Small Water Systems

Course # 2001

Part 2 of 2

Department of Environment & Conservation

Fleming Training Center

Your Partner in Clean Water

Updated 12/2/2019

Section 10

Regulations

COMMUNITY

PUBLIC WATER SYSTEMS

DESIGN CRITERIA

Division of Water Supply

Tennessee Department of Environment and Conservation

2008

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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.

j. have provisions for sand or gravel removal,

3.1.4 Impoundments and Reservoirs

a. Site preparation should provide for:

1. removal of brush and trees to high water elevation,

2. protection from floods during construction,

3. clearing and grubbing small reservoirs.

b. Construction may require:

1. approval of safety features for stability and spillway design of any structures to be obtained from the Department,

2. permit for controlling stream flow or structure on bed of navigable stream or interstate water, to be obtained from the appropriate agency.

3.2 GROUND WATER - A ground water source includes all water obtained from drilled wells or springs. Drilled wells shall meet requirements for construction and development delineated in the latest AWWA A-100 Standards. Springs shall meet the requirements for protection established by the Department on a case-by-case basis. Ground water sources must be evaluated for direct influence of surface water.

a. Drilled Wells - Two important design questions are involved. One is the provision for the proper depth to which the well casing shall be installed as a watertight conduit. The other is provision for positive sealing of the annulus between the outside of the well casing to prevent seepage of water vertically along the outside of the pipe.

1. Water tight construction of the cased portion of a well shall be carried to such depth as may be required by the Department to prevent polluted or inferior quality water from entering the well.

i. Wells completed in an unconsolidated aquifer such as sand, gravel, or what is commonly referred to as overburden shall be designed with watertight casing extending from the land surface to a depth of at least 10 feet below the lowest expected pumping level. Where the pumping level is less than 25 feet from the surface, the casing shall extend no less than 20 feet below the lowest pumping level.

ii. Wells completed in consolidated rock formations having little or no primary permeability such as limestone, dolomite, sandstone, siltstone and shale shall be designed with watertight casing extending through all overburden material and firmly seated in the bedrock. Where applicable the casing shall extend below any crevices that would release water of inferior quality into the well.

2. Provisions shall be made in the construction of a well for grouting and sealing the annular space between the borehole and the outside of the well casing. This normally means planning an oversize borehole to the proper depth to provide an annulus into which suitable grouting material can be placed. To assure a proper seal, the grout must be placed by a positive displacement method such as pumping or pressure injection from the bottom of the annulus to the top in one continuous operation.

b. Springs

1. Use of springs as a source of supply shall be considered only when it is not feasible to develop an acceptable well or surface supply.

2. Spring supplies shall be protected from entry of surface water.

3. Spring intakes shall be housed in permanent structures.

4. Spring supplies must be evaluated for direct influence of surface water. If determined to be under the direct influence of surface water, treatment must be provided in accordance with Division of Water Supply Filtration and Disinfection rules.

5. Spring supplies must be evaluated for dependable capacity during drought.

6. Downstream impacts of water withdrawals from springs must be considered and appropriate environmental permits obtained.

3.3 GENERAL WELL CONSTRUCTION REQUIREMENTS

a. Location - the Department shall be consulted as to required separation between sources of pollution and the ground water development.

b. Casing and liner pipe of wrought iron or steel:

1. shall be prime pipe meeting AWWA, ASTM, or APT standard specifications,

2. shall be surrounded by grout,

3. shall be capable of withstanding forces to which they are subjected,

4. shall have additional thickness and weight if standard thickness is not considered sufficient to assure reasonable life expectancy of well,

5. shall have welded or threaded pipe joints.

c. Pipe other than wrought iron or steel must be adaptable to the stresses to which they will be subjected during installation and to the corrosiveness of the water.

d. Packers shall be of a material that will not impart taste, odor, toxic substances or bacterial contamination to the water in the well.

e. Screens shall:

1. be constructed of material which will not be damaged by chemical action of ground water or future cleaning operations,

2. have size of openings to be based on sieve analysis, or based on size of gravel if an artificial gravel pack is installed,

3. be installed so that exposure above pumping level will not occur,

fully recovered or until sufficient data have been recovered to extrapolate full recovery.

3. The test pump shall be capable of pumping 150 percent of the desired yield of the well.

4. The pumping equipment shall be capable of operating continuously without interruption for the maximum period contemplated for the test.

5. The duration of the test depends on a number of factors including but not limited to the following:

(i) Local experience - Where wells have been operated nearby and in the same formation so that the water-yielding character of similar wells is fairly well known, the minimum period of testing shall be not less than 8 hours.

(ii) Intermittent pumping - If it is anticipated that the well will be pumped for 12 hours or less each day, the minimum period of testing shall be not less than 24 hours.

(iii) Limited draft - If the capacity of the permanent pump to be installed in the well is to be one-fourth or less of the demonstrated output of the well, the minimum period of testing shall be not less than 8 hours.

(iv) Season of the year - If the well is tested during the winter and spring months, the minimum period of testing shall be extended by 50 percent of the time otherwise required.

6. Data shall be provided to the Department's central office and appropriate basin office as follows:

(i) static water level, measurements prior to starting the pump,

(ii) pumping rates and duration of each period of pumping,

(iii) water-level measurements during test, and graph of drawdown vs. time,

(iv) recovery water level measurements, and graph of recovery vs. time,

(v) depth of pump setting,

(vi) analytical results of water samples collected during the test,

(viii) summary of determinations of well capacity, efficiency, aquifer characteristics, safe pumping rates, pump settings and water treatment needs.

g. Grouting requirements:

1. Types of grout:

(i) Concrete Grout - A mixture of Portland Cement (ASTM C150), sand and water in the proportion of at least 5 bags of cement per cubic yard of concrete to not more than 7 shall be used. Size of gravel should be no greater than 1/3 the diameter of the annular space.

(ii) Sand Cement Grout - A mixture of Portland Cement (ASTM C150), sand and water in the proportion of not more than two parts by weight of sand to one part of cement with not more than 7 gallons of water per cubic foot of cement shall be used.

(iii) Neat Cement Grout - A mixture of Portland Cement (ASTM C150) and not more than 7 gallons of water per cubic foot of cement shall be used.

The use of additives to reduce permeability, increase fluidity or control time of set may be used up to 5 percent by weight.

2. Placement of grout - To assure that grout will provide a satisfactory seal it must be introduced at the bottom of the annular space to be filled and placed in one continuous operation. Acceptable methods include the following:

(i) Tremie method - Grout material is placed by tremie pouring (after water or other drilling fluid has been circulated in the annular space sufficient to clear obstructions). The tremie method shall only be used where there is a minimum annular space of 3 inches between the outside surface of the inside casing and the inside surface of the borehole. The minimum size tremie pipe utilized shall be 2 inches inside diameter. Where concrete grout is used the minimum size tremie pipe used shall be three inches inside diameter. When making a tremie pour, the tremie pipe shall be lowered to the bottom of the zone being grouted, and raised slowly as the grout material is introduced. The tremie pipe shall be kept full continuously from start to finish of the grouting procedure with the discharge end of the tremie pipe being continuously submerged in the grout until the zone to be grouted is completed filled.

(ii) Positive placement exterior method - Grout material is placed by a positive displacement method such as pumping or forced injection by air pressure (after water or other drilling fluid has been circulated in the annular space sufficient to clear obstructions). Grout is injected in the annular space between the inner casing and the borehole. The annular space must be a minimum of 1½ inches for sand-and-cement or neat cement grout, and not less than three times the size of the largest coarse aggregate used. The grout pipe shall extend from the surface to the bottom of the zone to be grouted. The grout pipe shall have a minimum inside diameter of one inch for sand cement or neat cement grout. It shall have a minimum diameter of 1-1/2 inches for concrete grout. Grout shall be placed, from bottom to top, in one continuous operation. The grout pipe may be slowly raised as the grout is placed but the discharge end of the grout pipe must be submerged in the emplaced grout at all times until grouting is completed. The grout pipe shall be maintained full, to the surface, at all times until the completion of the grouting of the entire specified zone. In the event of interruption in the grouting operations, the bottom of the pipe should be raised above the grout level and should not be resubmerged until all air and water have been displaced from the grout pipe and the pipe flushed clean with clear water.

(iii) Positive placement - interior method - two plug - Grout is placed by the two-plug cementing method (after water or other drilling fluid has been circulated in the annular space sufficient to clear obstructions). The first spacer plug, which is a drillable plug such as a plaster type material, shall then be inserted and the casing capped. A measured volume of grout is pumped in which is a sufficient quantity to grout the casing in place. The casing is then uncapped, the second plug is inserted, and the casing recapped. A measured volume of water slightly less than the volume of the casing shall then be pumped into the casing until the second plug is pushed to the bottom of the casing, expelling the grout from the casing up and into the annular space.

The water in the casing shall be maintained constant to prevent backflow until the grout has set. Pressure shall be maintained for a minimum of 24 hours or until such time as a sample of the grout indicates a satisfactory set. Cement grout shall be used for this procedure with a minimum annular space thickness of l½ inches completely surrounding the casing. Concrete grout cannot be used with this method.

(iv) Positive placement - interior method - upper plug - Grout is placed by the upper plug casing method (after water or other drilling fluid has been circulated in the annular space sufficient to clear obstructions). A measured quantity of grout, sufficient to grout the casing in place, shall be pumped into the capped casing. Because this grout is in direct contact with the drilling fluid there will be a narrow zone of weak grout between the drilling fluid and the good grout. The casing is uncapped, and a drillable plug, constructed of plastic or other suitable material is inserted on top of the grout and the casing recapped. A measured volume of water, equal to the volume of the casing, is pumped into the casing, forcing the plug to the bottom of the casing and expelling the grout into the annular space surrounding the casing. Utilizing this method the weak grout zone at the interface of grout and drilling fluid will not be located at the critical position at the bottom of the casing. The water in the casing shall be maintained under pressure to prevent back flow until the grout has set. Pressure shall be maintained for a minimum of 24 hours or until such time as a sample of the grout indicates a satisfactory set. Neat cement or sand-cement grout is used for this procedure, with a minimum annular space opening of l½ inches completely surrounding the casing. Concrete grout cannot be used with this method.

(v) Positive placement - interior method - capped casing Grout is placed by pumping or air pressure injection through the grout pipe installed inside the casing from the casing head to a point 5 feet above the bottom of the casing (after water or other drilling fluid has been circulated in the annular space sufficient to clear obstructions). The grout pipe extends airtight, through a sealed cap on the casing head of the well casing. The casing head is equipped with a relief valve and the drop pipe is equipped at the top with a valve permitting injection. The lower end of the drop pipe and the casing is open. Clean water is injected down the grout pipe until it returns through the casing head relief valve. The relief valve is then closed and injection of water is continued until it flows from the bore hole outside of the casing to be grouted in place. This circulation of water is intended to clean the hole and condition it to better take the grout. Without significant interruption, grout is substituted for water and, in a continuous manner, injected down the grout pipe until it returns to the surface outside of the casing. A small amount of water, not to exceed 17 gallons per 100 feet of 2-inch drop pipe may be used to flush the grout pipe, but pressure shall be maintained constant on the inside of the grout pipe and the inside of the casing until the grout has set. Pressure shall be maintained for at least 24 hours, or until such time as a sample of the grout indicates a satisfactory set. Neat cement or sand-cement grout is used for this procedure with a minimum annular space of l½ inches completely surrounding the casing.

(vi) Continuous injection method - Grout is placed by the float shoe continuous injection method (after water or other drilling fluid has been circulated in the annular space sufficient to clear obstructions). The bottom of the casing is fitted with a suitable drillable float shoe equipped with a back pressure valve. Tubing or pipe is run to the float shoe to which it is connected by a bayonet fitting, left hand thread coupling, or similar release mechanism. Water or other drilling fluid is circulated through the tubing and up through the annular space outside the casing. when the annular space is clean and open, grout is pumped down the pipe or tubing and forced by continual pumping out into the annular space surrounding the casing. Pumping continues until the entire zone to be grouted is filled. The grout pipe is then detached from the float

shoe and raised to the surface for flushing. After the grout has set the float shoe, back pressure valve, and any concrete plug remaining in the bottom of the casing is drilled out. A neat cement or sand-cement grout is used for this procedure with a minimum annular space of 1.5 inches completely surrounding the casing.

(vii) Grout displacement method - The hole is filled with the estimated volume of grout required for the purpose intended. The casing fitted at the bottom with a drillable back pressure valve, metal plate, or similar seal shall be lowered through the grout to the bottom of the hole. If necessary to maintain the bottom of the casing at the bottom of the hole, the casing shall be filled with water, or drilling fluid, and in some cases by applying a load on the bottom with drill pipe. The load is maintained until the grout has set, after which the bottom plug is drilled out and the well deepened. Use of this method is limited to wells not more than 100 feet in depth.

3. Location of grout

(i) Surface formation seal - The annular space to be grouted and surrounding the permanent well casing at the upper terminus of the well, shall be not less than a nominal 2 inches. The length of the grout seal shall be whatever is necessary to prevent the entrance of surface water or undesirable subsurface water into the well. In any circumstance, the length of seal shall not be less than the minimum specified in the state or locally applicable construction code. The entire space to be grouted must be open and available to receive the grout at the time the grouting operation is performed. If a section of larger pipe (conductor pipe) is installed to keep the entire space open (in caving materials), this larger pipe must be removed, as the grout is installed, from the zone where the seal is required. The effective length of grout seal (for sanitary purposes) shall be that distance measured from the deepest limit of the seal up, to the depth of frost penetration. If a pitless adapter or unit is to be installed, the upper limit of the seal shall be one foot below the field connection of the adapter or unit.

(ii) Bottom seal grouting - Grout shall be placed in the annular space surrounding the bottom of the casing by the method specified.

(iii) Selected interval grouting - All zones containing water of unsuitable quality shall be grouted from a point at least 5 feet below, to a point at least 5 feet above the unsuitable zone. The annular space surrounding the casing between grouted zones shall be filled with sand or other suitable granular material.

(iv) Continuous grouting - Grout shall be placed in the annular space surrounding the casing by the method specified. Grouting shall be continuous from the bottom of the permanent casing to the land surface; or, where a filter pack has been installed, from the top of the pack (following development) to the land surface; or, where a well screen only has been installed, from a point 5 feet above the screen to the land surface. When a pitless adapter or unit is to be installed, the grout shall extend from such depth to within one foot of the field connection of the adapter or unit.

4. Guides or centralizers

(i) protective casing must be provided with sufficient guides or centralizers attached or welded to casing to permit unobstructed flow and uniform thickness of grout.

(ii) Guides or centralizers shall be attached to the bottom of the casing and at intervals not greater than 25 feet.

h. Plumbness and alignment requirements:

1. every well shall be tested for plumbness and alignment,

2. test method shall be clearly stated in specifications and shall be in accordance with the latest AWWA A100 standard,

3. test results shall be submitted to the Department prior to permanent pump installation.

i. Geological data shall:

1. be determined from samples collected at 10 foot intervals and at each pronounced change in formation,

2. be recorded and submitted to the Department,

3. be supplemented with information on accurate record of drillhole diameters and depths, assembled order of size and length of casings and liners, grouting depths, formations penetrated, and water levels.

4. be supplemented with complete pumping test data.

j. Upper terminal of well, requirements:

1. protective casing for all ground water sources must project not less than 6 inches, and preferably 12 inches, above pumphouse floor or cover installed,

2. site not subject to flooding must have floor of pumphouse at least one foot above original ground surface,

3. site subject to flooding must have the floor of the pumphouse at least two feet above the highest known flood elevation and be surrounded by earth fill as required by the Department.

k. Capping requirements:

1. properly fitted, firmly driven, solid wooden plug is the minimum acceptable method of capping a well until pumping equipment is installed,

2. a welded metal plate is preferred for capping a well,

3. well must be protected during construction.

l. Bacteriological quality:

1. every new, modified or reconditioned ground water source shall be disinfected upon completion of construction and after placement of final pumping equipment in accordance with AWWA A100 standards,

2. one or more water samples shall be submitted to a state certified laboratory for bacteriological analysis, with the results reported to the Department.

m. Chemical quality:

1. every new, modified or reconditioned ground water source shall be examined for chemical characteristics by tests of a representative sample in a state-certified laboratory with the results reported to the Department,

2. samples shall be collected and tested as soon as practical,

3. determination of pH and C02 shall be made in the field,

4. samples for iron analysis must be acidified,

5. in addition to standard tests, examination shall be made for hydrogen sulfide and methane where these gases are suspected.

n. Water level measurement:

1. provisions shall be made for periodic measurement of static and pumping water levels in completed production wells,

2. installation shall be made in such manner as to prevent entrance of foreign material,

3. reference data shall be stamped on plate affixed to pump base.

o. Well abandonment:

1. test wells and ground water sources which are not in use shall be sealed by such methods as to restore the controlling geological conditions which existed before they were constructed,

2. Wells to be abandoned shall:

(i) be sealed to prevent exchange of water from one geological strata to another, ideally mimicking the existing geological strata through which the well was drilled,

(ii) be filled with clay and sand, clay and concrete, or other suitable impermeable material,

(iii) if filled with concrete the latter shall not be dropped through water.

p. Observation wells:

1. shall be constructed in accordance with the requirements for permanent wells if to remain in service after completion of ground water supply,

2. shall be protected at the upper terminal to preclude entrance of foreign material.

10. means to observe the wastewater during backwashing,

11. construction to prevent cross-connection,

12. depth of filter media shall be the same as for gravity filters.

4.3 PACKAGE TREATMENT PLANTS, MEMBRANES AND OTHER TECHNOLOGIES - Will be reviewed on a case-by-case basis based on demonstrated performance criteria.

4.3.1 Package Treatment Plants – may be acceptable for source waters that are generally low in turbidity and do not experience large or frequent turbidity spikes. Filter backwash and clarifier flush/rinse frequencies along with water production efficiency must be considered for each application. Adequate detention times must be evaluated for oxidation processes, coagulation, TOC reduction and taste & odor control.

4.3.2 Membrane Filtration – is generally acceptable for turbidity/particulate removal. Each membrane module must have a continuous filtrate turbidity monitor and provisions for direct integrity testing. Other treatment processes such as coagulation, flocculation and oxidation must be used in conjunction with membranes where dissolved constituents such as TOC, iron and manganese are present in sufficient quantities to require treatment/removal. Clarification/sedimentation should be provided prior to membrane filtration where turbidity and suspended solids are very high in the raw water.

4.3.3 Cartridge and Bag Filters – will be considered for approval on a case-by-case basis depending on raw water quality and the size of the water system.

4.4 DISINFECTION - Chlorine is the preferred disinfecting agent. Other agents will be considered by the Department, provided reliable feeding equipment is available and testing procedures for a residual are recognized in "Standard Methods for the Examination of Water and Wastewater," latest edition. Continuous disinfection is recommended for all water supplies and is required at all community public water systems serving more than 50 connections or 150 persons.

4.4.1 Equipment

a. Type - Solution feed gas type chlorinator and hypochlorite feeders of the positive displacement type are acceptable (see Part 5). Alternative chlorine feeders such as tablet chlorinators may be considered for some applications.

b. Capacity - The chlorinator capacity shall be such that a free chlorine residual of at least 2 mg/L can be attained in the water after a contact time of at least 30 minutes when maximum flow rates coincide with anticipated maximum chlorine demands. The equipment shall be of such design that it will operate accurately over the desired feeding range.

c. Dual Chlorination - Two chlorinator shall be provided and operated simultaneously such that each feeds approximately half the chlorine requirement.

d. Spare Parts - Spare parts shall be provided so that either unit could be equipped to supply the entire chlorine requirement.

e. Automatic Switchover - Automatic switchover of chlorine cylinders should be provided where necessary to assure continuous disinfection. This does not take the place of having dual chlorination.

f. Automatic Proportioning - Automatic proportioning chlorinator will be required where the rate of flow either is not reasonably constant or where the quality of the water is subject to rapid changes.

4.4.2 Contact Time and Point of Application

a. Due consideration shall be given to the contact time of the chlorine in water with relation to pH, ammonia, taste producing substances, temperature, bacterial quality, trihalomethanes formation potential and other pertinent factors. Chlorine should be applied at a point which will provide adequate contact time. All basins used for disinfection must be designed to minimize short-circuiting.

b. At plants treating surface water, provisions should be made for applying chlorine to the raw water, top of filters, and filtered water.

c. At plants treating groundwater, provision should be made for applying chlorine to the clearwell inlet and the high lift pump suction.

d. Free residual (breakpoint) chlorination is required; 30 minutes contact time should be provided for ground waters and 2 hours for surface waters.

4.4.3 Chlorinator Piping

a. The water supply piping shall be designed to prevent contamination of the treated water supply by source of questionable quality.

b. Pipe material - The pipes carrying elemental liquid or dry gaseous chlorine under pressure and liquid chlorine 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.

c. Backflow Protection - All chlorine solution lines feeding into water having less than a full cycle of treatment (ahead of filters) shall be vented to the outside atmosphere. This venting shall be provided in such a manner that backflow into treated waters is prevented. Vacuum breakers and other mechanical devices shall not be substituted for a vent. Vents for chlorine lines shall:

1. be the same size as the solution line piping,

2. be connected to the solution line at a point where it is elevated a minimum of 6 feet above the maximum water level in the receiving basin,

3. have no shut off valves,

4. be extended to a high enough elevation outside the building that overflow from the vent tube during surges is prevented,

5. have a nylon or other suitable insert screen covering the vent which has been turned downward near its end,

6. not be subject to back pressures.

d. Distribution Panels - The Department recommends the use of chlorine solution distribution panels to ease the change of chlorine solution application points or the change of chlorine feed equipment. If a distribution panel is installed all chlorine solution lines except those feeding into the clear well or filter effluent must be vented as specified in section 4.4.3c. This venting is to be located between the distribution panel discharge and the point of application. Where chlorine solution from one chlorine feed unit is to be split to feed at more than one application point, a suitable rotameter shall be installed to allow accurate proportioning of the total flow among the application points.

4.4.4 Housing - Adequate housing must be provided for the chlorination equipment and for storing the chlorine supply (See Section 5.3).

4.4.5 Chlorine Dioxide – may be used for oxidation, disinfection and/or treatment of tastes and odors. Chlorine dioxide may be considered in conjunction with other treatment processes for meeting surface water treatment requirements or as an alternative to raw water chlorination where disinfection by-products must be reduced. Water systems that add chlorine dioxide must monitor for chlorine dioxide residual and chlorite.

4.4.6 UV Light - may be used for disinfection at water treatment plants in conjunction with chlorination and other treatment processes to meet surface water treatment requirements. UV light may also be used at groundwater treatment plants. Water systems using UV light must also provide chlorination for residual disinfection.

4.4.7 Ozone – may be used at water treatment plants for oxidation, disinfection, and meeting surface water treatment requirements. Water systems using ozone must monitor for bromate.

4.4.8 Hydrogen Peroxide – may be used at water treatment plants for raw water oxidation and/or disinfection. Hydrogen peroxide may be used to replace raw water chlorination where disinfection by-products must be reduced.

4.4.9 Permanganates – potassium permanganate or sodium permanganate may be used for raw water oxidation and/or disinfection. Permanganates may be used to replace raw water chlorination where disinfection by-products must be reduced.

4.4.10 Chloramines – will be considered for use in water distribution systems if other methods to reduce disinfection by-products have failed to achieve compliance. Effects of chloramination on water chemistry, corrosivity and microbiological water quality must be evaluated.

4. 5 SOFTENING - In all but a very few locations in Tennessee softening of available raw water is not needed. Unless there is a demonstrated need, softening should be avoided because of the additional expense and because of the increased sodium content of the water when ion exchange softening is used.

4.5.1 Lime-Soda Process - The applicable design standards for mixing, flocculation and sedimentation are the same for the lime-soda process as for conventional clarification. Where softening is included as a treatment process in conjunction with clarification, the clarification criteria shall govern(see sections 4.1.2, 4.1.3 and 4.1.4). For criteria pertaining to softening with solids contact units see section 4.1.5.

a. Aeration - Determinations should be made for the C02 content of the raw water. When concentrations exceed 10 mg/L, the economics of removal by aeration as opposed to removal with lime should be considered (See Section 4.6).

b. Stabilization - Equipment for stabilization of water softened by the lime-soda process is required.

c. Sludge Collection - Mechanical sludge removal equipment shall be provided in the sedimentation basin (see section 4.11 for sludge disposal).

d. Sludge Disposal - Provisions must be included for proper disposal of softening sludges(See Section 4.11).

e. Disinfection - The use of excess lime shall not be considered an acceptable substitution for chlorination or any other approved method of disinfection (See Section 4.4).

4.5.2 Cation Exchange Process - Iron, manganese, or a combination of the two, in the oxidized state or unoxidized state, should not exceed 0.3 mg/L in the water as applied to the ion exchange resin. Pretreatment is required when the content of iron, manganese, or a combination of the two, is 1 mg/L or more.

a. Design - The units may be of pressure or gravity type, using automatic or manual regeneration. Automatic regeneration is suggested for small plants.

b. Exchange Capacity - The design capacity for hardness removal should not exceed 20,000 grains per cubic foot when resin is regenerated with 0.3 pounds of salt per kilogram of hardness removed..

c. Depth of Media - The depth of the exchange material should not be less than 3 feet.

d. Flow Rates - the rate of softening should not exceed 7 gallons per square foot per minute and the backwash rate should be 6 to 8 gallons per square foot per minute. Rate-of-flow controllers or the equivalent must be installed for the above purposes.

e. Freeboard - The freeboard will depend upon the specific gravity of the media. Generally, the washwater collector should be 24 inches above the top of the media.

f. Underdrains and Supporting Gravel - The bottoms strainer systems, and support for the exchange material shall conform to criteria provided for rapid rate gravity filters (See Sections 4.2.lg and 4.2.1h).

g. Brine Distribution - Facilities should be included for even distribution of the brine over the entire surface.

h. Cross Connection Control - Backwash, rinse and air relief discharge pipes should be installed in such a manner as to prevent any possibility of back-siphonage.

i. Bypass - A bypass shall be provided around softening units to produce a blended water of desirable hardness. Meters should be installed on the bypass line and on each softener unit. An automatic proportioning or regulating device and shut-off valve should be provided on the bypass line. In some installations it may be necessary to treat the bypassed water to obtain acceptable levels of iron and/or manganese in the finished water.

j. Additional Limitations - Waters having 1.0 units or more turbidity should not be applied directly to the cation exchange softener. Silica gel materials should not be used for waters having a pH above 8.4 or containing less than 6 mg/L silica and should not be used when iron is present. The cation exchange material shall be a type that is not damaged by residual chlorine. Phenolic resin should not be used.

k. Sampling Taps - Smooth-nose sampling taps must be provided for the collection of representative samples for both bacteriological and chemical analyses. The taps shall be

located to provide for sampling of the softener influent, softener effluent, and the blended water. The sampling taps for the blended water shall be at least 20 feet downstream from the point of blending. Petcocks are not acceptable as sampling taps. Sampling taps should be provided on the brine tank discharge piping.

1. Brine and Salt Storage Tanks

    1. Salt dissolving or brine tanks and wet storage tanks must be covered and must be corrosion resistant.

    2. The make-up water inlet must be protected from back siphonage. Water for filling the tank should be distributed over the entire surface by pipes above the maximum brine level in the tank. The tanks should be provided with an automatic declining level control system on the make-up water line.

    3. Wet salt storage basins must be equipped with manholes or hatchways for access and for direct dumping of salt from truck or railcar. Openings must be provided with raised curbs and watertight covers having overlapping edges similar to those required for finished water reservoirs.

    4. Overflows, where provided, must be turned down, have a proper free fall discharge and be protected with corrosion resistant screens or self-closing flap valves.

    5. Two wet salt storage tanks or compartments designed to operate independently should be provided.

    6. The salt is to be supported on graduated layers of gravel under which is a suitable means of collecting the brine.

    7. Alternative designs which are conducive to frequent cleaning of the wet salt storage tank may be considered.

m. Storage Capacity - Salt storage basins should have sufficient capacity to store in excess of l-1/2 carloads or truckloads of salt, and to provide for at least 30 days of operation.

n. Stabilization - Stabilization for corrosion control shall be provided (See Section 4.9).

o. Waste Disposal - Suitable disposal must be provided for brine waste (See Section 4.11).

p. Construction Material - Pipes and contact materials must be resistant to the aggressiveness of salt. Plastic and red brass are acceptable piping material. Steel and concrete must be coated with a non-leaching protective coating which is compatible with salt and brine.

q. Housing - Salt Storage tanks and feed equipment should be enclosed and separated from other operating areas in order to prevent damage to equipment.

4.6 AERATION - Aeration treatment devices as described herein may be used for oxidation, separation of gases or for taste and odor control.

4.6.1 Natural Draft Aeration - Design should provide that:

a. water is distributed uniformly over the top tray,

b. water is discharged through a series of three or more trays with separation of trays not less than 12 inches,

c. trays are loaded at a maximum rate of 20 gpm for each square foot of the top tray area,

d. trays have heavy wire mesh or perforated bottoms,

e. perforations are 3/16 to 1/2 inches in diameter, spaced 1 to 3 inches on centers, when perforations are used,

f. 8 to 12 inches of inert media are used, such as coke or limestone, that will not disintegrate due to freezing cycles,

g. aerated water receives disinfection treatment,

h. sufficient trays to reduce carbon dioxide to 10-15 mg/L,

i. location to take advantage of prevailing wind direction.

4.6.2 Forced or Induced Draft Aeration - Devices shall be designed to:

a. provide adequate countercurrent of air through enclosed aeration column,

b. be insect proof and lightproof,

c. be such that air introduced into column shall be screened through insect tight screen and be as free of dust as possible,

d. insure that water outlet is adequately sealed to prevent unwanted loss of air,

e. be such that sections of the aerator can be easily reached and removed for maintenance.

4.6.3 Other Methods of Aeration - Other methods of aeration may be used if applicable to the treatment needs. Such methods include but are not restricted to spraying, diffused air and mechanical aeration. The treatment processes must be designed to meet the particular needs of the water to be treated and are subject to the approval of the Department.

4.6.4 Wind Protection - Aerators that discharge through the atmosphere should be protected by being placed in a louvered enclosure so designed as to provide easy access to the interior.

4.6.5 Protection from Contamination - Aerators that are used for oxidation or removal of dissolved gases from waters that will be given no further treatment other than chlorination shall be protected from contamination from insects and birds.

4.6.6 Bypass - A bypass shall be provided for all aeration units.

4.6.7 Corrosion Control - The aggressiveness of the water after aeration should be determined and corrected by additional treatment, if necessary (See Section 4.9).

4. 7 IRON AND MANGANESE CONTROL - Iron and manganese control, as used herein, refers solely to treatment processes designed specifically for this purpose. The treatment process used will depend upon the character of the raw water. The selection of one or more treatment processes must meet specific local conditions as determined by engineering investigations, including chemical analysis of representative

samples of water to be treated, and receive the approval of the Department. It may be necessary to operate a pilot plant in order to gather all information pertinent to the design.

4.7.1 Removal by Oxidation, Detention and Filtration.

a. Oxidation - Oxidation may be by aeration, as indicated in Section 4.6, or by chemical oxidation with chlorine or potassium permanganate.

b. Detention - A minimum detention of 20 minutes shall be provided following oxidation by aeration in order to insure that the oxidation reactions are as complete as possible. The detention basin shall be designed as a holding tank with no provisions for sludge collection but with sufficient baffling to prevent short circuits. Sedimentation basins should be provided when treating water with high iron and/or manganese content or where chemical coagulation is used to reduce the load on the filters.

c. Filtration - Filters shall conform to Section 4.2, except nominal rate shall not exceed 3 gpm/ft2 of filter area.

4.7.2 Removal by Lime-Soda Process - See Section 4.5.1.

4.7.3 Removal by Units Using Continuous Potassium Permanganate "Regeneration" - This process, consisting of a continuous feed of potassium permanganate to the influent of a manganese green-sand filter, is more applicable to the removal of manganese than to the removal of iron, due to economic considerations. The following apply:

a. The permanganate should be applied as far ahead of the filter as practical.

b. other oxidizing agents or processes such as chlorination or aeration may be used prior to the permanganate feed to reduce the cost of the chemical.

c. Anthracite media cap of at least six inches shall be provided over manganese treated greensand.

d. Normal filtration rate is 3 gpm/ft2.

e. Normal wash rate is 8 to 10 gpm/ft2.

f. Air washing should be provided.

g. Sample taps should be provided:

1. prior to application of permanganate,

2. immediately ahead of filtration,

3. at point between anthracite coal media and the manganese treated greensand,

4. halfway down the manganese treated greensand,

5. at the filter effluent.

4.7.4 Sequestration by polyphosphates - This process is only suitable only for concentrations of iron and manganese that are below the respective MCL’s. The dosage should not exceed 10 mg/L. Where

phosphate treatment is used, satisfactory chlorine residuals should be maintained in the distribution system.

a. Feeding equipment shall conform to requirements of Part 5.

b. Stock phosphate solution must be kept covered and disinfected by carrying approximately 10 mg/L chlorine residual.

c. The point of application should be prior to any aeration or oxidation if no iron or manganese removal treatment is provided.

d. Phosphate chemicals must be food grade and meet or exceed AWWA Specifications.

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 C02 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 returned to the head of the treatment plant or to an alternate location approved by the Division of Water Supply. Recycled water should be settled/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.l.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).

7. on-site generation of sodium hypochlorite. Provisions must be included for dilution and venting of potentially explosive hydrogen gas.

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:

1. be kept in closed, acid-resistant shipping containers or storage units;

2. not be handled in open vessels, but should be pumped in undiluted form from original containers, through suitable hose, to the point of treatment or to a covered day tank.

g. Carts, elevators and other appropriate means shall be provided for lifting chemical containers to minimize excessive lifting by operators.

h. Provisions shall be made for disposing of empty bags, drums or barrels, by approved procedures which will minimize exposure to dusts.

5.3 HOUSING

5.3.1 Structures, rooms and areas accommodating chemical feed equipment shall provide convenient access for

a. servicing and repair,

b. observation of operation.

5.3.2 Floor surfaces shall be smooth and impervious, slip-proof and well-drained with 2.5% slope, minimum.

5.3.3 open basins, tanks and conduits shall be protected from chemical spills or accidental drainage.

5.3.4 Chlorine gas feed and storage shall be:

a. enclosed and separated from other operating areas in order to prevent injury to personnel and damage to equipment; separate chlorine feed and storage rooms may be required for large installations;

b. provided with an inspection window to permit viewing of the interior of the room and the equipment;

c. provided with doors opening outward with a crash bar, assuring ready means of exit; doors opening to the building exterior only shall be provided.

d. provided with locks to prevent general public access.

5.3.5 Where chlorine gas is used, ventilation for each room shall be provided for one complete air change per minute; and

a. The air outlet from the room shall be near the floor and the point of discharge shall be so located as not to contaminate air inlets to any rooms or structures, or adversely affect the surrounding environment;

b. air inlets shall be through louvers near the ceiling, and temperature controlled to prevent adverse affect on chlorinator;

c. switches for fans and lights shall be outside of the room, at the entrance; signal light indicating fan operation shall be provided at each entrance when fan can be controlled from more than one point;

d. vents from feeders and storage shall discharge to the outside atmosphere, above grade.

5.3.6 Chlorinator rooms should be heated to 60 degrees F, but should be protected from excess heat; cylinders and gas lines should be protected from temperatures above that of the feed equipment.

5.3.7 Gaseous feed chlorine installations shall be equipped with a gas detection device connected to an audible alarm to prevent undetected, potentially dangerous leakage of chlorine gas.

5.4 OPERATOR SAFETY

a. Gases from feeders, storage and equipment exhausts shall be conveyed to the outside atmosphere, above grade and remote from air intakes.

b. Special provisions shall be made for ventilation of chlorine feed and storage rooms (see Section 5.3.5).

c. A M-S-A air mask, Model 401, Catalog No. 01-95066 or equal, complete with storage cabinet and 30 minute air cylinder shall be provided along with a 30 minute backup cylinder to prevent loss of utility while the primary air cylinder is being refilled or tested. The air mask shall be cabinet-mounted close by but not inside the chlorine room, and shall be easily accessible to the operator.

d. A bottle of ammonium hydroxide shall be available for chlorine leak detection during cylinder change.

e. All gaseous feed chlorine installations shall be equipped with appropriate leak repair kits.

f. At least one pair of rubber gloves with long gauntlets, a dust respirator of a type approved by the U.S. Bureau of Mines for toxic dusts, and an apron or other protective clothing shall be provided for each operator in any shift who will handle dry chemicals.

g. Rubber gloves with long gauntlets, rubber roots, goggles, rubber apron or other suitable protective clothing shall be provided for each operator preparing chemical solutions, or cleaning up spills.

h. Facilities shall be provided for washing of face, gloves and protective equipment.

i. A safety shower shall be provided in areas where hazardous chemicals are handled.

j. On-site generation of sodium hypochlorite must include dilution and venting of hydrogen gas.

Part 7 - PUMPING FACILITIES

7.0 GENERAL - Pumping facilities shall be designed to maintain the sanitary quality of pumped water. Subsurface pits or pump rooms and inaccessible installations should be avoided. No pumping station shall be subject to flooding.

7.1 LOCATION - The pumping station shall be so located that the proposed site will meet the requirements of the sanitary protection of the water quality, hydraulics of the system and be protected against interruption of service by fire, flood or any other hazard.

7.1.1 Site Protection - The station shall be:

a. elevated to a minimum of one foot above the 100-year flood elevation, or protected to such elevation;

b. accessible at all times unless permitted to be out of service for period of inaccessibility;

c. graded around station so as to lead surface drainage away from the station;

d. protected to prevent vandalism and entrance by unauthorized persons or animals.

7.2 GROUND WATER FACILITIES - Where pumping facilities are used, wells and springs shall be vented by properly hooded and screened pipe extending at least 12 inches above the pump floor. Where necessary, provision shall be made for lubricating the pump from a point at least 6 inches above the top of the well cover, by means which will prevent contamination of the water supply.

7.2.1 Drilled Wells - Pumping stations located over drilled wells shall;

a. have riser pipe or casing extending at least 6 inches, and preferably 12 inches, above the floor, and be equipped with flange or suitable stuffing box;

b. have riser pipe or casing firmly connected to the pump structure to provide a water tight connection.

c. have base of pump not less than 6 inches above pump room floor;

d. have pump foundation and base designed to prevent water from coming into contact with the joint.

7.2.2 Submersible Pumps - Where a submersible pump is used, the top of the casing shall be effectively sealed against entrance of water under all conditions of vibration or movements of conductors or cables.

7.2.3 Discharge Piping - Discharge piping should be provided with means to pump to waste but shall not be directly connected to a sewer. The discharge line shall:

a. have control valves located above pump floor;

b. be protected against freezing;

c. be valved to permit testing and control of each well;

d. have watertight joints;

e. have all exposed valves protected.

7.3 SURFACE WATER FACILITIES - Pump stations normally associated with surface water sources, either as raw or finished water pump stations, shall:

a. have adequate space for the installation of additional units if needed, and for the safe servicing of all equipment;

b. be of durable character, fire and weather resistant and with outward opening doors;

c. have floor elevation of at least 6 inches above finished grade;

d. have underground structure waterproofed;

e. have all floors drained without impairing the quality of water being handled and if equipment is contained on the floor, the floor shall have sufficient slope to drain adequately.

f. provide suitable outlet for drainage from pump glands without discharging onto the floor.

7.3.1 Suction Well - Suction wells shall:

a. be watertight;

b. have floors sloped to permit removal of water and entrained solids;

c. be covered or otherwise protected against contamination; including pump lubricant.

7.3.2 Equipment Servicing - Pump facilities shall be provided with;

a. crane-ways, hoist beams, eye bolts, or other adequate facilities for servicing or removal of pumps, meters or heavy equipment;

b. openings in floors, roofs or wherever else needed for removal of heavy or bulky equipment;

c. a convenient tool board or other facilities as needed for proper maintenance of the equipment.

7.3.3 Stairways and Ladders - Stairways or ladder shall

a. be provided between all floors, in pits or compartments which must be entered.

b. have handrails on both sides, and treads of non-slip material.

Stairs are preferred in areas where there is frequent traffic or where supplies are transported by hand. They shall have risers not exceeding 9 inches and treads wide enough for safety.

7.3.4 Heating - Provision shall be made for adequate heating for:

a. comfort of the operator;

b. the safe and efficient operation of the equipment.

In pump houses not occupied by personnel, only enough heat need be provided to prevent freezing of equipment or treatment process.

7.3.5 Ventilation - Adequate ventilation shall be provided for all pumping stations. Forced ventilation of at least 6 changes of air per hour shall be provided for:

a. all rooms, compartments, pits and other enclosures below grade floor;

b. any area where unsafe atmosphere may develop or where excessive heat may be built up.

7.3.6 Dehumidification - In areas where excess moisture could cause hazards to safety or damage to equipment means for dehumidification shall be provided.

7.3.7 Lighting - Pump stations shall be adequately lighted throughout. All electrical work shall conform to the requirements of the American Insurance Association and related agencies and to relevant State and/or local codes.

7.3.8 Sanitary and Other Conveniences - Pumping stations which are manned for extended periods shall be provided with potable water, lavatory and toilet facilities. Plumbing must be so installed as to prevent contamination of a public water supply. Wastes shall be discharged in accordance with Section 4.11 of these standards.

7.3.9 Pumps - At least 2 pumping units shall be provided. Each pumping unit shall be capable of carrying the peak demand. If more than 2 units are installed, they shall have sufficient capacity so that any 1 pump can be taken out of service and the remaining pumps are capable of carrying the peak demand. The pumping units shall:

a. have ample capacity to supply the peak demand without dangerous overloading;

b. be driven by a prime mover able to operate against the maximum head and air temperature which may be encountered;

c. have spare parts and tools readily available.

3600 RPM pumps are not desirable and should be avoided if at all possible.

7.3.10 Suction Lift - Suction lift pumps will be considered on an individual basis based on justification of design engineer.

7.4 BOOSTER PUMPS - Booster pumps shall be located or controlled so that:

a. they will not produce negative pressure anywhere in the distribution system;

b. the pressure in the suction line shall be maintained at or above 20 psi by the use of a pressure sustaining valve or low pressure cutoff device.

c. automatic or remote control devices shall have a range between the start and cutoff pressure which will prevent excessive cycling.

7.4.1 In-line Booster Pumps - In addition to the other requirements of this section, in-line booster pumps shall be accessible for servicing and repairs.

7.4.2 The criteria in this section also apply to fire pumps.

7.4.3 Booster pumps shall not serve more than 50 service connections unless gravity storage is provided or service pressure can be maintained above 20 psi without the pumps running.

7.5 AUTOMATIC AND REMOTE CONTROLLED STATIONS - All automatic stations should be provided with automatic signaling apparatus which will report when the station is out of service. All remote controlled stations shall be electrically operated and controlled and shall have signaling apparatus of proven performance. Installation of electrical equipment shall conform with the National Electrical Code.

7.6 APPURTENANCES

7.6.1 Valves - Pumps shall be adequately valved to permit satisfactory operation, maintenance and repair of the equipment. If foot valves are necessary they shall have a net valve area of at least 2½ times the area of the suction pipe and they shall be screened. Each pump shall have a positive acting check valve on the discharge side between the pump and shutoff valve.

7.6.2 Piping - In general, piping shall:

a. be designed so that the friction head will be minimized;

b. not be subject to contamination;

c. have watertight joints;

d. be protected against surge or water hammer;

e. be such that each pump has an individual suction line or the lines shall be so manifolded that they will insure similar hydraulic and operation conditions.

7.6.3 Gauges and Meters - Each pump shall:

a. shall have a standard pressure gauge on its discharge line;

b. shall have a compound gauge on its suction line;

c. shall have recording gauges in larger stations;

d. should have a means for measuring the discharge.

The larger stations should have indicating, totalizing and recording metering of the total water pumped.

7.6.4 Water Seals - Water seals shall not be supplied with water of a lesser sanitary quality than that of the water being pumped.

7.6.5 Controls - Pumps, their prime movers and accessories, shall be controlled in such a manner that they will operate at rated capacity without dangerous overload. Where two or more pumps are installed, provision shall be made for proper alternation. Provision shall be made to prevent operation of the pump during the backspin cycle. Electrical controls should be located above grade.

7.6.6 Power - When power failure would result in cessation of minimum essential service, power supply shall be provided from at least two independent sources or standby or auxiliary source shall be provided.

7.6.7 Auxiliary Power Supply - When automatic pre-lubrication of pump bearings is necessary, and an auxiliary power supply is provided, the pre-lubrication line shall be provided with a valved by-pass around the automatic control.

Part 8 - FINISHED WATER STORAGE

8.0 GENERAL - The materials and designs used for finished water storage structures shall provide stability and durability as well as protect the quality of the stored water. Steel structures shall follow the current AWWA standards concerning steel tanks, standpipes, reservoirs, and elevated tanks wherever they are applicable. Prestressed concrete tanks shall meet applicable AWWA Standards. Other materials of construction are acceptable when properly designed to meet the requirements of this part.

8.0.1 Location

a. The bottom of ground-level reservoirs should be placed at the normal ground surface and above maximum flood level.

b. Where the bottom must be below normal ground surface, it should be placed above the ground water table. Sewers, drains, standing water, and similar sources of contamination must be kept at least 50 feet from the reservoir. Mechanical-joint water pipe, pressure tested in place to 50 psi without leakage, may be used for gravity sewers at lesser separations.

c. The top of a ground-level reservoir should not be less than 2 feet above normal ground surface and any possible flood level. Clearwells constructed under filters may be excepted from this requirement when the total design gives the same protection.

8.0.2 Protection - All new finished water storage structures shall have suitable watertight roofs or covers which exclude birds, animals, insects, and excessive dust.

8.0.3 Protection from Trespassers - Fencing, locks on access manholes, and other necessary precautions shall be provided to prevent trespassing, vandalism, and sabotage.

8.0.4 Drains - No drain on a water storage structure may have a direct connection to a sewer or storm drain. Splash pad and drainway shall be provided to prevent erosion.

8.0.5 Overflow - The overflow pipe of a water storage structure should be brought down near the ground surface and discharged over a drainage inlet structure or a splash plate and flow onto a drainway which is rip-rapped or otherwise protected to minimize erosion. No overflow may be connected directly to a sewer or storm drain.

a. When an internal overflow pipe is used, it shall be located in the access tube.

b. The overflow of a ground-level structure shall be high enough above normal or graded ground surface to prevent the entrance of surface water.

c. The overflow shall be protected with a twenty-four mesh non-corrodible screen and a flap valve.

8.0.6 Access - Finished water storage structures shall be designed with reasonably convenient access to the interior for cleaning and maintenance. Manholes on scuttles above waterline:

a. shall be framed at least 4 inches, and preferably 6 inches, above the surface of the roof at the opening; on ground-level structures manholes should be elevated 24 to 36 inches above the top or covering sod;

b. shall be fitted with a solid watertight cover which overlaps the framed opening and extends. down around the frame at least 2 inches;

c. should be hinged at one side;

d. shall have a locking device,

e. shall be a minimum of 20 inches in diameter or equivalent.

8.0.7 Vents - Finished water storage structures shall be vented by special vent structures. Open construction between the side wall and roof is not permissible. These vents:

a. shall prevent the entrance of surface water;

b. shall exclude birds and animals;

c. shall exclude insects and dust, as much as this function can be made compatible with effective venting; for elevated tanks and standpipes, 4-mesh non-corrodible screen may be used;

d. shall, on ground-level structures, terminate in an inverted U construction, the opening of which is 24 to 36 inches above the roof of sod and is covered with 24-mesh non-corrodible screen cloth.

8.0.8 Roof and Sidewall - The roof and sidewalls of all structures must be watertight with no openings except properly constructed vents, manholes, overflows, risers, drains, pump mountings, control ports, or piping for inflow and outflow.

a. Any pipes running through the roof or sidewall of a finished water storage structure must be welded or properly gasketed in metal tanks, or should be connected to standard wall castings which were poured in place during the forming of a concrete structure; these wall castings should have flanges embedded in the concrete.

b. openings in a storage structure roof or top, designed to accommodate control apparatus or pump columns, shall be curbed and sleeved with proper additional shielding to prevent the access of surface or slop water to the structure.

c. Valves and controls should be located outside the storage structure so that valve stems and similar projections will not pass through the roof or top of the reservoir.

8.0.9 Drainage for Roof or Cover - The roof or cover of the storage structure should be well drained, but downspout pipes shall not enter or pass through the reservoir; parapets, or similar construction which would tend to hold water and snow on the roof will not be approved.

8.0.10 Safety - The safety of employees must be considered in the design of the storage structure. As a minimum, such matters shall conform to pertinent laws and regulations.

a. Ladders, ladder guards, balcony railings, and safe location of entrance hatches shall be provided where applicable.

b. Elevated tanks with riser pipes over 8 inches in diameter shall have protective bars over the riser openings inside the tank.

8.0.11 Freezing - All finished water storage structures and their appurtenances, especially the riser pipes, overflows, and vents, shall be designed to prevent freezing which will interfere with proper functioning.

8.0.12 Grading - The area surrounding a ground-level structure should be graded in a manner that will prevent surface water from standing within 50 feet of the structure.

8.0.13 Silt stop - The discharge pipe of the reservoir shall be located in a manner that will prevent the flow of sediment into the distribution systems. Either a permanent or removable silt stop shall be provided at least 4 inches above the bottom of the storage structure.

8.0.14 Painting and/or Cathodic Protection - Proper protection should be given to metal surfaces by paints or other protective coatings, by cathodic protective devices, or by both.

a. Paint systems consistent with current American Water Works Association standards, or otherwise acceptable to the Department shall be used. All paints must be acceptable to FDA and EPA for contact with potable water.

b. Cathodic protection should be designed and installed by competent technical personnel.

8.0.15 Turnover of water - If the storage reservoir is sized larger than required for initial demand and there is more than 2 days storage, provisions shall be made for turnover of the water in the tank and/or booster chlorination. Internal piping arrangements to prevent water stratification in ground level standpipes are recommended. For large, ground level tanks/reservoirs, piping and/or check valves can be installed to force water in and out of the tank at different locations in order to minimize dead/stagnant water zones.

8.0.16 Sampling - A suitable sampling tap should be provided on all storage structures and be protected from public access.

8.0.17 Disinfection - Finished water storage structures shall be disinfected in accordance with AWWA Standard C652 before being put in service.

8.1 PLANT STORAGE - The applicable design standards of this part shall be followed for plant storage.

8.1.1 Washwater Tanks - If washwater tanks are used, they shall be sized, in conjunction with available pump units and finished water storage, to give the back wash water required by Section 4.2.1.K.

a. Consideration must be given to the possibility of having to wash more than one filter at a time, or several filters in succession.

8.1.2 Clearwell - Clearwell storage should be sized, in conjunction with distribution system storage, to relieve the filters from having to follow fluctuations in water use to meet peak demands, including filter backwash water. Design shall include features to minimize short circuiting.

a. When finished water storage is used to provide proper contact time for chlorine, (see Section 4.4.2), special attention must be given to size and baffling.

b. An overflow shall be provided and must be protected with a screen and flap valve.

8.1.3 Adjacent Compartments - finished water must not be stored or conveyed in a compartment adjacent to unsafe water when the two compartments are separated by a single wall.

8.1.4 Basins and Wet-Wells - Receiving basins and pump wet-wells for finished water shall be designed as finished water storage structures.

8.2 PRESSURE TANKS - Hydropneumatic (pressure) tanks may be acceptable in some circumstances where the number being served is 50 connections or less. When used, they shall meet ASME code requirements or equal which comply with the requirements of state and local laws and regulations for the construction and installation of unfired pressure vessels.

8.2.1 Location - The tank should be located above normal ground surface and be completely housed, or earth-mounted with one end projecting into an operating house, to prevent freezing.

8.2.2 Bypass - tank should have bypass piping to permit operation of the system while the tank is being repaired or painted.

8.2.3 Appurtenances - Each tank should have an access manhole, a drain, a control equipment consisting of pressure gage, water sight glass, automatic or manual air blow-off, mechanical means for adding air, and pressure-operated start-stop controls for the pumps.

8.2.4 Sizing -

a. The capacity of each well and/or pump in a hydropneumatic system should be at least ten times the average daily consumption rate of the community or the maximum peak demand whichever is greater.

b. The gross volume of the hydropneumatic tank, in gallons, should be at least 20 times the capacity of the largest pump, rated in gallons per minute.

8.2.5 Auxiliary power - Auxiliary power with automatic takeover capability shall be provided when positive pressures are not available from system gravity flow.

8.3 DISTRIBUTION STORAGE - The applicable design standards of this part shall be followed for distribution storage.

8.3.1 The purpose of system storage is to have sufficient water available to provide adequate flow and pressure at peak demand as well as to provide for fire flows when needed. For most water systems a satisfactory rule-of-thumb to meet these needs is to provide at least the average 24-hour demand in elevated storage. In the absence of an acceptable engineering study of the amount of water the system needs to meet customer demand and to provide for fire emergencies, the projected 24-hour demand at the end of the planning period will be the minimum requirement for elevated storage. This requirement may be reduced when the source, treatment facilities and pumps have sufficient capacity with standby power capability to supplement peak demands of the system.

8.3.2 Pressure Variation - System pressure variation on account of changes in level of water in storage structures should be minimized. Elevated storage tanks or large diameter ground tanks located on high ground should be the usual choices. Standpipes will not normally be approved and must be completely justified if proposed.

8.3.3 Drainage - Storage structures which float on the distribution system should be designed to drain for cleaning or maintenance without necessitating loss of pressure in the distribution system. The drains should discharge to the ground surface with no direct connection to a sewer or storm drain. (See Section 8.0.4). A nearby fire hydrant may be considered as a drain as long as service is not interrupted and suitable erosion protection is provided.

8.3.4 Level Controls - Adequate controls shall be provided to maintain levels in distribution system storage structures.

a. Telemeter equipment should be used when pressure-type controls are employed and any appreciable head loss occurs in the distribution system between the source and the storage structure.

b. Altitude valves or equivalent controls may be required for a second and subsequent structures on the system.

c. Overflow and low-level warnings or alarms should be located at places in the community where they will be under responsible surveillance on a 24-hour basis.

Part 9 - DISTRIBUTION SYSTEMS

9.0 SYSTEM DESIGN

9.0.1 Minimum Pipe Size

a. The minimum size of pipe for principal water mains and for water mains where fire hydrants are to be attached shall be 6-inch diameter.

b. Size of water mains shall be justified by hydraulic analysis. 2-inch water mains will only be considered for short cul-de-sacs and permanent dead-ends where future growth is not feasible. The length of 2-inch mains shall be restricted to 3000 feet in any one direction.

c. All water mains including those not designed to provide fire protection shall be sized after a hydraulic analysis based on flow demands and pressure requirements. The system shall be designed to maintain a minimum pressure of 20 psi at ground level at all points in distribution system under all conditions of flow.

d. Wide variations in pressure above the minimum requirement of 20 psi may be inherent in the design of a distribution system but pressures no greater than 100 psi should be delivered to the customer (unless higher pressures are requested.). Main line pressure reducing valves can be used to reduce pressures below 100 psi where feasible. Where water pressures over 100 psi are necessary to the operation of the distribution system, customers must have individual pressure reducing valves.

e. All assumptions and any flow data used must be clearly documented and submitted with the hydraulic analysis. if actual flow data is not available theoretical calculations shall be based on all storage facilities half-full and the Hazen-Williams friction factor appropriate for type of pipe being used but in no case greater than 130.

f. Water distribution lines should be designed and sized for an instantaneous peak demand of 2 gpm per connection for water lines serving up to 100 residential connections. Peak design demands can be reduced to 1.5 gpm per connection for 150 residential connections, 1.0 gpm per connection for 300 residential connections, 0.75 gpm per connection for 500 residential connections, and 0.5 gpm per connection for 1000 or more residential connections.

9.0.2 Fire Protection

a. The minimum pipe size to which a fire hydrant may be connected is 6-inch.

b. Ordinarily fire hydrants shall not be connected to water mains which are not capable of providing a flow of 500 gpm at 20 psi. When a municipality or county enacts a restrictive use ordinance prohibiting pumper trucks from connecting to restricted fire hydrants which are painted a distinctive color and when a copy of this ordinance in on file at this office, we will permit fire hydrants to be connected to 6-inch mains which do not have the required pressure and flow.

c. When fire protection is to be provided, system design should consider the recommendations of the state Insurance Services Organization.

d. Fire hydrants shall meet current AWWA Standard C502.

9.0.3 Dead Ends

a. Dead ends shall be minimized.

b. Where dead-end mains occur they should be provided with a fire hydrant, when fire flows are available, or blow-off for flushing purposes. The blow-off shall be at least 2 inches in diameter, but should provide flushing velocities of 2 feet per second or greater.

c. No flushing device shall be directly connected to any sewer nor be subject to flooding or plugging.

9.1 INSTALLATION OF MAINS

9.1.1 Adequate support shall be provided for all pipes.

9.1.2 A continuous and uniform bedding shall be provided in the trench for all buried pipe.

9.1.3 Rock Excavation - Stones found in the trench shall be removed for a depth of at least six inches below the bottom of the pipe.

9.1.4 Cover - All distribution mains shall be provided with sufficient earth or other suitable cover to prevent freezing. This shall not be less than 30 inches measured above the top of the pipe.

9.1.5 Hydrostatic Tests

a. Pressure and leakage tests shall be performed in accordance with current AWWA Standard C600 and/or manufacturer's installation procedures.

b. The test pressure of the installed pipe shall be a minimum of 150 psi or 1.5 times the working pressure, whichever is greater.

c. Allowable leakage shall be no greater than as calculated in L = SD /P/133,200 where L is allowable leakage in gallons/hour, S is the length of pipe tested in feet, D is pipe diameter in inches and P is test pressure in psi.

9.1.6 Disinfection of New Water Mains - The specifications shall include detailed procedures for the adequate flushing, disinfection, and (Total Coliform) bacteriological testing of all new water mains. Disinfection as described in current AWWA Standard C651 will be accepted.

9.1.7 Disinfection When Cutting into or Repairing Existing Mains:

a. Shall be performed when mains are wholly or partially dewatered;

b. Shall follow current AWWA C651 procedures including trench treatment, swabbing with hypochlorite solution, flushing and/or slug chlorination as appropriate;

c. Bacteriological testing should be done after repairs are complete but the water main may be returned to service prior to completion of testing to minimize the time customers are out of water;

d. Leaks or breaks that are repaired with clamping devices while mains remain full of water under pressure require no disinfection.

9.1.8 When non-metallic pipe is installed, detection tape or other acceptable means of detection shall be installed.

9.2 SEPARATION OF WATER MAINS AND SEWERS

9.2.1 General - The following factors should be considered in providing adequate separation:

a. materials and type of joints for water and sewer pipes;

b. soil conditions;

c. service and branch connections into the water main and sewer line;

d. compensating variations in the horizontal and vertical separations;

e. space for repair and alterations of water and sewer pipes;

f. off-setting of pipes around manholes;

g. water mains and sanitary or storm sewers shall not be laid in the same trench.

9.2.2 Parallel Installation

a. Normal conditions - Water mains shall be laid at least 10 feet horizontally from any sanitary sewer, storm sewer or sewer manhole, whenever possible; the distance shall be measured edge-to-edge.

b. Unusual conditions - When local conditions prevent a horizontal separation of 10 feet, a water main may be laid closer to a storm or sanitary sewer provided that:

1. the bottom of the water main is at least 18 inches above the top of the sewer;

2. where this vertical separation cannot be obtained, the sewer shall be constructed of materials and with joints that are equivalent to water main standards of construction and shall be pressure tested to assure water-tightness prior to backfilling.

9.2.3 Crossings

a. Normal conditions - Water mains crossing house sewers, storm sewers or sanitary sewers shall be laid to provide a separation of at least 18 inches between the bottom of the water main and the top of the sewer, whenever possible.

b. Unusual conditions - when local conditions prevent a vertical separation as described in Section 9.2.3a, the following construction shall be used:

1. Sewers passing over or under water mains should be constructed of the materials described in Section 9.2.2b2.

2. Water mains passing under sewers shall, in addition, be protected by providing:

i. a vertical separation of at least 18 inches between the bottom of the sewer and the top of the water main;

ii. adequate structural support for the sewers to prevent excessive deflection of joints and settling on and breaking the water mains;

iii. that the length of water pipe be centered at the point of crossing so that the joints will be equidistant and as far as possible from the sewer.

iv. both the sewer and the water main shall be constructed of water pipe and tested in accordance with Section 9.1.5.

9.2.4 Sewer manholes - No water pipe shall pass through or come into contact with any part of a sewer or sewer manhole.

9.3 SURFACE WATER CROSSINGS - Surface water crossings, both over and under water, present special problems which should be discussed with the Department before final plans are prepared.

9.3.1 Above-water crossings - The pipe shall be:

a. adequately supported;

b. protected from damage and freezing;

c. accessible for repair or replacement.

9.3.2 When crossing water courses which are greater than 15 feet in width:

a. The pipe shall be of special construction, having flexible, watertight joints;

b. Valves shall be provided at both ends of water crossing so that the section can be isolated for test or repair; the valves shall be easily accessible and not subject to flooding;

c. Sampling taps should be available at each end of the crossing;

d. Permanent taps should be made for testing and locating leaks.

9.4 CROSS CONNECTIONS

a. There shall be no physical connection between the distribution system and any pipes, pumps, hydrants, or tanks whereby unsafe water and other contaminating materials may be discharged or drawn into the system.

b. The approval of the Department shall be obtained for interconnections between potable water supplies.

c. Neither steam condensate nor cooling water from engine jackets or other heat exchange devices shall be returned to the potable water supply.

9.5 WATER SERVICES AND PLUMBING - Water services and plumbing shall conform to relevant local and/or state plumbing codes, or to the Standard Plumbing Code.

9.6 MATERIALS - GENERAL

a. Pipe selected shall have been manufactured in conformity with the latest standards issued by the American Water Works Association, if such standards exist, and be acceptable to the Department.

b. in the absence of such standards, pipe meeting applicable ASTM and ANSI criteria and acceptable to the Department may be selected.

c. Used water mains that meet these standards may be used again, after the pipe has been thoroughly cleaned and restored practically to its original condition.

d. Packing and jointing materials used in the joints of pipe shall meet the standards of the American Water Works Association or the Department.

e. Mechanical joints or slip-on joints with rubber gaskets are preferred.

9.7 PIPE

9.7.1 Ductile iron and cast iron pipe shall meet the latest requirements of ANSI/AWWA - C106 or CIO8 for cast iron pipe and C151 for ductile iron pipe.

9.7.2 Concrete pressure pipe shall meet the latest requirements of AWWA C300 or AWWA C301.

9.7.3 PVC pipe - 2 inch through 12 inch

a. PVC pipe meeting the standards set forth in AWWA C-900 (latest edition) will be accepted for those working pressures as designated by class. (Note that C-900 refers only to 4-inch through 12-inch pipe).

b. SDR 21, Class 200 pressure rated pipe may be used where the working pressure does not exceed 135 psi. The pipe must meet all the requirements set forth in ASTM Standard D 2241 for 2-inch through 12-inch pipe designated SDR 21. The pipe must bear the National Sanitation Foundation Testing Laboratories, Inc. seal of approval for potable water, or an approved equal.

c. Provision must be made for contraction and expansion at each joint with flexible ring gaskets made from rubber or other suitable material. Gasket materials shall meet the requirements established in ASTM F477.

d. Joints for PR 200 (pressure rated) pipe (ASTM D2241) shall be manufactured in accordance with ASTM D3139. Section 5.3.1 of this standard refers to 2000-hour tests. If pipe is manufactured in accordance with that section, the testing must be done by an independent laboratory with the results being furnished to this Department. Note also that a separate test is required for each different type of gasket provided.

e. All fittings such as tees, ells, etc. using welded joints shall be factory welded and shall meet the same specifications as the welded bell section.

f. Lubricants shall be non-toxic and shall not promote biological growth.

g. Solvent cemented joints in the field are not permitted.

h. Forty-foot lengths will be permitted when the engineering specifications contain special conditions for handling such pipe lengths. These conditions shall include provisions for transporting pipe from storage areas to the installation area on specially designed racks to prevent the ends of the pipe from dragging.

i. This policy does not apply to plastic service lines.

9.7.4 Fiberglass Composite Pipe shall be composed of an inner core of PVC overwrapped with fiberglass bonded with epoxy. 350 Pressure Rated shall be in accordance with ASTM D-2992 and D-2996.

9.7.5 Polyethylene pipe for water distribution lines shall meet the requirements of AWWA C906.

9.7.6 Molecular oriented PVC pipe shall meet the requirements of AWWA C909.

9.7.7 Any pipe material which is not specifically covered in this section will be considered on an individual basis.

9.8 VALVE, AIR RELIEF, METER AND BLOW-OFF CHAMBERS

a. Sediment accumulations may be removed through a standard fire hydrant, and compressed air and pumping may be used for dewatering mains through hydrants.

b. At high points in water mains where air can accumulate, provisions shall be made to remove the air by means of hydrants or air relief valves. Automatic air relief valves shall not be used in situations where flooding of the manhole or chamber may occur.

c. Chambers of pits containing valves, blow-offs, meters or other such appurtenances to a distribution system, shall not be connected directly to any storm drain or sanitary sewer, nor shall blowoffs or air-relief valves be connected directly to any sewer.

d. Such chambers or pits shall be drained to the surface of the ground where they are not subject to flooding by surface water, or to absorption pits underground.

e. Valves are to be placed at all intersections of water mains but at no time greater than 4000 feet apart.

f. Gate valves shall meet current AWWA standards.

RULES
OF
TENNESSEE DEPARTMENT OF ENVIRONMENT AND CONSERVATION

DIVISION OF WATER RESOURCES

CHAPTER 0400-45-01
PUBLIC WATER SYSTEMS

TABLE OF CONTENTS

0400-45-01-.01 AUTHORITY.

(1) These rules and regulations are issued under the authority of Public Acts of 1983, Chapter 324.

(2) The Division of Water Supply is responsible for the supervision of public water systems.

Authority: *T.C.A. §§ 68-221-701 et seq. and 4-5-201 et seq.* ***Administrative History:*** *Original rule filed August 1, 2012; effective October 30, 2012. Rule was previously numbered 1200-05-01.*

0400-45-01-.02 PURPOSE.

(1) The purpose of these rules and regulations is to provide guidelines for the interpretation of T.C.A. § 68-221-701 et seq. and to set out the procedures to be followed by the Department in carrying out the Department's primary enforcement responsibility under the Federal Safe Drinking Water Act. These rules and regulations set out the requirements which agents, employees or representatives of public water systems must meet in the following areas: in the preparation and submission of plan documents for public water systems; in the supervision of all phases of construction; in supplying safe drinking water meeting all applicable maximum contaminant levels or treatment technique requirements; in providing

(Rule 0400-45-01-.02, continued)

adequate operation and maintenance of the system; and in complying with procedural requirements for appealing orders issued by the Commissioner of the Tennessee Department of Environment and Conservation against a public water system.

(2) Where the terms “shall” and “must” are used, practice and usage is sufficiently standardized to indicate a mandatory requirement, insofar as any complaint action by the Department is concerned. Other items, such as should, recommend, preferred, and the like, indicate desirable procedures or methods.

Authority: *T.C.A. §§ 68-221-701 et seq. and 4-5-201 et seq.* ***Administrative History:*** *Original rule filed August 1, 2012; effective October 30, 2012. Rule was previously numbered 1200-05-01.*

0400-45-01-.03 SCOPE.

These rules will apply to all public water supply systems that provide water for human consumption through pipes or other constructed conveyances, if such system has at least fifteen (15) service connections or regularly serves an average of at least twenty-five (25) individuals daily at least sixty (60) days out of the year. A public water supply system is either a community water system or a non-community water system. A community water system is a public water supply system which serves at least fifteen (15) service connections used by year-round residents or regularly serves at least twenty-five (25) year-round residents. A non-community water system is a public water supply system that is not a community water system and which generally serves a transient population such as hotels, motels, restaurants, camps, service stations churches, industry, etc. A Non-Transient Non-Community Water System is a non-community water system that regularly serves at least 25 of the same persons over six (6) months per year. These rules do not apply to public water systems which meet all of the following criteria:

(1) consists only of distribution and storage facilities (and does not have any collection and treatment facilities);

(2) obtains all of its water from, but is not owned or operated by, a public water system to which such regulations apply;

(3) does not sell water to any person; and

(4) is not a carrier which conveys passengers in interstate commerce.

Authority: *T.C.A. §§ 68-221-701 et seq. and 4-5-201 et seq.* ***Administrative History:*** *Original rule filed August 1, 2012; effective October 30, 2012. Rule was previously numbered 1200-05-01.*

0400-45-01-.04 DEFINITIONS.

(1) "Action level" is the concentration of lead or copper in water which may determine the treatment requirements that a water system is required to complete.

(2) “Bag Filters” are pressure-driven separation devices that remove particulate matter larger than 1 micrometer using an engineered porous filtration media. They are typically constructed on a non-rigid fabric filtration media housed in a pressure vessel in which the direction of flow is from the inside of the bag to outside.

(3) “Bank Filtration” is a water treatment process that uses a well to recover surface water that has naturally infiltrated into ground water through a river bed or bank(s). Infiltration is typically enhanced by the hydraulic gradient imposed by nearby pumping water supply or other wells.

(Rule 0400-45-01-.04, continued)

(4) “Benchmark” A disinfection benchmark is the lowest monthly average value of the monthly logs of Garidia Lamblia inactivation.

(5) “Business Plan” means a document which identifies source(s) of income or revenue sufficient to meet expenses over a three (3) year period. The business plan will identify costs related to retaining a certified operator, estimated annual infrastructure repair costs, depreciation, facility maintenance fees, estimated annual monitoring costs, estimated costs of providing public notices, estimated administrative costs, and any and all other operational, treatment, and related costs (e.g. chemicals and other supplies used to treat water, etc.). The business plan must include the re-payment of borrowed and amortized funds.

(6) “Capacity Development Plan” means a document(s) identifying what actions a public water system is taking or shall take to become a “viable water system.” Such plan shall include information concerning retention of a Certified Operator in direct charge; system ownership and accountability; staffing and organizational structure; fiscal management and controls, source water assessment and protection plan; “business plan;” and any and all other information identifying any further action that shall be taken.

(7) “Cartridge filters” are pressure-driven separation devices that remove particulate matter larger than 1 micrometer using an engineered porous filtration media. They are typically constructed a rigid or semi-rigid self-supporting filter elements housed in pressure vessels in which flow is from the outside of the cartridge to the inside.

(8) "Clean compliance history” is, for the purposes of Rule 0400-45-01-.41, a record of no MCL violations under paragraph (4) of Rule 0400-45-01-.06; no monitoring violations under Rule 0400-45-01-.07 or Rule 0400-45-01-.41; and no coliform treatment technique trigger exceedances or treatment technique violations under Rule 0400-45-01-.41.

(9) “Coagulation” means a process using coagulant chemicals and mixing by which colloidal and suspended materials are destabilized and agglomerated into flocs.

(10) "Combined distribution system” is the interconnected distribution system consisting of the distribution systems of wholesale systems and of the consecutive systems that receive finished water.

(11) "Community Water System" means a public water system which serves at least fifteen (15) service connections used by year round residents or regularly serves at least twenty five (25) year round residents.

(12) "Compliance cycle" means the nine year calendar year cycle during which public water systems must monitor for certain contaminants. Each compliance cycle consists of three three year compliance periods. The first calendar year cycle begins January 1, 1993 and ends December 31, 2001; the second begins January 1, 2002 and ends December 31, 2010; the third begins January 1, 2011 and ends December 31, 2019.

(13) “Compliance period" means a three year calendar year period within a compliance cycle. Each compliance cycle has three three year compliance periods. Within the first compliance cycle, the first compliance period runs from January 1, 1993 to December 31, 1995; the second from January 1, 1996 to December 31, 1998; the third from January 1, 1999 to December 31, 2001.

(14) "Comprehensive performance evaluation (CPE)” is a thorough review and analysis of a treatment plant’s performance based capabilities and associated administrative, operation and maintenance practices. It is conducted to identify factors that may be adversely impacting a plant’s capability to achieve compliance and emphasizes approaches that can be implemented without significant capital improvements. For purposes of compliance, the

(Rule 0400-45-01-.04, continued)

comprehensive performance evaluation must consist of at least the following components: assessment of plant performance; evaluation of major unit processes; identification and prioritization of performance limiting factors; assessment of the applicability of comprehensive technical assistance; and preparation of a CPE report.

(15) "Confluent growth" means a continuous bacterial growth covering the entire filtration area of a membrane filter, or a portion thereof, in which bacterial colonies are not discrete.

(16) “Connection” means the point at which there is a meter or service tap if no meter is present.

(17) "Consecutive system is a public water system that receives some or all of its finished water from one or more wholesale systems. Delivery may be through a direct connection or through the distribution system of one or more consecutive systems.

(18) "Contaminant” means any physical, chemical, biological, or radiological substance or matter in water.

(19) "Conventional filtration treatment" means a series of processes including coagulation, flocculation, sedimentation, and filtration resulting in substantial particulate removal.

(20) "Corrosion inhibitor" means a substance capable of reducing the corrosivity of water toward metal plumbing materials, especially lead and copper, by forming a protective film on the interior surface of those materials.

(21) "CT" or "CTcalc" is the product of "residual disinfectant concentration" (C) in mg/1 determined before or at the first customer, and the corresponding "disinfectant contact time" (T) in minutes, i.e., "C" x "T". If a public water system applies disinfectants at more than one point prior to the first customer, it must determine the CT of each disinfectant sequence before or at the first customer to determine the total percent inactivation or "total inactivation ratio". In determining the total inactivation ratio, the public water system must determine the residual disinfectant concentration of each disinfection sequence and corresponding contact time before any subsequent disinfection application point(s). "CT99.9" is the CT value required for 99.9 percent (3 log) inactivation of Giardia lamblia cysts. CT99.9 for a variety of disinfectants and conditions appear in Tables 1.1 through 1.6, 2.1, and 3.1 of part (5)(b)3 of Rule 0400-45-01-.31.

$$\frac{CTcalc}{CT_{99.9}}$$

is the inactivation ratio. The sum of the inactivation ratios, or total inactivation ratio shown as

$$\Sigma \quad \frac{(CTcalc)}{(CT_{99.9})}$$

is calculated by adding together the inactivation ratio for each disinfection sequence. A total inactivation ratio equal to or greater than 1.0 is assumed to provide a 3 log inactivation of Giardia lamblia cyst. Disinfectant concentrations must be determined by tracer studies or an equivalent demonstration approved by the Department.

(22) "Department” when used in these regulations shall mean the Division of Water Supply, Tennessee Department of Environment and Conservation, or one of the Division's Field Offices.

(23) "Diatomaceous earth filtration" means a process resulting in substantial particulate removal in which (1) a precoat cake of diatomaceous earth filter media is deposited on a support membrane (septum), and (2) while the water is filtered by passing through the cake on the

(Rule 0400-45-01-.04, continued)

septum, additional filter media known as body feed is continuously added to the feed water to maintain the permeability of the filter cake.

(24) "Direct filtration" means a series of processes including coagulation and filtration but excluding sedimentation resulting in substantial particulate removal.

(25) "Disinfectant" means any oxidant, including but not limited to chlorine, chlorine dioxide, chloramines, and ozone added to water in any part of the treatment or distribution process, that is intended to kill or inactivate pathogenic microorganisms.

(26) "Disinfectant contact time" ("T" in CT calculations) means the time in minutes that it takes for water to move from the point of disinfectant application or the previous point of disinfectant residual measurement to a point before or at the point where residual disinfectant concentration ("C") is measured. Where only one "C" is measured, "T" is the time in minutes that it takes for water to move from the point of disinfectant application to a point before or at where residual disinfectant concentration ("C") is measured. Where more than one "C" is measured, "T" is (a) for the first measurement of "C", the time in minutes that it takes for water to move from the first or only point of disinfectant application to a point before or at the point where the first "C" is measured and (b) for subsequent measurements of "C", the time in minutes that it takes for water to move from the previous "C" measurement point to the "C" measurement point for which the particular "T" is being calculated. Disinfectant contact time in pipelines must be calculated based on "plug flow" by dividing the internal volume of the pipe by the maximum hourly flow rate through that pipe. Disinfectant contact time within mixing basins and storage reservoirs must be determined by tracer studies or an equivalent demonstration.

(27) "Disinfection" means a process which inactivates pathogenic organisms in water by chemical oxidants or equivalent agents.

(28) "Disinfection profile" is a summary of daily Giardia lamblia inactivation through the treatment plant. The procedure for developing a disinfection profile is contained in 40 CFR 141.172.

(29) "Distribution System" means all water lines up to the point of a meter. For unmetered systems distribution system includes all lines up to the customer's service tap.

(30) "Domestic or other non distribution system plumbing problem" means a coliform contamination problem in a public water system with more than one service connection that is limited to the specific service connection from which the coliform positive sample was taken.

(31) "Dose Equivalent" means the product of the absorbed dose from ionizing radiation and such factors as account for differences in biological effectiveness due to the type of radiation and its distribution in the body as specified by the International Commission on Radiological Units and Measurements (ICRU).

(32) "Dual sample set" is a set of two samples collected at the same time and same location, with one sample analyzed for TTHM and the other sample analyzed for HAA5. Dual sample sets are collected for the purposes of conducting an IDSE under the provisions of Rule 0400-45-01-.37 and determining compliance with the TTHM and HAA5 MCLs under the provisions of Rule 0400-45-01-.38.

(33) "Effective corrosion inhibitor residual" for the purpose of the lead and copper rules only, means a concentration sufficient to form a passivating film on the interior walls of a pipe.

(34) "Engineer" means the person or firm who designed the public water system and conceived, developed, executed or supervised the preparation of the plan documents.

(35) “Enhanced coagulation” means the addition of sufficient coagulant for improved removal of disinfection byproduct precursors by conventional filtration treatment.

(36) “Enhanced softening” means the improved removal of disinfection byproduct precursors by precipitative softening.

(37) "Filter profile” is a graphical representation of individual filter performance, based on continuous turbidity measurements or total particle counts versus time for an entire filter run, from startup to backwash inclusively, that includes an assessment of filter performance while another filter is being backwashed.

(38) “Filtration” means a process for removing particulate matter from water by passage through porous media.

(39) "Finished water” is water that is introduced into the distribution system of a public water system and is intended for distribution and consumption without further treatment, except as treatment necessary to maintain water quality in the distribution system (e.g., booster disinfection, addition of corrosion control chemicals).

(40) “First draw sample" means a one liter sample of tap water, for the purposes of the lead and copper rules, that has been standing in plumbing pipes at least 6 hours and is collected without flushing the tap.

(41) “Flooculation” means a process to enhance agglomeration or collection of smaller floc particles into larger, more easily settleable particles through gentle stirring by hydraulic or mechanical means.

(42) “Flowing stream” is a course of running water flowing in a definite channel.

(43) “GAC10” means granular activated carbon filter beds with an empty-bed contact time of 10 minutes based on average daily flow and a carbon reactivation frequency of every 180 days, except that the reactivation frequency for GAC10 used as best available technology for compliance with disinfection byproducts shall be 120 days.

(44) "GAC20” means granular activated carbon filter beds with an empty-bed contact time of 20 minutes based on average daily flow and a carbon reactivation frequency of every 240 days.

(45) "Gross Alpha Particle Activity" means the total radioactivity due to alpha particle emission as inferred from measurements on a dry sample.

(46) “Gross Beta Particle Activity" means the total radioactivity due to beta particle emission as inferred from measurements on a dry sample.

(47) “Ground water under the direct influence of surface water” means any water beneath the surface of the ground with significant occurrence of insects or other macroorganisms, algae, or large diameter pathogens such as Giardia lamblia or Cryptosporidium, or significant and relatively rapid shifts in water characteristics such as turbidity, temperature, conductivity, or pH which closely correlate to climatological or surface water conditions. Direct influence must be determined for individual sources in accordance with criteria established by the Department. The Department determination of direct influence may be based on site specific measurements of water quality and/or documentation of well construction characteristics and geology with field evaluation.

(48) "Haloacetic acids (five) (HAA5)” mean the sum of the concentrations in milligrams per liter of the haloacetic acid compounds (monochloroacetic acid, dichloroacetic acid, trichloroacetic

(Rule 0400-45-01-.04, continued)

acid, monobromoacetic acid, and dibromoacetic acid), rounded to two significant figures after addition.

(49) “Halogen” means one of the chemical elements chlorine, bromine or iodine.

(50) "Human Consumption” - means the use of water that involves any drinking or ingestion of the water by humans, any human skin contact or food preparation where the food is not brought to boiling temperatures after contact with the water.

(51) “Initial compliance period" means the first full three year compliance period which begins January 1, 1993. For public water systems having fewer than 150 service connections initial compliance period shall be January 2, 1996, for the following contaminants:

(a)	Antimony	(m)	endrin
(b)	Beryllium	(n)	glyphosate
(c)	Cyanide	(o)	oxamyl
(d)	Nickel	(p)	picloram
(e)	Thallium	(q)	simazine
(f)	dichloromethane	(r)	benzo(a)pyrene
(g)	1,2,4-trichlorobenzene	(s)	di(2ethylhexyl)adipate
(h)	1,1,2-trichloroethane	(t)	di(2ethylhexyl)phthalate
(i)	dalapon	(u)	hexachlorobenzene
(j)	dinoseb	(v)	hexachlorocyclopentadiene
(k)	diquat	(w)	2,3,7,8 TCDD
(l)	endothall		

(52) "Lake/reservoir” refers to a natural or man-made basin or hollow on the earth’s surface in which water collects or is stored that may or may not have a current or single direction of flow.

(53) "Large water system" for the purpose of lead and copper rule, means a water system that serves more than 50,000 persons.

(54) "Lead service line" means a service line made of lead which connects the water main to the building inlet and any lead pigtail, gooseneck or other fitting which is connected to such lead line.

(55) “Legionella” means a genus of bacteria, some species of which have caused a type of pneumonia called Legionnaires Disease.

(56) "Level 1 assessment” is an evaluation to identify the possible presence of sanitary defects, defects in distribution system coliform monitoring practices, and (when possible) the likely reason that the system triggered the assessment. It is conducted by the system operator or owner. Minimum elements include review and identification of atypical events that could affect distributed water quality or indicate that distributed water quality was impaired; changes in distribution system maintenance and operation that could affect distributed water quality (including water storage); source and treatment considerations that bear on distributed water quality, where appropriate (e.g., whether a ground water system is disinfected); existing water quality monitoring data; and inadequacies in sample sites, sampling protocol, and sample processing. The system must conduct the assessment consistent with any Department directives that tailor specific assessment elements with respect to the size and type of the system and the size, type, and characteristics of the distribution system.

(57) "Level 2 assessment” is an evaluation to identify the possible presence of sanitary defects, defects in distribution system coliform monitoring practices, and (when possible) the likely

(Rule 0400-45-01-.04, continued)

reason that the system triggered the assessment. A Level 2 assessment provides a more detailed examination of the system (including the system's monitoring and operational practices) than does a Level 1 assessment through the use of more comprehensive investigation and review of available information, additional internal and external resources, and other relevant practices. It is conducted by an individual approved by the Department, which may include the system operator. Minimum elements include review and identification of atypical events that could affect distributed water quality or indicate that distributed water quality was impaired; changes in distribution system maintenance and operation that could affect distributed water quality (including water storage); source and treatment considerations that bear on distributed water quality, where appropriate (e.g., whether a ground water system is disinfected); existing water quality monitoring data; and inadequacies in sample sites, sampling protocol, and sample processing. The system must conduct the assessment consistent with any Department directives that tailor specific assessment elements with respect to the size and type of the system and the size, type, and characteristics of the distribution system. The system must comply with any expedited actions or additional actions required by the Department in the case of an E. coli MCL violation.

(58) "Locational running annual average (LRAA)" is the average of sample analytical results for samples taken at a particular monitoring location during the previous four calendar quarters.

(59) "Man-Made Beta Particle and Photon Emitter" means all radionuclides emitting beta particles and/or photons listed in "Maximum Permissible Body Burdens and Maximum Permissible Concentration of Radionuclides in Air or Water for Occupational Exposure, NBS Handbook 69", except the daughter products of thorium 232, uranium 235 and uranium 238..

(60) "Maximum Contaminant Level" means the maximum permissible level of a contaminant in water which is delivered at the free flowing outlet of the ultimate user of a public water system, except in the case of turbidity where the maximum permissible level is measured at the point of entry to the distribution system. Contaminants added to the water under circumstances controlled by the user, except those resulting from corrosion of piping and plumbing caused by water quality, are excluded from this definition.

(61) "Maximum contaminant level goal" or "MCLG" means that the maximum level of the contaminant in drinking water at which no known or anticipated adverse effect on the health of persons would occur, and which allows an adequate margin of safety. Maximum contaminant level goals are non-enforceable health goals.

(62) "Maximum residual disinfectant level (MRDL)" means a level of a disinfectant added for water treatment that may not be exceeded at the consumer's tap without an unacceptable possibility of adverse health effects. For chlorine and chloramines, a PWS is in compliance with the MRDL when the running annual average of monthly averages of samples taken in the distribution system, computed quarterly, is less than or equal to the MRDL. For chlorine dioxide, a PWS is in compliance with the MRDL when daily samples are taken at the entrance to the distribution system and no two consecutive daily samples exceed the MRDL. MRDLs are enforceable in the same manner as maximum contaminant levels under Section 1412 of the Safe Drinking Water Act. There is convincing evidence that addition of a disinfectant is necessary for control of waterborne microbial contaminants. Notwithstanding the MRDLs, operators may increase residual disinfectant levels of chlorine or chloramines (but not chlorine dioxide) in the distribution system to a level and for a time necessary to protect public health to address specific microbiological contamination problems caused by circumstances such as distribution line breaks, storm runoff events, source water contamination, or cross-connections.

(63) "Maximum Total Trihalomethane Potential (MTP)" means the maximum concentration of total trihalomethanes produced in a given water containing a disinfectant residual after 7 days at a temperature of 25°C or above.

(Rule 0400-45-01-.04, continued)

(64) "Medium- size water system" for the purpose of the lead and copper rule means a water system that serves greater than 3,300 and less than or equal to 50,000 persons.

(65) "Membrane filtration" is a pressure or vacuum driven separation process in which particulate matter larger than 1 micrometer is rejected by an engineered barrier, primarily through a size exclusion mechanism, and which has a measurable removal efficiency of a target organism that can be verified through the application of a direct integrity test. This definition includes the common membrane technologies of microfiltration, ultrafiltration, nanofiltration, and reverse osmosis.

(66) "Near the first service connection" means at one of the twenty percent of all service connections in the entire system that are nearest the water supply treatment facility, as measured by the water transport time within the distribution system.

(67) "Non-Community Water System" means a public water system that is not a community water system. A non-community water system is either a "transient non-community water system" (TNCWS) or a "non-transient non-community water system" (NTNCWS).

(68) "Non-Transient Non-Community Water System" or NTNCWS" means a non-community water system that regularly serves at least twenty five (25) of the same persons over six (6) months per year.

(69) "Optimal corrosion control treatment" for the purpose of lead and copper rule only means the corrosion control treatment that minimizes the lead and copper concentrations at user's taps while insuring that the treatment does not cause the water system to violate any primary drinking water regulation.

(70) "Person" means any individual, corporation, company, association, partnership, State, municipality, utility district, water cooperative, or Federal agency.

(71) "Picocurie" (pCi) means that quantity of radioactive material producing 2.22 nuclear transformations per minute.

(72) "Plan Documents" mean reports, proposals, preliminary plans, survey and basis of design data, general and detailed construction plans, profiles, specifications and all other information pertaining to public water system planning.

(73) "Plant intake" refers to the works or structures at the head of a conduit through which water is diverted from a source (e.g., river or lake) into the treatment plant.

(74) "Point of disinfectant application" is the point where the disinfectant is applied and water downstream of that point is not subject to recontamination by surface water runoff.

(75) "Point-of-Entry Treatment Device" (POE) means a device applied to the drinking water entering a house or building for the purpose of reducing contaminants in the drinking water distributed throughout the house or building.

(76) "Point-of-Use Treatment Device" (POU) means a treatment device applied to a single tap used for the purpose of reducing contaminants in drinking water at that one tap.

(77) "Presedimentation" is a preliminary treatment process used to remove gravel, sand and other particulate material from the source water through settling before the water enters the primary clarification and filtration processes in a treatment plant.

(Rule 0400-45-01-.04, continued)

(78) "Primary Drinking Water Regulation" means a regulation promulgated by the Department which:

(a) applies to public water systems;

(b) specifies contaminants which, in the judgment of the Department, may have any adverse effect on the health of persons;

(c) specified for each such contaminant either;

1. a maximum contaminant level, if, in the judgment of the Department, it is economically and technologically feasible to ascertain the level of such contaminant in water in public water systems, or

2. if, in the judgment of the Department, it is not economically or technologically feasible to so ascertain the level of such contaminant, each treatment technique known to the Department which leads to a reduction in the level of such contaminant sufficient to satisfy the requirements of Rule 0400-45-01-.06; and

(d) contains criteria and procedures to assure a supply of drinking water which dependably complies with such maximum contaminant levels; or treatment techniques including quality control and testing procedures to insure compliance with such levels and to insure proper operation and maintenance of the system, and requirements to (i) the minimum quality of water which may be taken into the system and (ii) siting for new facilities for public water systems.

(79) “Public Water System” means a system for the provision of piped water for human consumption if such serves 15 or more connections or which regularly serves 25 or more individuals daily at least 60 days out of the year and includes:

(a) any collection, treatment, storage or distribution facility under control of the operator of such system and used primarily in connection with such system; and

(b) any collection or pre-treatment storage facility not under such control which is used primarily in connection with such system,

The population of a water system shall be determined by actual count or by multiplying the household factor by the number of connections in the system. The household factor shall be taken from the latest federal census for that county or city. Water systems serving multi-family residences such as apartment complexes and mobile home parks shall include each individual residence unit as a connection in determining the population for the system.

(80) "Rem" means the unit of dose equivalent from ionizing radiation to the total body or any internal organ or organ system. A "millerem (mrem)" is 1/1000 of a rem.

(81) "Repeat compliance period" means any subsequent compliance period after the initial compliance period.

(82) "Residual disinfectant concentration" ("C" in CT calculations) means the concentration of disinfectant measured in mg/l in a representative sample of water.

(83) "Safe Drinking Water Act" means the Federal law codified in 42 United States Code 300f et seq., Public Law 93 523, dated December 16, 1974 and subsequent amendments.

(Rule 0400-45-01-.04, continued)

(84) "Sanitary defect" is a defect that could provide a pathway of entry for microbial contamination into the distribution system or that is indicative of a failure or imminent failure in a barrier that is already in place.

(85) "Sanitary Survey" means an on-site review of the water source, facilities, equipment, operation and maintenance of a public water system for the purpose of evaluating the adequacy of such sources, facilities, equipment, operation and maintenance for producing and distributing safe drinking water.

(86) "Seasonal system" is a non-community water system that is not operated as a public water system on a year-round basis and starts up and shuts down at the beginning and end of each operating season.

(87) "Secondary Drinking Water Regulation" mean a regulation promulgated by the Department which applies to public water systems and which specifies the maximum contaminant levels which, in the judgment of the Department are requisite to protect the public welfare. Such regulations may apply to any contaminant in drinking water

(a) which may adversely affect the odor or appearance of such water and consequently may cause the persons served by the public water system providing such water to discontinue its use, or

(b) which may otherwise adversely affect the public welfare. Such regulations may vary according to geographic and other circumstances.

(88) "Sedimentation" means a process for removal of solids before filtration by gravity or separation.

(89) "Service line sample" means a one liter sample of water collected in accordance with part (7)(b)3 of Rule 0400-45-01-.33, that has been standing for at least 6 hours in a service line.

(90) "Single family structure" for the purpose of lead and copper rules means a building constructed as a single family residence that is currently used as either a residence or a place of business.

(91) "Slow sand filtration" means a process involving passage of a raw water through a bed of sand at low velocity (generally less than 0.4 m/h) resulting in substantial particulate removal by physical and biological mechanisms.

(92) "Small water system" for the purpose of the lead and copper rules only, means a water system that serves 3,300 or fewer persons.

(93) "Subpart H systems" means public water systems using surface water or ground water under the direct influence of surface water as a source that are subject to the requirements of Rules 0400-45-01-.17, 0400-45-01-.31 and 0400-45-01-.39.

(94) "Supplier of Water" means any person who owns or operates a public water system.

(95) "Surface water" means all water which is open to the atmosphere and subject to surface runoff.

(96) "SUVA" means Specific Ultraviolet Absorption at 254 nanometers (nm), an indicator of the humic content of water. It is a calculated parameter obtained by dividing a sample's ultraviolet absorption at a wavelength of 254 nm (UV 254/ (in m) by its concentration of dissolved organic carbon (DOC) (in mg/L).

(Rule 0400-45-01-.04, continued)

(97) "System with a single service connection" means a system which supplies drinking water to consumers via a single service line.

(98) "Too numerous to count" means that the total number of bacterial colonies exceeds 200 on a 47 millimeter diameter membrane filter used for coliform detection.

(99) “Total Organic Carbon” (TOC) means total organic carbon in mg/L measured using heat, oxygen, ultraviolet irradiation, chemical oxidants, or combinations of these oxidants that convert organic carbon to carbon dioxide, rounded to two significant figures.

(100) "Total trihalomethane" (TTHM) means the sum of concentration in milligrams per liter of the trihalomethane compounds trihalomethane (chloroform), dibromochloromethane, bromodichloro-methane and tribomomethane (bromoform), rounded to two significant figures.

(101) “Transient Non-Community Water System” or “TNCWS” means a non-community water system that regularly serves at least twenty-five (25) individuals daily at least sixty (60) days out of the year. A transient non community water system is a public water supply system that generally serves a transient population such as hotels, motels, restaurants, camps, service stations churches, industry, and rest stops.

(102) "Trihalomethane" (THM) means one of the family of organic compounds, named as derivatives of methane, wherein three of the four hydrogen atoms in methane are each substituted by a halogen atom in the molecular structure.

(103) “Two-stage lime softening” is a process in which chemical addition and hardness precipitation occur in each of two distinct unit clarification processes.

(104) “Uncovered finished water storage facility” is a tank, reservoir, or other facility used to store water that will undergo no further treatment except residual disinfection and is open to the atmosphere.

(105) “Viable Water System” means a public water system which has the commitment and the financial, managerial and technical capacity to consistently comply with the Tennessee Safe Drinking Water Act and these regulations.

(106) "Virus" means a virus of fecal origin which is infectious to humans by waterborne transmission.

(107) “Waterborne disease outbreak" means a significant occurrence of acute infectious illness, epidemiologically associated with the ingestion of water from a public water system which is deficient in treatment, as determined by the appropriate local or State agency.

(108) “Wholesale system” is a public water system that treats source water as necessary to produce finished water and then delivers some or all of that finished water to another public water system. Delivery may be through a direct connection or through the distribution system of one or more consecutive systems.

Authority: *T.C.A. §§ 68-221-701 et seq. and 4-5-201 et seq.* ***Administrative History:*** *Original rule filed August 1, 2012; effective October 30, 2012. Rule was previously numbered 1200-05-01. Amendments and new rules filed November 24, 2015; effective February 22, 2016.*

0400-45-01-.05 SUPERVISION OF DESIGN AND CONSTRUCTION.

(1) Engineering - Plan documents for public water systems shall be submitted to the Department at least thirty (30) days prior to the date on which action by the Department is desired.

(Rule 0400-45-01-.05, continued)

(13) Delegation of Plans Review Authority – Under T.C.A § 68-221-706, any unit of local government may petition the Commissioner for certification to review and approve plans for water distribution facilities within its jurisdiction. The unit of local government must have adequate experience and expertise in water distribution and must adopt standards and impose requirements which are at least as stringent as the Department's. The request for certification must be in writing and contain at least the following:

(a) The names of the individual(s) responsible for the review and approval together with his/her experience and education. This person(s) must be employed by the unit of local government and be a registered professional engineer in Tennessee.

(b) A copy of the standards, requirements and design criteria legally adopted and enforceable by the unit of local government.

(c) The type of projects the unit of local government wishes to receive certification to review. This may include but is not limited to water lines, distribution pumping stations and distribution storage tanks.

(d) Procedures for maintaining records of all projects reviewed and approved by the unit of local government.

(e) The wording to be used on the approval stamp.

(f) Plans review authority fee.

The Division of Water Supply will be responsible for reviewing the application for certification and shall have up to 60 days from the receipt of the complete application to make a written response. Units of local government will not be certified to review projects involving state or federal funds, raw water pump stations, new water sources, treatment facilities, sludge handling facilities, or any project designed by the staff of the local government. Any unit of local government which receives certification for plans review shall submit one copy of any plan documents it has approved to the Division of Water Supply. This shall be done within 10 days of the local government's approval. The commissioner may periodically review the unit of local government's plans review program and prescribe changes as deemed appropriate. The Division of Water Supply may execute a written agreement with a unit of local government which has received plans review certification. Failure to comply with the terms of the agreement may result in revocation of the plans review certification.

Authority: *T.C.A. §§ 68-221-701 et seq. and 4-5-201 et seq.* ***Administrative History:*** *Original rule filed August 1, 2012; effective October 30, 2012. Rule was previously numbered 1200-05-01.*

0400-45-01-.06 MAXIMUM CONTAMINANT LEVELS.

(1) Inorganic Chemicals

(a) The maximum contaminant level for fluoride applies to community water systems. The maximum contaminant levels for nitrate, nitrite and total nitrate and nitrite are applicable to both community water systems and non-community water systems. The maximum contaminant levels for the remaining inorganic chemicals apply only to community water systems and non-transient non-community systems.

(b) The following are the maximum contaminant levels for inorganic chemicals:

CONTAMINANT	LEVEL, MILLIGRAMS PER LITER

(Rule 0400-45-01-.06, continued)

1.	Antimony	0.006
2.	Arsenic	0.010
3.	Asbestos	7 million fibers/liter (longer than 10 microns)
4.	Beryllium	0.004
5.	Barium	2.0
6.	Cadmium	0.005
7.	Chromium	0.1
8.	Cyanide (as free cyanide)	0.2
9.	Fluoride	4.0
10.	Mercury	0.002
11.	Nickel	0.1
12.	Nitrate	10.0 (as Nitrogen)
13.	Nitrite	1.0 (as Nitrogen)
14.	Total nitrate and nitrate	10.0 (as Nitrogen)
15.	Selenium	0.05
16.	Thallium	0.002

(2) Organic Chemicals - The following are the maximum contaminant levels for organic chemicals.

(a) The following maximum contaminant levels for organic contaminants apply to community water systems and non-transient non-community water systems. The maximum contaminant levels for volatile organic chemicals are given in paragraph (2) of Rule 0400-45-01-.25.

	CONTAMINANT	LEVEL, MILLIGRAMS PER LITER
1.	Alachlor	0.002
2.	Atrazine	0.003
3.	Carbofuran	0.04
4.	Chlordane	0.002
5.	Dibromo chloropropane (DBCP)	0.0002
6.	2,4 Dichlorophenoxyacetic acid	0.07
7.	Ethylene dibromide	0.00005
8.	Heptachlor	0.0004
9.	Heptachlor epoxide	0.0002
10.	Lindane	0.0002
11.	Methoxychlor	0.04
12.	Polychlorinated biphenyls	0.0005
13.	Toxaphene	0.003
14.	2,4,5 Trichlorophenoxyproprionic acid	0.05
15.	Pentachlorophenol	0.001
16.	Benzo(a)pyrene	0.0002
17.	Dalapon	0.2
18.	Di(2-ethylhexyl) adipate	0.4
19.	Di(2-ethylhexyl)phthalate	0.006
20.	Dinoseb	0.007
21.	Diquat	0.02
22.	Endothall	0.1
23.	Glyphosate	0.7
24.	Hexachlorobenzene	0.001
25.	Hexachlorocyclopentadiene	0.05
26.	Oxamyl (Vydate)	0.2
27.	Picloram	0.5
28.	Simazine	0.004

(Rule 0400-45-01-.06, continued)

29.	2,3,7,8-TCDD (Dioxin)	0.00000003
30.	Endrin	0.002

(3) Turbidity - The requirements of paragraph (3) of Rule 0400-45-01-.06 apply to filtered surface systems until June 29, 1993. The requirements in this paragraph apply to unfiltered systems that the Department has determined, in writing, must install filtration until June 29, 1993, or until filtration is installed, whichever is later.

The maximum contaminant level for turbidity is applicable to public water systems using surface water source(s) in whole or in part. Furthermore, the maximum contaminant level for turbidity is applicable to those systems using ground water which are required to install turbidimeters pursuant to paragraph (11) of Rule 0400-45-01-.05. The maximum contaminant levels for turbidity in drinking water, measured at a representative entry point(s) to the distribution system are:

(a) One (1.0) turbidity unit, as determined by monthly average pursuant to Rule 0400-45-01-.08.

(b) Two (2.0) turbidity units based on an average for two consecutive days pursuant to Rule 0400-45-01-.08.

To meet the maximum contaminant level for turbidity, a public water system must meet both subparagraphs (a) and (b) of this paragraph.

(4) Microbiological - The maximum contaminant levels for microbiologicals are applicable to both community water systems and non-community water systems.

(a) Until March 31, 2016, the total coliform maximum contaminant level (MCL) is based on the presence or absence of total coliforms in a sample, rather than coliform density. Beginning April 1, 2016, the MCL for total coliform shall no longer be in effect.

The number of total coliform positive samples shall not exceed any of the following:

1. For a system which collects at least 40 samples per month, if no more than 5.0 percent of the samples collected during a month are total coliform-positive, the system is in compliance with the MCL for total coliforms.

2. For a system which collects fewer than 40 samples/month, if no more than one sample collected during a month is total coliform-positive, the system is in compliance with the MCL for total coliforms.

3. A public water system which has exceeded the MCL for total coliforms must report the violation to the Department no later than the end of the next business day after it learns of the violation and notify the public in accordance with the schedule of Rule 0400-45-01-.19 using the language specified in Rule 0400-45-01-.19.

4. A public water system which has failed to comply with the coliform monitoring requirements, including a sanitary survey requirement must report the monitoring violation to the Department within ten (10) days after the system discovers the violation and notify the public in accordance with Rule 0400-45-01-.19.

(b) Until March 31, 2016, any fecal coliform-positive repeat sample or E. coli-positive repeat sample, or any total coliform-positive repeat sample following a fecal coliform-positive or E. coli-positive routine sample, constitutes a violation of the MCL for total

(Rule 0400-45-01-.06, continued)

coliforms. For purposes of the public notification requirements in Rule 0400-45-01-.19, this is a violation that may pose an acute risk to health.

(c) Fecal coliforms/Escherichia coli (E. coli) testing

1. If any routine or repeat sample is total coliform-positive, the system must analyze that total coliform-positive culture medium to determine if fecal coliforms are present, except that the system may test for E. coli in lieu of fecal coliforms. If fecal coliforms or E. coli are present, the system must notify the Department by the end of the day when the system is notified of the test result, unless the system is notified of the result after the Department office is closed, in which case the system must notify the Department before the end of the next business day.

2. The Department has the discretion to allow a public water system, on a case-by-case basis, to forgo fecal coliform or E. coli testing on a total coliform-positive sample if that system assumes that the total coliform-positive sample is fecal coliform-positive or E. coli-positive. Accordingly, the system must notify the Department as specified in part 1 of this subparagraph and the provisions of subparagraph (b) of this paragraph apply.

(d) A public water system must determine compliance with the MCL for total coliforms in subparagraph (a) and (b) of this paragraph for each month in which it is required to monitor for total coliforms.

(e) No variance or exemptions from the maximum contaminant level for total coliforms are permitted.

(f) Maximum contaminant level goals for microbiological contaminants.

1. MCLGs for the following contaminants are as indicated:

Contaminant		MCLG
(i)	*Giardia lamblia*	zero
(ii)	Viruses	zero
(iii)	*Legionella*	zero
(iv)	Total coliforms (including fecal coliforms and *Escherichia coli*)	zero
(v)	*Cryptosporidium*	zero
(vi)	*Escherichia coli (E. coli)*	zero

2. The MCLG identified in subpart 1(iv) of this subparagraph is no longer applicable beginning April 1, 2016.

(g) Beginning April 1, 2016, a system is in compliance with the MCL for E. coli for samples taken under the provisions of Rule 0400-45-01-.41 unless any of the conditions identified in parts 1 through 4 of this subparagraph occur. For purposes of the public notification requirements in Rule 0400-45-01-.19, violation of the MCL may pose an acute risk to health.

1. The system has an E. coli-positive repeat sample following a total coliform positive routine sample.

2. The system has a total coliform positive repeat sample following an E. coli-positive routine sample.

(Rule 0400-45-01-.06, continued)

3. The system fails to take all required repeat samples following an E. coli-positive routine sample.

4. The system fails to test for E. coli when any repeat sample tests positive for total coliform.

(h) Until March 31, 2016, a public water system must determine compliance with the MCL for total coliforms in subparagraphs (a) and (b) of this paragraph for each month in which it is required to monitor for total coliforms. Beginning April 1, 2016, a public water system must determine compliance with the MCL for E. coli in subparagraph (g) of this paragraph for each month in which it is required to monitor for total coliforms.

(i) The EPA Administrator, pursuant to section 1412 of the Federal Safe Drinking Water Act, hereby identifies the following as the best technology, treatment techniques, or other means available for achieving compliance with the maximum contaminant level for total coliforms in subparagraphs (a) and (b) of this paragraph and for achieving compliance with the maximum contaminant level for E. coli in subparagraph (g) of this paragraph:

1. Protection of wells from fecal contamination by appropriate placement and construction;

2. Maintenance of a disinfectant residual throughout the distribution system;

3. Proper maintenance of the distribution system including appropriate pipe replacement and repair procedures, main flushing programs, proper operation and maintenance of storage tanks and reservoirs, cross connection control, and continual maintenance of positive water pressure in all parts of the distribution system;

4. Filtration and/or disinfection of surface water, as described in Rules 0400-45-01-.17, 0400-45-01-.31 and 0400-45-01-.39, or disinfection of ground water, as described in Rule 0400-45-01-.40, using strong oxidants such as chlorine, chlorine dioxide, or ozone; and

5. For systems using ground water, compliance with the requirements of an EPA-approved State Wellhead Protection Program developed and implemented under section 1428 of the Federal Safe Drinking Water Act.

(j) The EPA Administrator, pursuant to section 1412 of the Federal Safe Drinking Water Act, hereby identifies the technology, treatment techniques, or other means available identified in subparagraph (i) of this paragraph as affordable technology, treatment techniques, or other means available to systems serving 10,000 or fewer people for achieving compliance with the maximum contaminant level for total coliforms in subparagraphs (a) and (b) of this paragraph and for achieving compliance with the maximum contaminant level for E. coli in subparagraph (g) of this paragraph.

(5) Radionuclides-

(a) The following maximum contaminant levels for radium-226, radium-228, and gross alpha particle radioactivity are applicable to all community water systems:

1. Combined radium-226 and radium-228: The maximum contaminant level for combined radium-226 and radium-228 is 5 pCi/L. The combined radium-226 and radium-228 value is determined by the addition of the results of the analysis for radium-226 and the analysis for radium-228.

(Rule 0400-45-01-.06, continued)

Bromate	Control of ozone treatment process to reduce production of bromate
Chlorite	Control of treatment processes to reduce disinfectant demand and control of disinfection treatment processes to reduce disinfectant levels

(b) TTHM and HAA5.

1. Running Annual Average compliance (Rule 0400-45-01-.36)

(i) Compliance dates. Subpart H systems serving 10,000 or more persons must comply with this part beginning January 1, 2002. Subpart H systems serving fewer than 10,000 persons and systems using only ground water not under the direct influence of surface water must comply with this this part beginning January 1, 2004. All systems must comply with these MCLs until the date specified for Locational Running Annual Average (Stage 2 Disinfection Byproducts Requirements (LRAA)) compliance in Rule 0400-45-01-.38.

Disinfection by-product	MCL (mg/L)
Total trihalomethanes (TTHM)	0.080
Haloacetic acids (five) (HAA5)	0.060

(ii) The Administrator, pursuant to section 1412 of the Federal Safe Drinking Water Act, hereby identifies the following as the best technology, treatment techniques, or other means available for achieving compliance with the maximum contaminant levels for TTHM and HAA5 identified in this part.

Disinfection by-product	Best available technology
Total trihalomethanes (TTHM) and Haloacetic acids (five) (HAA5)	Enhanced coagulation or enhanced softening or GAC10, with chlorine as the primary and residual disinfectant

2. LRAA compliance (Rule 0400-45-01-.38)

(i) Compliance dates. The Stage 2 Disinfection Byproducts Requirements (LRAA) MCLs for TTHM and HAA5 must be complied with as a locational running annual average (LRAA) at each monitoring location beginning the date specified for Stage 2 Disinfection Byproducts Requirements (LRAA) compliance in subparagraph (1)(c) of Rule 0400-45-01-.38.

Disinfection by-product	MCL (mg/L)
Total trihalomethanes (TTHM)	0.080
Haloacetic acids (five) (HAA5)	0.060

(ii) The Administrator, pursuant to section 1412 of the Federal Safe Drinking Water Act, hereby identifies the following as the best technology, treatment techniques, or other means available for achieving compliance with the maximum contaminant levels for TTHM and HAA5 identified in this part for all systems that disinfect their source water:

Disinfection by-product	Best available technology
Total trihalomethanes (TTHM) and Haloacetic acids (five) (HAA5)	Enhanced coagulation or enhanced softening or GAC10; nanofiltration and with a molecular weight cutoff of equal to or less than 1000 Daltons;

(Rule 0400-45-01-.06, continued)

	or GAC20

(iii) The Administrator, pursuant to section 1412 of the Federal Safe Drinking Water Act, hereby identifies the following as the best technology, treatment techniques, or other means available for achieving compliance with the maximum contaminant levels for TTHM and HAA5 identified in this part for consecutive systems and applies only to the disinfected water that consecutive systems buy or otherwise receive:

Disinfection by-product	Best available technology
Total trihalomethanes (TTHM) and Haloacetic acids (five) - (HAA5).	Systems serving 10,000 or more: Improved distribution system and storage tank management to reduce residence time, plus the use of chloramines for disinfectant residual maintenance. Systems serving <10,000: Improved distribution system and storage tank management to reduce residence time.

(c) Maximum residual disinfectant levels.

1. Maximum residual disinfectant levels (MRDLs) are as follows:

Disinfectant residual	MRDL (mg/L)
Chlorine	4.0 (as Cl_2).
Chloramines	4.0 (as Cl_2).
Chlorine dioxide	0.8 (as ClO_2).

(d) Compliance dates.

1. CWSs and NTNCWSs. Subpart H systems serving 10,000 or more persons must comply with MRDLs beginning January 1, 2002. Subpart H systems serving fewer than 10,000 persons and systems using only ground water not under the direct influence of surface water must comply with MRDLs beginning January 1, 2004.

2. Transient NCWSs. Subpart H systems serving 10,000 or more persons and using chlorine dioxide as a disinfectant or oxidant must comply with the chlorine dioxide MRDL beginning January 1, 2002. Subpart H systems serving fewer than 10,000 persons and using chlorine dioxide as a disinfectant or oxidant and systems using only ground water not under the direct influence of surface water and using chlorine dioxide as a disinfectant or oxidant must comply with the chlorine dioxide MRDL beginning January 1, 2004.

(e) Best Available Control Technology

1. The following are identified as the best technology, treatment technology or other means available for achieving compliance with the maximum residual disinfectant level:

(i) Control of the treatment processes to reduce disinfectant demand and control of disinfection treatment processes to reduce disinfectant levels.

(Rule 0400-45-01-.07, continued)

persons may collect all required samples on a single day if they are taken from different sites.

(f) A public water system that uses surface water or ground water under the direct influence of surface water, and does not practice filtration in compliance with Rule 0400-45-01-.31 must collect at least one sample near the first service connection each day the turbidity level of the source water exceeds 1 NTU. This sample must be analyzed for the presence of total coliforms. When one or more turbidity measurements in any day exceed 1 NTU, the system must collect this coliform sample within 24 hours of the first exceedance, unless the Department determines that the system, for reasons outside the system's control cannot have the sample analyzed within 30 hours of collection. Sample results from this coliform monitoring must be included in determining compliance with the MCL for total coliforms in paragraph (4) of Rule 0400-45-01-.06.

(g) Special purpose samples, such as those taken to determine whether disinfection practices are sufficient following pipe placement, replacement, or repair, shall not be used to determine whether the coliform treatment technique trigger has been exceeded compliance with the MCL for total coliforms in paragraph (4) of Rule 0400-45-01-.06 provided the water is not served to customers before negative analytical results are obtained. Samples representing water served to customers prior to obtaining analytical results shall not be special purpose samples and shall not count toward compliance with the MCL for total coliforms in paragraph (4) of Rule 0400-45-01-.06 with the MCL for total coliforms in paragraph (4) of Rule 0400-45-01-.06. After March 31, 2016, this subparagraph is no longer applicable.

(2) Repeat Monitoring

(a) If a routine sample is total coliform-positive, the public water system must collect a set of repeat samples within 24 hours of being notified of the positive result. A system which collects more than one routine sample per month must collect no fewer than three repeat samples for each total coliform-positive sample found. A system which collects one routine sample per month or fewer must collect no fewer than four repeat samples for each total coliform-positive sample found. The Department may extend the 24-hour limit on a case-by-case basis if the system has a problem in collecting the repeat samples within 24 hours that is beyond its control. In the case of an extension, the Department must specify how much time the system has to collect the repeat samples.

(b) The system must collect at least one repeat sample from the sampling tap where the original total coliform-positive sample was taken, and at least one repeat sample at a tap within five service connections upstream and at least one repeat sample at a tap within five service connections downstream of the original sampling site. If a total coliform-positive sample is at the end of the distribution system, or one away from the end of the distribution system, the Department may waive the requirement to collect at least one repeat sample upstream or downstream of the original sampling site.

(c) The system must collect all repeat samples on the same day and within 24 hours of being notified of a positive result, except that the Department may allow a system with a single service connection to collect the required set of repeat samples over a four consecutive day period or to collect a larger volume repeat sample(s) in one or more sample containers of any size, as long as the total volume collected is at least 400 ml (300 ml for systems which collect more than one routine sample per month.)

(Rule 0400-45-01-.07, continued)

.06(4)(c) that was initiated by a total coliform-positive sample taken before April 1, 2016, is completed, as well as analytical method, reporting, recordkeeping, public notification, and consumer confidence report requirements associated with that monitoring and testing. Beginning April 1, 2016, the provisions of Rule 0400-45-01-.41 are applicable, with systems required to begin regular monitoring at the same frequency as the system specific frequency required on March 31, 2016.

Authority: *T.C.A. §§ 68-221-701 et seq. and 4-5-201 et seq.* ***Administrative History:*** *Original rule filed August 1, 2012; effective October 30, 2012. Rule was previously numbered 1200-05-01. Amendments and new rules filed November 24, 2015; effective February 22, 2016. Amendments filed March 7, 2016; effective June 5, 2016.*

0400-45-01-.08 TURBIDITY SAMPLING AND ANALYTICAL REQUIREMENTS.

(1) Ground water sampling – Samples shall be taken by suppliers of water that serve more than 50 connections or that have been directed to conduct monitoring under paragraph (11) of Rule 0400-45-01-.05 for both community water systems and non–community water system at a representative entry point(s) to the water distribution system at least once per day for the purpose of making turbidity measurements to determine compliance with paragraph (3) of Rule 0400-45-01-.06. Public water systems using water from a source not under the direct influence of surface water are not required to monitor turbidity unless directed to do so under the provisions of paragraph (11) of Rule 0400-45-01-.05.

(2) Turbidity measurements of surface water and ground water under the direct influence that employs filtration - The minimum sampling requirements for systems using filtration treatment shall be as follows:

(a) Turbidity measurements must be performed on representative samples of the system's filtered water every four hours, (or more frequently, as authorized by the rules) that the system serves water to the public. A public water system may substitute continuous turbidity monitoring for grab samples if approved in writing by the Department. For systems serving 500 or fewer persons per day, the Department may allow the sampling frequency to be reduced to once per day if it determines that less frequent monitoring is sufficient to indicate effective filtration performance. Systems filtering surface water and ground water under the direct influence of surface water shall comply with the treatment technique standards found in paragraph (4) of Rule 0400-45-01-.31.

(3) Ground water systems under the direct influence of surface water and do not filter and have qualified to avoid filtration - The minimum sampling requirements for ground water systems under the direct influence of surface water and not employing filtration shall be as follows:

(a) Turbidity measurements must be performed on representative grab samples of source water immediately prior to the first or only point of disinfectant application every four hours (or more frequently, as authorized by the rules) that the system serves water to the public. A public water system may substitute continuous turbidity monitoring for grab sample monitoring if it validates the continuous measurement for accuracy on a regular basis using a protocol approved by the Department. Turbidity must comply with the limits specified in part (2)(a)2 of Rule 0400-45-01-.31.

(4) Reporting

(a) Ground water systems - All community water systems using a ground water source with turbidity removal facilities and not designated as ground water under the direct influence of surface water shall be required, if the results of a turbidity analysis indicate that the maximum allowable limit has been exceeded, to confirm by resampling as soon as practicable and preferably within one (1) hour. If the repeat sample confirms

(Rule 0400-45-01-.11, continued)
Authority: *T.C.A. §§ 68-221-701 et seq. and 4-5-201 et seq.* ***Administrative History:*** *Original rule filed August 1, 2012; effective October 30, 2012. Rule was previously numbered 1200-05-01.*

0400-45-01-.12 SECONDARY DRINKING WATER REGULATIONS.

(1) The following maximum contaminant levels are established to provide a water that is aesthetically pleasing to the consumer. These standards will apply to all community water systems and to those non-community water systems as may be deemed necessary by the Department. Monitoring for these contaminants will be set in the Monitoring Program for each system, but in no event less than once every year for a surface and surface/ground supply and once every three years for a ground water supply.

Maximum Contaminant Level

Contaminant		Milligrams per Liter (unless otherwise indicated)
(a)	Chloride	250
(b)	Color	15 (Color Units)
(c)	Copper	1
(d)	MBAS (Methyl Blue Active Substance)	0.5
(e)	Iron	0.3
(f)	Manganese	0.05
(g)	Odor	3 (Threshold Odor Number)
(h)	pH	6.5-8.5
(i)	Sulfate	250
(j)	TDS (Total Dissolved Solids)	500
(k)	Zinc	5
(l)	Fluoride	2
(m)	Aluminum	0.2
(n)	Silver	0.1

(2) The system may apply for monitoring waivers from the monitoring frequency specified in paragraph (1) of this rule. The Department may issue monitoring waivers after considering: historical data, whether or not there have been customer complaints concerning the contaminant to be waived, any corrective action taken by the water supplier to correct the secondary contaminant problem, and whether or not the system routinely monitors for the contaminant as part of its treatment process monitoring program. The Department shall determine the frequency, if any, a system must monitor after considering the historical data available, the number and nature of customer complaints and other factors that may affect the contaminant concentration, and specify the decision in writing to the system.

Authority: *T.C.A. §§ 68-221-701 et seq. and 4-5-201 et seq.* ***Administrative History:*** *Original rule filed August 1, 2012; effective October 30, 2012. Rule was previously numbered 1200-05-01.*

0400-45-01-.13 ALTERNATIVE ANALYTICAL TECHNIQUES.

If an alternative analytical technique is acceptable to the Administrator of the U.S. Environmental Protection Agency as being substantially equivalent to the prescribed test in both precision and accuracy as it relates to the determination of compliance with any maximum contaminant level, they shall become a part of these rules and regulations by inference.

Authority: *T.C.A. §§ 68-221-701 et seq. and 4-5-201 et seq.* ***Administrative History:*** *Original rule filed August 1, 2012; effective October 30, 2012. Rule was previously numbered 1200-05-01.*

(Rule 0400-45-01-.15, continued)

by the Environmental Protection Agency will have compliance with the MCL determined on the analytical results of its sampling.

(3) Those public water systems which purchase all their water and elect to use the analytical results of the system from which it purchases water shall be deemed to be in compliance with the monitoring and MCL requirements provided the seller of water is in compliance. Any violation of an MCL or monitoring requirement by the seller of water will constitute a violation for all systems which purchase water unless samples are taken as described in paragraph (2) of this rule.

(4) All public notification requirements as contained in Rule 0400-45-01-.19 are the responsibility of the individual public water system regardless of which public water system conducts the analysis.

(5) All public water systems must maintain records as required by Rule 0400-45-01-.20 of all analytical results which pertain to the system regardless of which system actually did the analysis.

Authority: *T.C.A. §§ 68-221-701 et seq. and 4-5-201 et seq.* ***Administrative History:*** *Original rule filed August 1, 2012; effective October 30, 2012. Rule was previously numbered 1200-05-01.*

0400-45-01-.16 SITING REQUIREMENTS.

(1) Before a person may enter into a financial commitment for or initiate construction of a new public water system or increase capacity of an existing public water system, he shall notify the Department and, to the extent practicable, avoid locating part or all of the new or expanded facility at a site which:

(a) Is subject to a significant risk from earthquakes, floods, fires, or other disasters which could cause a breakdown of the public water system or a portion thereof; or

(b) Except for intake structures, is within the flood plain of a 100-years flood.

(2) All other siting requirements shall be in accordance with those set forth in “Design Criteria for Public Water Systems” as published by the Department.

Authority: *T.C.A. §§ 68-221-701 et seq. and 4-5-201 et seq.* ***Administrative History:*** *Original rule filed August 1, 2012; effective October 30, 2012. Rule was previously numbered 1200-05-01.*

0400-45-01-.17 OPERATION AND MAINTENANCE REQUIREMENTS.

(1) All community water systems which are designated as a surface supply and classified as a filtration system and all iron removal plants which use gravity filters must have an operator in attendance and responsible for the treatment process when the plant is in operation. Gravity iron removal plants which have installed continuous monitoring equipment including equipment for turbidity and chlorine residual with alarms and/or shutdown ability may seek approval from the Department to operate the treatment plant in an automated mode without an operator in attendance. All iron removal plants with pressure filters and using a ground water source from an approved sand and gravel formation will not be required to have an operator in attendance during all periods of operation provided suitable protection, acceptable to the Department, is provided.

Non–community water systems which are classified as a surface supply will be required to have a full time operator in attendance unless certain continuous monitoring equipment is installed.

(Rule 0400-45-01-.17, continued)

Pursuant to T.C.A. § 68-221-904, all operators in direct responsible charge of a water supply system, including the treatment plant and/or distribution system, must be certified by the Department as competent to operate same.

Because the proper operation and maintenance of water systems is critical to a system's ability to provide safe water to the public and to comply with these rules, all water supply systems must comply with the provisions of Chapter 0400-49-01. A violation of those rules is a violation of this rule as well.

(2) All community water systems and those non-community water systems classified as a surface source shall compile and maintain accurate daily operating records of the water works system on forms prepared and furnished by the Department. The daily operating records shall be submitted in a timely manner so they are received by the Department no later than ten days after the end of the reporting month. Any special reports, deemed necessary by the Department to assure continuous satisfactory operation of the water system, shall be submitted to the Department.

Water systems which desire to use their own forms to report the daily operating results to the Department must have prior approval of the form from the Department.

(3) All water quality tests, other than those listed in Rule 0400-45-01-.06 shall be made in accordance with the latest edition of "Standard Methods for the Examination of Water and Wastewater" or alternate methods acceptable to the Department. The schedule of laboratory tests followed in controlling the operation of a waterworks system will vary with the character of the water; therefore, all waterworks systems must have the equipment necessary to perform all laboratory tests pertinent to the control of the plant or system operation, and the equipment shall be maintained in good working order at all times. Laboratory tests pertinent to proper operation shall be prescribed by the Department for each community water system.

(4) Chlorine is the recommended disinfection agent. Other agents will be considered by the Department provided they are effective and testing procedures for their effectiveness are recognized in the latest edition of "Standard Methods for the Examination of Water and Wastewater". All community water systems, using ground water as a raw water source and serving more than 50 connections or 150 persons shall continuously chlorinate (unless other disinfection methods are approved) and shall maintain a free chlorine residual in all parts of the distribution system in the amount of not less than 0.2 mg/l. Public Water Systems using surface water shall continuously chlorinate and maintain a free chlorine residual of 0.2 mg/l in all parts of the distribution system. The residual disinfectant concentration specified by this rule shall not be less than 0.2 mg/l in more than 5 percent of the samples each month, for any two consecutive months the system serves water to the public. All public water systems serving 50 or fewer connections that do not disinfect shall install continuous disinfection if the system fails to comply with the maximum contaminant level for coliform, experiences a disease outbreak or is directed to install disinfection by the department.

(5) All systems submitting samples for microbiological examination to the State laboratory must submit said sample in the bottle(s) provided by the State and return the samples to the proper State laboratory in the shipping carton provided by the State. The cost of postage for shipping the sample to the proper State laboratory shall be paid by the supplier of water. All samples submitted for microbiological examination must be collected and mailed to arrive at the proper State laboratory not later than Thursday noon of any week. Thirty hours is the limit allowed from the time of collection to the time of examination at the proper state laboratory.

(6) Pursuant to T.C.A. § 68-221-711(6) the installation, allowing the installation, or maintenance of any cross–connection, auxiliary intake, or bypass is prohibited unless the source and quality of water from the auxiliary supply, the method of connection, and the use and

(Rule 0400-45-01-.17, continued)

operation of such cross–connection, auxiliary intake, or bypass has been approved by the Department. The arrangement of sewer, soil, or other drain lines or conduits carrying sewage or other wastes in such a manner that the sewage or waste may find its way into any part of the public water system is prohibited.

All community water systems must adopt an ordinance or policy prohibiting all of the above and submit a copy of the executed ordinance or policy to the Department for approval. All community water systems shall develop a written plan for a cross–connection control program to detect and eliminate or protect the system from cross–connections. The written plan must be approved by the Department.

After adoption and approval of the cross–connection ordinance or policy and plan, each community water system must establish an ongoing program for the detection and elimination of hazards associated with cross–connections. Records of the cross–connection control program must be maintained by the water supplier and shall include such items as date of inspection, person contacted, recommendations, follow–up, and testing results.

(a) Public water systems must develop and implement an ongoing cross-connection program. Cross-connection plans and policies shall present all information in conformance with the "Design Criteria for Community Public Water Systems" as published by the Department.

(b) The public water system shall ensure that cross-connections between the distribution system and a consumer's plumbing are surveyed and/or inspected and determined not to exist or contain a significant risk or are eliminated or controlled by the installation of an approved backflow preventer commensurate with the degree of hazard.

(7) All community water system shall prepare and maintain an emergency operations plan in order to safeguard the water supply and to alert the public of unsafe drinking water in the event of natural or man-made disasters. Emergency operation plans shall be consistent with guidelines established by the Department and shall be reviewed and approved by the Department. Systems shall include a drought management plan as a part of the emergency operations plan. The drought management plans portions of the emergency operations shall be submitted for approval as follows:

(a) Systems serving 3,000 or more connections including consecutive systems: June 30, 2016.

(b) Systems serving more than 1,000 connections and less than 3,000 connections including consecutive systems: June 30, 2017.

(c) Systems serving 1,000 connections or less: June 30, 2018.

(8) (a) General-Public water systems, construction contractors and engineers shall follow and document sanitary practices used in inspecting, constructing or repairing water lines, finished water storage facilities, filters and wells. In lieu of writing their own disinfection standard operating procedures, public water systems, engineers and contractors may chose to follow the latest edition of the AWWA standards C-651, C-652 or equivalent methods provided the method has been approved in writing by the department and is available during the inspection, construction, maintenance or repair activity. The documentation shall include bacteriological sample results, construction logs, standard operating procedures and may include photographs where appropriate. All pipes, tanks, filters, filter media and other materials shall be properly disinfected prior to being placed in service. Any disinfectant used to disinfect shall be NSF approved or plain household bleach and used in a manner that assures sufficient contact time and concentration to inactivate any pathogens present. Bacteriological results including line

(Rule 0400-45-01-.17, continued)

repair records indicating adequacy of disinfection shall be maintained on file by the water system for five years. All public water systems, contractors, and engineers shall prepare and follow standard disinfection procedures approved by the Department when inspecting, maintaining, repairing or constructing lines, tanks, filters and wells. Procedures to ensure that water containing excessive concentrations of disinfectant is not supplied to the customers or discharged in such manner as to harm the environment shall be implemented.

All materials used for new or repaired water lines, storage facilities, filters, filter media, and wells will be inspected prior to use for any evidence of gross contamination. Any contamination observed shall be removed and the materials protected during installation.

(b) Disinfection of New Facilities-Bacteriological samples will be collected and analyzed to verify the effectiveness of the disinfection practices prior to placing new facilities in service. Bacteriological samples shall be collected to determine the effectiveness of the installation process including protecting the pipe material during storage, installation, and disinfection. This can be demonstrated by collecting two sets of microbiological samples 24 hours apart or collecting a single set of microbiological samples 48 hours or longer after flushing the highly chlorinated water from the lines. In either case microbiological samples in each set will be collected at approximately 2,500-foot intervals with samples near the beginning point and at the end point unless alternate sampling frequency and distance between sampling points approval has been obtained from the Department. Where sanitary conditions were not maintained before, during or after construction, an additional bacteriological sample shall be collected from a location representing the water from the contaminated area. Unsanitary conditions include failure to document the sanitary handling of materials, to conduct construction inspections and to maintain records, and to document sanitary practices during construction and other hazards such trench flooding during construction. If the constructed facility yields positive bacterial samples, additional flushing, disinfection and bacteriological sampling shall be repeated until the water is coliform free.

(c) Disinfection of Existing Facilities-Drinking water mains, storage facilities and filters that have been partially dewatered during inspection or repair shall, after the repair or inspection is completed, be disinfected, and flushed prior to placing it back in service. Bacteriological samples shall be collected immediately or as soon as possible after the repair is completed and from a location representing the water contained in the repaired line, tank or filter. The repaired facility may be returned to service prior to obtaining bacteriological results. If the repaired facility yields positive bacterial samples, additional flushing, disinfection and bacteriological sampling shall be repeated until the water is coliform free.

1. If one-half or more of either the original or repeat bacteriological samples collected from the repaired or renovated facility are total coliform positive, the system shall notify the Department within 30 days that it has reviewed its disinfection and sampling practices in an attempt to identify why the positive samples occurred and revise its disinfection and sampling plans accordingly.

2. If any public water system collects a fecal coliform positive repeat sample or e-coli positive repeat sample or a total coliform positive repeat sample following an initial positive fecal coliform or e-coli sample collected from the repaired or renovated facility, the system shall notify the Department within 24-hours and issue a tier 1 public notice using the language specified in Appendix B of Rule 0400-45-01-.19.

(Rule 0400-45-01-.17, continued)

(d) Inspectors, contractors, operators, public water systems or engineers that fail to document and follow adequate disinfection procedures, and fail to collect bacteriological samples during repairs, inspections or maintenance activities that potentially would compromise the microbial quality of the water shall issue a boil water advisory to the customers served by that portion of the public water system prior to returning the facility to service. The boil water advisory shall remain in effect until satisfactory microbial tests results are obtained.

(9) All community water systems shall be operated and maintained to provide minimum positive pressure of twenty (20) psi throughout the distribution system. No person shall install or maintain a water service connection to any premises where a booster pump has been installed unless such booster pump is equipped with a low pressure cut-off mechanism designed to cut off the booster pump when the pressure on the suction side of the pump drops to twenty (20) psi gauge.

(10) All community water systems having more than 50 service connections shall establish and maintain an adequate flushing program. The flushing program established shall help ensure that dead end and low usage mains are flushed periodically, drinking water standards are met, sediment and air removal and the free chlorine residual specified under paragraph (4) of this rule is maintained. Records of each flushing are to be maintained by the water system. These records shall include date, time, location, persons responsible and length of flushing. In addition to the above information, the free chlorine residual will have to be measured and recorded on the end of dead end mains after being flushed.

(11) All community public water systems serving more than 50 connections and which have their own source of water shall be required to install, operate and maintain duplicate disinfection equipment. Duplicate disinfection equipment means at least two chlorine cylinders connected to at least two chlorinators. Each set of chlorine cylinders consists of one or more cylinders which may be connected together by an automatic switchover valve. The two sets of chlorine cylinders may tee in to a common feed line leading to the chlorinators, but may not be connected together by an automatic switchover valve. The two sets of chlorine cylinders must be weighed independently and operated simultaneously. At least two chlorinators must be operated at all times with each feeding a part of the required dosage. The chlorinators may discharge to a common manifold piping network to allow multiple injection points. Facilities may be exempt from simultaneously operating duplicate disinfection equipment if the facility has a reliable chlorine residual analyzer with an alarm notifying a manned control center capable of immediately shutting down the treatment facility. Facilities, which are staffed during the time water is treated, can use one set of chlorine cylinders with the automatic switchover device provided the free chlorine residual is checked at the facility every two hours. A reliable free chlorine residual analyzer with an alarm system to a manned control center may be used for unmanned facilities that desire to use one set of chlorine cylinders with the automatic switchover device.

Community public water systems serving more than 50 service connections which use a hypochlorinator shall be required to have two solution pumps, two tanks for bleach solution and operate both units at the same time. Noncommunity systems and community systems serving less than 50 connections which use a hypochlorinator and show deficiencies in the disinfection process shall also be required to have duplicate disinfection units.

(12) All public water systems which utilize a filtration system shall use the following bed specifications and not exceed the following rates of filtration.

(a) Rapid Sand Filtration - 2.0 gallons per minute per square foot for turbidity removal, 3.0 gallons per minute per square foot for iron removal.

(Rule 0400-45-01-.17, continued)

There must be 30 inches of sand media with an effective size of 0.35 mm to 0.55 mm and a uniformity coefficient not greater than 1.70

(b) High Rate Filtration - 4.0 gallons per minute per square foot for turbidity removal, 4.0 gallons per minute per square foot for iron removal.

There must be 30 inches of dual media with 10 to 12 inches of sand and 18 to 20 inches of anthracite. The sand shall have an effective size of 0.35 mm to 0.55 mm and a uniformity coefficient not greater than 1.70. The anthracite shall have an effective size of 0.8 mm to 1.2 mm with a uniformity coefficient not greater than 1.85.

(c) Existing water systems with rapid sand filters and approved for higher rates of filtration by the Department will be allowed to continue at that rate provided the drinking water standards are met. The water supplier must be able to document that the Department approved the system for the higher rate.

(d) All mixed media filter beds will be at least 30 inches in depth and approved by the Department.

(e) Filtration rates above 4.0 gallons per minute per square foot will be considered on an individual basis. The Department will take into account the raw water characteristics, the treatment units, operational history, and operating personnel.

(13) All community water systems serving 50 connections or more shall install duplicate pumps for the raw water, finished water, and distribution pumping stations. A water system will not be required to have duplicate pumps in a distribution pumping station under the following conditions: limited number of service connections, availability of replacement pumps, maintaining adequate flows and pressures without the pumping station, and for emergency use only. All community public water systems using ground water supplies and having more than 50 service connections must have duplicate wells and/or duplicate pumps in a spring supply unless fed by gravity flow.

(14) All community water systems serving 50 connections or more are required to have 24 hours of distribution storage based on the average daily demand for the past twelve months. Distribution storage must be located so that the instantaneous demand can be met in all areas at any time.

(a) Systems which purchase water for resale may utilize the storage of the supplier provided the supplier has adequate distribution storage. Water systems that have large ground storage tanks will be given credit for distribution storage provided auxiliary power is available to pump water to the distribution system.

(b) Systems which have more than three (3) treatment facilities, have more than one source of water, and which have special power arrangements so that it is unlikely that all units would be down at the same time are not required to have distribution storage provided the peak demand can be met.

(c) Water systems which have an average daily demand of 10 million gallons or more are not required to have 24 hours of distribution storage provided the system has adopted a contingency plan for emergencies that has been approved by the Department. The contingency plan must demonstrate the water system is able to provide residential service to all customers for a 24 hour period during any emergency involving the shut down of the treatment facility.

(Rule 0400-45-01-.17, continued)

(d) Public water systems which utilize wells and provide only disinfection, pH adjustment, corrosion inhibitor and/or fluoridation as treatment, may use the capacity of the wells and the plant as part of the distribution storage under the following conditions:

1. The existing distribution storage tank(s) are adequate to meet the peak demands on the system,

2. The well(s), disinfection equipment and other pumping facilities needed to supply water to the distribution storage tank are equipped with an auxiliary power source with automatic controls, and

3. The well field capacity is determined by removing the largest well from consideration.

(e) Public water systems may take into account private distribution storage facilities in the following manner:

1. Private distribution storage may be counted as water system storage provided the private storage tank floats on the water utility's system and the water used serves both the private and utility system demand.

2. The water utility may reduce the amount of needed distribution storage by subtracting the average daily volume of any water user that has its own storage tank. This can be done provided the private storage tank is used on a daily basis.

3. Private distribution storage tanks used strictly for fire protection by the private owner cannot be in the water systems distribution storage capacity.

(15) All community water systems serving 50 or more service connections must have and maintain up-to-date maps of the distribution system. These maps must show the locations of the water mains, sizes of mains, valves, blow-offs or flush hydrants, air-release valves, and fire hydrants. One up-to-date copy of the overall system distribution map(s) is to be submitted to the Division of Water Supply every five years.

(16) All vents on wells, springs, storage tanks, overflows and clearwells shall be properly screened. All overflows on springs and tanks shall be screened and protected.

(17) All buildings and equipment used in and for the production and distribution of water (to include chemical and other storage buildings) must be well maintained and be reliable and fit for the purpose for which they are used. This includes, but is not limited to:

(a) When a water treatment plant is not producing water and an operator is not in attendance, plant entrances must be locked.

(b) Equipment such as chemical feeders, pumps, turbidimeters, pumpage meters, alarm systems, and air tanks shall be maintained and in good working condition. Pumps, tanks, hoses, and other equipment used by system personnel shall be disinfected and dedicated to its use if it comes into contact with water that may be consumed by humans.

(c) Duplicate or backup equipment shall be available as necessary to maintain the production of water meeting drinking water standards. Backup equipment or alternate treatment means shall be available for feeding all chemicals critical for adequate water treatment.

(Rule 0400-45-01-.17, continued)

(18) All community water systems planning to or having installed hydrants must protect the distribution system from contamination. All water mains designed for fire protection must be six inches or larger and be able to provide 500 gallons per minute with 20 pounds per square inch residual pressure. Fire hydrants shall not be installed on water mains less than six inches in diameter or on water mains that cannot produce 500 gpm at 20 psi residual pressure unless -the tops are painted red. Out of service hydrants shall have tops painted black or covered with a black shroud or tape.

Existing Class C hydrants (hydrants unable to deliver a flow of 500 gallons per minute at a residual pressure of 20 pounds per square inch (psi) shall have their tops painted red by January 1, 2008.

The water system must provide notification by certified mail at least once every five years beginning January 1, 2008, to each fire department that may have reason to utilize the hydrants, that fire hydrants with tops painted red (Class C hydrants) cannot be connected directly to a pumper fire truck. Fire Departments may be allowed to fill the booster tanks on any fire apparatus from an available hydrant by using the water system's available pressure only (fire pumps shall not be engaged during refill operations from a Class C hydrant).

(19) Before any new or modified community water treatment facility can be placed in service, it must be inspected and approved in writing by the Department.

(20) Each water system adjusting the fluoride content to the finished water must monitor for fluoride quarterly using a certified laboratory and the calculation of the fluoride level will be by running annual average. The recommended level of fluoridation in the finished water is 0.7 mg/l. Any public water system which determines to cease fluoridation treatment of its water supply shall notify the local environmental field office within the department of environment and conservation and the commissioner of the department of health of its decision to discontinue fluoridation within the timeframe as specified by T.C.A. § 68-221-708(c).

(21) New or modified turbidity removal facilities may not be placed into operation until the facility and the operator have been approved by the Department for the turbidity analysis.

(22) All pipe, pipe or plumbing fitting or fixture, solder, or flux which is used in the installation or repair of any public water system shall be lead free. The term "lead free" shall have the meaning given it in T.C.A. § 68-221-703.

(23) All dead end water mains and all low points in water mains shall be equipped with a blow-off or other suitable flushing mechanism capable of producing velocities adequate to flush the main.

(24) All community water systems must establish and maintain a file for customer complaints. This file shall contain the name of the person with the complaint, date, nature of complaint, date of investigation and results or actions taken to correct any problems.

(25) The Department may, upon written notice, require confirmation of any sampling results and also may require sampling and analysis for any contaminant when deemed necessary by the Department to protect the public health or welfare.

(26) Those public water systems required to monitor for turbidity and chlorine residual must have the laboratory approved by the Department before the results of these analyses can be accepted for compliance purposes.

(27) By December 30, 1991, or 18 months after the determination that a ground water system is influenced by surface water, all public water systems classified as a ground water system impacted by surface water shall utilize treatment techniques which achieve:

(Rule 0400-45-01-.17, continued)

(a) At least 99.9 percent (3 log) removal and/or inactivation of Giardia lamblia cysts between a point where the raw water is not subject to recontamination by surface water runoff and a point downstream before or at the first customer.

(b) At least 99.99 percent (4 log) removal and/or inactivation of viruses between a point where the raw water is not subject to recontamination by surface water runoff and a point downstream before or at the first customer.

(28) All public water systems using surface water shall provide disinfection to control the biological quality of the water. Due consideration shall be given to the contact time of the disinfectant in the water with relation to pH, ammonia, taste producing substances, temperature, presence and type of pathogens, and trihalomethane formation potential. All disinfection basins must be designed to prevent water short-circuiting the system. The disinfectant will be applied in the manner needed to provide adequate contact time.

(29) All community water systems using ground water as the raw water source serving water to more than 50 connections or 150 people will apply the disinfectant in the manner needed for adequate contact time. Contact time for ground water systems shall not be less than 15 minutes prior to the first customer.

(30) Any surface supplied public water system or ground water systems under the direct influence of surface water required to filter shall employ filtration in combination with disinfection that will achieve 99.9% (3 log) and 99.99% (4 log) inactivation of Giardia lamblia and viruses respectively between a point where the raw water is not subject to recontamination by surface water runoff and a point downstream before or at the first customer. For the purposes of determining removal or inactivation efficiencies for Giardia lamblia and viruses Table 0400-45-01-.17(30)1 and 0400-45-01-.17(30)2 shall apply. The free residual disinfectant concentration in the water entering the distribution system cannot be less than 0.2 mg/l for more than four hours.

TABLE 0400-45-01-.17(30)1

Assumed Log Removals by Filtration Method
and Required Levels of Disinfection

Treatment	Assumed Log Removal		Required Minimum Level of Disinfection	
	Giardia	Viruses	Giardia	Viruses
Conventional filtration	2.5	2.0	0.5	2.0
Direct filtration	2.0	1.0	1.0	3.0
Slow Sand filtration	2.0	2.0	1.0	2.0
Diatomaceous Earth filtration	2.0	1.0	1.0	3.0

TABLE 0400-45-01-.17(30)2

CT Values for Achieving 1-Log Inactivation of
Giardia Cysts[1]

	pH	Temperature			
		0.5°C	5°C	10°C	15°C
Free Chlorine[2,3]	6	55	39	29	19
	7	79	55	41	26
	8	115	81	61	41

(Rule 0400-45-01-.17, continued)

9	167	118	88	59
Ozone	0.97	0.63	0.48	0.32
Chlorine dioxide	1270	735	615	500

[1] Values to achieve 0.5 log inactivation are one half those shown in the table.

[2] CT values are for 2.0 mg/l free chlorine.

[3] CT values for other concentrations of free chlorine may be taken from Appendix E of the guidance manual for Compliance with the "Filtration and Disinfection Requirements For Public Water Systems Using Surface Water Sources," October, 1989, Edition, Science and Technology Branch Criteria and Standards Division, Office of Drinking Water, USEPA, Washington, D.C.

(31) Each public water system must certify annually in writing to the Department that when acrylamide and epichlorohydrin are used in drinking water systems, the combination (or product) of dose and monomer level does not exceed the levels specified as follows:

Acrylamide = 0.05% dosed at 1 ppm (or equivalent)
Epichlorohydrin = 0.01% dosed at 20 ppm (or equivalent)

Public water systems can rely on manufacturer's or third parties' certification for complying with this requirement.

(32) New service taps on existing mains that must be uncovered to make the tap, shall be flushed and the free chlorine residual measured and recorded prior to connecting the service lines. These records shall be retained until the next sanitary survey or for three years.

(33) All public water systems shall properly maintain their distribution system finished water storage tanks. Each community water system shall establish and maintain a maintenance file on each of its finished water and distribution storage tanks. These maintenance files must be available for inspection by Department personnel. These files must include the dates and results of all routine water storage tank inspections by system personnel, any reports of detailed professional inspections of the water storage tanks by contractor personnel, dates and details of routine tank cleanings and surface flushings, and dates and details of all tank maintenance activities. The tank inspection records shall include dates of the inspections; the sanitary, coating and structural conditions of the tank; and all recommendations for needed maintenance activities. Community Water Systems shall have a professional inspection performed and a written report produced on each of their finished water and distribution storage tanks at least once every five years. Non-community water systems shall have a professional inspection and written report performed on each of their atmospheric pressure finished water and distribution storage tanks no less frequently than every five years. Records of these inspections shall be available to the Department personnel for inspection. Persons conducting underwater inspections of finished water storage tanks shall comply with AWWA standard C652-92 or later versions of the standard.

(34) Paints and coatings for the interior of potable water storage facilities must be acceptable to the Department. Paints and coatings accepted by the Environmental Protection Agency (EPA) and/or the National Sanitation Foundation (NSF) for potable water contact are generally acceptable to the Department. Paint systems for steel tanks shall be consistent with AWWA Standard D102-78. Factory coated bolted steel tanks shall be in accordance with AWWA D103-87. Wire-wound circular prestressed concrete tanks shall be in accordance with AWWA D110-86.

(35) By January 1, 1996, public water systems using surface water and ground water systems under the direct influence of surface water that filter shall have rewash capability. Such systems shall perform a rewash cycle, or filter to waste each time a filter is backwashed. The

(Rule 0400-45-01-.17, continued)

rewash cycle shall be conducted in a way and manner necessary to prevent the introduction of contaminants such as pathogens and turbidity trapped in the filter into the clear well or distribution system.

Existing filter plants may be approved to operate without rewash (filter-to-waste provisions) if existing operational and backwash practices prevent water of unacceptable quality from entering the clearwell or distribution system. To operate without rewash the water system must demonstrate to the Department that filtered water turbidity after backwashing is reliably and consistently below 0.5 NTU immediately after backwashing each filter. Approval to operate without rewash must be approved in writing and approval must be renewed if any modifications are made to the operation or design of the plant. Each filter that operates without rewash must have a continuous recording turbidimeter and retain the records for a period of five years.

(36) By January 1, 1995, all chemicals, additives, coatings or other materials used in the treatment, conditioning and conveyance of drinking water must have been approved by the National Sanitation Foundation (NSF) or American National Standards Institute (ANSI) certified parties as meeting NSF product standard 60 and 61. Until 1995, products used for treatment, conditioning and conveyance of drinking water shall have been listed as approved by the US EPA or NSF.

(37) Any new Community Water System or Non-Transient Non-Community Water System commencing operation after September 30, 1999 shall have a “Capacity Development Plan” and be a “viable water system.”

(38) Public Water Systems identified as not complying or potentially not complying with the requirements of the Safe Drinking Water Act and in accordance with the priorities established in the Department’s Capacity Development Strategy shall prepare a “Capacity Development Plan” and demonstrate viability.

(39) Public water systems are not permitted to construct uncovered finished water reservoirs after the effective date of this subparagraph.

(40) Benchtop and continuous turbidimeters used to determine compliance with limits set forth in this rule chapter must be calibrated at least every three months with primary standards and documented. Documentation shall be maintained for a period not less than five years. Primary standards are Formazin, AMCO clear, Stablcal, or alternatives approved in writing by the Department. Dilute Formazin solutions are unstable and must be prepared on the day of calibration. Manufacturers’ recommendations on calibration procedure must be followed.

(41) Verifications for benchtop turbidimeters are comparisons to approved reference materials. Verifications for continuous turbidimeters are comparisons to approved reference materials or comparisons to a properly calibrated benchtop turbidimeter. Secondary reference materials are assigned a value immediately after acceptable primary calibration has been completed. Acceptable verifications for turbidity measurements greater than 0.5 NTU must agree within $\pm$10% from the reading assigned to the reference material after primary calibration. Acceptable verifications for measurements 0.5 NTU or less must be within $\pm$0.05 NTU or less from the reading assigned to the reference material after primary calibration. When comparisons are made from a continuous turbidimeter to a benchtop turbidimeter, the continuous measurement must be within $\pm$10% of the benchtop reading for measurements above 0.5 NTU and $\pm$0.05 NTU for reading 0.5 NTU or less. When acceptable verifications are not achieved the instrument must be re-calibrated with primary standards according to paragraph (40) of this rule. Approved reference materials for benchtop turbidimeters are primary standards and materials suggested by the manufacturer such as sealed sample cells filled with metal oxide particles in a polymer gel. The 0.5 NTU ICE-PIC™ from Hach is an approved reference material for secondary turbidity verifications for Hach continuous

(Rule 0400-45-01-.17, continued)

turbidimeters when utilized as per Manufacturers' recommendations. All other reference materials for turbidimeter verifications must be approved in writing by the Department. Verifications for turbidimeters must be performed according to the following:

(a) Verification of benchtop turbidimeters must be performed daily and documented. Verifications must include a sample in the expected working range of the instrument or as close to the working range as possible. Documentation must include: assigned reference material value after calibration, recorded daily reading for all reference standards, instrument identification, and date.

(b) Combined filter effluent turbidimeters as required by part (5)(c)1 of Rule 0400-45-01-.31 must be verified daily and documented. When reference material is utilized documentation must include: instrument identification, date, assigned reference material value after calibration, and daily value for reference material. When comparisons to benchtop turbidimeters are utilized documentation must include: instrument identification, date, continuous turbidimeter value, and benchtop turbidimeter value.

(c) Individual filter turbidimeters as required by part (5)(c)4 of Rule 0400-45-01-.31 must be verified weekly.

Authority: *T.C.A. §§ 68-221-701 et seq. and 4-5-201 et seq.* ***Administrative History:*** *Original rule filed August 1, 2012; effective October 30, 2012. Rule was previously numbered 1200-05-01. Amendments and new rules filed November 24, 2015; effective February 22, 2016. Amendments filed March 7, 2016; effective June 5, 2016.*

0400-45-01-.18 REPORTING REQUIREMENTS.

(1) Except where a shorter period is specified in this Chapter, the supplier of water shall report to the Department the results of any test measurement or analysis required by this part within (a) the first ten days following the month in which the result is received or (b) the first ten days following the end of the required monitoring period as stipulated by the Department, which ever of these is shortest.

(2) All systems shall report to the Department within forty-eight (48) hours of the failure to comply with Departmental drinking water regulations or other requirements (including failure to comply with monitoring, maximum contaminant level or treatment technique requirements) set forth in these rules and regulations, and in case of any of the following events shall immediately notify the Department and responsible local officials:

(a) any major breakdown or failure of equipment in water treatment process which affects the quality or quantity of the water leaving the treatment plant;

(b) any serious loss of water service due to a failure of transmission or distribution facilities; or

(c) any situation with the water system which presents or may present an imminent and substantial endangerment to health.

(3) Systems are not required to report analytical results to the Department in cases where a State laboratory performs the analysis and reports the results to the Department.

(4) The public water system, within 10 days of completing the public notification requirements under Rule 0400-45-01-.19 for the initial public notice and any repeat notices, must submit to the department a certification that it has fully complied with the public notification regulations. The public water system must include with this certification a representative copy of each

(Rule 0400-45-01-.19, continued)

Table 0400-45-01-.19(1)(a)

Violation Categories and Other Situations
Requiring a Public Notice

1. NPDWR violations:

   (i) Failure to comply with an applicable maximum contaminant level (MCL) or maximum residual disinfectant level (MRDL).
   (ii) Failure to comply with a prescribed treatment technique (TT).
   (iii) Failure to perform water quality monitoring, as required by the drinking water regulations.
   (iv) Failure to comply with testing procedures as prescribed by a drinking water regulation.

2. Variance and exemptions under sections 1415 and 1416 of SDWA:

   (i) Operation under a variance or an exemption.
   (ii) Failure to comply with the requirements of any schedule that has been set under a variance or exemption.

3. Special public notices:

   (i) Occurrence of a waterborne disease outbreak or other waterborne emergency.
   (ii) Exceedance of the alternate MCL for nitrate by non-community water systems (NCWS), where the non-community system has been granted an alternate standard by the department.
   (iii) Exceedance of the secondary maximum contaminant level (SMCL) for fluoride.
   (iv) Availability of unregulated contaminant monitoring data.
   (v) Other violations and situations determined by the department to require a public notice under this rule, not already listed in Appendix A.

(b) Public notice requirements are divided into three tiers to take into account the seriousness of the violation or situation and any potential adverse health effects that may be involved. The public notice requirements for each violation or situation listed in Table 0400-45-01-.19(1)(a) are determined by the tier to which it is assigned. Table 0400-45-01-.19(1)(b) provides the definition of each tier. Appendix A of this rule identifies the tier assignment for each specific violation or situation.

Table 0400-45-01-.19(1)(b)

Definition of Public Notice Tiers

1. Tier 1 public notice-required for NPDWR violations and situations with significant potential to have serious adverse effects on human health as a result of short-term exposure.

2. Tier 2 public notice--required for all other NPDWR violations and situations with potential to have serious adverse effects on human health.

3. Tier 3 public notice--required for all other NPDWR violations and situations not included in Tier 1 and Tier 2.

(c) Who must be notified?

(Rule 0400-45-01-.19, continued)

1. Each public water system must provide public notice to persons served by the water system, in accordance with this rule. Public water systems that sell or otherwise provide drinking water to other public water systems (i.e., to consecutive systems) are required to give public notice to the owner or operator of the consecutive system; the consecutive system is responsible for providing public notice to the persons it serves.

2. If a public water system has a violation in a portion of the distribution system that is physically or hydraulically isolated from other parts of the distribution system, the Department may allow the system to limit distribution of the public notice to only persons served by that portion of the system which is out of compliance. Permission by the department for limiting distribution of the notice must be granted in writing.

3. A representative copy of the each type of the notice distributed, published, posted and/or made available to the persons served by the system and/or to the media must also be sent to the Department within ten days of completion of each public notification.

(2) Tier 1 Public Notice-Form, manner, and frequency of notice.

(a) Violation of the MCL for total coliforms when fecal coliform or E. coli are present in the water distribution system as specified in Rule 0400-45-01-.06, or when the water system fails to test for fecal coliforms or E. coli when any repeat sample tests positive for coliform as specified in Rule 0400-45-01-.07; Violation of the MCL for E. coli (as specified in Rule 0400-45-01-.06(4)(f));

Table 0400-45-01-.19(2)(a)

Violation Categories and Other Situations
Requiring a Tier 1 Public Notice

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1. Violation of the MCL for total coliforms when fecal coliform or E. coli are present in the water distribution system as specified in Rule 0400-45-01-.06, or when the water system fails to test for fecal coliforms or E. coli when any repeat sample tests positive for coliform as specified in Rule 0400-45-01-.07;

2. Violation of the MCL for nitrate, nitrite, or total nitrate and nitrite, as defined in Rule 0400-45-01-.06, or when the water system fails to take a confirmation sample within 24 hours of the system's receipt of the first sample showing an exceedance of the nitrate or nitrite MCL, as specified in Rule 0400-45-01-.09;

3. Exceedance of the alternate MCL for nitrate by non-community water systems (NCWS), where the non-community system has been granted an alternate standard by the department;

4. Violation of the MRDL for chlorine dioxide, as defined in Rule 0400-45-01-.36, when one or more samples taken in the distribution system the day following an exceedance of the MRDL at the entrance of the distribution system exceed the MRDL, or when the water system does not take the required samples in the distribution system, as specified in Rule 0400-45-01-.36;

5. Violation of the turbidity MCL under Rule 0400-45-01-.06, where the department determines after consultation that a Tier 1 notice is required or where consultation does not take place within 24 hours after the system learns of the violation;

(Rule 0400-45-01-.19, continued)

6. Violation of the Surface Water Treatment Rule (SWTR) Rule 0400-45-01-.31, Interim Enhanced Surface Water Treatment Rule (IESWTR) or Long Term 1 Enhanced Surface Water Treatment Rule (LT1ESWTR) treatment technique requirement resulting from a single exceedance of the maximum allowable turbidity limit (as identified in Appendix A) where the department determines after consultation that a tier 1 notice is required or where consultation does not take place within 24 hours after the system learns of the violation;

7. Occurrence of a waterborne disease outbreak, as defined in Rule 0400-45-01-.04, or other waterborne emergency (such as a failure or significant interruption in key water treatment processes, a natural disaster that disrupts the water supply or distribution system, or a chemical spill or unexpected loading of possible pathogens into the source water that significantly increases the potential for drinking water contamination);

8. Other violations or situations with significant potential to have serious adverse effects on human health as a result of short-term exposure, as determined by the Department either in its regulations or on a case-by-case basis.

9. Detection of E. coli or enterococci in source water samples as specified in paragraph (3) of Rule 0400-45-01-.40.

(b) When is the Tier 1 public notice to be provided? What additional steps are required? Public water systems must:

1. Provide a public notice as soon as practical but no later than 24 hours after the system learns of the violation;

2. Initiate consultation with the Department as soon as practical, but no later than 24 hours after the public water system learns of the violation or situation, to determine additional public notice requirements; and

3. Comply with any additional public notification requirements (including any repeat notices or direction on the duration of the posted notices) that are established as a result of the consultation with the Department. Such requirements may include the timing, form, manner, frequency, and content of repeat notices (if any) and other actions designed to reach all persons served.

(c) What is the form and manner of the public notice? Public water systems must provide the notice within 24 hours in a form and manner reasonably calculated to reach all persons served. The form and manner used by the public water system are to fit the specific situation, but must be designed to reach residential, transient, and non-transient users of the water system. In order to reach all persons served, water systems are to use, at a minimum, one or more of the following forms of delivery:

1. Appropriate broadcast media (such as radio and television);

2. Posting of the notice in conspicuous locations throughout the area served by the water system;

3. Hand delivery of the notice to persons served by the water system; or

4. Another delivery method approved in writing by the department.

(3) Tier 2 Public Notice--Form, manner, and frequency of notice.

(Rule 0400-45-01-.19, continued)

(a) Which violations or situations require a Tier 2 public notice? Table 0400-45-01-.19(3)(a) lists the violation categories and other situations requiring a Tier 2 public notice. Appendix A to this rule identifies the tier assignment for each specific violation or situation.

Table 0400-45-01-.19(3)(a)

Violation Categories and Other Situations
Requiring a Tier 2 Public Notice

1.	All violations of the MCL, MRDL, and treatment technique requirements, except where a Tier 1 notice is required under subparagraph (2)(a) of this rule or where the department determines that a Tier 1 notice is required;
2.	Violations of the monitoring and testing procedure requirements, where the department determines that a Tier 2 rather than a Tier 3 public notice is required, taking into account potential health impacts and persistence of the violation; and
3.	Failure to comply with the terms and conditions of any variance or exemption in place.
4.	Failure to take corrective action or failure to maintain at least 4-log treatment of viruses (using inactivation, removal, or a Department-approved combination of 4-log virus inactivation and removal) before or at the first customer under subparagraph (4)(a) of Rule 0400-45-01-.40.

(b) When is the Tier 2 public notice to be provided?

1. Public water systems must provide the public notice as soon as practical, but no later than 30 days after the system learns of the violation. If the public notice is posted, the notice must remain in place for as long as the violation or situation persists, but in no case for less than seven days, even if the violation or situation is resolved. The department may, in appropriate circumstances, allow additional time for the initial notice of up to three months from the date the system learns of the violation. The department will not grant an extension to the 30-day deadline for any unresolved violation or to allow across-the-board extensions by rule or policy for other violations or situations requiring a Tier 2 public notice. Extensions granted by the department must be in writing.

2. The public water system must repeat the notice every three months as long as the violation or situation persists, unless the primacy agency determines that appropriate circumstances warrant a different repeat notice frequency. In no circumstance may the repeat notice be given less frequently than once per year. The Department will not through its rules or policies permit across-the-board reductions in the repeat notice frequency for other ongoing violations requiring a Tier 2 repeat notice. The Department will not allow through its rules or policies less frequent repeat notice for an MCL or treatment technique violation under Rule 0400-45-01-.07 (Monitoring) or Rule 0400-45-01-.41 (Revised Total Coliform Rule) or a treatment technique violation under Rule 0400-45-01-.31 (Filtration and Disinfection). Department determinations allowing repeat notices to be given less frequently than once every three months must be in writing.

3. For the turbidity violations specified in this paragraph, public water systems must consult with the Department as soon as practical but no later than 24 hours after the public water system learns of the violation, to determine whether a Tier 1 public notice under subparagraph (2)(a) of this rule is required to protect public

(Rule 0400-45-01-.19, continued)

health. When consultation does not take place within the 24-hour period, the water system must distribute a Tier 1 notice of the violation within the next 24 hours (i.e., no later than 48 hours after the system learns of the violation), following the requirements under subparagraphs (2)(b) and (c) of this rule. Consultation with the department is required for:

(i) Violation of the turbidity MCL under Rule 0400-45-01-.06; or

(ii) Violation of the SWTR, IESWTR or LT1ESWTR treatment technique requirement (Rule 0400-45-01-.31) resulting from a single exceedance of the maximum allowable turbidity limit.

(c) What is the form and manner of the Tier 2 public notice? Public water systems must provide the initial public notice and any repeat notices in a form and manner that is reasonably calculated to reach persons served in the required time period. The form and manner of the public notice may vary based on the specific situation and type of water system, but it must at a minimum meet the following requirements:

1. Unless directed otherwise by the department in writing, community water systems must provide notice by:

(i) Mail or other direct delivery to each customer receiving a bill and to other service connections to which water is delivered by the public water system; and

(ii) Any other method reasonably calculated to reach other persons regularly served by the system, if they would not normally be reached by the notice required in subpart (i) of this part. Such persons may include those who do not pay water bills or do not have service connection addresses (e.g., house renters, apartment dwellers, university students, nursing home patients, prison inmates, etc.). Other methods may include: publication in a local newspaper; delivery of multiple copies for distribution by customers that provide their drinking water to others (e.g., apartment building owners or large private employers); posting in public places served by the system or on the Internet; or delivery to community organizations.

2. Unless directed otherwise by the department in writing, non-community water systems must provide notice by:

(i) Posting the notice in conspicuous locations throughout the distribution system frequented by persons served by the system, or by mail or direct delivery to each customer and service connection (where known); and

(ii) Any other method reasonably calculated to reach other persons served by the system if they would not normally be reached by the notice required in subpart (i) of this part. Such persons may include those served who may not see a posted notice because the posted notice is not in a location they routinely pass by. Other methods may include: publication in a local newspaper or newsletter distributed to customers; use of E-mail to notify employees or students; or, delivery of multiple copies in central locations (e.g., community centers).

(4) Tier 3 Public Notice--Form, manner, and frequency of notice.

(a) Which violations or situations require a Tier 3 public notice? Table 0400-45-01-.19(4) lists the violation categories and other situations requiring a Tier 3 public notice.

(Rule 0400-45-01-.19, continued)

Appendix A to this rule identifies the tier assignment for each specific violation or situation.

Table 0400-45-01-.19(4)

Violation Categories and Other Situations Requiring a Tier 3 Public Notice

1.	Monitoring violations for the primary drinking water contaminants, except where a Tier 1 notice is required under subparagraph (2)(a) of this rule or where the department determines that a Tier 2 notice is required;
2.	Failure to comply with an approved departmental or EPA testing procedure, except where a Tier 1 notice is required under subparagraph (2)(a) of this rule or where the department determines that a Tier 2 notice is required;
3.	Operation under a variance granted under Section 1415 or an exemption granted under Section 1416 of the Safe Drinking Water Act;
4.	Availability of unregulated contaminant monitoring results, as required under paragraph (7) of this rule;
5.	Exceedance of the fluoride secondary maximum contaminant level (SMCL), as required under paragraph (8) of this rule; and
6.	Reporting and Recordkeeping violations under Rule 0400-45-01-.41.

(b) When is the Tier 3 public notice to be provided?

1. Public water systems must provide the public notice not later than one year after the public water system learns of the violation or situation or begins operating under a variance or exemption. Following the initial notice, the public water system must repeat the notice annually for as long as the violation, variance, exemption, or other situation persists. If the public notice is posted, the notice must remain in place for as long as the violation, variance, exemption, or other situation persists, but in no case less than seven days (even if the violation or situation is resolved).

2. Instead of individual Tier 3 public notices, a public water system may use an annual report detailing all violations and situations that occurred during the previous twelve months, as long as the timing requirements of part 1 of this subparagraph are met.

(c) What is the form and manner of the Tier 3 public notice? Public water systems must provide the initial notice and any repeat notices in a form and manner that is reasonably calculated to reach persons served in the required time period. The form and manner of the public notice may vary based on the specific situation and type of water system, but it must at a minimum meet the following requirements:

1. Unless directed otherwise by the Department in writing, community water systems must provide notice by:

(Rule 0400-45-01-.31, continued)

1. Representative samples of a system's filtered water effluent must be less than or equal to 1 NTU in at least 95 percent of the measurements taken each month. In systems using slow sand filtration, if the Department determines there is no significant interference with disinfection at a higher turbidity level, the Department may substitute this higher turbidity limit for a system.

2. The turbidity level of representative samples of a system's filtered water must at no time exceed 5 NTU.

(c) By December 31, 2001, subpart H systems that use conventional or direct filtration and serve 10,000 or more persons and by January 14, 2005, subpart H systems serving fewer than 10,000 persons shall employ filtration treatment that:

1. For systems using conventional filtration or direct filtration, the turbidity level of representative samples of a system's filtered water must be less than or equal to 0.3 NTU in at least 95 percent of the measurements taken each month, measured as specified in subparagraphs (5)(a) and (c) of this rule.

2. The turbidity level of representative samples of a system's filtered water must at no time exceed 1 NTU, measured as specified in subparagraphs (5)(a) and (c) of this rule.

3. A system that uses lime softening may acidify representative samples prior to analysis using a protocol approved by the Department.

(d) A public water system may use a filtration technology not listed in subparagraph (c) of this paragraph or in subparagraph (b) of this paragraph if it demonstrates to the Department, using pilot plant studies or other means, that the alternative filtration technology, in combination with disinfection treatment that meets the requirements of paragraph (30) of Rule 0400-45-01-.17, consistently achieves 99.9 percent removal and/or inactivation of Giardia lamblia cysts and 99.99 percent removal and/or inactivation of viruses, and 99 percent removal of Cryptosporidium oocysts, and the Department approves the use of the filtration technology. For each approval, the Department will set turbidity performance requirements that the system must meet at least 95 percent of the time and that the system may not exceed at any time at a level that consistently achieves 99.9 percent removal and/or inactivation of Giardia lamblia cysts, 99.99 percent removal and/or inactivation of viruses, and 99 percent removal of Cryptosporidium oocysts. The maximum allowable turbidity limits for subpart H systems serving fewer than 10,000 persons using an alternative filtration technology excluding slow sand and diatomaceous earth cannot exceed 1 NTU in 95 percent of the samples taken each month or 5 NTU on any single sample.

(5) Monitoring Requirements

(a) Reserved

(b) The public water system must comply with the maximum contaminant level (MCL) for total coliforms in paragraph (4) of Rule 0400-45-01-.06 and the MCL for E. coli in subparagraph (4)(g) of Rule 0400-45-01-.06. The system must achieve the standard at a frequency of at least 11 months of the 12 previous months that the system served water to the public, on an ongoing basis, unless the Department determines that failure to meet this requirement was not caused by a deficiency in treatment of the source water.

(Rule 0400-45-01-.31, continued)

[1] The day's samples cannot be taken at the same time. The sampling intervals are subject to Department review and approval.

If at any time the free chlorine concentration falls below 0.2 mg/l in a system using grab sampling in lieu of continuous monitoring, the system must take a grab sample every 4 hours until the free residual concentration is equal to or greater than 0.2 mg/l.

6. Until March 31, 2016, the residual disinfectant concentration must be measured at least at the same points in the distribution system and at the same time as total coliforms are sampled, as specified in paragraph (1) of Rule 0400-45-01-.07. Beginning April 1, 2016, the residual disinfectant concentration must be measured at least at the same points in the distribution system and at the same time as total coliforms are sampled, as specified in paragraphs (4) through (8) of Rule 0400-45-01-.41. The Department may allow a public water system which uses both a surface water source or a ground water source under direct influence of surface water, and a ground water source, to take disinfectant residual samples at points other than the total coliform sampling points if the Department determines that such points are more representative of treated (disinfected) water quality within the distribution system. Heterotrophic bacteria, measured as heterotrophic plate count (HPC) as specified in part (10)(a)4 of Rule 0400-45-01-.14, may be measured in lieu of residual disinfectant concentration.

(c) Until March 31, 2016, the residual disinfectant concentration must be measured at least at the same points in the distribution system and at the same time as total coliforms are sampled, as specified in paragraph (1) of Rule 0400-45-01-.07. Beginning April 1, 2016, the residual disinfectant concentration must be measured at least at the same points in the distribution system and at the same time as total coliforms are sampled, as specified in paragraphs (4) through (8) of Rule 0400-45-01-.41. The Department may allow a public water system which uses both a surface water source or a ground water source under direct influence of surface water, and a ground water source, to take disinfectant residual samples at points other than the total coliform sampling points if the Department determines that such points are more representative of treated (disinfected) water quality within the distribution system. Heterotrophic bacteria, measured as heterotrophic plate count (HPC) as specified in part (10)(a)4 of Rule 0400-45-01-.14, may be measured in lieu of residual disinfectant concentration.

1. Turbidity as required by paragraph (4) of this rule must be continuously measured and recorded on representative samples of the system's combined filtered water while the system serves water to the public. The highest turbidity value obtained during each four-hour period must be reported. A public water system may substitute grab sample monitoring if approved by the Department. For any system using slow sand filtration or filtration treatment other than conventional treatment, direct filtration, or diatomaceous earth filtration, the Department may reduce the sampling frequency to once per day if it determines that less frequent monitoring is sufficient to indicate effective filtration performance. For systems serving 500 or fewer persons, the Department may reduce the turbidity sampling frequency to once per day, regardless of the type of filtration treatment used, if the Department determines that less frequent monitoring is sufficient to indicate effective filtration performance. The highest turbidity measured each four hours must be reported according to the following four hour segments: 12:01 a.m. to 4:00 a.m., 4:01 to 8:00 a.m., 8:01 to 12 noon, 12:01 to 4:00 p.m., 4:01 p.m. to 8:00 p.m., 8:01 to 12 midnight. The intake of the combined filter effluent turbidity monitor shall be located at or near the entry point to the clearwell or at a location approved by the Department.

(Rule 0400-45-01-.31, continued)

2. The residual disinfectant concentration of the water entering the distribution system must be monitored continuously, and the lowest value must be recorded each day. If there is a failure in the continuous monitoring equipment, grab sampling every 4 hours may be conducted in lieu of continuous monitoring, but for no more than 5 working days following the failure of the equipment. Systems serving 3,300 or fewer persons may take grab samples each day in lieu of providing continuous monitoring on an ongoing basis at the frequencies prescribed below:

System Size by Population	Samples/ day[1]
≤500	1
501 to 1,000	2
1,001 to 2,500	3
2,501 to 3,300	4

[1]The day's samples cannot be taken at the same time. The sampling intervals are subject to Department review and approval.

If at any time the free residual disinfectant concentration falls below 0.2 mg/l in a system using grab sampling in lieu of continuous monitoring, the system must take a grab sample every 4 hours until the free residual disinfectant concentration is equal to or greater than 0.2 mg/l.

3. The residual disinfectant concentration must be measured at least at the same points in the distribution system and at the same time as total coliforms are sampled, as specified in paragraph (1) of Rule 0400-45-01-.07. The Department may allow a public water system which uses both a surface water source or a ground water source under direct influence of surface water, and a ground water source to take disinfectant residual samples at points other than the total coliform sampling points if the Department determines that such points are more representative of treated (disinfected) water quality within the distribution system.

4. In addition to monitoring required by parts 1, 2 and 3 of this subparagraph, a subpart H system serving 10,000 or more persons using conventional filtration treatment or direct filtration must conduct continuous monitoring of turbidity for each individual filter using an approved method in subparagraph (10)(b) of Rule 0400-45-01-.14 and must calibrate turbidimeters using the procedure specified in paragraphs (40) and (41) of Rule 0400-45-01-.17. Systems must record the results of individual filter monitoring every 15 minutes. In addition to monitoring required by parts 1, 2 and 3 of this subparagraph by January 14, 2005, a subpart H system serving fewer than 10,000 persons using conventional filtration treatment or direct filtration must conduct continuous monitoring of turbidity for each individual filter using an approved method in subparagraph (10)(b) of Rule 0400-45-01-.14 and must calibrate turbidimeters using the procedure specified in paragraphs (40) and (41) of Rule 0400-45-01-.17. Systems must record the results of individual filter monitoring every 15 minutes.

5. If there is a failure in the continuous turbidity monitoring equipment, the system must conduct grab sampling every four hours in lieu of continuous monitoring until the turbidimeter is repaired and back on-line. A system has a maximum of five working days after failure to repair the equipment or it is in violation.

(6) Reporting and recordkeeping requirements.

Record Category	Time frame required to keep records	Source
Microbiological Records		0400-45-1-.20(1)(a)
Routine distribution	5 years	
Line repair records	5 years	0400-45-1-.17(8)(a)
New line records	5 years	
Bacteriological sampling plan	Keep updated, at least every 3 years	
Chemical Analysis		0400-45-1-.20(1)(a)
Inorganics/ secondaries	10 years	
SOC's	10 years	
VOC's	10 years	
THM's and HAA5's	10 years	
Radionuclides	10 years	
Lead and copper	12 years	0400-45-1-.33(12)
Miscellaneous		
Action regarding violations	3 years	0400-45-1-.20(1)(b)
Certified Letters to Fire Departments regarding Class C hydrants	5 years	0400-45-1-.17(18)
Complaint file	5 years	0400-45-1-.20(1)(h)
Consumer Confidence Reports	3 years	0400-45-1-.35(h)
Cross connection plans and inspection records	5 years	0400-45-1-.20(1)(h)
Daily worksheets, strip charts, shift logs	5 years	0400-45-1-.20(1)(g)
Disinfection Profile	10 years	
Disinfection SOP	Keep updated	
Distribution map	Keep updated, submit copy to DWS every 5 years	0400-45-1-.17(15)
Distribution SOP	Keep updated	
Emergency Operation Plan	Keep updated	0400-45-1-.34(4)(a)
Facility Maintenance Records	5 years	0400-45-1-.20(1)(h)
Flushing records	Survey to survey or 3 years	0400-45-1-.17(10)
MOR's	5 years	
MSDS	At least 30 years	29 CFR 1910.1020
New tap records	Survey to survey or 3 years	0400-45-1-.17(32)
Notice of Construction	Survey to survey or 3 years	
Plant SOP	Keep updated	
Public Notices	3 years	0400-45-1-.20(i)
Sanitary surveys	10 years	
Storage Tank Inspection Records	5 years	0400-45-1-.17(33), 0400-45-1-.20(1)(h)
Tank maintenance records	Life of tank	0400-45-1-.17(33)
Turbidity analysis: daily worksheets, calibration data and strip charts	5 years	0400-45-1-.20(1)(f)
Variances or Exemptions	5 years	0400-45-1-.20(1)(d)

Rules and Regulation Exercise

Definitions:

1) Define a Subpart H system.

2) Define public water system.

MCL's

3) The contract laboratory has reported this data (are these violations and if so, what is the MCL?):

   a) arsenic level at 0.05 mg/L.

   b) nitrate level at 12 mg/L.

   c) fluoride level at 4.3 mg/L.

   d) atrazine level at 0.005 mg/L.

   e) lindane level at 0.005 mg/L.

   f) chromium level at 0.4 mg/L.

   g) THM level at 0.09mg/L.

   h) HAA5 level at 0.55 mg/L.

   i) chlorine level at 4.3 mg/L.

   j) chlorine dioxide level at 0.79 mg/L.

   k) chloramine level at 3.9 mg/L.

   l) fecal coliform-positive repeat sample

   m) E. coli-positive repeat sample

   n) Total coliform-positive repeat sample following a fecal coliform-positive or E. coli-positive routine sample

4) The maximum contaminant levels for turbidity in drinking water, measured at a representative entry point(s) to the distribution system are _____ NTU as determined by monthly average pursuant or _____ NTU based on an average for two consecutive days.

5) The maximum contaminant level for microbiologicals are based on the presence or absence of total coliforms, these numbers shall not exceed any of the following:

   a) A system that collects at least _____ samples per month shall have no more than _____ % samples that are total coliform positive.

   b) A system that collects fewer than _____ shall have no more than _____ sample collected for the month that are total coliform positive.

Sampling

6) You serve a community of 32,000 people, how many samples would you need to collect per month for total coliform?

7) You serve a community of 8,200 people, how many samples would you need to collect per month for total coliform?

8) If a routine sample is total coliform-positive, you must collect a set of repeat samples within _____ hours of being notified of the positive result. The system must collect at least _____ repeat sample from the sampling tap where the original total coliform-positive sample was taken, and at least _____ repeat sample at a tap within _____ service connections upstream and at a tap within _____ service connections downstream of the original sampling site.

9) Turbidity measurements must be performed on representative samples of the system's filtered water every _____ hours.

Operation and Maintenance Requirements

10) All community water systems that are designed as a _____ supply and classified as a _____ system and all _____ removal plants that use gravity filters must have an _____ in attendance and responsible for the treatment process when the plant is in _____ .

11) Daily operating records shall be submitted so the Department receives them no later than _____ after the end of the reporting month.

12) All water quality tests shall be made in accordance with the latest edition of _____ or alternate methods acceptable to the Department.

13) Free chlorine levels in the distribution system shall be maintained at no less than _____.

14) All community water systems shall develop a written plan for a _____ control program to detect and eliminate or protect the system from _____.

15) Newly constructed or repaired water distribution lines, finished water storage facilities, filters and wells shall be flushed and disinfected in accordance with _____ _____.

16) All community water systems shall be operated and maintained to provide a minimum positive pressure of _____ psi throughout the distribution system.

17) All community water systems having more than 50 service connections shall establish and maintain an adequate _____ program. Records must be maintained and shall include:

a) _____

b) _____

c) _____

d) _____

e) _____

18) All community public water systems serving more than 50 service connections and that have their own source of water shall be required to install, operate and maintain _____ disinfection equipment.

19) What is the filtration rate of a high rate filter?

20) How many inches of media are required?

a) Dual media:

i) Sand:

ii) Anthracite:

b) Mixed media beds:

21) All community water systems serving 50 connections or more are required to have _____ hours of distribution storage based on the _____ _____ demand for the past _____ months.

22) All community water systems serving 50 or more service connections must have and maintain up-to-date _____ of the distribution system. These maps must show the locations of the:

a) _____

b) _____

c) _____

d) _____

e) _____

f) _____

23) All vents on _____, springs, _____ _____, overflows and _____ shall be properly screened.

24) All community water systems planning to provide fire protection must have the distribution system designed to provide fire flow. All water mains designed for fire protection must be _____ inches or larger and be able to provide _____ gpm with _____ psi.

25) Public water systems that adjust the fluoride levels shall maintain the concentration of fluoride in the finished water between _____ mg/L and _____ mg/L.

26) All community water systems must establish and maintain a file for customer complaints. This file should include:

a) _____

b) _____

c) _____

d) _____

e) _____

27) Any surface supplied public water system or ground water systems under the direct influence of surface water required to filter shall employ filtration in combination with disinfection that will achieve _____% (_____ log) and _____% (_____ log) inactivation of Giardia lamblia and viruses respectively between a point where the raw water is not subject to recontamination by surface water runoff and a point downstream before or at the fist customer.

Rules and Regulation Exercise

Definitions:

1) Public water systems using surface water or ground water under the direct influence of surface water as a source that are subject to the requirements of filtration. 1200-5-1-.04(87)

2) A system for the provision of piped water for human consumption if such serves 15 or more connections or which regularly serves 25 or more individuals daily at least 60 days out of the year. 1200-5-1-.04(75)

MCL's

3)

a) arsenic level at 0.05 mg/L. MCL is 0.05 mg/L until 1/06, then 0.01 mg/L
b) nitrate level at 12 mg/L. MCL is 10 mg/L
c) fluoride level at 4.3 mg/L. MCL 4.0 mg/L
d) atrazine level at 0.005 mg/L. MCL is 0.003 mg/L
e) lindane level at 0.005 mg/L. MCL is 0.0002 mg/L
f) chromium level at 0.4 mg/L. MCL is 0.1 mg/L

1200-5-1-.06 (1)(b) and (2)(a)

g) THM level at 0.09mg/L. MCL is 0.08 mg/L
h) HAA5 level at 0.55 mg/L. MCL is 0.06 mg/L
i) chlorine level at 4.3 mg/L. MCL is 4.0 mg/L
j) chlorine dioxide level at 0.79 mg/L. MCL is 0.8 mg/L
k) chloramine level at 3.9 mg/L. MCL is 4.0 mg/L

1200-5-1-.06 (6)(b) and (6)(c)

l) fecal coliform-positive repeat sample violation
m) E. coli-positive repeat sample violation
n) violation

1200-5-1-.06 (4)

4) 1.0 and 2.0 - Page 16, 1200-5-1-.06(3)

5) a) 40 and 5 , 1200-5-1-.06(4)(a)(1); b) 40 and 1, 1200-5-1-.06(4)(a)(1)

Sampling

6) 30, 1200-5-1-.07(1)(c)

7) 9, 1200-5-1-.07(1)(c)

8) 24, 1, 1, 5, 5; 1200-5-1-.07(2)(a) and (b)

9) 4, 1200-5-1-.08(2)(a)

Operation and Maintenance Requirements

10) surface, filtration, iron, operator, operation; 1200-5-1-.17(1)

11) 10 days; 1200-5-1-.17(2)

12) "Standard Methods for the Examination of Water and Wastewater"; 1200-5-1-.17(3)

13) 0.2 mg/L; 1200-5-1-.17(4)

14) cross-connection, cross-connections; 1200-5-1-.17(6)

15) AWWA standards C-651, C-652 or equivalent methods provided the method has been approved in writing by the department and is available during the inspection, construction, maintenance or repair activity; 1200-5-1-.17(8)(a)

16) 20; 1200-5-1-.17(9)

17) flushing; a) date, b) time, c) location, d) persons responsible, e)length of flushing; 1200-5-1-.17(10)

18) duplicate; 1200-5-1-.17(11)

19) 4.0 gpm per square foot; 1200-5-1-.17(12)(b)

20) a) Dual media: 30 inches, i) Sand: 10-12 inches, ii) Anthracite: 18-20 inches, b) Mixed media beds: 30 inches; 1200-5-1-.17(12)(b) and (d)

21) 24, average daily, 12; 1200-5-1-.17(14)

22) maps; a) water mains, b) sizes of mains, c) valves, d) blow-offs or flush hydrants, e) air-release valves, f) fire hydrants; 1200-5-1-.17(15)

23) wells, storage, tanks, clearwells; 1200-5-1-.17(16)

24) 6, 500, 20; 1200-5-1-.17(18)

25) 0.9, 1.3; 1200-5-1-.17(20)

26) a)name of person with complaint, b) date, c) nature of complaint, d) date of investigation, e)results or actions taken to correct any problems

27) 99.9, 3, 99.99, 4; 1200-5-1-.17(27)(a) and (b)

Public Notification Exercise

Identify:

1. Tier 1:

2. Tier 2:

3. Tier 3:

Instructions: List what Tier of PN you would take with each situation listed below, no PN can be a result also:

1. The contract laboratory has reported the fluoride result as 4.1 mg/L.

2. The system has received a positive result on Fecal coliform on analysis after a positive total coliform repeat sample.

3. The contract lab has notified the system that the samples submitted for TMH's were analyzed after the holding times had expired. The specific monitoring period has also passed. The lab sent the results to the system two weeks prior to their discovery of the holding time error. This result has already been reported to the state.

4. A system has been notified by their lab that the Alachlor level was 0.001mg/L.

5. A small system must collect two total coliform samples per month, but failed to do so last month.

6. The analysis for nitrate was 10.5 mg/L. A confirmation sample was collected within 24 hours. Its value was 9.3 mg/L.

7. The free chlorine residual is 5.0 mg/L in the distribution system.

8. A system had one positive total coliform sample during the month. All the repeat samples and distribution samples were negative for the month.

9. A system has a sodium level of 5.9 mg/L.

10. A water system had one positive total coliform test and one positive total coliform on a repeat sample during the same month.

11. The contract laboratory has reported the fluoride result as 3.7 mg/L.

12. A system that collects 60 samples per month had four positive total coliform samples during the month. All the repeat samples and distribution samples were negative for the month.

13. A system has been notified by their lab that the Dioxin level was 0.0000001mg/L.

Answers

Identify:

1. **violations and situations with significant potential to have serious adverse effects on human health as a result of short-term exposure**
2. **public notice – required for all other NPDWR violations and situations with potential to have serious adverse effects on human health**
3. **public notice – required for all other NPDWR violations and situations not included in Tier 1 and Tier 2**

Instructions: List what Tier of PN you would take with each situation listed below, no PN can be a result also:

4. **Tier 2 (Tier 3 if between 2-4 mg/L)**
5. **Tier 1**
6. **Tier 2 (Tier 3 if not reported to State)**
7. **NO PN, below MCL**
8. **Tier 3 (Tier 2 if chronic problem)**
9. **No PN because avg. samples = 9.9 mg/L < MCL**
10. **Tier 2**
11. **NO PN, can have 5%**
12. **NO PN, but notify State within 10 days, page 97**
13. **Tier 2**
14. **Tier 3**
15. **Tier 2**
16. **Tier 2**

Section 11

Math

Basic Math Concepts

For Water and Wastewater Plant Operators
by Joanne Kirkpatrick Price

Updated 12-2017

Suggested Strategy

- Disregarding all numbers, what type of problem is it?
- What diagram, if any, is associated with the concept identified?
- What information is required to solve the problem and how is it expressed in the problem?
- What is the final answer?
- Does the answer make sense?

Solving for the Unknown Value (X)

Solving for X

- Solve for X

$$(4)(1.5)(x) = 1100$$

  - X must be by itself on one side of equal sign
    - 4 and 1.5 must be moved away from X

$$x = \frac{1100}{(4)(1.5)}$$

$$x = 183.3$$

  - How was this accomplished?

Movement of Terms

- To understand how we move the numbers, we will need to consider more closely the math concepts associated with moving the terms.
- An equation is a mathematical statement in which the terms or calculation on one side equals the terms or calculation on the other side.

Movement of Terms

- To preserve this equality, anything done to one side of the equation must be done to the other side as well.

$$(3)(x) = 14$$

- Since X is multiplied by 3, you can get rid of the 3 by using the opposite process: division.

Movement of Terms

- To preserve the equation, you must divide the other side of the equation as well.

$$\frac{3x}{3} = \frac{14}{3}$$

$$x = \frac{14}{3} \qquad x = 4.67$$

- Since both sides of the equation are divided by the same number, the value of the equation remains unchanged.

Example 1

$$730 = \frac{x}{3847}$$

What you do to one side of the equation, must be done to the other side.

$$730 = \frac{x}{3847} \times \frac{3847}{1}$$

$$\frac{3847}{1} \times 730 = \frac{x}{3847} \times \frac{3847}{1}$$

$$3847 \times 730 = x$$

$$2{,}808{,}310 = x$$

Example 2

$$0.5 = \frac{(165)(3)(8.34)}{x}$$

Simplify

$$0.5 = \frac{4128.3}{x}$$

What you do to one side of the equation, must be done to the other side.

$$0.5 = \frac{4128.3}{x} \times \frac{x}{1}$$

$$\frac{x}{1} \times 0.5 = \frac{4128.3}{x} \times \frac{x}{1}$$

$$(x)(0.5) = 4128.3$$

$$\frac{(x)(0.5)}{0.5} = \frac{4128.3}{0.5}$$

$$x = \frac{4128.3}{0.5}$$

$$x = 8256.6$$

Solving for X when squared

- Follow same procedure as solving for X
- Then take the square root

$$x^2 = 15{,}625$$

$$\sqrt{x^2} = \sqrt{15{,}625}$$

$$x = 125$$

Example 3

$$(0.785)(x^2) = 2826$$

$$\frac{(0.785)(x^2)}{0.785} = \frac{2826}{0.785}$$

$$x^2 = \frac{2826}{0.785}$$

$$x^2 = 3600$$

$$\sqrt{x^2} = \sqrt{3600}$$

$$x = 60$$

Fractions and Percents

Converting Decimals and Fractions

- To convert a fraction to a decimal
  - Simply divide the numerator by the denominator

$$\frac{1}{2} = 1 \div 2 = 0.5$$

$$\frac{10}{13} = 10 \div 13 = 0.7692$$

Percents and Decimals

- To convert from a decimal to a percent
  - Simply move the decimal point two places to the right

$0.46. \rightarrow 46.0\%$

- To convert from a percent to a decimal
  - Simply move the decimal two points to the left

$.79.5\% \rightarrow 0.795$

- Remember:

  You CANNOT have a percent in an equation!!

Writing Equations

- Key words
  - **Of** means "multiply"
  - **Is** means "equal to"
- Calculate 25% of 595,000

$$25\% \times 595{,}000$$

$$0.25 \times 595{,}000$$

$$148{,}750$$

Example 5

448 is what percent of 560?

$$448 = x\% \times 560$$

$$\frac{448}{560} = \frac{x\% \times 560}{560}$$

$$0.80 = x\%$$

$$80\% = x$$

Solving for the Unknown

Basics – finding x

1. $8.1 = (3)(x)(1.5)$

2. $(0.785)(0.33)(0.33)(x) = 0.49$

3. $\frac{233}{x} = 44$

4. $940 = \frac{x}{(0.785)(90)(90)}$

5. $x = \frac{(165)(3)(8.34)}{0.5}$

6. $56.5 = \frac{3800}{(x)(8.34)}$

7. $114 = \frac{(230)(1.15)(8.34)}{(0.785)(70)(70)(x)}$

8. $2 = \frac{x}{180}$

9. $46 = \frac{(105)(x)(8.34)}{(0.785)(100)(100)(4)}$

10. $2.4 = \frac{(0.785)(5)(5)(4)(7.48)}{x}$

11. $19{,}747 = (20)(12)(x)(7.48)$

12. $\dfrac{(15)(12)(1.25)(7.48)}{x} = 337$

13. $\dfrac{x}{(4.5)(8.34)} = 213$

14. $\dfrac{x}{246} = 2.4$

15. $6 = \dfrac{(x)(0.18)(8.34)}{(65)(1.3)(8.34)}$

16. $\dfrac{(3000)(3.6)(8.34)}{(0.785)(x)} = 23.4$

17. $109 = \dfrac{x}{(0.785)(80)(80)}$

18. $(x)(3.7)(8.34) = 3620$

19. $2.5 = \dfrac{1{,}270{,}000}{x}$

20. $0.59 = \dfrac{(170)(2.42)(8.34)}{(1980)(x)(8.34)}$

Finding x^2

21. $(0.785)(D^2) = 5024$

22. $(x^2)(10)(7.48) = 10{,}771.2$

23. $51 = \dfrac{64{,}000}{(0.785)(D^2)}$

24. $(0.785)(D^2) = 0.54$

25. $2.1 = \dfrac{(0.785)(D^2)(15)(7.48)}{(0.785)(80)(80)}$

Answers for Solving for the Unknown

Basics – Finding x

1.	1.8	8.	360	15.	2816.7
2.	5.7	9.	1649.4	16.	4903.5
3.	5.3	10.	244.7	17.	547,616
4.	5,976,990	11.	11	18.	117.3
5.	8,256.6	12.	5.0	19.	508,000
6.	8.1	13.	7993.9	20.	0.35
7.	0.005	14.	590.4		

Finding x^2

21. 80
22. 12
23. 40
24. 0.83
25. 10.9

Percent Practice Problems

Convert the following fractions to decimals:

1. ¾

2. ⅝

3. ¼

4. ½

Convert the following percents to decimals:

5. 35%

6. 99%

7. 0.5%

8. 30.6%

Convert the following decimals to percents:

9. 0.65

10. 0.125

11. 1.0

12. 0.05

Calculate the following:

13. 15% of 125

14. 22% of 450

15. 473 is what % of 2365?

16. 1.3 is what % of 6.5?

Answers for Solving for the Unknown

Basics – Finding x

1.	1.8	8.	360	15.	2817
2.	5.7	9.	1649	16.	4903
3.	5.3	10.	244.7	17.	547,616
4.	5,976,990	11.	11	18.	117
5.	8256.6	12.	5	19.	508,000
6.	8.1	13.	7994	20.	0.35
7.	0.005	14.	590.4		

Finding x^2

21.	80	23.	40	25.	10.9
22.	12	24.	0.83		

Percent Practice Problems

1.	0.75	7.	0.005	13.	18.75
2.	0.625	8.	0.306	14.	99
3.	0.25	9.	65%	15.	20%
4.	0.5	10.	12.5%	16.	20%
5.	0.35	11.	100%		
6.	0.99	12.	5%		

DIMENSIONAL ANALYSIS

MATHEMATICS MANUAL FOR WATER AND WASTEWATER TREATMENT PLANT OPERATORS
BY FRANK R. SPELLMAN

Updated 12-2017

DIMENSIONAL ANALYSIS

- Used to check if a problem is set up correctly
- Work with the units of measure, not the numbers
- Step 1:
  - Express fraction in a vertical format

$$gal/ft^3 \text{ to } \frac{gal}{ft^3}$$

- Step 2:
  - Be able to divide a fraction

$$\frac{\frac{lb}{day}}{\frac{min}{day}} \text{ becomes } \frac{lb}{day} \times \frac{day}{min}$$

DIMENSIONAL ANALYSIS

- Step 3:
  - Know how to divide terms in the numerator and denominator
  - Like terms can cancel each other out
    - For every term that is canceled in the numerator, a similar term must be canceled in the denominator

$$\frac{lb}{\cancel{day}} \times \frac{\cancel{day}}{min} =$$

- Units with exponents should be written in expanded form

$$ft^3 = (ft)(ft)(ft)$$

EXAMPLE 1

- Convert 1800 ft^3 into gallons.
- We need the conversion factor that connects the two units
- This is a ratio, so it can be written two different ways
- We want to use the version that allows us to cancel out units

EXAMPLE 1

$$\left(\frac{1800\ ft^3}{1}\right)$$

- Will anything cancel out?

NO

- Let's try the other version
- Will anything cancel out?

YES

Metric System & Temperature

For Water and Wastewater Plant Operators
by Joanne Kirkpatrick Price

Metric Units

Primary Unit

mega	....	kilo	hecto	deka	no	deci	centi	milli	....	micro
(M)		(k)	(h)	(da)	prefix	(d)	(c)	(m)		(μ)
1,000,000		1,000	100	10	1	$^1/_{10}$	$^1/_{100}$	$^1/_{1,000}$		$^1/_{1,000,000}$

↓

meter – linear measurement
liter – volume measurement
gram – weight measurement

King Henry Died By Drinking Chocolate Milk

Metric Units

Kilo	Hecto	Deca	Basic Unit	Deci	Centi	Milli
King	Henry	Died	By	Drinking	Chocolate	Milk
1000X larger	100X larger	10X larger	Meter Liter Gram ***1 unit***	10X smaller	100X smaller	1000X smaller

MULTIPLY numbers by 10 if you are getting smaller

DIVIDE number by 10 if you are getting bigger

Problem 1

- Convert 2500 milliliters to liters

Primary Unit

kilo	hecto	deka	no	deci	centi	milli
(k)	(h)	(da)	prefix	(d)	(c)	(m)

- Converting milliliters to liters requires a move of three place values to the left
- Therefore, move the decimal point 3 places to the left

2500. =
3 2 1

Problem 2

- Convert 0.75 km into cm

Primary Unit

kilo	hecto	deka	no	deci	centi	milli
(k)	(h)	(da)	prefix	(d)	(c)	(m)
1,000	100	10	1	$^1/_{10}$	$^1/_{100}$	$^1/_{1,000}$

- From kilometers to centimeters there is a move of 5 value places to the right

0.7 5 =
1 2 3 4 5

General Conversions

1. 325 ft^3 = gal

2. 2512 kg = lb

3. 2.5 miles = ft

4. 1500 hp = kW

5. 2.2 ac-ft = gal

6. 2100 ft^2 = ac

7. 92.6 ft^3 = lb

8. 17,260 ft^3 = MG

9. 0.6% = mg/L

10. 30 gal = ft^3

11. A screening pit must have a capacity of 400 ft^3. How many lbs is this?

12. A reservoir contains 50 ac-ft of water. How many gallons of water does it contain?

13. 3.6 cfs = gpm

14. 1820 gpm = gpd

15. 45 gps = cfs

16. 8.6 MGD= gpm

17. 2.92 MGD = lb/min

18. 385 cfm = gpd

19. 1,662 gpm = lb/day

20. 3.77 cfs = MGD

21. The flow through a pipeline is 8.4 cfs. What is the flow in gpd?

22. A treatment plant receives a flow of 6.31 MGD. What is the flow in cfm?

Basic Conversions Extra Problems

1. How many seconds are in a minute?

2. How many minutes are in an hour?

3. How many hours in a day?

4. How many minutes in a day?

5. How many inches in a foot?

6. How many feet in a mile?

7. How many feet in a meter?

8. How many meters in a mile?

9. How much does one gallon of water weigh?

10. How much does one cubic foot of water weigh?

11. Express a flow of 5 cfs in terms of gpm.

12. What is 38 gps expressed as gpd?

13. What is 0.7 cfs expressed as gpd?

14. What is 9164 gpm expressed as cfs?

15. What is 1.2 cfs expressed as MGD?

16. Convert 65 gpm into lbs/day.

17. Convert 345 lbs/day into gpm.

18. Convert 0.9 MGD to cfm.

19. Convert 1.2 MGD to ft^3/hour.

20. Convert a flow of 4,270,000 gpd to cfm.

21. What is 5.6 MGD expressed as cfs?

22. Express 423,690 cfd as gpm.

23. Convert 2730 gpm to gpd.

24. Convert 1440 gpm to MGD.

25. Convert 45 gps to ft^3/day.

Volume and Flow Conversions

1. 2,431 gal
2. 5,533 lb
3. 13,200 ft
4. 1,119 kW
5. 717,200 gal
6. 0.05 ac
7. 5,778.24 lb
8. 0.13 MG
9. 6,000 mg/L
10. 4.01 ft^3
11. 24,960 lb
12. 16,300,000 gal
13. 1,615.68 gal/min
14. 2,620,800 gal/day
15. 6.02 ft^3/sec
16. 5,968.4 gpm
17. 16,911.67 lb/min
18. 4,146,912 gal/day
19. 19,959,955.2 lb/day
20. 2.43 MGD
21. 5,428,684.8 gal/day
22. 585.82 ft^3/min

Basic Conversions Extra Problems

1. 60 sec
2. 60 min
3. 24 hr
4. 1440 min
5. 12 in
6. 5280 ft
7. 3.28 ft
8. 1610 m
9. 8.34 lbs
10. 62.4 lbs
11. 2244 gpm
12. 3,283,200 gpd
13. 452,390 gpd
14. 20.42 cfs
15. 0.78 MGD
16. 780,624 lbs/day
17. 0.03 gpm
18. 83.56 ft^3/min
19. 6684.49 ft^3/hr
20. 396.43 ft^3/min
21. 8.67 cfs
22. 2200.83 gpm
23. 3,931,200 gpd
24. 2.07 MGD
25. 519,786.10 ft^3/day

CIRCUMFERENCE AND AREA

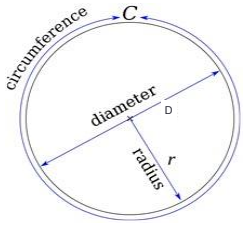
Updated 12-2017

Suggested Strategy to Solving Word Problems

- Disregarding all numbers, what type of problem is it?
- What diagram, if any, is associated with the concept identified?
- What information is required to solve the problem and how is it expressed in the problem?
- What is the final answer?
- Does the answer make sense?

Parts of a Circle

- Diameter is distance across the center of circle
- Radius is distance from circle's center to the edge
- Circumference is the distance around a circle or a circular object



Circumference & Perimeter

- Circumference of a Circle

$$Circumference = (3.14)(Diameter)$$

- Find the circumference in inches of a 6 inch diameter pipe.

$$Circumference = (3.14)(diameter)$$

$$C = (3.14)(6\ inches)$$

$$C = 18.85\ inches$$

Area

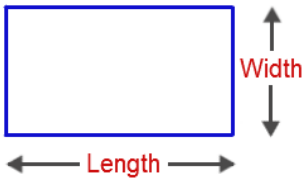
- Area is the measurement of the amount of space on the surface of an object
- Two dimensional measurement
- Measured in: in^2, ft^2, acres, etc.

Area

- Area of Rectangle

$$Area = (length)(width)$$

$$A = (L)(W)$$



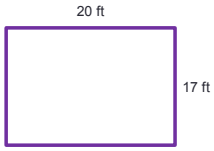
Example 1

- Find the area in ft² of a rectangular basin that is 20 feet long and 17 feet wide.

$$A = (L)(W)$$

$$A = (20ft)(17ft)$$

$$A = 340ft^2$$

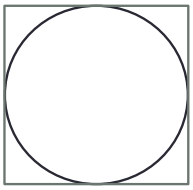


Area

- Area of Circle

$$Area = (0.785)\,(Diameter)^2$$

$$A = (0.785)(D)^2$$



A circle takes up 78.5% of a circle.

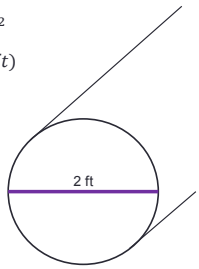
Example 2

- Find the area of the cross section of a pipe in ft² that has a diameter of 2 feet.

$$Area = (0.785)(D)^2$$

$$A = (0.785)(2ft)(2ft)$$

$$A = 3.14\ ft^2$$

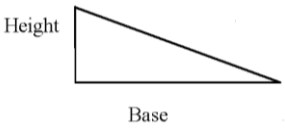


Area

- Area of Right Triangle

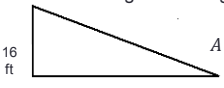
$$Area = \frac{(base)(height)}{2}$$

$$A = \frac{(b)(h)}{2}$$



Example 3

- Determine the area in ft² of a right triangle where the base is 23 feet long with a height of 16 feet.



$$A = \frac{(b)(h)}{2}$$

$$A = \frac{(23ft)(16ft)}{2}$$

$$A = \frac{368ft^2}{2}$$

$$A = 184ft^2$$

Volume

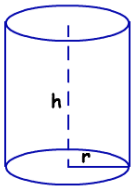
Volume

- Volume is the capacity of a unit or how much it will hold
- Measured in
  - cubic units (ft^3, m^3, yd^3) or
  - liquid volume units (gallons, liters, million gallons)
- The answer will come out in cubic units
  - You must then convert it to liquid volume units

Volume of a Cylinder

$$Volume = (0.785)(Diameter^2)(height)$$

$$Vol = (0.785)(D^2)(h)$$



Example 1

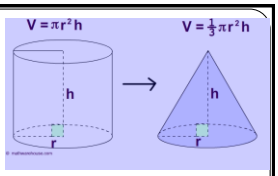
- Determine the volume in ft^3 for a tank that is 20 feet tall with a diameter of 7.5 ft.

$$Vol = (0.785)(D)^2(h)$$

$$Vol = (0.785)(7.5ft)(7.5ft)(20ft)$$

$$Vol = 883.13\ ft^3$$

Volume of a Cone



$$Volume = (1/3)(0.785)(Diameter^2)(height)$$

$$Vol = (1/3)(0.785)(D^2)(h)$$

Example 2

- Determine the volume in gallons of a conical tank that is 8 feet wide and 15 feet tall.

$$Vol = (1/3)(0.785)(D^2)(h)$$

$$Vol = (1/3)(0.785)(8ft)(8ft)(15ft)$$

$$Vol = (0.3333)(753.6\ ft^3)$$

$$Vol = 251.1749\ ft^3$$

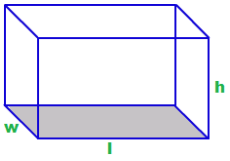
$$Vol, gal = (251.1749\ \cancel{ft^3})(7.48\ \frac{gal}{\cancel{ft^3}})$$

$$Vol, gal = 1878.78\ gallons$$

Volume of a Rectangle

$$Volume = (length)(width)(height)$$

$$Vol = (l)(w)(h)$$



Example 3

- Determine the volume in m^3 for a tank that measures 30 meters by 15 meters by 25 meters.

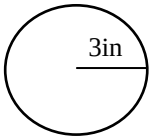
$$Vol = (l)(w)(h)$$

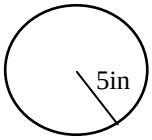
$$Vol = (30m)(15m)(25m)$$

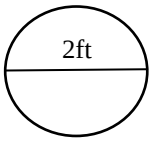
$$Vol = 11{,}250\ m^3$$

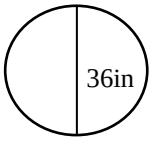
Basic Math for Water and Wastewater
CIRCUMFERENCE, AREA, AND VOLUME

Circumference

1. 

2. 

3. 

4. 

5. A chemical holding tank has a diameter of 24 feet. What is the circumference of the tank in feet?

6. An influent pipe inlet opening has a diameter of 4 feet. What is the circumference of the inlet opening in inches?

7. What is the length (in feet) around the top of a circular clarifier that has a diameter of 32 feet?

Area

1. A basin has a length of 45 feet and a width of 12 feet. Calculate the area in ft^2.

2. If the diameter of a circle is 10 inches, what is the cross-sectional area in square feet?

3. Calculate the surface area (in ft^2) of the top of basin which is 90 feet long, 25 feet wide, and 10 feet deep.

4. Calculate the area (in ft^2) for a 2 ft diameter main that has just been laid.

5. What is the area of the rectangle that is 3 feet by 9 feet?

6. Calculate the area (in ft^2) for an 18" main that has just been laid.

Volume

1. Calculate the volume (in ft^3) for a tank that measures 10 feet by 10 feet by 10 feet.

2. Calculate the volume (in gallons) for a basin that measures 22 feet by 11 feet by 5 feet.

3. Calculate the volume of water in a tank (in gallons), which measures 12 feet long, 6 feet wide, 5 feet deep, and contains 8 inches of water.

4. Calculate the volume (in ft^3) of a cone shaped chemical hopper with a diameter of 12 feet and a depth of 18 feet.

5. A new water main needs to be disinfected. The main is 30" in diameter and has a length of 0.25 miles. How many gallons of water will it hold?

6. A 3 million gallon water tank needs to be disinfected. The method you will use requires you to calculate 5% of the tank volume. How many gallons will this be?

DON'T THINK TOO HARD ON THIS ONE...

7. If you double the size of a pipe, does it double the volume that can be carried? For example, if you have 1000 feet of 12 inch line and you replace it with a 24 inch line, does your volume double?

ANSWERS:

Circumference

1. 18.85 in
2. 31.42 in
3. 6.28 ft
4. 113.10 in
5. 75.40 ft
6. 150.80 in
7. 100.53 ft

Area

1. 540 ft^2
2. 0.55 ft^2
3. 2250 ft^2
4. 3.14 ft^2
5. 27 ft^2
6. 1.77 ft^2

Volume

1. 1000 ft^3
2. 9050.8 gal
3. 359.04 gal
4. 678.58 ft^3
5. 48442.35 gal
6. 150,000 gal
7. 446671.14 gal
8. No, it quadruples it (4X)

Velocity & Flow

Updated 12-2017

Velocity

- The speed at which something is moving
- Measured in
  - $^{ft}/_{min}$ $^{ft}/_{sec}$ $^{miles}/_{hr}$ etc

$$Velocity = \frac{distance}{time}$$

Example 1

- Blue dye is placed in a sewer line at a manhole. Three (3) minutes later, the dye appears in a manhole 125 feet down stream. What is the velocity of the flow in ft/min?

$$Velocity = \frac{distance}{time}$$

$$Vel = \frac{125\ ft}{3\ min}$$

$$Vel = 41.67\ {}^{ft}/_{min}$$

Flow

- The volume of water that flows over a period of time
- Measured in
  - ${}^{ft^3}/_{sec}$ ${}^{ft^3}/_{min}$ ${}^{gal}/_{day}$ ${}^{MG}/_{D}$

$$Flow = (Area)(Velocity)$$

$$Q = AV$$

Example 2

- Water is flowing at velocity 3 ft/sec through a channel that is 2 feet wide and 1.5 feet deep. What is the flow in cubic feet per second?

$$Q = AV$$

$$Q = (l)(w)(velocity)$$

$$Q = (2ft)(1.5ft)\left(3\ {}^{ft}/_{sec}\right)$$

$$Q = 9\ {}^{ft^3}/_{sec}$$

Example 3

- Determine the flow in ft^3/sec through a 6 inch pipe that is flowing full at a velocity of 4.5 ft/sec.

$$D = (6\ in)\left(\tfrac{1\ ft}{12\ in}\right)$$

$$D = 0.5\ ft$$

$$Q = AV$$

$$Q = (0.785)(D^2)\ (vel)$$

$$Q = (0.785)(0.5\ ft)(0.5\ ft)\left(4.5\ {}^{ft}/_{sec}\right)$$

$$Q = 0.88\ {}^{ft^3}/_{sec}$$

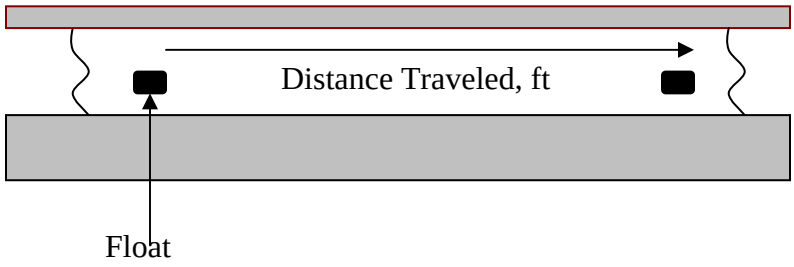
Basic Math for Water and Wastewater
Flow and Velocity

Velocity

1. A cork is placed in a channel and travels 370 feet in 2 minutes. What is the velocity of the wastewater in the channel, ft/min?

2. A float travels 300 feet in a channel in 2 minutes and 14 seconds. What is the velocity in the channel, ft/sec?

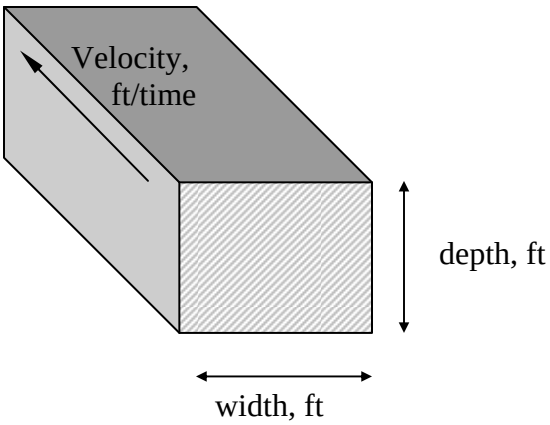
3. The distance between manhole #1 and manhole #2 is 105 feet. A fishing bobber is dropped into manhole #1 and enters manhole #2 in 30 seconds. What is the velocity of the wastewater in the sewer in ft/min?



$$\text{Velocity} = \frac{\text{Distance Traveled, ft}}{\text{Duration of Test, min}}$$

$$= \text{ft/min}$$

1.) 185 ft/min 2.) 2.2 ft/sec 3.) 210 ft/min



$$\underset{ft^3/time}{Q} = \underset{(ft)(ft)}{(A)} \quad \underset{(ft/time)}{(V)}$$

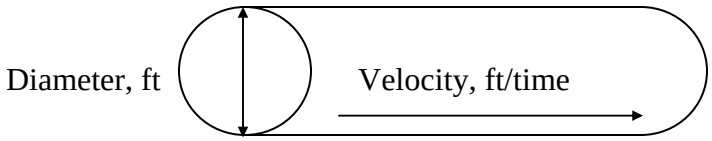
Flow in a channel

4. A channel 48 inches wide has water flowing to a depth of 1.5 feet. If the velocity of the water is 2.8 ft/sec, what is the flow in the channel in cu ft/sec?

5. A channel 3 feet wide has water flowing to a depth of 2.5 feet. If the velocity through the channel is 120 feet/min, what is the flow rate in cu ft/min? in MGD?

6. A channel is 3 feet wide and has water flowing at a velocity of 1.5 ft/sec. If the flow through the channel is 8.1 ft^3/sec, what is the depth of the water in the channel in feet?

4.) 16.8 ft^3/sec 5.) 900 ft^3/min; 9.7 MGD 6.) 1.8 ft



$$\underset{ft^3/time}{Q} = \underset{ft^2}{(A)} \quad \underset{(ft/time)}{(V)}$$

$$\underset{ft^3/time}{Q} = (0.785)\,(D)^2\,(vel) \qquad \underset{(ft)(ft)\ (ft/time)}{}$$

Flow through a full pipe

7. The flow through a 2 ft diameter pipeline is moving at a velocity of 3.2 ft/sec. What is the flow rate in cu ft/sec?

8. The flow through a 6 inch diameter pipeline is moving at a velocity of 3 ft/sec. What is the flow rate in ft^3/sec?

9. The flow through a pipe is 0.7 ft^3/sec. If the velocity of the flow is 3.6 ft/sec, and the pipe is flowing full, what is the diameter of the pipe in inches?

10. An 8 inch diameter pipeline has water flowing at a velocity of 3.4 ft/sec. What is the flow rate in gpm?

7.) 10.05 ft3/sec 8.) 0.59 ft3/sec 9.) 6 in 10.) 532.4 gpm

Basic Math for Water and Wastewater
FLOW RATE

$Q = AV$

1. A channel is 3 feet wide with water flowing to a depth of 2 feet. If the velocity in the channel is found to be 1.8 fps, what is the cubic feet per second flow rate in the channel?

2. A 12-inch diameter pipe is flowing full. What is the cubic feet per minute flow rate in the pipe if the velocity is 110 feet/min?

3. A water main with a diameter of 18 inches is determined to have a velocity of 182 feet per minute. What is the flow rate in gpm?

4. A 24-inch main has a velocity of 212 feet/min. What is the gpd flow rate for the pipe?

5. What would be the gpd flow rate for a 6” line flowing at 2 feet/second?

6. A 36” water main has just been installed. According to the Design Criteria for the State of Tennessee, the minimum flushing velocity is 2 ft/sec. If the main is flushed at 2.5 ft/second, how many gallons/minute should be flushed from the hydrant?

7. A 36” water main has just been installed. If the main is flows at 2 ft/second, how many MGD will the pipe deliver?

8. A certain pipe has a diameter of 18 inches. If the pipe is flowing full, and the water is known to flow a distance of 830 yards in 5 minutes, what is the MGD flow rate for the pipe?

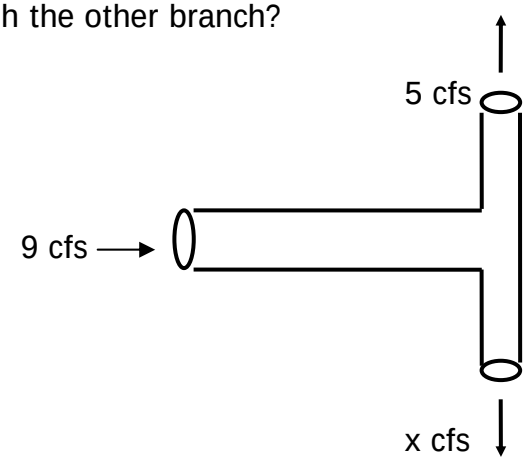
9. A float is placed in a channel. It takes 2.5 minutes to travel 300 feet. What is the velocity in feet per minute in the channel? (Assume that float is traveling at the average velocity of the water.)

10. A cork placed in a channel travels 30 feet in 20 seconds. What is the velocity of the cork in feet per second?

11. A channel is 4 feet wide with water flowing to a depth of 2.3 feet. If a float placed in the channel takes 3 minutes to travel a distance of 500 feet, what is the cubic-feet-per-minute flow rate in the channel?

12. The average velocity in a full-flowing pipe is measured and known to be 2.9 fps. The pipe is a 24" main. Assuming that the pipe flows 18 hours per day and that the month in question contains 31 days, what is the total flow for the pipe in MG for that month?

13. The flow entering the leg of a tee connection is 9 cfs. If the flow through one branch of the tee is 5 cfs, what is the flow through the other branch?



ANSWERS:

1. 10.8 ft^3/sec
2. 86.35 ft^3/min
3. 2,404.50 gpm
4. 7,170,172.42 gpd
5. 253,661.76 gpd
6. 7,926.93 gpm
7. 9.13 MGD
8. 9.47 MGD
9. 120 ft/min
10. 1.5 ft/sec
11. 1,533.33 ft^3/min
12. 136.83 MG
13. 4 ft^3/sec

Disinfection

Chlorination

- The pounds formula will be one of the most important formulas to learn this week.

$$feed\ rate, \frac{lb}{day} = \frac{(dose)(flow)(8.34\frac{lb}{gal})}{\%\ purity}$$

- If no purity provided, assume it is 100%

Example 1

- A water plant that treats 3,200,000 gallons per day. If the required dosage is 5.4 mg/L of 12.5 % sodium hypochlorite, what is the feed rate in lb/day?

$$feed\ rate, \frac{lb}{day} = \frac{(dose)(flow)(8.34\frac{lb}{gal})}{\%\ purity}$$

CT Calculation

Kill = C x T

- Concentration and contact time are two of the most important parameters in chlorination
- They are inversely proportional
  - As one decreases, the other must increase
- CT is simply the concentration of chlorine in your water times the time of contact that the chlorine has with your water
  - Measured in $\frac{mg \cdot min}{L}$

$$CT = (disinfectant\ residual, \frac{mg}{L})(time, min)$$

Example 3

- Treated water is dosed with 5 mg/L of chlorine for 30 minutes. What is the CT?

$$CT = (disinfectant\ residual, \frac{mg}{L})(time, min)$$

Hypochlorite

- 2 types of hypochlorite used for disinfection in typical drinking water systems
  - Sodium hypochlorite
    - NaOCl
    - Bleach
    - 5-15% concentration
  - Calcium hypochlorite
    - $Ca(OCl)_2$
    - High test hypochlorite (HTH)
    - 65% concentration

Hypochlorite Strength

$$Hypochlorite\ strength, \% = \frac{chlorine\ required, lbs}{(hypochlorite\ solution\ needed, gal)(8.34\frac{lb}{gal})} x100$$

- To be used when using bleach in the place of chlorine gas
- Can be used for HTH
  - Just drop the 8.34 conversion

Example 4

- A water plant is switching from chlorine gas to sodium hypochlorite. If 133 lbs of gas was fed each day and they now feed 130 gallons of bleach, what concentration of NaOCl is being used?

$$\%\ strength = \frac{chlorine\ required, lbs}{(hypochlorite\ solution\ needed, gal)(8.34\frac{lb}{gal})} x100$$

Two Normal equation

- C =concentration
- $V = volume\ or\ flow$

$$C_1 \times V_1 = C_2 \times V_2$$

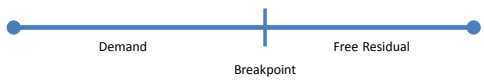
$$want = have$$

Example 5

- A distribution operator needs to make 10 gallons of a bleach dilution with a concentration 25 mg/L. The bleach on hand has a concentration of 100 mg/L. How many gallons of the concentrate must be used to achieve the dilution?

$$C_1 \times V_1 = C_2 \times V_2$$

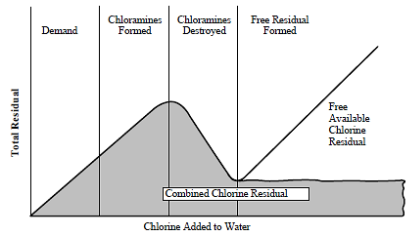
Breakpoint Chlorination



- Total chlorine dose = residual + demand
  -residual - residual
- Dose – residual = demand

Breakpoint Chlorination

- Total chlorine = free residual + combined residual



Applied Math for Water Treatment
Disinfection

1. Determine the chlorinator setting in lb/day required to treat a flow of 3.5 MGD with a chlorine dose of 1.8 mg/L.

2. A flow totalizer reading at 9 am on Thursday was 18,815,108 and at 9 am on Friday was 19,222,420 gallons. If the chlorinator setting is 16 lb for this 24 hour period, what is the chlorine dosage in mg/L?

3. Water from a well is disinfected by a hypochlorinator. The flow totalizer indicates that 2,330,000 gallons of water were pumped during a 7 day period. The 3% sodium hypochlorite solution used to treat the well water is pumped from a 3-foot diameter storage tank. During the 7 day period, the level in the tank dropped 2 ft 10 inches. What is the chlorine dosage in mg/L?

4. A storage tank is to be disinfected with 60 mg/L of chlorine. If the tank holds 86,000 gallons, how many lb of chlorine (gas) will be needed?

5. The chlorine demand of a water process is 1.6 mg/L. If the desired chlorine residual is 0.5 mg/L, what is the desired chlorine dose (in mg/L)?

6. How many pounds of 65% available HTH is needed to make 5 gallons of 18% solution?

7. How many lb of chloride of lime (25% available chlorine) will be required to disinfect a well if the casing is 18 inches in diameter and 200 ft long with the water level 95 ft from the top of the well? The desired chlorine dosage is 100 mg/L

8. A chlorinator setting is 43 lb per 24 hours. If the flow being treated is 3.35 MGD, what is the chlorine dosage expressed as mg/L?

9. The chlorine dosage at a plant is 5.2 mg/L. If the flow rate is 6,250,000 gpd, what is the chlorine feed rate (in lb/day)?

10. A sodium hypochlorite solution (3% available chlorine) is used to disinfect water pumped from a well. A chlorine dose of 2.9 mg/L is required for adequate disinfection. How many gallons per day of sodium hypochlorite will be required if the flow being chlorinated is 955,000 gpd?

11. A flow of 3,021,000 gpd is disinfected with calcium hypochlorite (65% available chlorine). If 49 lb of hypochlorite are used in a 24-hour period, what is the chlorine dosage (in mg/L)?

12. A storage tank that is going to be put back into service requires disinfection at a dosage of 30 mg/L. If the tank has a diameter of 102 ft and is 28.1 ft in height at the overflow, how many gallons of 10.25% sodium hypochlorite solution will be needed if the tank is filled to 10% capacity?

13. The chlorine dosage for a water process is 2.9 mg/L. If the chlorine residual after 30 minutes of contact time is found to be 0.7 mg/L, what is the chlorine demand expressed in mg/L?

14. How many pounds of HTH (65% available chlorine) will it take to make a 2% solution when dissolved in enough water to make 15 gallons of hypochlorite?

15. A chlorine dose of 42 lb/day is required to disinfect a flow of 2,220,000 gpd. If the calcium hypochlorite to be used contains 65% available chlorine, how many mg/L hypochlorite will be required?

16. Determine the chlorinator setting (lb/day) required to treat a flow of 5.5 MGD with a chlorine dose of 2.5 mg/L.

17. Hypochlorite is used to disinfect water pumped from a well. The hypochlorite solution contains 3% available chlorine. A chlorine dose of 2.2 mg/L is required for adequate disinfection throughout the distribution system. If the flow from the well is 245,000 gpd, how much sodium hypochlorite (gallons per day) will be required?

18. A total chlorine dosage of 10 mg/L is required to treat the water in a unit process. If the flow is 1.8 MGD and the hypochlorite has 65% available chlorine, how many lb/day of hypochlorite will be required?

19. Determine the chlorinator setting (lb/day) needed to treat a flow of 980,000 gpd with a chlorine dose of 2.3 mg/L.

20. A water flow of 928,000 gpd requires a chlorine dose of 2.7 mg/L. If calcium hypochlorite (65% available chlorine) is to be used, how many lb/day of hypochlorite are required?

21. A chlorine dose of 2.7 mg/L is required for adequate disinfection of a water unit. If a flow of 810,000 gpd will be treated, how many gallons per day of sodium hypochlorite will be required? The sodium hypochlorite contains 12% available chlorine.

22. A new well is to be disinfected with chlorine at a dosage of 40 mg/L. If the well casing diameter is 6 inches and the length of the water-filled casing is 140 ft, how may lb of chlorine will be required?

23. A flow of 1.34 MGD is to receive a chlorine dose of 2.5 mg/L. What should be the chlorinator setting in lb/day?

24. What should the chlorinator setting be (in lb/day) to treat a flow of 4.8 MGD if the chlorine demand is 8.8 mg/L and a chlorine residual of 3 mg/L is desired?

25. A flow of 3,880,000 gpd is to be disinfected with chlorine. If the chlorine demand is 2.6 mg/L and a chlorine residual of 0.8 mg/L is desired, what should be the chlorinator setting lb/day?

26. The water-filled casing of a well has a volume of 540 gallons. If 0.48 lb of chlorine were used in disinfection, what was the chlorine dosage in mg/L?

27. A hypochlorite solution (4% available chlorine) is used to disinfect a water unit. A chlorine dose of 1.8 mg/L is desired to maintain an adequate chlorine residual. If the flow being treated is 400 gpm, what hypochlorite solution flow (in gallons per day) will be required?

28. A total of 54 lb of hypochlorite (65% available chlorine) is used in a day. If the flow rate treated is 1,512,000 gpd, what is the chlorine dosage (in mg/L)?

29. A flow of 0.83 MGD requires a chlorine dosage of 8 mg/L. If the hypochlorite has 65% available chlorine, how many lb/day of hypochlorite will be required?

30. A total of 36 lb/day sodium hypochlorite is required for disinfection of a flow of 1.7 MGD. How many gallons per day sodium hypochlorite is this?

31. A new well with a casing diameter of 12 inches is to be disinfected. The desired chlorine dosage is 40 mg/L. If the casing is 190 ft long and the water level in the well is 81 feet from the top of the well, how many lb of chlorine will be required?

32. A chlorine dose of 42 mg/L is required to disinfect a flow of 2.22 MGD. If the calcium hypochlorite to be used contains 65% available chlorine, how many lb/day hypochlorite will be required?

33. The chlorine demand of a water unit is 1.8 mg/L. If the desired chlorine residual is 0.9 mg/L, what is the desired chlorine dose (in mg/L)?

34. A total of 51 lb/day sodium hypochlorite is required for disinfection of a flow of 2.28 MGD. How many gallons per day sodium hypochlorite is this?

35. The chlorine dosage for a water unit is 3.1 mg/L. If the chlorine residual after 30 minutes of contact time is found to be 0.6 mg/L, what is the chlorine demand expressed in mg/L?

36. What chlorinator setting (in lb/day) is required to treat a flow of 1620 gpm with a chlorine dose of 2.8 mg/L?

37. A chlorine dose of 2.8 mg/L is required for adequate disinfection of a water unit. If a flow of 1.33 MGD will be treated, how many gpd of sodium hypochlorite will be required? The sodium hypochlorite contains 12.5% available chlorine.

38. A pipeline 8 inches in diameter and 1600 ft long is to be treated with a chlorine dose of 60 mg/L. How many lb of chlorine will this require?

39. The average calcium hypochlorite use at a plant is 34 lb/day. If the chemical inventory in stock is 310 lb, how many days' supply is this?

40. The flow totalizer reading at 7 a.m. on Wednesday was 43,200,000 gallons and at 7 a.m. on Thursday was 44,115,670 gallons. If the chlorinator setting is 18 lb for this 24-hour period, what is the chlorine dosage (in mg/L)?

41. A chlorine dose of 32 mg/L is required to disinfect a flow of 1,990,000 gpd. If the calcium hypochlorite to be used contains 60% available chlorine, how many lb/day hypochlorite will be required?

42. Water from a well is disinfected by a hypochlorinator. The flow totalizer indicates that 2,666,000 gallons of water were pumped during a 7-day period. The 2% sodium hypochlorite solution used to treat the well water is pumped from a 4-foot-diameter storage tank. During the 7-day period, the level in the tank dropped 3 ft 4 inches. What is the chlorine dosage (in mg/L)?

43. A flow of 3,350,000 gpd is to be disinfected with chlorine. If the chlorine demand is 2.5 mg/L and a chlorine residual of 0.5 mg/L is desired, what should be the chlorinator setting (in lb/day)?

44. A total of 72 lb of hypochlorite (65% available chlorine) is used in a day. If the flow rate treated is 1,885,000 gpd, what is the chlorine dosage (in mg/L)?

45. How many lb of dry hypochlorite (65% available chlorine) must be added to 80 gallons of water to make a 2% chlorine solution?

46. An average of 32 lb of chlorine is used each day at a plant. How many lb of chlorine would be used in a week if the hour meter on the pump registers 140 hours of operation that week?

47. An average of 50 lb of chlorine is used each day at a plant. How many 150-lb chlorine cylinders will be required each month? Assume a 30-day month.

Answers

1. 52.54 lb/day
2. 4.7 mg/L
3. 1.93 mg/L
4. 43.03 lb
5. 2.1 mg/L
6. 11.55 lbs
7. 4.67 lb
8. 1.53 mg/L
9. 271.05 lb/day
10. 92.32 gal/day
11. 1.26 mg/L
12. 50.24 gal
13. 2.2 mg/L
14. 3.84 lb
15. 1.47 mg/L
16. 114.68 lb/day
17. 17.97 gal/day
18. 230.95 lb/day
19. 18.80 lb/day
20. 32.3 lb/day
21. 18.23 gal/day
22. 0.07 lb
23. 27.94 lb/day
24. 472.38 lb/day
25. 110.02 lb/day
26. 106.58 mg/L
27. 25.92 gal/day
28. 2.78 mg/L
29. 85.20 lb/day
30. 4.32 gal/day
31. 0.21 lb
32. 1,196.34 lb/day
33. 2.7 mg/L
34. 6.12 gal/day
35. 2.5 mg/L
36. 54.48 lb/day
37. 248.47 lb/day
38. 2.09 lb
39. 9.12 days
40. 2.36 mg/L
41. 885.15 lb/day
42. 2.35 mg/L
43. 83.82 lb/day
44. 2.98 mg/L
45. 20.53 lb
46. 186.67 lb/week
47. 10 cyl/month

Sedimentation

Sedimentation

- Sedimentation is the separation of solids and liquids by gravity
- Calculating volume must be done based on the shape of the tank
  - Typically rectangular or cylindrical
- Detention time is the amount of time the water is supposed to spend in the tank

Volume

- Cylindrical tank

$$volume, ft^3 = (0.785)(D^2)(h)$$

- Rectangular tank

$$volume, ft^3 = (l)(w)(d)$$

Detention Time

$$detention\ time = \frac{volume}{flow}$$

- Units must be compatible within the equation

Example 1

- A sedimentation tank has a volume of 137,000 gallons. If the flow to the tank is 121,000 gph, what is the detention time in the tank (in hours)?

$$detention\ time = \frac{volume}{flow}$$

$$DT = \frac{137{,}000\ gal}{121{,}000\frac{gal}{hr}}$$

$$DT = 1.13\ hours$$

Surface Overflow Rate

- Hydraulic loading rate (HLR) is used to determine loading on sedimentation basins and circular clarifiers
  - Measures the total water entering the process

$$HLR = \frac{total\ flow\ applied, gpd}{area, ft^2}$$

- Surface overflow rate (SOR) measures only the water overflowing the process

$$SOR = \frac{flow, gpd}{area, ft^2}$$

Example 2

- A circular clarifier has a diameter of 80 ft. If the flow to the clarifier is 2.6 MGD, what is the surface overflow rate in gpm/sq.ft?

$A = (0.785)(D^2)$

$$SOR = \frac{flow, gpd}{area, ft^2}$$

$$SOR = \frac{2{,}600{,}000\ gpd}{(0.785)(80ft)(80ft)}$$

$$SOR = \frac{2{,}600{,}000\ gpd}{5024\ ft^2}$$

$$SOR = 517.51\ \frac{gpd}{ft^2}$$

Weir Overflow Rate

- Weir overflow rate (WOR) is the amount of water leaving the settling tank per linear foot of weir
- Calculation result can then be compared to design
- Mesaured in gpd/ft

$$WOR = \frac{flow, gpd}{weir\ length, ft}$$

Example 3

- A circular clarifier receives a flow of 3.55 MGD. If the diameter of the weir is 90 ft, what is the weir overflow rate in gpd/ft?

$$circumference = \pi * Diameter$$
$$Circ = (\pi)(90ft)$$
$$Circ = 282.7433\ ft$$

$$WOR = \frac{flow, gpd}{weir\ length, ft}$$

$$WOR = \frac{3{,}550{,}000\ gpd}{282.7433\ ft}$$

$$WOR = 12555.56\ \frac{gpd}{ft}$$

Reduction in Flow

- To determine the reduction in flow after a period of time

$$Reduction\ in\ flow, \% = \left(\frac{original\ flow - reduced\ flow}{original\ flow}\right) \times 100$$

Example 4

- A sedimentation tank was designed to produce 500,000 gpd at start up. After 5 years in operation, the tank produces 425,000 gpd. What is the reduction in flow?

$$Reduction\ in\ flow, \% = \left(\frac{original\ flow - reduced\ flow}{original\ flow}\right) \times 100$$

$$Reduction = \left(\frac{500{,}000\ gpd\ - 425{,}000\ gpd}{500{,}000\ gpd}\right) \times 100$$

$$Reduction = \left(\frac{75{,}000\ gpd}{500{,}000\ gpd}\right) \times 100$$

$$Reduction = 15\%$$

Solids

- Total suspended solids are the amount of filterable solids in a water sample
  - Weigh dried filter
- Settleable solids will settle out due to gravity
  - Imhoff cone
- Dissolved solids are the amount of solids that pass through a filter in a water sample
  - Weigh filtered water

Solids Concentration

$$Solids\ concentration, \frac{mg}{L} = \frac{weight, mg}{volume, L}$$

$$Solids, \frac{mg}{L} = \frac{(dry\ solids, grams)(1{,}000{,}000)}{sample\ volume, mL}$$

Settleable Solids

- The settleable solids test is an easy, quantitative method to measure sediment found in water
- An Imhoff cone is filled with 1 liter of sample, stirred and allowed to settle for 60 minutes

$$Removal, \% = \left(\frac{in - out}{in}\right) \times 100$$

Example 6

- Calculate the percent removal of settleable solids if the settleable solids of the sedimentation tank influent is 13 mL/L and the settleable solids of the effluent is 0.5 mL/L.

$$Removal, \% = \left(\frac{in - out}{in}\right) \times 100$$

$$Removal = \left(\frac{13\frac{mL}{L} - 0.5\frac{mL}{L}}{13\frac{mL}{L}}\right) \times 100$$

$$Removal = \left(\frac{12.5\frac{mL}{L}}{13\frac{mL}{L}}\right) \times 100$$

$$Removal = 0.96 \times 100$$

$$Removal = 96\%$$

Small Water Systems
Sedimentation

1. Calculate the percent removal of settleable solids if the settleable solids of the sedimentation tank influent are 21.2 mL/L and the settleable solids of the effluent are 1.3 mL/L.

2. A sedimentation basin is 70 ft long by 30 ft wide. If the water depth is 14 ft, what is the volume of water in the tank in gallons?

3. A rectangular sedimentation basin is 70 ft long 25 ft wide and has water to a depth of 10 ft. The flow to the basin is 2,220,000 gpd. Calculate the detention time in hours for the sedimentation basin.

4. A rectangular sedimentation basin is 60 ft long and 25 ft wide. When the flow is 510 gpm, what is the surface overflow rate in gpm/ft^2?

5. A 22 ac pond receives a flow of 3.6 ac-ft per day. What is the hydraulic loading rate in gpd/ft^2?

6. A circular clarifier receives a flow of 2,520,000 gpd. If the diameter of the weir is 70 ft, what is the weir overflow rate (in gpd/ft)?

7. A tank is 30 ft wide and 80 ft long. If the tank contains water to a depth of 12 ft, how many gallons of water are in the tank?

8. The flow to a sedimentation tank that is 80 ft long, 20 ft wide, and 12 ft deep is 1.8 MGD. What is the detention time in the tank (in hours)?

9. A rectangular clarifier receives a flow of 5.4 MGD. The length of the clarifier is 99 feet 7 inches and the width is 78 feet 6 inches. What is the SOR in gpd/ft^2?

10. The weir in a basin measures 30 feet by 15 feet. What is the weir overflow rate (gpd/ft) when the flow is 1,098,000 gpd?

11. A flash mix chamber is 6 ft long, 5 ft wide, and 5 ft deep. It receives a flow of 9 MGD. What is the detention time in the chamber in seconds?

12. A sedimentation basin is 80 ft long and 25 ft wide. To maintain a surface overflow rate of 0.5 gallons per day per square foot, what is the maximum flow to the basin in gallons per day?

13. A circular clarifier receives a flow of 2.12 MGD. If the diameter of the weir is 60 ft, what is the weir overflow rate (in gpd/ft)?

14. A flocculation basin is 8 ft deep, 16 ft wide, and 30 ft long. If the flow through the basin is 1.45 MGD, what is the detention time (in minutes)?

15. A flash mix chamber is 4 ft square and has a water depth of 42 inches. If the flash mix chamber receives a flow of 3.25 MGD, what is the detention time (in seconds)?

16. A sedimentation tank has a total of 150 feet of weir over which the water flows. What is the weir overflow rate in gallons per day per foot of weir when the flow is 1.7 MGD?

17. A sedimentation tank is 90 feet long and 40 feet wide and receives a flow of 5.04 MGD. Calculate the SOR in gpd/ft^2.

18. A tank has a length of 100 feet, a width of 25 feet and a depth of 15 feet. What is the area of the water's surface in ft^2?

19. What is the gpd/ft^2 overflow to a circular clarifier that has the following:
Diameter: 70 feet
Flow: 1,950 gpm

20. The flow to a sedimentation tank that is 75 ft long, 30 ft wide, and 14 ft deep is 1,640,000 gpd. What is the detention time in the tank (in hours)?

21. A sedimentation tank 70 ft by 25 ft receives a flow of 2.05 MGD. What is the surface overflow rate (in gpd/sq ft)?

22. A flocculation basin is 50 ft long by 20 ft wide and has a water level of 8 ft. What is the detention time (in minutes) in the basin if the flow to the basin is 2.8 MGD?

23. The diameter of a tank is 90 ft. If the water depth in the tank is 25 ft, what is the volume of water in the tank (in gallons)?

24. A backwash lagoon receives a flow of 18,800 gpd. If the surface area of the pond is 16 acres, what is the hydraulic loading rate in gpd/ft^2?

25. The average width of a pond is 400 ft and the average length is 440 ft. The depth is 6 ft. If the flow to the pond is 200,000 gpd, what is the detention time (in days)?

26. A rectangular sedimentation basin has a total of 170 ft of weir. If the flow to the basin is 1,890,000 gpd, what is the weir overflow rate in gpd/ft^2?

27. A clarifier has a diameter of 82 feet and a depth of 12 feet. What is the length of the weir around the clarifier in ft?

28. The diameter of the weir in a circular clarifier is 125 feet. The flow is 6.33 MGD. What is the weir overflow rate (gpd/ft)?

29. A clarifier has a diameter of 82 feet and a depth of 12 feet. What is the surface area of the clarifier in ft^2?

30. A clarifier has a flow rate of 4,600 gpm and a diameter of 75 feet. What is the surface overflow rate in gpd/ft^2?

31. The flow rate to a particular clarifier is 528 gpm and the tank has a length of 30 feet and a width of 17.5 feet. What is the gpd/ft of weir?

32. Calculate the percent removal of settleable solids if the settleable solids of the sedimentation tank influent are 13.9 mL/L and the settleable solids of the effluent are 0.7 mL/L.

33. The flow to a flocculation basin is 6,625,000 gpd. If the basin is 60 ft long, 25 ft wide, 15 ft deep, and contains water to a depth 9 ft, what is the detention time of the flocculation basin in minutes?

34. A circular clarifier has a diameter of 70 ft. If the flow to the clarifier is 1610 gpm, what is the surface overflow rate in gpm/ft^2?

35. A waste treatment pond is operated at a depth of 6 ft. The average width of the pond is 500 ft and the average length is 600 ft. If the flow to the pond is 222,500 gpd, what is the detention time (in days)?

36. A sedimentation tank has a total of 200 feet of weir which the water flows over. What is the weir overflow rate (gpd/ft) when the flow is 2.2 MGD?

37. A tank has a length of 100 feet, a width of 25 feet, and a depth of 15 feet. What is the weir length around the basin in feet?

38. The flow to a sedimentation tank is 3.05 MGD. If the tank is 80 feet long and 20 feet wide, what is the surface overflow rate in gallons per day per square foot?

39. What is the weir overflow rate of a clarifier that is 50 feet 4 inches by 44 feet 3 inches and has an influent flow of 1.87 MGD?

40. The flow through a flocculation basin is 1.82 MGD. If the basin is 40 ft long, 20 ft wide, and 10 ft deep, what is the detention time (in minutes)?

41. A tank is 80 ft long, 20 ft wide, and 16 ft deep. What is the volume of the tank (in cubic feet)?

42. The flow to a circular clarifier is 2.66 MGD. If the diameter of the clarifier is 70 ft, what is the surface overflow rate (in gpd/sq ft)?

43. The flow rate to a clarifier is 1400 gpm. If the diameter of the weir is 80 ft, what is the weir overflow rate (in gpd/ft)?

44. A clarifier with a diameter of 55 feet receives a flow of 2.075 MGD. What is the surface overflow rate (gpd/ft^2)?

45. A circular clarifier has a diameter of 60 ft and an average water depth of 12 ft. What flow rate (MGD) corresponds to a detention time of 3 hours?

46. A circular clarifier has a diameter of 80 feet. If the water depth is 12 ft, how many gallons of water are in the tank?

47. A basin 3 ft by 4 ft is to be filled to the 3-ft level. If the flow to the tank is 6 gpm, how long will it take to fill the tank (in hours)?

48. The diameter of the weir in a circular clarifier is 85 feet. What is the weir overflow rate (gpd/ft) if the flow over the weir is 2.24 MGD?

49. A sedimentation tank is 110 ft long and 50 ft wide. If the flow to the tank is 3.45 MGD what is the surface overflow rate (in gpd/sq ft)?

50. A tank 6 ft in diameter is to be filled to the 4-ft level. If the flow to the tank is 12 gpm, how long will it take to fill the tank (in minutes)?

51. A rectangular clarifier has a total of 163 ft of weir. What is the weir overflow rate (in gpd/ft) when the flow is 1,410,000 gpd?

52. A circular clarifier has a diameter of 80 feet. If the flow to the clarifier is 3.8 MGD, what is the surface overflow rate (gpd/ft^2)?

53. The diameter of the weir in a circular clarifier is 85 feet. What is the weir overflow rate (gpd/ft) if the flow over the weir is 2.24 MGD?

54. A rectangular clarifier has a total of 240 ft of weir. What is the weir overflow rate (in gpd/ft) when the flow is 2.7 MGD?

55. A tank has a diameter of 49.4 feet. What is the gallons/day per foot of weir overflow when the tank receives 1,953,000 gpd?

56. The flow to a flocculation basin is 3,625,000 gpd. If the basin is 60 ft long by 25 ft wide and contains water to a depth of 9 ft, what is the detention time of the flocculation basin (in minutes)?

57. A flocculation basin is 50 ft long by 20 ft wide and has a water depth of 10 ft. If the flow to the basin is 2,250,000 gpd, what is the detention time (in minutes)?

58. The flow to a sedimentation tank is 50,000 gpd. If the tank is 55 feet long and 15 feet wide, what is the surface overflow rate (gpd/ft^2)?

59. A pre-sedimentation pond receives a flow of 1.2 MGD. This particular pond is 115 ft long, 40 ft wide and averages a depth of 15 ft. Determine the hydraulic loading rate in gpd/ft^2?

60. A circular clarifier has a diameter of 80 ft and an average water depth of 12 ft. If the flow to the clarifier is 2,920,000 gpd, what is the detention time in hours?

61. A rectangular sedimentation basin has a total weir length of 189 ft. If the flow to the basin is 4.01 MGD, what is the weir-loading rate (in gpd/ft)?

62. The flow rate to a circular clarifier is 5.20 MGD. If the clarifier is 80 ft in diameter with water to a depth of 10 ft, what is the detention time (in hours)? 1.7 hr

ANSWERS

1. 93.9%
2. 219,912 gal
3. 1.43 hrs
4. 0.34 gpm/ft^2
5. 1.22 gpd/ ft^2
6. 11,459.16 gpd/ft
7. 215,424 gal
8. 1.91 hrs
9. 690.78 gpd/ ft^2
10. 12,200 gpd/ft
11. 10.77 sec
12. 1000 gpd
13. 11,246.95 gpd/ft
14. 28.51 min
15. 11.13 sec
16. 11,333.33 gpd/ft
17. 1,400 gpd/ ft^2
18. 2,500 ft^2
19. 730.01 gpd/ ft^2
20. 3.45 hr
21. 1,171.43 gpd/ ft^2
22. 30.82 min
23. 1,189,039.5 gal
24. 0.027 gpd/ ft^2
25. 40.39 days
26. 11,117.65 gpd/ft
27. 257.61 ft
28. 80,596.06 gpd/ft
29. 5,278.34 ft^2
30. 1,500.13 gpd/ ft^2
31. 8,003.37 gpd/ft
32. 95%
33. 21.89 min
34. 0.42 gpm/ ft^2
35. 60.5 days
36. 11,000 gpd/ft
37. 250 ft
38. 1,906.25 gpd/ ft^2
39. 9,885.47 gpd/ft
40. 47.38 min
41. 25,600 ft^3
42. 691.54 gpd/ ft^2
43. 8,021.41 gpd/ft
44. 873.82 gpd/ ft^2
45. 2.03 MGD
46. 450,954.24 gal
47. 0.75 hrs
48. 8,388.40 gpd/ft
49. 627.27 gpd/ ft^2
50. 70.46 min
51. 8,650.31 gpd/ft
52. 756.37 gpd/ ft^2
53. 394.95 gpd/ ft^2
54. 11,250 gpd/ft
55. 12,584.19 gpd/ft
56. 40.18 min
57. 47.81 min
58. 60.61 gpd/ ft^2
59. 260.87 gpd/ ft^2
60. 3.71 hr
61. 212,168.93 gpd/ft
62. 1.74 hr

Filtration

Filtration

- Process of separating suspended and colloidal particle waste by passing the water through a granular material
- Involves straining, settling, and adsorption

Filter Flow & Backwash Rate

- Rate at which water flows through the filter
- Can be used to verify flow meter readings

$$\frac{gpm}{ft^2} = \frac{flow, gpm}{filter\ area, ft^2}$$

Example 1

- A filter 18 ft by 22 ft receives a flow of 1750 gpm. What is the filtration rate in gpm/ft^2?

$$\frac{gpm}{ft^2} = \frac{flow, gpm}{filter\ area, ft^2}$$

Example 2

- A filter that is 30 ft by 10ft has a backwash rate of 3120 gpm. What is the back wash rate in gpm/sq. ft?

$$\frac{gpm}{ft^2} = \frac{flow, gpm}{filter\ area, ft^2}$$

Filter Drop Test Velocity

- Speed at which water flows through the filter

$$\frac{ft}{min} = \frac{water\ drop, ft}{time\ of\ drop, min}$$

Example 3

- The influent to a filter is closed while the effluent valve remains open. It is measured that in 1 minute, the water level drops 1.5 feet. What is the filter drop test velocity?

$$\frac{ft}{min} = \frac{water\ drop, ft}{time\ of\ drop, min}$$

Filter Backwash Rise Rate

- Upward velocity of the water during backwashing

$$\frac{in}{min} = \frac{(backwash\ rate, \frac{gpm}{ft^2})(12\frac{in}{ft})}{7.48\frac{gal}{ft^3}}$$

Example 4

- A filter has a backwash rate of 16 gpm/sq. ft. What is the inch per minute backwash rate?

$$\frac{in}{min} = \frac{(backwash\ rate, \frac{gpm}{ft^2})(12\ \frac{in}{ft})}{7.48\ \frac{gal}{ft^3}}$$

Applied Math for Water Treatment
Filtration

1. A filter 40 ft by 20 ft receives a flow of 2230 gpm. What is the filtration rate (in gpm/sq ft)?

2. The influent valve to a filter is closed for a 5-minute period. During this time, the water level in the filter drops 12 inches. If the filter is 45 ft long by 22 ft wide, what is the gpm flow rate through the filter?

3. The influent valve to a filter is closed for 6 minutes. The water level in the filter drops 18 inches during the 6 minutes. If the filter is 35 ft long by 18 ft wide, what is the gpm flow rate through the filter?

4. During an 80 hour filter run, a total of 14.2 million gallons of water are filtered. What is the average gpm flow rate through the filter during this time?

5. A filter 18 ft long by 14 ft wide has a backwash flow rate of 3580 gpm. What is the filter backwash rate (in gallons per minute per square foot)?

6. A backwash flow rate of 6750 gpm for a total of 6 minutes would require how many gallons of water?

7. The desired backwash pumping rate for a filter is 20 gallons per minute per square foot. If the filter is 36 ft long by 26 ft wide, what backwash pumping rate (gallons per minute) will be required?

8. A filter 38 ft long by 22 ft wide receives a flow of 3,550,000 gpd. What is the filtration rate (in gallons per minute per square foot)?

9. A filter 40 ft by 20 ft treats a flow of 2.2 MGD. What is the filtration rate (in gpm/sq ft)?

10. A filter is 40 ft long by 30 ft wide. To verify the flow rate through the filter, the filter influent valve is closed for a 5-minute period and the water drop is measured. If the water level in the filter drops 14 inches during the 5 minutes, what is the gpm flow rate through the filter?

11. A filter has a surface area of 32 ft by 18 ft. If the filter receives a flow a 2,150,000 gpd, what is the filtration rate (in gallons per minute per square foot)?

12. The backwash flow rate for a filter is 3700 gpm. If the filter is 15 ft by 20 ft, what is the backwash rate expressed as gpm/ft^2?

13. A filter is 38 ft long by 18 ft wide. During a test of filter flow rate, the influent valve to the filter is closed for 5 minutes. The water level drops 22 inches during this period. What is the filtration rate for the filter (in gallons per minute per square foot)?

14. A backwash flow rate of 6650 gpm for a total backwashing period of 6 minutes would require how many gallons of water for backwashing?

15. A filter 30 ft by 18 ft has a backwash flow rate of 3650 gpm. What is the filter backwash rate (in gallons per minute per square foot)?

16. The desired backwash pumping rate for a filter is 24 gallons per minute per square foot. If the filter is 26 ft long by 22 ft wide, what backwash pumping rate (gallons per minute) will be required?

17. A filter 14 ft by 14 ft has a backwash flow rate of 4750 gpm. What is the filter backwash rate in gpm/sq ft?

18. A filter with a surface area of 380 square feet has a backwash flow rate of 3510 gpm. What is the filter backwash rate (in gallons per minute per square foot)?

19. A filter 38 ft long by 24 ft wide produces a total of 18.1 million gallons during a 71.6-hour filter run. What is the average filtration rate for this filter run in gpm/ft^2?

20. During an 80-hour filter run, a total of 14.2 million gallons of water are filtered. What is the average gpm flow rate through the filter during this time?

21. A filter 40 ft by 25 ft receives a flow of 3100 gpm. What is the filtration rate (in gpm/sq ft)?

22. A filter 20 ft long by 18 ft wide receives a flow of 1760 gpm. What is the filtration rate (in gallons per minute per square foot)?

23. A filter is 42 ft long by 22 ft wide. If the desired backwash rate is 19 gallons per minute per square foot, what backwash pumping rate (gallons per minute) will be required?

24. For a backwash flow rate of 9100 gpm and a total backwash time of 7 minutes, how many gallons of water will be required for backwashing?

25. A total of 59,200 gallons of water will be required to provide a 7-minute backwash of a filter. What depth of water in feet is required in the backwash water tank to provide this backwashing capability? The tank has a diameter of 40 ft.

26. At an average flow rate through a filter of 3200 gpm, how long a filter run (in hours) would be required to produce 16 million gallons of water?

27. A filter is 33 ft long by 24 ft wide. During a test of flow rate, the influent valve to the filter is closed for 6 minutes. The water level drops 21 inches during this period. What is the filtration rate for the filter (in gallons per minute per square foot)?

28. A backwash rate of 7150 gpm is desired for a total backwash time of 7 minutes. What depth of water in feet is required in the backwash water tank to provide this much water? The diameter of the tank is 40 ft.

29. A filter 25 ft by 15 ft. If the backwash flow rate is 3400 gpm, what is the filter backwash rate (in gpm/sq. ft)?

30. A filter 33 ft long by 24 ft wide produces a total of 14.2 million gallons during a 71.4-hour filter run. What is the average filtration rate for this filter run in gpm/ft^2?

31. A filter has a surface area of 880 sq ft. If the flow treated is 2850 gpm, what is the filtration rate (in sq. ft)?

32. At an average flow rate through a filter of 3200 gpm, how long a filter run (in hours) would be required to produce 16 million gallons of filtered water?

33. A filter 26 ft by 60 ft receives a flow of 2500 gpm. What is the filtration rate (in gpm/sq ft)?

34. A filter 25 ft by 30 ft at a rate of 3300 gpm. What is this backwash rate expressed as gpm/ft^2?

35. The flow rate through a filter is 2.97 MGD. What is the flow rate in gpm?

36. How many gallons of water would be required to provide a backwash flow rate of 4670 gpm for a total of 5 minutes?

37. A filter is 22 ft square. If the desired backwash rate is 16 gallons per minute per square foot, what backwash pumping rate (gallons per minute) will be required?

38. A filter 18 ft long by 14 ft wide has a backwash rate of 3080 gpm. What is this backwash rate expressed in inches minute of water?

39. The Quahog Water Treatment Plant treats an average of 5.18 MGD. The water is split equally to each of the 8 filters. Each filter measures 12 feet wide by 16 feet long and 24 feet deep. The influent to Filter 6 is closed while the effluent remains open to perform a drop test. Using a stop watch and a hook gauge, it is noted that the water level in the filter drops 6 inches in 80 seconds. A hook gauge was used to determine the rate of rise in the filter basin during the backwash cycle. The water rose 6 inches in 15 seconds.

    a. What is the filtration rate in gallons per minute per square foot?

    b. What is the backwash rate in gallons per minute per square foot?

40. The Central City Water Treatment Plant treats an average of 7.2 MGD. The water is split equally to each of the 12 filters. Each filter measures 12.5 feet wide by 16.5 feet long and 24 feet deep. Influent to Filter 6 is closed while the effluent remains open to perform a drop test. Using a stop watch and a hook gauge, it is noted that the water level in the filter drops 6 inches in 75 seconds. A hook gauge was used to determine the rate of rise in the filter basin during the backwash cycle. The water rose 6 inches in 13 seconds.

    a. What is the filtration rate in gallons per minute per square foot?

    b. What is the backwash rate in gallons per minute per square foot?

Answers

1. 2.78 gpm/ft^2
2. 1481.04 gpm
3. 1178.1 gpm
4. 2958.33 gpm
5. 14.21 gpm/ft^2
6. 40,500 gal
7. 18,720 gpm
8. 2.95 gpm/ft^2
9. 1.91 gpm/ft^2
10. 2094.46 gpm
11. 2.59 gpm/ft^2
12. 12.33 gpm/ft^2
13. 2.74 gpm/ft^2
14. 39,900 gal
15. 6.76 gpm/ft^2
16. 13,728 gpm
17. 24.23 gpm/ft^2
18. 9.24 gpm/ft^2
19. 4.62 gpm/ft^2
20. 2958.33 gpm
21. 3.1 gpm/ft^2
22. 4.89 gpm/ft^2
23. 17,556 gpm
24. 63,700 gal
25. 6.3 ft
26. 83.33 hr
27. 2.18 gpm/ft^2
28. 5.33 ft
29. 9.07 gpm/ft^2
30. 4.19 gpm/ft^2
31. 3.24 gpm/ft^2
32. 83.33 hr
33. 1.6 gpm/ft^2
34. 4.4 gpm/ft^2
35. 2061.8 gpm
36. 23,350 gal
37. 7744 gpm
38. 19.61 in/min
39. a. 2.81 gpm/ft^2
    b. 14.96 gpm/ft^2
40. a. 2.99 gpm/ft^2
    b. 17.26 gpm/ft^2

LABORATORY CALCULATIONS

MOLARITY & NORMALITY

AWWA Basic Science Concepts and Applications

TERMS

- Mole - a gram molecular weight; that is, the molecular weight expressed as grams
- Molecular weight - the weight of one molecule
  - Example: NaCl
    - Na weight = 22.9898 g/mol
    - Cl weight = 35.453 g/mole
    - Molecular weight of NaCl = 22.9898 + 35.453 = 58.4428 g/mol

NUMBER OF MOLES

- If 150 g of sodium hydroxide (NaOH) is mixed into water to make a solution, how many moles of solute have been used? (molecular weight of NaOH is 40.00 gram/mol)

$$\#\ of\ moles = \frac{total\ weight}{molecular\ weight}$$

$$\#\ of\ mol = \frac{150\ g}{40.00\ g/mol}$$

$$\#\ of\ mol = 3.75\ mol\ of\ NaOH$$

MOLARITY

- Once the number of moles of solute has been determined, the molarity of a solution may be calculated
  - Molarity is the concentration of a solution

$$Molarity = \frac{moles\ of\ solute}{liters\ of\ solution}$$

$$M = \frac{mol}{L}$$

EXAMPLE 1

- If 0.4 mol of NaOH is dissolved in 2 L of solution, what is the molarity of the solution?

$$Molarity = \frac{moles\ of\ solute}{liters\ of\ solution}$$

$$M = \frac{0.4\ mol}{2\ L}$$

$$M = 0.2\ \mathrm{M}$$

EQUIVALENT WEIGHTS

- The equivalent weight of an element or compound is the weight of that element or compound that in a given reaction has the same combining capacity as 8 grams of oxygen or as 1 gram of hydrogen
- The equivalent weight of a reactant will be *equal* to the reactant's molecular weight

$$milliequivalent = (mL\ of\ sol'n)(normality)$$

EXAMPLE 2
NUMBER OF EQUIVALENT WEIGHTS

- If 90 grams of sodium hydroxide (NaOH) were used in making up a solution, how many equivalent weights were used. Use 40.00 g as the equivalent weight for NaOH.

$$\#\ equivalent\ weights = \frac{total\ weight}{equivalent\ weight}$$

$$\frac{amt.\ used\ in\ sol'n}{weight\ of\ compound}$$

$$\#\ equivalent\ weights = \frac{90\ g}{40\ g}$$

$$\#\ equivalent\ weights = 2.25\ equivalent\ weights$$

NORMALITY

- When you have determined the number of equivalent weights of the dissolved solute, you can determine the normality of the solution
- Normality is a measure of the reacting power of a solution
  - i.e. 1 equivalent of a substance reacts with 1 equivalent of another substance

$$Normality = \frac{\#\ of\ equivalent\ weights\ of\ solute}{liters\ of\ solution}$$

$$N = \frac{equivalents}{L}$$

EXAMPLE 3

- If 2.1 equivalents of NaOH were used in making up 1.75 L of solution, what is the normality of the solution?

$$Normality = \frac{\#\ of\ equivalent\ weights\ of\ solute}{liters\ of\ solution}$$

$$N = \frac{2.1\ equivalents}{1.75\ liters}$$

$$N = 1.2\ N$$

TWO NORMAL EQUATION

- $C = concentration$
- $V = volume\ or\ flow$

$$C_1 \times V_1 = C_2 \times V_2$$

want = have

EXAMPLE 4

- To titrate a sample for alkalinity, 200 mL 0.02 N H_2SO_4 is needed. How much mL of 1.0 N H_2SO_4 is needed to obtain the desired amount and concentration?

$$C_1 \times V_1 = C_2 \times V_2$$

THREE NORMAL EQUATION

- $N = normality$
- $V = volume\ or\ flow$

$$(N_1 \times V_1) + (N_2 \times V_2) = (N_3 \times V_3)$$

Be sure to follow order of operations!

HARDNESS, ALKALINITY

AWWA Basic Science Concepts and Applications

HARDNESS

- Measurement of the effects that water impurities have on corrosion scaling and soap
- Measured in mg/L as $CaCO_3$

$$Hardness = \frac{(Titrant\ volume, mL)(1000)}{sample\ volume, mL}$$

EXAMPLE 5

- If 18 mL of EDTA were used to titrate a sample to the end point of a 100 mL sample, what is the hardness in mg/L as $CaCO_3$?

$$Hardness = \frac{(titrant\ volume, mL)(1000)}{sample\ volume, mL}$$

ALKALINITY

- A measure of the water's ability to resist change to pH
- Measured in mg/L as $CaCO_3$
- Composed of the carbonate, bicarbonate, and hydroxide content of the water

$$Alkalinity = \frac{(titrant\ vol, mL)(acid\ normality)(50{,}000)}{sample\ volume, mL}$$

EXAMPLE 6

- A 100 mL sample was titrated a pH of 8.3 with 9 mL of 0.02N H_2SO_4. What is the alkalinity?

$$alkalinity = \frac{(titrant\ vol., mL)(acid\ normality)(50{,}000)}{sample\ volume, mL}$$

TOTAL AND PHENOLPHTHALEIN ALKALINITY

- Phenolphthalein alkalinity (P) found by titrating sample to pH of 8.3
  - Phenolphthalein powder pillow
- Total alkalinity (T) found by titrating sample to pH of 4.5
  - Bromcresol green – methyl red powder pillow
  - Methyl orange powder pillow
- Alkalinity is composed of the carbonate, bicarbonate, and hydroxide content of the water

ALKALINITY RELATIONSHIPS

Result of Titration	Hydroxide	Carbonate	Bicarbonate
$P = 0$	0	0	T
$P < {}^1/_2\ T$	0	$2P$	$T - 2P$
$P = {}^1/_2\ T$	0	$2P$	0
$P > {}^1/_2\ T$	$2P - T$	$2(t - p)$	0
$P = T$	T	0	0

P = Phenolphthalein alkalinity
T = Total alkalinity

EXAMPLE 7

- A water sample is tested for phenolphthalein and total alkalinity. If the phenolphthalein alkalinity is 10 mg/L as $CaCO_3$, and the total alkalinity is 52 mg/L as $CaCO_3$, what are the bicarbonate, carbonate, and hydroxide alkalinities of the water?

EXAMPLE 7 CONT'D

P = 10 mg/L
T = 52 mg/L
$P < {}^1/_2\,T$

$$Hydroxide =$$

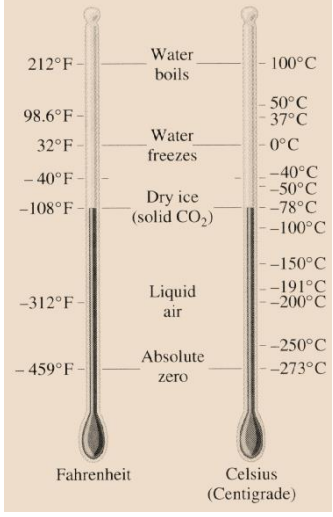
$$Carbonate =$$
$$Carbonate =$$
$$Carbonate =$$

$$Bicarbonate =$$
$$Bicarbonate =$$
$$Bicarbonate =$$
$$Bicarbonate =$$

TEMPERATURE CONVERSIONS

TEMPERATURE SCALES

The **Fahrenheit** scale is named for the 18th-century German physicist Daniel Fahrenheit.
His scale is based on 32 for the freezing point of water and 212 for the boiling point of water, the interval between the two being divided into 180 parts.
The scale was in common use in English speaking countries until the 1970's when Europe and Canada adopted the centigrade (Celsius) scale.
The U.S is the only country that still uses the Fahrenheit scale.



The **Celsius** temperature scale is named for the in the Swedish astronomer Anders Celsius who invented the scale in 1742.

The scale is based on 0 for the freezing point of water and 100 for the boiling point of water.

It is sometimes called the centigrade scale because of the 100-degree interval between the defined points.

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TEMPERATURE FORMULAS

- Degrees Fahrenheit

$$°F = (°C)(1.8) + 32$$

Remember your Order of Operations!!

- Degrees Celsius

$$°C = \frac{(°F - 32)}{1.8}$$

EXAMPLE 8

- Determine the temperature in $°F$ if the temperature is measured as $43°C$.

$$°F = (°C)(1.8) + 32$$

EXAMPLE 9

- Water temperature is measured with a pH probe to be $87\ °\mathrm{F}$. What is this in Celsius?

$$°\mathrm{C} = \frac{(°\mathrm{F} - 32)}{1.8}$$

LANGELIER SATURATION INDEX (LSI)

LANGELIER SATURATION INDEX

- Used to determine the stability of the water
  - Aggressive vs scale forming
  - More negative the number = more aggressive water
  - More positive the number = more scale forming water

$$LSI = pH - pH_s$$

- pH_S = pH of Saturation
  - Temperature (°C)
  - Total Dissolved Solids (TDS in mg/L)
  - Alkalinity (mg/L as $CaCO_3$)
  - Calcium Hardness (mg/L as $CaCO_3$)

LANGELIER SATURATION INDEX

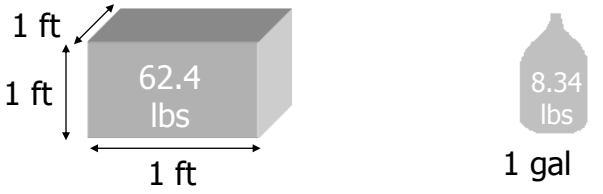
Corrosivity Characteristics as Addressed by Indices		
Corrosive Characteristics	Langelier Index (LSI)	Aggressive Index (AI)
Highly Aggressive	< - 2.0	< 10.0
Moderately Aggressive	- 2.0 to < 0.0	10.0 to < 12.0
Non-aggressive	> 0.0	> 12.0

SPECIFIC GRAVITY AND DENSITY

DENSITY

- weight per unit volume
  - solids and gases expressed in lb/ft^3
  - liquids measured in lb/gal or lb/ft^3
- density of water varies slightly with temperature and pressure
- density of gases changes significantly with changes in temperature and pressure

DENSITY OF WATER



The density of water is

8.34 lbs/gal

or

62.4 lbs/ft^3

SPECIFIC GRAVITY

- compares density of a substance to a standard density
- does not have units
- for solids and liquids
  - compare to standard density of water
    - 62.4 lb/ft^3
    - 8.34 lb/gal

SPECIFIC GRAVITY

$$Specific\ Gravity = \frac{weight\ of\ substance}{weight\ of\ water}$$

- Weights can be measured in $^{lb}/_{gal}$ or $^{lb}/_{ft^3}$
  - Be sure the units are consistent within the equation

EXAMPLE 10

- Determine the specific gravity of a liquid chemical that has a density of 10.5 lb/gal.

$$Specific\ Gravity = \frac{weight\ of\ substance}{weight\ of\ water}$$

COMPOSITE SAMPLES

COMPOSITE SAMPLES

- Composite samples
  - Representative of average water quality of location over a period of time
  - Series of grab samples mixed together
  - Determines average concentration
  - Not suitable for all tests

$$Composite\ Sample\ Single\ Portion = \frac{(Instantaneous\ Flow)(Total\ Sample\ Volume)}{(Number\ of\ Portions)(Average\ Flow)}$$

EXAMPLE 11

- Filter effluent flows at 2.0 gpm/ft^2 on average. You want to collect 5 samples for a composite sample of 10 gallons. If the water is flowing at 2.7 gpm/ft^2 at the time of sampling, what should the volume of sample #1 be in gallons?

$$Composite\ Sample\ Single\ Portion = \frac{(Instantaneous\ Flow)(Total\ Sample\ Volume)}{(Number\ of\ Portions)(Average\ Flow)}$$

EXAMPLE 11 CONT'D

Avg flow= 2.0 gpm/ft^2
samples = 5
Total volume = 10 gal
Inst. Flow = 2.7 gpm/ft^2

$$Composite\ Sample\ Single\ Portion = \frac{(Instantaneous\ Flow)(Total\ Sample\ Volume)}{(Number\ of\ Portions)(Average\ Flow)}$$

THRESHOLD ODOR NUMBER

THRESHOLD ODOR NUMBER (TON)

- Threshold Odor Numbers are whole numbers that indicate how many dilutions it takes to produce odor-free water
- Dilute multiple volumes of the odored water to 200 mL with odor free water
  - Include 2 blanks (2 - 200 mL flasks of odor free water)
  - After heating and shaking flasks, smell each flask (starting with the pure odor free water) proceeding from the lowest to the highest concentration of sample water
  - Record the volume of sample water in the first flask an odor is detected by each tester

THRESHOLD ODOR NUMBER (TON)

$$TON = \frac{A + B}{A}$$

- Where A = volume of odor causing sample

  and B = volume of odor free water

$$A + B \; will \; always = 200 \; mL$$

EXAMPLE 12

- Find the TON when odor is first detected in a flask containing 50 mL of sample water.

$$TON = \frac{A + B}{A}$$

$$TON = \frac{50 \; mL + 150 \; mL}{50 \; mL}$$

$$A + B \; will \; always = 200 \; mL$$

$$TON = \frac{200 \; mL}{50 \; mL}$$

$$TON = 4 \; TON$$

Applied Math for Water Treatment
Laboratory Calculations

1. Mechanical seals should never exceed 160°F. What is this temperature expressed in °C?

2. A sample of water contains 25 mg/L phenolphthalein alkalinity as $CaCo_3$. If the total alkalinity of the water is 121 mg/L as $CaCo_3$, what is the hydroxide, carbonate, and bicarbonate alkalinity?

3. What is the percent removal across a settling basin if the influent turbidity is 8.8 ntu and the effluent turbidity at the settling basin is 0.89 ntu?

4. The phenolphthalein alkalinity of a water sample is 12 mg/L as $CaCO_3$, and the total alkalinity is 23 mg/L as CaCO3. What are the bicarbonate, carbonate, and hydroxide alkalinities of the water?

5. The atomic weight of a certain chemical is 66. If 35 grams of the chemical are used to make up a 1 liter solution, how many moles are used?

6. To determine the average turbidity coming into a plant, an operator collects 5 samples to combine into a 250 mL composite sample. The average flow at the intake is 230,000 gpd. If the flow at the time of the sample collection is 180 gpm. How many mL should the sample portion be at the time of collection?

7. A 100-milliliter (mL) sample of water is tested for alkalinity. The normality of the sulfuric acid used for titrating is 0.02 N. If 0.5 mL titrant is used to pH 8.3 and 5.7 mL titrant to pH 4.6, what are the phenolphthalein and total alkalinity of the sample?

8. A 100 mL water sample is tested for phenolphthalein alkalinity. If 2 mL of titrant is used to reach pH of 8.3 and the sulfuric acid solution has a normality of 0.02 N, what is the phenolphthalein alkalinity of the water (in mg/L as $CaCo_3$)?

9. Determine the specific gravity of a gold bar that weighs 521.47 lb and occupies a space of 0.433 ft^3.

10. What is the molarity of 2 moles of solute dissolved in 1 liter of solvent?

11. How many pounds of liquid can be pumped per day?
    Pump rate desired: 25 gpm
    Liquid weight: 74.9 lbs/ft^3

12. Find the density (lbs/ft^3) of a certain oil that has a S.G. of 0.92.

13. If 2 equivalents of a chemical are dissolved in 1.5 liters of solution, what is the normality of the solution?

14. Convert 170°F to °C.

15. Three hundred grams of calcium is how many equivalents of calcium? (The equivalent weight of calcium is 20.04.)

16. Find the density (lbs/gal) of caustic soda that has a S.G. of 1.530.

17. A gallon of solution is weighed. After the weight of the container is subtracted, it is determined that the weight of the solution is 9.1 lb. What is the density of the solution in lb/ft^3?

18. An 800 mL solution contains 1.6 equivalents of a chemical. What is the normality of the solution?

19. What is the turbidity removal efficiency through a water plant if the source water turbidity is 18.8 ntu and the treated water entering the distribution system is 0.035 ntu?

20. The magnesium content of water is 25 mg/L. How many milliequivalents/liter is this? The equivalent weight of magnesium is 12.15.)

21. The density of an unknown liquid is 74.1 lb/ft^3. What is the specific gravity of the liquid?

22. What is the iron removal efficiency through a water plant if the source water iron content is 4.25 mg/L and the treated water entering the distribution system is 0.030 mg/L?

23. A 100-milliliter (mL) water sample is tested for phenolphthalein alkalinity. If 1.40 mL titrant is used to pH 8.3 and the normality of the sulfuric acid solution is 0.02 N, what is the phenolphthalein alkalinity of the water (in mg/L as $CaCO_3$)?

24. The effluent of a treatment plant is 23°C. What is this expressed in degrees Fahrenheit?

25. What is the specific gravity of a polymer solution that weighs 11.1 lb/gal?

26. If 2.9 moles of solute are dissolved in 0.8 liter of solution, what is the molarity of the solution?

27. Convert 17°C to degrees Fahrenheit.

28. A water sample is found to have a phenolphthalein alkalinity of 0 mg/L and a total alkalinity of 67 mg/L. What are the bicarbonate, carbonate, and hydroxide alkalinities of the water?

29. What is the density of a substance in pounds per cubic foot if it weighs 29.27 kg and occupies a space of 0.985 ft^3?

30. Alkalinity titrations on a 100-mL water sample gave the following results: 1.5 mL titrant used to pH 8.3, and 2.9 mL total titrant used to pH 4.5. The normality of the sulfuric acid was 0.02 N. What are the phenolphthalein, total, bicarbonate, carbonate, and hydroxide alkalinities of the water?

31. The magnesium content of a water source averages 0.24 mg/L. What is the percent removal if the treated water averages 0.020 mg/L Mg?

32. A 100-milliliter (mL) sample of water is tested for phenolphthalein and total alkalinity. A total of 0 mL titrant is used to pH 8.3 and 6.9 mL titrant is used to titrate to pH 4.4. The normality of the acid used for titrating is 0.02 N. What are the phenolphthalein and total alkalinity of the sample (in mg/L as CaCO3)?

33. A 1.7 molar solution is to be prepared. If a 900 mL solution is to be prepared, how many moles solute will be required?

34. A certain pump delivers 14 gallons of water per minute.
    A. How many lbs of water does the pump deliver in 24 hours?
    B. How many lbs/day will the pump deliver if the liquid weighs 8.1 lbs/gal?

35. A tank holds 1,240 gallons of a certain liquid. The specific gravity is 0.93. How many pounds of liquid are in the tank?

36. Calculate the percent removal of settleable solids if the settleable solids of the sedimentation tank influent are 16 mL and the settleable solids of the effluent are 0.8 mL/L.

37. Determine the specific gravity of a polymer solution that weighs 1067 lb/gal.

38. The molecular weight of calcium is 40. If a total of 28 grams of calcium are used in making up a 1-liter solution, how many moles are used?

39. Convert 43°C to degrees Fahrenheit.

40. If 2.3 equivalents of a chemical are dissolved in 1.4 liters of solution, what is the normality of the solution?

41. The influent to a treatment plant has a temperature of 75°F. What is the temperature expressed in degrees Celsius?

42. If the influent turbidity for a water plant is 17.5 ntu and the effluent turbidity is 0.03, what is the percent removal?

43. What is the molarity of a solution that has 0.5 moles solute dissolved in 1800 mL of solution?

44. What is the specific gravity for a solution that weighs 9.44 lb/gal?

45. To preserve a bacteriological sample, the sample must be cooled to 4°C. What is this expressed in degrees Fahrenheit?

46. What is the turbidity removal efficiency through a water plant if the source water turbidity is 22.6 ntu and the treated water entering the distribution system is 0.040 ntu?

47. A certain pump delivers 23 gallons per minute.
    A. How many lbs of water does the pump deliver in 1 minute?
    B. How many lbs/min will the pump deliver if the liquid weighs 71.9 lbs/ft^3?

48. Find the density (lbs/gal) of ferric chloride that has a S.G. of 1.140.

49. A 780 milliliter solution contains 1.3 equivalents of a chemical. What is the normality of the solution?

50. Find the density (lbs/ft^3) of potassium permanganate that has a S.G. of 1.522.

51. What is the specific gravity of an unknown liquid that has a density of 68.4 lb/ft^3?

Answers

1. 71.1°C
2. H=0; C=50; B=71
3. 89.9%
4. H=1; C=22; B=0
5. 1.88
6. 56.4 mL
7. 5 mg/L; 57 mg/L
8. 20 mg/L
9. 19.3
10. 2 M
11. 360,481.28 lb/day
12. 57.41 lb/ft^3
13. 1.33N
14. 76.67°C
15. 15
16. 12.76 lb/gal
17. 68.07 lb/ft^3
18. 2 N
19. 99.81%
20. 2.06
21. 1.19
22. 99.29%
23. 14 mg/L
24. 73.4°F
25. 1.33
26. 3.63 M
27. 62.6°F
28. H=0; C=0; B=67
29. 65.45 lb/ft3
30. H=1; C=28; B=0
31. 91.67%
32. 69%
33. 1.53 moles
34. A. 168,134.4 lb/day
    B. 163,296 lb/day
35. 9,617.69 lb
36. 95%
37. 127.94
38. 0.7
39. 109.4°F
40. 1.64 N
41. 23.89°C
42. 99.83%
43. 0.28
44. 1.13
45. 39.2°F
46. 99.82%
47. A. 191.82 lb/min
    B. 221.08 lb/min
48. 9.51 lb/gal
49. 1.67 N
50. 94.97 lb/ft^3
51. 1.10