CHAPTER 100
DISINFECTION

101. GENERAL

Disinfection of the effluent shall be provided as necessary to meet applicable standards. The design shall consider meeting both the bacterial standards and the disinfectant residual limit in the effluent. The disinfection process should be selected after due consideration of waste characteristics, type of treatment process provided prior to disinfection, waste flow rates, pH of waste, disinfectant demand rates, current technology application, cost of equipment and chemicals, power cost, and maintenance requirements.

Chlorine is the most commonly used chemical for wastewater disinfection. The forms most often used are liquid chlorine and calcium or sodium hypochlorite. Other disinfectants, including chlorine dioxide, ozone, bromine, or ultraviolet disinfection, may be accepted by the reviewing authority in individual cases. If halogens are utilized, it may be necessary to dehalogenate if the residual level in the effluent exceeds effluent limitations or would impair the natural aquatic habitat of the receiving stream.

Where a disinfection process other than chlorine is proposed, supporting data from pilot plant installations or similar full scale installations may be required as a basis for the design of the system. Refer to Paragraph 53.2.

102. CHLORINE DISINFECTION

102.1 Type

Chlorine is available for disinfection in gas, liquid (hypochlorite solution), and pellet (hypochlorite tablet) form. The type of chlorine should be carefully evaluated during the facility planning process. The use of chlorine gas or liquid will be most dependent on the size of the facility and the chlorine dose required. Large quantities of chlorine, such as are contained in ton cylinders and tank cars, can present a considerable hazard to plant personnel and to the surrounding area should such containers develop leaks. Both monetary cost and the potential public exposure to chlorine should be considered when making the final determination.

102.2 Dosage

For disinfection, the capacity shall be adequate to produce an effluent that will meet the applicable bacterial limits specified by the regulatory agency for that installation. Required disinfection capacity will vary, depending on the uses and points of application of the disinfection chemical. The chlorination system shall be designed on a rational basis and calculations justifying the equipment sizing and number of units shall be submitted for the whole operating range of flow rates for the type of control to be used. System design considerations shall include the controlling wastewater flow meter (sensitivity and location), telemetering equipment and chlorination controls. For normal domestic wastewater, the following may be used as a guide in sizing chlorination facilities.

Type of Treatment	Dosage
Trickling filter plant effluent	10 mg/L
Activated sludge plant effluent	8 mg/L
Tertiary filtration effluent	6 mg/L
Nitrified effluent	6 mg/L

102.3 Containers

102.31 Cylinders

One hundred fifty pound (68 kg) cylinders are typically used where chlorine gas consumption is less than 150 pounds per day (68 kg/d). Cylinders should be stored in an upright position with adequate support brackets and chains at 2/3 of cylinder height for each cylinder.

102.32 Ton Containers

The use of one-ton (907 kg) containers should be considered where the average daily chlorine consumption is over 150 pounds (68 kg).

102.33 Tank Cars

At large installations, the use of tank cars, generally accompanied by evaporators, may be considered. Area wide public safety shall be evaluated. No interruption of chlorination shall be permitted during tank car switching.

The tank car being used for the chlorine supply shall be located on a dead end, level track that is a private siding. The tank car shall be protected from accidental bumping by other railway cars by a locked derail device or a closed locked switch or both. The area shall be clearly posted "DANGER-CHLORINE". The tank car shall be secured by adequate fencing with gates provided with locks for personnel and rail access.

The tank car site shall be provided with a suitable operating platform at the unloading point for easy access to the protective housing or the tank car for connection of flexible feedlines and valve operation. Adequate area lighting shall be provided for night time operation and maintenance.

102.34 Liquid Hypochlorite Solutions

Storage containers for hypochlorite solutions shall be of sturdy, non-metallic lined construction and shall be provided with secure tank tops and pressure relief and overflow piping. Storage tanks

should be either located or vented outside. Provision shall be made for adequate protection from light and extreme temperatures. Tanks shall be located where leakage will not cause corrosion or damage to other equipment. A means of secondary containment shall be provided to contain spills and facilitate cleanup. Due to deterioration of hypochlorite solutions over time, it is recommended that containers not be sized to hold more than one month's needs. At larger facilities and locations where delivery is not a problem, it may be desirable to limit on-site storage to one week. Refer to Section 57.

102.35 Dry Hypochlorite Compounds

Dry hypochlorite compounds should be kept in tightly closed containers and stored in a cool, dry location. Some means of dust control should be considered, depending on the size of the facility and the quantity of compound used. Refer to Section 57.

102.4 Equipment

102.41 Scales

Scales for weighing cylinders and containers shall be provided at all plants using chlorine gas. At large plants, scales of the indicating and recording type are recommended. At least a platform scale shall be provided. Scales shall be of corrosion-resistant material.

102.42 Evaporators

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

102.43 Mixing

The disinfectant shall be positively mixed as rapidly as possible, with a complete mix being effected in 3 seconds. This may be accomplished by either the use of turbulent flow regime or a mechanical flash mixer.

102.44 Contact Period and Tank

For a chlorination system, a minimum contact period of 15 minutes at design peak hourly flow or maximum rate of pumpage shall be provided after thorough mixing. For evaluation of existing chlorine contact tanks, field tracer studies should be done to assure adequate contact time.

The chlorine contact tank shall be constructed so as to reduce short-circuiting of flow to a practical minimum. Tanks not provided with continuous mixing shall be provided with "over-

and-under" or "end-around" baffling to minimize short-circuiting.

The tank should be designed to facilitate maintenance and cleaning without reducing effectiveness of disinfection. Duplicate tanks, mechanical scrapers, or portable deck-level vacuum cleaning equipment shall be provided. Consideration should be given to providing skimming devices on all contact tanks. Covered tanks are discouraged.

102.45 Piping and Connections

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

Due to the corrosiveness of wet chlorine, all lines designated to handle dry chlorine shall be protected from the entrance of water or air containing water. Even minute traces of water added to chlorine results in a corrosive attack. Low pressure lines made of hard rubber, saran-lined, rubber-lined, polyethylene, polyvinylchloride (PVC), or other approved materials are satisfactory for wet chlorine or aqueous solutions of chlorine.

The chlorine system piping shall be color coded and labeled to distinguish it from other plant piping. Refer to Paragraph 54.5. Where sulfur dioxide is used, the piping and fittings for chlorine and sulfur dioxide systems shall be designed so that interconnection between the two systems cannot occur.

102.46 Standby Equipment and Spare Parts

Standby equipment of sufficient capacity should be available to replace the largest unit during shutdowns. Spare parts shall be available for all disinfection equipment to replace parts which are subject to wear and breakage.

102.47 Chlorinator Water Supply

An ample supply of water shall be available for operating the chlorinator. Where a booster pump is required, duplicate equipment should be provided, and, when necessary, standby power as well. Protection of a potable water supply shall conform to the requirements of Paragraph 56.2. Adequately filtered plant effluent should be considered for use in the chlorinator.

102.48 Leak Detection and Controls

A bottle of 56 percent ammonium hydroxide solution shall be available for detecting chlorine leaks. Where ton (907 kg) containers or tank cars are used, a leak repair kit approved by the Chlorine Institute shall be provided. Consideration should be

given to the provision of caustic soda solution reaction tanks for absorbing the contents of leaking one-ton (907 kg) containers where such containers are in use. Consideration should be given to the installation of automatic gas detection and related alarm equipment.

102.5 Housing

102.51 Feed and Storage Rooms

If gas chlorination equipment or chlorine cylinders are to be in a building used for other purposes, a gas-tight room shall separate this equipment from any other portion of the building. Floor drains from the chlorine room should not be connected to floor drains from other rooms. Doors to this room shall open only to the outside of the building, and shall be equipped with panic hardware. Rooms shall be at ground level and should permit easy access to all equipment.

Storage areas for one-ton (907 kg) cylinders should be separated from the feed area. In addition, the storage area shall have designated areas for "full" and "empty" cylinders. Chlorination equipment should be situated as close to the application point as reasonably possible. For additional safety considerations, refer to Section 57.

102.52 Inspection Window

A clear glass, gas-tight, window shall be installed in an exterior door or interior wall of the chlorinator room to permit the units to be viewed without entering the room.

102.53 Heat

Rooms containing disinfection equipment shall be provided with a means of heating so that a temperature of at least 60°F (16 °C) can be maintained. The room should be protected from excess heat. Cylinders shall be kept at essentially room temperature. If liquid hypochlorite solution is used, the containers may be located in an unheated area.

102.54 Ventilation

With chlorination systems, forced, mechanical ventilation shall be installed which will provide one complete fresh air change per minute when the room is occupied. The entrance to the air exhaust duct from the room shall be near the floor. The point of discharge shall be so located as not to contaminate the air inlet to any buildings or present a hazard at the access to the chlorinator room or other inhabited areas. Air inlets shall be so located as to provide cross ventilation with air and at such temperature that will not adversely affect the chlorination equipment. The outside air inlet shall be at least three feet above grade. The vent hose

from the chlorinator shall discharge to the outside atmosphere above grade. Where public exposure may be extensive, scrubbers may be required on ventilation discharge.

102.55 Electrical Controls

Switches for fans and lights shall be outside of the room at the entrance. A labeled signal light indicating fan operation should be provided at each entrance, if the fan can be controlled from more than one point.

102.56 Protective and Respiratory Gear

Respiratory air-pac protection equipment, meeting the requirements of the National Institute for Occupational Safety and Health (NIOSH), shall be available where chlorine gas is handled, and shall be stored at a convenient location, but not inside any room where chlorine is used or stored. Instructions for using the equipment shall be posted. The units shall use compressed air, have at least 30-minute capacity and be compatible with the units used by the fire department responsible for the plant.

102.6 Sampling and Control

102.61 Sampling

Facilities shall be included for sampling disinfected effluent after the contact chamber as monitoring requirements warrant. In large installations, or where stream conditions warrant, provisions should be made for continuous monitoring of effluent chlorine residual.

102.62 Testing and Control

Equipment shall be provided for measuring chlorine residual using accepted test procedures. The installation of demonstrated effective facilities for automatic chlorine residual analysis, recording, and proportioning systems should be considered at all large installations.

Equipment shall also be provided for measuring fecal coliform organisms using accepted test procedures as required by the regulatory agency.

103. DECHLORINATION

103.1 Types

Dechlorination of wastewater effluent may be necessary to reduce the toxicity due to chlorine residuals. The most common dechlorination chemicals are sulfur compounds, particularly sulfur dioxide gas or aqueous solutions of sulfite or bisulfite. Pellet dechlorination systems are also available for small facilities.

The type of dechlorination system should be carefully selected considering criteria including the following: type of chemical storage required, amount of chemical needed, ease of operation, compatibility with existing equipment, and safety.

103.2 Dosage

The dosage of dechlorination chemical should depend on the residual chlorine in the effluent, the final residual chlorine limit, and the particular form of the dechlorinating chemical used. The most common dechlorinating agent is sulfite. The following forms of the compound are commonly used and yield sulfite (SO_2) when dissolved in water.

Dechlorination Chemical	Theoretical mg/L Required to Neutralize 1 mg/L Cl_2
Sodium thiosulfate (solution)	0.56
Sodium sulfite (tablet)	1.78
Sulfur dioxide (gas)	0.9
Sodium meta bisulfite (solution)	1.34
Sodium bisulfite (solution)	1.46

Theoretical values may be used for initial approximations, to size feed equipment with the consideration that under good mixing conditions 10% excess dechlorinating chemical is required above theoretical values. Excess sulfur dioxide may consume oxygen at a maximum of 1.0 mg dissolved oxygen for every 4 mg SO_2.

The liquid solutions come in various strengths. These solutions may need to be further diluted to provide the proper dose of sulfite.

103.3 Containers

Depending on the chemical selected for dechlorination, the storage containers will vary from gas cylinders, liquid in 50 gallon (190 L) drums or dry compounds. Dilution tanks and mixing tanks will be necessary when using dry compounds and may be necessary when using liquid compounds to deliver the proper dosage. Solution containers should be covered to prevent evaporation and spills.

103.4 Feed Equipment, Mixing, and Contact Requirements

103.41 Equipment

In general, the same type of feeding equipment used for chlorine gas may be used with minor modifications for sulfur dioxide gas. However, the manufacturer should be contacted for specific equipment recommendations. No equipment should be alternately used for the two gases. The common type of

dechlorination feed equipment utilizing sulfur compounds include vacuum solution feed of sulfur dioxide gas and a positive displacement pump for aqueous solutions of sulfite or bisulfite.

The selection of the type of feed equipment utilizing sulfur compounds shall include consideration of the operator safety and overall public safety relative to the wastewater treatment plant's proximity to populated areas and the security of gas cylinder storage. The selection and design of sulfur dioxide feeding equipment shall take into account that the gas reliquifies quite easily. Special precautions must be taken when using ton (907 kg) containers to prevent reliquefaction.

Where necessary to meet the operating ranges, multiple units shall be provided for adequate peak capacity and to provide a sufficiently low feed rate on turn down to avoid depletion of the dissolved oxygen concentrations in the receiving waters.

103.42 Mixing Requirements

The dechlorination reaction with free or combined chlorine will generally occur within 15 to 20 seconds. The dechlorination chemical should be introduced at a point in the process where the hydraulic turbulence is adequate to assure thorough and complete mixing. If no such point exists, mechanical mixing shall be provided. The high solubility of SO_2 prevents it from escaping during turbulence.

103.43 Contact Time

A minimum of 30 seconds for mixing and contact time shall be provided at the design peak hourly flow or maximum rate of pumpage. A suitable sampling point shall be provided downstream of the contact zone. Consideration shall be given to a means of reaeration to assure maintenance of an acceptable dissolved oxygen concentration in the stream following sulfonation.

103.44 Standby Equipment and Spare Parts

The same requirements apply as for chlorination systems. See Paragraph 102.46.

103.45 Sulfonator Water Supply

The same requirements apply as for chlorination systems. See Paragraph 102.47.

103.5 Housing Requirements

103.51 Feed and Storage Rooms

The requirements for housing SO_2 gas equipment shall follow the same guidelines as used for chlorine gas. Refer to Paragraph 102.5 for specific details.

When using solutions of the dechlorinating compounds, the solutions may be stored in a room that meets the safety and handling requirements set forth in Section 57. The mixing, storage, and solution delivery areas must be designed to contain or route solution spillage or leakage away from traffic areas to an appropriate containment unit.

103.52 Protective and Respiratory Gear

The respiratory air-pac protection equipment is the same as for chlorine. See Paragraph 102.56. Leak repair kits of the type used for chlorine gas that are equipped with gasket material suitable for service with sulfur dioxide gas may be used. (Refer to The Compressed Gas Association Publication CGA G-3-1995, "Sulfur Dioxide") For additional safety considerations, see Section 57.

103.6 Sampling and Control

103.61 Sampling

Facilities shall be included for sampling the dechlorinated effluent for residual chlorine. Provisions shall be made to monitor for dissolved oxygen concentration after sulfonation when required by the regulatory agency.

103.62 Testing and Control

Provision shall be made for manual or automatic control of sulfonator feed rates based on chlorine residual measurement or flow.

104. ULTRAVIOLET RADIATION DISINFECTION

Design standards, operating data, and experience for this process are not well established. Therefore, expected performance of the ultraviolet radiation disinfection (UVRD) units shall be based upon experience at similar full scale installations or thoroughly documented prototype testing with the particular wastewater. Critical parameters for UVRD units are dependent upon manufacturers' design, lamp selection, tube materials, ballasts, configuration, control systems, and associated appurtenances. Proposals on this disinfection process will be reviewed on a case-by-case basis at the discretion of the reviewing authority under the provisions of Paragraph 53.2.

Open channel designs with modular UVRD units that can be removed from the flow are required. At least two banks in series shall be provided in each channel

for disinfection reliability and to ensure uninterrupted service during tube cleaning or other required maintenance. Operator safety (electrical hazards and UV radiation exposure) and tube cleaning frequency shall be considered. The hydraulic properties of the system shall be designed to simulate plug flow conditions under the full operating flow range. In addition, a positive means of water level control must be provided to achieve the necessary exposure time. Also refer to Paragraphs 54.2 and 54.3. Closed chamber units will be reviewed on a case by case basis in accordance with Paragraph 53.2.

This process should be limited to a high quality effluent having at least 65% ultraviolet radiation transmittance at 254 nanometers wave length, and BOD and suspended solids concentrations no greater than 30 mg/L at any time. The UV radiation dosage shall be based on the design peak hourly flow. As a general guide in system sizing for an activated sludge effluent with the preceding characteristics, a UV radiation dosage not less than 30,000 $\mu W \cdot s/cm^2$ may be used after adjustments for maximum tube fouling, lamp output reduction after 8760 hours of operation, and other energy absorption losses.

An alarm system shall be provided to separately indicate lamp failure and low UV intensity.

105. OZONE

Ozone systems for disinfection should be evaluated on a case-by-case basis. Design standards, operating data, and experience for this process are not well established. Therefore, design of these systems should be based upon experience at similar full scale installations or thoroughly documented prototype testing with the particular wastewater.