A mechanical aeration system shall accomplish the following:

1. Maintain a minimum of 2.0 mg/L of dissolved oxygen in the mixed liquor at all times throughout the tank or basin;

2. Maintain all biological solids in suspension (for a horizontally mixed aeration tank

system an average velocity of 1 foot per second (0.3 m/s) shall be maintained);

3. Meet maximum oxygen demand and maintain process performance with the largest unit out of service;

4. Provide for varying the amount of oxygen transferred in proportion to the load demand on the activated sludge process; and

5. Allow for motors, gear housing, bearings, grease fittings, etc., to be easily accessible and protected from inundation and spray as necessary for proper functioning of the unit.

c. Winter Protection

Where extended cold weather conditions occur, the aerator mechanism and associated structure shall be protected from freezing due to splashing and spray. Due to high heat loss, subsequent treatment units shall be protected from freezing.

92.4 Return Sludge Equipment

92.41 Return Sludge Rate

The minimum permissible withdrawal rate of return sludge 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 design average flow of wastewater should generally be variable between the limits set forth as follows:

Type of Process	% Design Average Flow	
	Minimum	Maximum
Conventional, Step Aeration or Complete Mix	15	100
Contact Stabilization	50	150
Single Stage Nitrification	50	150
Extended Aeration	50	150
Carbonaceous Stage of Separate Stage Nitrification	15	100
Nitrification Stage of Separate Stage Nitrification	50	200

The rate of sludge return shall be varied by means of variable speed motors, drives, or timers (small plants) to pump sludge at the above rates. All designs shall provide for flexibility in operation and should provide for operation in various process modes, if feasible.

92.42 Return Sludge Pumps

If motor drive return sludge pumps are used, the maximum return sludge capacity shall be obtained with the largest pump out of service. A positive head should be provided on pump suctions. Pumps should have at least 3 inch (80 mm) 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 facilitates their rapid and easy cleaning and provided other suitable standby measures are provided. Air lifts should be at least 3 inches (80 mm) in diameter.

92.43 Return Sludge Piping

Discharge piping should be at least 4 inches (100 mm) in diameter and should be designed to maintain a velocity of not less than 2 feet per second (0.6 m/s) when return sludge facilities are operating at normal return sludge rates. Suitable devices for observing, sampling, and controlling return activated sludge flow from each settling tank hopper shall be provided, as outlined in Paragraph 73.24.

92.44 Waste Sludge Facilities

Waste sludge control facilities should have a capacity of at least 25 percent of the design average rate of wastewater flow and function satisfactorily at rates of 0.5 percent of design average wastewater flow or a minimum of 10 gallons per minute (0.6 L/s), whichever is larger. Means for observing, measuring, sampling, and controlling waste activated sludge flow shall be provided. Waste sludge may be discharged to the primary settling tank, sludge digestion tank, sludge thickening or dewatering processes, storage tank, or any practical combination of these units.

92.5 Measuring Devices

Devices should be installed in all plants for indicating flow rates of raw wastewater or primary effluent, return sludge, and air to each tank unit. For plants designed for design average wastewater flows of 1 mgd (3,785 m^3/d) or more, these devices should totalize and record, as well as indicate flows. Where the design provides for all return sludge to be mixed with the raw wastewater (or primary effluent) at one location, then the mixed liquor flow rate to each aeration unit should be measured.

92.6 Biological Nutrient Removal

Biological Nutrient Removal (BNR) processes may be approved at the discretion of the reviewing authority on a case-by-case basis under the provisions of Paragraph 53.2. Many proprietary BNR systems are available and vendors should be consulted for design details. The design shall meet the applicable requirements under Chapters 50, 70 and 90, except as modified in this Paragraph.

All BNR designs shall provide for flexibility in operation and should provide for operation in various modes, if feasible. Vital components for internal mixed liquor recycle and mechanical mixing systems shall meet the guidelines for continuity of treatment established by the reviewing authority.

92.61 Definitions

The following terms shall be used by the design engineer to describe biological nutrient removal processes in an Engineering Report or Facility Plan.

a. Aerobic (or Oxic) Condition Defined

A condition in which free and dissolved oxygen is available in an aqueous environment.

b. Anoxic Condition Defined

A condition in which oxygen is only available in a combined form, such as nitrate (NO_3^-), nitrite (NO_2^-), or sulfate (SO_4^{--}), in an aqueous environment.

c. Anaerobic Condition Defined

A condition in which free, dissolved and combined oxygen are not available in an aqueous environment.

92.62 Biological Phosphorus Removal

A number of process configurations for enhanced biological phosphorus removal (BPR) have been developed as alternatives to phosphorus removal by chemical treatment (outlined in Section 111). BPR microorganisms incorporate phosphorus into their cell mass in excess of their metabolic requirements, allowing them to remove phosphorus from wastewater. Exposure of activated sludge microorganisms to alternating anaerobic and aerobic conditions allows BPR microorganisms to proliferate in numbers sufficient to remove phosphorus.

The design shall ensure that readily biodegradable organic matter in sufficient quantities is available in an anaerobic environment to promote the growth of BPR microorganisms. The amount of readily biodegradable organic matter can be increased by fermentation of wastewater or sludge or by the addition of a supplemental carbon source such as methanol or acetic acid.

To create truly anaerobic conditions, both oxygen and nitrate shall be excluded. Many BPR configurations include the denitrification process to limit the nitrate concentration in anaerobic zones.

Sludge containing the excess phosphorus from the BPR microorganisms can be wasted, or the excess phosphorus can be removed from the sludge by a sidestream treatment process. The BPR process may require chemical treatment as a backup system or for polishing to achieve very low effluent phosphorus levels. The BPR process is often combined with nitrification and denitrification processes.

92.63 Biological Nitrogen Removal

Biological nitrogen removal is accomplished by biological oxidation of ammonia to nitrate (nitrification) followed by biological denitrification of nitrate to nitrogen gas.

92.631 Nitrification

Biological nitrification is used to remove ammonia to meet effluent requirements or as the first step in nitrogen removal. Ammonia is oxidized to nitrite and then to nitrate by nitrifying bacteria in an aerobic environment. Nitrification consumes alkalinity.

Nitrification can be achieved with either a single stage nitrification process (combined carbonaceous oxidation and nitrification) or with a separate stage nitrification process. In each case, suspended growth, attached growth or hybrid systems can be used. Temperature, alkalinity, pH and dissolved oxygen shall be considered in nitrification design.

92.632 Denitrification

Denitrification is the biological process where bacteria convert nitrate to nitrogen gas under anoxic conditions. Denitrification generates alkalinity and therefore restores some of the alkalinity consumed during nitrification.

A soluble carbon source is required to drive the denitrification process. The carbon requirements for denitrification may be provided by influent wastewater or by an external source such as methanol.

92.64 Combined Biological Nitrogen and Phosphorus Removal

A number of BNR processes have been developed for the combined removal of nitrogen and phosphorus. Many of these are proprietary and use a form of the activated sludge process. Combinations of anaerobic, anoxic and aerobic zones or compartments are designed to accomplish biological nitrogen and phosphorus removal.

92.7 Sequencing Batch Reactors

The fill and draw mode of the activated sludge process commonly termed the Sequencing Batch Reactor may be approved at the discretion of the reviewing authority on a case-by-case basis under the provisions of Paragraph 53.2. The design shall be based on experience at other facilities and shall meet the applicable requirements under Chapters 50, 70 and 90, except as modified in this Paragraph. Continuity and reliability of treatment equal to that of the continuous flow through modes of the activated sludge process shall be provided. Supplemental treatment units may be required to meet applicable effluent limitations and reliability guidelines. The reviewing authority should be contacted for design guidance and criteria where such systems are being considered. See also Section 65 where in-line flow equalization units are provided in addition to the decantable volume.

a. Design F/M ratios in the range of 0.05 to 0.1 are permissible. The aeration tank volumetric loading should not exceed 15 lb BOD_5/d/1000 ft^3 [0.24 kg $BOD_5/(m^3 \cdot d)$]. The reactor MLSS and MLVSS concentrations and aeration tank volumetric loading should be calculated at the low-water level.

b. More than two tanks should be provided.

c. The decantable volume and decanter capacity of the sequencing batch reactor system with the largest basin out of service should be sized to pass at least 75 percent of the design maximum day flow without changing cycle times. A decantable volume of at least 4 hours with the largest basin out of service based on 100 percent of the design maximum day flow is permissible.

d. System reliability with any single aeration tank unit out of service and the instantaneous delivery of flow shall be evaluated in the design of decanter weirs and approach velocities. The treated effluent from each reactor should be free of scum and should have a suspended solids concentration no greater than 30 mg/L at any time. See Paragraphs 53.413 and 72.43. Scum removal shall be provided. An adequate zone of separation between the sludge blanket and the decanter(s) shall be maintained throughout the decant phase.

e. Decanters that draw the treated effluent from near the water surface throughout the decant phase are recommended.

f. Solids management to accommodate tank dewatering shall be considered.

g. The blowers shall be provided in multiple units, so arranged and in such capacities as to meet the maximum air demand in the oxic portions of the fill/react and react phases of the cycle with the single largest unit out of service. See Paragraph 92.332(e).

h. Mechanical mixing independent of aeration shall be provided for all systems where biological phosphorus removal or denitrification is required. The mixing equipment should be sized to thoroughly mix the entire tank from a settled condition within 5 minutes without aeration.

i. The design effluent quality performance requirements for the plant should be sufficiently stringent to ensure acceptable effluent quality from any reactor. Flow paced composite sampling equipment and continuous turbidity metering for separately monitoring the effluent quality from each tank may be required by the regulatory agency. All 24-hour effluent quality composite samples for compliance reporting or monitoring plant operations shall be flow-paced and include samples collected at the beginning and end of each decant phase. A programmable logic controller (PLC) shall be provided. Multiple PLCs should be provided as necessary to ensure rapid process recovery and minimize the deterioration of effluent quality from the failure of a single controller. An uninterruptible power supply with electrical surge protection shall be provided for each PLC to retain program memory (i.e., process control program, last-known set points and measured process/equipment status, etc.) through a power loss. A hard-wired backup for manual override shall be provided in addition to automatic process control. Both automatic and manual controls shall allow independent operation of each tank. In addition, a fail-safe control that cannot be adjusted by the operator shall be provided, allowing at least 20 minutes of settling between the react and decant phases.

93. WASTEWATER TREATMENT PONDS

93.1 General

This Section deals with generally used variations of treatment ponds capable of achieving secondary treatment including controlled-discharge pond systems, flow-through pond systems and aerated pond systems. Ponds utilized for equalization, percolation, evaporation, and sludge storage are not discussed in this Section. The term "pond" is used in this Section to include the total earthen treatment facility and the term "cell" is used to designate the individual units of the total facility.

93.2 Location

93.21 Surface Runoff

Adequate provision shall be made to divert stormwater runoff around the pond and protect pond embankments from erosion.

93.22 Ground Water Separation

A minimum separation of 4 feet (1.2 m) between the bottom of the pond and the maximum ground water elevation should be maintained.

93.23 Bedrock Separation

A minimum separation of 10 feet (3.0 m) between the pond bottom and any bedrock formation is recommended.

93.3 Basis of Design

93.31 Area and Loadings for Controlled-Discharge Facultative Treatment Pond Systems

Pond design for design average BOD_5 loading may range from 15 to 35 pounds per acre per day [17 kg/(ha·d) to 40 kg/(ha·d)] at the mean operating depth in the primary cells and at least 180 days detention time between the minimum and maximum operating depths of the entire pond system, as described in Paragraph 93.416. Refer to Paragraph 11.251. The detention time and organic loading rate shall depend on climatic conditions and effluent discharge limits.

93.32 Area and Loadings for Flow-Through Facultative Treatment Ponds Systems

Pond design for design average BOD_5 loading may vary from 15 to 35 pounds per acre per day [17 kg/(ha·d) to 40 kg/(ha·d)] for the primary cell(s). Refer to Paragraph 11.251. The major design considerations for BOD_5 loading shall be directly related to the climatic conditions.

Design variables such as pond depth, multiple units, detention time, and additional treatment units shall be considered with respect to applicable standards for BOD_5, total suspended solids (TSS), bacteria, dissolved oxygen and pH.

A detention time of 90 to120 days should be provided; however, this shall be properly related to other design considerations. It should be noted that the major factor in the design is the duration of the cold weather period [water temperature less than 40°F (5 °C)].

93.33 Aerated Treatment Pond Systems

For the development of final design parameters, it is recommended that actual experimental data be obtained. However, the aerated treatment pond system design for minimum detention time may be estimated using the following formula, applied separately to each aerated cell:

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

t = hydraulic detention time, days

E = percent of BOD_5 to be removed in an aerated cell

k_1 = reaction coefficient, aerated pond, base 10. For normal domestic wastewater, the k_1 value may be assumed to be 0.12/day at 68°F (20 °C) and 0.06/day at 34°F (1 °C).

The reaction rate coefficient for domestic wastewater which includes some industrial wastes, other wastes, and partially treated wastewater shall be determined experimentally for the various conditions that might be encountered in the aerated pond cells. Conversion of the reaction rate coefficient at other temperatures shall be made based on experimental data.

The design should consider the effect of any return sludge. Additional storage volume for 20 years of operation should be considered for sludge, and in northern climates, for ice cover.

Oxygen requirements generally will depend on the design average BOD_5 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 2 mg/L in the cells at all times. Suitable protection from weather shall be provided for electrical controls. Aerated pond cells shall be followed by a polishing cell with a volume of at least 0.3 of the total volume of the aerated cells.

See Paragraph 92.33 for details on aeration equipment.

93.34 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 to the wastewater treatment pond.

Industrial wastes shall not be discharged to ponds without assessment of the effects such substances may have upon the treatment process and discharge requirements in accordance with state and federal laws.

93.35 Number of Cells Required

At a minimum, a wastewater treatment pond system should consist of three cells designed to facilitate both series and parallel operations. The maximum size of a pond cell should be 40 acres (16 ha). Two-cell systems may be utilized in very small installations where authorized by the regulatory agency.

All pond systems should be designed with piping flexibility to permit isolation of any cell without affecting the transfer and discharge capabilities of the total system. The piping should be arranged such that effluent from any primary cell cannot be discharged directly to the receiving stream. In addition, the ability to discharge the influent waste load to a minimum of two cells and/or all primary cells in the system should be provided.

93.351 Controlled-Discharge Facultative Treatment Pond Systems

For controlled-discharge pond systems, the area specified as the primary cells should be equally divided into two cells. The third or secondary cell volume should, as a minimum, be equal to the volume of each of the primary cells.

In addition, the design should permit for adequate elevation difference between primary and secondary cells to allow for gravity filling of the secondary from the primary. Where this is not feasible, pumping facilities shall be provided.

93.352 Flow-Through Facultative Treatment Pond Systems

At a minimum, primary cells shall provide adequate hydraulic detention time to maximize BOD_5 removal. Secondary cells should then be provided for additional detention time with depths to 8 feet (2.4 m) to facilitate solids reduction. Design should also consider recirculation within the system.

93.353 Aerated Treatment Pond Systems

A minimum of two aerated cells, plus a polishing cell, are required. A tapered mode of aeration is recommended. The first two aerated cells should be of equal size and no one aerated cell should provide more than 50 percent of the total required volume.

93.36 Pond Shape

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

93.4 Pond Construction Details

93.41 Embankments and Dikes

93.411 Material

Dikes shall be constructed of relatively impervious soil and compacted to at least 95 percent Standard Proctor Density to form a stable structure. Vegetation and other unsuitable materials shall be removed from the area where the embankment is to be placed.

93.412 Top Width

The minimum dike width shall be 8 feet (2.4 m) to permit access for maintenance vehicles.

93.413 Maximum Slopes

Inner and outer dike slopes shall not be steeper than 1 vertical to 3 horizontal (1:3).

93.414 Minimum Slopes

Inner slopes should not be flatter than 1 vertical to 4 horizontal (1:4). Flatter slopes can be specified for larger installations because of wave action, but such slopes have the disadvantage of added shallow areas that are conducive to emergent vegetation. Outer slopes shall be sufficient to prevent surface runoff from entering the pond.

93.415 Freeboard

Minimum freeboard shall be 3 feet (0.9 m). For small systems, 2 feet (0.6 m) may be acceptable.

93.416 Design Depth

The minimum operating depth should be sufficient to prevent the growth of aquatic plants and damage to the dikes, pond bottom, control structures, aeration equipment, and other appurtenances. In no case shall the minimum pond depth be less than 2 feet (0.6 m).

a. Controlled-Discharge and Flow-Through Facultative Treatment Pond Systems

The maximum water depth shall be 6 feet (1.8 m) in the primary cells. Greater depths in subsequent cells are permissible, but supplemental aeration or mixing may be necessary.

b. Aerated Treatment Pond Systems

The design water depth should be 10 to 15 feet (3 m to 4.6 m). This depth limitation may be altered depending on the aeration equipment, wastewater strength, and climatic conditions.

93.417 Erosion Control

A justification and detailed discussion of the method of erosion control encompassing all relative factors such as pond location and size, seal material, topography, prevailing winds, cost breakdown, application procedures, etc., shall be provided.

a. Seeding

The dikes shall have a covered layer of at least 4 inches (100 mm) of fertile topsoil to promote establishment of an adequate vegetative cover wherever riprap is not utilized. Prior to prefilling (in accordance with Paragraph 93.424), adequate vegetation shall be established on dikes from the outside toe to 2 feet (0.6 m) above the pond bottom on the interior as measured on the slope. Perennial-type, low-growing, spreading grasses that minimize erosion and can be mowed are most satisfactory for seeding on dikes. In general, alfalfa and other long-rooted crops should not be used for seeding since their roots are apt to impair the water-holding efficiency of the dikes.

b. Additional Erosion Protection

Riprap or some other acceptable method of erosion control shall be provided as a minimum around all piping entrances and exits. For aerated cells, the 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 to protect the embankment from erosion due to severe flooding of a watercourse.

c. Alternate Erosion Protection

Alternate erosion control on the interior dike slopes may be necessary for ponds that are subject to severe wave action. In these cases, riprap or an acceptable equal shall be placed from at least 1 foot (0.3 m) above the high water mark to 2 feet (0.6 m) below the low water mark (measured on the vertical).

93.42 Pond Bottom

93.421 Soil

The soil used to construct the pond bottom (not including the seal) and dike cores shall be relatively incompressible, tight, and compacted at or up to 4 percent above the optimum water content to at least 95 percent Standard Proctor Density.

93.422 Seal

Ponds shall be sealed such that seepage loss through the seal is as low as practicably possible. Seals consisting of soils, bentonite, or synthetic liners may be considered, provided the permeability, durability, and integrity of the proposed material can be satisfactorily demonstrated for anticipated conditions. Results of a testing program which substantiates the adequacy of the proposed seal shall be incorporated into and/or accompany the engineering report. Standard ASTM International procedures or acceptable similar methods shall be used for all tests.

To achieve an adequate seal in pond systems using soil, bentonite, or other seal materials, the hydraulic conductivity (k) in centimeters per second specified for the seal shall not exceed the value derived from the following expression, where L equals the thickness of the seal in centimeters.

$$k = 2.6 \times 10^{-9} L$$

The "k" obtained by the above expression corresponds to a percolation rate of pond water of less than 500 gallons per day per acre [4.7 $m^3/(ha \cdot d)$] at a water depth of 6 feet

(1.8 m) and a liner thickness of 1 foot (0.3 m), using the Darcy's law equation.

For a seal consisting of a synthetic liner, seepage loss through the liner shall not exceed the quantity equivalent to seepage loss through an adequate soil seal.

93.423 Uniformity

The pond bottom shall be as level as possible at all points. Finished elevations shall not be more than 3 inches (75 mm) from the average elevation of the bottom.

93.424 Prefilling

Prefilling the pond should be considered in order to protect the liner, to prevent weed growth, to reduce odor, and to maintain moisture content of the seal. However, the dikes shall be completely prepared as described in Paragraphs 93.417 (a) and (b) before the introduction of water.

93.43 Influent Lines

93.431 Material

Generally accepted material for underground sewer construction will be given consideration for the influent line to the pond. Unlined corrugated metal pipe should be avoided due to corrosion problems. In material selection, consideration shall be given to the characteristics of the wastewater, exceptionally heavy external loadings, abrasion, soft foundations, buoyancy and similar problems.

93.432 Manhole

A manhole or vented cleanout wye shall be installed prior to entrance of the influent line into the primary cell and shall be located as close to the dike as topography permits. Its invert shall be at least 6 inches (150 mm) above the maximum operating level of the pond and shall provide sufficient hydraulic head without surcharging the manhole.

93.433 Flow Distribution

Flow distribution structures shall be designed to effectively split hydraulic and organic loads equally to primary cells.

93.434 Placement

Influent lines may be located along the bottom of the pond with the top of the pipe just below the average upper elevation of the pond seal or liner. However, the full seal depth shall be maintained below the bottom of the pipe and throughout the transition area from the bottom of the pipe to the pond bottom.

In situations where pipes penetrate the pond seal, provisions to prevent seepage (such as anti-seep collars) shall be made.

93.435 Point of Discharge

All primary cells shall have individual influent lines which terminate approximately at the midpoint of the width and at approximately two-thirds the length away from the outlet structure so as to minimize short-circuiting of the wastewater.

All aerated cells shall have influent lines which distribute the load within the mixing zone of the aeration equipment.

93.436 Influent Discharge Apron

The influent line shall discharge horizontally into a shallow, saucer-shaped depression.

The end of the discharge line shall rest on a suitable concrete apron large enough to prevent the terminal influent velocity at the end of the apron from causing soil erosion. A minimum size apron of 2 feet (0.6 m) square shall be provided.

93.44 Control Structures and Interconnecting Piping

93.441 Structure

Where possible, facilities design shall consider the use of multi-purpose control structures to facilitate normal operational functions such as drawdown and flow distribution, flow and depth measurement, sampling, pumps for recirculation, chemical additions and mixing, and minimization of the number of construction sites within the dikes.

As a minimum, control structures shall be: (a) accessible for maintenance and adjustment of controls; (b) adequately ventilated for safety and to minimize corrosion; (c) locked to discourage vandalism; (d) contain controls to permit water level and flow rate control, and complete shutoff; (e) constructed of non-corrodible materials (metal-on-metal contact in controls should be of similar alloys to discourage electrochemical reactions); and (f) located to minimize short-circuiting within the cell and avoid freezing and ice damage.

Recommended devices to regulate water level are valves, slide tubes or dual slide gates. Stop logs shall not be used to regulate water levels. Regulators should be designed so that they can be preset to prevent the pond surface elevation from dropping below the desired operational level.

93.442 Piping

All piping shall be of ductile iron or other acceptable material. Pipes should be anchored with adequate erosion control.

In situations where pipes penetrate the pond seal, provisions to prevent seepage (such as anti-seep collars) shall be made.

a. Drawdown Structure Piping

1. Submerged Takeoffs

For ponds designed for shallow or variable depth operations, submerged takeoffs are recommended. Intakes shall be located a minimum of 10 feet (3.0 m) from the toe of the dike and 2 feet (0.6 m) from the top of the seal, and shall employ vertical withdrawal.

2. Multi-Level Takeoffs

For ponds that are designed deep enough to permit stratification of pond content, multiple takeoffs are recommended. There shall be a minimum of 3 withdrawal pipes at different elevations. The bottom pipe shall conform to a submerged takeoff. The other pipes may utilize a horizontal entrance, provided that the design includes provisions to ensure that scum and floating materials shall not be drawn off with the cell effluent. Adequate structural support shall be provided.

3. Near Surface Takeoffs

For use under constant discharge conditions and/or for relatively shallow ponds under warm weather conditions, near surface overflow-type withdrawal is recommended. Pond design should evaluate a floating weir box or slide tube entrance with baffles for scum control and should permit adequate drawoff approximately 2 feet (0.6 m) below the water surface.

4. Emergency Overflow

To prevent overtopping of dikes, emergency overflow should be provided with capacity to carry the expected peak instantaneous flow.

b. Hydraulic Capacity

The hydraulic capacity for continuous discharge structures and piping shall allow for a minimum of 250 percent of the design maximum day flow of the wastewater treatment system.

The hydraulic capacity for controlled-discharge pond systems shall permit transfer of water at a minimum rate of 6 inches (150 mm) of pond water depth per day at the available head.

93.5 Sludge Removal and Disposal

Sludge removal may be required when upgrading an existing pond system to ensure the best effluent quality. The final disposal site shall be acceptable to the regulatory agency. Transferring sludge from an existing pond into a new primary pond cell for disposal is unacceptable.

Controlled discharge facultative treatment pond systems should provide a sludge storage volume which does not exceed one half of the minimum operating depth of the primary cells.

The pond system following sludge removal shall remain sealed and shall meet applicable seepage loss requirements.

93.6 Miscellaneous

93.61 Fencing

The pond area shall be enclosed with an adequate fence to prevent entry by livestock and discourage trespassing. Fencing should not obstruct maintenance vehicle traffic on top of the dikes. A vehicle access gate of sufficient width to accommodate mowing equipment shall be provided. All access gates shall be provided with locks.

93.62 Access

An all-weather access road shall be provided to the pond site to allow year-round maintenance of the facility.

93.63 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 sign shall be provided on each side of the site and one sign shall be provided for every 500 feet (150 m) of its perimeter.

93.64 Flow Measurement

Flow measurement requirements are presented in Paragraph 56.6. Effective weather protection shall be provided for the recording equipment.

93.65 Groundwater Monitoring

An approved system of wells or lysimeters may be required around the perimeter of the pond site to facilitate groundwater monitoring. The need for such monitoring will be determined on a case-by-case basis.

93.66 Pond Level Gauges

Pond level gauges shall be provided.

93.67 Service Building

A service building for laboratory and maintenance equipment shall be provided, if required. Refer to Section 58.

94. OTHER BIOLOGICAL SYSTEMS

94.1 General

Biological treatment processes not included in these standards may be considered in accordance with Paragraph 53.2.

CHAPTER 100
DISINFECTION

101. GENERAL

Disinfection of the effluent shall be provided as necessary to meet applicable standards. The design shall consider meeting both the bacterial standards and the disinfectant residual limit in the effluent. The disinfection process should be selected after due consideration of waste characteristics, type of treatment process provided prior to disinfection, waste flow rates, pH of waste, disinfectant demand rates, current technology application, cost of equipment and chemicals, power cost, and maintenance requirements.

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, bromine, or ultraviolet disinfection, may be accepted by the reviewing authority in individual cases. If halogens are utilized, it may be necessary to dehalogenate if the residual level in the effluent exceeds effluent limitations or would impair the natural aquatic habitat of the receiving stream.

Where a disinfection process other than chlorine is proposed, supporting data from pilot plant installations or similar full scale installations may be required as a basis for the design of the system. Refer to Paragraph 53.2.

102. CHLORINE DISINFECTION

102.1 Type

Chlorine is available for disinfection in gas, liquid (hypochlorite solution), and solid (hypochlorite tablet) forms. The type of chlorine should be carefully evaluated during the facility planning process. The use of chlorine gas or liquid will be most dependent on the size of the facility and the chlorine dose required. Large quantities of chlorine, such as are contained in ton cylinders and tank cars, can present a considerable hazard to plant personnel and to the surrounding area should such containers develop leaks. Both monetary cost and the potential public exposure to chlorine should be considered when making the final determination.

102.2 Dosage

For disinfection, the capacity shall be adequate to produce an effluent that will meet the applicable bacterial limits specified by the regulatory agency for that installation. Required disinfection capacity will vary, depending on the uses and points of application of the disinfection chemical. The chlorination system shall be designed on a rational basis and calculations justifying the equipment sizing and number of units shall be submitted for the whole operating range of flow rates for the type of control to be used. System design considerations shall include the controlling wastewater flow meter (sensitivity and location), telemetering equipment and chlorination controls. For normal domestic wastewater, the following may be used as a guide in sizing chlorination facilities.

Type of Treatment	Dosage
Trickling filter plant effluent	10 mg/L
Activated sludge plant effluent	8 mg/L
Tertiary filtration effluent	6 mg/L
Nitrified effluent	6 mg/L

102.3 Containers

102.31 Cylinders

One hundred fifty pound (68 kg) cylinders are typically used where chlorine gas consumption is less than 150 pounds per day (68 kg/d). Cylinders should be stored in an upright position with adequate support brackets and chains at 2/3 of cylinder height for each cylinder.

102.32 Ton Containers

The use of one-ton (907 kg) containers should be considered where the average daily chlorine consumption is over 150 pounds (68 kg).

102.33 Tank Cars

At large installations, the use of tank cars, generally accompanied by evaporators, may be considered. Area wide public safety shall be evaluated. No interruption of chlorination shall be permitted during tank car switching.

The tank car being used for the chlorine supply shall be located on a dead end, level track that is a private siding. The tank car shall be protected from accidental bumping by other railway cars by a locked derail device, a closed locked switch or both. The area shall be clearly posted "DANGER-CHLORINE". The tank car shall be secured by adequate fencing that includes gates provided with locks for personnel and rail access.

The tank car site shall be provided with a suitable operating platform at the unloading point for easy access to the protective housing or the tank car for the connection of flexible feedlines and valve operation. Adequate area lighting shall be provided for night time operation and maintenance.

102.34 Liquid Hypochlorite Solutions

Storage containers for hypochlorite solutions shall be of sturdy, non-metallic lined construction and shall be provided with secure tank tops and pressure relief and overflow piping. The overflow piping should be provided with a water seal or other device to prevent tanks from venting to the indoors. Storage tanks should be either located or vented outside. Provision shall be made for adequate protection from light and extreme temperatures. Tanks shall be located where leakage will not cause corrosion or damage to other equipment. A means of secondary containment shall be provided to contain spills and facilitate cleanup. Due to deterioration of hypochlorite solutions over time, it is recommended that containers not be sized to hold more than one month's needs. At larger facilities and locations where delivery is not a problem, it may be desirable to limit on-site storage to one week. Refer to Section 57.

102.35 Dry Hypochlorite Compounds

Dry hypochlorite compounds should be kept in tightly closed containers and stored in a cool, dry location. Some means of dust control should be considered, depending on the size of the facility and the quantity of compound used. Refer to Section 57.

102.4 Equipment

102.41 Scales

Scales for weighing cylinders and containers shall be provided at all plants using chlorine gas. At large plants, scales of the indicating and recording type are recommended. At a minimum, a platform scale shall be provided. Scales shall be of corrosion-resistant material.

102.42 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.

102.43 Mixing

The disinfectant shall be positively mixed as rapidly as possible, with a complete mix being effected in 3 seconds. This may be accomplished by either the use of turbulent flow regime or a mechanical flash mixer.

102.44 Contact Period and Tank

For a chlorination system, a minimum contact period of 15 minutes at design peak hourly flow or maximum rate of pumpage shall be provided after thorough mixing. When evaluating existing chlorine contact tanks, field tracer studies should be performed to assure adequate contact time.

The chlorine contact tank shall be constructed so as to reduce short-circuiting of flow to a practical minimum. Tanks not provided with continuous mixing shall be provided with "over-and-under" or "end-around" baffling to minimize short-circuiting.

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.

102.45 Piping and Connections

Piping systems should be as simple as possible, specifically selected and manufactured to be suitable for chlorine service, with a minimum number of joints. Piping should be well supported and protected against temperature extremes.

Due to the corrosiveness of wet chlorine, all lines designated to handle dry chlorine shall be protected from the entrance of water or air containing water. Even minute traces of water added to chlorine results in a corrosive attack. Low pressure lines made of hard rubber, saran-lined, rubber-lined, polyethylene, polyvinylchloride (PVC), or other approved materials are satisfactory for wet chlorine or aqueous solutions of chlorine.

The chlorine system piping shall be color coded and labeled to distinguish it from other plant piping. Refer to Paragraph 54.5. Where sulfur dioxide is used, the piping and fittings for chlorine and sulfur dioxide systems shall be designed so that interconnection between the two systems cannot occur.

102.46 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.

102.47 Chlorinator 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 Paragraph 56.2. Adequately filtered plant effluent should be considered for use in the chlorinator.

102.48 Leak Detection and Controls

A bottle of 56 percent ammonium hydroxide solution shall be available for detecting chlorine leaks. Where one-ton (907 kg) containers or tank cars 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 one-ton (907 kg) containers where such containers are in use. Consideration should be given to the installation of automatic gas detection and related alarm equipment.

102.5 Housing

102.51 Feed and Storage Rooms

If gas chlorination equipment or chlorine cylinders 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. Rooms shall be at ground level and should permit easy access to all equipment.

Storage areas for one-ton (907 kg) cylinders should be separated from the feed area. In addition, the storage area shall have designated areas for "full" and "empty" cylinders. Chlorination equipment should be situated as close to the application point as reasonably possible. For additional safety considerations, refer to Section 57.

102.52 Inspection Window

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

102.53 Heat

Rooms containing disinfection equipment shall be provided with a means of heating so that a temperature of at least 60°F (16 °C) can be maintained. The room should be protected from excess heat. Cylinders shall be kept at essentially room temperature. If liquid hypochlorite solution is used, the containers may be located in an unheated area.

102.54 Ventilation

With chlorination systems, forced, mechanical ventilation shall be installed which will provide one complete fresh air change per minute when the room is occupied. The entrance to the air exhaust duct from the room shall be near the floor. The point of discharge shall be so located as not to contaminate the air inlet to any buildings or present a hazard at the access to the chlorinator room or other inhabited areas. Air inlets shall be so located as to provide cross ventilation with air and at such temperature that will not adversely affect the chlorination equipment. The outside air inlet shall be at least three feet above grade. The vent hose from the chlorinator shall discharge to the outside atmosphere above grade. Where public exposure may be extensive, scrubbers may be required on ventilation discharge.

102.55 Electrical Controls and Ambient Gas Detectors

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 one point. An ambient chlorine gas detector should be provided in the chlorine storage room. The gas detector should be interlocked with the fan and audible or visual alarms.

102.56 Protective and Respiratory Gear

Respiratory air-pac protection equipment that meets 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 the equipment shall be posted. The units shall use compressed air, have at least 30-minute capacity and be compatible with the units used by the fire department responsible for the plant.

102.6 Sampling and Control

102.61 Sampling

Facilities shall be included for sampling disinfected effluent after the contact chamber as monitoring requirements warrant. In large installations, or where stream conditions warrant, provisions should be made for continuous monitoring of effluent chlorine residual.

102.62 Testing and Control

Equipment shall be provided for measuring chlorine residual using accepted test procedures. The installation of demonstrated effective facilities for automatic chlorine residual analysis, recording, and proportioning systems should be considered at all large installations.

Equipment shall also be provided for measuring bacterial organisms using accepted test procedures as required by the regulatory agency.

103. DECHLORINATION

103.1 Types

Dechlorination of wastewater effluent may be necessary to reduce the toxicity due to chlorine residuals. The most common dechlorination chemicals are sulfur compounds, particularly sulfur dioxide gas or aqueous solutions of sulfite or bisulfite. Tablet dechlorination systems are also available for small facilities.

The type of dechlorination system should be carefully selected considering criteria including: type of chemical storage required, amount of chemical needed, ease of operation, compatibility with existing equipment, and safety.

103.2 Dosage

The dosage of dechlorination chemical should depend on the residual chlorine in the effluent, the final residual chlorine limit, and the particular form of the dechlorinating chemical used. The most common dechlorinating agent is sulfite. The following forms of the compound are commonly used and yield sulfite (SO_2) when dissolved in water.

Dechlorination Chemical	Theoretical mg/L Required to Neutralize 1 mg/L Cl_2
Sodium thiosulfate (solution)	0.56
Sodium sulfite (tablet)	1.78
Sulfur dioxide (gas)	0.9
Sodium meta bisulfite (solution)	1.34
Sodium bisulfite (solution)	1.46

Theoretical values may be used for initial approximations, to size feed equipment with the consideration that under good mixing conditions 10% excess dechlorinating chemical is required above theoretical values. Excess sulfur dioxide may consume oxygen at a maximum of 1.0 mg dissolved oxygen for every 4 mg SO_2.

The liquid solutions come in various strengths. These solutions may need to be further diluted to provide the proper dose of sulfite.

103.3 Containers

Depending on the chemical selected for dechlorination, the storage containers will vary from gas cylinders, liquid in 50 gallon (190 L) drums or dry compounds. Dilution tanks and mixing tanks are required when using dry compounds and may be required when using liquid compounds to deliver the proper dosage. Solution containers should be covered to prevent evaporation and spills.

103.4 Feed Equipment, Mixing, and Contact Requirements

103.41 Equipment

In general, the same type of feeding equipment used for chlorine gas may be used with minor modifications for sulfur dioxide gas. However, the manufacturer should be contacted for specific equipment recommendations. No equipment should be alternately used for the two gases. The common type of dechlorination feed equipment utilizing sulfur compounds include a vacuum solution feed of sulfur dioxide gas and a positive displacement pump for aqueous solutions of sulfite or bisulfite.

The selection of the type of feed equipment utilizing sulfur compounds shall include consideration of the operator safety and overall public safety relative to the wastewater treatment plant's proximity to populated areas and the security of gas cylinder storage. The selection and design of sulfur dioxide feeding equipment shall take into account that the gas reliquifies quite easily. Special precautions shall be taken when using ton containers to prevent reliquefaction.

Where necessary to meet the operating ranges, multiple units shall be provided for adequate peak capacity and to provide a sufficiently low feed rate on turn down to avoid depletion of the dissolved oxygen concentrations in the receiving waters.

103.42 Mixing Requirements

The dechlorination reaction with free or combined chlorine will generally occur within 15 to 20 seconds. The dechlorination chemical should be introduced at a point in the process where the hydraulic turbulence is adequate to assure thorough and complete mixing. If no such point exists, mechanical mixing shall be provided. The high solubility of SO_2 prevents it from escaping during turbulence.

103.43 Contact Time

A minimum of 30 seconds for mixing and contact time shall be provided at the design peak hourly flow or maximum rate of pumpage. A suitable sampling point shall be provided downstream of the contact zone. Consideration shall be given to a means of reaeration to assure maintenance of an acceptable dissolved oxygen concentration in the stream following sulfonation.

103.44 Standby Equipment and Spare Parts

The same requirements apply as for chlorination systems. See Paragraph 102.46.

103.45 Sulfonator Water Supply

The same requirements apply as for chlorination systems. See Paragraph 102.47.

103.5 Housing Requirements

103.51 Feed and Storage Rooms

The requirements for housing SO_2 gas equipment shall follow the same guidelines as used for chlorine gas. Refer to Paragraph 102.5 for specific details.

When using solutions of the dechlorinating compounds, the solutions may be stored in a room that meets the safety and handling requirements set forth in Section 57. The mixing, storage, and solution delivery areas shall be designed to contain or route solution spillage or leakage away from traffic areas to an appropriate containment unit.

103.52 Protective and Respiratory Gear

The respiratory air-pac protection equipment is the same as for chlorine. See Paragraph 102.56. Leak repair kits of the type used for chlorine gas that are equipped with gasket material suitable for service with sulfur dioxide gas may be used (refer to The Compressed Gas Association Publication CGA G-3-1995, "Sulfur Dioxide"). For additional safety considerations, see Section 57.

103.6 Sampling and Control

103.61 Sampling

Facilities shall be included for sampling the dechlorinated effluent for residual chlorine. Provisions shall be made to monitor for dissolved oxygen concentration after sulfonation when required by the regulatory agency.

103.62 Testing and Control

Provision shall be made for manual or automatic control of sulfonator feed rates based on chlorine residual measurement or flow.

104. ULTRAVIOLET DISINFECTION

104.1 General

Ultraviolet (UV) disinfection process design, operating data, and experience are developed, but design standards are not well established. Expected performance of the UV disinfection units for the full operating range of flow rates shall be based upon experience at similar full scale installations or thoroughly documented prototype testing with the particular wastewater. Critical parameters for UV disinfection units are dependent upon manufacturers' design, lamp selection, tube materials, ballasts, configuration, control systems, and associated appurtenances. Proposals on this disinfection process will be reviewed on a case-by-case basis at the discretion of the reviewing authority under the provisions of Paragraph 53.2.

104.2 Lamp Type

UV disinfection lamps should be low pressure-low intensity, low pressure-high intensity or medium pressure-high intensity.

104.3 Channel Design and Hydraulics

Open channel designs with modular UV disinfection units that can be removed from the flow are required. At least two banks in series shall be provided in each channel for disinfection reliability and to ensure uninterrupted service during tube cleaning or other required maintenance. The hydraulic properties of the system shall be designed to simulate plug flow conditions without short circuiting under the full operating flow range. In addition, water level control shall be provided to achieve the necessary exposure. Also refer to Paragraphs 54.2 and 54.3. Closed chamber units will be reviewed on a case by case basis in accordance with Paragraph 53.2.

104.4 Transmittance

This process should be limited to a high quality effluent having at least 65% UV radiation transmittance at 254 nanometers wave length, and BOD_5 and suspended solids concentrations no greater than 30 mg/L at any time.

104.5 Dosage

The UV dosage shall be based on the design peak hourly flow. As a general guide in system sizing for an activated sludge effluent with the characteristics described in Paragraph 104.4, a UV dosage not less than 30 $(mW \cdot s)/cm^2$ may be used after adjustments for maximum tube fouling, lamp output reduction after 8,760 hours of operation, and other energy absorption losses.

104.6 Operations, Safety and Alarm System

Operator safety (electrical hazards and exposure to UV radiation) and tube cleaning frequency shall be considered. An alarm system shall be provided to separately indicate lamp failure, low UV intensity and any other cause of UV disinfection unit failure.

104.7 Electrical Controls

A programmable logic controller (PLC) shall be provided. Multiple PLCs should be provided as necessary to ensure rapid recovery and minimize the deterioration of effluent quality from the failure of a single controller. An uninterruptable power supply with electrical surge protection shall be provided for each PLC to retain program memory (i.e. process control program, last known set-points and measured process/equipment status etc.) through a power loss. A hard-wired backup for manual override shall be provided in addition to automatic process control. Both automatic and manual controls shall allow independent operation of each UV disinfection unit.

105. OZONE DISINFECTION

Ozone systems for disinfection should be evaluated on a case-by-case basis. Design standards, operating data, and experience for this process are not well established. Therefore, design of these systems should be based upon experience at similar full scale installations or thoroughly documented prototype testing with the particular wastewater.

CHAPTER 110
SUPPLEMENTAL TREATMENT PROCESSES

111. PHOSPHORUS REMOVAL BY CHEMICAL TREATMENT

111.1 General

111.11 Method

Addition of aluminum salts, iron salts, or lime may be used for the chemical removal of soluble phosphorus. The phosphorus reacts with the aluminum, iron, or calcium ions to form insoluble compounds. These insoluble compounds may be flocculated with or without the addition of a coagulant aid (such as a polyelectrolyte) to facilitate separation by sedimentation, or sedimentation followed by filtration.

111.12 Design Basis

111.121 Preliminary Testing

Laboratory, pilot, or full scale studies of various chemicals, feed points, and treatment processes are recommended for existing plant facilities to determine the achievable performance level, cost-effective design criteria, and ranges of required chemical dosages.

The selection of a treatment process and chemical dosage for a new facility should be based on such factors as influent wastewater characteristics, the proposed chemical, effluent requirements, and anticipated treatment efficiency.

111.122 System Flexibility

Systems shall be designed with sufficient flexibility to allow for several operational adjustments in chemical feed locations, chemical feed rates, and for feeding alternate chemical compounds.

111.2 Process Requirements

111.21 Dosage

The design chemical dosage shall include the amount needed to react with the phosphorus in the wastewater, the amount required to drive the chemical reaction to the desired state of completion, including consideration of competing reactions, and the amount required due to inefficiencies in mixing or dispersion. Excessive chemical dosage should be avoided.

111.22 Chemical Selection

The choice of aluminum salts, iron salts, or lime should be based on the wastewater characteristics, chemical availability and handling, sludge processing and disposal methods, 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. Problems associated with lime usage, handling, and sludge production and dewatering shall be evaluated.

111.23 Chemical Feed Points

Selection of chemical feed points shall include consideration of the chemicals used in the process, necessary reaction times between precipitant chemical and polyelectrolyte additions, and the wastewater treatment processes and components utilized. Flexibility in feed locations shall be provided to optimize chemical usage and overall treatment efficiency.

111.24 Flash Mixing

Each chemical shall be mixed rapidly and uniformly with the wastewater flow stream. Where separate mixing basins are provided, they should be equipped with mechanical mixing devices. The detention period should be at least 30 seconds.

When a chemical solution is added on a batch basis to the contents of a secondary cell of a controlled-discharge facultative treatment pond system, a means of adequate dispersal and mixing should be provided, such as an outboard (propeller driven) motorboat.

111.25 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 floc growth, control deposition of solids, and prevent floc destruction.

111.26 Liquid - Solids Separation

The velocity through pipes or conduits from flocculation basins to settling basins should not exceed 1.5 feet per second (0.5 m/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 the criteria outlined in Chapter 70. For design of the sludge handling system, special consideration should be given to the type and volume of sludge generated in the phosphorus removal process.

111.27 Filtration

Effluent filtration, such as with granular media filters or membrane separation technologies, shall be considered in conjunction with chemical treatment where effluent phosphorus concentrations of less than 1 mg/L must be achieved.

111.3 Feed Systems

111.31 Location

All liquid chemical mixing and feed installations should be installed on corrosion-resistant pedestals and elevated above the highest liquid level anticipated during emergency conditions.

The chemical feed equipment shall be designed to meet the maximum dosage requirements for the design conditions.

Lime feed equipment should be located so as to minimize the length of slurry conduits. All slurry conduits shall be accessible for cleaning.

111.32 Liquid Chemical Feed System

Liquid chemical feed pumps should be of the positive displacement type with variable feed rate. Pumps shall be selected to feed the full range of chemical quantities required for the anticipated phosphorus mass loading conditions with the largest unit out of service. Consideration should be given to systems including pumps and piping that will feed either iron or aluminum compounds to provide flexibility. Refer to Paragraph 111.51.

Screens and valves shall be provided on the chemical feed pump suction lines.

An air break or anti-siphon device shall be provided where the chemical solution stream 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.

111.33 Dry Chemical Feed System

Each dry chemical feeder shall be equipped with a dissolver which is capable of providing a minimum retention time of 5 minutes at the maximum feed rate.

Polyelectrolyte feed installations should be equipped with two solution vessels and transfer piping for solution make-up and daily operation.

Make-up 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.

111.4 Storage Facilities

111.41 Size

Storage facilities shall be sufficient to ensure that an adequate supply of the chemical is available at all times. Exact storage size requirements will depend on size of shipment, length of delivery time, and process requirements. Storage for a minimum supply of 10 days should be provided.

111.42 Location and Containment

The liquid chemical storage tank and tank fill connections shall be located within a containment structure that has 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. Refer to Paragraph 57.2.

Auxiliary facilities within the containment area, including pumps and controls, 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 make-up point to avoid unnecessary transportation and housekeeping problems.

111.43 Accessories

Platforms, stairs, and railings shall be provided as necessary, to afford convenient and safe access to all filling connections, storage tank entries, and measuring devices.

Storage tanks shall be provided with reasonable access to facilitate cleaning.

111.5 Other Requirements

111.51 Materials

All chemical feed equipment and storage facilities shall be constructed of materials resistant to chemical attack by all chemicals normally used for phosphorus removal. Refer to Section 57.

111.52 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 shall be given to temperature, humidity, and dust control in all chemical feed room areas.

111.53 Cleaning

Consideration shall be given to the accessibility of piping. Piping should be installed with plugging wyes, tees or crosses with removable plugs at changes in direction to facilitate cleaning.

111.54 Filling Drains and Draw-Off

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. Provisions shall be made in the fill lines to prevent back siphonage of chemical tank contents.

111.6 Safety and Hazardous Chemical Handling

The chemical handling facilities shall meet the appropriate safety and hazardous chemical handling facilities requirements of Section 57.

111.7 Sludge Handling

Consideration shall be given to the type and additional capacity of the sludge handling facilities that will be needed when chemicals are added. Refer to Chapter 80.

112. HIGH RATE EFFLUENT FILTRATION

112.1 General

112.11 Applicability

Granular media filters may be used as an advanced treatment device for the removal of residual suspended solids from secondary effluents. Filters may be necessary where effluent concentrations of less than 20 mg/L of suspended solids and/or 1.0 mg/L of phosphorus must be achieved or to obtain adequate turbidity reduction for urban water reuse. A pre-treatment process such as chemical coagulation, flocculation and sedimentation, or other acceptable process should precede the filter units where effluent suspended solids requirements are less than 10 mg/L.

112.12 Design Considerations

Care should be given in designing pipes or conduits ahead of filter units, if applicable, to minimize shearing of floc particles. Consideration should be given in the plant design to provide flow equalization facilities to moderate filter influent quality and quantity.

112.2 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 inspection or cleaning. Where abnormal quantities of greases or similar solids that result in filter plugging are expected, filters should be of the gravity type.

112.3 Filtration Rates

112.31 Allowable Rates

Filtration rates shall not exceed 5 gpm/sq ft [3.40 L/($m^2 \cdot s$)] based on the design peak hourly flow rate applied to the filter units. The expected design maximum suspended solids loading to the filter should also be considered in determining the necessary filter area.

112.32 Number of Units

Total filter area shall be provided in two or more units, and the filtration rate shall be calculated on the total available filter area with one unit out of service.

112.4 Backwash

112.41 Backwash Rate

The backwash rate shall be adequate to fluidize and expand each media layer by a minimum of 20 percent based on the media selected. The backwash system shall be capable of providing variable backwash rates. Minimum and maximum backwash rates shall be based on demonstrated satisfactory field experience under similar conditions. The design shall provide for a minimum backwash period of 10 minutes.

112.42 Backwash Pumps

Pumps for backwashing filter units shall be sized and interconnected to provide the required backwash rate to any filter with the largest pump out of service. Filtered water from the clear well or chlorine tank shall be used as the source of backwash water. Waste filter backwash shall be adequately treated.

112.43 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 15 percent of the design average daily flow rate to the treatment unit. 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 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.

112.44 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 complete backwash cycles.

112.5 Filter Media Selection

Selection of proper filter media type and size will depend on the required effluent quality, the type of treatment provided prior to filtration, the filtration rate selected, and filter configuration. In dual- or multi-media filters, media size selection shall consider compatibility among media. Media shall be selected and provided to meet specific conditions and requirements relative to the project under consideration. The selection and sizing of the media shall be based on demonstrated satisfactory field experience under similar conditions. All media shall have a uniformity coefficient of 1.7 or less. The uniformity coefficient, effective size, depth, and type of media shall be set forth in the specifications.

112.6 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. If air is to be used for filter backwash, separate backwash blower(s) shall be provided. Provision shall be made to allow for periodic chlorination of the filter influent or backwash water to control slime growth. When chemical disinfection is not provided at the plant, manual dosage of chlorine compounds is acceptable.

112.7 Access and Housing

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. Housing for filter units shall be provided. The housing shall be constructed of suitable corrosion-resistant materials. All controls shall be enclosed and the structure housing filters, controls, and equipment shall be provided with adequate heat and ventilation equipment to minimize problems with excess humidity.

112.8 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. Such proprietary equipment will be reviewed on a case-by-case basis at the discretion of the regulatory agency. Refer to Paragraph 53.2.

APPENDIX
HANDLING AND TREATMENT OF SEPTAGE
AT A
WASTEWATER TREATMENT PLANT

General

One method of septage disposal is the discharge to a municipal wastewater treatment plant. All plants require special design considerations prior to the acceptance of septage.

Definition

Septage is a general term for the contents removed from septic tanks, portable vault toilets, privy vaults, holding tanks, very small wastewater treatment plants, or semi-public facilities (i.e., schools, motels, mobile home parks, campgrounds, small commercial endeavors) receiving wastewater from domestic sources.

Non-domestic (industrial) wastes are not included in the definition and are not covered by this appendix.

Contents from grease traps should not be hauled to most municipal wastewater treatment plants for disposal.

Characteristics

Compared to raw domestic wastewater from a conventional municipal sewer collection system, septage usually is quite high in organics, grease, hair, stringy material, scum, grit, solids, and other extraneous debris. Substantial quantities of phosphorus, ammonia nitrogen, bacterial growth inhibitors, and cleaning materials may be present in septage, depending on the source. Tables No. 1 and No. 2 (Tables 3-4 and 3-8 from the U.S. EPA Handbook entitled "Septage Treatment and Disposal" 1984, EPA-625/6-84-009 reprinted herein) give a comparison of some of the common parameters for septage and municipal wastewater.

Data for local septage to be received should be collected for design of septage receiving and treatment systems. The characteristics of septage should be expected to vary widely from load to load depending on the source.

Treatment

Septage is normally considered treatable at a plant. However, unless proper engineering planning and design is provided, septage may represent a shock loading or have other adverse impacts on plant processes and effluent quality which will be influenced by many factors, including the following:

a. Capacity (mgd) (m^3/d) of the plant relative to the amount and rate of septage directed to the plant;

b. Unused plant capacity available (above current sewer collection system loadings) to treat septage loadings;

c. Sensitivity of the treatment plant process to daily fluctuations in loadings brought about by the addition of septage;

d. Slug septage loadings of BOD, ammonia nitrogen, or phosphorus which may cause process upset, odor nuisance, aeration tank/aerated digester foaming, or pass through to the effluent;

e. The point of introduction of the septage into the plant process. Feasible alternative points of feed to the treatment units shall be evaluated including feed to the sludge processing units provided the unit function will not be adversely affected;

f. The ability to control feed rates of septage to the plant for off peak loading periods; and,

g. The volume and concentrations of bacterial growth inhibitors in septage from some portable vault toilets and recreational dump station holding tanks.

The permitted plant effluent limits shall be considered when evaluating these factors.

Considerations

An adequate engineering evaluation shall be made of the existing plant and the anticipated septage loading prior to receiving septage at the plant. The regulatory agency shall be contacted to obtain the appropriate approvals prior to the acceptance of septage. For proposed plant expansion and upgrading, the Engineering Report or Facility Plan (refer to Chapter 10) shall include anticipated septage loading when addressing treatment plant sizing and process selection. The following items should be included, as appropriate, in the engineering evaluation and facility planning:

a. The uninterrupted and satisfactory treatment (within the plant regulatory limits) of waste loads from the sewer system shall not be adversely affected by the addition of septage to the plant;

b. In general, the smaller the plant design capacity relative to the septage loading, the more subject the plant will be to upset and potential violation of permitted discharge effluent limits;

c. Allocation of organic plant capacity originally planned for future growth;

d. For plants to be expanded and upgraded, the sensitivity of the treatment process to receiving septage and the impact on discharge parameter limits should be jointly considered;

e. An evaluation of available plant operating personnel and the staffing requirements necessary when septage is to be received. Plant staff should be present when septage is received and unloaded. Added laboratory work associated with receiving septage for treatment should be included in the staffing and laboratory facilities evaluation;

f. The space for constructing septage receiving facilities that are to be off-line from the raw wastewater from the sewer system. Other plant activity and traffic flow should be considered when locating the septage receiving facility and the septage hauler unloading area; and,

g. The impact of the septage handling and treatment on the plant sludge handling and processing units and ultimate sludge disposal procedures.

Receiving Facility

The design of the septage receiving station at the plant should provide for the following elements:

a. A hard surface haul truck unloading ramp sloped to a drain to allow ready cleaning of any spillage and washing of the haul tank, connector hoses, and fittings. The ramp drainage shall be tributary to treatment facilities and shall exclude excessive stormwater;

b. A flexible hose fitted with easy connect coupling to provide for direct connection from the haul truck outlet to minimize spillage and help control odors;

c. Washdown water with ample pressure, hose, and spray nozzle for convenient cleaning of the septage receiving station and haul trucks. The use of chlorinated effluent may be considered for this purpose. If a potable water source is used, it shall be protected in accordance with Paragraph 56.2;

d. An adequate off-line septage receiving tank designed to provide complete draining and cleaning by means of a sloped bottom equipped with a drain sump should be provided. The design should give consideration to adequate mixing for testing, uniformity of septage strength, chemical addition (if necessary), for treatability and odor control. The capability to collect a representative sample of any truck load of waste accepted for discharge at the plant shall be provided. The operator shall have authority to prevent and/or stop any disposal that is likely to cause an effluent violation;

e. Screening, grit, and grease removal of the septage as appropriate to protect the treatment units;

f. Pumps for handling the septage should be nonclogging and capable of passing 3-inch (75 mm) diameter solids;

g. Valving and piping for operational flexibility to allow the control of the flow rate and point of septage discharge to the plant;

h. Safety features to protect the operational personnel. Refer to Section 57; and

i. Laboratory and staffing capability to determine the septage strength and/or toxicity to the treatment processes and provisions for operation reports to include the plant load attributed to septage.

TABLE NO. 1*

PHYSICAL AND CHEMICAL CHARACTERISTICS OF SEPTAGE, AS FOUND IN THE LITERATURE, WITH SUGGESTED DESIGN VALUES[a,b]

	United States (5) (9-19)				Europe/Canada (4) (20)					
Parameter	Average	Minimum	Maximum	Variance	Average	Minimum	Maximum	Variance	EPA Mean	Suggested Design Value
TS	34,106	1,132	130,475	115	33,800	200	123,860	619	38,800	40,000
TVS	23,100	353	71,402	202	31,600	160	67,570	422	25,260	25,000
TSS	12,862	310	93,378	301	45,000	5,000	70,920	14	13,000	15,000
VSS	9,027	95	51,500	542	29,900	4,000	52,370	13	8,720	10,000
BOD_5	6,480	440	78,600	179	8,343	700	25,000	36	5,000	7,000
COD	31,900	1,500	703,000	469	28,975	1,300	114,870	88	42,850	15,000
TKN	588	66	1,060	16	1,067	150	2,570	17	677	700
NH_3-N	97	3	116	39	—	—	—	—	157	150
Total P	210	20	760	38	155	20	636	32	253	250
Alkalinity	970	522	4,190	8	—	—	—	—	—	1,000
Grease	5,600	208	23,368	112	—	—	—	—	9,090	8,000
pH	—	1.5	12.6	8.0	—	5.2	9.0		6.9	6.0
LAS	—	110	200	2	—	—	—		157	150

a Values expressed as mg/L, except for pH.

b The data presented in this table were compiled from many sources. The inconsistency of individual data sets results in some skewing of the data and discrepancies when individual parameters are compared. This is taken into account in offering suggested design values.

* Appendix - Table No. 1 including footnotes is taken from the USEPA Handbook entitled "Septage Treatment and Disposal", 1984, EPA-625/6-84-009 and is designated in that document as "Table 3-4".

TABLE NO. 2*

COMPARISON OF SEPTAGE AND MUNICIPAL WASTEWATER[a]

Parameter	Septage[b]	Wastewater[c]	Ratio of Septage to Wastewater
TS	40,000	720	55:1
TVS	25,000	360	69:1
TSS	15,000	210	71:1
VSS	10,000	160	62:1
BOD_5	7,000	190	37:1
COD	15,000	430	35:1
TKN	700	40	17:1
NH_3-N	150	25	6:1
Total P	250	7	36:1
Alkalinity	1,000	90	11:1
Grease	8,000	90	89:1
pH	6.0	—	—
Linear Alkyl Sulfonate	150	—	—

a Values expressed as mg/L, except for pH.

b Based on suggested design values in Appendix - Table No. 1 (USEPA Table 3-4).

c From Metcalf and Eddy, 4th Edition, "medium strength sewage".

* Appendix - Table No. 2 including footnotes is taken from the USEPA Handbook entitled "Septage Treatment and Disposal", 1984, EPA-625/6-84-009 and is designated in that document as "Table 3-8”.