Adopted February 18, 1986

IOWA WASTEWATER FACILITIES DESIGN STANDARDS
CHAPTER 20
DISINFECTION

20.1 GENERAL

20.1.1 Applicability

This chapter is applicable to construction, installation or modification of any disposal system required to obtain a construction permit from this Department under the Iowa Code Section 455B.183 and 900 – 64.2 of the Iowa Administrative Code.

20.1.2 Variances [900 – 64.2 (9) “c” I.A.C.]

When engineering justification satisfactory to the executive director is provided substantially demonstrating that variation from the design standards or siting criteria will result in either: at least equivalent effectiveness while significantly reducing costs, or improved effectiveness, such a variation from design standards or siting criteria may be accepted by the executive director.

20.1.3 Explanation of Terms

The terms “shall” or “must” are used in these standards when it is required that the standard be used. Other terms such as “should” and “recommended” indicate desirable procedures or methods which should be considered but will not be required.

20.2 PROCESS SELECTION

20.2.1 Applicability

The disinfectants discussed in this chapter include chlorine, calcium or sodium hypochlorite, chlorine dioxide, ozone, bromine and ultra-violet radiation. These disinfectants can be used as appropriate to treat wastewater which requires disinfection.

20.2.2 Specific Process Selection

Chlorination is the most commonly used method for wastewater disinfection. The forms most often used are liquid or gaseous chlorine and calcium or sodium hypochlorite. Other disinfectants, including chlorine dioxide, ozone, bromine or ultra-violet radiation may be accepted by the Department. The chemical or method should be selected after due consideration of waste flow rates, application and demand rates, pH of the wastewater, cost of equipment, chemical availability, reliability and maintenance problems. If chlorination is utilized, it may be necessary to dechlorinate to meet discharge permit limitations.

20.3 CHLORINE FEED EQUIPMENT

20.3.1 Type

Solution-feed vacuum-type chlorinators are generally preferred for large chlorination installations. The use of hypochlorite feeders of the positive displacement type should be considered when flow discharge is intermittent. The preferred method of generation of chlorine dioxide is the injection of a sodium chlorite solution into the discharge line of a solution-feed gas-type chlorinator, with subsequent formation of the chlorine dioxide in a reaction chamber at a pH of 4.0 or less.

20.3.2 Capacity

Required disinfection capacity will vary, depending on the uses and points of application of the disinfection chemical. For disinfection, the capacity shall be adequate to produce an effluent that will meet the limits specified by the Department for that installation. For domestic wastewater, the following may be used as an estimating guide in sizing chlorination facilities.

Type of Treatment	Chlorine Dosage, mg/1 (based on flow)
Primary effluent	15
Trickling filter plant effluent	10
Activated sludge plant effluent	8
Tertiary filtration effluent	6
Nitrified effluent	6

When industrial wastes are present, laboratory estimation of chlorine demand may be necessary.

Equipment shall be provided to handle the entire range of expected flows and dosages throughout the design period.

20.3.3 Standby Equipment and Spare Parts

Where disinfection is required for the entire year, standby equipment of sufficient capacity shall be installed to provide disinfection with the largest unit out of service. Spare parts shall be available for all disinfection equipment to replace parts which are subject to wear and breakage.

20.3.4 Water Supply

An ample supply of water shall be available for operating the chlorinator injector. The water source can be either potable water or effluent taken from the chlorine contact chambers. When a booster pump is required, duplicate equipment or an alternate water supply shall be provided. Protection of a potable water supply shall conform to the requirements of Section 14.7.1, Water Supply.

20.3.5 Automatic Switchover

Where disinfection is required for the entire year, automatic switchover of chlorine cylinders or containers shall be provided.

20.3.6 Dosage Control

For plants with less than 3000 P.E., automatic chlorine feed-rate control will not be required.

Plants for more than 3000 P.E. shall be provided with chlorine feed-rate control proportional to the wastewater flow.

In all cases where dechlorination is required, a compound loop control system should be considered.

20.4 CHLORINE SUPPLY

20.4.1 Tank Cars

At large chlorination installations, consideration should be given to the use of tank cars, generally accompanied by evaporators. Liquid chlorine lines from tank cars to evaporators shall be buried and installed in a conduit and shall not enter below grade spaces. Systems shall be designed for the shortest possible pipe transportation of liquid chlorine.

20.4.2 Scales

Scales or load cells for weighing cylinders or ton containers shall be provided at all plants using chlorine gas. Scales shall be provided for each cylinder or container in service; one scale is adequate for a group of cylinders or containers connected to a common manifold. At large plants, scales of the indicating and recording type are recommended. Scales shall be of corrosion-resistant material.

20.4.3 Evaporators

Where manifolding of several containers will be required to evaporate sufficient chlorine, consideration should be given to the installation of evaporators, to produce the quantity of gas required.

20.4.4 Leak Detection and Alarms

A bottle of 56% ammonium hydroxide solution shall be available for detecting chlorine leaks.

All installations utilizing 2,000 pound cylinders shall have suitable continuous chlorine leak detectors. Continuous chlorine leak detectors should be considered at all other installations. Whenever chlorine leak detectors are installed, they shall be connected to a centrally located alarm system and should automatically start exhaust fans.

20.4.5 Handling Equipment

The following handling equipment shall be provided:

20.4.5.1 100 and 150 pound Cylinders

1. A hand-truck specifically designed for cylinders.
2. A method of securing cylinders to keep them upright.

20.4.5.2 Ton Containers

1. Two-ton capacity hoist.
2. Container lifting bar.
3. Monorail or hoist with sufficient lifting height to pass one container over another.
4. Cylinder trunnions to allow rotating the container for proper connection.

20.5 CHLORINE PIPING AND CONNECTIONS

20.5.1 General

Piping systems shall be as simple as possible, specifically selected and manufactured to be suitable for chlorine service, with a minimum number of joints. Piping should be well supported and protected against temperature extremes. Due to the corrosiveness of moist chlorine gas, all lines designed to handle dry chlorine gas should be protected from the entrance of water or air containing water.

20.5.2 Chlorine Piping

20.5.2.1 Chlorine Supply System

That portion of the system between the cylinder or ton container and the chlorinator inlet should be constructed of Schedule 80 black seamless steel pipe with 2,000 pound forged steel fittings. Unions should be ammonia type with lead gaskets; never use a ground joint union. The use of bushings should be avoided; use reducing fittings.

All valves shall be Chlorine Institute approved.

Gauges shall be equipped with a silver diaphragm protector.

Piping can be assembled by either welded or threaded connections. All threaded pipe must be cleaned with a solvent, preferable trichloroethylene and dried with nitrogen gas or dry air. Teflon tape should be used for thread lubricant in lieu of pipe tape.

20.5.2.2 Injector Vacuum Lines

The vacuum lines between the chlorinator and the injector should be Schedule 80 PVC or fiber glass pipe approved for moist chlorine gas use.

20.5.2.3 Chlorine Solution Lines

The chlorine solution lines can be Schedule 80 PVC; fiber glass; PVC-, Saran-, or rubber-lined steel; polyethylene tubing; or rubber hose with either natural or reclaimed rubber lining, all approved for moist chlorine gas use. Valves shall be PVC, PVC-lined, or rubber-lined.

Gauges should be provided to show the injector operating water pressure and the chlorine solution pressure. The chlorine solution gauge must be a compound unit reading to 30 inches Hg vacuum and to a pressure greater than the anticipated operating pressure. The gauge must also be equipped with a silver diaphragm protector.

20.5.2.4 Nuts and Bolts

Nuts and bolts used on piping systems should be 316 stainless steel, galvanized or cadmium plated steel.

20.5.3 Diffusers

Diffusers located in open channels are of two general types: a series of nozzles suspended from a flexible hose and a perforated pipe across the channel; the latter being the preferred type. Both types must be located in a highly turbulent zone with a minimum water cover of nine inches.

The minimum recommended velocity through the diffuser holes is 10 – 12 feet per second. All diffusers should be removable for cleaning.

20.6 CHLORINE HOUSING

20.6.1 General

If gas chlorination equipment or chlorine cylinders are to be in a building used for other purposes, a gas-tight room shall separate this equipment from any other portion of the building. There must not be any means by which chlorine gas can enter other areas of a common building. Floor drains from the chlorine room shall not be connected to floor drains from other rooms. Doors to this room shall open only to the outside of the building, and shall be equipped with panic hardware. Areas housing chlorinators and chlorine cylinders or containers in use shall be located on or above ground level.

The storage area should be separated from the feed area. Chlorine cylinder or container storage areas shall be located on or above ground level and shaded from direct sunlight.

Chlorination equipment should be situated as close to the application point as reasonably possible.

Chlorination systems should be protected from fire hazards and water should be available for cooling cylinders in case of fire.

There must be adequate room provided for easy access to all equipment for maintenance and repair. The minimum acceptable clearance around and in back of equipment is two feet, except for units designed for wall or cylinder mounting.

20.6.2 Inspection Window

A clear glass window shall be installed in an exterior door or interior wall of the chlorinator room to permit the units to be viewed without entering the room. The window shall be gas-tight if installed in an interior wall. Windows in both the door and wall are recommended.

20.6.3 Heat

Rooms containing disinfection equipment shall be provided with a means of heating so that a temperature of at least 60° F can be maintained. Cylinders or containers in a separate room shall be kept at a temperature equal to or slightly less than the chlorinator room, except when liquid chlorine is withdrawn from 2,000-pound containers.

20.6.4 Ventilation

With chlorination systems, forced, mechanical ventilation shall be installed which will provide one complete air change every four minutes when the room is occupied and one complete air change every fifteen minutes at all times. The inlet to the air exhaust duct from the room shall be near the floor and the point of discharge shall be so located as not to contaminate the air inlet to any buildings. Air inlets and exhausts shall be so located as to provide cross ventilation and at such temperature that will not adversely affect the chlorination equipment.

20.6.5 Vents

Chlorinators and some accessories require individual vents to a safe outside area. The vent should terminate not more than 25 feet above the chlorinator or accessory and have a slight downward slope from the highest point. The outside end of the vent should bend down to preclude water entering the vent and be covered with an insect screen.

20.6.6 Electrical Controls

Electrical controls for lights and fans should operate automatically when entrance doors are opened. Manually controlled over-ride switches shall be located adjacent to and outside of all entrance doors with an indicator light indicating fan operation at each entrance. Electrical controls shall be excluded, insofar as possible, from chlorine rooms.

20.7 CHLORINE RESPIRATORY PROTECTION

Respiratory air-pac protection equipment of the pressure-demand type, 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 near the chlorine room, but not inside any room where chlorine is used or stored. Instructions for using the equipment shall be posted. The units shall use compressed air, have at least 30-minute capacity, and be compatible with the units used by the fire department responsible for the plant.

20.8 APPLICATION OF CHLORINE

20.8.1 Mixing

The disinfectant shall be positively mixed as rapidly as possible, with a complete mix being affected in three seconds and prior to entering the contact chamber. This may be accomplished by the use of turbulent flow regime (hydraulic jump), mechanical flash mixer or jet disinfection. The mixer shall be located at or immediately downstream from the point of chlorine injection and the mixing chamber shall be as small as possible.

20.8.2 Contact Period

For a chlorination system, a minimum period of 30 minutes detention at AWW flow or 15 minutes detention at PHWW flow, whichever is greater, shall be provided after thorough mixing. If dechlorination is required, no contact time is necessary after complete mixing of the effluent with the dechlorination chemical.

20.8.3 Contact Tank

The chlorine contact tank shall be constructed so as to reduce short-circuiting of flow to a practical minimum. “End-around” baffling for serpentine flow shall be provided to minimize short-circuiting. Baffles shall be designed to provide a length-to-width ratio of at least 40 to 1.

Duplicate tanks (each equal to half of the required volume), mechanical scrapers, or portable deck-level vacuum cleaning equipment shall be provided to facilitate maintenance and cleaning. Drainage from contact tanks shall be discharged to the head end of the plant. Baffles shall be provided to prevent the discharge of floating material and provision shall be made for removal of floating solids.

20.9 OZONE

20.9.1 Feed Equipment

Ozone dissolution is accomplished through the use of conventional gas diffusion equipment, with appropriate consideration of materials. When ozone is being produced from air, gas preparation equipment (driers, filters, compressors) is required. When ozone is being produced from pure oxygen, this equipment may not be needed.

20.9.2 Capacity

Required disinfection capacity will vary, depending on the uses and points of application of the disinfection chemical. For disinfection, the capacity shall be adequate to produce an effluent that will meet the limits specified by the Department for that installation. Ozone systems proposed to meet disinfection requirements will be reviewed on a case-by-case basis.

Equipment shall be provided to handle the entire range of expected flows and dosages throughout the design period.

20.9.3 Standby Equipment and Spare Parts

Where disinfection is required for the entire year, standby equipment of sufficient capacity shall be installed to provide disinfection with the largest unit out of service. Spare parts shall be available for all disinfection equipment to replace parts which are subject to wear and breakage.

20.9.4 Piping

Piping systems shall be as simple as possible, specifically selected and manufactured to be suitable for ozone service, with a minimum number of joints. Piping should be well supported and protected against temperature extremes.

The selection of material should be made with due consideration for ozone’s corrosive nature. Copper or aluminum alloys should be avoided. Only materials at least as corrosion-resistant to ozone as Grade 304 L stainless steel should be specified for piping containing ozone in non-submerged applications. Un-plasticized PVC, Type 1, may be used in submerged piping, provided the gas temperature is below 140°F and the gas pressure is low.

20.9.5 Housing

20.9.5.1 General

If ozone generation equipment is to be in a building used for other purposes, a gas-tight room shall separate this equipment from any other portion of the building. Doors to this room shall open only to the outside of the building, and shall be equipped with panic hardware.

There must be adequate room provided for easy access to all equipment for maintenance and repair. The minimum acceptable clearance around and in back of equipment is two feet.

20.9.5.2 Inspection Window

A clear glass window shall be installed in an exterior door or interior wall of the ozone generator room to permit the units to be viewed without entering the room. The window shall be gas-tight if installed in an interior wall. Windows in both the door and wall are recommended.

20.9.5.3 Heat

The room containing the ozone generation units shall be maintained above 35°F at all times.

20.9.5.4 Ventilation

For ozonation systems, continuous ventilation to provide at least one complete air change ever ten minutes should be installed. The inlet to the air exhaust duct from the room shall be near the floor and the point of discharge shall be so located as not to contaminate the air inlet to any buildings. Air inlets and exhausts shall be so located as to provide cross ventilation and at such temperature that will not adversely affect the ozone generation equipment.

20.9.5.5 Electrical Controls

Electrical controls for lights and fans should operate automatically when entrance doors are opened. Manually controlled override switches shall be located adjacent to and outside of all entrance doors with an indicator light indicating fan operation at each entrance. Electrical controls shall be excluded, insofar as possible, from ozone generation rooms.

20.9.6 Application of Ozone

20.9.6.1 Mixing

The disinfectant shall be positively mixed as rapidly as possible, with a complete mix being affected in three seconds and prior to entering the contact chamber. This may be accomplished by the use of turbulent flow regime (hydraulic jump), mechanical flash mixer or jet disinfection. The mixer shall be located at or immediately downstream from the point of ozone injection and the mixing chamber shall be as small as possible.

20.9.6.2 Contact Period

The required contact time for an ozonation unit varies with the type of dissolving equipment used. Certain high rate devices require contact times less than one minute to achieve disinfection while conventional dissolving equipment may require contact times similar to chlorination systems.

20.9.6.3 Contact Tank

The ozone contact tank shall be constructed so as to reduce short-circuiting of flow to a practical minimum. “End-around” baffling for serpentine flow shall be provided to minimize short-circuiting. Baffles shall be designed to provide a length-to-width ratio of at least 40 to 1.

Duplicate tanks (each equal to half of the required volume), mechanical scrapers, or portable deck-level vacuum cleaning equipment shall be provided to facilitate maintenance and cleaning. Drainage from contact tanks shall be discharged to the head end of the plant. Baffles shall be provided to prevent the discharge of floating material and provision shall be made for removal of floating solids.

20.10 BROMINE

Bromine has had limited use for disinfection, mostly due to high cost and handling difficulties. There has been successful use of bromine in stick form for swimming pool disinfection. The stick is a compound of both bromine and chlorine known as bromo-chloro-dimethyl hydantion (Dihalo), and is used in conjunction with a stick feeder. A discussion of bromine and its application for disinfection may be found in "White, George Clifford, Handbook of Chlorination, Van Nostrand Reinhold Company, 1972, pp. 707-713".

20.11 ULTRA-VIOLET RADIATION

The following requirements shall apply for the use of ultra-violet radiation units for disinfection:

1. Ultra-violet radiation at a level of 2,537 angstrom units must be applied at a minimum dosage of 16,000 microwatt-seconds per square centimeter at all points throughout the waste water disinfection chamber.

2. Maximum water depth in the chamber, measured between tube surfaces or from the tube surface to the chamber wall, shall not exceed three inches for low intensity units or eight inches for high intensity units.

3. The ultra-violet tubes shall be:

    a. Jacketed or otherwise designed so that a proper operating tube temperature of about 105°F is maintained for low intensity units. High intensity units should not be affected by water temperatures between 35° and 85° F.

    b. The jacket shall be of quartz or high silica glass with similar optical characteristics.

4. A time delay mechanism shall be provided to permit a two-to-five minute tube warm-up period before water flows from the unit, as recommended by the manufacturer.

5. The unit shall be designed to permit frequent mechanical, chemical or ultrasonic cleaning of the water contact surface of the jacket without disassembly of the unit.

6. An automatic flow control valve, accurate within the expected pressure range, or suitable weirs shall be installed to restrict flow to the maximum design flow of each treatment unit, or a dual set point flow meter shall be provided to accurately measure the minimum and maximum flows allowed by the unit.

7. An adequate number of ultra-violet intensity meters calibrated in accordance with the standards set forth by the Bureau of Standards and properly filtered to restrict sensitivity to the disinfection spectrum shall be installed in the wall of each disinfection chamber at the points of greatest water depth from the tubes.

8. An automatic audible alarm shall be installed to warn of malfunction or shutdown of the unit. Flow shall be directed automatically to the standby unit if disinfection is required for the entire year.

9. The unit shall be designed to protect the operator against electrical shock or excessive radiation.

10. Electrical controls shall be installed in a locked and protected enclosure not subject to extremes of temperature which could cause malfunction. The design shall provide that power must be shut off prior to opening the enclosure.

11. Where disinfection is required for the entire year, multiple units (including controls and electrical gear) shall be provided so that with the largest unit out of service, the remaining units shall have the capacity to handle the PHWW flow.

12. A hand-held photocell with light filters, meter and mounting cradle shall be provided to check the wave length output of the ultra-violet lamps prior to installation.

13. Provisions shall be made for continuous monitoring of the power status of each lamp using individual pilot lights (light-emitting diodes).

14. Provisions shall be made for adequate cooling of the ultra-violet control panels to avoid premature shutdown due to overheating.

20.12 DE-CHLORINATION

1. Dechlorination shall be provided in accordance with discharge permit requirements.

2. Dechlorination chemicals shall be rapidly mixed with the effluent.

3. Sulfur dioxide dechlorination systems shall be designed with the same equipment as chlorination systems for maximum interchangeability.

4. Effluent reaeration shall be provided after dechlorination if necessary to insure adequate dissolved oxygen concentration in the receiving stream.

5. Dechlorinated effluent shall be monitored for chlorine residual and dissolved oxygen in accordance with discharge permit requirements.

20.13 EVALUATION OF EFFECTIVENESS

20.13.1 Sampling

Facilities shall be included for sampling the disinfected effluent after contact. In large installations, or where stream conditions warrant, provisions should be made for continuous monitoring of effluent chlorine residual. All sample lines should be designed so that they can be easily purged of slimes and other debris.

20.13.2 Testing and Control

If chlorine is the disinfectant, appropriate equipment shall be provided for measuring chlorine residual using accepted test procedures.