

**COMMUNITY
PUBLIC WATER SYSTEMS
DESIGN CRITERIA**

**Division of Water Supply
Tennessee Department of Environment and Conservation**

1997

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INTRODUCTION

This publication is a revised edition of our Design Criteria for Community Public Water Systems. They have been prepared as a guide to water systems, design engineers, and our own staff. There has been no attempt to address every situation. We also know that there will be occasions when these criteria will not apply. Exceptions will be handled on an individual basis.

The Tennessee Safe Drinking Water Act of 1983 requires The Department of Environment & Conservation to:

"Exercise general supervision over the construction of public water systems throughout the state. Such general supervision shall include all the features of construction of public water systems which do or may affect the sanitary quality or the quantity of the water supply. No new construction shall be done nor shall any change be made in any public water system until the plans for such new construction or change have been submitted and approved by the department."
(Extract of part of Section 68-13-706, Tennessee Code)

Where the terms shall and must are used, it is intended to be a mandatory requirement. Other terms such as should, recommend, preferred, and the like, are intended to show desirable equipment, procedures, or methods.

We encourage development of new methods and equipment. However, any new developments must be demonstrated to be satisfactory before we can approve their use. Operating data from other installations, or demonstration of the equipment by a manufacturer's representative, or both, may be needed for our review.

These criteria are a compilation of information from a number of sources. The principle source, however, is Recommended Standards for Water Works, 1982 Edition. This publication is a report of "The Committee of the Great Lakes Upper Mississippi River Board of State Sanitary Engineers" and is commonly known as Ten-State Standards.

- 4.7.5 Sampling Equipment - Smooth-nosed sampling taps shall be provided for control purposes. Taps shall be located on each raw water source, each treatment unit influent and each treatment unit effluent.
- 4.7.6 Testing Equipment - Testing equipment shall be provided for all plants. The equipment should have the capacity to accurately measure the iron content to a minimum of 0.1 mg/L and the manganese content to 0.05 mg/L.
- 4.8 FLUORIDATION - Commercial sodium fluoride, sodium silicofluoride and hydrofluosilicic acid shall conform to the applicable AWWA Standards. Other chemicals which may be made available must be approved by the Department.
- 4.8.1 Fluoride Compound Storage - Compounds shall be stored in covered or unopened shipping containers. Bulk storage units and day tanks, including carboys and drums in use for hydrofluosilicic acid, shall be vented to the atmosphere at a point outside any building.
- 4.8.2 Dry Conveyers - Provision must be made for the proper transfer of dry fluoride compounds from shipping containers to storage bins or hoppers, in such a way as to minimize the quantity of fluoride dust.
- 4.8.3 Chemical Feed Installations
- a. shall conform to Part 5,
 - b. shall provide scales or loss-of-weight recorders for dry or acid chemical feeds. Dry volumetric feeders are to have percent-of-cycle timer or variable speed SCR drive. A minimum of 35-gallon dissolver with mechanical agitation,
 - c. shall have an accuracy that actual feed will be within 5% of that intended,
 - d. shall be such that the point of application of hydrofluosilicic acid, if into a pipe, shall be in the lower third of the pipe and project upward,
 - e. downflow saturators are not acceptable,
 - f. shall provide adequate anti-siphon devices for all fluoride feed lines,
 - g. piping from bulk storage to day tank should be schedule 80 PVC.
- 4.8.4 Protective Equipment - Suitable protective equipment shall be provided.
- 4.8.5 Dust Control Equipment - Suitable equipment shall be provided for wet-mopping and hosing dust that might accumulate in the plant.
- 4.8.6 Testing Equipment - Equipment shall be provided for measuring the quantity of fluoride ion in the water. Such equipment shall be subject to the approval of the Department.
- 4.9 CORROSION CONTROL - corrosion is caused by a reaction between the pipe material and the water in direct contact with each other. Consequently, there are three basic approaches to corrosion control:
- a. Using pipe materials and designing the system so it is not corroded by a given water,
 - b. Modifying the water quality so it is not corrosive to the pipe material,

c. Placing a protective barrier or lining between the water and the pipe.

4.9.1 System design

- a. Choose compatible materials throughout system where possible to avoid forming galvanic cells,
- b. Avoid dead ends and stagnant areas,
- c. Reduce mechanical stress, sharp turns and elbows,
- d. Provide adequate insulation and avoid uneven heat distribution,
- e. Eliminate grounding of electrical circuits to system.

4.9.2 Cathodic Protection - Metal tanks and reservoirs should be considered for protection from corrosion by this method.

4.9.3 Modification of Water Quality

- a. pH adjustment by addition of lime, caustic soda or soda ash, in order to stabilize the water with regard to calcium carbonate.
- b. Control of oxygen. Advantages of aeration for iron, H₂S Or CO₂ removal should be balanced against the fact that dissolved oxygen is a corrosive agent.

4.9.4 Use of inhibitors. These may be used as appropriate.

- a. Addition of lime or alkalinity increases the tendency of water to deposit CaCO₃ forming a protective coating inside of pipe.
- b. Inorganic phosphorus. Care is needed to select a chemical which not only masks the symptoms, but also reduces corrosion. (Sodium hexametaphosphate in low dosages of 2-4 mg/L only masks the symptoms while corrosion continues). Recent developments indicate the addition of zinc with a phosphate is effective in both inhibiting corrosion and controlling red water.
- c. Sodium silicate. Effective in water with low hardness, alkalinity and pH less than 8.4 under relatively high velocity conditions.

4.9.5 Coatings and linings - Metal distribution system components' surfaces in contact with water shall be protected by being coated or lined.

- a. Pipe linings include coal tar enamels, epoxy paint, and cement mortar.
- b. Storage tanks are protected by such coatings as coal tar enamels, paints, vinyls, and epoxy.

4.10 TASTE AND ODOR CONTROL

4.10.1 Chlorination - Chlorination can be used for the removal of some objectionable odors. Adequate contact time must be provided to complete the chemical reactions involved.

4.10.2 Chlorine Dioxide - Chlorine dioxide has been generally recognized as a treatment for tastes caused by industrial wastes, such as phenols; however, chlorine dioxide can be used in the treatment of any taste

or odor that is treatable by an oxidizing compound. Provision shall be made for proper storing and handling of sodium chlorite, so as to eliminate any danger of explosion (See Part 5).

4.10.3 Powdered Activated Carbon

- a. Powdered activated carbon may be added prior to coagulation to provide maximum contact time, although facilities to allow the addition at several points is preferred, but not near the point of chlorine application.
- b. The carbon can be added as a pre-mixed slurry or by means of a dry-feed machine as long as the carbon is properly "wetted".
- c. Agitation is necessary to keep the carbon from depositing in the mixing chamber.
- d. Provision shall be made for adequate dust control.
- e. The required dosage of carbon in a water treatment plant depends upon the tastes and/or odors involved, but provision shall be made for adding 0 mg/L to at least 40 mg/L.
- f. Powdered activated carbon shall be handled as a potentially combustible material. It should be stored in a building or compartment as nearly fireproof as possible. Other chemicals should not be stored in the same compartment. Carbon feeder rooms should be equipped with explosion-proof electrical outlets, lights and motors.

4.10.4 Granular Activated Carbon Adsorption Units - Granular activated carbon units shall not be used in place of filters described in Section 4.2. Rates of flow shall be consistent with the type and intensity of the problem. The design used must be supported by the results of pilot plant studies when granular activated carbon units are used for organic removal.

4.10.5 Copper Sulfate and Other Copper Compounds - Continuous or periodic treatment of water with copper compounds to kill algae or other growths shall be controlled to prevent copper in excess of 1.0 mg/L as copper in the plant effluent or distribution system. Care shall be taken in obtaining a uniform distribution:

- a. if alkalinity is less than 50 mg/L, dose at 0.9 lb/acre foot,
- b. if alkalinity is greater than 50 mg/L, dose at 5.4 lb/acre foot.

4.10.6 Aeration - See Section 4.6.

4.10.7 Potassium Permanganate - Application of potassium permanganate may be considered provided the point of application is prior to filtration.

4.10.8 Ozone - Ozonation can be used as a means of taste and odor control. Adequate contact time must be provided to complete the chemical reactions involved. Ozone is generally more desirable for treating water with high threshold odors.

4.10.9 Other Methods - The decision to use any other methods of taste and odor control should be made only after careful laboratory tests and on consultation with the Department.

4.10.10 Flexibility - Plants treating water that is known to have taste and odor problems should be provided with equipment that makes several of the control processes available so that the operator will have flexibility in operation.

4.11 WASTE DISPOSAL - Provisions must be made for proper disposal of water treatment plant waste such as sanitary, laboratory, clarification, softening and ion sludges, filter backwash, and brines. The quantity of waste produced in water treatment shall be minimized by choice of treatment processes and chemicals. If supernatant water from backwash/sludge holding tanks or lagoons is to be recycled through the treatment plant, potential impacts on the treatment process must be considered. Recycled water must be clarified to reduce contaminants that may be concentrated in sludges and backwash water.

4.11.1 Waste Water and Sludge - The following means of waste and sludge disposal may be considered:

- a. Lagoons - Design should provide:
 1. location free from flooding,
 2. when necessary, dikes, deflecting gutters, or other means of diverting surface water,
 3. a minimum usable depth of 4 to 5 feet with adequate freeboard,
 4. 3 to 5 years solids storage volume,
 5. multiple cells,
 6. adjustable decanting devices,
 7. convenient cleaning,
 8. effluent sampling point,
 9. adequate safety provisions.
- b. Sludge Beds - Beds for lime softening sludges should provide for an application of slurry of at least 12 inches. Multiple beds should be provided so designed as to permit a minimum of one year's total storage. The storage capacity should be based on assumption that for each part per million of hardness removed there will be two parts per million of dry solids, and the accumulated sludge density being 120 pounds per cubic foot. Distribution channels are required for spreading sludge over the entire area. Provisions must be made for easy access and for paved loading ramps and underdrains. See Section 4.11.1.1 for provisions on flooding and surface water diversion.
- c. Disposal to Sanitary Sewer System
 1. Approval must be obtained from sewer system officials.
 2. Consideration shall be given to the effects the water plant waste will have at the sewer plant including:
 - i. effect on the sewage treatment process,
 - ii. additional sludge to be handled.
 3. Consideration shall be given to the effects of disposal into the sewage collection system. A schedule for disposal shall be determined in conjunction with sewer system officials.

d. other methods - These include holding tanks, vacuum filters, centrifuging, and recalcining. Detailed studies should be made to justify their use.

4.11.2 Sanitary Waste - The sanitary waste from water treatment plants, pumping stations, etc., must receive treatment. Waste from these facilities must be discharged either directly to a sanitary sewer system or to an individual waste disposal facility providing suitable treatment.

Part 5 - CHEMICAL APPLICATION

5.0 GENERAL - Plans and specifications describing water treatment plants (new, modified or expanded) shall include the chemicals and chemical feed equipment to be used in the treatment process.

5.0.1 These plans and specifications shall include:

- a. descriptions of feed equipment, including maximum and minimum feed ranges,
- b. location of feeders, piping layout and points of application,
- c. storage and handling facilities,
- d. specifications for chemicals to be used,
- e. operating and control procedures,
- f. descriptions of testing equipment and procedures.

5.0.2 Chemical shall be applied to the water at such points and by such means as to:

- a. provide maximum flexibility of operation through various points of application, when appropriate, and
- b. prevent backflow at all points of feed.

5.1 FEED EQUIPMENT

5.1.1 Number of Feeders

- a. Where chemical feed is essential to the production of safe drinking water or necessary for continuous operation
 1. a minimum of two feeders shall be provided,
 2. a standby unit or combination of units of sufficient capacity should be available to replace the largest unit during shut-downs.
- b. Spare parts shall be available for all feeders to replace parts which are subject to wear and damage.

5.1.2 Design and Capacity - Design and capacity shall be such that:

- a. feeders will be able to supply, at all times, the necessary amounts of chemical at an accurate rate, throughout the range of feed;
- b. feeders are adjustable to handle all plant flow rates;
- c. positive displacement type solution feed pumps shall be used to feed liquid chemicals, and shall not be used to feed chemical slurries;
- d. chemical solutions cannot be siphoned into the water supply;
- e. service water supply cannot be contaminated by chemical solutions by:

1. equipping the supply line with backflow prevention devices (see Section 5.1.8.c), or
 2. providing an air gap between supply line and solution tank.
- f. chemical-contact materials and surfaces are resistant to the aggressiveness of the chemical solution;
- g. [dry chemical feeders will:](#)
1. [measure chemicals volumetrically or gravimetrically,](#)
 2. provide effective solution of the chemical in the solution pot,
 3. provide gravity feed from solution pots, in open troughs when feasible,
 4. completely enclose chemicals to prevent emission of dust to any of the operating areas (see Section 5.2.3d).
- h. no direct connection exists between any sewer and a drain or overflow from the feeder or solution chamber or tank.

5.1.3 Location - chemical feed equipment

- a. shall be conveniently located near points of application to minimize length of feed lines;
- b. shall be readily accessible for
 1. servicing, repair and calibration, and
 2. observation of operation;
- c. shall be located and protective curbing provided, so that chemicals from equipment failure, spillage or accidental drainage shall not enter the water through conduits, treatment or storage basins, or result in hazardous discharge.

5.1.4 Control

- a. Feeders may be manually or automatically controlled, with automatic control reverting to manual control as necessary.
- b. Process must be manually started following shutdown, unless otherwise approved by the Department.
- c. Feed rates proportional to flow must be provided.
- d. Automatic chemical dose or residual analyzers may be approved for use and must provide
 1. alarms for critical values, and
 2. recording charts.

5.1.5 Solution Tanks

- a. Means shall be provided in a solution tank to maintain uniform strength of solution, consistent with the nature of the chemical solution; continuous agitation is necessary to maintain slurries in suspension.
- b. Two solution tanks may be required for a chemical, of specific capacity, to assure continuity of supply in servicing a solution tank.
- c. Each tank shall be provided with a drain;
 - 1. No direct connection between any tank or drain and a sewer shall be permitted, and
 - 2. Any drain must terminate at least two pipe diameters above the overflow rim of a receiving sump, conduit or waste receptacle.
- d. Means shall be provided to indicate the solution level in the tank.
- e. Make-up water shall enter the tank from above the maximum solution level, providing an air gap of two pipe diameters but not less than six inches, or shall be protected with an approved backflow prevention devices (see Section 5.1.8.c).
- f. Chemical solutions shall be kept covered. Large tanks with access openings shall have such openings curbed and fitted with tight covers.
- g. Subsurface locations for solution tanks shall:
 - 1. be free from sources of possible contamination.
 - 2. assure positive drainage for ground waters, accumulated water, chemical spills and overflows.
- h. Overflow pipes, when provided, should:
 - 1. be turned downward, with end screened.
 - 2. have free discharge, and
 - 3. be located where noticeable.

5.1.6 Weighing Scales

- a. shall be provided for weighing cylinders, at all plants utilizing chlorine gas; for large plants, indicating and recording type are desirable;
- b. shall be provided to measure the amount of fluoride fed with the exception of the use of a saturator, which shall have a water meter;
- c. should be provided for volumetric dry chemical feeders;
- d. should be accurate to measure increments of 0.5% of load;

5.1.7 Feed Lines

- a. should be as short as possible in length of run, and

1. of durable, corrosion-resistant material,
 2. easily accessible throughout entire length,
 3. protected against freezing,
 4. easily cleaned,
 5. lime feed lines should be designed so they can be readily replaced, and
 6. avoiding sharp bends when possible.
- b. should slope upward from chemical source to feeder, when conveying gases;
 - c. should introduce corrosive chemicals in such manner as to minimize potential for corrosion;
 - d. shall be designed consistent with scale-forming or solids depositing properties of the water, chemical, solution or mixture conveyed;
 - e. shall not carry chlorine gas beyond chlorine storage and feeder room(s) except under vacuum;
 - f. should be color coded.

5.1.8 Service Water Supply

- a. Water used for dissolving dry chemicals, diluting liquid chemicals or operating chemical feeders shall be:
 1. only from a safe, approved source,
 2. protected from contamination by appropriate means (see Section 5.1.8c),
 3. ample in supply and adequate in pressure,
 4. provided with means for measurement when preparing specific solution concentrations by dilution,
 5. properly treated for hardness, when necessary.
- b. Where a booster pump is required, duplicate equipment should be provided and, when necessary, standby power.
- c. Back-flow prevention shall be achieved by appropriate means such as:
 1. an air gap between fill pipe and maximum flow line of solution or dissolving tank equivalent to 2 pipe diameters but not less than 6 inches, or
 2. an approved reduced pressure backflow preventer, consistent with the degree of hazard, aggressiveness of chemical solution, back pressure sustained, and available means for maintaining and testing the device, or
 3. a satisfactory vacuum relief device.

5.2 CHEMICALS

5.2.1 Quality

- a. Chemical containers shall be fully labeled to include:
 1. chemical name, purity and concentration,
 2. supplier name and address, and
 3. expiration date where applicable.
- b. Chemicals shall be listed under ANSI/NSF Standard 60(or equivalent) and meet American Water Works Association specifications, where applicable.
- c. Provisions should be made for assay of chemicals delivered.
- d. Chemicals shall not impart any toxic material to the water under recommended dosages.

5.2.2 Storage

- a. Space should be provided for:
 1. at least 30 days of chemical supply,
 2. convenient and efficient handling,
 3. dry storage conditions,
 4. a minimum of 1-1/2 truck loads storage volume where purchase is by truck load lots,
 5. protection against excessive, damaging or dangerous extremes in temperature.
- b. Cylinders of chlorine shall be:
 1. isolated from operating areas,
 2. restrained in position to prevent upset,
 3. stored inside for sufficient time before being connected to chlorinator that temperature has been approximately equalized,
 4. provided shade from direct sun and given physical security if stored outside of building.
- c. **Liquid chemical storage tanks must:**
 1. **have a liquid level indicator,**
 2. have an overflow and a receiving basin or drain capable of receiving accidental spills or overflows,
 3. provide for protection against freezing and/or loss from solution due to temperature drop.
- d. Special precautions must be taken with:

1. sodium chlorite, to eliminate any danger of explosion;
 2. activated carbon, which is a potentially combustible material, requiring isolated, fireproof storage and explosion-proof electrical outlets, lights and motors in areas of dry handling.
 3. calcium hypochlorite and potassium permanganate, which may ignite spontaneously on contact with combustible substances;
 4. hydrofluosilicic acid, which is extremely corrosive. Fumes or spillage may damage equipment or structures.
 5. liquid caustic (50% sodium hydroxide solution) which is hazardous and may be lost from solution at low temperature.
 6. gaseous chlorine (see Sections 5.3.4-5.4).
- e. Chemicals shall be stored in covered or unopened shipping containers, unless the chemical is transferred into an approved covered storage unit.
- f. Solution storage or day tanks supplying feeders directly should have sufficient capacity for one day of operation.
- g. Acid storage tanks must be vented to the outside atmosphere, but not through vents in common with day tanks.

5.2.3 Handling

- a. Provisions shall be made for
1. measuring quantities of chemicals used to prepare feed solutions, and
 2. for easy calibration of solution pumps measured from the suction side.
- b. Storage tanks and pipelines for liquid chemicals shall be specific to the chemicals and not for alternates.
- c. Chemicals that are incompatible shall not be fed, stored or handled together.
- d. Provisions must be made for the proper transfer of dry chemicals from shipping containers to storage bins or hoppers, in such a way as to minimize the quantity of dust which may enter the room in which the equipment is installed; control should be provided by use of:
1. vacuum pneumatic equipment or closed conveyer systems, or
 2. facilities for emptying shipping containers in special enclosures, or
 3. exhaust fans and dust filters which put the hoppers or bins under negative pressure.
- e. Precautions shall be taken with electrical equipment to prevent explosions, particularly in the use of sodium chlorite and activated carbon.
- f. Acids shall: