4.3 DISINFECTION

Chlorine is historically the preferred disinfecting agent. Disinfection may be accomplished with gas and liquid chlorine, calcium or sodium hypochlorites, chlorine dioxide, ozone, or ultraviolet light. Other disinfecting agents will be considered, providing reliable application equipment is available and testing procedures for a residual are recognized in "Standard Methods for the Examination of Water and Wastewater," latest edition or an equivalent means of measuring effectiveness exists. Disinfection is required for all surface water supplies, groundwater under the direct influence of surface water, and for any groundwater supply of questionable sanitary quality or where other treatment is provided. Disinfection with chloramines is not recommended for primary disinfection. The required amount of primary disinfection needed shall be specified by the reviewing authority. Continuous disinfection is recommended for all water supplies. Consideration must be given to the formation of disinfection byproducts (DBP)when selecting the disinfectant.

4.3.1 Chlorination equipment

4.3.1.1 Type

Solution-feed gas chlorinators or hypochlorite feeders of the positive displacement type must be provided. (see Part 5).

4.3.1.2 Capacity

The chlorinator capacity shall be such that a free chlorine residual of at least 2 mg/L can be maintained in the water once all demands are met after contact time of at least 30 minutes when maximum flow rate coincides with anticipated maximum chlorine demand. The equipment shall be of such design that it will operate accurately over the desired feeding range.

4.3.1.3 Standby equipment

Where chlorination is required for protection of the supply, standby equipment of sufficient capacity shall be available to replace the largest unit. Spare parts shall be made available to replace parts subject to wear and breakage. If there is a large difference in feed rates between routine and emergency

dosages, a gas metering tube should be provided for each dose range to ensure accurate control of the chlorine feed.

4.3.1.4 Automatic switch-over

Automatic switch-over of chlorine cylinders should be provided, where necessary, to assure continuous disinfection.

4.3.1.5 Automatic proportioning

Automatic proportioning chlorinators will be required where the rate of flow or chlorine demand is not reasonably constant.

4.3.1.6 Eductor

Each eductor must be selected for the point of application with particular attention given to the quantity of chlorine to be added, the maximum injector waterflow, the total discharge back pressure, the injector operating pressure, and the size of the chlorine solution line. Gauges for measuring water pressure and vacuum at the inlet and outlet of each eductor should be provided.

4.3.1.7 Injector/diffuser

The chlorine solution injector/diffuser must be compatible with the point of application to provide a rapid and thorough mix with all the water being treated. The center of a pipeline is the preferred application point.

4.3.2 Contact time and point of application

a. Due consideration shall be given to the contact time of the disinfectant in water with relation to pH, ammonia, taste-producing substances, temperature, bacterial quality, disinfection byproduct formation potential and other pertinent factors. The disinfectant should be applied at a point which will provide adequate contact time. All basins used for disinfection must be designed to minimize short circuiting. Additional baffling can be added to new or existing basins to minimize short circuiting and increase contact time.

b. At plants treating surface water, provisions shall be made for applying the disinfectant to the raw water, settled water, filtered water, and water entering the distribution system.

c. As a minimum, at plants treating groundwater, provisions shall be made for applying the disinfectant to the detention basin inlet and water entering the distribution system.

d. The amount of contact time provided will depend on the type of disinfectant used along with the parameters mentioned in 4.3.2.a. As a minimum, for surface waters and groundwaters under the direct influence of surface water, the system must be designed to meet the CT standards set by the reviewing authority. If primary disinfection is accomplished using ozone or some other chemical that does not provide a residual disinfectant, then chlorine must be added to provide a residual disinfectant as mentioned in 4.3.3. Disinfection for groundwaters shall be as determined by the reviewing authority.

4.3.3 Residual chlorine

a. Minimum free chlorine residual in a water distribution system should be 0.2 mg/L. Minimum chloramine residuals, where chloramination is practiced, should be 1.0 mg/L at distant points in the distribution system.

b. Higher residuals may be required depending on pH, temperature and other characteristics of the water.

4.3.4 Testing equipment

a. Chlorine residual test equipment recognized in the latest edition of Standard Methods for the Examination of Water and Wastewater shall be provided and should be capable of measuring residuals to the nearest 0.1 milligrams per liter. It is recommended that all systems, as a minimum, use an instrument using the DPD colorimetric method with a digital readout and a self contained light source.

b. Automatic chlorine residual recorders should be provided where the chlorine demand varies appreciably over a short period of time.

c. All treatment plants having a capacity of 0.5 million gallons per day or greater should be equipped with recording chlorine analyzers monitoring water entering the distribution system. (see Section 2.9).

d. All surface water treatment plants that serve a population greater that 3300 must have equipment to measure chlorine residuals continuously entering the distribution system.

e. Systems that rely on chlorination for inactivation of bacteria or other microorganisms present in the source water shall have continuous chlorine residual analyzers and other equipment that automatically shut down the facility when chlorine residuals are not met unless otherwise approved by the reviewing authority.

4.3.5 Chlorinator piping

4.3.5.1 Cross-connection protection

The chlorinator water supply piping shall be designed to prevent contamination of the treated water supply by sources of questionable quality. At all facilities treating surface water, pre- and post-chlorination systems must be independent to prevent possible siphoning of partially treated water into the clear well. The water supply to each eductor shall have a separate shut-off valve. No master shut-off valve will be allowed.

4.3.5.2 Pipe material

The pipes carrying elemental liquid or dry gaseous chlorine under pressure must be Schedule 80 seamless steel tubing or other materials recommended by the Chlorine Institute (never use PVC). Rubber, PVC, polyethylene, or other materials recommended by the Chlorine Institute must be used for chlorine solution piping and fittings. Nylon products are not acceptable for any part of the chlorine solution piping system.

4.3.6 Housing

Adequate housing must be provided for the chlorination equipment and for storing the chlorine. (see Part 5).

4.3.7 Ozone

4.3.7.1 Design considerations

Ozonation systems are generally used for the purpose of disinfection, oxidation and microflocculation. When applied, all of these reactions may occur but typically only one is the primary purpose for its use. The other reactions would become secondary benefits of the installation.

Effective disinfection occurs as demonstrated by the fact that the "CT" values for ozone, for inactivation of viruses and Giardia cysts, are considerably lower than the "CT" values for other disinfectants. In addition, recent research indicates that ozone can be an effective disinfectant for the inactivation of cryptosporidium. Microflocculation and enhanced filterability has been demonstrated for many water supplies but has not occurred in all waters. Oxidation of organic compounds such as color, taste and odor, and detergents and inorganic compounds such as iron, manganese, heavy metals and hydrogen sulfide has been documented. The effectiveness of oxidation has been varied, depending on pH and alkalinity of the water.

These parameters affect the formation of highly reactive hydroxyl radicals, or, conversely the scavenging of this oxidant. High levels of hydroxyl radicals cause lower levels of residual ozone. Depending on the desired oxidation reaction, it may be necessary to maximize ozone residual or maximize hydroxyl radical formation. For disinfection, residual ozone is necessary for development of "CT".

As a minimum, bench scale studies shall be conducted to determine minimum and maximum ozone dosages for disinfection "CT" compliance and oxidation reactions. More involved pilot studies shall be conducted when necessary to document benefits and DBP precursor removal effectiveness. Consideration shall be given to multiple points of ozone addition. Pilot studies shall be conducted for all surface waters. Extreme care must be taken during bench and pilot scale studies to ensure accurate results.

Particularly sensitive measurements include gas flow rate, water flow rate, and ozone concentration.

Following the use of ozone, the application of a disinfectant which maintains a measurable residual will be required in order to ensure a bacteriologically safe water is carried throughout the distribution system.

Furthermore, because of the more sophisticated nature of the ozone process a higher degree of operator maintenance skills and training is required. The ability to obtain qualified operators must be evaluated in selection of the treatment process. The necessary operator training shall be provided prior to plant startup.

The production of ozone is an energy intensive process: substantial economies in electrical usage, reduction in equipment size, and waste heat removal requirements can be obtained by using oxygen enriched air or 100% oxygen as feed, and by operating at increased electrical frequency.

Use of ozone may result in increases in biologically available organics content of the treated water. Consideration of biologically active filtration may be required to stabilize some treated waters. Ozone use may also lead to increased chlorinated byproduct levels if the water is not stabilized and free chlorine is used for distribution protection.