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IOWA WASTEWATER FACILITIES DESIGN STANDARDS

CHAPTER 17

Sludge Handling and Disposal

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Sludge Handling and Disposal

17.1 DESIGN CONSIDERATIONS

The selection of sludge handling and disposal methods shall address the following:

a. Volume of sludge to be treated. Whenever possible, the design information should be obtained from chemical analysis and measurement;

b. Energy requirements;

c. Efficacy of sludge thickening;

d. Complexity of equipment;

e. Staffing requirements;

f. Toxic effects of heavy metals and other substances on sludge stabilization and disposal;

g. Prior treatment process e.g., poor quality supernatant results from anaerobic digestion of activated sludge;

h. Treatment of side-stream flow such as digester and thickener supernatant;

i. A back-up method of sludge handling and disposal; and

j. Methods of ultimate sludge disposal.

Complete calculations including design basis, unit sizing and process reliability shall be presented in the preliminary report or facility plan.

17.2 SLUDGE THICKENING AND CONDITIONING

17.2.1 Sludge Thickening

As the first step of sludge handling, the need for sludge thickeners to reduce the volume of sludge shall be addressed in the preliminary report or facilities plan. If it is determined that sludge thickening is needed, the design of thickeners (gravity, dissolved-air flotation, centrifuge, and others) shall consider the type and concentration of sludge, the sludge stabilization processes, the method of ultimate sludge disposal, chemical needs, and the cost of operation. Particular attention shall be given to the pumping and piping of the concentrated sludge and possible onset of anaerobic conditions. Sludge should be thickened to at least 5% solids prior to transmission to digesters.

17.2.2 Sludge conditioning

Conditioning is the treatment of sludge to facilitate water removal by a thickening or dewatering process. Conditioning normally has a significant effect on both the efficiency of the thickening and/ or dewatering process and the liquid treatment portion of the plant. A thorough discussion shall address the effects of conditioning on all processes.

17.3 SLUDGE STABILIZATION AND HOLDING

17.3.1 Anaerobic Sludge Digestion

17.3.1.1 General

a. Multiple Units

Multiple tanks are recommended. Where a single tank is used, an alternate method of sludge pro-cessing or emergency storage to maintain con-tinuity of service shall be provided.

b. Depth

For those units proposed to serve as supernatant separation tanks, the depth shall be sufficient to allow for the formation of a reasonable depth of supernatant liquor. A minimum sidewater depth of 20 feet is recommended.

c. Maintenance Provisions

To facilitate draining, cleaning, and maintenance, the following features shall be provided:

1. Slope

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

2. Access Manholes

At least two access manholes not less than 24-inch diameter shall be provided in the top of the tank. The gas dome, if provided, shall not be considered an access manhole. There shall be stairways or attached ladders to reach the access manholes. A separate sidewall manhole shall be provided. The opening shall be large enough to permit the use of mechanical equipment to remove grit and sand. All access manholes shall be provided with gas tight and water tight covers.

3. Safety

Nonsparking tools, safety lights, rubber-soled shoes, safety harness, gas detectors for inflammable and toxic gases, and at least two self-contained breathing units shall be provided for emergency use.

17.3.1.2 Sludge Inlets and Outlets

Multiple recirculation withdrawal and return points, to enhance flexible operation and effective mixing, shall be provided, unless mixing facilities are incorporated within the digester. The returns, in order to assist in scum breakup, shall discharge above the liquid level and be located near the center of the tank.

Raw sludge discharge to the digester shall be through the sludge heater and recirculation return piping, or directly to the tank if internal mixing facilities are provided.

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

17.3.1.3 Tank Capacity

The total digestion tank capacity should be determined by rational calculations based upon such factors as volume of sludge to be treated, total solids concentration, volatile solids concentration, percent solids and character, the temperature to be maintained in the digesters, the degree or extent of mixing to be obtained, the degree of volatile solids reduction required, and further treatment and/or disposal of digested sludge and supernatant liquors. Sufficient sludge storage capacity shall be provided for periods of inclement weather and equipment failure. If possible, adequate detention should be provided to avoid sludge application on frozen or snow covered ground. Calculations shall be submitted to justify the basis of design.

When such calculations are not based on the above factors, the minimum combined digestion tank capacity outlined below will be required. Such requirements assume that a raw sludge is derived from ordinary domestic wastewater, that a digestion temperature is to be maintained in the range of 90^{o} to 100^{o}F. (32^{o}C to 38^{o}C), that 40 to 50 percent volatile matter will be maintained in the digested sludge, and that the digested sludge will be removed frequently from the system.

Mixing is required as part of the digestion process, and each tank requiring mixing shall have sufficient mixing equipment or flexibility in system design to ensure that the total capability for mixing is not lost with the loss of any one piece of mixing equipment (motors, pumps, compressors, etc.). It is permissible for the backup equipment to be uninstalled.

a. Completely-Mixed Systems

Completely-mixed systems shall provide for intimate and effective mixing to prevent stratification and to assure homogeneity of digester content. The system may be loaded at a rate up to 80 pounds of volatile solids per 1,000 cubic feet of volume per day in the active digestion units. The minimum sludge retention time shall be 15 days.

b. Moderately-Mixed

For digestion systems where mixing is accomplished only by circulating sludge through an external heat exchanger, it is recommended that the system be loaded at a rate of no more than 40 pounds of volatile solids per 1,000 cubic feet of volume per day in the active digestion units. Subject to Departmental concurrence, this loading may be modified upward or downward depending upon the degree of mixing provided. The minimum sludge retention time shall be 30 days.

17.3.1.4 Gas Collection, Piping and Appurtenances

a. General

All portions of the gas system, including the space above the tank liquor, the storage facilities and the piping, shall be so designed that under all normal operating conditions, including sludge withdrawal, the gas will be maintained under positive pressure. All enclosed areas where gas leakage might occur shall be adequately ventilated.

b. Safety Equipment

Safety facilities shall be included where gas is produced. Pressure and vacuum relief valves and flame traps, together with automatic safety shutoff valves, shall be provided. Water seal equipment shall not be installed. Gas safety equipment and gas compressors shall be housed in a separate room with an exterior entrance.

c. Gas Piping and Condensate

Gas piping shall be of adequate diameter and shall slope to condensate traps at low points. The use of float-controlled condensate traps is not permitted.

d. Gas Utilization Equipment

Gas-fired boilers for heating digesters shall be located in a separate room not connected to the digester gallery. Such separated room would not ordinarily be classified as a hazardous location. Gas lines to these units shall be provided with suitable flame traps.

e. Electrical Fixtures

Electrical fixtures and controls, in places enclosing anaerobic digestion appurtenances, where hazardous gases are normally contained in the tanks and piping, shall comply with the National Electrical Code for Class I, Group D, Division 2 locations. Digester galleries should be isolated from normal operating areas, in accordance with para-graph g. of this section, to avoid an extension of the hazardous location.

f. Waste Gas

Waste gas burners shall be readily accessible and should be located at least 25 feet away from any plant structure if placed at ground level, or may be located on the roof of the control building if sufficiently removed from the tank.

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

g. Ventilation

Any underground enclosures connecting with digestion tanks or containing sludge or gas piping or equipment shall be provided with forced ventilation in accordance with Sections 32.7 and 32.72 of Ten States Standards for Sewage Works, 1978 edition. The piping gallery for digesters should not be connected to other passages. Where used, tightly fitting, self-closing doors shall be provided at connecting passage-ways and tunnels to minimize the spread of gas.

h. Meter

A gas meter with bypass shall be provided to meter total gas production.

17.3.1.5 Digester Heating

a. Insulation

Digestion tanks should be constructed above groundwater level and shall be suitably insulated to minimize heat loss.

b. Heating Facilities

Sludge may be heated by circulating the sludge through external heaters or by heating units located inside the digestion tank.

1. External Heating

Piping should be designed to provide for the preheating of feed sludge before introduction to the digesters.

Provisions shall be made in the layout of the piping and valving to facilitate cleaning of these lines. Heat exchanger sludge piping shall be sized for heat transfer requirements.

2. Other Heating Methods:

Other types of heating facilities will also be considered on their own merits.

c. Heating Capacity

Heating capacity sufficient to consistently maintain the design sludge temperature shall be provided. Where digester tank gas is used for sludge heating, an auxiliary fuel supply is required.

d. Hot Water Internal Heating Controls

1. Mixing Valves

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

2. Boiler Controls

The boiler shall be provided with suitable automatic controls to maintain the boiler temperature at approximately 180°F (82°C) to minimize corrosion and to shut off the main gas supply in the event of pilot burner or electrical failure, low boiler water level, or excessive temperature.

3. Thermometers

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

17.3.1.6 Supernatant Withdrawal

a. Piping Size

Supernatant piping shall not be less than 6 inches in diameter.

b. Withdrawal Arrangements

1. Withdrawal Levels

Piping shall be arranged so that withdrawal can be made from three or more levels in the digester. A positive unvalved vented overflow shall be provided.

2. Supernatant Selector

If a supernatant selector is provided, provisions shall be made for at least one other drawoff level located in the supernatant zone of the tank in addition to the unvalved emergency supernatant drawoff pipe. High pressure backwash facilities shall be provided.

c. Sampling

Provisions shall be made for sampling each supernatant drawoff level. Sampling pipes shall be at least 1½ inches in diameter, and shall terminate at a suitably-sized sampling sink or basin.

d. Supernatant Disposal

The supernatant shall be returned to the treatment process at an appropriate point. Consideration should be given to the effect of supernatant on plant performance and effluent quality and whether supernatent conditioning is appropriate.

17.3.2 Aerobic Sludge Digestion

17.3.2.1 Tank Duplication

Multiple tanks are recommended. A single sludge digestion tank may be used in the case of small treatment plants or where adequate provision is made for sludge handling and where a single unit will not adversely affect normal plant operations.

17.3.2.2 Mixing and Air Requirements

Aerobic sludge digestion tanks shall be designed for effective mixing. Sufficient aeration shall be provided to maintain dissoved oxygen of at least 1 mg/l.

a. Diffused Air Systems

To meet minimum mixing and oxygen requirements, an aeration rate of 30 cfm per 1,000 cubic feet of tank volume shall be provided with the largest blower out of service.

1. Bottom Diffusers

The nonclog type of diffuser is required. All plants employing less than four independent tanks shall be designed to ncorporate removable diffusers that can be serviced and/or replaced without dewatering the tank.

The air diffusion system for the total aerobic digestion system shall be designed such that the diffusers can be isolated without losing more than 25% of the oxygen transfer capability of the total system.

2. Jet Aeration

If jet aerators are utilized, a complete spare aeration system (pumps and aerator) shall be pro provided on site and shall be capable of being installed without dewatering the tank, unless at least 75% of the oxygen transfer capability of the system can be maintained with the largest aeration unit inoperable.

b. Mechanical Aeration Systems

Mechanical aerators shall not be used unless adequate performance data is submitted for existing comparable installation of the aerators proposed to satisfactorily demonstrate that the aerators are capable of continuous operation during periods of severe climatic conditions.

If mechanical aerators are utilized, a minimum of 1.0 horsepower per 1,000 cubic feet shall be provided. At least two aerators shall be installed. A complete spare mechanical aerator shall be provided on site unless at least 75% of the oxygen transfer capability of the system can be maintained with the largest aeration unit inoperable. Replacement of mechanical aerators shall be provided such that re-placement can be accomplished without dewatering the tank. Where mechanical aerators are used, if the solids concentration is greater than 8,000 mg/l, bottom mixers shall be provided.

17.3.2.3 Tank Capacity

The determination of tank capacities shall be based on rational calculations, including such factors as quantity of sludge produced, sludge characteristics, time of aeration, and sludge temperature. Sufficient sludge storage capacity shall be provided for periods of inclement weather and equipment failure. If possible, adequate detention should be provided to avoid sludge application on frozen or snow covered ground. Calculations shall be submitted to justify the basis of design.

a. Volatile Solids Loading

It is recommended that the volatile suspended solids loading not exceed 100 pounds per 1,000 cubic feet of volume per day in the digestion units. Lower loading rates may be necessary depending on temperature, type of sludge, and other factors.

b. Solids Retention Time

Required minimum solids retention time for stabilization of biological sludges vary depending on type of sludge. A minimum of 15 days retention shall be provided for waste activated sludge and 20 days for combination of primary and waste activated sludge, or primary sludge alone. Where sludge temperature is lower than 59°F (15°C), additional detention time shall be provided so that digestion will occur at the lower biological reaction rates.

17.3.2.4 Supernatant Separation

Provisions shall be made for effective separation and withdrawal of supernatant and for effective collection and removal of scum and grease. The supernatant shall be returned to the treatment process at an appropriate point.

17.3.3 Other Methods of Sludge Stabilization

If other sludge stabilization methods, such as heat treatment, lime stabilization or composting are considered a detailed description of the process and design data shall accompany the preliminary report or facility plan.

17.3.4 Sludge Holding Tanks

Sludge holding may be provided either (1) as storage where the sludge has been stabilized through the treatment process itself or (2) in addition to the storage provided in the digestor.

17.3.4.1 Tank Reliability

A single sludge holding tank may be used when adequate provisions are made for sludge handling and when a single unit will not adversely affect normal plant operation.

17.3.4.2 Tank Capacity

The determination of capacity shall be based on rational calculations, including such factors as quantity of sludge, sludge characteristics, and climatic conditions.

Sufficient sludge storage capacity shall be provided for periods of inclement weather and equipment failure. If possible, adequate detention should be provided to avoid sludge application on frozen or snow covered ground. Calculations shall be submitted to justify the basis of design.

17.3.4.3 Mixing and Air Requirements

Holding tanks shall be designed for mixing by satisfactory aeration equipment.

a. Diffused Air Systems

To meet minimum mixing requirements, an aeration rate of 20 cfm per 1,000 ft^3 of tank volume shall be provided with the largest blower out of service. If diffusers are used, the nonclog type is required and they shall be designed to permit continuity of service.

b. Mechanical Aeration Systems

If mechanical aerators are utilized, a minimum of 1.0 horsepower per 1000 ft^3 shall be provided. Use of mechanical equipment is discouraged when freezing temperatures are normally expected.

17.3.4.4 Supernatant Separation

Facilities shall be provided for effective separation and withdrawal of supernatant and for effective collection and removal of scum and grease. Supernatant shall be returned to the treatment process at an appropriate point.

17.3.5 Sludge Holding Lagoons

Sludge holding lagoons shall not be utilized for final disposal of sludges. Unless adequate justification is provided to the Department, sludge holding lagoons should not be utilized either (1) as storage where the sludge has been stabilized through the treatment process itself or (2) in addition to the storage provided in the digestor. When sludge holding lagoons are justified, they must be designed in accordance with 17.3.5.1 through 17.3.5.6.

17.3.5.1 Lagoon Reliability

A single lagoon may be used where adequate provisions are made for sludge handling and where a single lagoon will not adversely affect normal plant operation.

17.3.5.2 Lagoon Capacity

Capacity shall be in accordance with 17.3.4.2.

17.3.5.3 Mixing and Air Requirements

Mixing and air requirements shall be in accordance with 17.3.4.3.

17.3.5.4 Cleaning

The Lagoon(s) shall be designed to facilitate cleaning.

17.3.5.5 Lagoon Construction Details

The lagoon shall, in general, be constructed in accordance with 18C.7 of these design standards.

17.3.5.6 Supernatant Separation

Facilities may be provided for effective separation and withdrawal of supernatant. Supernatant shall be returned to the treatment process at an appropriate point.

17.4 SLUDGE PUMPS AND PIPING

17.4.1 Sludge Pumps

17.4.1.1 Capacity

Provision for varying pump capacity is recommended.

17.4.1.2 Duplicate Units

Duplicate units shall be provided such that with any one pump out of service, the remaining pumps will have capacity to handle the peak flow.

17.4.1.3 Type

Plunger pumps, screw feed pumps, recessed impeller type centrifugal pumps, progressive cavity pumps, or other types of pumps with demonstrated solids handling capability shall be provided for handling raw sludge.

17.4.1.4 Minimum Head

A minimum positive head of 24 inches shall be provided at the suction side of centrifugal-type pumps and is desirable for all types of sludge pumps. Maximum suction lifts shall not exceed 10 feet for plunger pumps.

17.4.1.5 Sampling Facilities

Unless sludge sampling facilities are otherwise provided, quick-closing sampling valves shall be installed at the sludge pumps. The size of valve and piping shall be at least 1½ inches.

17.4.2 Sludge Piping

17.4.2.1 Size and Head

Sludge withdrawal piping should have a minimum diameter of 8 inches for gravity withdrawal and gravity withdrawal and 6 inches for pump suction and discharge lines. Where withdrawal is by gravity, the available head on the discharge pipe should be adequate to provide at least 3.0 feet per second velocity.

17.4.2.2 Slope

Gravity piping shall be laid on uniform grade and alignment. The hydraulic slope of gravity discharge piping shall not be less than 3 percent. Provisions shall be made for cleaning, draining, and flushing discharge lines.

17.4.2.3 Supports

Special consideration shall be given to the corrosion resistance and continuing stability of supporting systems located inside the digestion tank.

17.5 SLUDGE DEWATERING

17.5.1 Sludge Drying Beds

17.5.1.1 Area

In determining the area of sludge drying beds, given to climatic conditions, the character and volume of the sludge to be dewatered, the method and schedule of sludge removal, and other methods of sludge disposal. In general, the sizing of the drying bed may be estimated on the basis of 2.0 ft^2/capita when the drying bed is the primary method of dewatering, and 1.0 ft^2/capita if it is to be used as a back-up dewatering unit.

17.5.1.2 Percolation Type

The lower course of gravel around the underdrains shall be properly graded and shall be 12 inches in depth, extending at least 6 inches above the top of the underdrains. It is desirable to place this in two or more layers. The top layer of at least three inches shall consist of gravel 1/8 to 1/4 inch in size.

a. Sand

The top course shall consist of 6 to 9 inches of clean coarse sand. The finished sand surface shall be level.

b. Underdrains

Underdrains shall be clay pipe, plastic or concrete drain tile at least 4 inches in diameter laid with open joints. Underdrains shall be spaced not more than 20 feet apart. The disposal of the underdrain filtrate is covered in Section 17.6.4.

17.5.1.3 Partially Paved Type

The partially paved drying bed shall be designed with consideration for space requirement to operate mechanical equipmenmt for removing the dried sludge.

17.5.1.4 Walls

Walls shall be watertight and extend 15 to 18 inches above and at least 6 inches below the surface. Outer walls shall be curbed to prevent soil from washing onto the beds.

17.5.1.5 Sludge Removal

Not less than two beds shall be provided and they shall be arranged to facilitate sludge removal. Concrete truck tracks shall be provided for all percolation-type sludge beds. Pairs of tracks for the percolation-type beds shall be on 20 foot centers.

17.5.1.6 Sludge Influent

The sludge pipe to the drying beds shall terminate at least 12 inches above the surface and be so arranged that it will drain. Splash plates for percolation-type beds shall be provided at sludge discharge points.

17.5.2 Sludge Lagoons

Sludge lagoons shall not be substituted for adequate sludge digestion and shall not be approved for use as a sludge volume reduction process except as provided for in 17.3.5.6.

17.5.3 Mechanical Dewatering Facilities

Provision shall be made to maintain sufficient continuity of service so that sludge may be dewatered without accumulation beyond storage capacity. The number of vacuum filters, centrifuges, filter presses, belt filters, or other mechanical dewatering facilities should be sufficient to dewater the sludge produced. Unless other standby facilities are available, adequate storage facilities shall be provided. The storage capacity should be sufficient to handle at least a three-month sludge production.

17.5.3.1 Spare Parts for Mechanical Dewatering Facilities

a. Spare parts shall be available for all mechanical dewatering facilities to replace parts which are subject to wear and breakage.

b. There shall be a back-up vacuum pump and filtrate pump installed for each vacuum filter. It is permissible to have an uninstalled back-up vacuum pump or filtrate pump for every three or less vacuum filters, provided that the installed unit can easily be removed and replaced.

17.5.3.2 Ventilation

Adequate facilities shall be provided for ventilation of dewatering area. The exhaust air should be properly conditioned to avoid odor nuisance.

17.5.3.3 Chemical Handling Enclosures

Lime-mixing facilities should be completely enclosed to prevent the escape of lime dust. Chemical handling equipment should be automated to eliminate the manual lifting requirement.

17.5.4 Drainage and Filtrate Disposal

Drainage from beds or filtrate from dewatering units shall be returned to the sewage treatment process at appropriate points.

17.5.5 Other Dewatering Facilities

If it is proposed to dewater or dispose of sludge by other methods, a detailed description of the process and design data shall accompany the preliminary report or facility plan.

17.6 FINAL DISPOSAL OF SLUDGE

17.6.1 Sludge Disposal on Land

The program of land spreading of sludge must be evaluated as an integral system which includes stabilization, storage, transportation, application, soil, crop, and surface groundwater. The following guidelines were formulated to provide the criteria of municipal sludge disposal and land.

17.6.1.1 General Limitations to be Observed

Disposal of municipal sewage sludge on land shall be in accordance with IAC 121 (455B).

17.6.1.2 Site Selection

By proper selection of the sludge application site, the nuisance ptential and public health hazards should be minimized. Siting restrictions are as stated in IAC 121 (455B). The following items shall be addressed:

a. Land ownership information;
b. Groundwater table and bedrock location;
c. Location of dwellings, road, and public access;
d. Location of wells, springs, creeks, streams, and flood plains;
e. Slope of land surface;
f. Soil characteristics;
g. Climatological information and periods of ground freezing;
h. Land use plan; and
i. Road weight restrictions.

17.6.1.3 Management of Spreading Operation

a. Hauling Equipment

The sludge hauling equipment shall be designed to prevent spillage, odor, and other public nuisance. A paved and drained loading pad should be provided.

b. Valve Control

The spreading tank truck should be provided with a control so that the discharge valve can be opened and closed by the driver while the vehicle is in motion. The spreading valve shall be of the "failsafe" type (i.e., self-closing) or an additional manual stand-by valve shall be employed to prevent uncontrolled spreading or spillage.

c. Spreading Methods

The selection of spreading methods depends on the sludge characteristics, enviornmental factors, and others. Spreading requirements are stated in IAC 121 (455B).

The sewage sludge should be spread uniformly over the surface when tank truck spreading, ridge and furrow irrigation, or other methods are used.

Proposals for subsurface application sludge shall include for review a description of the equipment program for application.

d. Public Access

Public access of the disposal site must be controlled by either positive barriers or remoteness of the site.

17.6.1.4 Monitoring and Reporting

The requirements on the monitoring and reporting of the sludge spreading operation are as outlined in IAC 121 (455B).

17.6.2 Other Sludge Disposal Methods

When other sludge disposal methods, such as incineration and landfill, are considered, a detailed description of the process and design data shall accompany the preliminary report or facility plan. Disposal of sludge in a sanitary landfill shall be in accordance with IAC 103 (455B).

References:

Recommended Standards for Sewage Works, 1978 Edition.
Great Lakes - Upper Mississippi River Board of State Stanitary Engineers (Ten-State Standards)

Process Design Manual for Sludge Treatment and Disposal, 1974
U.S. EPA, Technology Transfer

Wastewater Engineering. 1972 Metcalf. Eddy.

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