DIVISION OF WASTEWATER MANAGEMENT
DEPARTMENT OF PUBLIC WORKS
CITY AND COUNTY OF HONOLULU

DESIGN STANDARDS

Volume 2

GENERAL REQUIREMENTS FOR WASTEWATER FACILITIES

DESIGN OF TREATMENT PLANTS

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FOREWORD

These standards of design are established as a guide and aid for the design engineer engaged in the design of wastewater treatment and disposal facilities to be operated and maintained by the Division of Wastewater Management, Department of Public Works, City and County of Honolulu. The requirements presented in Chapters 40 through 120 of these standards pertain to municipally-owned wastewater treatment facilities and private facilities intended for dedication to the City and County of Honolulu.

It is not the intent of these standards to restrict the engineer from applying engineering knowledge and experience, or from exercising skill judgment, but rather to standardize major requirements and procedures. Approval by the City shall in no way relieve the design engineer of any responsibilities and obligations. The engineer shall be held responsible for the adequacy of design and accuracy and completeness of the plans and specifications.

Where there is evidence that a wastewater treatment and disposal system is the cause of a water quality problem or a public health hazard, the State of Hawaii Department of Health may impose additional requirements deemed necessary to eliminate the problem or hazard.

Where these standards prohibit or otherwise restrict either the location of or the use of wastewater treatment and disposal methods, materials, or practices, a request for a variance from these standards may be requested from the Director and Chief Engineer of the Department of Public Works, City and County of Honolulu.

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CHAPTER 40

GENERAL REQUIREMENTS FOR WASTEWATER TREATMENT FACILITY DESIGN

40.0 GENERAL

40.1 Purpose of Facility and Design Objectives

The purpose of wastewater treatment facilities is to provide adequate treatment and disposal of wastewater in order to safeguard public health and the environment. It is the goal of the City and County of Honolulu to promote the design and construction of facilities which will ensure that the effluent from the facilities:

1) Does not contaminate or pollute any drinking water or potential drinking water supply, or the waters of any beaches, shores, ponds, lakes, streams, or shellfish growing areas;

2) Does not become a hazard or potential hazard to public health, safety and welfare; and

3) Does not cause nuisances such as odor, noise, unsightly appearance, or other such forms of public impact.

Effective planning and design of wastewater facilities is a necessity in meeting the above objectives. Three critical aspects of wastewater facility design which deserve utmost attention are reliability of performance, operability, and safety.

It is essential to the overall objectives of environmental and public health protection that the design of treatment facilities be reliable. This requires that the design engineer select and design critical treatment processes, tankage, and process equipment for continuous operation, with full consideration of potential equipment breakdowns, electrical outages, process disruptions, etc. As noted in Section 46.2,

compliance with the design intent of the Design Criteria for Mechanical, Electric and Fluid System and Component Reliability of the U.S. Environmental Protection Agency is required of all City facilities.

System and facility operability pertains to the expectation that processes, equipment, and systems be designed with full consideration for all possible operational conditions and be provided with adequate controls, accessibility for maintenance, etc. In particular, the design engineer must address the operational concepts of the system where, because of process or equipment failure, significant changes in conventional operating routine are required. Such considerations would include the installation of standby or spare units, bypasses or other means of readily circumventing equipment or processes out of function, and alternative operational modes that can be employed until normal operations are restored. Considerations associated with operability are generally equally applicable to reliability of facility performance.

Every effort must be made to avoid hazardous working conditions which stem from inadequate lighting, high noise levels, slippery walking surfaces, low head room clearances, exposed moving mechanical elements, and electrical, chemical and fire hazards. No element in the design of treatment facilities shall take precedence over operator safety, and no compromises concerning safeguards should be made.

40.2 Applicability and Scope of Standards

These design standards shall apply to new wastewater treatment facilities and additions or expansions to existing treatment facilities to be operated and maintained by the City and County of Honolulu. Municipal wastewater treatment facilities as well as new privately constructed facilities intended for dedication to the City shall be designed in accordance with these standards. Portions of existing City facilities, for which the addition or expansion is dependent for reliable operation, shall comply with these standards to the degree practicable. Provisions regarding takeover of existing private treatment facilities by the City are addressed in Section 42.7.

40.3 Responsibility of the Design Engineer

The City requires that wastewater facilities to be operated and maintained by the City perform in accordance with the design intent and without excessive and unforeseen manpower, energy, or material expenditures.

The design engineer shall be responsible for demonstrating the adequacy of the facility design and performance. The conditions and requirements for such demonstration shall be developed by the design engineer for each facility design and shall be subject to the approval of the Director. Generally the following will be required:

1) A satisfactory level of performance reliability and stability shall be established over an extended period under operating conditions that closely parallel the design loadings;

2) The period of time necessary to demonstrate stability of performance shall generally be not less than twelve months;

3) Where design-level loadings cannot reasonably be simulated, actual performance shall be extrapolated in a rational manner to project design-level loading performance to the extent practicable;

4) The facility shall be shown to function essentially in conformance with the design intent, as measured by actual operational experience compared with design projections;

5) Should the level of performance be less than the design intent, corrective measures shall be taken to eliminate the observed deficiencies. Such corrective measures shall include redesign and all necessary modifications and construction; and

6) The demonstration period shall not be restricted to the warranty period for manufactured equipment or manufactured systems. It shall be the design engineer's responsibility to provide adequate specifications for equipment performance demonstration.

Wherever possible, the design engineer shall restrict his design to the use of processes, systems, and equipment with a proven record of reliable performance under conditions similar to those expected to be encountered in the proposed facility.

41.0 SUBMITTALS

41.1 General

Design submittals for wastewater treatment facilities shall conform to the requirements and procedures of Chapter 10, "General Requirements," of Volume I of the Division's Design Standards. As specified in Chapter 10, the design engineer shall make the following submittals to the Division for review and approval prior to and during the design stage of the project:

1) Engineering report, including preliminary plans;

2) Environmental documents and applicable comments;

3) Construction plans and specifications; and

4) Cost estimates.

The following subsections address submittal requirements and procedures specifically applicable to the planning and design of wastewater treatment facilities.

41.2 Engineering Report and Facility Plan

For facilities seeking financial assistance through the U.S. EPA Construction Grant Program, a facility plan shall be prepared in accordance to applicable federal regulations. The facility plan shall be supplemented as necessary by preliminary engineering data and information prior to the start of design as required by the Division.

For non-grant projects, a comprehensive engineering report shall be prepared and submitted to the Division. The format and general contents of the engineering report for wastewater treatment facilities shall generally conform to guidelines presented in Appendix A of these standards and with applicable requirements of Section 11, "Engineering Report" of Chapter 10. The comprehensiveness of the report shall be commensurate with the size and complexity of the proposed project. Diagrams and preliminary plans, design calculations, outline specifications of process units, special equipment, unusual construction methods, etc., shall be included as appropriate. It is recommended that design requirements and considerations presented in these standards be reviewed during preparation of the engineering report.

41.3 Construction Plans

The format and general contents of construction plans for wastewater treatment facilities shall conform to applicable requirements of Section 12, "Construction Plans" of Chapter 10. Requirements applicable to the preparation of construction plans for treatment facilities shall conform to Section 12.1 and the following subsections.

41.3.1 General Layout

General plans for the proposed sewage treatment facility shall be submitted showing:

1) Requirements of Section 12.3.1. (Chapter 10);

2) Size and location of proposed and future plant structures;

3) Schematic flow diagram showing the flow through various plant units and elements;

4) Piping, including any arrangements for bypassing individual units, material handled, and direction of flow through pipes;

5) Hydraulic profiles showing the flow of wastewater and recycle flows; and

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

41.3.2 Detail Plans

Detail plans shall consist of the following:

1) Requirements of 12.3.2. (Chapter 10);

2) Location, dimensions and elevations of all existing and proposed plant facilities;

3) Type, size, pertinent features, and rated capacity of all pumps, blowers, motors and other mechanical devices; and

4) Adequate description of any pertinent features not otherwise covered by specifications.

41.4 Other Submittal Requirements and Procedures

Other submittal requirements and procedures applicable to the design and construction of wastewater treatment facilities shall be identical to those in Chapter 10. The following sections of Chapter 10 shall apply:

1) Section 13, Specifications;

2) Section 14.1, Design Calculations;

3) Section 14.2, Revisions to Approved Plans and Specifications;

4) Section 14.3, Operation During Construction;

5) Section 14.4, Record Plans;

6) Section 14.5, Shop Drawings;

7) Section 14.6, Equipment Manuals; and

8) Section 14.7, Facilities Operations and Maintenance Manual.

Requirements for equipment manuals and operation and maintenance manuals are addressed in further detail in Section 47.5 of these standards.

Progress review submittals for design-related documents shall be provided at appropriate completion milestones specified by the Division. Tabulations of detailed design criteria shall be included in the submittals as appropriate. Deviations in the design criteria from those set forth in these standards shall be noted and shall be accompanied by explanatory documentation. Informal submittals may be made, at the discretion of the design engineer, at any point in the design. Informal or partial submittals shall be made as required by the Division.

42.0 REGULATORY REQUIREMENTS, POLICIES AND GUIDELINES

42.1 General

All work shall proceed in conformance with applicable requirements of county, state, and federal agencies. All licenses, permits, authorizations, and other regulatory requirements shall be obtained by appropriate parties and all aspects of planning, design, construction, and operation shall be in full compliance with said requirements.

42.2 Code Requirements, Design Standards, and Design References

The design shall comply with applicable county, state, and federal requirements, including all City ordinances and rules and regulations, statutes of the State of Hawaii, and requirements of the U.S. Environmental Protection Agency and other applicable federal agencies.

The design engineer shall be aware of and comply with all applicable design standards, codes, regulations, and planning documents of the City

and County of Honolulu and the State of Hawaii. These include but are not limited to those documents listed in Appendix B.

The design of wastewater facilities shall also comply with relevant national codes and industry standards as described in Section 46.5 to the extent applicable.

The design engineer shall be responsible for compliance with the most recent edition of the applicable standard, code, regulation, or guideline, as well as any associated amendments, supplements, or policy memos. In addition, the design engineer shall be aware of the development of new standards that may become applicable to wastewater facility design.

Reference to any codes and standards within specific sections of these standards is intended to identify those documents that are most relevant and does not preclude the applicability of other codes and guidelines.

42.3 Effluent Quality and Disposal

Treatment facilities operated and maintained by the City and County of Honolulu shall be designed to comply with all effluent quality requirements promulgated by the State of Hawaii Department of Health (DOH) and the City. Current effluent quality and disposal requirements are addressed in Chapter 100.

As discussed in Section 46.2, the reliability of treatment facilities shall be commensurate with effluent quality requirements and potential adverse impacts on the receiving environment associated with malfunctions in treatment and disposal.

42.4 Sludge Disposal

The disposal of sludge from treatment facilities shall comply with any sludge disposal requirements promulgated by the State of Hawaii Department of Health (DOH) and the City. General sludge disposal requirements are addressed in Section 118.0.

42.5 Temporary Facilities

Where the expected service life of treatment facilities is ten years or less, the provisions of these standards regarding materials of construction, redundant components and equipment, and certain other design requirements relating to long-term reliability, may be waived by the Director. Specific provisions and exceptions applicable to temporary facilities are described in the appropriate sections of these standards.

42.6 Packaged Wastewater Treatment Works

Packaged wastewater treatment works generally refer to plants that are prefabricated or supplied as easily-assembled standard components. Packaged plants, although available in capacities in excess of 1 mgd, are most commonly used for treating flows of less than 50,000 gpd.

Packaged wastewater treatment plants to be maintained and operated by the City may be permitted for temporary facilities and privately constructed facilities dedicated to the City. Packaged treatment facilities, however, will generally not be permitted for facilities with design average flows in excess of 1.0 mgd. The requirements of Chapters 10 through 120 shall apply to packaged treatment facilities, unless waived by the Director.

Underground installation of packaged wastewater treatment facilities, although discouraged, may be acceptable in individual cases. Despite the space saving and aesthetic advantages of underground installation, the primary consideration for acceptance shall be accessibility for operation, maintenance, and monitoring.

Should an underground installation be selected, consideration shall be given to a vault-type facility, where clearance in all directions is provided for process tankage and equipment that require access for maintenance. A maintenance gallery at least 4 feet wide shall surround the process tankage and major pieces of equipment. A clearance of 7 feet above operating walkways (i.e., catwalks across tankage) shall also

be provided. In no case shall any inhabitable building be allowed above the treatment facility. Access hatches, which are large enough to remove equipment from the facility, shall be provided above all equipment not accessible from the maintenance gallery. Ventilation systems for underground installations shall conform to requirements of Section 123.4.

42.7 Takeover of Existing Private Treatment Facilities

At the discretion of the Director, the Department may agree to operate and maintain existing private treatment plants and associated pumping and sewerage facilities serving 10 or more lots in remote areas or 40 or more lots in any area if the facilities are upgraded to conform to Department standards and requirements. Facilities to be taken over shall be in good repair, capable of reliable performance, and have adequate and satisfactory means for disposal of effluent and waste sludge. The rate of infiltration/inflow of the collection system shall not be excessive. The owner shall be responsible for arranging for a detailed engineering evaluation of the facilities to provide the required information as described in Appendix C.

Should the Director agree to accept the facilities based upon the findings and recommendations of the engineering evaluation, the owner shall be required to provide for the engineering and construction services for the necessary corrective, upgrading, or repair work. The owner shall bear all costs associated with the purchase of any required spare parts and materials. Both the design and the completed construction shall be acceptable to the Director.

43.0 BASIS OF DESIGN

43.1 Design Period

In general, treatment plant layout shall be based upon the ultimate service area, or a 50-year design period. Installed units and facilities should be capable of being expanded to accommodate the future

ultimate design flows. Installed treatment units and mechanical equipment shall generally have a capacity suitable for a 20-year design period. Design periods specified by Federal or other legal requirements may be utilized as approved by the Department.

The design period for temporary facilities shall be as approved by the Director.

43.2 Population and Flow Projections

Population projections shall be based on available census data; the extent of existing industrial, commercial, resort, and institutional development; and documented projections for anticipated service area increases throughout the design period. Documentation of the projection shall include reference to all zoning ordinances, sewerage system planning, and other relevant development planning documents addressing the design service area.

Design average, maximum, and peak wastewater flows shall be determined in accordance with Section 22, "Quantity of Wastewater," in Chapter 20 of Volume I. Design flows for wastewater treatment facilities shall be modified as appropriate and as approved by the Division based on field monitoring data for existing service areas, anticipated changes in wastewater generation patterns, and the performance related impacts of significant flow variations. Flow variations stemming from diurnal variation, seasonal variation, and variations due to nondomestic consumption and influent pump cycling shall be carefully evaluated and documented. In evaluating field monitoring data, pump cycling effects, and impacts to downstream treatment units, definitions for the design flows specified in Chapter 20 of Volume I shall be expanded as follows:

1) "Design average flow" shall mean the average wastewater flow rate during a 24-hour period or shorter significant period during a prolonged period of dry weather.

2) "Design maximum flow" shall mean the highest average wastewater flow rate during a 1-hour period during a prolonged period of dry weather.

3) "Design peak flow" shall mean the highest instantaneous wastewater flow rate during a prolonged period of wet weather.

Wastewater flow rates in the above definitions shall be the flow rates downstream of influent pumping facilities whenever such facilities are employed.

43.3 Waste Characterization

Determination of wastewater strengths and characteristics shall be based on field sampling and monitoring data for existing service areas, allowances for anticipated changes in existing service areas, and allowances for contributions from new service areas. The allowances for newly-served domestic contributors shall be not less than:

Biochemical Oxygen Demand (BOD_5): 0.20 pounds per capita per day

Suspended Solids (SS): 0.20 pounds per capita per day

Projected nondomestic waste characterization shall be estimated based upon the nature of the projected commercial/industrial developments and estimates of water usage and process requirements.

The influent wastewater characterization (IWWC) should include evaluation and quantification of wastewater BOD_5, SS, temperature, pH, and constituents such as chlorides, nitrogen, phosphorus, and sulfides. Whenever possible, septicity of influent waters shall be analyzed by sampling. The IWWC program shall be subject to approval by the Director prior to implementation. A report on the findings of the IWWC program shall be submitted to the City no later than two months after completion of sampling and analyses.

Waste characterizations shall consider the anticipated degree of waste load variations and the potential impact of such variations on treatment facility performance.

43.4 Development of Process Design Criteria

43.4.1 Modeling

Pilot-scale, benchscale, and other detailed process modeling techniques may be utilized to support process selection and/or to assist in the development of process design criteria. Where sufficient doubt exists concerning either process selection or process design criteria, the Director may require that such modeling studies be conducted as a condition of Division approval.

Modeling studies shall be designed to provide the required information and data for an appropriate range of simulated process loading conditions. Applicable scale-up factors shall be fully considered in any modeling studies.

43.4.2 Analogy

Data from similar operating full-scale installations may be used to develop design criteria. The validity of the analogy with respect to all critical process variables and conditions of service shall be fully demonstrated.

43.5 Hydraulic Capacity

The overall hydraulic design of wastewater treatment facilities shall ensure the capability of continuous operation, without flooding or overflows, throughout the full range of operating conditions.

A hydraulic profile of the flow through the treatment facility shall be prepared on the basis of design peak flow, realistic estimates of all

recycle flows, and with consideration of process units out of service. The maximum hydraulic capacity of each hydraulic element in the flow profile shall be included on the hydraulic profile.

The hydraulics for the projected ultimate peak flows shall be considered in conduit design and arrangement as appropriate. The collection system tributary to the treatment facility shall remain free of surcharge under all conditions. For design purposes, the level in the receiving waters shall be based on the regulatory flood or wave action condition.

Where multiple flow configurations are possible, calculations shall be prepared on the basis of the more critical hydraulic routing. Hydraulic calculations shall also consider surface deterioration and increases in friction losses resulting from aging of conduits and channels.

Where pumping units are incorporated in the treatment facility, the maximum control-permissible output of the pumping system may override the calculated peak gravity flow; in such cases, this output shall form the basis of hydraulic computations.

The design of wastewater conveyance piping and conduits shall conform to the requirements described in Chapter 120.

44.0 TREATMENT FACILITY SITE SELECTION

44.1 Site Selection Requirements and Considerations

The following factors shall be considered in the selection of a treatment facility site:

1) Proximity of residential areas;

2) Direction of prevailing winds;

3) Accessibility by all-weather roads;

4) Availability of land area;

5) Local soil characteristics, geology, and topography;

6) Accessibility and suitability of surface and subsurface receiving waters (or effluent disposal sites) and sludge disposal sites;

7) Compatibility of treatment process with present and planned future land use; and

8) Location with respect to flood plain.

Wastewater treatment facilities shall be excluded from areas where such use is inconsistent with the Comprehensive Zoning Code (CZC). The location of treatment facilities shall not be contrary to the locations fixed for utilities by the City and County of Honolulu General Plan and/or Development Plan, or for treatment facilities by the Water Quality Management Plan for the City and County of Honolulu (208 Plan).

In general, wastewater treatment facilities shall be sited as far from existing or potential residential developments as practical and in such a manner as to minimize the potential nuisance impacts upon neighboring areas. Impacts to be considered shall include odors, noise, excessive traffic, and visual appearances.

Buffer zones, compatible use of adjacent land and/or screening shall be provided as necessary.

44.2 Flood Protection

The design engineer shall utilize appropriate regulatory flood (or wave action) elevations in the design of treatment facilities. The latest flood zone map shall be consulted. All treatment facility structures and electrical and mechanical equipment shall be adequately protected from physical damage by flooding. All reasonable efforts shall be taken to site treatment facilities above the flood zone. Ground level floors

of at-grade buildings should be a minimum of one foot above the regulatory flood level.

45.0 SITE IMPROVEMENTS

45.1 Grading and Storm Drainage

Wastewater treatment facility sites shall be properly graded and provided with adequate drainage facilities to convey surface runoff off and away from the site. Adjacent properties shall not be jeopardized by such provisions and surface runoff shall in no event be discharged into process tankage.

45.2 Driveways and Parking Areas

Paved driveways, access roads and parking areas shall be provided as necessary. Driveways shall be a minimum of 12 feet wide and suitable for heavy vehicular traffic.

45.3 Fencing and Security

For protection against vandalism or other unauthorized intrusions, treatment facility sites shall be provided with fencing or other suitable enclosures. Six feet high chain link fence of substantial corrosion resistant material should be provided. If architectural or the Comprehensive Zoning Code (CZC) dictates, masonry walls or other approved types of enclosures may be provided or fences may be screened with landscaping.

Where aluminum chain link fences are used, the wire fabric shall be 9 gauge minimum and the fence post shall be anodized. In suspected corrosive areas, corrosion protection or additional thickness shall be provided.

In isolated areas, three strands of barbed wire should be installed along the top of the fence on an arm projecting inward at an angle of 45°.

A minimum 1 foot wide gravel strip shall be provided under fencing. The gravel strip shall be contained with redwood headers.

Gates shall be provided with padlocks. For City facilities, padlocks shall be keyed to the Division of Wastewater Management master keying system. Gates shall be designed for safe opening and closing during strong winds.

45.4 Utilities

All treatment facilities shall be provided with a potable water or potable/recycled wastewater system to supply water for sanitary fixtures, grounds irrigation, and other maintenance and process related purposes. The main potable water supply line shall be metered and provided with a master valve and a suitable backflow prevention apparatus near the treatment facility entrance. Water supply requirements are addressed in further detail in Section 123.9.

Electrical service requirements are addressed in Section 122.0.

Telephone service shall be provided at all facilities. Trunk lines, distribution terminals, and network layout should be designed to permit future off-site telemetered signal transmission if such transmission capabilities are not included in the present design.

Natural gas service shall be provided as necessary and available.

45.5 Landscaping and Irrigation System

Landscaping plantings should not be extensive except where necessary to provide a visual buffer. Plantings should be of varieties requiring minimal maintenance. Trees shall be selected and positioned to eliminate potential root-intrusions into pipes and tankage and to avoid nuisance due to falling leaves. Seeded areas should be minimized to reduce maintenance requirements and be fully accessible to mechanical mowing equipment. Inaccessible areas should be provided with a weed-retardant subgrade and overlain with crushed stone or coral.

Adequate automatic sprinkler systems should be installed as necessary for watering the grounds of wastewater treatment facilities. Requirements for irrigation piping systems are addressed in Section 123.9.

46.0 GENERAL DESIGN REQUIREMENTS AND CONSIDERATIONS RELATED TO RELIABILITY

46.1 General

A primary objective of these standards is to promote the design of wastewater treatment facilities exhibiting a high degree of reliability. The following subsections address general requirements and considerations associated with treatment facility reliability. Specific requirements related to process and equipment reliability are included throughout the remaining chapters of these standards. It should be noted that the reliability of any treatment facility is closely linked with operation and maintenance. General design requirements and consideration related to operation and maintenance are addressed in the next section.

Reliability is a measure of the ability of a system or component to perform its designed function continuously without failure. Failure shall mean, for the purpose of these standards, any discontinuity in system or component performance which results in violation of any established regulatory effluent limitation or creation of a public health hazard due to discharge of inadequately treated wastewater. In general, fluid, mechanical, and electrical equipment components shall be designed for a level of performance reliability consistent with that required for the overall system. Primary consideration shall be given to elimination of discontinuities in service and adverse consequences stemming from power outages.

46.2 Reliability Classes and General Redundancy and Standby Requirements

Minimum standards for system and component reliability for facilities seeking financial assistance through the U.S. EPA Construction Grants Program are established by the EPA document entitled Design Criteria for

Mechanical, Electric, and Fluid System and Component Reliability. All facilities, regardless of the method of funding, shall generally comply with minimum requirements of this document. The majority of the provisions of the EPA document, including the facility reliability classification system, have been incorporated into these standards.

The wastewater treatment facility classifications described below shall be utilized to determine the appropriate reliability classification of a treatment facility. The classification guidelines are based on EPA reliability classifications and the classification system of state waters and water uses contained in Chapter 54, "Water Quality Standards," of Title 11, Administrative Rules of the State Department of Health.

46.2.1 Reliability Class I

Reliability Class I treatment facilities shall include facilities discharging to receiving waters or other environments which could be permanently or unacceptably damaged by short-term effluent quality degradations lasting on the order of a few hours. Reliability Class I facilities shall include facilities, which upon failure, would result in a threat to public health or cause discharge or diversion of effluent to inland waters, embayments, Class AA marine waters, and Class I marine bottom ecosystems. Facilities discharging to injection wells and effluent reclamation systems shall be classified as Reliability Class I, except as otherwise approved by the Director.

46.2.2 Reliability Class II

Reliability Class II treatment facilities shall include facilities discharging to receiving waters or other environments which would not be permanently or unacceptably damaged by short-term effluent quality degradations, but could be damaged by continued degradations lasting on the order of several days.

Reliability Class II facilities shall generally include all facilities with outfalls discharging to Class A open coastal waters and Class II marine bottom ecosystems which are not otherwise classified as Reliability Class I.

46.2.3 Reliability Class III

Reliability Class III Treatment facilities shall include facilities not otherwise classified as Reliability Class I or Class II.

The above classifications of treatment facilities, which shall apply to all facilities, may vary depending on the size of facility and degree of treatment provided. The selected reliability class shall be as approved by the Director.

Determination of process unit and component redundancy and standby shall, where applicable, be based on requirements presented throughout the remainder of these standards. Redundancy and standby requirements in these standards are generally referenced to the three reliability classes of wastewater treatment facilities. Unless identified as applying to a particular reliability class, all criteria presented in these standards shall apply equally to all three classes. Where redundancy and standby criteria are undefined or insufficient, the Director shall have the discretion of specifying additional criteria as the impact of malfunction so warrants.

46.3 Continuity of Service

The hydraulic capacity of all treatment facilities shall be assured under all conditions, including loss of normal power supply, equipment failure, and circumstances requiring either equipment or unit processes to be taken out of service. The hydraulic capacity shall be assured through the provision of alternative power supply, redundant equipment and processes, bypasses, and flow containment measures, or various combinations of the above measures.

Measures to assure continuity of critical utility services shall be considered in the design of all treatment facilities. These services include electrical supply, potable water supply, telephone service, and gas supply, as applicable. The history and experience with disruptions in the supply of these utilities should be examined and, where necessary, measures shall be taken to minimize or eliminate possible adverse consequences. Standby power shall be provided as specified in Section 122.2.

Where applicable, wastewater treatment facilities shall be provided with a controlled diversion channel or pipe sized to handle peak wastewater flow. Actuation of the controlled diversion should be by gravity overflow. The overflow elevation shall be such that the maximum feasible storage capacity of the wastewater collection system will be utilized before the controlled diversion will be initiated. The controlled diversion flow shall be screened to remove large solids unless the wastewater flow has been previously screened. Controlled diversions shall be alarmed and annunciated, and the flow measured and recorded.

46.4 Treatment Unit Bypassing

The design of wastewater treatment systems shall include provisions for bypassing around each treatment unit operation, except as follows. Unit operations such as sedimentation and activated sludge, which employ two or more large open basins, shall not be required to have provisions for bypassing if the design peak wastewater flow can be handled hydraulically with the largest flow capacity unit out of service. Except as otherwise noted in these standards, all other unit operations with three or more units shall not be required to have provisions for bypassing if the design peak wastewater flow can be handled hydraulically with the two largest flow capacity units out of service.

46.5 Codes and Industry Standards

Wastewater treatment facilities, particularly equipment and associated systems and appurtenances, shall be designed and specified to be in

compliance with all applicable codes and with industry accepted standards and conventions. National codes, industry standards, and standard references listed in Appendix D shall be fully considered and, wherever applicable, supplemented or amended by local requirements and guidelines.

46.6 Materials of Construction

It is the responsibility of the design engineer to assure that all materials of construction are suited to the expected conditions of service. The design engineer shall be aware of accelerated materials deterioration resulting from the normally harsh environment of treatment facilities acting in conjunction with potentially corrosive local conditions. Durability and suitability of materials for the expected application should generally take precedence over initial cost considerations in the selection of materials.

Utilization of corrosion resistant materials is recommended. Where protective coatings are employed, their selection shall be on the basis of suitability for the expected conditions of service. Surface preparation requirements and methods of application shall be specified for protective coatings.

The selection of construction materials for all equipment shall receive full consideration with regards to the severity of duty and the adverseness of the service environment. Both moving and stationary elements shall be designed to resist deterioration, abrasion, and chemical and electro-chemical corrosion. Specifications covering supplied equipment shall indicate the conditions of service as they apply to the operating environment. Extreme ranges of the service and environmental conditions shall be presented in the specifications in order to assure equipment supplier awareness. Special consideration shall be given to proper selection of materials for equipment, piping, storage tanks, and appurtenances that may handle or be exposed to hazardous or corrosive chemicals.

Where contacting surfaces are subject to wear, the wearing surfaces shall, where feasible, be of such materials that one wearing surface will be sacrificial. The sacrificial wearing surface shall be readily replaceable.

Requirements related to materials of construction for buildings, tankage, and other structures are addressed in Section 123.2. Materials of construction for specific treatment facility components and appurtenances are addressed as appropriate throughout these standards.

46.7 Unit Responsibility and Installation of Equipment

Where possible, operating systems shall be specified as a complete system furnished by one manufacturer in order to assure compatibility of operating components.

All major mechanical/electrical equipment and systems shall be installed either under the supervision or the explicit instruction of the manufacturer or his representative. The initial testing and operation of the equipment shall be supervised by a qualified representative of the manufacturer. The representative shall certify that the installation is acceptable and operable in all respects and without qualification, or shall otherwise supervise the remedy of any deficiencies.

46.8 Spare Parts

A list of spare parts for all equipment shall be specified. The inventory shall be adequate to cover reasonable consumption and replacement for at least one year of operation. In addition, because of the difficulty and time involved in parts supply, any equipment considered critical to the continuous satisfactory operation of the facility shall be protected by a suitable supply of spare equipment and emergency parts.

46.9 Unproven Equipment

Process components should be selected based upon a demonstrated history of reliable performance. Where new or innovative equipment is proposed for use without being supported by a past record of reliable and satisfactory performance under comparable service conditions, the Director may require that either conventional backup equipment be installed or that provisions be included in the design to permit future replacement with conventional equipment.

47.0 GENERAL DESIGN REQUIREMENTS AND CONSIDERATIONS RELATED TO OPERATION AND MAINTENANCE

47.1 General

Ease of operation and maintenance shall be a principal factor in the design of wastewater treatment facilities. The following subsections address general requirements and considerations related to the operation and maintenance of facilities.

The following requirements and consideration are general in nature. Specific provisions, where applicable, are included in Chapter 120 and in other chapters of these standards. It may be noted that previous discussions addressing reliability are also applicable to the subject of facility operation and maintenance.

47.2 Operational Flexibility

Treatment facility reliability and ease of operation and maintenance shall be enhanced wherever practicable by providing facilities with a high degree of operational flexibility. All units and plant components, including process and auxiliary units and mechanical equipment, shall be arranged for maximum flexibility in operations. Arrangement and configuration shall permit ready transfer to alternative operating modes in the event of equipment or process outages.

The operational flexibility of any system, as measured by the system's ability to provide satisfactory operation over the complete range of expectable conditions, shall not be impaired by the lack of versatility or control of any component part of the system. Each feature of the design shall be examined as an integral part of the overall system, with all appropriate controls, arrangements, and flexibility designed to meet the requirements of both the equipment and the system.

47.3 Operating Schedule and Personnel Staffing

Plant design shall consider the intended basis of operation. Normally, plants less than 1.0 mgd in size may have the bulk of the required active operational measures performed within a five-day, single-shift time frame. These active operational measures would include such items as sludge dewatering, treatment process adjustments, pumping adjustment, and fine tuning of controls. Beyond this limited time frame, most plants would be attended, but may not be staffed for intensive operations. In the design of small facilities, limitations in process selection, the level of operational complexity, and process sensitivity shall be fully considered by the design engineer.

Plants larger than 1.0 mgd should normally be staffed for active operations seven days per week. Active operational measures should normally be limited to one shift per day, except with systems such as mechanical sludge dewatering, where processing may be extended to two shifts per day for some portion of the work week.

Facility design shall consider both the capabilities of operational personnel and the expected level of facility staffing. The design engineer shall address both the complexity of the process and the complexity of the operations required by the process. The design engineer shall present initial recommendations concerning plant staffing to the Division at the time of plan approval.

47.4 Automation and Instrumentation

Systems should be wired and instrumented for automatic or semi-automatic operation whenever performance can benefit, manpower requirements can be reduced, technology is proven, and overall cost effectiveness is clearly evident. The availability of capable maintenance and repair technicians, however, shall be considered in the application of all control and instrumentation systems.

Plant operating personnel shall have access to all input data and performance data necessary to make operational decisions. Such data shall include but are not limited to flow measurements, pressure and temperature measurements, running time recorders, power consumption readings, and level information. As a minimum, any process data essential to rational process control shall be indicated. Where historical data can be used in process operations, such data shall be recorded as well as indicated.

In larger facilities, consideration shall be given to centralized data collection and centralized operational control systems. Utilization of microprocessors and hard disc storage shall be considered to facilitate collection, storage and retrieval of data.

Centralized control and alarm information shall be telemetered to regional facilities as required by the Director.

Provision of facilities to allow interfacing with a centralized mainframe computer to access preventive maintenance, equipment history, and inventory data shall be discussed with the Director.

Control systems and instrumentation shall be designed in accordance with additional requirements presented in Section 122.5.

47.5 Equipment and O&M Manuals

The manufacturer's equipment manual or other appropriate detailed operations and maintenance instructions shall be furnished with all

equipment. These instructions shall be in the form of a manual and shall contain clear and concise information. The following items, as a minimum, shall be included as applicable:

1) Parts list (including description, part number, quantity, etc.);

2) Manufacturer recommended spare parts;

3) Cross sectional/cut away drawing;

4) Exploded view drawing;

5) Dimension prints;

6) Circuit diagram (elementary, one line, connection, interconnection, list of abbreviations);

7) Operation and maintenance instructions (including time intervals and glossary of terms);

8) Lubrication instructions (including types of lubricant and frequency);

9) Assembly and disassembly instructions;

10) Calibration instructions;

11) Installation and removal instructions;

12) Troubleshooting and repair instructions;

13) Special tools required;

14) Safety instructions;

15) Warranty (including limitation of liabilities and return of equipment fees); and

16) Estimated equipment cost and replacement requirements under normal usage (for equipment replacement planning and funding purposes).

In general, all equipment shall be furnished with adequate technical information (wiring diagrams, operating pattern, parts list, etc.) to permit servicing by personnel on Oahu. Parts listings shall be referenced to generic equivalents (OEM part number) as appropriate. Equipment manual materials shall be provided in a loose leaf binder with appropriate indexing and tabs. Irrelevant material shall be crossed out or otherwise omitted.

An Operations and Maintenance (O&M) manual shall be furnished for all facilities. The scope of the manual should be determined on the basis of plant size and complexity. In general, the manual shall cover:

1) Operation and maintenance instructions for each treatment unit or process under normal conditions, subnormal or alternate operational modes, and emergency conditions of power outage or equipment malfunction;

2) Control parameters for the treatment system and subsystems;

3) Troubleshooting, corrective, and preventive measures to be taken to maintain process control and treatment performance;

4) Equipment operating, repair, safety, and preventive maintenance measures and requirements;

5) Process and performance sampling and testing procedures;

6) Special requirements for operation and maintenance of the effluent disposal system (i.e., method and frequency of injection well rehabilitation); and

7) Manpower requirements.

The O&M manual shall address the full range of possible operating conditions, including those varying substantially from design level conditions. The content, format and level of detail of each manual shall be discussed with the Director prior to its development. The O&M manual should be updated after approximately one year of operation of the facilities.

47.6 Accessibility, Materials Handling and Equipment Removal

In the layout and design of facilities, all aspects related to accessibility, materials handling, and equipment removal shall be given full consideration to promote ease of operation and maintenance and personnel safety. Requirements and considerations related to this area of facility design are addressed in Section 123.0.

47.7 Washdown Facilities and Building and Tank Drainage Provisions

Requirements and considerations for washdown facilities and building and tank drainage are addressed in Section 123.0.

47.8 Monitoring

47.8.1 Sampling

Provisions shall be included in all facilities for the collection of representative wet stream samples for analysis of both plant and process performance.

Sampling for plant performance shall, as a minimum, include plant influent and effluent sampling. Plant performance sampling shall generally be accomplished by automatic samplers capable of accommodating 24-hour compositing and being paced by an appropriate flow measurement signal to allow compositing in proportion to flow. Sample preservation by refrigeration shall be required for all automatic samplers. Sampling locations shall be selected to eliminate any potential interference from sidestreams.

Process performance sampling should generally be by manual means except where continuous and automatic sampling is considered critical to operational performance. Where sludge processing or other recycle streams can be expected to have a major impact upon plant performance, automatic process performance sampling should be considered.

Representative sampling stations or facilities shall be provided for all unit process influents, removed or captured material (such as sludge), and unit effluents (or recycles). Conveniently located sampling ports shall be installed in tankage or piping as appropriate and as required by the Division.

47.8.2 Laboratory Facilities

Except as otherwise approved by the Director, all treatment facilities shall be provided with the necessary laboratory facilities to conduct routine analytical determinations and operating control tests. The extent of onsite laboratory facilities required will be dependent on the availability of offsite laboratory facilities and personnel. For treatment facilities operated and maintained by the City, the extent of onsite facilities to be provided shall be coordinated with the Division for compatibility with Division operations.

Recommended guidelines for wastewater treatment plant laboratory facilities are included in Appendix E.

47.9 Sanitary and Personnel Facilities

Wash and toilet facilities shall be provided at all treatment plants. Shower and locker facilities shall be provided at plants larger than 0.1 mgd and at smaller plants where required by the Director. Separate male and female facilities shall be provided as required by Chapter 11, "Sanitation" of the DOH Title 11, Administrative Rules and by applicable

federal and local equal opportunity regulations. Sanitary facility provisions for handicapped personnel shall conform to building code requirements. Eating rooms shall be located to minimize exposure to pathogens, injurious dust, and toxic materials.

47.10 Administration Facilities

The extent of facilities for administration to be provided for treatment facilities operated and maintained by the City shall be evaluated on a case-by-case basis by the Division.

47.11 Maintenance Facilities

Onsite maintenance facilities shall be sufficient to permit routine maintenance and light overhauling of equipment. The amount of maintenance area provided shall be adequate for the size and complexity of the treatment plant and shall be based on input by Division personnel.

The extent of onsite facilities for heavy equipment maintenance will be dependent on the availability of offsite facilities and personnel. For treatment facilities operated and maintained by the City, the extent of onsite heavy maintenance facilities to be provided shall be coordinated with the Division for compatibility with Division operations.

Where extensive, sophisticated, or extraordinary service and maintenance requirements are anticipated, the design engineer shall provide recommendations to the Division regarding the possible use of special contract services. Such contract services may be necessary with certain instrumentation systems, electrical equipment, and specialized process equipment.

47.12 Tools and Maintenance Equipment

Special tools required for operation, maintenance, adjustment, disassembly, or lubrication shall be furnished with the equipment.

A reasonable complement of conventional tools and equipment necessary for servicing and maintenance of all process and auxiliary equipment shall be provided. Lawn and grounds maintenance equipment shall also be provided as necessary. A general listing of typical conventional tools and equipment is included in Appendix F. For facilities to be operated by the City, the Division shall be consulted for detailed recommendations regarding the number, size and type of tools and equipment to be provided for the specific project.

Safety equipment requirements are addressed separately in Section 123.14.

48.0 SAFETY REQUIREMENTS AND CONSIDERATIONS

Adequate provisions shall be included in the design of all wastewater treatment facilities to minimize exposure of facility personnel and visitors to safety hazards. Treatment facilities shall be designed in full compliance with the Occupational Safety and Health Standards of the State of Hawaii Division of Occupational Safety and Health (DOSH). Pertinent safety requirements and considerations, many of which are universally applicable, are primarily addressed in appropriate sections of Chapter 120.

49.0 MISCELLANEOUS DESIGN REQUIREMENTS AND CONSIDERATIONS

49.1 Influent Pump Station

Treatment facility influent pump station design shall generally conform to the requirements set forth in Chapter 30, "Design of Wastewater Pump Stations," of Volume I. Special consideration shall be given to the minimization of flow fluctuations to downstream treatment units by the use of multiple pumping units and/or variable speed drives.

49.2 Flow Splitting

The design of flow splitting facilities shall provide proper hydraulic distribution of both flow and solids.

49.3 Odor Control

Control of odors shall be thoroughly investigated in the design of all wastewater treatment facilities. Analyses shall be conducted to evaluate septicity of influent wastewaters and the potential for in-plant generation or release of odorous compounds. Consideration shall be given to minimization of odor generation caused by prolonged hydraulic and solids detention and by putrefaction of accumulated solids on exposed surfaces. Potential odor generation by solids processing units such as thickeners, anaerobic digesters, heat-treatment units, incinerators, and drying beds shall be evaluated. In the evaluation of odor control requirements, the existing and future sensitivity of surrounding areas to odors shall be evaluated. Uncertainties of the severity of impact shall be resolved in favor of implementing odor control options.

Odor generation shall be mitigated as necessary by chlorination or addition of other chemicals, aeration, use of covers and enclosures, and treatment of foul air. Masking compounds shall not be considered as an effective means of controlling odors.

Special consideration shall be given to containment, collection, and treatment of foul air and vapors at such locations as wet wells, scum wells, grit and sludge storage tanks, thickeners, dewatering equipment, and septage receiving stations. Treatment of collected foul air may be by wet scrubbing, incineration, oxidation, or adsorption. All facility designs, as a minimum, should include provisions for the installation of future hydrogen sulfide air stripping, chemical oxidation, or chemical precipitation facilities. Air-stripping facilities may be designed for integration with preaeration, aerated grit removal, or flow equalization facilities.

Methods and components to be utilized for control of odors shall generally have been tried and proven in full-scale installations. Pilot-scale tests shall be conducted as necessary and where practicable.

49.4 Architectural Design

Administrative and service buildings and other superstructures should be designed primarily on the basis of function. Aesthetic presentation should be secondary to simplicity, ease of maintenance, and accessibility. Such factors as surrounding land use, plant visibility, and regulatory requirements may dictate the degree of aesthetic concern. Architectural design shall be rendered by a registered architect whenever deemed necessary by the Director.

49.5 Provisions for Facility Expansion

Site arrangement as well as system and equipment layouts shall consider future facility expansion requirements. Design of existing facilities should facilitate addition of and connection to future units and appurtenances. Provisions should include such items as plugged stubs in buried piping, blind flanges on force mains and suction header piping, installed splitter and junction boxes, and open construction joints for future adjacent structures. Roadway layouts, piping runs, electrical conduit routing, etc. should be routed to avoid potential conflicts with future construction.

The above requirements for future facility expansion do not apply to temporary plants except that piping should be arranged to facilitate connection to a future collection system.

49.6 Innovative and Alternative Technology

The best practicable and proven technology available shall be utilized to the extent possible. Where innovative technology is proposed, substantial and positive evidence shall be presented to assure that any potential risk of process or system failure has been eliminated to a reasonable extent. Such assurances might be in the form of extensive pilot and model studies. Unavoidable risks shall be reasonable with respect to the benefits to be derived.

The use of alternative technology, referring to fully proven methods providing for reclamation and reuse of effluents, elimination of point source pollutant discharges and/or the recovery of energy is encouraged.

49.7 Reuse and Reclamation

It is the firm position of the City to encourage the reuse of wastewater effluent and wastewater sludges to the maximum extent feasible. The potential for reuse should be investigated and addressed in all treatment facility planning and design. In those cases where reuse is not currently feasible and therefore not a part of the design, provisions should be included as necessary to keep future reuse options open.

Effluent and sludge reuse requirements are addressed in detail in Chapters 100 and 110 respectively.

49.8 Energy Conservation

Energy-efficient wastewater treatment processes, systems, and equipment shall be selected wherever they are found to be cost effective. Selection of wastewater and sludge processing methods and technology should be conducted with utmost care due to the potential for realizing substantial reductions in energy consumption. Within the framework of a given process, individual equipment and systems may also exhibit considerable variations in energy consumption. Other factors being equal, the most energy-efficient equipment should be selected.

Utilization of energy-recovering or energy-producing systems are encouraged. Systems employing such technology as methane-to-energy from anaerobic digestion, effluent heat recovery utilizing heat pumps to preheat sludges for heat treatment systems, and waste heat boilers/steam engine energy recovery from incineration of sludge or sludge/solid waste mixtures should be considered.

CHAPTER 50

PRELIMINARY TREATMENT

50.0 GENERAL

50.1 Function and General Process Types

Preliminary treatment refers to those processes which provide initial treatment of wastewater at the plant headworks. The principal function of preliminary treatment unit processes such as screening, comminution, and grit removal is to remove equipment-impairing materials from the wastewater. Various preliminary treatment processes may also be provided to enhance the efficiency of subsequent treatment units and to control odors. Preaeration and addition of chemicals such as chlorine and hydrogen peroxide may be employed to assist in the removal of grease, to freshen the wastewater, and to help control odors resulting from septic wastewater. Equalization facilities are utilized to dampen diurnal flow variations and to equalize hydraulic and mass loadings on downstream unit processes.

50.2 Flow Splitting and Hydraulic Considerations

The design of flow splitting facilities for preliminary treatment units shall assure accurate flow and solids distribution.

Certain preliminary processes may cause substantial variations in hydraulic gradients, thereby impacting upstream open-channel metering systems. Such variations in hydraulic gradients shall be examined in the design analyses and shown in the hydraulic profile on the contract drawings.

Where influent pumping is employed, the design of preliminary treatment units shall consider the range of flows and load fluctuations caused by pump cycling.

50.3 Odor Control

The extent of odor control facilities required at the headworks shall be based on an evaluation of the sensitivity of areas near the plant and the anticipated degree of in-plant release of odorous compounds (see Section 49.3).

All facility designs should consider the installation of hydrogen sulfide air stripping facilities. Air-stripping facilities may be integrated with preaeration, aerated grit removal, or flow equalization units. Installation of pre-chlorination facilities (see Section 55.0) and/or hydrogen peroxide or other chemical addition facilities should be also considered for the control of odor.

51.0 COARSE SCREENING DEVICES

51.1 Applicability and Types

Protection of in-plant pumps and process equipment shall be provided by coarse screening devices which intercept and remove oversized material from raw wastewater. Coarse screening should generally be accomplished by mechanically or manually cleaned bar screens. Comminution-type equipment that intercept, shred, and return material to the flowstream are addressed in Section 52.0.

51.2 Locations

Bar screens shall be located ahead of grit removal, preaeration and equalization tanks. Where practicable, bar screens should also be located ahead of raw wastewater pumps and meters.

51.3 Redundancy and Standby Provisions

A standby bar screen shall be provided at all facilities. The use of a standby bar screen designed for manual cleaning only may be permitted where approved by the Director. The above requirements shall apply to Reliability Class I, II, and III facilities.

51.4 Hydraulic Requirements and Considerations

51.4.1 Flow Distribution

Entrance channels shall be designed to provide equal and uniform distribution of flow to the screens. In mechanically cleaned bar screen installations with a manually cleaned backup screen, any hydraulic bias in the flow path shall favor the mechanically cleaned units.

51.4.2 Flow Capacity

Bar screening facilities shall be designed to allow any unit to be taken out of service without sacrificing the capabilities to handle the design peak flow and without adversely impacting channel hydraulics.

51.4.3 Flow Velocity

Channel approach velocities should be no less than 1.25 fps under design average flow conditions to prevent settling of solids and no greater than 3.0 fps under design peak flow conditions to prevent forcing of material through the openings.

51.4.4 Backwater Variations

The effect of changes in backwater elevations due to intermittent cleaning of screens shall be considered in the location of open channel flow measurement equipment.

51.5 Bar Spacing and Slope

Clear openings between bars for mechanically cleaned screens should be a minimum of 1/2-inch. Clear openings between bars should be a minimum of 1-inch for manually cleaned screens. Maximum clear openings should be 1-3/4 inches for manually cleaned screens and 1-inch for mechanically cleaned screens.

Mechanically cleaned screens may be of any suitable inclination up to vertical. Manually cleaned screens should be placed on slope at 30 to 45 degrees from the horizontal.

51.6 Channel Requirements

A minimum of two channels shall be provided. Each channel shall be equipped with the necessary gates to isolate flow to any screening unit. Provisions shall be made to facilitate dewatering of each channel for cleaning. As a minimum, a dewatering sump shall be provided.

Channels preceding and following the screen shall be sloped to facilitate solids transport. Installation of air diffusers in screen channels shall be considered to prevent excessive grit deposition. Turbulence from air diffusers, however, shall be minimized in the vicinity of water level measurement devices.

The screen channel invert shall be 3 to 6 inches below the invert of the influent pipeline.

51.7 Control Systems

The cleaning mechanism of mechanical screening units shall generally be designed to operate at a preset differential water level across the screen. Additional auxiliary controls shall be provided to initiate operation of the cleaning mechanism based on signals from a timing device as well as a preset emergency high water level switch. The controls should be designed to reset the timing device whenever the cleaning cycle is initiated by the differential water level switch. The activation of the emergency high level switch shall also sound an alarm.

51.8 Handling and Disposal of Screenings

Screening facilities shall be designed to allow removal, handling, storage, and disposal of screenings in a convenient and sanitary manner. Where screening equipment is installed below grade, conveyors or hoisting equipment should be provided to lift and remove screenings. Special

consideration shall be given to the design of indoor screening facilities to assure ready access, proper lighting, and adequate ventilation. Electrical equipment and appurtenances located in indoor screening facilities shall be supplied for National Electric Code (NEC) Class 1, Division 2, Group D hazard area.

Manually cleaned screening facilities shall be provided with an accessible platform from which the operator may readily and safely rake screenings. A suitable perforated drainage plate shall be provided for gravity drainage of screenings. An aluminum rake matching the bar screen slots shall be provided to facilitate manual cleaning.

When the anticipated period of storage for collected screenings is greater than two days, the design shall provide for a sealed screenings container and include additional provisions as necessary for odor and vector control.

Separate screenings incineration shall be considered for all facilities and provided wherever feasible. Separate grinding of screenings and return to the sewage flow shall be unacceptable.

52.0 COMMINUTORS

52.1 Applicability

The term "comminutors" shall refer to devices that intercept rags and oversized debris and cut, shred, or otherwise reduce the size of solid material prior to permitting the material to reenter the wastewater flow stream.

Comminutor should be used only in those facilities where manually or mechanically cleaned bar screens are not practical or where downstream process operations and equipment are not sensitive to clogging, blinding, or fouling by "retwined" screenings. The use of comminutors shall be evaluated on a case-specific basis by the Director.

52.2 Location and Pretreatment

Comminutors should be located downstream of grit removal facilities to reduce wear on the equipment. Each comminutor that is not preceded by grit removal equipment should be protected by a 6 inch deep trap extending the full width of the comminutor channel. Utilization of coarse bar screens for protection of the comminutors shall be considered.

52.3 Redundancy and Standby Provisions

A backup bar screen in a bypass channel shall be provided for all comminution facilities. Diversion of excess flows through the screened bypass channel shall be accomplished by gravity overflow at depths of flow exceeding the design capacity of the comminutor.

52.4 General Design and Installation Requirements

Comminutor hydraulic capacity requirements and comminution channel design consideration shall generally be identical to that of mechanically cleaned bar screens (Sections 51.4 and 51.6). The comminutor motor shall be located above the channel to eliminate the possibility of flooding. Adequate submergence of comminutor cutter blades shall be assured at all flows. Provisions shall be made to facilitate servicing units in place and also for removing units from their location for servicing elsewhere.

53.0 GRIT REMOVAL FACILITIES

53.1 Applicability and Types

Grit removal facilities serve to minimize abrasion and abnormal wearing of pumps and other mechanical equipment and to reduce grit deposition and accumulation in conduits and treatment units. Grit removal unit processes shall be required at all wastewater treatment facilities except those utilizing stabilization ponds or other treatment schemes not requiring pumping or dewatering of sludge.

Commonly employed methods of grit removal include: 1) horizontal flow, velocity-controlled grit channels, 2) aerated grit chambers, and 3) constant-level short term sedimentation tanks. The process of sludge degritting is addressed in Section 112.0.

53.2 Locations

Grit removal facilities should be located downstream of coarse bar screens and ahead of pumps and comminuting devices. Wear on influent lift station pumps may be tolerated, however, to obtain the convenience of ground-level construction of grit chambers.

53.3 Redundancy and Bypass Provisions

Provisions for a backup grit chamber should be considered. As a minimum for Reliability Class I, II, and III facilities, grit chambers shall be provided with a means of bypassing the design peak flow with the largest or only unit out of service.

53.4 Performance

The design effectiveness of grit removal facilities shall be commensurate with the requirements of subsequent process units. Grit removal facilities shall generally be designed to remove particles with a specific gravity equal to or greater than 2.5 and retainable on 65-mesh.

53.5 Hydraulic Design and Operational Control

Inlet and outlet turbulence shall be minimized in grit chambers. Inlet and tank configurations shall be selected to minimize entrapment of scum and floating debris.

Horizontal-flow, velocity-controlled grit channels should be designed to control velocities during normal variations in flow to as close as possible to 1.0 fps by the use of a proportional or Sutro weir. Aerated grit chambers should generally be designed for a detention period of 3 minutes at peak flow.

Grit removal facilities shall be provided with control devices, where practicable, to allow regulation of applicable operating parameters. In aerated grit chambers, the air supply shall be variable to allow the degree of agitation to be regulated.

53.6 Grit Collection, Separation and Removal Equipment

Grit chambers should generally be provided with mechanical grit collection, separation, and removal equipment. The use of manual cleaning may be considered for backup grit chambers and for grit facilities at treatment plants with average design flows less than 1 mgd.

Intermittent operation of mechanical cleaning mechanisms should be considered to avoid excessive abrasion of equipment resulting from continuous movement.

53.7 Handling and Disposal of Grit

Design considerations for the handling and disposal of grit shall be similar to that for screenings (Section 51.8). Grit transportation facilities shall be designed to minimize spillage.

The need for grit washing should be determined by the method of final grit disposal. Where grit is to be disposed of by landfilling or onsite burial, proximity to residential areas should dictate the need for grit washing.

54.0 PREAERATION

54.1 Applicability

Preaeration of wastewater shall be considered for all facilities to reduce and prevent septicity, control odors, facilitate grease and grit separation, and improve the performance of primary sedimentation tanks.

54.2 Location and Configuration

Preaeration should follow screening operations. Where feasible, preaeration should be integrated with aerated grit removal or equalization facilities or provided in open channels utilized to convey flows to subsequent primary or other unit processes.

54.3 Aeration System Design Requirements

Preaeration shall be provided by diffused air systems. Design requirements for aeration equipment and systems are addressed in Sections 71.0 and 121.0.

55.0 PRECHLORINATION AND CHEMICAL ADDITION AT THE HEADWORKS

55.1 Applicability

Installation of prechlorination facilities at the headworks for the purpose of controlling odor, corrosion, and septicity, and as an aid in grease removal shall be considered in the design of all wastewater treatment facilities. Where prechlorination facilities are not incorporated into the current design, provisions shall be made available to facilitate installation of such facilities in the future.

The rational and design of facilities associated with addition of chemicals other than chlorine at the headworks shall be reviewed on a case-specific basis by the City.

55.2 Prechlorination System Design Requirements

Design requirements for chlorination equipment and systems are addressed in Chapter 90.

56.0 EQUALIZATION FACILITIES

56.1 Applicability

Flow equalization shall be provided as necessary to minimize variations in organic and hydraulic loading resulting from diurnal variations and/or cycling of influent pumps. Facilities with design average flows less than or equal to one mgd shall be provided with flow equalization to reduce the design maximum to design average flow ratios at downstream facilities to not greater than 2.5 to 1.0. Facilities with design average flows greater than one mgd shall be provided with flow equalization to reduce design maximum to design average flow ratios at downstream facilities to not greater than 2.0 to 1.0. The design average and design maximum flows shall be determined in accordance with the provisions of Section 43.2.

The capability to divert sludge processing side streams to equalization basins to further reduce peak organic loadings shall be considered.

56.2 Location

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

56.3 Compartmentalization and Bypassing

For Reliability Class I, II, and III facilities, equalization tankage shall be provided with a minimum of two compartments with a means of bypassing the design peak flow with any one compartment out of service.

56.4 Type

Flow equalization may be provided by either in-line or side-line aerated basins. Unused future process tankage, such as sedimentation or aeration tanks, may be utilized as equalization basins during the early

years of the design period. In situations involving facility upgrading, tankage which might otherwise be demolished or abandoned may be utilized.

56.5 Sizing

The capacity of equalization basins should be sufficient to effectively reduce expected flow and load variations to an extent deemed economically advantageous. Capacity to equalize design peak flows shall be provided to the extent practicable. As a minimum, flows shall be equalized to the extent described in Section 56.1. The volume required to achieve the desired degree of equalization of diurnal and pump cycling flow variations should be determined from a measured or projected flow plot over a representative 24-hour period.

56.6 Mixing

Aeration or mechanical mixing equipment shall be provided to maintain adequate mixing for the full range of operating levels. Corner fillets and hopper bottoms with drawoffs should be provided to minimize sludge and grit accumulations. The design of equalization basins shall also include provisions for the control of surface accumulations of scum and grease.

56.7 Aeration

Aeration equipment shall be provided to maintain aerobic conditions within the mixed basin contents. Air supply rates should generally be not less than 1.25 cfm/1000 gallons of storage capacity. The air supply should be independent from that of other unit processes. Other process air supply equipment, however, may be utilized as a source of standby aeration.

56.8 Flow Control and Pumping

Inlets and outlets for all basin compartments shall be suitably equipped with simple and reliable devices to permit flow control and the removal

of individual compartments or basins from service. Facilities shall also be provided to measure and indicate liquid levels. Basins shall have emergency overflow provisions.

Pumps shall be sized to handle the required range of flows and be provided with the necessary speed variation capabilities. Horizontal non-clog centrifugal pumps should be utilized where possible. The use of mixed flow pumps should be considered at large treatment facilities.

57.0 FINE SCREENS

Fine screening devices are addressed in Chapter 60.

CHAPTER 60

PRIMARY TREATMENT

60.0 GENERAL

60.1 Function and General Process Types

Primary treatment unit processes are employed following preliminary treatment to remove a large fraction of settleable and floatable solids. Primary treatment unit processes typically achieve suspended solids (SS) removals of approximately 50 percent and corresponding five-day biochemical oxygen demand (BOD_5) removals in the range of 20 to 35 percent. Primary treatment is generally accomplished by conventional mechanically cleaned sedimentation basins. However, other types of units processes such as fine screens, septic tanks, and Imhoff tanks are sometimes utilized in lieu of sedimentation basins.

Advanced primary treatment processes shall refer to those processes intended to achieve approximately 65 percent removal of suspended solids and BOD_5 removals on the order of 40 percent. Typical advanced primary processes include flotation-sedimentation, chemical-aided sedimentation, and primary effluent filtration.

60.2 Redundancy

Sedimentation basins for Reliability Class I and II facilities shall be of sufficient numbers and sizes such that with any one basin out of service, the remaining units shall have a design flow capacity not less than 50 percent of the total design capacity of all basins. Reliability Class III facilities shall be provided with a minimum of two sedimentation basins.

Redundancy requirements for other types of primary treatment unit processes will be determined on a case-specific basis but shall generally be comparable to the above requirements for conventional

sedimentation basins. As a minimum, at least two process units shall be provided for Reliability Class I, II and III facilities.

60.3 Flow Distribution

Facilities shall be designed to satisfactorily control flow and solids distribution for optimum treatment. The distribution and control methods shall permit a reasonable redistribution of flow and solids to the remaining operating units when a unit must be removed from service.

61.0 PRIMARY SEDIMENTATION BASINS

61.1 General Process Description

Primary sedimentation basins typically utilize circular or rectangular reinforced concrete tankage equipped with mechanical bottom scrapers and surface skimmers for the collection and removal of settled solids and floatables. Sedimentation basin inlet and outlet baffles and overflow weirs are designed to promote effective settling by assisting in the achievement of quiescent conditions and the minimization of short circuiting.

61.2 Surface Overflow Rates

For primary sedimentation tanks, maximum surface overflow (settling) rates (based on flows downstream of equalization facilities if equalization is provided) shall be as follows:

Design Average Flow of facility (mgd)	Maximum Overflow Rate at Design Average Flow (gpd/sq ft)	Maximum Overflow Rate at Design Maximum Flow (gpd/sq ft)
Less than 0.1	400	1,000
0.1 to 1.0	600	1,500
More than 1.0	900	1,800

Lower overflow rates shall be employed where the magnitude, frequency and duration of design peak flows are such that unacceptable degradation of sedimentation basin performance occurs. Exceptions to the above surface overflow criteria and the minimum detention period requirements in Section 61.3 may be permitted upon demonstration to the Division that sedimentation basin performance will be satisfactory. In addition, exceptions to such criteria may be permitted, such as during expansion of existing facilities, when the downstream processes are designed for increased loadings imposed by subnormal primary sedimentation performance.

61.3 Hydraulic Detention Time

Hydraulic detention times in primary sedimentation tanks may be a dependent variable due to overflow rates specified in Section 61.2 and minimum tank depths specified in Section 61.4. Hydraulic detention time at the design average flow should not be less than 1.5 hours. Where detention at minimum flows is anticipated to exceed 3 hours, consideration shall be given to providing plant effluent recycle or other positive means of controlling septicity in the primary sedimentation tanks.

In the determination and evaluation of hydraulic detention times, the potential impacts of wastewater temperatures on the primary sedimentation process shall be fully accounted for. Consideration shall be given to the relatively high wastewater temperatures in Hawaii and the corresponding high level of biochemical activity which may cause odor generation/release where primary sedimentation detention periods are in excess of 1 or 2 hours. Special consideration shall be given to the mitigation of problems associated with excessive hydraulic detention during low flow periods in the early years of the design period.

61.4 Tank Geometry

61.4.1 Rectangular Basins

Rectangular tankage shall have a minimum length-to-width ratio of 3 to 1. Length-to-width ratios shall be higher where practical. Tank widths should generally not exceed 20 feet in order to accommodate conventional sludge collection equipment. Width-to-depth ratios should not exceed 2.5 to 1. Rectangular tanks shall generally be designed to limit maximum longitudinal flow velocity to less than four feet per minute to prevent scouring and resuspension of settled solids.

The length of flow, from the influent baffling device to the effluent weir zone, shall not be less than 10 feet.

Sidewater depths, measured at the influent end of conventional rectangular tankage, shall range from a minimum of 8 feet for tanks less than 20 feet in length to a minimum of 10 feet for tanks 100 feet in length.

Tank bottoms shall be sloped to facilitate drainage and to assist in bottom sludge transport to sludge withdrawal hoppers. Minimum slope shall be one percent.

61.4.2 Circular Basins

Circular sedimentation basins, particularly those with diameters less than 40 feet, shall be designed with special emphasis on the minimization of short circuiting.

Minimum tank diameter for circular basins shall be 25 feet to provide a minimum length of flow from inlet baffle to outlet weir of 10 feet.

Minimum sidewater depths, measured at the perimeter wall, shall range from 8 feet for 25-feet diameter tanks to 10 feet for tanks 100 feet in diameter. Deeper tankage shall be utilized as required to suit equipment configuration and geometry.

Tank bottoms shall be sloped a minimum of 1/4-inch per foot to facilitate drainage and to assist in bottom sludge transport to the withdrawal hopper(s). Hopper size, shape, and location should be designed to minimize impacts due to influent flow turbulence.

61.5 Inlet Design

Inlets should be designed to dissipate the inlet velocity, to distribute flow and solids equally both horizontally and vertically, and to prevent short circuiting and minimize density currents. Baffling shall be provided and shall be arranged to prevent scouring of the sludge blanket and sludge hoppers. Inlet baffle arrangements shall be designed to minimize scum entrapment.

61.6 Scum Baffle

A scum retention baffle shall be provided before the outlet weirs. The outlet arrangement shall be designed to minimize scour and resuspension of settled solids. The scum baffle shall be continuous and shall extend approximately 12 inches below the water surface.

61.7 Scum Removal Equipment

Effective scum collection and removal facilities shall be provided for all primary sedimentation tanks. Scum collection in circular tanks shall be automatic and shall generally utilize surface skimmers appended to the sludge collection equipment. In rectangular tanks, scum may be manually removed by hand-tilt troughs when scum is positively transported to the trough by such means as collector flights on the return track.

Scum trough placement, especially on circular tanks, should consider the direction of the prevailing wind.

Collected scum should be directed to separate scum wells or storage vessels. Direct pump connections to scum hoppers is not recommended.

61.8 Weirs, Weir Troughs and Launders

Outlet weirs should be adjustable for purposes of leveling. The weir plates should be of the V-notch type. Weir plates shall be non-metallic and preferably reinforced glass-fiber with an ultraviolet retardant. Effluent weirs shall be located to optimize actual hydraulic detention time and minimize the effects of density currents and short circuiting.

In rectangular tanks with multiple weir troughs, the troughs shall be placed sufficiently far apart to avoid excessive upward velocity between the troughs. Spacing shall be selected such that vertical velocities are lower than horizontal velocities in the vertical tank cross section before the weir zone.

Weir launders shall be designed to prevent weir submergence at the design peak flow. Sedimentation basins shall generally utilize inboard launder arrangements to improve sedimentation performance.

61.9 Sludge Removal Equipment

Sludge collection and withdrawal equipment shall be designed to assure rapid removal of sludge and for long, continuous and uninterrupted service. Primary sedimentation tanks for facilities with average design flows greater than 0.1 mgd shall generally be equipped with rake-type mechanical sludge removal equipment. Such mechanical sludge collection mechanisms shall be capable of effectively moving sludge to hoppers for withdrawal by pumping. Facilities smaller than 0.1 mgd may utilize other positive means of sludge collection and removal, subject to the approval of the Director. All sludge collectors shall have the ability to transport and remove very dense sludge that may accumulate during a mechanical breakdown or power outage.

Mechanical rake-type sludge collectors for circular sedimentation tanks shall generally be of the center drive type. The center drive may be bridge supported for sedimentation tanks smaller than 40 feet in diameter and should be column supported for tanks greater than 50 feet in diameter. Sludge collectors for rectangular sedimentation tanks shall generally be of the chain and flight type. Consideration shall be given to the use of non-metallic chains and reinforced glass-fiber flights. Flights constructed of wood shall not be employed with non-metallic chains.

Sludge hopper walls shall have a minimum side slope of 1.7 vertical to 1 horizontal. Hopper corners shall have filleted corners to minimize accumulation of solids. The hopper bottom shall have a maximum dimension of 2 feet. Each sludge hopper shall have an individually valved sludge withdrawal line at least 6 inches in diameter. Where more than one hopper is connected to a single sludge withdrawal pump, the piping and control system shall allow only one hopper to be pumped at a time to eliminate short circuiting by nonuniform sludge withdrawal. In rectangular sedimentation tanks, cross collectors or screw conveyors are preferred to the use of multiple hoppers, unless each hopper is served by a separate pump.

Sludge withdrawal pump shall be sized and capable of being controlled to accommodate the range of expected conditions, including sludge concentrations less than that for the design condition. Pump sizing shall consider the need, under certain conditions, to pump sludge from the primary sedimentation tanks at a high rate to help alleviate problem odor conditions. Sludge pumping system capacity, however, shall consider the requirements and capacities of subsequent sludge processing equipment. Positive displacement pumps shall be utilized whenever gravity thickening facilities are not provided. General requirements applicable to sludge withdrawal pumps, piping and appurtenances are addressed in Sections 111.0 and 121.0.

The controls for sludge withdrawal pumps shall be designed to permit sludge to be removed from the hoppers as soon as reasonably possible to

minimize odor generation. Means shall be provided to vary sludge pumping frequencies or rates so that sludge removal can be made to correspond with the delivery of sludge to the hoppers. In facilities with average design flows less than 1 mgd, sludge pumping may be controlled by the use of automatic adjustable timers. In facilities 1 mgd and larger, pumping units should be provided with variable speed drives and controlled by automatic adjustable timers in conjunction with sludge density measuring elements.

A means of measuring the sludge removal flow rate shall be provided. In plants smaller than 1 mgd, running time meters, or revolution counters, may be used in conjunction with positive displacement pumps provided that pumping rate calibration may be really checked periodically.

61.10 Walkway

Walkways to obtain access to drive mechanisms on circular tanks shall have a minimum width of 3 feet and be designed for a minimum live load of 100 psf.

61.11 Special Maintenance Considerations

General operation and maintenance provisions addressed in Chapters 40 and 120 shall apply to sedimentation facilities. Special consideration shall be given to assuring safe and convenient access to such elements as gear boxes, grease fittings, scum removal mechanisms, effluent launders, weirs and baffles for cleaning and general maintenance.

61.12 Co-Settling

A form of gravity thickening is accomplished by returning activated sludge or other biological sludges to primary sedimentation tanks for the purpose of co-settling. Co-settling is discouraged; however, if this method is utilized, overflow rates for the primary sedimentation basin should be restricted to under 600 gpd/sq ft and 1,500 gpd/sq ft at design average and maximum flows respectively and primary sedimentation

sidewater depths should be increased by 2 to 3 feet to provide sludge storage capacity. Biological sludge recycled to primary sedimentation tanks for co-settling can increase the potential septicity within the tanks. Solids mass balances should consider the strong probability that suspended solids removal efficiency will not be increased by co-settling.

62.0 CHEMICAL-AIDED SEDIMENTATION

62.1 Applicability

The use of chemical-aided sedimentation for primary treatment shall generally be restricted to upgrading of overloaded existing facilities or to those cases where adequate settleable solids removal cannot be achieved with the application of conventional criteria for plain sedimentation. The use of chemical-aided sedimentation shall be approved by the Director.

62.2 Design Criteria

Design criteria for chemical-aided sedimentation shall be developed from detailed laboratory analysis of the particular waste to be treated. Such criteria shall include detention and mixing requirements for flash mix and flocculation tankage, and overflow rates and detention requirements for sedimentation.

Whenever chemical-aided sedimentation is utilized, consideration shall be given to the impacts upon subsequent biological treatment and upon the sludge treatment process. Sludge production quantification shall include the influence of added chemicals.

63.0 FLOTATION-SEDIMENTATION

63.1 Applicability

Flotation-sedimentation process is used largely to remove suspended, colloidal, and floatable (oil and grease) wastewater constituents. This

process can be expected to remove from 65 to 75 percent of the influent suspended solids and from 35 to 45 percent of the influent BOD_5 without chemical addition. The increased performance in comparison to plain sedimentation is obtained only at a substantial increase in energy consumption.

Flotation-sedimentation employs essentially the same treatment principle as dissolved air flotation thickening systems described in Chapter 110.

63.2 Surface Loading Rates

Surface overflow rates, based on total tankage area and inclusion of all recycle flows, shall not exceed 120 percent of the rates for plain sedimentation.

Maximum surface overflow rates for the flotation zone shall be 2 gpm/sq ft at design average flow.

The flotation zone surface area to total tank surface area ratio shall be in the range to 0.25 to 0.35.

63.3 Pressurization System

Pressurization system design considerations shall generally be similar to that for flotation thickening systems addressed in Section 113.3. Suspended solids in the recycled flow as well as in the plant influent and side stream flows shall be accounted for in the design of flotation sedimentation systems. Pressurization pressure established for the pressurization pumps and air compressors should be determined by an economic analysis of the tradeoffs between alternative operating pressure and recycle flow rates. Means should be provided to control the rate of pressurization recycle flow for flotation-sedimentation systems.

63.4 Tank Geometry and Details

Tank geometry shall conform to the requirements for plain sedimentation.

Tank details shall generally conform to the requirements for plain sedimentation. The flotation zone baffle shall be as deep below the water surface as practicable. The scum baffle in circular tanks may be designed to assist in the support of float and scum removal mechanisms.

Installation of a chemical feed system and addition of chemicals as flotation aids shall be investigated. Where a chemical feed system is not incorporated into the current design, inclusion of provisions to facilitate the installation of such facilities in the future shall be considered.

63.5 Sludge Removal

Sludge removal shall conform to the requirements of plain sedimentation. The sludge collection mechanism should preferably operate independent of the float collection mechanism.

63.6 Float and Scum Removal

Float and scum removal equipment should generally conform to applicable requirements for plain sedimentation. The float collection mechanism should have a speed variation capability of not less than 4:1 for rectangular tanks and 10:1 for circular tanks. The speed range should allow satisfactory removal of float at all anticipated flows and solids loadings. Consideration shall be given to the use of independent drives for the sludge and float collection.

64.0 FINE SCREENING DEVICES

64.1 Applicability

Static, mechanically cleaned, or backwashed fine screens may be allowed in lieu of primary sedimentation when subsequent treatment units are designed on the basis of anticipated screen performance and where conventional primary treatment facilities are not deemed practical or not normally provided. Fine screens should not be considered equivalent

to primary sedimentation as their performance efficiencies are generally lower than that of sedimentation systems. Where fine screens are used, additional provisions for the removal of floatable oils and grease shall be considered.

64.2 Pretreatment Required

Fine screens shall be preceded by coarse bar screens or other protective devices. Comminuting devices shall not be used ahead of fine screens.

64.3 Design Criteria

Tests shall be conducted to determine screening quantities, and BOD_5 and suspended solids removal efficiencies at the design average and design maximum hydraulic, organic and solids loadings.

64.4 Handling and Disposal of Screenings

Design considerations for the handling and disposal of fine screenings and/or backwash water shall be based on a detailed evaluation of the anticipated characteristics of the constituents removed. Fine screenings with low organic content and low odor potential may be handled in a manner similar to coarse screenings; otherwise, fine screenings and/or backwash water shall be appropriately handled as a primary or secondary sludge.

65.0 FILTRATION

65.1 Applicability

Granular media filtration of primary effluent may be employed to achieve higher levels of suspended solids and BOD_5 removals than otherwise achievable using primary sedimentation only.

65.2 Design Criteria

Filtration shall generally comply with the requirements of Section 81.2 of these standards. Pilot-scale studies shall be conducted to determine application rates and backwash requirements and to assist in media selection. Primary effluent filtration units shall consider the need for chemical cleansing of the filter media during backwashing to aid in the control of grease accumulations.

66.0 OTHER PRIMARY TREATMENT PROCESSES

Primary treatment processes other than those addressed herein, including Imhoff and septic tanks, will be evaluated on a case-specific basis.

CHAPTER 70

SECONDARY TREATMENT

70.0 GENERAL

70.1 Function and General Process Types

Secondary treatment unit processes are utilized following primary treatment of wastewater to provide further removal of biodegradable organics and suspended solids. The objective of secondary treatment is generally to achieve effluent five-day biochemical oxygen demand (BOD_5) and suspended solids (SS) levels of less than 30 mg/l and associated average removals of at least 85 percent of plant influent concentrations.

Secondary treatment is principally associated with biological unit processes. Secondary treatment unit processes addressed in these standards include activated sludge, trickling filters, rotating biological contactors, stabilization ponds and land treatment. All proposed secondary unit processes shall be approved for use by the City on a case-specific basis.

Secondary sedimentation units, where employed, are an integral component of biological secondary treatment facilities. Applicable requirements for secondary sedimentation units are addressed in this chapter.

70.2 Process Selection Considerations

Factors to be examined in the selection of the type and configuration of secondary unit treatment processes shall include the following:

1) Effluent quality requirements (degree and reliability of treatment);

2) Capital and operation and maintenance costs;

3) Variability of wastewater flows and characteristics;

4) Size of plant;

5) Compatibility with existing facilities;

6) Availability and cost of land;

7) Size and skill level of operation and maintenance staff required;

8) Potential for odor problems and aesthetic impacts;

9) Energy requirements; and

10) Ease of solids handling and disposal.

71.0 ACTIVATED SLUDGE UNITS

71.1 General Process Description

The activated sludge process is a suspended growth biological treatment process in which influent wastewater, and biological sludge floc called activated sludge, are aerated and mixed to allow microorganisms to metabolize and biologically flocculate organic material. The activated sludge is separated from the aerated mixed liquor in the secondary sedimentation tank and returned to the aeration tank. Sludge produced in excess of process requirements is wasted to solids handling processes. Plant effluent is the supernatant of the secondary sedimentation tank.

The activated sludge process has the capability of producing effluent of very high quality and offers considerable flexibility in terms of operational control. The performance, however, is sensitive to many factors and requires close attention and competent operating supervision.

71.2 Pretreatment Requirements

Activated sludge process units shall generally be preceded by preliminary and primary treatment. Less than primary level pretreatment may be acceptable under certain circumstances such as when space limitations do not permit conventional primary treatment or where extended aeration activated sludge processes are employed. As a minimum, effective removal of grit, debris, and excessive floatables shall be provided.

71.3 Activated Sludge Process Modifications

Common configurations and modifications of the activated sludge process are briefly described below. Applicable factors listed in Section 70.2 shall be considered in the evaluation of alternative activated sludge process modifications.

71.3.1 Conventional

The conventional activated sludge process consists of aeration tankage, secondary clarification, and return activated sludge systems. Both influent wastewater and return sludge are introduced at the head end of the tank and aerated. As the mixed liquor moves through the aeration tankage designed for plug flow, adsorption, flocculation, and oxidation of organic matter occur. If low loading conditions exist, excellent substrate removals are possible. At high loading conditions, however, the first portion of the tankage may exhibit low dissolved oxygen (DO) levels and result in poor performance. A tapered aeration sub-modification provides additional air in the first pass to help satisfy the high oxygen demand and overcome the initial DO deficiency.

71.3.2 Step Aeration

The step aeration process is a modification of the activated sludge process where influent wastewater is introduced at

several points along a plug flow system to minimize the peak oxygen demand. Return activated sludge is introduced at the head end of the tankage. Higher organic loadings are possible as the system operates at more uniform food to microorganism (F/M) levels and oxygen demands are well distributed. A sub-modification of this process involves reaeration of return sludge in the first pass prior to mixing with influent wastewater.

71.3.3 Contact Stabilization

The contact stabilization process takes advantage of the sorptive properties of activated sludge. Return activated sludge is aerated separately for several hours to stabilize absorbed and adsorbed organic matter. This stabilized sludge is then mixed with the influent wastewater in the contact portion of the reactor to entrap suspended solids and colloidal BOD and absorb soluble BOD. Following the contact period, the sludge is settled in a secondary clarifier. A small portion of sludge is wasted, while the remainder is returned to the stabilization reactor. This system is capable of treating wastewater at higher volumetric loading than the conventional configuration. Removal efficiency, however, is dependent on the relative portions of soluble and colloidal organic matter.

71.3.4 Complete Mix

The complete mix activated sludge process introduces the influent wastewater and return sludge together at several points in the aeration tank. The mixed liquor is quickly distributed throughout the tank, resulting in uniform oxygen demand and solids concentration. This configuration reduces the impact of toxic substances and avoids front-end overloading of organics.

71.3.5 Extended Aeration

The extended aeration process operates in the endogenous respiration phase and therefore requires a low organic loading and a long aeration period. This system should only be considered for prefabricated package plants or engineered plants with average design flows of 1 mgd or less.

71.3.6 Oxidation Ditch

The oxidation ditch is essentially an extended aeration process with a "race track" configuration. The original system utilized brush aerators for aeration and circulation. More recent system adaptations employ mechanical aerators or rotating vertical disks.

71.4 Process Parameter Definitions

Process parameters are defined as follows:

71.4.1 Organic Loading

The weight of carbonaceous BOD_5 material applied per day to the process. Expressed as pounds BOD_5 per day (lbs BOD_5/day).

71.4.2 Hydraulic Detention Time (HDT)

The average time period influent wastewater is retained in a tank. Expressed as hours (hr).

71.4.3 Mixed Liquor Volatile Suspended Solids (MLVSS)

Volatile suspended solids under aeration, consisting of biological solids and organic matter. Expressed as milligrams per liter (mg/l).

71.4.4 Mixed Liquor Suspended Solids (MLSS)

Suspended solids under aeration, consisting of biological solids, organic matter, and nonvolatile matter. Expressed as milligrams per liter (mg/l).

71.4.5 Volumetric Loading

Organic loading applied per unit volume of aeration tankage. Expressed as pounds BOD_5 per day per 1,000 cubic feet of aeration tankage (lbs BOD_5/day/1,000 cu ft).

71.4.6 Food to Microorganism Ratio (F/M)

The ratio of organic loading to the weight of mixed liquor volatile suspended solids in the aeration tank. Expressed as pounds of BOD_5 per day per pounds of MLVSS (lbs BOD_5/day/lb MLVSS).

71.4.7 Mean Cell Residence Time (MCRT)

The average residence time that the activated sludge solids are retained in the process or the time period in which the entire solids inventory (solids under aeration and in the secondary clarifier) is wasted. Expressed as days (days).

71.4.8 Oxygen Requirements

The amount of oxygen required to oxidize the carbonaceous BOD_5 in a wastewater. Expressed as pounds of oxygen per pounds of BOD_5 (lbs O_2/lb BOD_5).

71.5 Loading and Sizing of Aeration Tanks

71.5.1 Flow and Influent Characteristics

In the design of activated sludge systems, special attention shall be given to the characterization of wastewater flows, influent characteristics, and associated diurnal and seasonal variations with respect to potential adverse impacts on process stability. The process design shall also fully consider the impacts of process side streams and recycles. Utilization of effective equalization facilities may be considered by the City as justification for allowing higher loading than otherwise permitted herein.

71.5.2 Method of Tank Sizing

The size of the aeration tank for any particular mode of the activated sludge process shall be determined by pilot plant study, volumetric loadings, and/or rational calculations based primarily on F/M ratio and MLVSS. Where pilot data are available on substrate removals and sludge yield coefficients, the MCRT approach should be considered.

71.5.3 Loading and Design Operating Criteria

Volumetric loading and F/M ratio shall not exceed the values shown in Table 70-1, and the MLSS, HDT, and MCRT should be in the design ranges shown. The values listed for volumetric loading and F/M ratio are maximum values based on higher biological activity and growth rates at the elevated wastewater temperature of 25 to 28°C, availability of a sufficient supply of oxygen, and absence of inhibiting substances (i.e., chlorides, heavy metals, excessive oil and grease). If these conditions do not or will not exist, lower volumetric loading values must be utilized to account for actual wastewater temperatures and oxygenation rates and the presence of any inhibiting substances.

TABLE 70-1

ACTIVATED SLUDGE PROCESS CRITERIA

Process Modification	Flow Model	Maximum Design Volumetric Loading (# BOD_5/ 1000 cf)	Maximum Design F/M Ratio (# BOD_5/# MLVSS/day)	Operable Mixed Liquor Suspended Solids (mg/l MLSS)	Operable Return Ratio Range Q_R/Q_{ACT}** (%)	Hydraulic Detention Time (hr)	Operable Mean Cell Retention Time (days)
Conventional	Plug Flow	50	0.55	1000 - 2000	25 - 125	4 - 8	3 - 10
Step Aeration	Plug Flow	70	0.6	1000 - 2500	25 - 125	3 - 5	3 - 10
Complete Mix	Complete Mix	75	0.6	1000 - 3000	25 - 125	3 - 5	3 - 10
Contact-Stabilization	Plug Flow	85*	0.65	1000 - 2000+ 3000 - 6000++	25 - 125	0.3 - 0.7+ 3 - 6++	3 - 10
Extended-Aeration	Complete Mix	25	0.2	1200 - 3000	50 - 200	18 - 30	15 - 25
Oxidation Ditch	Plug Flow/ Recycle	25	0.2	1200 - 3000	50 - 200	18 - 30	7 - 25

* Total aeration capacity, includes contact and reaeration capacities.

** Q_{ACT} is the average daily flow which varies throughout the design period.

\+ Contact unit

++ Reaeration unit

Reference: Wastewater Engineering: Treatment, Disposal, Reuse by Metcalf & Eddy, Inc., 1979, modified as appropriate to reflect local conditions and experiences.

The required aeration tank capacity, if determined by both volumetric loading and rational calculations, should be based on the method yielding the larger tank size.

Pilot plant studies shall be required for designs that are based on criteria substantially different from those in Table 70-1.

71.6 Number, Geometry, and Configuration of Aeration Tanks

71.6.1 Number of Tanks

For Reliability Class I and II facilities, a backup aeration basin shall not be required; however, a minimum of two basins of equal volume shall be provided. Utilization of more than two aeration basins shall be considered as design average flows approach and exceed 5 mgd. Utilization of a single aeration basin may be permitted by the City for Reliability Class III facilities.

Where applicable, determination of the number and size of aeration basins shall be based on a tankage phasing and load matching scheme which will facilitate treatment of all flows from beginning to end of the design period.

71.6.2 Configuration and Geometry

With the exception of complete mix and extended aeration-type processes, activated sludge tank configurations and hydraulics shall allow operation in the conventional, step-aeration and contact stabilization modes.

Tank depth shall generally be in the range of 12 to 14 feet for mechanical and coarse bubble diffused air systems and 15 to 20 feet for fine bubble diffused air systems to promote optimum efficiency. Plant capacity and site-specific conditions, such

as depth to groundwater, presence of rock and/or need for pile foundations may alter the desired range of aeration tank depth.

Tank geometry shall be selected to facilitate satisfactory mixing throughout the tank contents. Tank shall be filleted and contoured to minimize stagnant areas. Interior partitions and tank outlets should be designed to minimize scum entrapment.

For plug-flow configurations, serpentine channel arrangements maximizing the length-to-width ratio should be considered.

71.7 Air Requirements

71.7.1 Minimum Air for Mixing

Sufficient air shall be provided to ensure thorough mixing of the aeration tank contents. Mixing should prevent solids deposition without causing excessive shearing of biological floc.

For fine bubble dome diffusers with a multiline, full floor coverage layout pattern, the minimum air requirement shall be 0.12 scfm/sq ft. For coarse bubble diffusers employing spiral roll mixing, the minimum air requirement shall be 20 scfm/1,000 cu ft. Low speed mechanical aeration systems shall be provided with a minimum of 0.5 hp/1,000 cu ft.

71.7.2 Minimum Dissolved Oxygen in Aeration Tank

For plug-flow activated sludge processes, the air supply system shall be capable of maintaining minimum dissolved oxygen (DO) levels of 0.5 mg/l at the head end and 2.0 mg/l at the outlet of aeration basins under normal operating conditions. A minimum DO level of 1.0 mg/l shall be capable of being maintained at the outlet under all operating conditions.

For complete mix and extended aeration activated sludge modes, the air supply system shall be capable of maintaining a minimum DO level of 1.0 mg/l in the aeration tank under all operating conditions.

71.7.3 Standard Oxygen Required

The minimum standard oxygen supplied to the aeration tank shall be 1.2 pounds of oxygen (O_2) per pound of carbonaceous BOD_5 applied, with the exception of extended aeration-type processes, which shall be supplied with 1.8 pounds.

71.7.4 Supplied Air/Oxygen

Oxygen transfer efficiency claims by the aeration equipment manufacturer shall be supported by test data for the actual model and size of aerator. Since aeration devices are rated using clean water at standard conditions, their rated performance must be converted to actual field conditions by application of temperature corrections and factors that relate waste characteristics to clean water characteristics. Standard conditions are 14.7 psia atmospheric pressure, 20°C clean water temperature, 0.0 mg/l dissolved oxygen, and clean (tap) water.

The amount of oxygen required at process conditions (N_o) for both the average and peak organic loads shall be determined from the amount of oxygen required at standard conditions (N) by the equation:

$$N_o = \frac{N}{\alpha\left(\frac{\beta C_s - Cd}{C_{st}}\right)\theta^{(T-20)}}$$

where:

N_o = field oxygen required for oxidation (at process conditions), lb oxygen/day

N = standard oxygen required for oxidation, lb oxygen/day

C_s = oxygen saturation in clean water at temperature T and corrected for elevation, mg/l

C_d = process operating dissolved oxygen concentration, mg/l

C_{st} = oxygen saturation in clean water at stated test conditions, mg/l (normally 9.17 mg/l)

T = process operating temperature, °C (generally 25° to 28°C in Hawaii)

θ = temperature correction factor (normally 1.024)

α = ratio of oxygen mass transfer in wastewater to that of clean water at the same temperature and partial pressure

β = ratio of oxygen saturation in wastewater to that of clean water at the same temperature and partial pressure

When the α and β factors are not measured for the wastewater under study, values of 0.85 and 0.95 shall be used for α and β respectively.

The above formula may be converted to pounds oxygen per bhp per day for mechanical aerators to determine minimum horsepower requirements.

The above formula may also be converted to volumetric air flow rates for diffused air systems by utilizing a value for C_s corrected for depth and oxygen fraction in the air. The value may also require adjustment due to the degree of turbulence afforded, particularly with fine bubble diffusers. Volumetric air flow is calculated by the equation:

$$Q_A = \frac{N_O}{\rho\,(0.232)\,(1440)\,(OTE)}$$

where:

Q_A = air flow, cfm

N_O = field oxygen required, lbs O_2/day

ρ = air density at ambient temperature, lb/cf

OTE = aerator rated oxygen transfer efficiency at standard conditions, % (decimal form)

0.232 = percent (decimal form) of oxygen in air, weight basis

1440 = number of minutes per day

Diurnal load variations shall be considered when determining the maximum output of the aeration system. As a minimum, the aeration system shall be designed to transfer 150 to 200 percent of the required oxygen under average design organic loading conditions. Calculations shall be furnished to indicate the adequacy of oxygen transfer at peak demand; where equalization is provided, the calculations shall be based upon the largest equalization chamber out of service.

71.8 General Requirements for Aeration Equipment

Aeration equipment shall have the flexibility to meet the process requirements for supplied air from the beginning to end of the design period for each operable process mode.

Reliability Class I and II facilities shall be provided with a sufficient number of blowers or mechanical aerators to enable design oxygen transfers to be maintained with the largest capacity unit out of service. Reliability Class III facilities shall be provided with a minimum of two blowers or mechanical aerators. For all Reliability Classes, the backup unit may be an uninstalled unit, provided that the installed unit can be easily removed and replaced. For Reliability Class I, II, and

III facilities, the air diffusion system for each aeration basin shall be designed such that the largest section of diffusers can be isolated without measurably impairing the oxygen transfer capability of the system.

Equipment controlling the supply of activated sludge process air shall be capable of matching supply with demands by manual and/or automatic means. Facilities with average design flows greater than 1 mgd should be provided with automatic dissolved oxygen control systems. Air flow to each aeration tank shall be metered and totalized. Each diffuser system drop-pipe shall be provided with a flow indicator.

Specific equipment requirements for blowers, diffusers, air filters, air piping, valves, and other diffused aeration system components are addressed Chapter 120. Requirements for mechanical aerators are addressed below in the following section.

71.9 Mechanical Aerators

71.9.1 General

Mechanical aerators utilized in wastewater treatment may be classified as either surface or submerged turbine aerators. Surface aerators, which include high speed axial flow and low speed radial flow aerators and horizontal brush rotors, are designed to entrain air from the atmosphere. Submerged turbine aerators, which may either employ by sparge systems located beneath a radial or axial flow configuration, entrain air admitted by sparge systems located beneath submerged low speed impellers.

71.9.2 Aerator Design and Construction

The aeration mechanism and drive unit for mechanical aerators shall be designed for the expected conditions in the aeration basin based on proven performance of the equipment. The

aerator installation shall include all necessary access provisions for service and maintenance. Both fixed and floating surface aerators shall be capable of operating efficiently over the range of operating water surfaces without spraying or misting.

Surface aerators shall be provided with draft tubes, surge rings, and/or lower mixing impellers as necessary. The bridge for bridge-mounted surface aerators shall be designed for a minimum of four times the maximum torque and impeller side load moment anticipated. Floating surface aerators shall be designed to handle the anticipated torque and vibrations and have a minimum factor of safety of 1.7 against sinking.

Low speed aerators shall be equipped with heavy-duty gear reduction units specifically designed for aeration service and capable of withstanding shock loads. High speed axial-flow aerators should be equipped with dynamically balanced nonclog impellers.

71.10 Return Activated Sludge (RAS) System

Return activated sludge (RAS) systems and controls shall be designed to maintain an adequate concentration of solids under aeration for all expected conditions of service. The necessary flexibility shall be provided to facilitate achievement of satisfactory performance in each operable process modification.

RAS pumping rates shall be variable and infinitely adjustable throughout the intended operating range. RAS flow to each aeration tank should be metered and totalized.

Provisions shall be included to isolate and separately pump RAS flow from each sedimentation tank in order to facilitate control over the sludge blanket in individual tanks. Suction line manifolding shall be provided to allow standby unit operation. RAS flow shall discharge

above the water surface of the aeration tank to permit sampling and visual observation of the rate of return flow.

General sludge pumping and piping requirements applicable to RAS systems are addressed in Section 111.0. Centrifugal pumps utilized for pumping of RAS shall have minimum suction and discharge nozzle diameters of 3 inches.

71.11 Waste Activated Sludge (WAS) System

The waste activated sludge (WAS) system shall be capable of accomplishing the necessary degree of wasting of excess activated sludge for satisfactory process control (F/M ratio or MCRT). WAS systems shall be provided with the required flexibility to facilitate achievement of satisfactory performance in each operable process modification.

Maximum wasting system capacity shall be based on peak sludge production at design conditions and intermittent wasting where such wasting is an operational possibility. Minimum wasting system capacity should be based on low-rate continuous wasting during periods of minimum sludge production at the beginning of the design period.

Wasting to a flotation-type sludge thickening process is generally preferred. Provisions for wasting to the primary sedimentation tank shall be included when thickener units are not utilized or if the thickening units are provided with limited back-up provisions. If WAS is to be discharged to the primary sedimentation tank for co-settling on a regular basis, the design capacity of the activated sludge system shall be increased to account for the lower solids capture in the primary units.

Continuous wasting systems should be provided where feasible. If continuous wasting of sedimentation tank underflow is not feasible, continuous wasting of mixed liquor should be considered. Noncontinuous wasting shall be performed at intervals most compatible with the operation of the sludge handling units and the plant operating schedule.

Wasting of excess activated sludge at facilities with design average flows less than 1 mgd may be by WAS pumps separate from that for RAS or by bleeding from the RAS discharge header. Facilities 1 mgd and larger shall utilize separate WAS pumps.

WAS pumping rates shall be variable and infinitely adjustable throughout the intended operating range. WAS flow shall be metered and totalized.

General sludge pumping and piping requirements applicable to WAS systems are addressed in Section 111.0.

71.12 Secondary Sedimentation Tanks for Activated Sludge

71.12.1 General Requirements

Secondary sedimentation basins for activated sludge systems shall conform to the requirements for primary sedimentation basins addressed in Chapter 60 except as noted below.

71.12.2 Redundancy and Standby Provisions

Secondary sedimentation basins for Reliability Class I facilities shall be such that with any one unit out of service, the remaining units shall have a design flow capacity not less than 75 percent of the total design capacity of all basins. For Reliability Class II facilities, the remaining basins with any one basin out of service shall have a design flow capacity not less than 50 percent of the total design capacity of all units. A minimum of two sedimentation basins shall be provided for Reliability Class III facilities.

71.12.3 Surface Overflow and Solids Loading Rates

Allowable surface overflow and solid loading rates are shown on Table 70-2. Selection of design overflow and loading rates shall consider potentially adverse impacts resulting from influent pump cycling and peak wet weather flows, and beneficial effects of upstream flow equalization and dampening.

TABLE 70-2

ACTIVATED SLUDGE SECONDARY SEDIMENTATION BASIN OPERATING CRITIERIA

Process	Size of Plant (mgd)	Maximum Surface Overflow Rates at Design Average Flow[1] (gpd/sq ft)	Maximum Surface Overflow Rates at Design Maximum Flow[1] (gpd/sq ft)	Maximum Solids Loading Rates at Design Average Flow[2] (lb/sq ft/day)	Maximum Solids Loading Rates at Design Maximum Flow[2] (lb/sq ft/day)
Extended-Aeration	Less than 1.0	200	500	15	30
	Greater than 1.0	300	600	20	30
All Other A/S Processes	Less than 1.0	400	1000	15	30
	1.0 to 5.0	500	1000	25	40
	Greater than 5.0	600	1200	30	45

[1] Based on clarifier effluent flow rates rather than influent mixed liquor flow rates. RAS is withdrawn from the bottom of the tank and does not contribute to the upward flow velocity.

[2] Based on MLSS concentrations and on the sum of the influent mixed liquor peak RAS flow rates.

Reference: Wastewater Engineering: Treatment, Disposal, Reuse by Metcalf & Eddy, Inc., 1979, modified as appropriate to reflect local conditions and experiences.

71.12.4 Hydraulic Detention Time

Hydraulic detention time of secondary sedimentation basins shall be a dependent variable. Concerns related to excessive hydraulic detention noted in Section 61.3 for primary sedimentation basins need not be addressed in detail for activated sludge secondary sedimentation basins; detention time of solids in activated sludge secondary sedimentation basins, however, shall be minimized by providing appropriate sludge removal equipment.

71.12.5 Tank Geometry

Tank geometry for activated sludge secondary sedimentation basins shall generally conform to the requirements of Section 61.4 except that minimum sidewater depth requirements shall be increased.

Sidewater depths for conventional rectangular tankage, measured at the influent end, shall range from a minimum of 10 feet for tanks less than 20 feet in length to a minimum of 12 feet for tanks 100 feet in length. For circular tankage, minimum sidewater depths measured at the perimeter wall shall range from 12 feet for 25-foot diameter tanks to 14 feet for tanks 100 feet in diameter.

71.12.6 Center Well Design

Circular tank center well baffles shall have a diameter of not less than 20 percent of the tank diameter and a depth of not less than 50 percent of the sidewater depth.

71.12.7 Sludge Removal Equipment

Removal of sludge from the bottom of circular activated sludge secondary sedimentation basins should generally be accomplished

by the use of rapid sludge return-type mechanisms. These mechanisms should remove sludge directly from the entire tank bottom with each revolution by employing suction orifices spaced along the rotating arms. Scraper- or plow-only type mechanisms shall only be used in circular basins when approved by the Director. Sludge removal for rectangular secondary clarifiers may be accomplished by chain and flight mechanisms, by suction-type continuous sludge withdrawal bridge mechanisms, or by direct suction from multiple hoppers.

For suction-type mechanisms, the number and size of riser pipes shall be based on the sludge withdrawal capacities required and the size of the basin. Riser pipes shall terminate in a central sludge well where each pipe flow rate is independently regulated by a flow control device. The minimum velocity in the riser pipes at the minimum sludge return rate shall be 1 foot per second.

71.12.8 Scum Removal Equipment

Efficient scum collection and removal equipment complying with the requirements addressed in Section 61.9 shall be provided for activated sludge secondary sedimentation basins. The collection and removal equipment shall be capable of satisfactorily handling floating sludge generated during any activated sludge process upsets.

72.0 TRICKLING FILTERS

72.1 General Process Description

The trickling filter or biofiltration process is an attached growth (fixed film) biological treatment process in which wastewater is allowed to flow through a bed of coarse media of rocks, plastic packing, or redwood slats. Biological slime growths attached to the media provide removal of organics by adsorption and assimilation of soluble and

suspended wastewater constituents. Oxygen is supplied to the process primarily by air passing through the voids of the media. Secondary sedimentation is utilized to remove biomass sloughed off the media. Recirculation of effluent may be utilized to improve filter efficiency.

72.2 Pretreatment Requirements

Trickling filter units shall be preceded by preliminary and primary level treatment. Primary sedimentation units shall be equipped with effective scum and grease collection devices.

72.3 Trickling Filter Process Modifications

Trickling filters are usually classified as either low-rate or high-rate. Low-rate filters typically employ rock media, utilize no recirculation, and are lightly loaded both organically and hydraulically. High-rate filters generally incorporate the use of rock, wood or plastic media in conjunction with recirculation of either filter effluent or final effluent. For treatment of high strength wastes or for improved effluent quality, two-stage trickling filter systems may be utilized with or without an intermediate settling tank. Applicable factors listed in Section 70.2 shall be considered in the evaluation of alternative trickling filter process modifications. The following requirements in this section shall generally apply to multi-stage as well as single stage trickling filter systems.

72.4 Loading and Sizing of Units

72.4.1 Flow and Influent Characteristics

Flow and influent characterization considerations in Section 71.5.1 for activated sludge shall be applicable to trickling filter systems.

72.4.2 Method of Tank Sizing

Determination of filter volume and depth of media shall be based on pilot testing and/or on empirical design equations that have been satisfactorily verified by past full-scale experiences. Applicable design calculations shall be submitted for review whenever pilot testing is not conducted.

72.4.3 Loading and Sizing Criteria

Maximum permissible organic loading rates are shown on Table 70-3 along with typical ranges for hydraulic loading rates, media depths, and specific media surface areas. Use of higher organic loading rates shall be permissible when supported by pilot testing data. Permissible organic loading rates and other design requirements for redwood slats or other types of filter media shall be evaluated on a case-specific basis. Rock filter media depths shall generally not exceed 10 feet and manufactured plastic media filter depths shall generally not exceed 30 feet.

Trickling filters for Reliability Class I facilities shall be such that with any one filter out of service, the remaining units shall have a design flow capacity not less than 75 percent of the total design capacity of all filters. For Reliability Class II Facilities, the remaining filters with any one unit out of service shall have a design flow capacity not less than 50 percent of the total design capacity of all units. Multiple trickling filter units are not required for Reliability Class III facilities.

72.5 Recirculation

Low-rate filters employ little or no recirculation while high-rate filters generally require recirculation rates of 100 to 200 percent of the filter influent flow. Low-rate filters shall be provided with

TABLE 70-3

TRICKLING PROCESS CRITERIA

	Low-Rate Filter	High-Rate Filter	
	Rock Media	Rock Media	Plastic Media
Maximum Organic Loading[1], lb BOD_5/1,000 cu ft/day	15	40	60
Typical Range of Hydraulic Loading[2], gpd/sq ft	25 - 100	200 - 1,000	300 - 1,700
Typical Range of Media Depth, ft	4 - 8	3 - 6	15 - 25
Typical Range of Media Specific Surface Area, sq ft/cu ft	10 - 20	10 - 20	30 - 45

[1] Based on design average flow and BOD_5 load.

[2] Based on design average flow and recirculated flow.

Reference: Wastewater Engineering: Treatment, Disposal, Reuse by Metcalf & Eddy, Inc., 1979, modified as appropriate to reflect local conditions and experiences.

recirculation capability as necessary to allow continuous media wetting. High-rate filters utilizing manufactured packed plastic media shall, as a minimum, be provided with recirculation capability to satisfy minimum media wetting flow rates recommended by the manufacturer.

Devices should be provided to measure and totalize recirculated flows. Recirculation rates shall be variable over the range of no flow to maximum recirculation flow.

72.6 Ventilation

The design of trickling filters shall consider the adequacy of ventilation to provide satisfactory air exchange between the filter and surrounding atmosphere. Sufficient air exchange shall be assured to prevent oxygen limiting conditions which restrict substrate removals by attached growth organisms. Whenever practical, particularly with deep synthetic media filters, pilot study should be undertaken to establish the minimum required rate of ventilation.

Evaluation of filter ventilation shall consider the possibility that naturally induced drafts are not assured in Hawaii because differences in ambient air and wastewater temperatures are usually small. Factors that should be considered in evaluating air flow through a filter include: 1) heat transfer (water warming or cooling air), 2) increased relative humidity of air in filter, 3) wind blowing across top of filter (whistle effect), 4) oxygen partial pressure decreases and carbon dioxide partial pressure increases, and 5) downward motion of water drawing air. If adequate natural ventilation cannot be assured, then forced draft ventilation shall be provided.

Where forced draft ventilation is not provided, the filter design shall include provisions to facilitate its future installation. The adequacy of ventilation shall be determined by inspection of the lower media after sufficient time in operation to develop full media growth has passed. If anaerobic biomass is found to predominate, improved ventilation shall be provided.

72.7 Influent Distribution and Dosing

Flow to distribution devices may be provided by siphons, pumps or simple gravity discharge from preceding treatment units. Wastewater may be distributed over filter surfaces by rotary distributors, fixed nozzles, or other devices designed to provide uniform surface distribution. Careful attention shall be given to all hydraulic factors involved in the proper distribution of wastewater on the filters. Dosing equipment and piping shall be capable of simultaneously handling design peak and recirculated flows.

A minimum clearance of 9 inches between media and rotary distributor arms shall be provided. Mercury seals for rotary distributors shall not be employed. Ease of rotary distributor seal replacement shall be considered in the design to facilitate continuity of operation.

Application of wastewater on the filters shall be continuous where practical. In the design of all trickling filters, consideration shall be given to the installation of recirculation piping.

72.8 Filter Media

72.8.1 Rock Media

Crushed rock media shall be durable, resistant to spalling or flaking, relatively insoluble in wastewater, free from dust, clay, sand, or fine material. Rock media shall be free of thin, elongated, and flat pieces and shall not contain more than 5 percent by weight of pieces whose longest dimension is two times the least dimension. The following gradation for rock media is recommended:

Passing 4-1/2" screen - 100% by weight

Retained on 3" screen - 95-100% by weight

Passing 2" screen - 0-2% by weight

Passing 1" screen - 0-1% by weight

72.8.2 Manufactured and Redwood Media

Suitability of manufactured and redwood media shall be evaluated on the basis of experience with installations handling similar wastes and loadings. Media design and configuration shall minimize short circuiting potential and maximize the circulation of air. Manufactured media shall be resistant to ultraviolet degradation, disintegration, erosion, common acids and alkalies, and fungus and biological attack. Filters with media not structurally capable of supporting the weight of a person shall be provided with an access walkway for distributor maintenance.

72.9 Underdrain System

Underdrains with semicircular inverts or equivalent should be provided. The underdrainage system shall service the entire floor of the filter. Inlet openings into the underdrains shall have an unsubmerged gross combined area equal to at least 20 percent of the surface area of the filter.

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 at the design average rate of application to the filter.

The underdrain system, effluent channels, and effluent pipe should 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 peak design rate of wastewater application.

Provisions should be included for flushing and inspection underdrains. In small filters, use of a peripheral head channel with vertical vents is acceptable for flushing purposes. Inspection facilities should be provided.

72.10 Fly and Odor Control

Special consideration shall be given to control of flies and odors particularly where the potential for adverse impacts is high due to predominant wind directions and proximity to residential areas. Filters shall be designed to allow flooding of tankage to aid in filter fly control. Covered filters shall be considered in residential areas. Utilization of microscreens or other devices shall be considered for removal of fly larvae from the effluent.

72.11 Secondary Sedimentation Tanks for Trickling Filters

The requirements and considerations set forth in section 61.0 for primary sedimentation basins shall generally apply to sedimentation units following trickling filters. Surface overflow rates for trickling filter sedimentation basins shall not exceed 600 gpd/sq ft and 1,500 gpd/sq ft based on design average and maximum flows respectively. Any recirculated flows shall be included in the computation of surface settling rates. Selection of design overflow rates shall consider potentially adverse impacts resulting from peak wet weather flows and beneficial effects of upstream flow equalization and dampening.

73.0 ROTATING BIOLOGICAL CONTACTORS

73.1 General Process Description

The rotating biological contactor (RBC) process is an attached growth (fixed film) biological treatment process in which wastewater is passed through tankage containing a series of partially submerged rotating plastic discs. Biological growths attached to the discs provide removal of organics by biochemical oxidation and assimilation of soluble and suspended wastewater constituents. Disk rotation supplies oxygen to the process by exposing the media growth to air. Shearing forces caused by the disc rotation assist in sloughing off excess biomass. Secondary sedimentation is utilized to remove the sloughed biomass from the RBC effluent.

73.2 Pretreatment Requirements

RBC units shall be preceded by preliminary and primary level treatment.

73.3 Loading, Sizing and Configuration of Units

Determination of unit loading, sizing and configuration shall be based on experience at similar full-scale installations and/or thoroughly documented pilot testing with the particular wastewater to be treated. Media arrangements (number of stages and unit area in each stage), rotational velocity of the media, and retention time within the process tankage shall be fully evaluated in the design of RBC units. Both hydraulic and organic loading parameters based on unit media surface areas shall also be evaluated.

Special consideration shall be given to maintaining an aerobic environment in the first stage, particularly when treating septic and high strength wastes. Supplemental aeration shall be considered to prevent limitations of first-stage oxygen transfer capability. High density media shall not be used in the first stage.

RBC systems for Reliability Class I facilities shall be such that with any one unit (consisting of one or more stages) out of service, the remaining units operating in parallel shall have a design flow capacity not less than 75 percent of the total design capacity of all units. For Reliability Class II facilities, the remaining units with any one unit out of service shall have a design flow capacity not less than 50 percent of the total design capacity of all units. Multiple RBC units are not required for Reliability Class III Facilities.

RBC units shall be provided with suitable sumps and tank drains to facilitate cleaning and periodic removal of accumulated solids.

73.4 Weather Protection

Biological growths on RBC units shall be protected from adverse weather conditions by suitable enclosures.

73.5 Secondary Sedimentation Tanks for Rotating Biological Contactors

The requirements and considerations set forth in Section 61.0 shall generally apply to sedimentation units following rotating biological contactors. Surface overflow rates for RBC sedimentation basins shall not exceed 600 gpd/sq ft and 1,500 gpd/sq ft based on the design average and maximum flows respectively. Selection of design overflow rates shall consider potentially adverse impacts resulting from peak wet weather flows and beneficial effects of upstream flow equalization and dampening.

74.0 STABILIZATION PONDS

74.1 General Process Description

Stabilization ponds refer to wastewater treatment systems utilizing open earthen basins, with or without liners, within which natural biological, chemical, and physical treatment and stabilization processes occur. These processes include sedimentation, oxygenation, aerobic bioconversion and assimilation, and anaerobic digestion. Oxygenation of stabilization ponds, which occurs naturally by surface diffusion and photosynthesis, may be assisted by diffused air systems or mechanical surface aerators.

Stabilization pond treatment performance with respect to BOD removal has been generally acceptable with conservatively designed and properly operated ponds. Treatment performance with respect to suspended solids is often complicated by the presence of algae cells in the pond effluent. Due to the probable occurrence of periodic low suspended solids removal efficiencies, an approved effluent polishing system will be generally required prior to discharge of effluent to surface waters or injection wells.

74.2 Pretreatment Required

Stabilization pond systems shall be preceded by coarse screening devices. Primary treatment by conventional sedimentation basins shall be

considered and provided where justified on the basis of cost effectiveness.

74.3 Stabilization Pond Classifications

Three major types of stabilization ponds most commonly employed in the treatment of wastewater are described below. Applicable factors listed in Section 70.2 shall be considered in the evaluation of alternative pond configurations.

74.3.1 Facultative Ponds (Non-aerated)

Facultative ponds are the most common type of pond used in wastewater stabilization. These ponds develop two primary zones of treatment: an aerobic surface layer and an anaerobic bottom layer. Facultative ponds typically exhibit depths of 4 to 8 feet. Oxygen for aerobic stabilization in the surface layer is provided by photosynthesis and by reaeration from wind action. The facultative basin is usually designed to provide sufficient waste dilution and natural aeration to insure that the surface liquid will remain aerobic.

74.3.2 Aerated Facultative Ponds

Aerated facultative ponds are similar to that of non-aerated facultative ponds with the exception that mechanical aeration is employed to assist in maintenance of aerobic conditions in the upper layer. Mechanical aeration is typically employed where supplemental oxygen is needed due to high organic loading or to permit higher organic loading in a pond designed for lower loading.

74.3.3 Aerated (Completely Mixed) Ponds

Aerated (completely mixed) ponds utilize mechanical aeration systems to maintain a completely mixed, aerobic environment without stratification.

74.4 Pond Sizing, Loading and Configuration

74.4.1 Loading and Oxygen Requirements

Approval of the criteria used in the design of stabilization ponds will be on an individual case basis, with full documentation required for all selected design parameters. The following criteria may be used as a guide for the initial cell in multi-cell systems:

	Non-aerated Facultative	Aerated Facultative Aerobic	Completely Mixed Aerated
Detention (days)	15-30	8-10	3-10
Loading (lbs BOD_5/acre-day)	75-120	120-250	300-500
Depth (ft)	4-8	10-15	10-20

Oxygen demand calculations and reasonable estimates of oxygen supply shall be performed for worst case conditions to demonstrate the presence of an adequate aerobic stabilizing environment. Adequate aerobic stabilizing conditions shall be defined as the existence of a minimum dissolved oxygen concentration of 2 mg/l.

The potential for odors generated by accumulation of solids at the bottom of ponds shall be evaluated in detail. Loading rates lower than those presented above shall be utilized where necessary to minimize the generation of odors.

74.4.2 Geometry and Configuration

A minimum of three active treatment cells should be provided, exclusive of polishing ponds. Basin geometry and influent and effluent arrangement for facultative systems shall be of the plug-flow design with high length to width ratios. Non-facultative aerated ponds shall be designed as completely mixed flow models.

All ponds shall be designed to minimize the possibility of short circuiting due to hydraulic design, thermal stratification, and wind-induced currents. In facultative ponds, suitable baffling shall be designed to minimize intermixing of the anaerobic and aerobic zones by wind action and by basin hydraulics.

Facultative ponds shall provide for long-term sludge storage in the initial or primary cell(s). The depth of storage should be sufficient to provide storage for a 10- to 20-year period, but shall not exceed 2 feet. Provisions for recirculation to the primary cells shall be required, with recirculate drawn from either the last or next to last stage.

74.5 Flow Distribution and Control

Flow distribution shall permit operation in series or in parallel. Any cell shall be capable of being isolated. The piping and control arrangements shall allow a different water level to be maintained in each cell when operated in series.

All ponds shall have provisions for draining and dewatering. Emergency overflows shall be provided to prevent overtopping of dikes.

74.6 Outlet Design

Outlets for aerobic and facultative ponds shall be designed to minimize loss of algal and microbial solids. The zone adjacent to the outlet shall be designed to be quiescent.

74.7 Basin Construction

Stabilization ponds shall be designed to substantially eliminate seepage or exfiltration in areas of existing or potential potable water supply by the use of appropriate liners. The Honolulu Board of Water Supply (BWS) shall review and approve the design of ponds located in the BWS "No-Pass Zone" (see Section 100.3).

Containment and intercell dikes shall be constructed of stable material capable of resisting all forces of erosion. Consideration shall be given to interior slope protection on small ponds. Riprap or other protective measures shall be provided on ponds with surface areas greater than 10 acres or on smaller ponds where deemed necessary to provide protection from excessive wave action. The top of dikes shall be of a sufficient width to permit access for maintenance equipment.

74.8 Removal of Solids

The required frequency of solids removal from the pond and recommended methods for removing and disposing of the solids shall be fully evaluated during the design phase for all pond systems. For lined ponds, the potential for damaging or otherwise reducing the integrity of the lining during cleaning operations and the adverse impacts and mitigative measures related to lining failure shall be addressed.

75.0 LAND TREATMENT

Land treatment systems may be utilized following primary treatment units to provide secondary level treatment. Requirements for land treatment systems are addressed in Chapter 100.

76.0 OTHER SECONDARY TREATMENT PROCESS

Secondary treatment processes other than those addressed herein will be evaluated on an individual case basis.

CHAPTER 80

ADVANCED WASTEWATER TREATMENT

80.0 GENERAL

Advanced wastewater treatment involves the employment of treatment processes capable of either: 1) achieving effluent quality beyond 30 mg/l for five-day biochemical oxygen demand (BOD_5) and suspended solids (SS), or 2) reducing the concentration of substances normally not substantially removed by conventional wastewater treatment operations. Substances removed by advanced wastewater treatment process may range from relatively simple inorganic ions, such as nitrate and phosphate, to highly complex synthetic organic compounds. Four principal areas of advanced wastewater treatment addressed in this chapter are effluent polishing, nitrogen conversion and removal, phosphorus removal, and removal of refractory organics.

The primary intent of this chapter is to describe the scope of capabilities and applicability of various advanced wastewater treatment options. The treatment processes described herein should not be considered the only applicable or acceptable processes available. Design of advanced treatment processes will generally require a variety of special considerations and detailed pilot studies. Review and approval will be on a case-specific basis. Design and performance criteria presented in this chapter should be only utilized as a general guide due to inherent process variability and rapid advancement of the state of the art.

81.0 EFFLUENT POLISHING

81.1 General

Effluent polishing processes are employed following secondary level treatment to reduce suspended solids concentrations to levels well below 30 mg/l. A minor reduction in BOD_5 is usually realized from the removal of additional volatile solids. Two effluent polishing processes addressed below are granular media filtration and microscreening.

81.2 Granular Media Filtration

Effluent polishing by granular media filtration is typically accomplished by the use of rapid sand filters operating at rates on the order of 2 to 6 gpm/sf. Such filters generally employ single-, dual- or multi-media filter beds and fully automatic backwashing equipment and controls.

Pilot studies are generally required to evaluate the filterability of the wastestream, to assist in media selection, and to determine application rates and backwash requirements. The overall design of the treatment facility must consider the increased hydraulic and contaminant loading resulting from filter backwashing operations. Provisions for chemical addition is generally required to control grease accumulation and slime growth on the filter media. Possible adverse impacts on downstream unit processes stemming from the use of chemicals shall be considered.

Filtered effluent SS concentrations may be expected to be below 20 mg/l. Effluent SS concentrations below 5 mg/l are achievable. Addition of chemical coagulants and flocculants may be utilized to increase removal efficiency and reliability.

81.3 Microscreening

Microscreening is a physical straining process which may be utilized for polishing of secondary effluent. The process typically employs a partially submerged rotating drum mounted horizontally in a tank. The influent enters the drum from one end and flows radically through a filtering media attached to the drum periphery. The filtering media is generally a polyester or stainless steel screen. Backwashing is accomplished at the top of the drum where high pressure jets spray strained effluent onto the screen to dislodge accumulated solids. Solids flushed from the screen may be recycled to the head of the plant or to the sludge handling system.

Apertures in the screen filtering media normally range from 15 to 60 microns although screens with apertures as small as 1 micron are available. Hydraulic loading rates of 5 to 10 gpm per square foot of submerged drum surface area are typical. Head losses through the microscreens are generally on the order of 3 to 6 inches. Backwash flow requirements, depending on backwash pressure, may vary from 2 to 5 percent of the throughput. Chlorination or ultraviolet light may be utilized to control biological growths on the screen media. Use of a variable speed drive on the rotating drum should be considered to improve operational flexibility.

Effluent SS concentrations may be expected to be below 15 mg/1. Effluent SS concentrations below 5 mg/1 are achievable.

82.0 NITROGEN REMOVAL

82.1 General

Nitrogen in wastewater may exist in four forms: organic nitrogen, ammonia nitrogen, nitrite nitrogen, and nitrate nitrogen. The principal forms of nitrogen in untreated wastewater are organic and ammonia nitrogen. Organic nitrogen in wastewater is converted to ammonia nitrogen through bacterial decomposition.

The presence of various forms of nitrogen in treated wastewater may, in certain situations, have undesirable impacts on the receiving environment. Nitrogen in the discharged effluent is a nutrient which may be the cause of objectionable biostimulation of receiving water aquatic growth. In addition, conversion (oxidation) of ammonia, first to nitrite and then to nitrate by an aerobic process known as nitrification, may exert an unacceptable oxygen demand on the receiving water. Excessive effluent nitrate concentrations may be undesirable as nitrates are a potential drinking water contaminant.

The effects of nitrogenous oxygen demand on receiving waters may be mitigated by employing treatment processes which nitrify ammonia in the wastewater by biological means or which remove nitrogen from the

wastewater altogether by physical-chemical methods. Concerns related to eutrophication of receiving waters and excessive nitrate levels may be alleviated by employing denitrification processes following nitrification to remove nitrates, or by directly utilizing physical-chemical nitrogen removal techniques. Means of physical-chemical nitrogen removal include ammonia stripping, selective ion exchange, and breakpoint chlorination.

82.2 Biological Nitrification

82.2.1 General

Nitrification may be accomplished by maintaining conditions suitable for the growth of nitrifying organisms. In a controlled aerobic environment, nitrosomonas act on dissolved ammonia to form nitrite, which in turn is converted to nitrate by nitrobacter. It is important to note that biological nitrogen conversion and the associated kinetic reaction rates are strongly influenced by temperature, pH and dissolved oxygen.

82.2.2 Suspended Growth Nitrification

Suspended growth nitrification is normally accomplished in an independent activated sludge system, downstream from conventional secondary treatment processes for carbonaceous BOD removal. The process should be preceded by a treatment process which reduces BOD_5 to less than 50 mg/l and to a primarily soluble form. The aeration tankage for nitrification should have a configuration to promote plug flow. If the wastewater is deficient in alkalinity, chemical addition provisions for pH control is generally required.

Effluent NH_3-N concentrations between 2 and 4 mg/l are typical for suspended growth nitrification systems. Concentrations as low as 0.5 mg/l of NH_3-N may be achievable.

82.2.3 Fixed Growth Nitrification

Fixed growth nitrification processes utilize nitrifying microbial populations attached to synthetic or other types of media. Fixed growth nitrification reactors, which may be of either the trickling filter or rotating biological contractor (RBC) configuration, generally cannot provide the process control or operational flexibility available in a suspended growth reactor. Fixed growth nitrification systems, however, are generally more stable and exhibit greater ease of operation.

In trickling filter systems, the development and maintenance of nitrifying organisms is mainly dependent upon organic loading and wastewater temperature. Field operating data, while limited, indicate that trickling filters may achieve a high degree of nitrification at organic loading rates of less than 5 lb BOD_5 per 1000 cf per day.

In RBC units, low BOD levels are generally required before nitrifying bacteria become predominant and ammonia oxidation proceeds at its maximum rate. Influent BOD_5 and suspended solids concentrations in the range of 30 and 40 mg/l, hydraulic loading rates of 1.5 to 2.5 gpd/sf, and organic loading rates of not more than 0.6 lb BOD_5 per 100 sf per day are typically recommended. A minimum of four stages is usually required for significant nitrification to occur. An influent pH of 7.0 or greater is desirable.

82.3 Biological Denitrification

82.3.1 General

Nitrogen in the form of nitrates may be converted to nitrogen gas by bacterial populations in the absence of oxygen. Although the bacteria may obtain energy for growth from the nitrate-nitrogen reaction, an external source of carbon is required for synthesis since nitrified effluents usually

exhibit low concentrations of carbonaceous matter. Methanol is the most commonly used carbon source.

Denitrification processes may typically be expected to produce effluent NO_3-N concentrations on the order of 1 to 4 mg/1.

82.3.2 Suspended Growth Denitrification

Suspended growth denitrification may be accomplished in a plug-flow activated sludge-type system where mixing facilities are followed by a settling basin equipped with sludge return. Nitrogen gas formed in the denitrification reaction will hinder mixed liquor settling and therefore a nitrogen gas stripping reactor should precede the denitrification sedimentation basin. The stripping reactor also provides for the reduction of residual methanol-induced BOD.

82.3.3 Fixed Growth Denitrification

Fixed growth denitrification may be accomplished in a columnar reactor containing coarse sand or synthetic media with attached denitrifying bacterial growths. Depending on the media size, such reactors may not need to be followed by a sedimentation basin. Adequate solids wasting generally occurs through low level suspended solids carryover in the effluent. Periodic backwashing and/or air scour, however, is necessary to prevent excessive solids buildup and head losses in the column. Application rates of 2 to 10 gpm/sq ft and the use of well rounded sand media 2 to 4 mm in diameter have been suggested.

82.4 Physical-Chemical Nitrogen Removal

82.4.1 Ammonia Stripping

Ammonia stripping involves the conversion of NH_4^+ ions to dissolved NH_3 gas by raising the pH of the wastewater to within the range of 10.8 to 11.5. The ammonia, essentially

insoluble at this pH level, is then removed from solution by providing air-water contact in stripping towers or ponds.

In air stripping towers, effective removal of ammonia results from the drawing of large quantities of air through the tower and the formation of water droplets which provide extensive surface area for air contact. The high pH wastewater is usually applied at a rate of 1 to 3 gpm/sq ft in conjunction with an air rate of 300 to 500 cf/gal. Towers are of the crossflow or countercurrent type, with depths typically in the 20- to 24-foot range. Access to tower packing material must be provided for the removal of scale, an unavoidable result of contact between carbon dioxide in the air and the high pH wastewater. Countercurrent towers are less susceptible to scaling.

High pH holding ponds have also been used for ammonia stripping. Ammonia release is accelerated above normal surface transfer rates by agitation of the pond contents.

The effluent concentration of NH_3-N is normally expected to be in the range of 2 to 4 mg/l. Concentrations of 1 mg/l NH_3-N may be achievable.

82.4.2 Selective Ion Exchange

Certain natural zeolites or synthetic resins may be utilized to selectively remove ammonia from solution in columnar reactors of either the gravity or pressure flow type. When the removal capacity of a column is exhausted, spent media may be regenerated with concentrated solutions of regenerants such as sodium chloride, calcium chloride, and lime (high pH), or calcium, sodium, magnesium, and potassium chlorides (neutral pH).

The effluent concentration of NH_3-N is normally expected to be in the range of 1 to 4 mg/l.

82.4.3 Breakpoint Chlorination

When chlorine is added to wastewater containing nitrogen in the ammonia form, hypochlorous acid reacts with ammonia to produce chloramines. Further addition of chlorine beyond the breakpoint converts the chloramines to nitrogen gas. The reactions involved are dependent on pH, temperature, contact time, and the chlorine to ammonia ratio. A pH control system is generally necessary, particularly with wastewaters of low alkalinity. Air may be added to the reaction chamber to aid in mixing and to strip nitrogen trichloride, carbon dioxide, and nitrogen gases from solution.

The concentration of NH_3-N in the effluent is normally in the range of 0.2 to 1.0 mg/l.

83.0 PHOSPHORUS REMOVAL

83.1 General

Phosphorus removal is desirable primarily to prevent excessive biostimulation of aquatic growths in the receiving water. Phosphorus in wastewater may be present in three forms: orthophosphate, polyphosphate, and organic phosphorus. With most wastewaters, approximately 90 percent of the phosphorus content is soluble and, since none of the phosphorus forms are gaseous under normal conditions, the most effective removal is accomplished by the formation of an insoluble precipitate that can be removed by gravity settling. Some removal of phosphorus can also be achieved using biological treatment which incorporates the phosphorus into cell tissue.

83.2 Chemical Phosphorus Removal

Addition of lime, or salts of aluminum or iron, may be used for the chemical removal of soluble phosphorus. The phosphorus reacts with the calcium, aluminum, and iron ions to form insoluble compounds. These insoluble compounds may be subsequently removed by sedimentation.

Effluent phosphorus concentrations in the range of 1 to 2 mg/l as P are typical for chemical phosphorus removal methods.

83.3 Biological-Chemical Phosphorus Removal

Combining biological and chemical mechanisms to effect phosphorus removal results in considerably reduced chemical usage compared to that of chemical addition methods alone. Biological-chemical phosphorus removal is only applicable to treatment facilities which utilize the activated sludge form of secondary treatment.

Biological-chemical phosphorus removal typically involves three major process steps. First, primary effluent is introduced into the aeration tanks where dissolved phosphorus in the wastewater is biologically adsorbed by the phosphorus deficient microorganisms present. The return sludge from the final sedimentation basins is then introduced to an anaerobic stripping tank prior to recirculation to the aeration tank. Under the anaerobic conditions of the stripping tank, microorganisms release the adsorbed phosphorus to the supernatant and renders the return sludge to the aeration tank devoid of sludge to allow the cycle to be repeated. In the last step, the concentrated supernatant is treated with chemicals and returned to the primary sedimentation basins where the chemical sludge is allowed to settle and be processed in the conventional manner.

Effluent phosphorus concentrations, for influent phosphorus concentrations of up to 10 mg/l as P, may normally be expected to be less than 1 to 2 mg/l as P. An effluent phosphorus concentration as low as 0.2 mg/l as P may be achievable.

84.0 REFRACTORY ORGANICS REMOVAL

84.1 General

Refractory contaminators are those contaminants generally resistant to or totally unaffected by conventional treatment processes. Refractory organic contaminants include various high molecular weight materials

such as pesticides. Two processes which may be applicable to the removal of refractory organic compounds are carbon adsorption and chemical oxidation.

84.2 Carbon Adsorption

Removal of refractory organic compounds as well as other wastewater contaminants may be accomplished by passing wastewater through a columnar bed of granular activated carbon. The soluble refractory organic species are removed by adsorption of the contaminant in the micropore structure of the carbon. Carbon adsorption systems generally require an upstream filtration unit to reduce the suspended solids to between 10 and 30 mg/l. A furnace is typically utilized to allow regeneration of the carbon.

84.3 Chemical Oxidation

Organic compounds can be oxidized with chlorine or ozone subsequent to secondary treatment. Pilot study is required to determine the potential effectiveness and the required doses.

CHAPTER 90

CHLORINATION AND EFFLUENT DISINFECTION

90.0 GENERAL

90.1 Objectives and Processes

The principal objective of effluent disinfection is to destroy pathogenic microorganisms in the treated wastewater to safeguard public health and prevent the spread of disease. The extent of effluent disinfection required is primarily dependent upon the use and character of the receiving environment.

Chlorination is the most extensively utilized method of effluent disinfection. Methods of chlorinating wastewater include gas chlorination and sodium and calcium hypochlorination. Other disinfection technologies include ozonation, ultraviolet light radiation, gamma radiation, and use of bromine, iodine, chlorine dioxide, and silver oxide as disinfectants.

Chlorine residuals in chlorinated effluent may have toxic effects on receiving water biota. The practice of removing all or part of the total combined residual remaining after chlorination is referred to as dechlorination. Sulfur dioxide and sodium metabisulfite are commonly used in dechlorination systems.

In many wastewater facilities, chlorine is utilized for purposes other than effluent disinfection. Prechlorination of influent wastewater and intermediate chlorination at various downstream liquid and solids stream unit processes is often practiced to aid in odor control, grease removal, sludge thickening, reduction of sludge bulking, and overall process control.

90.2 Selection of Disinfection Method

The method of disinfection should be selected after due consideration of chemical handling and feeding requirements, degree and reliability of disinfection required, characteristics of the wastewater, availability of chemicals, maintenance requirements, economic factors and safety. The design engineer should compare the cost-effectiveness of employing conventional gaseous chlorine as a disinfecting agent with the utilization of other applicable technologies such as onsite or close-vicinity generation of sodium hypochlorite.

90.3 Capacity of Disinfection Facilities

Capacity of the disinfection system shall be based on the degree and reliability of effluent disinfection required and where applicable, the demand of other uses and points of application of the disinfectant. For disinfection of wastewater effluent, the disinfection system capacity and efficiency shall be sufficient to assure compliance with bacteriological effluent limitations determined in accordance to provisions of Chapter 100.

The capacity of the disinfection system shall be selected with due consideration of abnormal operating conditions. Such conditions may include treatment process malfunctions which result in effluent degradations and out of service disinfectant contact basins. Additional capacity required for abnormal conditions may be separate and independent from the disinfection facilities utilized for disinfection under normal conditions. Provisions to disinfect effluent diversions and bypassed flows shall be included in the design of all facilities.

Additional considerations applicable to the evaluation of chlorine dosage and feed capacity are addressed in Section 91.2.

90.4 Redundancy and Standby Requirements

Standby disinfection equipment shall be provided for Reliability Class I, II and III facilities except as otherwise approved by the Director. Each installed unit shall be capable of adequately disinfecting the design peak flow with the largest capacity unit out of service.

91.0 CHLORINATION

91.1 General

The design of chlorination systems is dependent upon the form of the chlorine disinfectant utilized. Gaseous chlorine, which is delivered and stored in liquified form in 150 lbs and ton cylinders, is the most widely used form of chlorine in wastewater treatment. Wastewater may also be chlorinated by available chlorine in the form of sodium or calcium hypochlorite. Sodium hypochlorite is delivered as a liquid in concentrations from 1.5 to 15 percent by weight. Calcium hypochlorite is generally delivered in a dry form as dry powder, granules, pellets or tablets, and typically exhibits strengths of 35 to 70 percent chlorine by weight.

Hypochlorite solutions may be manufactured onsite by an electrolysis process utilizing seawater, brackish water, or concentrated salt brines. The cost-effectiveness of onsite generation is highly dependent upon the cost of equipment, electricity and brine supply.

Selection of the method of chlorination and design of chlorination facilities shall be based on consideration of factors discussed in Section 90.2.

91.2 General Design Considerations

Chlorination facilities shall be designed to assure that the discharged effluent is in compliance with all applicable bacteriological effluent limitations. The designer shall consider all factors that may influence

the disinfection efficiency of chlorination facilities. Such factors shall include chlorine dosage, initial coliform concentrations, contact time, degree of mixing at the point of chlorine solution addition, and reaction of chlorine with ammonia and other organic nitrogen compounds. The above factors shall be considered for the full range of anticipated flows and effluent characteristics.

Utilization of flow pacing and/or residual feedback chlorine feed control systems should be considered where a high degree of disinfection reliability is required, where significant diurnal variations in flow and chlorine demand are anticipated, and where such systems may cost-effectively reduce chlorine usage.

Consideration shall be given to present and future non-disinfection application of chlorine in the design of chlorination systems. Chlorination systems should be designed with a high degree of operational flexibility and with provisions to facilitate installation of additional chlorination equipment for future demands and uses.

Design of all chlorination systems should comply with requirements and guidelines presented herein and applicable recommendations of the Chlorine Institute.

91.3 Gaseous Chlorination

91.3.1 General

Gaseous chlorination systems shall generally be of the solution feed type employing vacuum chemical feed.

91.3.2 Chlorine Containers

Selection of chlorine container size (150 lb or ton cylinders) shall be based on economic considerations as well as nonmonetary factors such as ease of handling and potential of chlorine

exposure hazards to nearby residents. The use of ton containers should be considered wherever the average daily consumption of chlorine is greater than 40 lb/day.

91.3.3 Chlorine Container Handling

Proper handling equipment shall be provided for ton containers. Handling equipment should include: 1) two-ton capacity electric hoist and monorail system, 2) cylinder lifting bar, and 3) cylinder trunnions. The height of the monorail above the floor shall be sufficient to lift cylinders off delivery vehicles and to lift one cylinder over another.

91.3.4 Chlorine Container Scales

Scales, preferably of the indicating type, shall be provided for weighing cylinders in use. Two separate scales or a single scale with two weighing platforms should be provided to permit weighing of both in-use and standby cylinders. Each scale or weighing platform should be sized to accommodate the maximum number cylinders required to deliver the maximum chlorine feed rate. Scales shall be constructed to resist corrosion.

91.3.5 Chlorine Supply Piping and Appurtenances

The chlorine supply systems shall be provided with appropriate piping and appurtenances for proper chlorine gas withdrawal. Separate headers should be considered for the bank of cylinders on each scale to facilitate periodic cleaning. Provisions for automatically switching the withdrawal of chlorine from exhausted cylinders to standby cylinders shall be considered.

Header valves and isolating container valves on individual supply lines shall be provided. Gas lines shall be provided with the necessary pressure reducing valves, isolating valves,

sediment traps, filters, and auxiliary pressure gages. Expansion tanks shall be provided wherever liquid chlorine may become trapped in the supply line. Automatic electric shut-off valves, pressure gages, pressure switches, and alarms shall be provided as appropriate on liquid chlorine supply lines.

Liquid and gas chlorine connecting piping between the chlorine containers and headers should be Type K soft copper. Header piping and piping up to the inlet pressure-reducing valve of the chlorinator should consist of Schedule 80 seamless black steel tubing and 2000 lb forged steel fittings. Reducing fittings shall be utilized in place of bushings. Unions shall be of the ammonia type with a lead gasket joint. All valves on gas or liquid chlorine supply lines shall be approved by the Chlorine Institute.

91.3.6 Evaporators

The feasibility of utilizing evaporators and liquid chlorine withdrawal should be investigated wherever manifolding of several ton cylinders would otherwise be required to supply a sufficient amount of chlorine gas. All evaporator systems shall be equipped with a low temperature alarm circuit interlocked with a chlorine shut-off valve on the discharge line of the evaporator to prevent liquid chlorine from flowing to the chlorinator. Evaporators should be equipped with a cathodic protection system to minimize corrosion of evaporator components. A gas pressure gage, water bath temperature gage, water level indicator, and low temperature alarm switch should be provided on all evaporators.

91.3.7 Chlorinator

Chlorinators shall be designed to provide accurate and safe metering of chlorine gas. Chlorinators should consist of the following components: 1) inlet chlorine pressure-reducing

valve, 2) rotameter, 3) gas metering orifice with manual feed rate adjuster, 4) vacuum differential-regulating valve, 5) pressure-vacuum relief valve, and 6) injector. Chlorinators should be designed with alarms to signal chlorine gas supply failure and water supply or injector vacuum failure. Injector check valves or vacuum relief devices should be provided to prevent injector water from being drawn into the chlorine cylinders. All chlorinators shall be provided with a chlorine pressure gage and injector vacuum gage.

The chlorine metering orifice shall be provided with accurate and reliable automatic positioning devices where the metering orifice is to be paced by flow or chlorine residual signals. The chlorine feed rate shall be manually controllable when the control signal is disengaged from the chlorine metering orifice. The use of a compound-loop control system, utilizing a differential-regulatory valve controlled by a chlorine residual signal and a metering orifice paced by flow, should be considered where large variations in chlorine requirements are to be encountered.

91.3.8 Chlorine Vacuum and Solution Piping and Appurtenances

Vacuum and solution piping and fittings for chlorine may be constructed of PVC, reinforced fiberglass, hard rubber or saran lined steel, or other suitable materials capable of resisting corrosion. Appropriate PVC ball type or diaphragm type valves should be utilized. Chlorine solution lines larger than 2-inches in diameter should be provided with rubber or PVC lined Saunders type diaphragm valves.

91.3.9 Water Supply

An ample and reliable supply of potable water or adequately treated recycled wastewater shall be available for the chlorinator solution water. A hydraulic analysis of the chlorine

solution line between the injector and the point of application shall be performed to establish the expected back pressure and to determine the required water pressure and flow. Where a booster pump is required, a backup pump and provisions for standby power shall be available. Potable water suppliers shall be adequately protected from backflow.

91.3.10 Mixing and Chlorine Solution Diffusers

Chlorine solution shall be introduced into the waste flow by an appropriate diffuser and positively mixed as rapidly as possible. Sufficient mixing should be provided to homogenize the chlorine solution and wastewater in less than three seconds and to provide a minimum mean velocity gradient of 500 fps/ft. Adequate mixing may be accomplished by the addition of the solution to a turbulent flow regime in pipes or open channels or by the use of turbine type mechanical mixers. Diffusers shall be designed to maximize diffusion, to resist corrosion, and to facilitate removal and maintenance.

A sufficiently long contact period shall be provided after rapid mixing of the chlorine solution and effluent. Contact period and contact chamber design requirements and considerations are addressed in Section 91.6.

91.3.11 Chlorine Housing and Storage

Chlorination facilities shall be located at or near the point of application wherever practicable. Chlorine storage and feed equipment rooms should be located at ground level and shall be situated to permit easy access. Rooms containing chlorine and chlorination equipment should be located in separate buildings or isolated from other sections of the building by gas-tight panels. Access to such rooms shall only be through outside doors.

Doors for chlorination facilities shall open outwards and be equipped with panic hardware and a gas-tight inspection window. A minimum of two doors, located at opposite ends of the room, should be provided for each room in which chlorine is stored, handled or used.

A partition separating the chlorine cylinder storage room and the chlorination feed equipment room should be provided. A gas-tight window should be installed in at least one wall of the chlorination equipment room to permit observation of the chlorinators without entering the room.

Ventilation for chlorination facilities shall be adequate for both normal operations and for adverse conditions created by a severe leak. One complete air change every fifteen minutes shall be provided under normal conditions. Under emergency conditions, the ventilation system shall be capable of providing one complete air change per minute. The suction of exhaust fans shall be located at or near floor level and preferably opposite or away from entrance doors. Fresh air inlets located to provide cross ventilation shall be provided. Exhausted gases shall be conveyed to a safe location. Switches for all ventilating fans should be provided outside of chlorine rooms or buildings, regardless of whether an inside switch is installed.

Chlorine containers in either storage or use shall be shielded from direct sunlight and protected from overheating above 140°F. The temperature in the cylinder storage room should not be allowed to increase above that of the chlorine feed equipment room. All elements of the chlorine system shall be protected from fire hazards. Water shall be readily available to cool chlorine cylinders in the event of a fire.

Floor drains from chlorine rooms shall not be connected to floor drains from other rooms. All electrical fixtures and

conduits in chlorine rooms shall be gas tight. Chlorinator vent lines shall discharge above grade to the outside atmosphere.

91.3.12 Chlorine Residual Monitoring

Equipment shall be provided for measuring chlorine residual by accepted test procedures. Chlorine measuring equipment shall preferably be of the electrode-type. An on-line chlorine residual analyzer and recorder shall be provided as necessary to facilitate residual monitoring and automatic or manual regulation of chlorine feed rates. High and low chlorine residual alarms should be considered for on-line analyzers.

91.3.13 Safety Equipment and Miscellaneous Safety Provisions

An automatic chlorine leak detector and alarm system should be provided at all facilities. The system should be capable of sensing atmospheric chlorine at concentrations as low as 0.5 mg/l. A bottle of 50 percent ammonium hydroxide solution shall be provided for manually detecting chlorine leaks.

At least two complete sets of emergency breathing apparatuses (gas masks), meeting the requirements of the National Institute for Occupational Safety and Health (NIOSH), shall be available where chlorine gas is handled. The equipment 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. At least one of the breathing apparatuses should be of the refillable compressed air tank type having a minimum service period of 30 minutes.

Where ton containers are utilized, a leak repair kit approved by the Chlorine Institute shall be provided. Caustic soda solution reaction tanks for adsorbing the contents of leaking ton containers shall be provided whenever chlorination facilities are situated near residences and other populated areas.

Instructions should be posted to alert operators of safety and emergency measures. A sign for a national industry-sponsored emergency response center shall be posted outside the storage area. The sign shall read:

CHEMTREC
Chemical Transportation Emergency Center
Manufacturer Chemists Association
Washington, D.C.
1-202-483-7616

Note: The design engineer shall verify that the above phone number is currently that of CHEMTREC.

91.4 Hypochlorination (Sodium Hypochlorite)

91.4.1 General

Sodium hypochlorination systems shall be designed to achieve the same end result as gaseous chlorination systems. The design of sodium hypochlorination facilities shall consider the deterioration of the available chlorine strength with time. Differences in chemistry and germicidal efficiency between hypochlorites and gaseous chlorine should be evaluated, particularly with respect to effects related to pH. Chlorine contact time and contact tank requirements for hypochlorination shall be similar to that of gaseous chlorination.

Sodium hypochlorination systems shall generally utilize feed pumps of the positive displacement type. Consideration should be given to a gravity feed system utilizing a modulating valve where conditions allow the use of such a system. The use of eductor-type hypochlorite feed systems shall be avoided.

91.4.2 Storage Facilities

The capacity of sodium hypochlorite storage facilities shall be based on such considerations as dosage requirements, frequency and volume of deliveries, and reliability of the hypochlorite source. Storage capacity should be available to store a minimum of one week's supply of hypochlorite. Multiple storage tanks should be provided.

Storage vessels may consist of polyethylene or hypochlorite-resistant fiberglass-resin tanks, or concrete or steel tanks with suitable protective linings. Storage tanks should be provided with a suitable level indicator and low level alarm.

91.4.3 Feed Pumps

Sodium hypochlorite feed pumps shall be selected and designed to resist corrosion and to provide accurate and reliable metering of hypochlorite solution. Sodium hypochlorite feed pumps shall be of the positive displacement diaphragm type wherever practicable. Feed rates shall be controlled by a variable speed drive and/or by adjustment of stroke length. Where high feed rates are required, centrifugal pumps constructed of suitable materials may be utilized by providing a downstream modulating valve to control feed rates.

Considerations for use and design of automatic feed control systems based on flow pacing and/or chlorine residual information shall be similar to that for gaseous chlorination. For diaphragm pump systems, use of compound loop systems employing flow and chlorine residual signals to the pump speed controller and automatic stroke positioner should be considered. Combination of flow and residual signals by a summation device should be considered for systems employing a modulating control valve.

91.4.4 Piping and Appurtenances

Piping and related appurtenances for sodium hypochlorite systems shall be similar to that for chlorine solutions in gaseous chlorination systems. Flow modulating valves should be the Saunders-type diaphragm valve constructed of or lined with suitable corrosion resistant materials. Magnetic, variable-area, or other approved types of flow meters shall be provided as necessary to monitor solution feed rates. Continuous recording of hypochlorite flow should be considered.

91.4.5 Mixing and Chlorine Solution Diffusers

Design considerations for sodium hypochlorite solution diffusers and initial mixing shall be similar to that of gaseous chlorination.

91.4.6 Housing and Storage

Storage tanks shall be protected against light and heat to minimize deterioration of the hypochlorite solution. Natural or forced mechanical ventilation shall be provided to maintain normal room temperatures.

91.4.7 Safety Provisions

Eye baths and overhead showers shall be provided in the storage and metering areas. A high capacity drain and containment dikes shall be provided adjacent to storage tanks to mitigate adverse consequences of tank ruptures. Other standard safety provisions for handling of hazardous chemicals, including those addressed in Chapter 120, shall be provided as applicable.

91.5 Hypochlorination (Calcium Hypochlorite)

91.5.1 General

Calcium hypochlorite dissolved in water may be fed as an aqueous chlorine solution in a manner similar to that of sodium hypochlorite. Sludge from precipitates in calcium hypochlorite solutions, however, make this form of chlorine difficult to handle and feed. Calcium hypochlorite shall not be utilized for large or permanent chlorination applications.

91.5.2 General Design Requirements and Considerations

In general, design considerations for calcium hypochlorite facilities shall be similar to that of sodium hypochlorite facilities. Calcium hypochlorination facilities, unlike sodium hypochlorination facilities, shall be designed to handle precipitates that may form in the solution. Provisions shall be included in the design for removal of sludge from any solution storage containers. Use of steel plug valves with PVC or polyethylene lining is preferred over the use of ball valves.

Special consideration shall be given to the storage of dry calcium hypochlorite. Dry calcium hypochlorite should never be exposed to heat, damp conditions, and organic compounds due to the possibility of spontaneous combustion, fire and explosion.

91.6 Chlorine Contact Period and Contact Chambers

91.6.1 Chlorine Contact Period

The contact period for all disinfection systems shall be adequate to permit the disinfecting agent to reduce coliform bacteria populations to the required levels. The contact period shall normally be provided in a contact tank. Contact

period in pipelines and outfalls may be credited under certain circumstances, particularly if the effluent discharge point can be sampled.

91.6.2 Chlorine Contact Chambers

Contact chambers for chlorination systems should be constructed to cost-effectively minimize short circuiting of flow. Baffling shall be provided as necessary to promote plug-flow.

The contact tank shall be designed to facilitate maintenance and cleaning without significantly sacrificing effectiveness of the disinfection process. Multiple tanks or bypassing facilities shall be provided for all facilities.

Provisions shall be made to facilitate removal of accumulated solids from the tank bottom. Either drains or drainage sumps shall be provided for ease of dewatering. Provisions shall be made for the conveyance of the accumulated solids to appropriate unit processes for proper treatment and handling. Mixing systems, such as roll-type aeration, shall be provided for the suspension of solids unless directed otherwise by the Division. Provisions shall be included in the design to control foam generation and scum accumulation.

92.0 DECHLORINATION

92.1 General

Chlorine residuals in chlorinated effluents may, under certain conditions, have objectionable toxic effects upon biota of the receiving water. Dechlorination facilities shall be provided wherever it is deemed necessary to eliminate chlorine-induced toxicity. For surface water discharges, the need for dechlorination and extent of dechlorination required shall be determined by a joint effort between the City and the State Department of Health on a case-specific basis. The design

engineer shall be responsible for supplying the necessary design data to assist in the determination.

Dechlorination shall generally be accomplished by the use of sulfur-bearing compounds which hydrolize in water to produce sulfite ions. Selection of the dechlorinating compound shall be based on consideration of factors discussed in Section 90.2. Other methods of dechlorination such as activated carbon, ion exchange resins, aeration, and long-term storage shall be utilized only as approved by the Division.

92.2 Sulfur Dioxide

92.2.1 General

Sulfur dioxide is the most widely used dechlorinating compound and is well suited for use at large wastewater treatment facilities, Liquid/gaseous sulfur dioxide, which is most readily available in ton containers, is handled and fed in a manner similar to that of gaseous chlorine. Approximately 1 mg of sulfur dioxide is required to dechlorinate 1 mg of total or free chlorine residual.

92.2.2 Storage and Supply System

Like chlorine, sulfur dioxide may be withdrawn from the supply containers as either a gas or liquid. Due to the low vapor pressure of sulfur dioxide, special consideration shall be given to prevention of reliquefaction. For gas withdrawal, control of reliquefaction by heating of the header or other means shall be considered. An evaporator similar to that used in chlorination systems is required for liquid withdrawal. Sulfur dioxide container weighing and handling facilities, automatic container switch-over devices, and supply piping and appurtenances shall be similar to that required for chlorination in both design and materials of construction.

92.2.3 Feed Equipment and Appurtenances

Sulfur dioxide feed equipment and appurtenances shall generally be designed in a manner identical to that of gaseous chlorination systems. Automatic sulfur dioxide feed control systems shall generally be provided. Chlorine residual signals obtained before and after dechlorination shall be utilized as appropriate.

Requirements for sulfur dioxide solution diffusers and initial rapid mixing provisions shall be comparable to that of chlorination systems. A contact minimum time of 1 to 5 minutes at design peak flow shall be provided.

92.2.4 Sulfur Dioxide Housing and Storage

Housing and ventilation provisions for sulfur dioxide facilities shall be similar to that of chlorination facilities. Sulfur dioxide and chlorination facilities may be housed in the same building. A sulfur dioxide detector and alarm system shall be provided.

92.3 Sodium Metabisulfite

92.3.1 General

Dechlorination by the use of sodium metabisulfite should be considered for treatment facilities which discharge less than 1 mgd or which would require less than 5 lbs/day of sulfur dioxide. Sodium metabisulfite is a white or cream-colored powder readily soluble in water. Approximately 1.5 mg of metabisulfite should be provided to dechlorinate each 1 mg of chlorine.

92.3.2 General Design Requirements

Sodium metabisulfite should be made up as a solution and metered with a diaphragm pump. Feed equipment, storage and housing requirements, and materials of construction shall be similar to that of hypochlorite solutions. Automatic feed control systems shall be provided as necessary. Sodium metabisulfite may be handled as a nonhazardous material.

93.0 OTHER DISINFECTION METHODS

The use of chlorine dioxide, ozone, bromide, iodine, silver oxide, gamma radiation, ultraviolet light radiation and other technologies for disinfection and/or sterilization of effluent shall be evaluated and approved by the City on a case-specific basis. Supporting information describing the proposed system, costs, potential hazards, toxicity to receiving waters, availability of chemicals, disinfection efficiency and reliability, and other factors shall be provided. Design requirements and considerations for chlorination presented in the previous sections shall apply to other disinfection methods wherever appropriate.

CHAPTER 100

EFFLUENT DISPOSAL

100.0 GENERAL

100.1 Objectives and General Disposal Methods

The primary objective of effluent disposal facilities and systems shall be to provide safe, reliable and cost-effective ultimate disposal of the treated wastewater with minimal negative impacts on public health and the receiving environment.

Methods of effluent disposal include disposal to marine and inland surface waters, subsurface disposal by injection wells, and disposal by land application and various effluent reclamation/reuse systems.

100.2 Selection of Disposal Method

Alternative effluent disposal methods and systems shall be analyzed for their specific merits and limitations. Selection of the effluent disposal system shall be based on public health considerations, economic factors, degree and reliability wastewater treatment required, location of the wastewater discharge, sensitivity of the effluent receiving environment, and regulatory constraints. Wherever applicable, utilization and integration of two or more disposal methods shall be considered in an effort to increase the cost-effectiveness and reliability of the effluent disposal system. Wherever feasible, reclamation/reuse disposal systems shall be employed as the primary means of effluent disposal. Injection wells shall generally be utilized only after all reasonable disposal alternatives have been explored and found to be unsatisfactory.

Selection of an effluent disposal method shall consider restrictions that may be imposed by regulatory agencies to protect drinking water sources, public health, and the environment. General regulatory requirements applicable to effluent is addressed in Section 100.3

100.3 General Regulatory Requirements for Effluent Disposal

Effluent disposal systems shall be located and designed in accordance to applicable regulatory requirements intended to protect drinking water sources and public health. No effluent disposal system shall be constructed or placed in operation before the completion of the review and approval process by the appropriate agencies. The following discussion summarizes general effluent disposal regulatory requirements. Additional regulatory requirements are included in other sections of this chapter as appropriate.

The location of all effluent disposal systems shall be evaluated with respect to the "No-Pass" line established by the Honolulu Board of Water Supply (BWS). Areas inland of the line shall be referred to herein as the "No-Pass Zone" while areas seaward of the line shall be designated the "Pass Zone". In the No-Pass Zone, no new subsurface disposal systems will be permitted unless approved in writing by the BWS. Likewise, all land application/treatment systems located in No-Pass Zones shall be subject to BWS review and approval. In the Pass Zone, BWS review shall be required for any subsurface disposal system which extends deeper than 30 feet below the ground surface or which is located within 1000 feet of an existing domestic water source.

Both surface and subsurface effluent disposal of any form is prohibited within areas designated by the Department of Health as problem "seepage areas," except as approved in writing. Subsurface disposal by injection wells shall conform to the requirements of Chapter 23, "Underground Injection Control" of Title 11, Administrative Rules.

Treatment facilities shall be designed to meet all minimum effluent quality requirements imposed by the Department of Health (DOH) and where applicable, any additional or more rigorous federal and county requirements. Effluent quality requirements for disposal to surface waters shall be governed by applicable effluent and receiving water quality standards discussed below. Effluent quality for subsurface disposal systems shall conform to requirements presented in Section 103.2. Effluent quality requirements for reclamation and reuse systems shall be established on a case-specific basis by a joint review among the DOH, and the City. Where effluent disposal occurs in the "No-Pass Zone", the BWS shall be included in the joint review.

Effluent disposal systems discharging to inland and marine surface waters of the State of Hawaii shall comply with both effluent and receiving water quality standards. Effluent standards, consisting of effluent limitations and standards of performance for treatment facilities discharging to surface waters, are established by the National Pollutant Discharge Elimination System (NPDES) permit. Chapter 55, "Water Pollution Control", of Title 11, Administrative Rules describes and provides for the administration of the NPDES permit by the DOH. Water quality standards enforced by the DOH are established by Chapter 54 "Water Quality Standards" of the Administrative Rules. Chapter 54 addresses physical, chemical and bacteriological water quality criteria, allowable uses, and zone of mixing requirements to protect and/or preserve the integrity of the ecosystem and the beneficial uses of the receiving waters.

100.4 Treatment Reliability

The reliability classification of treatment facilities associated with specific effluent disposal systems shall be based on the consequences of degradation of the effluent on the receiving environment. Determination of reliability classifications for treatment facilities is addressed in Section 46.2.

101.0 DISCHARGE TO MARINE WATERS

101.1 General

Effluent disposal in marine surface waters is most often accomplished by submarine outfalls. Outfalls generally consist of a long section of pipe to transport the effluent a sufficient distance from shore and a diffuser section with ports to facilitate dispersion of the discharged wastewater. The principal mechanisms involved in submarine outfall disposal are initial dilution with the surrounding seawater, further dilution from dispersion by currents, and decay and assimilation of the waste.

101.2 Surveys, Data Collection and Assessments

Hydrographic surveys and oceanographic, water quality, and marine biological studies shall be conducted as necessary on the proposed outfall site and surrounding areas. Water quality, bathymetry, biological characteristics, prevailing tidal-current structure, and other information necessary for the outfall design and assessment of potential impacts of the discharge shall be determined as required to supplement existing data.

101.3 Outfall Sizing

The diameter of the outfall shall be based on an evaluation of minimum scouring velocities, head losses, structural considerations, and economic factors.

101.4 Dilution and Dispersion Considerations

Ocean outfalls shall be designed and located to cost-effectively maximize initial dilution, submergence, and subsequent far field dispersion. Assessment of discharge impacts on the receiving environment shall be conducted for all critical conditions including

those resulting in minimum dilution. Consideration shall be given to seasonal variations in ambient dissolved oxygen and turbidity levels, current structure, and stratification.

101.5 Diffuser Location Alignment and Design

Diffuser location and alignment shall be based on bathymetry, sensitivity of the marine ecosystem, potential impacts to beneficial uses, anticipated wastewater dispersion and assimilation characteristics, economic factors, and other applicable considerations. The design engineer shall consider maximization of dispersion of the effluent during transport in the most critical direction (i.e., towards shore or critical ecosystems), and minimization of diffuser inundation by drifting bottom sands.

The design of outfall diffuser sections shall fully consider diffuser length and diameter, and port sizing, spacing and orientation. Total effluent flow should ideally be equally distributed among the diffuser ports. Maintenance of scouring velocities, minimization of head losses, and elimination of seawater intrusion during diffuser operation shall also be considered. Diffuser ports shall be provided with removable and replaceable plugs, caps, shear gates or other means of isolation as necessary.

101.6 Assessment of Bacteriological Impacts

Potential bacteriological impacts shall be assessed based on bacterial (coliform organism) die-off computations employing an appropriate T_{90} time (time required for 90 percent coliform die-off). The T_{90} time may be based on actual field measurements but in no case shall be less than one hour.

101.7 Protection and Maintenance

Outfalls shall be designed to exhibit a high degree of structural integrity and include protective features to withstand all reasonable

stresses caused by currents, wave action and other forces. A manhole should be provided at the shore end of all gravity outfalls. A flap gate or other provisions to facilitate periodic flushing and cleaning shall be provided at the end of all outfalls.

102.0 DISCHARGE TO INLAND WATERS

102.1 General

Discharge of wastewater to inland waters is generally highly restricted due to a scarity of inland waters and the potential for adverse impacts on the biota and beneficial uses of such waters. Discharge to inland waters, where permitted, is typically accomplished by the use of a submerged outfall.

102.2 General Design Requirements

Wherever applicable, design procedures and considerations for inland water outfalls shall be similar to that of marine outfalls. Outfalls discharging to inland waters shall be submerged below the water surface and be provided with a permanent headwall. Special consideration shall given to provision of sufficient initial dilution and dispersion of effluent to minimize the occurrence of large localized oxygen deficits.

103.0 SUBSURFACE DISPOSAL (INJECTION WELLS)

103.1 General

Subsurface disposal requirements of this section shall apply to injection wells. Injection wells shall be defined as any shaft driven or drilled into the ground which has a large vertical dimension compared to its lateral dimension, and which permits the injection of treated wastewater into an underground formation. The use of trenches, seepage pits, and other soil absorption systems for the

disposal of treated wastewater shall be allowed only by approval of the Director and shall comply with applicable requirements and guidelines for onsite disposal systems.

The initial capacity of an injection well is dependent to a large extent on the permeability of the aquifer, groundwater levels, and the presence of fractures, solution channels, and intrinsic structural openings. Virtually all injection wells utilized for the disposal of treated wastewater exhibit a decrease in injection rates with time due to clogging. The magnitude of the clogging is generally variable, time dependent, and often unpredictable. In wastewater injection wells, the long-term injection rate is virtually always much less than the initial clean-water injection rates.

103.2 Effluent Quality Requirements

Effluent being disposed of in injection wells shall meet the following minimum requirements. Where, in the opinion of the Director, well failure and overflow would result in a serious threat to public health or water quality, or where hydrogeologic conditions are marginal, more stringent effluent requirements may be imposed.

1) Biochemical Oxygen Demand (BOD_5) shall not exceed 30 milligrams per liter (mg/l) based on a 30-day arithmetic average of composite samples, and no single sample shall exceed 60 mg/l BOD_5.

2) Suspended solids shall not exceed 30 mg/l based on a 30-day arithmetic average of composite samples, and no single sample shall exceed 60 mg/l suspended solids.

3) Installed provisions shall include the capability of providing a chlorine residual of not less than 1.0 mg/l at the injection well.

4) Appropriate filtering, straining, or screening shall be performed such that the maximum particulate size in the effluent entering the injection well does not exceed 0.25 millimeters.

103.3 Site Investigations

As a minimum, site investigations described in the following subsections shall be performed. Results of the investigations shall be submitted with pertinent design calculations for review by the Division.

103.3.1 Location Map

A map shall be prepared to identify the location of the proposed injection well site together with the State of Hawaii Underground Injection Control boundary, the Honolulu Board of Water Supply "No Pass" boundary, and boundaries of restricted "seepage areas" established by DOH.

103.3.2 Injection Background

All other injection well sites within a radius of 1500 feet of the proposed site shall be listed and their location shown on the location map required above. A description of any operational problems being experienced by nearby injection wells shall be provided. A plan of action shall be developed to indicate how the occurrence of similar problems will be avoided or mitigated at the proposed site.

Any proposed well within 1000 feet of an existing domestic water source shall also be identified on the location map.

103.3.3 Test Well Requirements For Preliminary Feasibility Investigation

One or more test wells shall be constructed or otherwise made available at the injection well site. The test well

shall consist of a borehole driven or drilled into the ground having sufficient diameter and depth to allow determination of all required information pertaining to geology, hydrology, and injection capacity. After all data collection and testing requirements are satisfied, the test well may be utilized as one of the operating injection wells providing all injection well flow and construction requirements are met.

103.3.4 Geology

A geologic log providing a detailed description of the subsurface formations, especially with regard of their injection potential, shall be prepared.

193.3.5 Hydrology

The following hydrologic information shall be provided:

1) elevation of ground surface at proposed well sites;

2) elevation of ground water table above sea level (or its depth below ground surface);

3) record of ground water level fluctuations over at least one 24-hour period (to determine possible tidal effects);

4) record of groundwater salinity (either total salinity, chlorides, or electrical conductivity) at the top, bottom, and mid-point of the test well; and

5) information on groundwater dynamics, including all available data on seasonal fluctuations, flow direction, and aquifer permeability.

103.3.6 Injection Testing

Injection testing as described in Section 103.4 below shall be conducted on all test wells.

103.4 Injection Testing

103.4.1 General Requirements

Well flow capacity testing shall be conducted on the test well and all installed injection wells. Flow testing results of the test well shall be used in the design phase to aid in the prediction on injection capacity of the proposed wells. Final well system approval and determination of compliance with sizing and capacity requirements shall be based on flow testing of the installed injection wells.

A description of proposed procedures for well testing, including all well details, elevations, geologic log etc. shall be submitted for approval prior to testing. Testing shall not proceed without the written approval of the Director. The Director may require that testing be witnessed by Division personnel.

Testing shall consist of injection testing with wastewater effluent or potable water. Pump testing will be allowed only if water for injection testing cannot be made available, and only as approved by the Director. Groundwater pumped during testing shall be disposed in an approved manner.

The duration of the injection test shall be sufficient to demonstrate steady state flow rate and head build-up conditions. The duration of the test shall in no case be less than four hours.

103.4.2 Test Procedures

The purpose of injection testing is to estimate the rate at which effluent, or clean water, is capable of being injected into a well without overflowing. The testing procedures consists of injection at a rate which produces a head build-up which does not exceed some specified allowable head build-up condition.

Allowable head build-up under gravity feed conditions shall be the injection head build-up under which the well can operate without danger of overflowing. Under gravity feed conditions, the allowable head build-up shall be a minimum of three feet below the ground surface or effluent feed elevation, except as otherwise approved by the Director.

If injection is by means other than gravity flow (i.e., any form of pressurized injection), the pressure head build-up under which the injection testing is conducted shall not place undue stress on the injection well system and subsurface hydrogeologic environment, and shall be subject to approval by the Director and the Board of Water Supply.

At sites where the capacity of the injection formation is very high, it may be impractical or impossible to attain the maximum injection rate during injection testing. In such cases, the maximum injection rate and corresponding head build-up during testing shall be reported, recognizing that the maximum injection capacity exceeds the reported value.

In general, injection tests shall be conducted under conditions as similar as possible to anticipated operating conditions. Where injection under gravity feed conditions is planned, injection testing should be conducted under these conditions.

If pump testing rather than injection testing is utilized to determine injection capacity, the pumping rate which produces a drawdown equal to the allowable injection head build-up shall be determined.

If the water level in the well is subject to tidal fluctuations, injection testing shall be coordinated with the tidal cycle such that testing is conducted during a period corresponding to the high tide cycle in the well.

If the water level in the well is subject to possible seasonal groundwater fluctuations, the allowable head build-up shall be based on the highest expected groundwater level.

103.4.3 Data Reporting

The following well test data shall be reported:

1) Static groundwater level immediately before testing;

2) Injection (or pumping) rates and water levels (or pressure heads) in the well as a function of time throughout the minimum four-hour test period;

3) Record of water level recovery for a minimum of 1/2 hour after the test; and

4) Tidal cycle conditions at the time of testing if the well is subject to tidal effects.

All water level measurements should be referenced to a common datum point, and the location of the datum shall be specified.

103.5 Individual Well Capacity

The flow rates obtained from injection (or pump) testing, by practical necessity, are based on very short periods of testing, usually with clean water, and thus do not reflect the effects of long-term clogging. In order to estimate long-term sustainable injection capacity, the test values must be adjusted for clogging effects. The following definitions and criteria shall apply in the determination of the required injection capacity.

103.5.1 Definitions

1) Injection test flow is the flow rate recorded at the end of the injection test period.

2) Pumping test flow is the flow rate recorded at the end of the pumping test period.

3) Injection capacity is the test flow rate after adjustment for clogging and environmental effects, and is the flow rate stipulated in the sizing requirements of Section 103.6.

103.5.2 Injection Capacity Criteria

Injection capacity shall be determined by the criteria presented below, unless otherwise demonstrated by a duly registered professional engineer that other criteria will provide comparable reliability of injection well performance.

1) For wells having injection test flows greater than 100 gallons per minute (gpm), the injection capacity shall be no greater than 33 percent of the injection test flow.

2) For wells having injection test flows in the range of 50-100 gpm, the injection capacity shall be no greater than 25 percent of the injection test flow.

3) For wells having injection test flows in the range of 25-49 gpm, in the injection capacity shall no greater than 20 percent of the injection test flow.

4) Wells having injection test flows less than 25 gpm shall not be allowed for injection.

5) For wells where pump testing is substituted for injection testing, the injection test flow shall be assumed to be equal to 75 percent of the pump test flow, and criteria (1)-(4) above shall be applied to the computed injection test flow to determine injection capacity.

103.6 Number of Wells and Total Injection Capacity

The total injection capacity of the injection system shall be equal to or greater than 200 percent of the design peak flow rate. In no case shall less than 2 injection wells be constructed at any site. With the largest capacity well out of service, the available injection capacity shall be not less than 100 percent of the design peak flow rate.

Provisions, including land area, for the installation of new wells to provide additional injection capacity equal to not less than 100 percent of the design peak flow rate shall be made available at all sites.

Where, in the opinion of the Director, well failure and overflow would result in a serious health to public threat or water quality, more stringent injection capacity requirements may be imposed.

103.7 Well Spacing

Spacing between injection wells shall be a minimum of 50 feet.

103.8 Well Depth

No minimum depth requirements are applicable other than those necessary to satisfy minimum injection capacity (Section 103.6) and construction (Section 103.10) requirements.

Where applicable, injection wells shall comply with restrictions on depth imposed by the Honolulu Board of Water Supply.

103.9 Well Diameter and Casing

The well casing shall have a minimum inside diameter of 4 inches. Boreholes shall have a diameter at least 3 inches greater than the casing outside diameter to provide a minimum annulus of 1.5 inches around the casing. The annular space shall be gravel packed.

Wells shall be cased throughout their entire length. The top 10 feet of each injection well shall have blank casing with the annular space sealed with grout. The remainder of the well shall be cased with slotted or perforated casing.

Casing material shall be suitable for the intended service. As a minimum, casing shall be PVC Schedule 80 or equivalent.

103.10 Effluent Piping and Well Head Design

Effluent feed piping to injection wells shall be interconnected and designed to permit rotation of wells in service and to minimize the possibility of well overflow. Well rotation capability and automatic overflow provisions should be provided by such means as the use of removable risers attached to the well head and adjustable distribution box weirs.

Effluent feed piping to each well shall be valved to permit isolation.

103.11 Injection Well Monitoring

Provisions shall be included in the design of the injection well system to allow measurement of effluent flow rate to each injection well and injection head build-up in each injection well. Provisions to facilitate sampling of effluent from each well shall also be included in the design.

103.12 Injection Well Rehabilitation

Provisions shall be included in the design of the injection well system to allow periodic rehabilitation of each injection well. Backflushing by either compressed air or pumping, or other rehabilitation methods acceptable to the Director shall be provided for.

Backflush waters shall be collected and recycled through the treatment plant or properly disposed of by approved alternate methods. Where chemicals are used for well rehabilitation and/or where injection occurs in brackish groundwaters, the potential deleterious effects on plant operations from recycling backflush waters shall be considered in the design. Backflush waters shall not be returned to the plant at a rate greater than 25 percent of the design peak flow.

104.0 LAND APPLICATION/LAND TREATMENT

104.1 General

The terms "land application" and "land treatment" shall refer to any wastewater management system in which wastewater is applied to land. Three major types of land application/treatment are: (1) slow-rate irrigation, (2) rapid infiltration (infiltration-percolation), and (3) overland flow.

Slow-rate irrigation land application systems essentially involves irrigation of crops or other vegetation with treated wastewater. A rapid infiltration system involves application of wastewater to permeable soils. The applied wastewater, which is treated as it travels down through the soil matrix, may be collected by underdrains or allowed to percolate into the groundwater. In overland flow systems, wastewater applied to sloping land is treated as it flows downhill. The treated effluent is collected in a ditch at the bottom of the system and disposed of by some other method. Overland flow systems are generally designed to primarily provide treatment rather than both treatment and effluent disposal.

Land application/treatment systems may be employed in conjunction with, or independent of reclamation-reuse schemes. The approval of land application/treatment systems shall be on a case-by-case basis. The City may require that full-scale demonstration facilities be constructed before final acceptance.

104.2 Effluent Quality Requirements

Wastewater applied to land shall generally receive secondary treatment. In no case shall the applied wastewater receive less than primary-level treatment. Specific effluent quality requirements, including bacteriological limitations, for land application/treatment systems shall be established on a case-specific basis by a joint review among the DOH, the City, and in "No-Pass Zones," the Honolulu Board of Water Supply.

104.3 Design Report

A detailed design report for land application systems shall be prepared for review and approval by the Director. The report shall address:

1) Site location and topography;

2) Adjacent land uses within 1/4 mile of the project boundary;

3) Complete site geology and hydrogeology, including all geologic formations and geologic discontinuities, soil types, groundwater contours, groundwater movement, groundwater quality, and permeability of the soil mantle; and

4) Climatological data tabulated by month, including precipitation, wind velocity and direction, and evaporation rates.

Information shall be sufficiently detailed to permit evaluation of the technical and public health aspects of the proposed decision. Available data shall be supplemented as necessary by results of project-specific testing and investigations.

104.4 Site Layout and Site Improvements

A buffer zone, equal to at least 20 percent of the wetted area and extending a minimum of 200 feet from the wetted area, shall generally be provided. Surface runoff shall generally not be permitted to leave the project site. Where necessary, the site shall be totally secured from public access by fencing, and shall have warning signs conspicuously posted.

104.5 Application Rates

Design application rates shall be determined based upon soil type, climatic conditions, site topography, waste characteristics and loading, type of vegetation, and other applicable design factors. Selection of design application rates shall be fully documented and supported as necessary by testing and demonstration. Storage capacity shall be provided where the application rate (precipitation and wastewater) exceeds the estimated application capacity of the site.

104.6 Monitoring

Monitoring wells shall be provided as necessary to detect groundwater contamination and leachate movement. Wells should be located

downstream of groundwater flow along the project site boundary, and where necessary, between the project site and the Board of Water Supply "No-Pass" line.

Wastewater flow to each major site subdivision should be measured and recorded. Rainfall at the treatment site should also be measured and recorded.

105.0 RECLAMATION-REUSE

105.1 General

Wastewater reclamation is encouraged. Potential uses of wastewater in addition to irrigation include cooling water, aquaculture, noncontact recreational water bodies and industrial process waters. Wastewater reclamation-reuse schemes shall be subject to review and approval by the City, the Department of Health, and where applicable, other regulatory agencies. The Department of Health shall have the authority to impose any conditions of acceptance with regards to the particular reuse scheme.

105.2 General Requirements

Review of the technical acceptability of reclamation-reuse schemes shall be on a case-by-case basis. Protection of public health shall be a primary consideration in any wastewater reuse scheme. A backup effluent disposal system may be required.

CHAPTER 110

SLUDGE TREATMENT AND DISPOSAL

110.0 GENERAL

110.1 Function and General Process Types

The primary objectives of sludge processing facilities are volume reduction and stabilization of organic material. Sludge handling and treatment systems may employ a wide variety of processes, including conveyance and transfer, grinding and degritting, thickening, stabilization, dewatering, and reduction. A combination of physical, chemical, and biological unit processes is typically employed in handling sludges. The extent and methods of sludge processing are generally dependent on the volume and characteristics of the sludge, economic considerations, and requirements associated with the method of ultimate disposal.

Selection of the method of ultimately disposing dewatered and stabilized sludges is generally based on economics and mitigation of adverse impacts to the environment. Landfilling is the most commonly employed method of ultimate solids disposal. Sludges that have been satisfactorily stabilized, however, may be disposed of by surface land application methods.

110.2 System Compatibility

Design of solids treatment units shall consider the entire treatment facility to ensure compatibility of units throughout the total system. Sludge treatment and handling units, in particular, shall be designed and integrated such that each operation adequately and cost-effectively prepares the solids residue for subsequent handling.

The effect of recycled solids process flows on the liquid treatment processes and effluent quality shall be considered. Solids treatment

processes exhibiting a high solids capture and low concentration recycle flows are generally preferable.

Special consideration shall be given to the impact of future wastewater treatment facilities expansion or upgrading the solids treatment facilities. Provisions shall be included in the design to facilitate future installation and operation of additional treatment units, as well as auxiliary equipment such as chemical feed systems.

110.3 Flexibility and Redundancy

The sludge treatment and disposal scheme shall be provided with the flexibility to allow alternative operating modes. The sludge handling system shall be reasonably capable of handling actual sludge flows and characteristics differing from the projected design values.

The flexibility to reroute sludge flows around one or more sludge processing units to backup or alternative processing units shall be provided to assure satisfactory sludge handling during either routine or emergency equipment shutdowns. Alternate methods of sludge treatment and/or disposal shall be provided for each sludge treatment unit without installed backup capability.

Sludge holding tanks may be permitted as an alternative to component or system backup for sludge handling units downstream of the tank. The volume of the holding tank shall be based on the estimated time necessary to repair or perform maintenance on the applicable components. If a holding tank is utilized as a backup to a sludge treatment system designed for continuous operation, excess capacity in all downstream components shall enable processing of the retained sludge together with the normal sludge flow.

The redundancy and backup requirements for sludge processing units and components presented above and elsewhere in this chapter shall apply equally to Reliability Class I, II and III facilities.

110.4 Sludge Production and Characteristics

110.4.1 Quantities

Quantities of sludge to be processed shall be estimated by actual measurement at existing facilities and/or by computations based on reasonable assumptions. Quantity projections shall consider initial year, design year, and future or ultimate year quantities and shall address both average and peak flow conditions. The expected range of solids production (i.e., lbs of dry solids per 1,000 gal of sludge) and solids concentration (i.e., percent solids) shall be determined for the various treatment processes (i.e., primary sedimentation, activated sludge, etc.). Consideration shall be given to all recycle streams and chemical additions.

110.4.2 Characteristics

Physical and chemical characteristics of the sludge to be treated shall be determined as necessary to aid in selection of handling and disposal methods (i.e., ease of dewaterability, concentration of toxic substances, fertilizer value for land application, thermal value for incineration, etc.).

110.4.3 Mass Balance

Distribution of solids throughout the overall treatment facility shall be determined by employing mass balance computations. Calculations and assumptions should reflect actual or expected conditions as accurately as is possible. Where feasible, the design engineer shall prepare a mathematical expression for individual wastewater and solids processing unit processes. The expression shall take the form of a performance equation relating process input and

output variables and shall be prepared based upon actual (existing or similar full-scale process) performance data, supplemented with literature research as necessary. The performance equation shall be arranged to permit adjustment and refinement based upon actual operating experience of the constructed facility.

110.5 Basis of Operation

The time of operation (i.e., hours per day or week) shall be considered in sizing of solids handling, treatment, and disposal units. Facilities with design average flows less than 5 mgd should typically employ a 24-hour per week active processing period as the basis of design and operation of mechanical dewatering equipment. Selection of active sludge processing periods for facilities larger than 5 mgd shall be on a case-by-case basis.

111.0 SLUDGE CONVEYANCE AND TRANSFER

111.1 General

Sludge conveyance and transfer pumps, piping, and appurtenances shall be considered as an integral component of any sludge handling and treatment system. Specific requirements for the pumping of sludge addressed in this section shall supplement general pumping and piping system requirements and recommendations in Section 121.0.

111.2 Sludge Pumps

111.2.1 Selection

Selection of sludge pumps is primarily dependent on the viscosity and solids content of the sludge to be pumped. The ability of the sludge to flow from the withdrawal point to the pump is a primary consideration. A positive displacement type pump shall be provided when sludge cannot

freely flow to the pump. A centrifugal pump may be applicable with free flowing sludges, but only where controlled flow rates are not essential.

Plunger pumps, screw feed pumps, recessed impeller-type centrifugal pumps, progressive cavity pumps, or other types of pumps with demonstrated solids handling capability may be utilized for handling sludge. The abrasive nature of sludges, particularly those containing grit, shall be considered in the selection of pump type and materials of construction.

The final selection of pumping equipment should be based on such factors as the type of application, size of facility, maintenance requirements, and past experience with similar equipment. The efficiency of sludge pumps should be subordinate to dependable, satisfactory, and trouble-free operation.

111.2.2 Pump Capacity

Capacity shall be adequate to cover the full range of solids concentrations and sludge volumes anticipated. Variable speed or other rate control systems shall generally be required in all installations to provide the capability of regulating sludge pumping to match sludge production or reduced rate downstream processing operations. Constant speed units may be used for scum pumps, pumps transferring digested sludge to drying beds, and similar transfer pumping units where rate of transfer is not critical to the performance of upstream or downstream unit processes. Pumping head and friction loss computations should consider both the maximum and minimum anticipated head conditions and account for the possible thixotropic characteristics of the sludge being pumped.

111.2.3 Minimum Head

A minimum positive head of 24 inches shall be provided at the suction of centrifugal type sludge pumps. Other types of sludge pumps should be provided with a comparable positive head. Maximum suction lifts should not exceed 10 feet for positive displacement sludge pumps.

111.3 Piping Systems

111.3.1 Pipe Sizing

Sludge withdrawal piping should have a minimum diameter of 8 inches for gravity withdrawal and 6 inches for pump suction withdrawal. Pump discharge piping for sludge should generally have a minimum diameter of 6 inches. Four-inch diameter discharge piping should be utilized only for short discharge piping runs. Where sludge flow is by gravity, available head should be adequate to provide a mean velocity of 2 feet per second.

111.3.2 Pipe Slopes

Gravity piping should be laid on a uniform grade and alignment. The slope of gravity discharge lines should not be less than 3 percent.

111.3.3 Materials of Construction

Sludge piping shall generally be ductile iron with flanged connections for exposed piping and mechanical joint connections for buried piping. Steel sludge piping may be utilized for exposed lines. Glass lining, or lining of comparable material capable of resisting surface accumulation and abrasion, should be utilized for all scum and raw sludge piping and for long buried sludge piping runs.

Coal tar enamel linings should be utilized for all other sludge piping.

111.3.4 Valves

Valves for sludge service shall normally be nonlubricated eccentric plug valves capable of being repacked under line pressure. Utilization of 100 percent opening type plug valves should be considered. Resilient seating gate valves may be utilized where approved by the Director.

111.3.5 Pipe Maintenance Provisions

Provisions should be included in the design for cleaning, draining, and flushing sludge piping. Cleanouts shall be provided at all changes in direction for buried sludge piping to allow rodding of the lines. Access through blind flanges or other means shall be provided at frequent intervals for exposed piping. Where the sludge pipe size, because of minimum sizing requirements, is the cause of low flow velocities, means shall be provided to clear the lines by periodic high-rate pumping and/or high pressure air/water flushing. Provisions to allow backflushing of lines with the discharge of positive displacement pumps shall be considered. Provisions for cleaning by hot water, steam injection, or chemical degreasing shall be considered in long lines conveying raw sludge or scum.

111.4 Appurtenances

111.4.1 Flow Meters

Flow meters shall be provided as necessary on sludge lines. Meters shall be obstructionless and preferably of the magnetic type. Provisions should be included for isolation, cleaning, and calibration of metering equipment.

111.4.2 Pressure Gauges and High Pressure Cutouts

Pressure gages, either direct reading or of the differential type, shall be provided at each piece of equipment. Pump suction gages shall be of the compound (vacuum/pressure) type. Protection against excessive pressures shall be provided as necessary to guard against system or equipment damage.

111.4.3 Sampling Facilities

Unless sludge sampling facilities are otherwise provided, quick-closing sampling valves shall be installed at the sludge pump discharge. Size of the sampling valve and piping shall be a minimum of 1.5 inches.

112.0 PRELIMINARY OPERATIONS

112.1 Function and Applicability

Preliminary sludge processing such as grinding and degritting may be provided to enhance the efficiency and reliability of downstream sludge processes. Degritting and grinding of sludge serve to reduce equipment wear and clogging and assist in promoting better contact between chemicals and sludge particles in downstream treatment processes. Degritting and grinding equipment often require considerable maintenance and should therefore generally be considered only when comminuting and degritting of raw influent wastewater is not provided, or upon the specific recommendation of the manufacturer of downstream sludge processing equipment.

112.2 Grinding

112.2.1 General Process Description

Sludge grinding is the process in which large material contained in the sludge is cut or sheared into smaller particles. Sludge grinding may be accomplished by either hammermill pulverizing or cutting. The use of sludge grinders shall be considered wherever small high pressure positive displacement pumps are utilized.

112.2.2 Upstream Treatment Requirements

Coarse screening of raw wastewater shall be provided in upstream facilities to adequately protect grinders from damage by large objects.

112.2.3 Selection of Grinders

The selection of sludge grinders shall be based on an evaluation of data from full scale installations processing similar sludges. The use of in-line grinders with twin countercurrent cutters is preferred.

112.3 Degritting

112.3.1 General Process Description

As with raw wastewater degritting, sludge degritting involves the separation of grit particles from the other waste constituents. Degritting of primary sludges prior to thickening should be considered when adequate grit removal is not provided at the headworks.

112.3.2 Selection of Degritting Equipment

The selection of sludge degritting equipment shall be based on an evaluation of data from full scale installations processing similar sludges. The use of hydrocyclones with tangential feed inlets is preferred.

112.3.3 Handling and Disposal of Grit

Removed grit shall be washed and dewatered prior to disposal. Handling requirements and considerations shall be similar to those of grit removed from raw wastewater.

113.0 THICKENING

113.1 General

113.1.1 Function and General Process Types

Thickening may be employed to concentrate sludges and reduce volumetric loading on downstream sludge handling and treatment unit processes.

In general, gravity thickening is utilized for primary sludges and flotation thickening for lighter biological sludges. The use of solid-bowl centrifuges for thickening of biological sludges may be permitted by the Director on a case-specific basis.

113.1.2 Process Applicability and Selection

Evaluation of thickening needs and alternative thickening methods should include consideration of the type and concentration of sludge, anticipated improvements in downstream processing efficiency, and the full range of economic factors. Utilization of thickening facilities is

most often economically justified in larger facilities due to substantial allowable reductions in downstream unit and equipment capacities and decreased chemical requirements for sludge conditioning. Strong consideration shall be given to the potential for septicity and odor generation within the thickener during periods of nonoperation.

113.1.3 Redundancy and Standby Requirements

Multiple thickening units shall be considered for facilities with average design flows greater than 5 mgd. Facilities with a single thickening unit shall be capable of satisfactorily processing unthickened sludge in downstream units.

113.1.4 Odor Control

Covered tankage and odor control systems should be considered for gravity and flotation thickeners.

113.2 Gravity Thickening

113.2.1 General Process Description

Gravity thickeners generally employ circular tanks with high depth to diameter ratios and floor slopes steeper than standard sedimentation basins. The bottom scraper mechanism, utilized to move settled solids toward a central withdrawal hopper, may be furnished with deep trusses or pickets to facilitate the release of water and gas bubbles from the sludge.

General design requirements and considerations for primary sedimentation basins addressed in Section 61.0 shall apply to gravity thickeners where appropriate.

113.2.2 Solids Loading and Surface Overflow Rates

Typical solids loading rates and resulting solids concentration for gravity thickening are as follows:

Type of Sludge	Solids Loading Rate lbs/day/sq ft	Yield, % Solids
Primary	20-30	4-6
Trickling Filter	8-10	3-5
Activated Sludge	4-8	1-2
Primary and Trickling Filter	10-12	4-6
Primary and Activated Sludge	6-10	2-4

Hydraulic loading to produce surface overflow rates of 400 to 800 gpd/sq ft is recommended to minimize septicity. This may be accomplished by utilizing secondary effluent to supplement thickener influent.

113.2.3 Hydraulic Detention Time

Septicity, odor generation, poor thickening efficiency, and other adverse consequences related to excessive hydraulic detention time shall be considered in the design of gravity thickeners. Design of gravity thickeners within the recommended ranges of hydraulic loadings and sidewater depths without excessive hydraulic detention may be accomplished by methods such as utilizing secondary effluent to supplement thickener influent.

113.2.4 Tank Geometry

Sidewater depths of 10 to 14 feet are recommended for gravity thickeners. The recommended range for basin floor slopes is 2 to 3 inches per foot.

113.2.5 Sludge and Scum Removal Equipment

Rake-type mechanical sludge removal equipment for gravity thickeners shall be designed for reliable service. Heavy-duty scrapers and drive mechanisms and/or automatic scraper hoisting mechanisms shall be provided as necessary to handle dense sludge accumulations.

The use of scum skimming equipment should be considered for gravity thickeners.

113.2.6 Chemical Addition

Consideration shall be given to providing facilities to inject chlorine solution and/or hydrogen peroxide to prevent septicity and improve settleability.

113.2.7 Co-Settling

Requirements and considerations for co-settling and thickening biological sludges in primary sedimentation tanks are addressed in Section 61.12.

113.3 Flotation Thickening

113.3.1 General Process Description

Flotation thickening of sludges is most often accomplished by dissolved air flotation systems. Dissolved air systems force air into solution under elevated pressure and utilize the finely divided bubbles released upon depressurization to float sludge to the tank surface for removal. The pressurization solution water may be primary, secondary, or flotation tank effluent. Chemical aids are often employed to increase process efficiency.

113.3.2 Solids Loading and Surface Overflow Rates

Typical solids loading rates for flotation thickeners are 30 to 50 lbs/sq ft/day with polymer addition and 20 to 30 lbs/sq ft/day without polymer addition. Surface overflow rates should generally be less than 1,200 gpd/sq ft. Flotation thickeners typically yield float solids concentrations between 3.5 and 5.0 percent.

113.3.3 Tank Geometry

Sidewater depths for flotation thickeners typically range from 5 to 10 feet.

113.3.4 Pressurization Criteria

Air to solids ratio utilized in the design of dissolved air flotation systems should generally be determined by pilot study or full-scale data from comparable operations. Consideration shall be given to provision of controls to permit the air to solids ratio to be varied.

Air solubility is temperature dependent; therefore, reasonably accurate minimum and maximum wastewater temperatures should be utilized in solubility determinations. The fraction of air dissolved at pressurization pressure must include allowances for both air mass transfer and dissolved air saturation concentration in the wastewater. Both factors are influenced by the dissolved and suspended solids in the wastewater.

Pressurization pressure, as controlled by the back pressure regulating valve, should generally range from 60 to 85 psig.

113.3.5 Pressurization Equipment

Pressurization equipment such as pumps and air compressors shall comply with applicable mechanical equipment provisions of Section 121.0. Pressurization pumps should be of the centrifugal type and be designed to meet the full range of operating requirements. Utilization of variable speed drives on pressurization pumps should be considered.

Pressurization air dissolving tanks should be designed to mix the pressurization flow with air under pressure using an atomizing splash bottle or other similar device. The flow leaving the tank shall essentially be free of large air bubbles. Hydraulic detention time should range from 30 to 60 seconds. Interior corrosion protection shall be considered. Automatic level control (air add, air vent) shall be provided. Each tank shall be fitted with large diameter pressure-type manhole or handhole, depending on tank size, to provide access to interior appurtenances.

The back pressure regulating valve shall be designed to release the air-saturated pressurized flow, providing micro-sized bubbles without producing free air or air coalescence in the interconnecting piping. The valve shall be designed to be self-cleaning.

113.3.6 Sludge and Float Removal

Requirements and considerations applicable to sedimentation basin sludge and scum collection equipment shall be considered in the design of flotation thickener sludge and float removal equipment. Drives for sludge and float collection mechanisms shall be independent. The use of variable speed drive units shall be considered.

113.3.7 Tank Details and Appurtenances

Inlet, effluent weirs, launders, walkways, and other general flotation basin design considerations shall be similar to that of conventional sedimentation basins.

113.3.8 Chemical Addition

Installation of polymer feed equipment to increase unit capacity and capture efficiency shall be considered for all flotation thickening installations.

113.4 Other Thickening Process

Other thickening processes, such as centrifugation, shall be designed on the basis of solids and hydraulic loading and the manufacturer's recommendations. Pilot studies to determine sizing criteria shall be performed as necessary.

114.0 STABILIZATION

114.1 General

114.1.1 Function and General Process Types

Sludge stabilization involves processing of raw or partially oxidized sludge for the purpose of reducing pathogens and minimizing the potential for subsequent putrefaction and release of odors. Stabilization is most often accomplished by reduction and oxidation of volatile matter in the sludge.

Sludge stabilization may be achieved by biological sludge digestion, composting, or physical and chemical means. Both anaerobic and aerobic digesters are widely employed

for biological digestion of sludge. Methods of physically and chemically stabilizing sludge include heat treatment, chlorine oxidation, and lime stabilization.

114.1.2 Process Applicability and Selection

All wastewater sludges shall be stabilized as necessary to assure safe and nuisance free ultimate disposal. Stabilization of sludge shall generally be accomplished by either anaerobic or aerobic biological digestion processes. Composting and physical/chemical stabilization methods shall be utilized only as approved by the Director.

A comparative evaluation between anaerobic and aerobic digestion shall be performed wherever the cost-effectiveness of one mode of biological stabilization does not clearly outweigh that of the other. Utilization of anaerobic digestion, wherever practicable, is preferred over aerobic digestion due to the generally lower operating energy requirements and potential for implementing energy recovery. The lower capital costs, reduced odor potential, lower supernatant BOD concentrations, and simpler operation of aerobic digesters, however, shall be considered in any comparative evaluation.

114.2 Anaerobic Digestion

114.2.1 General Process Description

The anaerobic digestion process employs facultative anaerobic acid-producing bacteria and anaerobic methane-fermenting bacteria to reduce volatile matter in wastewater sludges. In addition to stabilizing the sludge, anaerobic digestion may improve sludge dewaterability by destroying the collodial water-binding structure of the sludge.

Anaerobic digesters may be classified as standard rate or high rate, single stage or two stage, heated or unheated, or unmixed or mixed. Standard rate digestion generally utilizes an unmixed single stage process in which digestion, gravity sludge thickening, supernatant formation, and sludge storage occur in the same tankage. High rate anaerobic digesters are designed to accept higher sludge loading rates and employ heating and mixing facilities, usually in a two-stage process, to optimize digestion. In two-stage digestion systems, a heated and mixed primary tank is utilized for digestion and an unmixed secondary tank for storage and formation of supernatant. The secondary tank may either be heated or unheated. Process tankage in either standard or high rate systems may be provided with floating covers to allow variability in the effective volume of the tankage. Gas-holding covers may be utilized to facilitate gas storage.

114.2.2 General Requirements

All anaerobic digestion systems shall be designed to provide for satisfactory active digestion, supernatant separation, sludge concentration, and storage. Anaerobic digestion systems shall generally be two stage and of the high rate type.

Heating and mixing facilities shall be provided for all primary digestion tanks, and for all secondary digestion tanks required to have the capability of functioning as a primary digestion tank. A secondary digester shall be functionally interchangeable with the primary digester in facilities with only one primary digester. Both primary and secondary digestion tanks shall be provided with gas collection systems.

In the design of anaerobic digesters, special consideration shall be given to the materials of construction. All materials internal to the digester, including piping, piping anchors and supports, bolts, draft tubes, and all other appurtenances, shall be specifically selected for resistance to the expected corrosive conditions.

114.2.3 Redundancy and Standby

A minimum of two tanks should be provided for anaerobic digestion facilities. A minimum of two tanks shall be designed to permit processing of all types of sludges normally digested. Interchangeability of primary and secondary tanks described above shall be provided where applicable.

Each tank requiring mixing should have sufficient mixing capacity or flexibility in system design to ensure that the total capability for mixing is not lost when any one piece of mixing equipment is taken out of service.

114.2.4 Tank Loading, Sizing, and Configuration

Total digestion tank capacity should be determined by rational calculations based upon such factors as volume of sludge added, sludge percent solids and character, the temperature to be maintained in the digesters, the degree or extent of mixing to be provided, and the degree of volatile solids reduction required. Calculations should be submitted to justify the basis of design. When calculations based on the above factors are not performed, the minimum tank capacities specified below should be provided. The requirements described below assume that raw sludge derived from ordinary domestic wastewater is being digested, that digestion temperature will be maintained in the range of 90° to 100°F, and that the digested sludge will be

removed at least every three days from the system. When grit removal facilities are not provided, the reduction of digester volume due to grit accumulation shall be considered, regardless of the method of tank sizing.

Completely mixed primary digestion tanks shall generally not be loaded at a rate exceeding 120 pounds of volatile solids per 1,000 cubic feet of volume per day nor have a hydraulic detention less than 20 days. Completely mixed tanks shall be defined as those providing intimate and effective mixing on a continuous basis to prevent stratification and to assure homogeneity of digester contents. In moderately mix systems, where mixing is accomplished only by circulating sludge through an external heat exchanger, the primary tanks should not be loaded at a rate exceeding 40 pounds of volatile solids per 1,000 cubic feet of volume per day nor have a hydraulic detention less than 30 days. In general, maximum loading rates may be modified upward or downward to correspond with the degree of mixing provided.

Secondary digestion tanks shall be provided with sufficient depth to allow for the formation of a reasonable depth of supernatant liquor. In plants with one primary digester, the secondary digester shall be identical in size as well as functionally interchangeable with the primary digester. In facilities with two or more primary digesters, the secondary digester shall be sized to provide at least 10 days hydraulic detention and not less than 25 percent of the total digestion capacity.

Digestion tank bottoms should slope to drain toward the bottom sludge withdrawal pipe. A minimum bottom slope of 3 inches per foot is recommended.

114.2.5 Tank Covers

Digestion tanks shall be covered. Primary and secondary tanks may be equipped with gas-tight fixed steel or concrete covers, or floating steel covers made gas tight by extended rim skirts. Floating covers shall be equipped with a guide rail system to prevent rotation and tipping, and with lower-landing corbels and cover restraints.

114.2.6 Tank Access

At least two 36-inch diameter access manholes shall be provided in the digester cover. Stairways shall be provided as necessary to reach the access manholes. A separate sidewall manhole shall be provided. The sidewall manhole opening should be large enough to permit the use of mechanical equipment to remove grit and sand.

114.2.7 Mixing Systems

For completely mixed digesters, sludge mixing by gas recirculation through lances or draft tubes shall be provided in addition to the mixing available through pump recirculation. Mechanical mixing will not be permitted.

114.2.8 Sludge Inlets and Outlets

Unless mixing facilities are incorporated within the digester, multiple recirculation withdrawal and return points shall be provided to enhance operational flexibility and mixing effectiveness. The return points, in order to assist in scum breakup, should be located to discharge above the liquid level and near the center of the tank. Raw sludge input to the digester through recirculation return piping (downstream of recirculation pumps but upstream of the heat exchanger) should be considered.

Sludge withdrawal to disposal should be from the bottom of the tank. This pipe should be interconnected with the recirculation piping, if such piping is provided, to increase versatility in mixing the tank contents.

Sampling ports shall be provided in all tank covers with water seal tubes beneath the liquid surface. The ports should be provided with quick access covers.

114.2.9 Supernatant Withdrawal

Valves and piping should be arranged so that withdrawal may be made from three or more levels in the digester. The design of supernatant withdrawal facilities shall minimize supernatant withdrawal shortcircuiting in which excessive solids from the sludge blanket is unintentionally drawn off. The installation of multiple supernatant withdrawal points in the same plane as well as at different elevations should be considered.

A positive unvalved atmospheric vented overflow shall be provided. The overflow shall be trapped by locating the overflow inlet well below the minimum digester liquid surface to prevent gas or digester scum escape or air intrusion.

If a supernatant selector is provided, provisions shall be made for a least one other drawoff level located in the supernatant zone of the tank in addition to the unvalved emergency supernatant overflow pipe. High pressure back-wash facilities shall be provided for the supernatant selector to facilitate prevention of clogging of the device.

Recycled supernatant and overflows shall be recycled to a point downstream of the influent sampling point. Consideration should be given to supernatant conditioning where appropriate, based on the anticipated effect of the supernatant on plant performance and effluent quality.

Provisions should be made for sampling at each supernatant drawoff level. Sampling pipes should be at least 1.5 inches in diameter and should terminate at a suitably sized sampling sink or basin.

114.2.10 Digestion Tank Heating

Sludge heating in anaerobic digestion systems is provided to accelerate the rate of activity of the anaerobes responsible for volatile solids reduction. Heating of sludge shall generally be accomplished by circulating the sludge through external heaters.

Heating capacity sufficient to consistently maintain the design sludge temperature shall be provided. Where digester gas is used for sludge heating, an auxiliary fuel supply shall be provided. Where a continuous supply such as a natural gas pipeline is not practical, minimum onsite auxiliary fuel storage shall be equivalent to a 5-day supply.

External heat exchangers shall be of the water bath or spiral type, sized to be capable of adequate heat transfer under the least favorable conditions of temperature and sludge concentration. The sludge piping in the heat exchanger shall be adequately sized to prevent fouling by debris and shall be completely accessible for cleaning.

Each digester shall have a heated sludge recirculation pump to recirculate sludge from the digester through the heat

exchanger and back to the digester. The pump shall be programmable to start at adjustable time intervals and to run for variable lengths of time. A temperature indicator on the outlet of the heat exchanger shall sense the sludge temperature. If the temperature is lower than required, the recirculation pump shall override timer controls and continue to run until the desired temperature is achieved.

A suitable automatic mixing valve shall be provided to temper boiler water with return water so that the inlet water to the heat jacket can be held below a temperature at which caking will be accentuated. Manual control should also be provided by suitable bypass valves.

The boiler should be provided with suitable automatic controls to maintain the boiler temperature at approximately 180°F to minimize corrosion and to shut off the main fuel supply in the event of pilot burner or electrical failure, low boiler water level, or excessive temperatures.

Thermometers shall be provided to indicate the temperature of the sludge, hot water feed, hot water return, and boiler water.

114.2.11 Gas Collection, Piping, and Appurtenances

All portions of the gas system, including the space above the tank liquor, storage facilities, and piping, shall be so designed that under all normal operating conditions, including sludge withdrawal, the gas will be maintained under positive pressure. Gas withdrawal pipe inlets should be located such that no intrusion of sludge or scum occurs even if the tanks are inadvertently operated at higher-than-design levels.

Sludge gas piping shall be Schedule 40 black steel. Sludge gas piping shall be of adequate diameter to convey anticipated gas flows and shall slope to isolatable condensate traps located at low points. The use of float-controlled condensate traps will generally not be permitted. Flame traps and flame checks, thermal shutoff valves, and sediment traps shall be provided at appropriate locations. Flame traps shall be provided on gas lines to boilers, waste gas burners, and all other flame sources. Special consideration shall be given to provisions to facilitate the cleaning of sludge gas piping in the design of the piping system. The piping system shall be thoroughly pressure and leak tested prior to being placed into service.

An adequate number of gas sampling cocks shall be provided. Gas meters with bypasses shall be included on appropriate piping runs to meter total and waste gas production and, where applicable, the recovered or utilized fraction.

Sludge gas piping and gas compression systems shall conform to additional requirements presented in Section 121.0.

114.2.12 Gas Utilization Equipment

Gas-fired boilers for heating digesters shall be located in a separate room not connected to the digester gallery.

At larger plants, consideration should be given to gas utilization by dual fuel engines on major pumps or blowers, with possible recovery of exhaust and jacket cooling heat for use in digester heating. An alternate system would involve direct electric power generation.

Gas cleaning and storage may be required in the design of gas engine systems, depending upon the sulfide level of the gas and the type of engine.

114.2.13 Waste Gas System

Waste gas burners shall be readily accessible and should be located at least 25 feet away from any plant structure or boundary if placed at ground level. Waste gas burners may be located on the roof of buildings if sufficiently removed from the digester tanks.

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 insure reliability of the pilot light.

114.2.14 Special Safety Provisions

The following special safety provisions shall apply to anaerobic digestion systems due to the explosive and toxic nature of the gases produced. These provisions shall supplement and reinforce general safety requirements presented in Chapters 40 and 120.

All necessary safety facilities shall be included at locations of gas generation, transport, and utilization. Pressure and vacuum relief valves and piping appurtenances such as those described in Section 114.2.11 shall be provided as necessary. Methane, hydrogen sulfide, and explosive mixture monitoring and alarm systems shall be provided as appropriate for enclosed environments. These monitors shall be installed such that gas levels can be observed without entering the enclosed space or room.

Any underground enclosures or passages connected to digestion tanks or containing sludge or gas piping or equipment shall be provided with forced ventilation. Piping galleries for digesters should not be connected to other passages. Gas compressors shall be housed in a separate room with an exterior entrance or shall be installed out of doors, with suitable weather protection.

Nonsparking tools, safety lights, rubber-soled shoes, safety harness, portable gas detectors for flammable and toxic gases, and at least two self-contained tank-type breathing units shall be provided for emergency use.

114.3 Aerobic Digestion

114.3.1 General Process Description

The aerobic digestion process employs long-term aeration to reduce BOD and destroy volatile solids in the sludge. Micro-organisms in an aerobic digester are essentially maintained in the endogenous phase so that cell protoplasm is consumed for cell maintenance reactions. Diffused air systems or mechanical aerators may be utilized to provide the necessary degree of aeration and mixing. Aerobic digesters may be operated either on a continuous or batch basis.

114.3.2 Redundancy and Standby

Multiple aerobic digestion basins shall be considered where adequate provisions for alternate sludge handling are not available.

A minimum of two blowers or mechanical aerators shall be provided. It may be permissible for the backup unit to be

an uninstalled unit, provided that the installed unit can be readily removed and replaced.

The air diffusion system for each aeration basin shall be designed such that the largest section of diffusers can be isolated without measurably impairing the oxygen transfer capability of the system.

114.3.3 Tank Loading and Sizing

The determination of aerobic digester tank capacities shall be based on rational calculations and include consideration of such factors as quantity of sludge handled, sludge characteristics, time of aeration, and sludge temperature.

The volatile suspended solids loading shall generally not exceed 100 lbs per 1,000 cubic feet of digester volume per day. Lower loading rates may be necessary, depending on the type and concentration of sludge and the requirements of subsequent dewatering and sludge handling operations.

Required minimum solids retention times for stabilization of biological sludges vary, depending on the type of sludge. Normally, a minimum of 10 days retention should be provided for waste activated sludge and 15 days for combined primary and secondary sludges or primary sludge alone.

114.3.4 Aeration and Mixing Requirements

Aerobic sludge digestion tanks shall be designed for effective mixing by aeration equipment. Sufficient air shall be provided to keep the solids in suspension and to maintain dissolved oxygen between 1 and 2 mg/l. In general, aerobic digester aeration systems shall be designed in accordance with applicable requirements of Chapters 70 and 120. In a diffused air system, a minimum aeration capacity

of 30 cfm per 1,000 cubic feet of tank volume should be provided with the largest blower out of service. Diffusers of the nonclog type designed to minimize discontinuity of service shall be provided. If mechanical aerators are utilized, a minimum of 1.0 horsepower per 1,000 cubic feet of tank volume should be provided.

114.3.5 Supernatant Withdrawal

Facilities shall be provided for effective separation and withdrawal of supernatant and for effective collection and removal of scum and grease. Multiple level decant withdrawal lines shall be provided. Multiple withdrawal lines at the same elevation are recommended.

114.3.6 Foam Control

Water piping and spray nozzles for foam control should be provided.

114.4 Composting

114.4.1 General Process Description

Composting of sludge involves the microbial degradation of putrescible organic solids by thermophillic aerobic metabolism. The stable humus-like end product, which is generally free of pathogens, may be utilized as a soil amendment. Preparation of the sludge for composting involves mixing the sludge with a bulking agent such as wood chips or leaves.

Composting is most often accomplished by either the aerated static pile or windrow methods. Aeration is accomplished through the use of forced air circulation in the static

pile method. In the windrow method, air is drawn into the compost pile by natural convection and turning.

114.4.2 Sludge Preparation

The design of composting systems should provide for the mixing of sludge with bulking agents such as wood chips, bark, sawdust, or refuse to attain a moisture content of 45 to 60 percent.

114.4.3 Composting Period

The composting period should be at least 21 days for the static pile method and 42 days for the windrow method. Temperatures ranging from 140 to 160°F should be achieved during the composting period. An additional curing period of at least two weeks should be provided for both methods.

114.4.4 Odor Control

For the static pile method, installation of facilities to send blower exhaust air through a pile of previously composted material or employment of other appropriate odor control methods shall be considered.

114.4.5 Runoff and Leachate Control

Runoff and leachate control and treatment shall be considered and provided as necessary.

114.5 Heat Treatment

114.5.1 General Process Description

Heat treatment of liquid sludges consists of increasing the temperature of the sludge to 300 to 500°F while at a

pressure of 150 to 400 psig for periods of 20 to 40 minutes. Under these conditions, a partial breakdown of cell structures results in improved sludge dewaterability due to the release of bound water. In addition, the elevated temperature results in destruction of most pathogenic organisms.

Major components in a heat treatment system typically include compressors, sludge grinders, high pressure feed pumps, heat exchangers, reactor, boiler or other heat source, decant tank, and odor control devices.

114.5.2 Redundancy and Standby

Multiple heat treatment units are recommended unless nuisance free storage or alternate stabilization methods are available to avoid serious disruption to sludge processing operations. Standby grinders and feed pumps should be provided for each reactor.

114.5.3 System Sizing and Loading

Heat treatment systems should be designed on a hydraulic basis with required heat input dependent on sludge characteristics and concentration. The system should preferably be designed for continuous 24-hour operation to minimize additional heat input required to start up the system.

Sludge storage shall be provided to equalize processing loads prior to input into the heat conditioning system.

114.5.4 Sludge Grinding

Sludge grinders shall be provided to protect the process heat exchangers from rag fouling.

114.5.5 Heat Exchanger and Reactor

Special consideration shall be given to the selection of materials of construction for the heat exchangers and reactor vessel in order to minimize corrosion. If the sludges contain significant chloride concentrations from industrial sources or salt water infiltration, the use of titanium shall be considered.

An acid wash system shall be provided to remove scale from heat exchangers and reactors.

114.5.6 Decant Tank

The decant tank shall be equipped with a sludge scraper mechanism and scum skimmer. Decant tanks shall be covered to prevent odor release and provisions shall be included to minimize condensation.

114.5.7 Recovery of Waste Heat

If heat treatment is utilized in conjunction with sludge incineration, waste heat recovery to provide process steam requirements should be considered.

114.5.8 Odor Control

Special consideration shall be given to the control of odors resulting from heat treatment systems. The following sources of odors should be evaluated and controlled as necessary: reactor off-gas, decant tank, sludge dewatering room air, and where vacuum filters are employed, vacuum filter exhaust.

114.6 Other Stabilization Methods

Other sludge stabilization methods may be considered as an alternative to previously addressed stabilization processes. Alternative stabilization methods include lime stabilization, chlorine oxidation, and sludge irradiation. Approval for the utilization of these sludge stabilization methods shall be on a case-specific basis. The following sections are intended to provide only a brief overview of the three alternate stabilization processes.

114.6.1 Lime Stabilization

Lime stabilization of sludge involves raising the pH of sludge to above 11.0 by the addition of lime to prevent immediate decomposition, to kill or inhibit pathogenic organisms, and to minimize odor generation. While lime stabilization is capable of achieving pathogen reductions beyond those of anaerobic digestion, sludge stabilized by lime addition may experience microbial regrowth and putrefaction since volatile organic matter is not destroyed.

114.6.2 Chlorine Oxidation

Sludge may be stabilized by oxidizing organic matter with heavy doses of chlorine of up to 2,000 mg/l. Chlorine oxidation systems require special consideration with regard to handling of liquid recycle streams from dewatering devices or sludge drying beds. The low pH and high chlorine residual level of the recycle flows may have toxic effects upon biological unit processes. The potential for formation of chlorinated hydrocarbons must also be considered with regard to the ultimate disposal of both sludge and recycle streams.

114.6.3 Sludge Irradiation

Sludge irradiation involves the use of high energy electrons or gamma radiation from radioisotopes, such as Cesium 137, to destroy pathogenic organisms in sludge and prevent immediate sludge decomposition. As with lime stabilization, volatile solids are not destroyed and consideration must be given to the prevention of microbial regrowth.

115.0 DEWATERING

115.1 General

115.1.1 Function and General Process Types

Sludge dewatering involves the reduction of moisture in sludge to decrease sludge volume, to facilitate sludge handling and transportation, to increase the caloric value for incineration, and to minimize the generation of odors and leachates. Sludge dewatering may be accomplished by employing mechanical dewatering devices or by applying sludge to drying beds or shallow lagoons. Typical mechanical dewatering devices include vacuum filters, centrifuges, filter presses, and belt filters.

115.1.2 Process Applicability and Selection

Evaluation of sludge dewatering needs and methods should be based on the type and volume of sludge, requirements associated with the method of ultimate disposal, land availability and treatment site sensitivity, process reliability, ease of operation, and economic considerations. Land intensive non-mechanical dewatering facilities such as sludge drying beds are most often utilized at small facilities with available space. Mechanical dewatering methods are generally most cost-effective for larger

facilities. It should be noted that certain sludges are not suited for mechanical dewatering.

115.2 General Requirements for Mechanical Dewatering Units

115.2.1 General

This section addresses general requirements applicable to all mechanical dewatering units. Areas of discussion include conditioning, redundancy and standby, period of operation, sludge storage and conveyance, equipment housing, sampling, and instrumentation. Specific design requirements are discussed within the appropriate sections addressing each mechanical dewatering method. Requirements for non-mechanical dewatering methods are addressed separately within individual sections covering drying beds and lagoons.

115.2.2 Chemical Conditioning

Sludge shall be satisfactorily conditioned prior to processing by mechanical dewatering units. Conditioning by the use of chemicals will generally be required unless stabilization processes that provide adequate sludge conditioning, such as heat treatment, are utilized. Chemicals typically employed in chemical conditioning include lime, ferric chloride, and polyelectrolytes.

Selection of the type and dosage of chemical shall include consideration of the chemical and physical characteristics of the sludge, type of dewatering process, availability and cost of chemicals, and ease of handling and feeding the chemical. The chemical dosage shall be determined based on laboratory tests and bench scale studies where practicable.

The design of the chemical feed system shall be based on consideration of the type and form of chemical to be utilized, the physical and chemical characteristics of the chemical, the range of chemical doses required, and reliability of the feeding devices. Input from the Division, equipment manufacturers, and the chemical suppliers should be fully considered in the design of chemical feed systems for sludge conditioning.

115.2.3 Redundancy and Standby

For facilities utilizing mechanical dewatering units, there shall be a sufficient number of mechanical dewatering units to enable the design sludge flow to be dewatered with the largest capacity unit out of service.

Where undigested or partially digested sludge is to be mechanically dewatered, a minimum of two mechanical dewatering units shall generally be provided. Standby chemical conditioning equipment, sludge feeders, filtrate/centrate pumps, and other appurtenances shall be provided.

Where digested sludge is to be mechanically dewatered, a single mechanical dewatering unit may be permitted if adequate capacity is provided on the basis of 24 hours of operation per week and if alternate dewatering means are provided. Key components of the dewatering units, however, shall be provided with spares and be capable of being readily removed and replaced.

Where multiple dewatering units are utilized, each unit shall generally be fed by a separate feed pump to ensure control over the feed rate.

115.2.4 Period of Operation

The period of operation for mechanical dewatering units shall be considered in the sizing of the units. Limited manpower at facilities with design average flows less than about 5 mgd will generally require that the effective dewatering period not exceed 24 hours per week to allow time for chemical conditioning, cleanup, and equipment maintenance. At larger facilities, effective dewatering periods up to 14 hours per day and 56 hours per week may be permitted by the Director.

115.2.5 Sludge Storage and Conveyance

Where raw sludge is to be dewatered, installation of upstream facilities to provide short-term storage and blending is recommended. Utilization of mechanical agitation or air mixing should be considered for such facilities. Provisions for chemical addition to prevent septicity and for odor control should also be considered.

Where sludge feed or chemical pumps are not adjacent to the dewatering units, remote speed controls should be provided.

Where applicable, dewatered solids should be removed and transported by belt conveyors or other proven means. The angle of inclination of standard belt conveyors should be less than 18 degrees. Conveyors should be provided with skirts at cake loading points to control cake splashing. Continuous skirts should be considered, especially on sloping conveyors, to prevent cake from spilling onto the floor.

The sizing of dewatered sludge storage hoppers and other similar facilities shall be based on the size of the treatment facility, the availability of trucks for hauling,

and recommendations provided by Division personnel. Hoppers shall be designed to allow sludge to flow freely without clogging by bridging. Hopper discharge outlets should be equipped with flexible skirts to control cake splashing.

115.2.6 Filtrate/Centrate Handling

The filtrate or centrate from mechanical dewatering processes shall be recycled back to raw or settled waste streams for treatment. Flows recycled to the raw waste stream shall be introduced downstream of the influent sampling point.

115.2.7 Equipment Housing

All mechanical dewatering components, including sludge conveyors and hoppers, shall be adequately sheltered from inclement weather. Special consideration shall given to lighting, ventilation, and odor control requirements in the design of dewatering facilities.

115.2.8 Sampling

Taps shall be provided for sampling of sludge feed and filtrate/centrate at each dewatering unit.

115.2.9 Instrumentation and Controls

All necessary instrumentation and operating controls shall be provided, including filter and accessory stop-start and speed controls, sludge feed pump start-stop and speed controls, and level alarms. Means shall be provided to measure the quantity of sludge processed.

115.3 Vacuum Filtration

115.3.1 General Process Description

A vacuum filter consists of a cylindrical drum, covered with a porous filter cloth, rotating on its horizontal axis while partially submerged in a vat of liquid sludge. A vacuum is applied under the filter cloth for the larger part of each revolution to form a dewatered filter cake that is continuously scraped off. Filtrate and air are removed from behind the filter medium by filtrate and vacuum pumps.

115.3.2 Filtration Rate

The following rates of vacuum filtration, in pounds of dry solids per square foot of filter area per hour, shall be considered for processing properly conditioned sludges.

Type of Treatment	Pounds of Solids/Sq Ft/Hr	
	Raw Solids	Stabilized Solids
Primary	3-5	3-4
Primary & Trickling Filter	2-4	2-3
Primary & Activated Sludge	2-3	2-3

115.3.3 Filter

Drum and agitator assemblies shall be equipped with variable speed drives. The capability to alter the liquid level shall be provided. Special consideration shall be given to the use of corrosion resistant material for wetted parts. Provision of a hot water supply to the filter media spray system for use in cleanup should be considered to reduce grease accumulations on the filter deck and media.

115.3.4 Vacuum Pumps

Vacuum pumps having a minimum capacity of 1.5 cfm per square foot for fabric-coated drums or 3 cfm per square foot for metal-covered drums shall be provided. Vacuum receivers shall be required with all vacuum pumps. Vacuum pumps shall be manifolded in multiple unit installations to promote operational flexibility.

115.3.5 Filtrate Pumps

Filtrate pumps shall be of adequate capacity to pump the maximum amount of liquid anticipated to be removed from the sludge.

115.4 Centrifuges (Solid-Bowl)

115.4.1 General Process Description

Centrifuges utilize centrifugal forces to dewater sludges. The preferred type of centrifuge for sludge dewatering is the solid-bowl centrifuge.

The solid-bowl centrifuge consists of a long horizontally mounted bowl tapered at one end and a helical scroll conveyor rotated together at slightly different speeds by a planetary gear. Solids from continuously introduced sludge are concentrated at the bowl periphery and moved by the scroll conveyor toward the tapered end to a sludge cake discharge hopper. Centrate may be removed either by gravity or by pumping.

115.4.2 Feed Rate

Centrifuge size shall be based on pilot study results and/or full-scale operational data for similar sludges.

115.4.3 Centrifuge Bowl and Scroll Assembly

Centrifuges shall be equipped with the capability to vary scroll speed and pool depth during operation. Special consideration shall be given to the use of corrosion and abrasion resistant materials for the bowl liner and the leading edges of the scroll.

115.4.4 Feed Pumps

Feed pumps shall be equipped with variable speed drives.

115.4.5 Centrifuge Foundation

Centrifuge units shall be provided with appropriate foundations and equipment mounts to minimize vibration and noise resulting from the centrifuge operation.

115.5 Plate and Frame Filter Press

115.5.1 General Process Description

Dewatering by filter presses is achieved by forcing water from the sludge under high pressure. Plate and frame filter presses consist of vertical recessed plates that are held rigidly in a frame and pressed together between a fixed and moving end. A filter cloth is mounted on each face of individual plates. Water passes through the cloth while solids are retained to form a cake on the surface of the cloth. The filter press cycle involves sludge filling, pressing, cake removal, media washing, and press closing.

115.5.2 Filter Press Sizing

Filter press unit sizing should be based on the number of chambers, chamber volume, and operating cycle. Anticipated

performance, sludge conditioning requirements, and cycle times shall be based on pilot unit testing data and/or operational data of full-scale facilities handling similar type sludges.

115.5.3 Filter Press

Filter press systems shall be designed to resist pressure filter plate warpage and plate gasket deterioration.

High pressure water or acid wash systems shall be provided to clean filter cloths. One or more spare sets of filter cloths shall be specified and furnished.

115.5.4 Cake Handling

Equipment for cake breaking shall be provided. Reduction of cake to particle sizes one inch and less should be provided when the cake is to be incinerated.

Storage provisions to dampen and equalize batch loadings onto conveyors should be provided where necessary.

115.6 Belt Filter Press

115.6.1 General Process Description

A belt filter press generally consists of an endless horizontal filter belt similar to a conveyor belt and a press belt running in the same direction and at the same speed above the filter belt. Sludge is fed on the upper face of the filter belt and continuously dewatered between the filter and press belts.

115.6.2 Belt Filter Sizing

Hydraulic and solids loading rates, conditioning requirements, and performance shall be based on pilot unit performance or operational results of full-scale facilities handling similar sludges.

115.6.3 Belt Filter Assembly

Belt speed shall be variable. Individual pressure rollers shall be individually adjustable in both the horizontal and vertical planes.

115.7 Sludge Drying Beds

115.7.1 General Process Description

Sludge drying beds dewater sludge by both drainage through the sludge mass and by evaporation from the surface exposed to air. Drying beds typically consist of a series of cells containing sand supported by graded gravel. Underdrains are utilized to collect filtrate.

115.7.2 Siting Limitations

The use of sludge drying beds will generally be approved only in areas remote from residential development and where climatic conditions will allow adequate dewatering by drying and drainage. Drying beds located in areas above the BWS "No-Pass" line may require the use of impermeable subsurface liners to eliminate any potential for groundwater contamination.

115.7.3 Redundancy and Standby

No less than two drying beds shall be provided to ensure availability of surplus bed space during cleaning, maintenance, or emergency conditions. Sludge storage, covered beds, or alternate dewatering methods shall be provided for in areas with rainfall in excess of 75 inches per year.

115.7.4 Drying Bed Sizing

In determining the required area for sludge drying beds, consideration shall be given to climatic conditions, the characteristics and volume of the sludge to be dewatered, the method and schedule of sludge removal, and availability of other methods of sludge disposal. When operational data from comparable full-scale facilities are not available, the sizing of the drying beds for leeward areas of Oahu should be based on solids loadings of 20 to 40 lbs/sq ft/year if drying beds are the primary method of dewatering and 40 to 80 lbs/ sq ft/year if sludge drying beds are to be used as a backup dewatering process. The above rates may be reduced by 50 percent for windward areas of Oahu. Bed areas should be increased by 25 percent for paved beds.

115.7.5 Gravel and Sand Media

The supporting lower course of gravel should be stratified into two or more gradations. The gravel course around the underdrains should extend a minimum of 6 inches above the top of the underdrains. The top gravel layer should be a minimum of 3 inches in depth and consist of gravel 1/8-inch to 1/4-inch in size.

The top course of the drying bed media should consist of at least 6 to 9 inches of clean sand, with an effective size

of 0.3 to 0.75 mm and a uniformity coefficient not greater than 4.0. The finished sand surface should be level.

115.7.6 Underdrains

Underdrains should consist of clay pipe or concrete drain tile at least 4 inches in diameter laid with open joints. Underdrains should be spaced not more than 20 feet apart. Underdrainage should be returned to the raw or settled wastewater flowstream.

115.7.7 Walls

Walls should be water-tight and extend 24 to 32 inches above and at least 6 inches below the bed surface. The access opening should be provided with curbing to prevent soil from washing onto beds.

115.7.8 Sludge Influent Piping

The sludge influent pipe entering the drying beds should terminate at least 12 inches above the bed surface. Piping downstream of the shutoff valve for each bed shall be arranged and sloped to drain into the bed. Concrete splash plates should be provided at the sludge discharge points.

115.7.9 Sludge Removal

Beds should be arranged to facilitate sludge removal. Removable ramp planks should be provided for vehicle access where necessary. Concrete truck tracks shall generally be provided for all sludge drying beds.

Partially paved drying beds should be designed with consideration for minimum dimensions required for removal of dried sludge with mechanical equipment.

115.8 Sludge Drying Lagoons

115.8.1 General Process Description

Sludge drying lagoons are similar in concept to sludge drying beds, except that the depth of sludge application is typically three to four times greater than that of drying beds. Generally, sludge in drying lagoons is allowed to dewater and dry to some predetermined solids concentration for periods of a year or more before removal. Evaporation is the primary dewatering mechanism in drying lagoons. Facilities for decanting and recycling supernatant to the treatment units may be provided.

115.8.2 Applicability

Due to the high potential for odor generation, only digested sludges shall be dewatered in drying lagoons. Siting limitations addressed in Section 115.7.2 for sludge drying beds shall also apply to sludge drying lagoons.

115.8.3 Redundancy and Standby

Redundancy and standby requirements addressed in Section 115.7.3 for a sludge drying beds shall generally apply to sludge drying lagoons. A single lagoon may be permitted when satisfactory sludge storage or alternate means of dewatering is provided.

115.8.4 Lagoon Sizing

Depth and area requirements for sludge drying lagoons shall be based on precipitation and evaporation rates, the type of sludge, sludge volume, and the solids concentration of the sludge. Solids loading rates up to 2 to 3 lbs of solids per year per cubic foot may be permitted.

115.8.5 Lagoon Construction

Lagoons shall be of a shape which facilitates sludge removal and maintenance. Access ramps shall be provided for sludge removal equipment. Dike materials should be selected to minimize nuisance growths of vegetation. Dikes should have a maximum slope of 1:3. Surrounding areas should be graded to prevent surface water runoff from entering the lagoon. Fencing shall be provided to limit public access.

116.0 HEAT DRYING

116.1 General

Heat drying of sludge involves reducing water content by vaporization of water to the air. Heat drying is typically utilized to produce a drier sludge for either incineration or processing into fertilizer. Alternative heat drying methods include flash drying and rotary kiln drying. The following sections are intended to only provide a brief overview of the two processes.

116.2 Flash Drying

In flash drying, wet sludge cake and dried sludge are mixed in a cage mill and hot combustion gases are introduced to dry the sludge. Gas and dried sludge are separated in a cyclone. A portion of the dried sludge is recycled to the cage mill.

166.3 Rotary Kiln Drying

In kiln drying, sludge is dried in rotary kiln units that are either directly fired by gas or oil burners, or heated by combustion gases.

117.0 INCINERATION

117.1 Function and General Process Types

Sludge incineration involves drying and combustion of dewatered sludge to reduce the quantities of solid material for disposal. Incineration results in total or partial conversion of organic solids to oxidized end products such as carbon dioxide and water. The most widely used incineration process is the multiple hearth furnace. Other methods of incineration, which are not addressed in these standards, include fluidized-bed incineration, flash combustion, and co-incineration.

117.2 Multiple Hearth Incineration

117.2.1 General Process Description

The multiple hearth furnace utilizes a vertical cylindrical, refractory lined, steel structure containing 4 to 13 horizontal hearths. Sludge cake is dropped into the top hearth and is raked radially by rabble arms in each hearth, either toward the center or to the periphery, so that the cake drops downward from hearth to hearth. Flow of air for combustion is concurrent to that of the sludge. Multiple hearth incinerators may utilize gas or oil burners for start up or to provide supplemental heat.

117.2.2 Process Applicability

Multiple hearth furnaces are generally most applicable to large facilities located on areas where land for the disposal of sludge is limited. Although unstabilized sludge may be incinerated, the applied sludge cake must be adequately dewatered. Multiple hearth incinerators require specially trained personnel for proper and reliable operation.

117.2.3 Redundancy and Standby

Where single multiple hearth units are utilized, storage or an alternative sludge handling plan shall be available.

117.2.4 Unit Sizing

Incinerator capacity should be determined based on the anticipated quantity of sludge to be incinerated, sludge moisture content, and heat value of the sludge.

Satisfactory autogenous combustion (i.e., combustion without the use of auxiliary fuel) may generally be achieved at a solids concentration of 25 to 50 percent, depending on the volatile solids percentage of the sludge and control of excess combustion air. For incineration of sludge in the range of 15 to 30 percent solids, the evaporative capacity of the furnace should be fully considered in the sizing of the unit.

The sizing and design of a multiple hearth furnace should minimize startup fuel costs by allowing for as near continuous operation as possible.

Wet sludge loadings for multiple hearth incinerators, which may range from 5 to 15 lbs per square foot of hearth area, are normally on the order of 8 to 10 lbs/sq ft.

117.2.5 Auxiliary Fuel Burners

Auxiliary fuel burners shall be provided as necessary to allow combustion to be sustained for a wide range of sludges.

117.2.6 Combustion Air Fans

Installation of variable speed combustion air fans shall be considered.

117.2.7 Air Pollution and Odor Control

Air pollution control facilities to meet federal and state air quality regulations shall be provided. Sufficiently tall exhaust stacks shall be utilized to minimize drawdown of plume to ground level downwind of the incinerator building.

Capability to raise the temperature of exhaust gas to 1,200 to 1,400°F within the furnace or in an external afterburner for deodorization shall be considered.

118.0 ULTIMATE DISPOSAL

118.1 General

118.1.1 Objective and General Disposal Methods

All wastewater sludges, including screenings and grit, shall be ultimately disposed of by cost-effective methods which minimize the potential for contamination of surface waters and subsurface drinking water sources and the creation of public health hazards and nuisances. Advantages of beneficial utilization of sludge and sludge byproducts shall generally be considered secondary to environmental and public health protection.

Methods of sludge disposal are generally limited to land disposal in landfills, dedicated land application, and agricultural reclamation involving nonedible crops. Ocean disposal of sludge shall not be permitted. Screenings and

grit may be disposed of by onsite burial procedures and methods approved by the Director, the State Department of Health, and where applicable, the Honolulu Board of Water Supply.

118.1.2 Selection of Disposal Method

The disposal of sludge shall be evaluated as part of an integrated system which includes such operations as stabilization, dewatering and volume reduction, storage, and transportation. Economic factors of sludge disposal shall be carefully evaluated with respect to environmental and public health considerations. Sludge characteristics which should be evaluated in the selection of sludge disposal methods include degree of stabilization; pathogen content; heavy metal, pesticide, and other toxicant concentrations; and solids/moisture content. The general applicability of individual sludge disposal methods is addressed in the following sections.

118.1.3 General Regulatory Requirements

The disposal of wastewater sludges shall comply with all applicable federal, state, and county regulations and policies. The design engineer shall be responsible for formulating a wastewater sludge disposal plan which will assure that public health and the environment will not be adversely impacted. Specific regulatory requirements and policies for various sludge disposal methods are addressed in the following sections.

118.2 Landfill Disposal

118.2.1 Description and Applicability

Landfilling of sludge involves the disposal of sludge by burial in trenches or mounds with or without utilizing municipal refuse as a bulking agent.

Stabilized and dewatered sludges are generally well suited for disposal by landfilling. Ash produced by sludge incineration is also readily disposed of by landfilling.

118.2.2 General Requirements and Consideration

Sludge disposal schemes involving landfilling of sludge shall be approved by the Director and shall comply with requirements imposed by the State Department of Health (DOH) and all applicable federal regulations. Landfilling of stabilized domestic wastewater sludges as nonhazardous solid waste is generally permitted by the DOH. Where the sludge is identified as being inadequately stabilized or found to contain excessive amounts of pathogens and toxicants by the DOH, the sludge shall be landfilled as a hazardous waste in accordance with DOH and federal requirements.

Volume reduction and moisture removal should be maximized due to limited available landfill space. Sludge solids concentrations in excess of 25 percent may be required for landfill disposal at City-operated facilities.

Leachate and surface runoff shall be controlled by providing proper daily cover, grading, and final cover. Groundwater quality control measures, including impervious liners

and underdrain systems with leachate treatment, shall be provided in accordance with DOH and federal regulatory requirements and as required by the Department and the Honolulu Board of Water Supply.

Sludge shall not be deposited within five feet of the high water table without the use of an impervious liner. Facilities for groundwater quality monitoring shall be provided as necessary.

118.3 Land Application

118.3.1 Description and Applicability

Land application of sludge involves application of liquid sludge, dried sludge, composted sludge, or sludge cake to land by utilizing tank trucks, injection systems, ridge and furrow spreading, spray irrigation, plowing, disking, or other techniques. In a sludge reclamation scheme, sludge, which contains organic matter and essential crop nutrients, is utilized as a soil amendment and/or fertilizer for agricultural or forested land. Land application of sludge may also involve nonreclamation schemes, such as dedicated land disposal. Dedicated land disposal involves the repetitive heavy application of sludge on nonproductive land specifically designated to receive sludge on a long-term basis.

As with landfill sludge disposal, reclamation and dedicated land application schemes must consider the degree of sludge stabilization provided, pathogen and toxicant levels, and leachate and surface runoff control. The nature and constituents of the sludge may result in numerous limitations, including the acceptable rate of application, the

type of crop or vegetation that can be grown, and the location, hydrogeology, and topography of the site required.

118.3.2 General Requirements and Consideration

Land application of sludge shall comply with requirements imposed by the State Department of Health (DOH) and all applicable federal regulations concerning environmental and public health impacts. Systems applying sludge to agricultural land or forests shall be reviewed and approved on a case-specific basis by the DOH, the Department, and, where applicable, the Honolulu Board of Water Supply. Dedicated land application systems shall be subjected to review and approval procedures similar to those of landfills.

Only stabilized and adequately disinfected sludge shall be applied to farmland or pasture. The degree of sludge stabilization and disinfection required, as well as allowable concentrations of heavy metals and other toxicants, shall be determined by the DOH on a case-by-case basis and, where applicable, by federal regulations. The designer shall submit for review pertinent design information relating to anticipated nitrogen loading and cadmium and other toxicant uptake by crops. Sludge shall not be applied to land which is utilized for growing food crops to be eaten raw, such as leafed vegetables and root crops. Provisions for groundwater quality monitoring shall be provided as necessary.

118.3.3 Site Selection

The primary consideration for land application of sludge shall be minimization of public health hazards and nuisances. Land ownership, land use, public access,

topography, climate, soil characteristics, and site hydrogeology shall be considered.

118.3.4 Sludge Storage

Sufficient sludge storage capacity shall be provided for periods of inclement weather and equipment failure. The storage facilities shall be designed, located, and operated so as to avoid nuisance conditions.

118.3.5 Land Application, Equipment, and Procedures

The design engineer shall provide detailed information on hauling, spreading, and/or subsurface injection equipment and a description of the proposed application program. Wastewater sludge shall be uniformly applied by tank truck spreading, ridge and furrow irrigation, or other acceptable methods. When control of nuisance odors and runoff is required, subsurface injection or immediate incorporation of sludge into the soil by plowing or disking shall be considered. Manure spreaders may be utilized for application of dewatered sludge cake. Spray systems, except for downward directed types, should not be utilized.

The sludge hauling equipment shall be designed to minimize spillage, odor, and other nuisances. Sludge spreading devices shall be equipped with self-closing type valves to prevent uncontrolled spreading or spillage.

118.3.6 Public Access

Fencing shall generally be provided to control public access to the site.

CHAPTER 120

DESIGN REQUIREMENTS FOR PROCESS COMPONENTS, APPURTENANCES AND STRUCTURES

120.0 GENERAL

This chapter focuses on design requirements and considerations for general process components, appurtenances, and structures commonly utilized in the treatment of wastewater. Requirements of this chapter are intended to supplement general requirements in Chapter 40 and specific process component requirements of other chapters. The primary objectives of this chapter, as in previous chapters, are to promote and assure continuity of operations, equipment and equipment systems reliability, personnel safety, and ease of treatment facility operation.

Mechanical systems, electrical systems, and buildings/process tankage are the three major subject areas addressed in this chapter. It shall be noted that requirements and guidelines for wastewater treatment facility components, particularly mechanical equipment and their appurtenances, are necessarily broad and generalized due to the wide variety and function of processes and systems employed. The Division shall be consulted for clarification as necessary, and wherever practicable, the design shall conform to accepted industry practices and standards.

121.0 MECHANICAL EQUIPMENT, SYSTEMS AND APPURTENANCES

121.1 General

Wastewater treatment facilities typically employ a wide variety of mechanical equipment, systems and appurtenances. General design requirements and considerations applicable to typical mechanical equipment and systems are addressed in Section 121.2 Subsequent sections are devoted to discussion of specific mechanical components and systems which are commonly utilized in treatment facilities. The four major subject areas addressed are pumps, compressor and blower systems, piping and valves.

121.2 General Design Requirements and Considerations

121.2.1 Compatibility with Operating and Environmental Conditions

Mechanical equipment and systems shall be suitable for both the intended process and the environment in which the equipment will be located. The anticipated range of operating speeds, service pressures, fluid types, temperatures, loads and other process related variables shall be thoroughly evaluated prior to equipment selection to assure equipment compatibility. Actions to counter adverse operating environments resulting from exposure to moisture and humidity, corrosive gases and process fluids, extreme temperatures, and other detrimental elements and conditions shall also be fully investigated.

The design and materials of construction of all equipment shall be fully considered with respect to operating and environmental conditions. Enclosures, mechanical ventilation, and other appurtenances to promote equipment reliability shall be provided as appropriate.

121.2.2 Equipment Reliability and Redundancy

Reliability and the requirement for either equipment backup or redundant units shall be commensurate with the requirements for process reliability unless noted otherwise by these standards. Process reliability is addressed in Chapter 40 and in applicable sections throughout these standards.

121.2.3 Equipment Access Space

Adequate access and equipment removal space shall be provided around all mechanical components to promote safety and to facilitate equipment inspection, operation and

maintenance. A minimum clear access space of 36 inches on the side where servicing will most often be performed and 30 inches on at least two other sides should generally be provided. A greater amount of clear access space shall be provided as necessary for large equipment and for equipment requiring additional room for disassembly and/or removal. Adequate vertical clearance shall be provided, particularly with respect to removal of equipment by hoisting equipment.

121.2.4 Vibration Isolation

Mechanical equipment shall be provided with adequate isolation from external vibrations and piping stresses and strains to prevent unusual wear and premature equipment failure. Vibrations originating from the mechanical equipment should be attenuated by use of vibration isolators in the form of springs, rubber mounts or cork padding under equipment, and flexible couplings on piping connected to the equipment.

121.2.5 Electric Motors

Electric motors shall conform to the latest standards of the National Electric Manufacturers Association (NEMA) and the American Institute of Electrical Engineers (AIEE) and shall be the product of a reputable manufacturer. Electric motors shall generally be rated for continuous duty operation. Selected motors should develop ample torque for its required service and be non-overloading at all points along the starting and operational curve of the driven equipment. Consideration shall be given to the use of high-efficiency electric motors, especially in sizes 5 horsepower and greater.

Depending on the severity of service, electric motors shall be specified with either a 1.0 or 1.15 service factor. Use

of motors with a 1.0 service factor should be limited to applications requiring not more than 87 percent of the nameplate horsepower. Motors with a 1.15 service factor should be limited to applications not requiring more than the nameplate horsepower.

Fractional horsepower requirements less than or equal to 1/2 hp may generally be satisfied by single-phase capacitor-start induction motors, connected to 115 volt, 60 Hz alternating current electrical systems. Bearings for such motors should be of the permanently lubricated sealed type.

Motors larger than 1/2 horsepower should generally be three phase, squirrel cage induction motors designed for 460 volts and 60 Hz operation. For heavy duty applications requiring low starting current and smooth acceleration, wound rotor motors should be considered. Synchronous motors may be considered in slow speed, large horsepower applications and for power factor correction. Bearings for three-phase motors should be conservatively designed. Antifriction motor bearings should be initially filled with a grease suited to the expected motor operating temperature and be capable of being relubricated. Consideration shall be given to the installation of temperature detectors in the stator and bearings of large motors to indicate overheating.

Selection of motor enclosures shall receive careful consideration with regards to the motor location, intended service, and possible exposure to unusual or hazardous service conditions. Protection of motors from moisture is addressed in greater detail in Section 122.8.

All motors shall have a manufacturer's name plate fastened to the motor frame. The name plate shall clearly indicate all NEMA-required information for the motor.

121.2.6 Operating Speed

To reduce wear, mechanical equipment should be operated at the lowest possible speed that will achieve the required performance.

To minimize large amplitude vibrations and the probability of premature equipment failure, critical speeds in large mechanical equipment should be identified. Normal operating speeds should be selected such that lateral vibration of machinery shafts do not coincide with a resonant frequency.

121.2.7 Bearings

A minimum L-10 design life of 50,000 hours shall generally be required for bearings on vital and frequently employed mechanical equipment. On large equipment and equipment for which bearing replacement is difficult or costly, the use of bearings with 100,000 to 200,000 hour L-10 design lives should be considered.

121.2.8 Equipment Regulation

Mechanical equipment with motors 1/2 horsepower and larger should generally be selected and regulated to limit the maximum number of on/off operating cycles from 4 to 6 cycles per hour. The maximum number of operating cycles per hour for motors 50 horsepower and larger shall be based on recommendations of the motor manufacturer.

121.2.9 Variable Speed Drives

In general, mechanical process equipment speed may be varied by regulating motor speed or by mechanical, electromechanical slip, and fluid-type variable speed drives.

Selection of the variable speed drive system should include consideration of the following aspects of the driven equipment:

1) Frequency of speed changes;

2) Severity of duty (hours of operation per day, extent of shock loadings, etc.);

3) Drive motor horsepower and desired efficiency; and

4) Range of speed variation.

In applications where speed changes are infrequent, duty periods are relatively short, and horsepower requirements are small (less than 15 Hp), adjustable sheaves and belt drives may be considered. Although eddy-current clutches and hydraulic drives exhibit low efficiencies when operated at less than approximately 80 percent of full load speed, the use of these devices should be considered when reliability is critical and service conditions are severe. In large horsepower applications requiring variable speed control, solid state variable frequency devices or slip recovery wound rotor motors may be considered due to the high efficiency of these devices.

Induced-pressure variable output (valve throttling) may be acceptable for certain fluid conveyance systems which utilize small centrifugal pumps and blowers and require minimal output variations.

121.2.10 Starter and Controls

Motor starter and controls for mechanical equipment shall comply with the requirements of Section 122.4. Automatic control systems shall comply with requirements presented in Section 122.5.

121.2.11 Metering and Instrumentation

Metering and instrumentation devices for mechanical equipment shall be selected and designed to provide the required range and degree of accuracy.

Meters and instrumentation shall be suitable for the environmental conditions anticipated at the site of installation. Outdoor instrumentation should be installed in gasketed, corrosion-resistant enclosures.

Meters and instrumentation, including alarms and annunciators, shall comply with requirements of Section 122.5.

121.2.12 Auxiliary Systems

Mechanical equipment and systems shall be provided with the necessary auxiliary systems. Common auxiliary systems for mechanical equipment include equipment drains, compressed air systems for pneumatic controls, service water systems for gland seals, fuel supply systems, lubrication oil systems, and chemical supply and addition systems.

The reliability of auxiliary systems shall be appropriate with respect to its intended function. If a malfunction of the auxiliary system may result in bypassing of wastewater, violation of effluent limitations, or damage to equipment, the system shall be provided with backup capability. Backup components for an auxiliary system need not be provided where the system performs functions which can be performed manually or by some other means.

Auxiliary systems requiring backup components shall have a sufficient number of each type of component such that the design function of the system can be fulfilled with any one component out of commission. It is permissible for the

backup component to be uninstalled, provided that the installed component can be easily removed and replaced. A minimum of two components, however, should be installed.

121.2.13 Testing

Testing requirements for mechanical equipment shall be specified to assure compliance of equipment performance with specification requirements. The requirement for shop testing, in addition to field testing, should be based on equipment complexity and type.

121.2.14 Safety Considerations

Moving parts on mechanical equipment, such as belts, gears and rotating drums, shall be provided with protective enclosures.

All pumps or feeders for hazardous chemicals shall have guards which will effectively prevent spray of chemicals into space occupied by personnel.

Lifting attachments such as hooks or eyes shall be provided on heavy equipment.

Mechanical equipment, associated electrical equipment, and all areas adjacent to mechanical equipment shall be designed to comply with all other safety requirements presented in these standards.

121.3 Pumps

121.3.1 General

Pumps may be classified as being of either of the dynamic or displacement type. Dynamic pumps are most often repre-

sented by centrifugal-type pumps, while displacement pumps include the piston, diaphragm, screw and gear types.

The following section addresses general requirements and considerations associated primarily with centrifugal pumps utilized in wastewater treatment facilities. Specific requirements for sludge pumps are discussed in Section 111.2. Chemical feed pumps are discussed in Section 91.4.3 with respect to metering of hypochlorite solution and in Section 115.2.2 with respect to chemical conditioning of sludge.

121.3.2 Redundancy and Standby

For Reliability Class I, II and III facilities, a backup pump shall generally be provided for each set of pumps which performs the same function. The capacity of the pumps shall be such that with any one pump out of service, the remaining pumps will have the capacity to handle the design peak flow. One pump, however, may serve as backup to more than one set of pumps.

121.3.3 Pump Selection

Pumping requirements shall be thoroughly evaluated and selection of pumps shall include consideration of the following:

1) Range and variation of flows;

2) System head, pump capacity and pump efficiency relationships;

3) Characteristics of the fluid to be pumped;

4) Environmental conditions of the proposed pump location; and

5) Reliability and ease of maintenance.

Common wastewater treatment facility pumping requirements and recommended pump selections are as follows:

Fluid Requiring Pumping	Recommended Pump Selection
Influent or raw wastewater	Dry pit, non-clog open impeller centrifugal pumps; archimedean screw pumps
Effluent (selection to be based on flow/head requirements and type) of effluent)	Radial flow (centrifugal) pumps; axial flow pumps; mixed flow pumps
Raw sludge and scum	Positive displacement pumps (progressive cavity)
Digested and MLSS sludge	Recessed impeller torque flow pumps
Grit	Airlift pumps; recessed impeller torque flow pumps
Chemical Solution Feed	Positive displacement pumps (diaphragm, gear)
Service Pumps (chlorine (injector water, foam spray water, effluent irrigation water, etc.)	End-suction centrifugal pumps; split-case centrifugal pumps; turbine pumps (clean fluids only); vertical turbine centrifugal pumps

A pump capacity and system head evaluation shall be conducted for each pump application to assure satisfactory selection of pumping units and operating points. For centrifugal pumps, system head-capacity curves should be prepared to show all conditions of head and capacity under which the pumps will be required to operate. The system head-capacity curves should show minimum and maximum head losses based on standard hydraulic methods for determining friction losses. Selection of friction factors should consider any significant differences between new and aged pipe. Where other factors are not applicable, pumps should be selected to operate at or near the best efficiency point. To insure efficient operation at reduced speeds, variable speed pumps should be selected such that the rated (full speed) condition point is to the right of the best efficiency point on the system head-capacity curve.

121.3.4 Pump Construction

The pump construction shall be appropriate for the intended service. Where applicable, pumps should be provided with cast iron casings with bronze or stainless steel trim and with cast-iron or bronze impellers. Impellers constructed of special nickel alloys should be considered for the handling of fluids containing grit.

Larger pumps should normally be provided with bronze wear rings at the suction side of the impeller. Small pumps without wear rings may be permitted.

Pump shafts should be constructed of high-grade forged steel and protected by renewable bronze or stainless steel sleeves where the shaft passes through the stuffing box. Stainless steel shafts without shaft sleeves may be permitted on small pumps. Bearings for large pumps should be of the antifriction type utilizing grease lubrication.

Pump stuffing boxes shall be provided with mechanical seal or packing as appropriate for the intended service. Where either mechanical seals or packing may be utilized, the use of mechanical seals is recommended. In such circumstances, however, stuffing boxes shall be designed to also be capable of accepting packing. Stuffing boxes shall be lubricated as necessary by oil, grease or water.

Pumps shall be provided with valved drain and vent lines. Large pumps should have handholes for impeller inspection and cleaning.

121.3.5 Instrumentation and Controls

Pressure gages and other instrumentation shall be provided as necessary based on the type of pump and the application. Indicating pressure gages should be provided on the pump suction and discharge. Pump suction gages shall be of the compound (vacuum/pressure) type.

Pumping systems shall be equipped with the necessary control and alarms to provide operational flexibility and protection of the pump and pumping system. Where applicable, HAND-OFF-AUTOMATIC pump operation selector switches shall be provided. High or low process fluid level and pressure shutdown circuits, as well as other shutdown circuits for other conditions which may adversely affect pump operation, shall be provided as necessary.

Provisions shall be included for automatic shutdown of pumps and sounding of alarms when failure occurs in a pressurized hazardous chemical discharge line.

121.3.6 Pump Testing

All pumps, regardless of size or type, should be subjected to testing prior to final acceptance. Testing requirements

should be developed based on pump type, application, and reliability requirements. Pump testing should be conducted in accordance to the Hydraulic Institute Standards. Shop tests performed by the manufacturer shall be conducted under carefully controlled conditions and cover the entire range of required head and flow. Field tests shall be conducted as appropriate on the installed pump to evaluate pump performance under actual operating conditions.

121.4 Compressors, Blowers and Compressed Gas Systems

121.4.1 General

The term compressor shall apply to equipment in which air or some other gas is compressed to a discharge pressure in excess of 25 inches water column. Equipment unable to provide a discharge pressure in excess of 25 inches water column shall be referred to as fans.

Compressors may be classified as either low pressure or high pressure compressors. Low pressure compressors providing discharge pressures on the order of 2 to 15 psig are commonly referred to as blowers. Blowers, which may be of the centrifugal or rotary lobe type, are typically utilized to supply process air for tank agitation and oxygen for biological treatment. High pressure compressors, which are typically capable of generating discharge pressures ranging from 40 to 250 psig, are normally of the reciprocating, screw or axial type. High pressure compressor applications in wastewater treatment facilities include instrument air, service air, and starting air.

121.4.2 Compressor Selection

The selection of compressors shall be based on considerations similar to that of pumps. The type of compressor

shall be appropriate for the intended service application. Specific requirements for various compressor applications are addressed in Section 121.4.6.

Compressors shall have the required capacity to meet maximum process air demands under the following conditions:

1) Maximum operating pressure;

2) Maximum inlet air temperature;

3) Maximum inlet air pressure; and

4) Maximum moisture content.

Compressor rated pressure should be determined by calculation of maximum static and dynamic losses at the maximum required air flow rate. Dynamic loss calculations should include the effects of all air system appurtenances, including filters, silencers, throttling vanes and throttling valves, isolation valves, meters, piping, and fittings. Such calculations shall include reasonable allowances for clogging in both air filters and air diffusers.

Compressor motors should be sized to be non-overloading at the maximum pressure, or shutdown point, in the duty cycle. Maximum motor load should include compression at the minimum ambient air temperature anticipated.

121.4.3 Cooling Systems

Compressors should be air cooled wherever practicable. Air cooled compressors shall be provided with adequate air circulation to assure proper cooling.

121.4.4 Instrumentation and Shut-down Circuits.

Pressure gages and other instrumentation shall be provided as necessary. Compressors shall be provided with safety shutdown circuits as necessary for low oil pressures, high discharge pressure, low cooling water pressure, high cooling water discharge temperature, low oil level, high discharge air temperature, and excessive vibration.

121.4.5 Noise Control

Compressors and compressor silencers shall be designed to facilitate conformance to the State of Hawaii Occupational Safety and Health Standards as well as to Chapter 43, "Community Noise Control Oahu" of Title 11, Administrative Rules.

121.4.6 Compressed Air and Gas System Requirements

The following subsections address requirements for various compressed air and gas systems. These requirements are supplemented by the general requirements for air and gas piping presented in Section 121.5. Specific requirements for chlorine and sludge gas are addressed in Sections 91.0 and 114.2 respectively.

a. Process Air

Process air compressors should generally be single or multi-stage centrifugal type blowers. In process air systems, total distribution losses (losses from piping, valves, meters, diffusers, etc.) should not exceed 25 percent of the depth of the diffuser submergence.

As a minimum, supply air for the blowers shall be drawn through medium-high efficiency filters. A common supply duct shall be employed where feasible. Air filters shall be provided in adequate numbers and capacities to assure at all times, an air supply sufficiently dust free to prevent blower damage and diffuser clogging. Filter pressure drops shall be gaged, with the filter replacement or cleaning pressure drop red-lined.

Appropriate air diffusers shall be located to promote efficient and reliable oxygen transfer and/or mixing. Individual diffuser assemblies shall be provided with control valves for throttling and shutoff. Diffusers in any single assembly shall exhibit relatively uniform pressure losses. Processes employing less than three independent aeration or mixing tanks should be designed to incorporate removable diffusers which may be serviced and/or replaced without dewatering the tank.

b. Instrument Air

Compressed air utilized to actuate remote valves, switches, instrumentation and other appurtenances shall be referred to as instrument air. Compressors for instrument air should be of the non-lubricated, water cooled type. Discharge pressure should be a minimum of 75 psig.

Discharge air should be cooled through an aftercooler to a temperature of no more than 5°F above inlet air temperature. The dew point (at line pressure) should be 20°F below the minimum ambient temperature.

The maximum particle size in the instrument air system should be less than 3 microns. Oil contamination in the air should be limited to 1 ppm and no corrosive, flammable or toxic gases should be present in the system. Cartridge-type filters should be provided at all service manifolds.

Standby instrument air compressors or other appropriate provisions shall be provided as necessary. Provisions to facilitate connection of instrument air systems to high pressure bottled nitrogen gas during standby compressor outages should be considered.

c. Service Air

Compressed air utilized for portable pneumatic tool operation and other non-instrument plant requirements shall be referred to as service air. Service air compressors should be lubricated multistage units with either air or water cooling. Distribution system pressure should be maintained at 120 psig minimum. Discharge air should be cooled by aftercoolers to a temperature of no more than 10 degrees F over inlet air temperature.

In large distribution systems, installation of satellite air receiver tanks should be considered to minimize large pressure fluctuations caused by rapid usage of air.

d. Starting Air

Compressed air or inert gas utilized to start large internal combustion engines shall be referred to as starting air. Starting air compressors should be

lubricated multistage units with either air or water cooling. Air receiver tanks should be sized to provide a minimum of three engine starts without compressor cycling.

e. Compressed Flammable Gas Systems

Sludge gas and other flammable gases may be compressed for anaerobic digester agitation, storage, or engine fuel. Compressors used for flammable gases shall employ non-sparking internal components and be specially designed to prevent both contamination of the gas by atmospheric air and leakage of the gas to the atmosphere. Compressors and motors should be adequately grounded and the equipment location shall be selected such that hazardous conditions will not develop as a result of gas leakage.

121.5 Piping and Piping Systems

121.5.1 General

The following subsections address requirements applicable to the design of wastewater treatment facility piping systems. Typical fluids conveyed through conduits at treatment facilities include raw and treated wastewaters, sludges, chemicals, potable water, air and flammable gases, liquid fuels, and drainage water. Although the discussions below focus on piping, it should be noted that certain requirements and considerations may be applicable to open channel conveyance systems as well as pipelines.

The design of piping systems shall conform to requirements of these standards, and where applicable, to accepted industry design standards and codes. Piping system requirements presented in these standards are intended to

supplement and expand on applicable provisions of Volume I of the Division's Design Standards. Specific provisions for sludge, sludge gas, and chlorine piping systems are addressed in Sections 111.0, 114.2 and 91.0 respectively. Special requirements for drainage and potable water piping are included in Sections 123.8 and 123.9 respectively. Wherever applicable, plumbing shall be designed in accordance to the Uniform Plumbing Code as amended by the Plumbing Code of the City and County of Honolulu. Design of any specialized piping systems not addressed by these standards shall be based on consultation and discussions with the Division. The Division shall also be consulted wherever the acceptable or preferred materials of construction for piping is not evident.

121.5.2 General Design Requirements and Considerations

Requirements for piping and fluid conveyance shall be thoroughly evaluated. The design of piping systems shall include consideration of the following factors:

1) Range of flows and flow velocities;

2) Maximum working pressures;

3) Available head and friction losses;

4) Characteristics of the fluid being conveyed;

5) Environmental conditions and structural stresses; and

6) Clogging potential and ease of maintenance.

All fluid conveyance systems shall be designed to minimize and facilitate maintenance. Pipes and channels shall be designed to minimize the deposition and accumulation of solids. The number and location of unions, coupling

adaptors, or other couplings shall be selected to promote ease of pipe dismantling. Cleanouts, blind flanges, flushing connections, and other maintenance provisions shall be provided at appropriate locations. Alternatives routing or redundant conduits shall be provided where necessary. All piping systems should be arranged to promote operational flexibility.

Special consideration shall be afforded to all aspects related to the corrosion resistance and structural integrity of pipelines. Pipes shall be protected against both interior and exterior corrosion by appropriate materials selection and by specifying suitable coatings and linings. Insulation of dissimilar metallic piping materials shall be provided to prevent dielectric corrosion. The structural integrity of subsurface piping systems shall be assured by fully considering such factors as pipe depths, soil type, and anticipated loads. Piping systems shall be provided with flexible connections, crushed rock or concrete cradles, reaction blocks, pipe supports, hangers or other anchorage as applicable and necessary to withstand all internal and external forces. Buried piping exiting large concrete structures should be provided with two flexible couplings or joints near the structure to allow for the shearing effects of differential settlement. As a minimum, pipe sleeves shall be provided whenever small piping passes through concrete walls. Wall pipes shall be utilized for small piping where leakage is undesirable or not permissible. Wall pipes shall be utilized for all large piping.

All exposed piping shall be service-labeled or coded and provided with arrows to indicate flow direction. Pipes containing or transporting hazardous chemicals shall be identified with labels every 10 feet with at least two labels in each room, closet, or pipe chase. High temperature and high pressure cautions shall also be similarly labeled on pipes. Piping shall also be color coded to

promote ease of recognition. The coding scheme shall be posted at various locations. Color coding, however, shall not be substituted for labeling. Warning signs shall be provided at each non-potable water outlet. Buried non-metallic pipes shall be provided with tracer tapes.

The design engineer shall specify that liquid and gas piping be tested at pressures or vacuums sufficient to assure leak proof operation upon completion of piping installation work and prior to start-up of any process. All testing should be conducted using certified gauges or other required measuring equipment. Special consideration should be given to the proper isolation of equipment which may be damaged by test conditions.

121.5.3 Wastewater Piping

Piping for wastewater shall generally conform to applicable design and materials of construction requirements presented in Chapters 20 and 30 of the Division's Design Standards. Wastewater piping shall be designed in accordance to hydraulic capacity considerations discussed in Section 43.5. The hydraulic design of wastewater piping shall be based on conveyance of design peak flows without surcharge of upstream weirs or other upstream controls, and on minimum and maximum velocities.

A minimum mean velocity of 2.0 fps shall generally be provided for pipes and channels conveying raw wastewater or other wastewaters with substantial quantities of settleable solids. Mean velocities of 1.0 fps may be acceptable for wastewaters having undergone primary sedimentation treatment. Where scouring velocities cannot be adequately sustained in open channel flow, mixing systems, such as diffused air mixing, shall be provided. Flow velocities should generally not exceed 10 fps in pipes.

Selection of the configuration and slope for wastewater piping should consider the type of flow (gravity versus pressure), transport of solids, provisions for draining, and venting requirements. Manual or automatic relief vents shall be provided as necessary at high points in the system to allow proper venting of conduits. Where applicable, low points in the piping system shall be provided with blowoffs or other maintenance provisions for draining and flushing.

121.5.4 Air and Gas Piping

The design of air and other gas piping systems should be based on general piping considerations addressed earlier in this section as well as on considerations for specific systems discussed in Section 121.4. The following discussions include additional requirements applicable to air and gas piping. It should be noted that piping requirements for chlorine gas and sludge gas are addressed separately in Sections 91.3 and 114.2 respectively. It should also be noted that the design requirements and precautions in Section 114.2 for sludge gas are applicable to other flammable gases as well.

Air and other gas piping should be sloped to a grade which will permit proper draining of condensate. As a minimum, driplegs and blow-down valves should be provided at appropriate locations for condensate removal in air systems. Isolatable condensate traps should be utilized in systems conveying flammable gases. Air and other gas piping shall be adequately supported to prevent sagging and formation of low points which may collect condensate.

Materials of construction for air and gas piping shall be suitable for the intended service. Steel, PVC, fiberglass reinforced polyester, ductile iron, or other suitable materials may be utilized as approved by the Division for the specific service. Heat-sensitive materials, such as PVC,

shall not be utilized for piping in the vicinity of blowers. Black steel should be utilized for conveyance of flammable gases. Pipes subject to interior or exterior corrosion shall protected as necessary by epoxy linings, thermoplastic coatings, or other suitable means. Small steel air lines should be galvanized.

121.5.5 Chemical Solution Piping

All chemical solution piping shall be constructed of materials suitably resistant to chemical attack. Materials selection for chemical piping are chemical and concentration specific. Pipes constructed of PVC, polyethylene, and fiberglass reinforced polyester have been found to to be satisfactory for a variety of chemical solution piping systems. Pipe manufacturers and the Division shall be consulted as necessary for specific applications.

Where applicable, chemical piping systems shall be designed with sufficient flexibility to provide alternative chemical feed locations and applications. The selection of chemical feed points should be based on consideration of such factors as the type of process and chemical involved, the necessary reaction times, chemical mixing and dispersion requirements, and ease of conveyance.

All connections (flanged or other type), except those in or adjacent to storage or feeder areas, should have guards that 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.

121.6 Valves and Gates

121.6.1 General

The selection of valve types and materials of construction for valves should be based on consideration of the following factors:

1) Potential of fouling due to the amount and/or nature of the solids in the fluid;

2) Corrosive and abrasive nature of the fluid;

3) Type of service and control requirements (shutoff, throttling, non-reversal of flow, etc.);

4) Allowable friction losses;

5) Operating pressures;

6) Operating temperatures;

7) Size of valve required;

8) Cost and availability of the valves; and

9) Ease of valve maintenance (including on-line vs. off-line repairs).

While valves should be provided to promote operational flexibility and ease of maintenance, they should be utilized only where they are essential.

Valve parts in contact with the fluids shall be suitably corrosion resistant. Packing materials shall be properly selected for the intended service and be compatible with the mechanical design of the valve.

All valving and gates shall be readily accessible for operation. Extension stems, chain wheels, or other such means shall be provided to permit operation from normal working levels. Manual valve operation shall require no more than a 40-pound pull on levers, handwheels and chains. Reduction gearing, motor or cylinder assist, or other mechanical advantage shall be provided as necessary. Where applicable, rising stems and outside yokes, or disc position indicators, should be utilized to allow determination of the degree of opening.

General recommendations and requirements for commonly utilized valved and gates are described in the following subsections. Specific valving requirements for sludge and chlorine applications are addressed in Section 111.3 and 91.0 respectively. The Division shall be consulted wherever the acceptable or preferred valve type or materials of construction is not evident.

121.6.2 Gate Valves

Gate valves should be utilized primarily to isolate flows which do not contain excessive amounts of grit and other solids due to the likelihood of entrapment of solids on the valve seat. Gate valves should not be utilized for throttling applications since the valve components may be damaged by the vibration and chattering of a partially closed valve disc. Hazardous fluids should not be isolated with gate valves due to inherent packing gland leakage problems. Knife-gate valves may be used only where the entire line can be removed from service in the event of the need for repacking of the valve stem assembly.

121.6.3 Plug Valves

Plug valves are especially suited for liquids, slurries and gases exhibiting a high solids content since the shearing

action of the valve port minimizes the accumulation of solids in the valve. Plug valves provide a tight shutoff and are quick-opening in the smaller sizes. Plug valves may be utilized for isolating and throttling sludge, scum and other wastewater lines as well as for various other liquid or gas service isolation and throttling applications.

121.6.4 Ball Valves

Ball valves are typically utilized for isolation of small lines conveying water, air, polymer, and other liquids or gases which are relatively free of grit and large solids.

121.6.5 Diaphragm Valves

Diaphragm valves are most often installed on chemical solution piping and utilized for throttling on small lines and both throttling and isolation on large lines.

121.6.6 Butterfly Valves

Butterfly valves are applicable to throttling and isolation of large lines conveying relatively clean gases and liquids.

121.6.7 Globe and Angle Valves

Globe valves may be utilized to modulate the flow of relatively solid-free fluids in small lines. Angle valves exhibit similar flow modulation characteristics as a globe valve except that an angle valve provides a change in flow direction.

121.6.8 Check Valves

Check valves are designed to allow unlimited flow in one direction and restrain flow in the opposite direction. Check valves should be installed on the discharge side of centrifugal pumps to prevent backflow and impeller counter-rotation. Check valves should also be installed on separate services connected to a common system to prevent backflow.

Check valves should generally be installed in a horizontal position to minimize problems resulting from accumulation of solids. When detrimental effects associated with water hammer are anticipated, check valves with a controlled rate of closure should be installed.

121.6.9 Slide Gates

Hand-operated slide gates of fiberglass reinforced polyester, aluminum or steel may be utilized in small flow channels where gate operation is infrequent. In channels, the guides for slide gates should be cast in place and installed flush to the channel bottom and walls to minimize restriction of flow. Aluminum guides cast in concrete should be pre-coated with bituminous compounds to insulate the aluminum from the chemical action of the concrete.

121.6.10 Sluice Gates

Sluice gates may be utilized on conduits that do not operate under pressure and which are of a size and shape that is not readily adaptable to valve service. Sluice gates may be constructed of steel, cast iron or other suitable materials.

122.0 ELECTRICAL EQUIPMENT AND APPURTENANCES

122.1 General

Wastewater treatment facilities shall be provided with an electrical power system which is adequately sized, reliable, safe and cost-effective. The design of treatment facility electrical systems shall conform to applicable codes and regulations including the National Electric Code as amended by the Electric Code of the City and County of Honolulu, the National Electrical Safety Code, and the Occupational Safety and Health Standards of the State Division of Occupation Safety and Health (DOSH). Electrical systems of treatment facilities shall also conform to operating rules of the Hawaiian Electric Company and Design Criteria for Mechanical, Electric, and Fluid System and Component Reliability of the U.S. EPA. Pertinent provisions of the EPA guidelines have been integrated into the following sections.

122.2 Electrical Power Sources and Emergency Power Requirements

The design engineer shall make every effort to provide treatment facilities with electrical power from two full capacity utility substations in a manner to minimize common mode failures. Wherever practicable, electrical power supplied by at least one substation should be from a preferred source (i.e., a utility source which is one of the last to lose power from the electrical grid when power generating capacity is lost). All treatment facilities shall be equipped with an emergency generator to provide an alternate power source.

The capacity of the backup emergency generator system for Reliability Class I facilities shall be sufficient to operate all vital components during peak wastewater flow conditions together with critical lighting and ventilation systems. A vital component shall be defined as a component whose operation or function is required to prevent bypassing of wastewater, to meet effluent limitations, or to protect other vital components from damage. Backup generation systems for Reliability Class II and III facilities shall be capable of operating screening or

comminution facilities, primary sedimentation tanks, disinfection facilities, and main wastewater pumps together with critical lighting and ventilation systems during peak wastewater flow conditions. Diesel driven wastewater pumps may be substituted for electrical pumps to maintain continuity of the hydraulic capacity of the plant.

The means for starting an emergency power generator shall be completely independent of the normal electrical power source. Starting air systems shall be designed in accordance to requirements presented in Section 121.4.6. Battery starting systems shall have a sufficient charge to permit starting the generator engine a minimum of three times without recharging. The starting systems shall be appropriately alarmed and instrumented to indicate loss of readiness and system malfunctions.

Treatment facilities with dual electrical utility power sources and an emergency generator system shall be provided with the necessary switch gear to automatically or manually change from one utility power source to another and to initiate operation of the generator. A mechanical or electrical safety device shall be provided to assure that two unsynchronized power sources cannot be cross-connected. Automatic power transfer shall be provided where the time delay required to manually transfer power could have adverse impacts on effluent quality and hydraulic capacity, or cause damage to equipment. The actuation of an automatic transfer switch shall be alarmed and annunciated. An automatic transfer switch utilized with an engine generator shall be equipped with an in-phase monitor relay which will enable proper transfer from engine generator power to commercial power upon return of commercial power.

122.3 Transformers

Each electrical utility power source supplying the treatment facility shall be transformed to usable voltage by a separate transformer. Transformers shall be protected from common mode failure by physical separation or other means. The installation of transformers shall be coordinated with the Hawaiian Electric Company.

122.4 Power Distribution and Motor Control Center

The preferred electrical service for City facilities is 480-volt, 60 Hz, 3-phase. High-voltage in-plant distribution, with multiple transformers for 480-volt service, may be considered for larger facilities. Small motors (less than 1/2 hp) and lighting systems shall be 120-volt, 60 Hz, single-phase.

Total distribution system analysis shall be conducted to assure complete protection of both operating personnel and equipment from transient conditions, including overloads, phase failure, faults, and overheating.

Electrical power distribution networks shall be designed to provide maximum service flexibility and to minimize systems vulnerability in the event of in-plant system fault or component failure. The internal power distribution system shall be designed such that no single fault or loss of a power source will result in an extended disruption of electrical service to more than one motor control center associated with vital components requiring backup power. Where practicable, components of the same type serving the same function shall be divided as equally as possible between two or more motor control centers.

Motor starters for induction motors shall generally be of the magnetic across-the-line type. Reduced voltage motor starting requirements shall be coordinated with the Hawaiian Electric Company. Reduced voltage starters shall be of the auto-transformer type. Where the standby source of power is supplied by engine generator units, reduced voltage starting should be considered as a means of reducing the size of generator required.

Where applicable, voltage monitor relays shall be provided in the starter circuit to reenergize the motor starter following motor shutdowns resulting from temporary low voltage or short-term power outages. To minimize undesirable transients in torque, current, and

voltage in motors of freewheeling equipment such as blowers, a time delay shall be provided to prevent reenergizing the motor before it slows to a standstill.

Three phase motors and their starters shall be protected from electric overload and short circuits on all three phases. Large motors shall have a low voltage protection device which, on the reduction or failure of voltage across any one phase, will cause and maintain interruption of power to that motor.

Power factor correction, to a minimum of 0.95 factor, should be provided on all motors 15 horsepower and greater. Bank capacitors should be used for power factor correction for all smaller sized units, with the capacitance located adjacent to central motor control centers or to other power distribution centers.

Electrical lockouts shall be provided at motor control centers, or other starter locations remote from operating equipment. Running status lights shall be provided at remote starters. Local (at equipment) shutoff shall override remote starting. Elapsed time meters should be installed for each starter.

Automatic control systems and instrumentation, including alarms and annunciators, shall conform to requirements presented in Section 122.5.

To avoid common mode failures, conductors to components which perform the same function in parallel shall not be routed in the same conduit or cable tray. Conduit size shall be a minimum of 3/4-inch. Wiring size shall be a minimum of No. 12 wire. All wiring shall be properly insulated and concealed. All equipment and wirings shall be properly grounded. Where overhead electrical service is employed, fencing, structures, etc., beneath the service shall also be grounded.

Wires in underground conduits or in conduits that can be flooded shall have moisture resistant insulation as identified in the National Electric Code. Buried conduit for high voltage runs shall be encased

in a protective concrete encasement. All conduit runs shall be sloped to drain toward manholes or handholes. Appropriate provisions for dewatering shall be provided at the manholes and handholes.

122.5 Automatic Control Systems and Instrumentation

Where system automation is employed, a manual override or backup shall be provided. Automatic controls critical to plant performance which require the use of manual override shall be provided with alarms and annunciators to indicate malfunctions. Systems shall be designed such that no single failure will result in disabling both automatic controls and the alarm/annunciator. Automated systems shall be designed for "fail-safe" operation to the extent practicable.

Where appropriate, automatically operated systems with standby components should first activate an alarm on failure, then actuate standby components automatically.

Equipment operated by instrumented remote control systems should also be operable and monitorable at the equipment. As a minimum, equipment operated by remote controls shall be capable of being shut down at the equipment.

Instrumentation whose failure could result in wastewater bypassing or a violation of the effluent limitations shall be provided with an installed backup sensor and readout. The backup equipment may be of a different type and located at a different point, provided that the same function is performed. No single failure shall result in disabling both sets of parallel instrumentation.

Alarms and annunciators shall be provided to monitor the condition of equipment whose failure could result in a wastewater bypassing or a violation of the effluent limitations. Alarms and annunciators shall also be provided to monitor conditions which could result in damage to vital equipment or hazards to personnel. The alarms shall sound in

areas normally manned and also in areas near the equipment. The combination of alarms and annunciators shall be such that each announced condition is uniquely identified.

Vital instrumentation and control equipment shall be designed to permit alignment and calibration without requiring bypassing of wastewater or a violation of the effluent limitations. Automated systems shall have provisions for operator verification of performance and all necessary systems calibration devices. Test circuits shall be provided to enable the alarms and annunciators to be tested and verified to be in working order.

Instrumentation systems should be specified as being the furnished responsibility of one supplier in order to assure component compatibility and coordination. The supplier shall demonstrate the capability of the equipment to be serviced locally.

122.6 Breaker Settings or Fuse Ratings

Breaker settings or fuse ratings should be coordinated to effect sequential trippings such that the breaker or fuse nearest the fault will clear the fault prior to activation of other breakers or fuses.

122.7 Electric Motors

Electric motors shall conform to requirements addressed in Sections 121.2.5 and 122.8.

122.8 Equipment Housing and Location

Failure of electrical equipment from such causes as fire and flooding shall be minimized by provision of suitable equipment housing and location, as well as by proper equipment design. Electrical equipment shall be installed in a manner to facilitate access for operation and maintenance.

Motor control centers, electric switchgear and other related equipment shall generally be located indoors in a suitably ventilated environment, free from corrosive gases, moisture and dust. The equipment shall be protected by suitable enclosures from sprays and moisture from liquid processing equipment and from breaks in liquid piping. Where practicable, electrical equipment shall be located in a separate room having an adequately controlled environment. Mechanical ventilation shall be provided as necessary to protect electrical equipment from excessive temperatures. Motor control centers and electric switchgear shall be located above ground and above the regulatory flood or wave action elevation. All outdoor electrical equipment shall be adequately protected from adverse weather conditions by appropriate enclosures.

All electrical enclosures shall be suitable for the expected environmental conditions and be of approved National Electric Manufacturers Association (NEMA) design and Underwriters Laboratories Inc. listing. Nameplates shall be provided for all enclosures and for all mounted devices. Motor starter cubicles shall be sufficiently sized to provide adequate ventilation and room for servicing.

Motors and associated components shall be adequately protected from moisture. Totally enclosed or weather-protected open motor enclosures shall be utilized for exposed outdoor motors. Motors located indoors and near liquid handling piping or equipment shall, as a minimum, be of splash-proof design. Consideration shall be given to providing heaters in motors located outdoors or in areas where condensation may occur. All outdoor motors, and where practical, indoor motors, shall be located at an elevation to preclude flooding from the regulatory flood or wave or from clogged floor drains. Indoor motors located at or below the regulatory flood or wave action elevation shall be housed in a room or building protected from flooding.

Explosive atmospheres where flammable liquid, gas or dust is likely to be present shall be clearly defined in the design. All electrical

equipment including motors, controls, conduit and fittings, fixtures, and wiring devices in such atmospheres shall be explosion proof, National Electric Code (NEC) Class 1, Division 1, Group D.

122.9 Spare Components

An adequate number of spare components, generally not less than 20 percent, shall be specified by the design engineer to permit in-plant modifications and adjustment. These components include starter cubicles, low voltage contactors, and buried conduit. Spare electrical components which are subject to wear, such as motor brushes and switches, should also be specified by the design engineer as appropriate to minimize downtime.

122.10 Maintainability and Equipment Testing

Electrical distribution systems and equipment shall be designed to permit inspection and maintenance of individual items without requiring bypassing of wastewater or causing violation of effluent limitations.

Provisions shall be included in the design of equipment requiring periodic testing to enable the tests to be accomplished while maintaining electrical power to all vital components. Such tests may include actuating and resetting automatic transfer switches, and starting and loading emergency generating equipment.

122.11 Miscellaneous Safety Requirements

Control circuit voltages shall not exceed 120 volts.

Nonconducting rubber mats shall be provided in front of all switchgear, control centers, panelboards, and other power distribution and supply equipment.

123.0 BUILDINGS, TANKAGE, AND WORK AREAS

123.1 General

The following subsections address requirements applicable to the design of wastewater treatment facility buildings, tankage, and associated work areas. The provisions of this section and other sections of these standards shall be supplemented by requirements of applicable building and structural design codes and standards and the Occupational Safety and Health Standards of the State Division of Occupational Safety and Health (DOSH).

123.2 Structural Design

Buildings and drywells shall be designed with adequate space for equipment, piping and appurtenances to promote ease of maintenance and personnel safety. The size and configuration of tankage and wetwells shall be selected to assure satisfactory and reliable performance and to facilitate cleaning and maintenance. Space and provisions for future equipment and expansion shall be provided as appropriate.

The structural design of wastewater treatment facility structures shall conform to applicable requirements of the Uniform Building Code as amended by the Building Code of the City and County of Honolulu. Reinforced concrete design shall conform to Building Code Requirements for Reinforced Concrete and Concrete Sanitary Structures of the American Concrete Institute (ACI). Structural steel design shall conform to the Steel Construction Manual of the American Institute of Steel Construction (AISC).

Ground level floors of at-grade buildings should be a minimum of one foot above the regulatory flood level of the general area. The ceiling height of buildings, dry wells and other work areas shall provide adequate working height, particularly with respect to removal of equipment by hoisting equipment. All structures below-grade shall be waterproof and watertight. Thorough subsurface investigations

shall be conducted to determine the soil characteristics at all treatment plant sites, and foundations shall be suitably designed for all structures.

The following materials of construction are acceptable for construction of permanent above-grade buildings:

1) Beams and Columns - reinforced concrete or structural steel;

2) Roofs and Floor Slabs - reinforced concrete; and

3) Walls - masonry or reinforced concrete.

For permanent facilities, tankage and below-grade structures, such as drywells and wet wells, shall be of reinforced concrete construction. Materials of construction for temporary facilities shall be approved on a case-specific basis by the Director. Steel tankage for temporary facilities will be approved by the Director only when there is complete assurance of adequate corrosion protection. Unless otherwise approved by the Director, steel tankage shall be provided with cathodic protection in addition to suitable protective coatings. The minimum wall thickness (excluding corrosion allowance) for steel tankage shall be 1/8-inch. A minimum corrosion allowance of 1/16-inch should be provided.

Unless otherwise approved, roofing for all buildings shall be 15 lb asphalt felt built-up roofing. Roofing shall be 5-ply for permanent installations and a minimum of 3-ply for temporary installations.

123.3 Access, Walkways and Working Areas

Tankage and equipment layouts shall be such as to permit reasonable access for operations and maintenance. Adequate clearances shall be provided for vehicular access to large pieces of equipment. Openings in structures (i.e., doors, manholes, floor hatches, etc.) shall be appropriately located and sized to facilitate the passage of equipment, and to minimize the need for extensive equipment dismantling.

Primary access to dry wells, equipment areas, and to upper and lower floors shall be by straight run reinforced concrete, structural steel, or aluminum stairways. Stairways shall be provided with non-slip stair treads and landings. Ships ladders, and ladder or manhole rungs shall be utilized only as a means of secondary access or in areas of infrequent use.

Double handrails or chains, fencing, or guards of proper height shall be provided at floor and wall openings, pumps wells, influent structures, open tanks, and above ground ramps. Stairways shall be provided with kickplates around stairwell openings and with DOSH approvable railings.

Tank, manholes, wet wells, etc., shall have access ladders or manhole rungs. Where possible, extension rungs shall be provided above the entrance level for handholds. Safety cages or wells shall be provided as necessary.

Ramps shall have slopes satisfactory for the intended use. Elevators shall be provided for access where appropriate.

Commonly used passageway doors should be equipped with a glass panel to prevent accidental opening into another person. Where appropriate, interior doors having glass panels may be designed to swing both ways. Rooms which may develop hazardous conditions, such as those utilized to store dangerous chemicals, should be separated from other work areas and be equipped with tight-fitting, self-closing, outward opening doors with panic hardware. Door locks for City facilities shall be keyed to the Division of Wastewater Management master keying system.

Heavy hatchway covers should be provided with spring assistance to prevent injury. Hatchway covers should be provided with springs or positive locking devices to hold covers open unless the covers maybe be swung free of the opening and laid flat.

Areas with low headroom, created by low pipes, valves, ceiling and suspended equipment, shall be eliminated wherever practicable. Signs, or signs and padding, shall be provided in areas with low head clearances to minimize injuries.

Walkways and floors shall be smooth but not slippery. Non-slip floor covering and non-slip surfaces such as broom-finished concrete shall be utilized as necessary. Wherever spillage may occur, sufficient faucets, adequate floor drainage, and water repellant wall surfaces shall be provided to encourage and facilitate cleanup.

Dust collection equipment should be provided to protect personnel from chemical dust injurious to the lungs or skin and to prevent dust from accumulating on walking surfaces. Special consideration should be given to the minimization of polymer dust on floors since the floors may become exceedingly slippery when wetted.

123.4 Ventilation

Facilities shall be furnished with mechanical forced ventilation systems where necessary to provide sufficient fresh air and air movement. Whenever hazardous substances in the form of gases, vapors, fumes, mists and dusts exist or are produced, their concentrations shall not exceed the limits specified by "Hazardous Substances", Chapter 202 of the Occupational Safety and Health Standards. Natural ventilation should be utilized to the maximum extent practicable. The design of ventilation systems shall conform to applicable requirements of Chapter 39, "Air Conditioning and Ventilation" of Title 11, Administrative Rules.

Ventilation equipment shall be sized to provide adequate air flow and velocity. Exhaust outlets should be situated to maximize dispersion and to minimize contamination of air inlets. Design of ductwork shall consider all pressure losses in the system and space requirements. Traps and other devices shall be provided as necessary for collection of condensate in ducts.

Ventilation systems for buildings or other structures which enclose areas with open wastewater surfaces shall be designed to maintain the contained space under positive pressure to suppress entrained gas and vapor release. Ventilation systems for such areas shall be designed to provide a minimum of one complete air change per minute. Ventilation systems for other enclosed wastewater or sludge processing areas should be designed to provide no less than 15 complete air changes per hour. Operation of ventilation systems for the above situations may be continuous, or where applicable, be based on an automatic time clock.

Hazardous and non-hazardous atmosphere and environments shall be separated. Hazardous atmosphere include enclosed spaces where toxic or suffocating gases or vapors may be present and where potential fire or explosion hazards exist. Enclosed areas that may contain potentially hazardous or explosive atmospheres shall be provided with a ventilation system capable of furnishing not less than one complete air change per minute. The actuation of the ventilation system shall be interlocked with the light switch. At least one light/ventilation switch shall be mounted outside the enclosed area. Ventilation equipment for such areas shall be provided with standby power in the event of failure of the normal power supply.

Automatic gas alarm systems, both visual and audible, shall be provided as necessary to detect explosive, combustible, toxic gases and vapors. Consideration shall be given to automatic emergency shut down provisions for all power except to emergency and explosion proof ventilating and lighting equipment in potentially explosive atmospheres.

All openings in buildings for ventilation (or light), except doorways, shall be equipped with removable insect screens of substantial corrosion resistant fabric.

123.5 Lighting

Adequate lighting throughout the wastewater treatment facility shall be provided, particularly in areas of operation and maintenance activities. Lighting intensities shall be appropriately selected based upon the anticipated usage of the area. Lighting systems shall be designed to minimize glare and secure a satisfactory distribution of light on the area. Both objectionable shadows and excessively sharp shadows should be minimized. Natural daylight lighting should be utilized to the maximum extent practicable.

Light fixtures should be located such that relamping may be accomplished with reasonable ease. Light fixtures located below ground level or in areas that may be exposed to combustible or explosive gases and vapors shall be vapor tight. Adequate emergency lighting shall be provided in the event of power failure.

Exterior flood lighting shall be provided for nighttime operation, maintenance, and inspection of each non-enclosed unit as well as for general illumination of plant operational areas. Light fixtures shall be installed outside next to exterior doors and around the perimeter of buildings. Lamp shades shall be provided to minimize nuisances stemming from glare. Night lights should be automatically controlled by photocells.

123.6 Noise Control

Wherever practicable, equipment and equipment areas shall be designed to maintain noise levels at or below exposure levels specified in Chapter 200, "Occupational Noise Exposure" of the Occupational Safety and Health Standards to minimize the need for ear protection equipment. Air compressors, vacuum pumps, centrifuges, blowers and other equipment producing high noise levels should be located either in isolated building or rooms, or within sound attenuating enclosures for maximum noise reduction.

Noise generated by wastewater treatment facilities shall be below levels specified in Chapter 43, "Community Noise Control for Oahu" of Title 11, Administrative Rules.

123.7 Floorplates and Gratings

Floorplates and gratings shall be utilized as necessary for closing floor openings and, where appropriate, for walkways and stair treads. Floorplates and gratings shall be designed to adequately support all anticipated loads. Where appropriate, use of corrosion resistant fiberglass reinforced polyester (FRP) floorplates and gratings is recommended.

Floorplates shall be provided with a checkered surface to improve footing. The maximum weight per floorplate section shall be 60 lb. Plate finger holes or drop handles shall be provided for section removal. Tread surfaces of grating shall be non-skid. Lift-rings and grating locks shall be mounted flush to prevent tripping.

123.8 Dewatering and Drainage

Tank drains or other provisions shall be included in the design to enable dewatering of pump wells and tankage within a reasonable length of time. Where practicable, pump wells and tankage shall be provided with sloped bottoms to facilitate washdown and to enable the basins to be completely drained. All drains shall discharge to an appropriate point in the wastewater flowstream to ensure adequate treatment. Drains flowing to a two-compartment wetwell shall be designed to discharge to either compartment of the wetwell.

Building and work area floor drainage systems shall be provided to facilitate washdown and to enable spilled or leaked wastewater, sludge, chemicals, or any other objectionable substances to freely drain out of the area of concern. Area drains, trench drains, sumps and sump pumps shall be provided as necessary. All floors shall be

sloped to permit complete draining. Special attention shall be given to specifying sufficient cleanouts in drain lines which are likely to clog.

Sump pumps shall be of a non-clog type. Each sump shall be provided with two full capacity sump pumps. Sump pump discharge lines shall have a minimum diameter of 2-inches. Velocity in discharge risers shall not be less than 3 fps.

Drains shall be designed to prevent backflow from other sources which would cause flooding or violation of effluent limitations. The drain system shall be designed to prevent the entrance of storm water during the regulatory flood or wave action condition. All indoor equipment which are capable of overflowing shall be equipped with an adequately sized overflow pipe. The overflow shall be directed to a gravity drain.

Hazardous chemical storage areas shall be enclosed in dikes or curbs to provide sufficient storage to contain any major spillage or leakage. Emergency provisions shall be included to allow chemicals to be safely transferred to alternate storage or to be released to the wastewater at controlled rates that will not damage facilities, inhibit the treatment processes, or contribute excessively to receiving water pollution.

Drain lines and fittings shall generally be extra heavy cast iron soil type. Piping 2-1/2-inches in diameter or smaller which are installed above ground or indoors may be standard weight galvanized steel pipe with standard cast iron screwed, recessed drainage fittings.

123.9 Water Supply

All in-plant uses of water shall be fully considered in the design of wastewater treatment facility water supply systems. The following uses of water shall be considered:

1) Sanitary uses, including water for lavatories, showers, urinals, shop sinks, lunch room sinks, laboratories, and drinking fountains;

2) Flushing needs, including water for hosing down of all tankage, floors and equipment areas;

3) Cooling needs, including water for compressors, shafting, bearings, after coolers, and sprays in incinerators;

4) Equipment operation requirements, including water for pump sealing and/or flushing water, operation of hydraulically operated valves and gates, boiler heating, and chlorinators;

5) Treatment process uses, including water for dilution of chemicals and defoaming sprays;

6) Sprinkling needs, including lawn sprinkling, plant and shrubbery watering, and vehicle washing; and

7) Fire protection, including water for fire hydrants, fire sprinklers, and hose lines.

Wherever practicable and where approved by the Division, adequately treated plant effluent should be utilized for such purposes as lawn sprinkling, tank washdown, foam control and chlorinator injector operation. Screening or filtering of treated wastewater shall be considered to minimize plugging of transmission and distribution lines. Cross connection control and backflow prevention should be given utmost consideration in the planning and design of water supply system. Warning signs shall be provided at each non-potable water outlet.

Special consideration shall be given to provision of adequate facilities for flushing and washdown. Flushing and washdown water should be provided at a minimum pressure of 30 psi. Flushing water standpipes shall be provided throughout the wastewater facility to allow complete

spray and washdown coverage utilizing a standard 50-foot length hose. Flushing and washdown water standpipes shall be 1-1/2-inch diameter wherever practicable.

Water piping 3 inches or smaller shall generally be copper. Water piping 1-inch and smaller within structures should be Type K copper pipe with standard brass fittings. Water piping larger than 3 inches should be ductile iron. Galvanized steel and polyvinyl chloride (PVC) rigid plastic piping may be utilized in lieu of copper where appropriate and as approved by the Division. The sprinkler piping systems should be constructed of PVC pipe and fittings with galvanized steel risers. PCV pipe and fittings should be Schedule 40, with the fittings being of the solvent welded type.

123.10 Hoisting Equipment and Materials Handling

The design engineer shall consider all aspects of equipment removal and materials handling systems. Equipment removal and materials handling shall be accomplished by use of installed provisions or by conventional rigging equipment in a safe, reasonable, and convenient manner.

Equipment handling systems shall be designed to readily lift, transfer, and remove installed equipment. Where applicable, provisions shall be made to allow loading and unloading of equipment onto and from vehicles. Similar ease of handling shall be provided for the receipt of materials such as bulk chemicals. Where space and arrangement permit, lateral equipment movement by dollies or rollers may be acceptable. Where such space is not available, or where vertical transport is necessary, installed eye bolts, monorails, or traveling cranes shall be provided.

The structural design of buildings shall consider the live load effects of hoisting conditions. The supporting structure to which the hoist is attached should be designed for a safe working load not less

than that of the hoist. The building design shall also consider the structural requirements of any floor slab on which equipment may be rested.

The hoisting equipment should be arranged and located to provide for free movement of the hoist and to allow the hoist to be positioned directly above the intended load. Auxiliary systems, such as ventilation ducts and room lighting, shall be positioned to avoid obstructing hoisting operations.

Hoisting equipment shall be supplied with all applicable safety features, including safety stops and overload protection. Hoisting cables and chains, shall have a minimum load safety factor of 5 to 1. Hoist capacity shall be clearly marked on the unit. Motors for large (2 hp and above) hoisting equipment shall be three phase. Controls for hoisting equipment shall be single phase. Explosion-proof requirements shall be dictated by the working environment.

Except where obstructed by monorails, eyebolts shall be installed above all mechanical equipment and over valves and header piping to facilitate removal and servicing. Eyebolts alone shall be acceptable where the load lifting requirement does not exceed one ton and where lateral transport is practical. The selection of monorail or traveling crane will depend on the need for hoist positioning to cover the arrangement of hoisted equipment.

All monorails shall be equipped with locking trolleys and hoists. Trolleys and hoists shall either be manual or electric, depending upon accessibility for operation, the expected frequency of use, and service capacity. Electric trolleys and hoists should be utilized where the service capacity is greater than or equal to two tons. Bridge cranes, where used, should be entirely electrically controlled.

A minimum of two portable manual hoists shall be furnished for use with eyebolts and monorail trolleys. One hoist shall have a rated capacity of one ton, and the second shall be rated as required for the expected service.

Where practical, chemical receiving and handling facilities shall be designed to minimize excessive manual handling. Manual lifting requirements associated with chemical bags and drums should be kept to a minimum. Discharge of chemicals should preferably be through a floor chute with low curbing. Handlift trucks should be provided wherever applicable. Chemical storage areas should be situated such that personnel are not required to stretch or lift beyond safe handling limits.

123.11 Fire Protection

Fire protection provisions such as portable fire extinguishers, fixed extinguishing systems, fire detection systems and fire alarms shall be provided. Firefighting devices shall be located in each separate structure at accessible points near the entrance to areas of likely conflagration. Fire extinguishers shall be suitable for the area and the equipment to be protected. Provision of automatic firefighting systems should be considered. Alarm systems shall provide both audible and visual warnings which may be perceived above anticipated ambient noise and light levels.

Hazardous chemicals, including chlorine, acids and caustics shall be stored in separate isolated areas in compliance with National Fire Protection Association requirements.

Fuel combustion equipment (incinerators, boilers, waste gas burners, engines, etc.) shall be isolated from nonrelated, nonhazardous work areas. All combustion systems shall have adequate safety measures protecting fuel supply, ignition, and combustion/burning equipment.

123.12 Signs

Appropriate signs shall be provided to warn personnel of potentially hazardous conditions or unsafe practices and to instruct personnel in safety practices. Signs and related appurtenances shall be designed and located such that they do not in themselves pose a potential hazard.

Accident prevention tags, such as "Do not Start" tags, shall be provided as a temporary means of identifying hazardous or potentially hazardous conditions.

The identification and hazard warning data included on shipping containers shall also appear on all other containers (regardless of size or type) used to store, carry, or use a hazardous substance.

Warning signs designating areas requiring the use of goggles shall be located near chemical loading and unloading stations, pumps, and other locations where personnel may be exposed to hazardous chemical spray.

Exit signs shall be properly designed, located and, where necessary, illuminated.

Piping shall be color coded and labeled as described in Section 121.5.

123.13 Eye Wash Fountains and Safety Showers

Eye wash fountains and safety showers utilizing potable water shall be provided in the laboratory and on each floor or in each work location involving hazardous or corrosive chemical storage, mixing (or slaking), pumping, metering, or unloading. These emergency facilities should be as close as practicable to possible chemical exposure sites and generally no more than 25 feet from points of hazardous chemical exposure.

The eye wash fountains shall be supplied with water of moderate temperature (50° to 90°F), separate from the hot water supply, and capable of providing 15 to 30 minutes of continuous irrigation of the eyes. The emergency showers shall be capable of discharging 30 to 50 gpm of water at moderate temperature and at pressures of 20 to 50 psi.

123.14 Miscellaneous Safety Equipment

Miscellaneous safety equipment listed below shall be specified by the design engineer wherever the potential for use of such equipment

exists. The number, size, and type of equipment shall be appropriate for the type and size of facility. For facilities to be operated by the City, recommendations by the Division pertinent to the specific project shall be considered. Other safety equipment, including those described in other sections of these standards, shall be specified as necessary and appropriate.

1) Life preservers attached to ropes and located near tanks;

2) Safety poles;

3) Safety harnesses for entering vaults or pits containing potentially harmful or explosive gases;

4) Nonsparking tools (where explosive-rated atmospheres exist);

5) Ladders with non-skid feet;

6) Chemical storage cabinet (explosion-proof);

7) Portable hazardous gas detection meters/devices for hydrogen sulfide, chlorine, oxygen deficiency, and carbon monoxide;

8) Portable ventilation blower and flexible non-collapsible ducting;

9) Flashlights (explosion-proof);

10) Respirator and self contained breathing units;

11) First aid kits;

12) Headsets for protection against excessive noise levels;

13) Safety goggles;

14) Industrial type vacuum cleaner; and

15) Chlorine cylinder repair kit.

APPENDICES

APPENDIX A

GUIDELINES FOR THE PREPARATION OF WASTEWATER TREATMENT FACILITY ENGINEERING REPORT

The following outline shall serve as a guideline for the preparation of engineering reports for wastewater treatment facilities. The contents of the outline shall be modified as appropriate for the specific project.

I. Introduction

A. Purpose

B. Scope

II. Existing Conditions and Projections

A. Planning and Design Period

B. Land Use

1. Existing area, ultimate planning area

2. Residential, commercial and industrial land use, zoning, population densities, type and concentration of industries

C. Demographic and Economic Data

1. Population growth, trends, increase during design life of facility

2. Assessed valuation, tax structure, tax rates, etc., for residential, commercial, industrial property

3. Employment, from within and outside service area

4. Transportation systems, effect on commuter influx

5. Exempt property: schools, colleges, churches, foundations, governmental agencies, etc., and effect on project

6. Costs of present water and wastewater services

D. General

1. Topography, general geology, and effect on project

2. Meteorology, precipitation, runoff, flooding, etc., and effect on project

E. Applicable Regulations

III. Existing Facilties Evaluation (Where Applicable)

A. Existing Collection System

1. Inventory of existing sewers and wastewater pump stations

2. Adequacy to meet project needs

3. Infiltration/inflow analysis

4. Required maintenance, repairs and improvements

B. Existing Treatment Plant Site

1. Area for expansion

2. Terrain

3. Subsurface conditions

4. Isolation and habitation

5. Odor Control, flood protection, etc.

C. Existing Treatment Facilities

1. Capacities and adequacy of units (wastewater treatment, effluent disposal, sludge processing, and sludge disposal)

2. Relationship and/or applicability to proposed project

3. Age and condition

IV. Development and Evaluation of Proposed Facilities

A. Wastewater Flows and Characteristics

1. Analyses of the design equivalent population, including the design population, and commercial and industrial wastes population equivalents

2. Analyses of the strength of sewage, including BOD and suspended solids (mg/l and/or lbs. per day) for domestic sewage and for industrial wastes

3. Analyses of wastewater flows and design flow rates, including per captia flow; infiltration/inflow allowances; design average, maximum, peak flow rates

B. Receiving Water Considerations

1. Receiving water quality and characteristics (physical, chemical, biological, etc.)

2. Receiving water uses

3. Impact of proposed discharge on receiving waters

C. Treatment Plant Site Selection

D. Evaluation of Alternatives

Such items as regional solutions, utilization of individual onsite systems, modification and expansion of existing facilities, flow and waste reduction, location of facilities, phased construction, flexibility and reliability, sludge disposal, alternative processes, and institutional arrangements should be evaluated.

Evaluation of alternative processes should include:

1. Development, description and preliminary screening of alternatives

2. Development of cost estimates (construction, annual O&M, total present worth) and cost-effectiveness evaluation of alternatives

3. Evaluation of nonmonetary advantages, disadvantages and limitations, including discussion and comparison of process performance, reliability, flexibility, energy usage, environmental impact, public health protection, regulatory constraints, and ease of operation and maintenance

V. Environmental Assessment

VI. Project Implementation

A. Financing

B. Phasing

C. Legal Considerations and Approvals

D. Other

VII. Technical Information and Design Criteria

A. Collection System

1. Design tabulations (flow, size, velocities, etc.)

2. Pump station description and calculations

3. Special appurtenances

4. Stream crossings

5. System Map

B. Treatment Facilities

1. Hydraulic and organic loadings

2. Process removal efficiencies

3. Unit dimensions

4. Rates and velocities

5. Detentions

6. Concentrations

7. Recycle

8. Chemical addition

9. Flow metering and process control

10. Energy requirements

11. Operational modes including redundancy and operational flexibility

12. Topographic sketch of the selected site including process layout and configuration, interconnecting piping, etc.

13. Preliminary flow diagram

14. Preliminary hydraulic profile

15. Preliminary solids and organics mass balance

16. Odor control measures and septicity of incoming wastewater

17. Corrosion control measures

18. Provisions for operation during power failure

D. Operation and Maintenance

1. Routine and special maintenance duties

2. Tools, spare parts, chemical, equipment, vehicles, etc.

3. Maintenance workspace and storage

4. Personnel requirements (number, type, qualifications, training)

5. Special safety provisions

E. Administration, Laboratory, Sanitary and Miscellaneous Support Facilities

F. Other Pertinent Information and Design Criteria

APPENDIX B

LOCAL STANDARDS, CODES AND REGULATIONS

1) Administrative Rules, Title 11 (Department of Health, State of Hawaii)

2) Building Code of the City and County of Honolulu (Building Department, City and County of Honolulu)

3) Comprehensive Zoning Code (City and County of Honolulu)

4) Design Standards (Division of Wastewater Management, Department of Public Works, City and County of Honolulu)

5) Electric Code of the City and County of Honolulu (Building Department, City and County of Honolulu)

6) General Provisions of Construction Contracts (Department of Finance, City and County of Honolulu)

7) Hawaii Coastal Zone Management Program (Department of Planning and Economic Development, State of Hawaii)

8) Hawaii Statewide Uniform Design Manual for Streets and Highways (Department of Transportation, State of Hawaii)

9) Occupational Safety and Health Standards (Division of Occupational Safety and Health, Department of Labor and Industrial Relations, State of Hawaii)

10) Rules and Regulations (Board of Water Supply, City and County of Honolulu)

11) Shoreline Management Area (City and County of Honolulu)

12) Soil Erosion Standards and Guidelines (Department of Public Works, City and County of Honolulu)

13) Standard Details for Public Works Construction (Department of Public Works, City and County of Honolulu)

14) Standard Specifications for Public Works Construction (Department of Public Works, City and County of Honolulu)

15) Storm Drainage Standards (Department of Public Works, City and County of Honolulu)

16) Subdivision Rules and Regulations (Department of Land Utilization, City and County of Honolulu)

17) Water Quality Management Plan (208 Plan) for the City and County of Honolulu (Department of Health, State of Hawaii, and City and County of Honolulu)

18) Water System Standards (Board of Water Supply, City and County of Honolulu)

Note: The above list shall not be construed to be a complete listing of all applicable local standards, codes, and regulations.

APPENDIX C

ENGINEERING EVALUATION REPORT REQUIREMENTS FOR THE TAKEOVER OF EXISTING PRIVATE TREATMENT FACILITIES

The engineering evaluation report for the takeover of existing private treatment facilities shall provide the following data and information:

1. Basic Influent Flow Data

   - flow and diurnal variation (generally based upon pump start frequency and duration)
   - service area saturation ratio
   - influent waste characteristics
   - infiltration/inflow

2. Equipment Service Reports

   - pumps and pump motors, including pump capacity test data
   - comminutors
   - blowers and blower motors
   - air-lift pumps, including capacity test data
   - chlorinator
   - all other operating equipment

3. Injection Well Capacity Test Data

4. Performance Records for Both Treatment and Disposal Facilities

5. Maintenance Records, including detailed equipment inventory operation and maintenance manuals, repair records, and equipment manuals

6. Staffing Plan

7. Plans, Specifications, Engineering Reports, including "as-built" drawings

8. Utility Records

9. Safety Inspection Findings, including:

   . adequacy of safety, first-aid and emergency supplies

   . adequacy of ventilation and lighting

   . adequacy of security

   . structural integrity, including walkways, stairways, railways, etc.

10. Electrical Inspection Findings

The engineering evaluation report shall present a summary of estimated costs to correct deficiencies noted, to upgrade the facilities as necessary to meet City standards, and to provide the following items prior to take-over:

1. Telephone Service, including 10-pair terminal strip

2. Spare Parts Inventory

   a. Pumps

      . one entire rotating assembly, including motor

. complete set of gaskets

. set of wear rings (if applicable)

. shaft sleeve

. packing gland (if applicable)

b. Blowers

. if no installed standby or spare, one complete blower, including motor

. set of bearings, gaskets, seals

. set of V-belts

. two filter elements

c. Comminutor

. one complete replacement comminutor, including motor

. removable cutter assembly

. set of replacement teeth (if applicable)

d. Other spare parts as determined on case-by-case basis.

3. Expended Material Inventory

a. Six-month supply of all grease and lubricants.

b. Three-month supply of chlorine.

c. Other materials as determined on case-by-case basis.

All facilities, as a minimum, shall provide for onsite sludge stabilization and storage. Facilities without sludge dewatering and disposal capabilities shall have pertinent sludge disposal information included in the engineering evaluation report. The sludge disposal information shall include, as a minimum: 1) the existing or anticipated method of sludge wasting, transportation and disposal, and 2) the volume, wasting frequency and characteristics of the wasted sludge.

APPENDIX D

NATIONAL CODES, INDUSTRY STANDARDS, AND STANDARD REFERENCES

1) American Association of State Highway Officials (AASHO)
   341 National Press Building
   Washington, DC 20004

2) American Concrete Institute (ACI)
   P.O. Box 19150
   Detroit, MI

3) Association of Edison Illuminating Companies (AEIC)
   51 East 42nd Street
   New York, NY 10017

4) Anti-Friction Bearing Manufacturer's Association (AFBMA)
   60 East 42nd Street
   New York, NY 10017

5) American Gas Association (AGA)
   8501 East Pleasant Valley Road
   Cleveland, OH 44131

6) American Gear Manufacturer's Association (AGMA)
   1330 Massacusetts Avenue, N.W.
   Washington, DC

7) American Institute of Steel Construction (AISC)
   101 Park Avenue
   New York, NY 10017

8) American Iron and Steel Institute (AISI)
   150 East 42nd Street
   New York, NY 10017

9) American Institute of Timber Construction (AITC)
33 West Hampden Avenue
Englewood, CO 80110

10) Air Moving and Conditioning Association, Inc. (AMCA)
30 West University Drive
Arlington Heights, IL 60004

11) American National Standards Institute, Inc. (ANSI)
1430 Broadway
New York, NY 10018

12) American Plywood Association (APA)
1119 A Street
Tacoma, WA 98401

13) American Petroleum Institute (API)
1801 K Street N.W.
Washington, DC 20006

14) Air-Conditioning and Refrigeration Institute (ARI)
1814 North Fort Myer Drive
Arlington, VA 22209

15) American Society of Civil Engineers (ASCE)
345 East 47th Street
New York, NY 10017

16) American Standard Code for Information Interchange (ASCII)
United States of America Standards Institute
10 East 40th Street
New York, NY 10016

17) American Standard Safety Code for Elevators, Dumbwaiter and Escalators
American National Standards Institute
1430 Broadway
New York, NY 10018

18) American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE)
United Engineering Center
345 East 47th Street
New York, NY 10017

19) American Society of Mechanical Engineers (ASME)
345 East 47th Street
New York, NY 10017

20) American Society for Testing and Materials (ASTM)
1916 Race Street
Philadelphia, PA 19103

21) American Wood Preservers Association (AWPA)
1625 Eye Street
Washington, DC 20006

22) American Welding Society (AWS)
2501 N.W. 7th Street
Miami, FL 33125

23) American Water Works Association (AWWA)
Two Park Avenue
New York, NY 10016

24) Building Officials and Code Administrators (BOCA)
17926 Halstead
Homewood, IL 60430

25) Certified Ballast Manufacturers (CBM)
2120 Keith Building
Cleveland, OH 44115

26) Chlorine Institute, Inc.
342 Madison Avenue
New York, NY 10017

27) Crane Manufacturers Association of America, Inc. (CMAA)
(Formerly called: Overhead Electrical Crane Institute)
1326 Freeport Road
Pittsburgh, PA 15238

28) Diesel Engine Manufacturer's Association (DEMA)
122 East 42nd Street
New York, NY 10017

29) Edison Electric Institute (EEI)
90 Park Avenue
New York, NY 10016

30) Electronic Industries Association (EIA)
2001 Eye Street N.W.
Washington, DC 20006

31) Expansion Joint Manufacturer's Association (EJMA)
331 Madison Avenue
New York, NY 10017

32) Factory Mutual Research (FMR)
1151 Boston-Providence Turnpike
Norwood, MA 02062

33) Heat Exchange Institute (HEI)
122 East 42nd Street
New York, NY 10017

34) Hydraulic Institute
1230 Keith Building
Cleveland, Ohio 44115

35) International Association of Plumbing and Mechanical Officials (IAPMO)
5032 Alhambra Avenue
Los Angeles, CA 90032

36) International Conference of Building Officials (ICBO)
5360 South Workman Mill Road
Whittier, CA 90601

37) Insulated Cable Engineers Association (ICEA)
P.O. Box P
South Yarmouth, MA 02664

38) Institute of Electrical and Electronics Engineers, Inc. (IEEE)
345 East 47th Street
New York, NY 10017

39) Illuminating Engineering Society (IES)
c/o United Engineering Center
345 East 47th Street
New York, NY 10017

40) Instrument Society of America (ISA)
400 Stanwix Street
Pittsburgh, PA 15222

41) Joint Industrial Council (JIC)
2130 Wisconsin Avenue
Washington, DC 20007

42) National Association of Architect Metal Manufacturers (NAAMM)
100 South Marion Street
Oak Park, IN 60302

43) National Association of Corrosion Engineers (NACE)
P.O. Box 986
Katy, TX 77450

44) National Electric Code (NEC)
National Fire Protection Association
470 Atlantic Avenue
Boston, MA 02210

45) National Electrical Manufacturer's Association (NEMA)
155 East 44th Street
New York, NY 10017

46) National Electric Safety Code (NESC)
American National Standards Institute
1430 Broadway
New York, NY 10018

47) National Forest Products Association (NFPA)
(Formerly National Lumber Manufacturer's Association)
1619 Massachusetts Avenue, N.W.
Washington, DC 20036

48) National Fire Protection Association (NFPA)
470 Atlantic Avenue
Boston, MA 02210

49) Occupational Safety and Health Act (OSHA)
U.S. Department
Occupational Safety and Health Administration
San Francisco Regional Office
450 Golden Gate Avenue, Box 36017
San Francisco, CA 94102

50) Society of Automotive Engineers (SAE)
2 Pennsylvania Plaza
New York, NY 10001

51) Scientific Apparatus Makers Association (SAMA)
One Thomas Circle
Washington, DC 20005

52) Tubular Exchanger Manufacturer's Association (TEMA)
331 Madison Avenue
New York, NY 10017

53) Uniform Building Code (UBC)
Published by ICBO

54) Underwriters Laboratories Inc. (UL)
207 East Ohio Street
Chicago, IL 60611

55) Uniform Plumbing Code (UPC)
Published by ICBO

56) Uniform Plumbing Code (UPC)
Published by IAPMO

Note: The above list shall not be construed to be a complete listing of all applicable national codes, industry standards, and standard references. Names and addresses of the organizations are subject to change.

APPENDIX E

GUIDELINES FOR THE DESIGN OF LABORATORY FACILITIES FOR WASTEWATER TREATMENT FACILITIES

The following guidelines shall be considered in the design of laboratory facilities for wastewater treatment facilities.

LOCATION AND SPACE

The laboratory should be located on ground level, easily accessible to all sampling points, with environmental control as an important consideration. It shall be located away from vibrating machinery or equipment which might have adverse effects on the performance of laboratory instruments or the analyst, or shall be designed to prevent adverse effects from vibration. The laboratory should also be located to minimize the entry of dust and odors.

A minimum of 400 square feet of floor space should be allocated for the laboratory. Less space may be allowed if the sampling and analysis program, approved by the Division, does not require a full-time laboratory chemist. If more than two persons will be working in the laboratory at any given time, 100 square feet of additional space should be provided for each additional person. Bench-top working surface should occupy at least 35 percent of the total floor space. Additional floor and bench space should be provided where necessary to facilitate analysis of industrial wastes. The above minimum space guidelines does not include office or administration space.

Minimum ceiling height should be 8 feet 6 inches. If possible, this height should be increased to provide for the installation of wall-mounted water stills, distillation racks, and other equipment with extended height requirements.

MATERIALS

Ceilings

Accoustical tile should be used for ceilings except in high humidity areas, where they should be constructed of plaster.

Walls

For ease of maintenance and a pleasant working environment, light-colored ceramic tile should be used from floor to ceiling for all interior walls.

Floors

Floor surfaces should be either vinyl asbestos or rubber, fire resistant, and highly resistant to acids, alkalies, solvents, and salts.

Doors

A minimum of two exit doors should be located to permit a straight egress from the laboratory, preferably at least one to outside the building. Panic hardware should be used. Doors 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.

CABINETS AND BENCH TOPS

Wall-hung cabinets are useful for dust-free storage of instruments and glassware. Units with sliding glass doors are preferable. They should be hung so the top shelf is easily accessible to the analyst. Thirty inches from the bench top is recommended.

One or more cupboard-style base cabinets should be provided for storing large items; however, drawer units are preferred for the remaining cabinets. Drawers should slide out so that the entire contents are easily visible. They should be provided with rubber bumpers and with stops which prevent accidental removal. Drawers should be supported on ball bearings or nylon rollers which pull easily in adjustable steel channels. All metal drawer fronts should be double-wall construction.

All cabinet shelving should be acid resistant and adjustable from inside the cabinet. Water, gas, air, and vacuum service fixtures; traps, strainers, overflow, plugs and tailpiece; and all electrical service fixtures shall be supplied with the laboratory furniture.

Generally, bench-top height should be 36 inches. However, areas to be used exclusively for sit-down type operations should be 30 inches high and include kneehole space. One-inch 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, 1-1/4 inches 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.

FUME HOODS

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.

Personnel safety should be considered in locating a hood. If a hood is situated near a doorway, a second means of egress must be provided. Bench surfaces should be available next to the hood so that chemicals need not be carried long distances.

Design and Materials

The selection of fume hoods, their design and materials of construction, must be made by considering the variety of analytical work to be performed and the characteristics of the fumes, chemicals, gases, or vapors that will or may be released by the activities therein. Special design and construction is necessary if perchloric acid use is anticipated. Consideration should be given for providing more than one fume hood to minimize potential hazardous conditions throughout the laboratory.

Fume hoods are not appropriate for operation of heat-releasing equipment that does not contribute to hazards, unless these fumes hoods are provided in addition to those needed to perform hazardous tasks.

Fixtures

One cup sink should be provided inside each fume hood.

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

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. The exhaust blower shall be sized to provide a face velocity equal to or greater than 100 feet per minute. The exhaust ducts and blower housing and impeller shall be constructed of corrosion resistant materials.

Alarms

A buzzer for indicating exhaust fan failure and a static pressure gauge should be placed in the exhaust duct. A high temperature sensing device located inside the hood should be connected to the buzzer.

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 steel, plastic, or equivalent material, and finished with enamel to blend with other laboratory furnishings.

SINKS

The laboratory should have a minimum of three sinks (not including cup sinks). At least two of them should be double-well with drainboards. Additional sinks should be provided in separate work areas as needed, and identified for the use intended. Sinks should be made of epoxy resin or plastic material with all appropriate characteristics for laboratory applications. Waste openings should be located toward the back so that a standing overflow will not become an obstacle. All water fixtures on which hoses may be used should be provided with reduced pressure backflow preventers to prevent contamination of water lines. The sinks should be constructed of material highly resistant to acids, alkalies, solvents, and salts, and should be abrasion and heat resistant, non-adsorbent, and lightweight. Traps should be made of glass, plastic, or lead and easily accessible for cleaning.

VENTILATION AND LIGHTING

Laboratories should be separately air conditioned, with external air supply for 100% make-up volume. In addition, separate exhaust ventilation should be provided. Ventilation inlet locations should be remote from ventilation outlets and fume hood exhausts. Ventilation inlets should be located based on consideration of the direction of prevailing winds.

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

GAS AND VACUUM

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

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

BALANCE AND TABLE

An analytical balance of the automatic, digital readout, single pan, minimum 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 balance 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. The balance table shall also be located as far as practical from sources of vibration such as pumps, motors and blowers.

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. References such as Standard Methods and the U.S. EPA Analytical Procedures Manual should be consulted prior to specifying equipment items.

POWER SUPPLY REGULATION

To eliminate voltage fluctuation, electrical lines supplying the laboratory should be controlled with a constant voltage, harmonic neutralized type of transformer. This transformer should contain less than 3% total root mean square (RMS) harmonic content in the output, should regulate to ±1% for an input range of ±15% of nominal voltage, with an output of 118 volts. For higher voltage requirements, the 240-volt lines should be similarly regulated.

Electrical devices in the laboratory not requiring a regulated supply (i.e. ordinary resistance heating devices) that are non-portable may be wired to an unregulated supply.

WATER STILL

An all-glass water still, with at least one gallon per hour capacity, shall be installed complete with all utility connections.

APPENDIX F

TYPICAL CONVENTIONAL TOOLS AND EQUIPMENT FOR WASTEWATER TREATMENT FACILITIES

1) Tool Box

2) Hammers (claw, soft face, non-sparking, chipping, ball peen)

3) Files (bastard, crosscut, fine cut)

4) Saw (hacksaw with blades, crosscut, keyhole)

5) Pipe Wrenches

6) Combination Wrench Set (standard, metric)

7) Socket Wrench Set (standard, metric)

8) Crescent Wrenches

9) Hex Wrench Set

10) Tap and Die Set

11) Screw Extractor Set

12) Pliers (combination, general purpose, lineman's, diagonal cutting, long-nose, lever-wrench)

13) Snips (metal cutting, aviation)

14) Screw Drivers (standard, Phillips)

15) Wood Chisel Set

16) Cold Chisel Set

17) Center Punch

18) Drift Pin Punch Set

19) Electric Drill and Bits

20) Circular Saw

21) Jig Saw

22) Wire Brush with Handle

23) C-Clamps

24) Tape Rule, Steel Tape

25) Calipers, Dividers, Feeler Gage, Micrometer, Scale

26) Packing Hooks

27) Wrecking Bar, Pry Bar

28) Pipe Tap and Die Set

29) Pipe Extractor Set

30) Pipe Reamer Set

31) Pipe Cutter Set

32) Washer and Gasket Cutter

33) Portable Pipe Vise Set

34) Combination Pipe and Machinist's Vise

35) Chain Wrench

36) Strap Wrench

37) Spud Wrench

38) Cable Hoist

39) Portable Grinder

40) Hydraulic Pump Oiler

41) Grease Guns

42) Portable Sludge Level Detector

43) Powered Sewer Rodder

44) Hand Truck

45) Vacuum Cleaner

46) Ladders (various sizes)

47) Typewriter and Stand

48) Desk-top Calculator

49) Lawn Mower

50) Powered Cultivator

51) Trimmer/Edger

52) Electric Hedger

53) Hedge Shears

54) Pruning Shears

55) Sickle

56) Machete

57) Pitch Fork

58) Shovel

59) Hoe

60) Pick Mattock

61) Rake

62) Garden Sprayer

63) Wheelbarrow

64) Paint Brushes

65) Rubber Hoses

66) Fire Hoses

67) Lamp with Cord

68) Flashlights

69) Voltage Tester

70) Circuit Guard

71) Soldering Iron

72) Extension Cords

73) Safety Gasoline Cans

GLOSSARY

GLOSSARY

The usage of these terms in this glossary is intended only for these Design Standards. These definitions may conflict with City and County of Honolulu legal documents.

"Board of Water Supply" or "BWS" means Honolulu Board of Water Supply, City and County of Honolulu.

"City" means City and County of Honolulu a municipal corporation.

"Department" means Department of Public Works, City and County of Honolulu.

"Department of Health" or "DOH" means State of Hawaii Department of Health.

"Design Engineer" means a registered engineer actively furnishing the professional and technical skill required in planning, administration, and construction of the works.

"Shall" indicates a mandatory requirement.

"Should," "Preferred," or "Recommended" indicates discretionary use on the part of the City.

"Director" means the Director and Chief Engineer of the Department of Public Works, City and County of Honolulu, or his authorized representatives.

"Division" means Division of Wastewater Management, Department of Public Works, City and County of Honolulu.