STATE OF COLORADO

Colorado Department of Public Health and Environment

# DESIGN CRITERIA

# FOR

# POTABLE WATER SYSTEMS

WATER QUALITY CONTROL DIVISION

Revised March 31, 1997

Price: $5.00

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# PART 1 - INTRODUCTION

## 1.0 GENERAL

1.0.1 These design criteria have been developed to assure that public drinking water treatment facilities in Colorado will provide potable water that does not endanger the public health, based upon the best proven technology.

1.0.2 The purpose of the design criteria is to provide information regarding the State's plans review process for drinking water treatment works. It is a compilation of design parameters considered representative of good design practice.

1.0.3 Design review covers all phases of potable water treatment including: applicability of treatment, reliability, capacities, equipment, chemicals, flow rates, detention times, velocities, and any other aspects which can possible impact the quality of the finished water. An existing system making physical modifications that will result in changes to the water quality are required to submit plans to the Division. The design review does not cover distribution systems.

1.0.4 Deviations from the design criteria may be approved as long as the proposed parameters used in the design are adequately justified by pilot plant results, research results, or documented experience. This Department supports the use of new technology as long as its effectiveness has been shown through pilot plant and/or field testing under water conditions relevant to Colorado.

1.0.5 Submittal of preliminary plans is recommended, particularly if deviations from the design criteria or for innovative treatment processes are involved. The Department will, within 45 days of receipt of the preliminary plans, review the documents submitted and either approve the treatment or send a list of deficiencies to the engineer.

1.0.6 Approval of the proposed project is based only on engineering design and the facility's anticipated ability to meet the Colorado Primary Drinking Water Regulations. Approval shall in no way influence local planning decisions.

1.0.7 Upon completion of construction, a written statement from a licensed representative of the engineering firm stating that the facility was build as approved by this office must be submitted to this Department.

## 1.1 PLAN SUBMITTAL

The plan submittal package must include the following:

1.1.1 An engineering report addressing the water system, proposed treatment, and design calculations (see Section 1.2);

1.1.2 A completed "Plans Review" form (see Appendix II) with a completed "100 Year Flood Plain Certification" with a professional engineer seal, and signatures of both

the local health department and the facility owner. Forms can be obtained by calling the Drinking Water Unit of the Colorado Department of Health;

1.1.3 A raw water chemical analysis for inorganics, organics and radioactivity according to the Colorado Primary Drinking Water Regulations;

1.1.4 The control of lead and copper concentrations in the distribution system is a function of: temperature, pH, alkalinity, calcium and TDS. An analysis of the stability of the water should be performed;

1.1.5 The technical specifications with a professional engineer seal;

1.1.6 The final proposed blueprint drawings with a professional engineer seal;

1.1.7 A statement certifying that all needed permits (for discharges, wells, overflow, stream crossings, highway crossings, etc.) have been applied for, or are otherwise addressed. Consideration must be given to the design requirements of other federal, state and local regulatory agencies for items such as safety requirements, special designs for the disabled, plumbing and electrical codes, etc.

1.1.8 All systems should perform a vulnerability assessment to determine their future sampling requirements. Forms can be obtained by contacting the Drinking Water Section;

1.1.9 The Department shall, within 45 days after receipt of the complete set of final plans, review the documents submitted and, based thereon, shall either approve the plans or send a list of deficiencies to the engineer. Deficiencies not addressed and rectified within 60 days of notification will result in a written disapproval.

1.1.10 Approval for construction will not be issued until final, complete, detailed plans have been received and approved by this Department. Construction of treatment works prior to plans approval will result in legal enforcement action by this Department.

1.1.11 All change orders and addendums involving requirements set forth in these design criteria must be submitted to this Department for approval.

1.1.12 If construction of the treatment facility is not begun within 365 days, the Division's approval will expire. All information will be required to be updated and resubmitted for review and approval by the Division.

## 1.2 ENGINEERING REPORT

The engineering report must address the scope of the project with respect to its purpose, need, alternatives considered, and a general description of the treatment process. The report must include, but is not limited to, the following:

1.2.1 Service area definition including existing and future population estimates, per capita consumption estimates, and relationship to other water treatment plants and distribution systems in the area;

1.2.2 Analysis of existing treatment facilities;

1.2.3 Analysis of source selection with regard to groundwater sources versus surface water sources;

1.2.4 Analysis of treatment alternatives considered, including estimates of capital and operational costs;

1.2.5 Implementation plan and schedule including estimated construction time and estimated start-up date;

1.2.6 Watershed or wellhead control plans and procedures;

1.2.7 Location of all existing and potential sources of contamination within 250 feet (76m) of the source and within 100 feet (30m) of underground treated water storage;

1.2.8 Chemical analyses for all primary MCL parameters and other contaminants that are known or suspected to be present and which may affect treatment processes;

1.2.9 Summarization of raw water turbidity data with special reference to fluctuations throughout the year that may affect treatment;

1.2.10 Standby power and fire protection flows will be addressed so that water may be available at all times in the distribution system.

1.2.11 Any chemical additives or materials that come in contact with the water will be certified under the ANSI standard 60 or 61, respectively.

## 1.3 DESIGN REQUIREMENTS

A complete set of design calculations must be submitted, containing but not limited to the following, as applicable:

1.3.1 A listing of all design constants, engineering assumption, and values used for variables;

1.3.2 Reservoir surface area and volume;

1.3.3 Area of watershed;

1.3.4 Estimated average and maximum day water demands for the design period;

1.3.5 Number of proposed services and projected population for twenty years;

1.3.6 Flash mix, flocculation, and settling basin design characteristics;

1.3.7 Retention times;

1.3.8 Unit loadings;

1.3.9 Proposed filtration rate and filter area;

1.3.10 Backwash rate;

1.3.11 Feeder capacities and ranges.

1.3.12 Treatment for conformance to maximum contaminant levels (MCL's);

1.3.13 Proper disinfection and contact time;

1.3.14 Schematic flow diagrams and hydraulic profiles showing the flow through various plant units;

1.3.15 Piping in sufficient detail to show flow through the plant, including waste lines;

1.3.16 Locations of all chemical feeding equipment and points of chemical application;

1.3.17 Proposed chemicals for addition;

1.3.18 Storage and safety details for chemical handling;

1.3.19 All appurtenances, specific structures, equipment, water treatment plant waste disposal units, and points of discharge having any relationship to the plans for water mains and water works structures;

1.3.20 Locations of sanitary or other facilities, such as laboratories, showers, toilets, and lockers when applicable or required by the reviewing authority or local health agencies;

1.3.21 Locations, dimensions, and elevations of all proposed plant facilities;

1.3.22 Locations of all sampling taps, and monitoring equipment;

1.3.23 Assessment of operation under all weather conditions;

1.3.24 Walkways with guardrails around plant to view various process operations and conditions;

1.3.25 Location of flow meters;

1.3.26 Type and location of cross-connection control devices;

1.3.27 Any significant deviations from the approved plans involving the treatment process must be submitted to this Department for approval. The revisions shall be submitted in time to review and approve such revisions before construction of the affected treatment process has begun.

## PART 2 - GROUND WATER SOURCES

This section applies to source water that is to be classified as a ground water source.

### 2.1 GENERAL WELL CONSTRUCTION

2.1.1 All wells shall be constructed in accordance with the latest edition of The Rules and Regulations of Colorado's State Board of Water Well and Pump Installation Contractors.

2.1.2 Wells shall not be constructed in close proximity of a waterway or in a geological formation which would allow direct intrusion of surface water.

2.1.3 A microscopic particulate analysis of the product water may be required on a case-by-case basis depending upon the well log information and the hydrogeologic conditions.

2.1.4 Wells should not be constructed within the 100 year flood plain. Wells within the 100 year flood plain shall be designed to prevent damage or contamination by the 100 year flood event.

2.1.5 All wells shall be protected from surface contamination through use of a sanitary seal.

2.1.6 Sanitary seals shall be designed to prevent the entrance of liquids and solids, and shall include a water tight port for electrical connection.

2.1.7 Vents shall be covered with 24 mesh, corrosion resistant screen.

2.1.8 The ground level grading must be such that any surface water will be diverted away from the well for a distance of 20 feet. Wells with a static water level of less than 100 feet from the surface, should have a four-foot diameter (minimum) concrete pad poured around the well casing.

2.1.9 No well shall be located closer than one hundred (100) feet horizontally to any source of contamination. Potential sources of contamination include septic tanks, sewer lines, storm sewer lines, petroleum tanks, etc. A system may request a variance prepared by a professional engineer or a professional geologist based on hydro-geologic information.

2.1.10 Well vaults are not permitted unless a variance is granted based on positive gravity drainage of the vault through a floor drain to daylight.

### 2.2 SPRING CONSTRUCTION

2.2.1 Springs should not be constructed within the 100 year flood plain or in areas subject to flooding. Springs within the 100 year flood plain shall be protected against damage or contamination by the 100 year flood event.

2.2.2 Springs shall not be constructed in an area where either under ground or surface contamination can impact such water source.

2.2.3 Springs shall be enclosed by reinforced concrete walls and cover, or other durable and watertight material.

2.2.4 Spring boxes shall have an overlapping, lockable, water tight access cover.

2.2.5 Water from springs shall be carried by gravity flow directly into storage or the distribution system. Pumping is allowed only from a sump or other storage.

2.2.6 A microscopic particulate analysis will be performed on the project water following completion of the spring collector for each spring. These results will be submitted to this Department for final determination of the source as a surface or ground water. Those springs determined to be influenced by surface water must meet all surface water filtration requirements.

Spring Design will include:

2.2.7 screened drain pipe with exterior valve;

2.2.8 overflow pipe just below maximum water level elevation protected by 24 mesh screen;

2.2.9 supply outlet from spring will be located 6 inches above drain outlet and be protected by 24 mesh screen;

2.2.10 perforated collection pipe - see infiltration gallery requirement Section 2.3;

2.2.11 an earth cover, natural or fill, of at depth least 5 feet should be provided over the water bearing strata and should extend at least 50 feet on a radius from the point of out-crop. Hypalon or similar water proof fabric maybe required as a seepage barrier;

2.2.12 a surface water drainage ditch shall be located approximately 25 feet uphill from the source so as to intercept surface water runoff and carry it away from the source;

2.2.13 a fence should be constructed to prevent entry of unauthorized persons and all but small animals. This fence shall be uphill of the drainage ditch and completely surround the collection area.

## 2.3 INFILTRATION GALLERIES

2.3.1 A microscopic particulate analysis will be performed on the product water following completion of the infiltration gallery. These results will be submitted to this Department for final determination of the source as a surface or ground water. Those infiltration galleries determined to be influenced by surface water must meet all surface water filtration requirements.

2.3.2 Infiltration galleries should not be constructed within the 100 year flood plain. Infiltration galleries constructed within the 100 year flood plain shall be protected against damage or contamination by the 100 year flood event.

2.3.3 Infiltration galleries shall not be constructed in close proximity of a waterway or in a geological formation which would allow direct intrusion of surface water.

2.3.4 The area around infiltration lines shall be under the control of the water purveyor to prevent entrance to the system by unauthorized persons.

2.3.5 The area around infiltration lines shall be graded to divert surface water drainage away from the site.

2.3.6 The area around infiltration lines should be fenced. A fence around the lines will be required if livestock animals will be grazing in the area.

2.3.7 Flow in the infiltration lines shall be by gravity directly into storage or the distribution system. Pumping is allowed only from a sump or other storage.

2.3.8 Infiltration gallery media shall be clean, well rounded grains which are 90-95% quartz bearing.

2.3.9 Media shall have a uniformity coefficient of $\leq 2.5$.

2.3.10 A minimum 3" annulus of this media shall be placed around each collection pipe.

2.3.11 An earth cover, natural or fill, of at least 5 feet, shall be provided over the infiltration lines. Hypalon or similar water proof fabric will be required as a seepage barrier.

2.3.12 A surface water drainage ditch shall be located approximately 25 feet uphill from the source so as to intercept surface water runoff and carry it away from the source.

# PART 3 FACILITY LAYOUT

## 3.0 GENERAL

The design of a water supply system or treatment process encompasses a broad area. Application of this part is dependent upon the type of system or process involved.

## 3.1 LOCATION OF STRUCTURES

All facilities must be certified as out of the 100 year flood plain or otherwise flood proofed. Provisions for diversion or flood proofing against the 100 year flood cannot interrupt plant operations during a 100 year flood event and will be reviewed on a case-by-case basis.

## 3.2 PLANT LAYOUT

Design shall consider:

3.2.1 functional aspects of the plant layout;

3.2.2 provisions for future plant expansion;

3.2.3 provisions for waste treatment and disposal facilities;

3.2.4 access roads;

3.2.5 site grading and drainage;

3.2.6 snow removal;

3.2.7 walks and driveways;

3.2.8 utility easements;

3.2.9 yard piping;

3.2.10 chemical delivery;

3.2.11 plant security.

## 3.3 BUILDING LAYOUT

Design shall provide for:

3.3.1 adequate ventilation;

3.3.2 adequate lighting;

3.3.3 adequate heating;

3.3.4 adequate drainage;

3.3.5 dehumidification equipment, if necessary;

3.3.6 accessibility of equipment for operation, servicing, and removal;

3.3.7 flexibility of operation;

3.3.8 operator safety;

3.3.9 convenience of operation;

3.3.10 chemical storage and feed equipment in a separate room to minimize hazards and dust problems;

3.3.11 sludge disposal.

## 3.4 ELECTRICAL CONTROLS

Main switch gear electrical controls shall be located above grade.

## 3.5 STANDBY POWER

Standby power may be required by the local reviewing authority so that water may be treated and/or pumped to the distribution system during major power outages.

## 3.6 SHOP SPACE AND STORAGE

Adequate facilities should be included for shop storage consistent with the designed treatment and must be located and arranged in a manner which will not allow contamination of any water.

## 3.7 LABORATORY EQUIPMENT

Laboratory equipment and facilities shall be compatible with the raw water source, intended use of the treatment plant, and the complexity of the treatment process involved.

3.7.1 Testing equipment provided shall be adequate for the purpose intended and recognized procedures must be utilized.

3.7.2 Sufficient bench space, ventilation, lighting, storage room, laboratory sinks, and auxiliary facilities shall be provided. Air conditioning may be necessary.

## 3.8 MONITORING EQUIPMENT

3.8.1 Water treatment plants utilizing surface water sources shall be provided with continuous monitoring turbidimeters and recording devices after the filters and prior to the clearwell. In addition, turbidimeters shall be provided for each filter train in the treatment system.

3.8.2 For systems that serve water to more than 3300 people, and utilizing surface water, shall have continuous chlorine monitoring and a recording devices located after the clearwell.

3.8.3 All water systems will have portable equipment for determination of chlorine residual.

3.8.3 Other operational equipment is recommended depending upon the treatment process used.

3.8.4 Laboratory tests for determination of MCL compliance, other than turbidity, must be run by a State Certified Laboratory.

## 3.9 SAMPLE TAPS

Sample taps should be provided so that water samples can be obtained from each water source and from appropriate locations in each unit operation of treatment. Taps shall be consistent with sampling needs and shall not be of the petcock type. Taps used for obtaining samples for bacteriological analysis shall be of the smooth-nosed type without interior or exterior threads, shall not be of the mixing type, and shall not have a screen, aerator, or other such appurtenance.

## 3.10 FACILITY WATER SUPPLY

The facility water supply service line and the plant finished water sample tap shall be supplied from a source of finished water at a point where all chemicals have been thoroughly mixed. Plant finished water shall be protected from cross-connection hazards created from the use of the facility water service.

## 3.11 WALL CASTINGS

Consideration shall be given to providing extra wall castings build into the structure to facilitate future uses whenever pipes pass through walls of concrete structures.

## 3.12 METERS

All water supplies shall have means of metering the finished water.

## 3.13 PIPING COLOR CODE AND ARROWS

To facilitate identification of piping in plants and pumping stations, it is recommended that the following color scheme be utilized:

### Water Lines

| | |
|---|---|
| Raw | Olive Green |
| Settled or Clarified | Aqua |
| Finished or Potable | Dark Blue |

### Chemical Lines

| | |
|---|---|
| Alum | Orange |
| Ammonia | White |
| Carbon Slurry | Black |
| Chlorine (Gas and Solution) | Yellow |
| Fluoride | Light Blue with Red Band |
| Lime Slurry | Light Green |
| Potassium Permanganate | Violet |
| Sulfur Dioxide | Light Green w/Yellow Band |
| Ozone | White with Black Band |

Waste Lines

| | |
|---|---|
| Backwash Waste | Light Brown |
| Sludge | Dark Brown |
| Sewer (Sanitary or Other) | Dark Grey |

Other

| | |
|---|---|
| Compressed Air | Dark Green |
| Gas | Red |
| Other Lines | Light Gray |

In situations where two colors do not have sufficient contrast to easily differentiate between them a six-inch band or contrasting color should be painted on one of the pipes at approximately 30 inch (0.75m) intervals and at all bends in pipe. The name of the liquid or gas should also be painted on the pipe. In some cases it may be advantageous to paint arrows indicating the direction of flow.

## 3.14 DISINFECTION

All wells, pipes, tanks, and equipment which can convey or store potable water shall be disinfected in accordance with AWWA procedures prior to start-up of the facility. Plans or specifications shall outline the procedure and include the disinfectant dosage, contact time, and method or testing the results of the procedure.

## 3.15 MANUALS, DRAWINGS AND PARTS LISTS

An operation and maintenance manual, including a parts list and parts order form, shall be supplied to the water works as part of any proprietary unit installed in the facility. As-built drawings will be supplied with the operation and maintenance manual to be kept at the facility.

## 3.16 OPERATOR INSTRUCTION

Provisions shall be made for operator instruction at the time of start-up of a plant or pumping station.

## 3.1 OTHER CONSIDERATIONS

The owner of the facility is responsible for compliance with any requirements by other state, federal and/or local regulatory agencies for items such as safety, special designs for the disabled, plumbing and electrical codes, building permits, etc.

## PART 4 - PREFILTRATION TREATMENT

### 4.0 GENERAL

Treatment process design shall be appropriate for the nature and quality of the particular waters to be treated and shall consistently yield the desired quality finished water as set forth in the Colorado Primary Drinking Water Regulations.

### 4.1 PLANT RELIABILITY

All surface water treatment plants must be constructed to permit units to be taken out of service without disrupting operation, and with drains or pumps sized to allow dewatering in a reasonable period of time. The plant should have a minimum of two units each for: flocculation, sedimentation (if required), and filtration.

### 4.2 PRESEDIMENTATION

4.2.1 Systems treating raw water with turbidities in excess of 100 NTU, must provide presedimentation with the addition of coagulation chemicals. Presedimentation basins shall be designed to reduce raw water turbidity to levels which can be adequately and effectively handled using the chosen treatment process(es).

4.2.2 Ponds are suitable for use as presedimentation basins with the provision for periodic manual cleaning.

4.2.3 Inlet and outlet design should prevent short-circuiting. Incoming water shall be dispersed across the full width of the basin as quickly as possible. The outlet structure should be capable of drawing water at different depths in the basin.

4.2.4 Provisions for bypassing presedimentation basins should be included.

4.2.5 Sufficient detention time shall be provided to adequately reduce raw water turbidity. While maintaining an adequate detention time, the basin shall also be sized to store sludge between cleaning cycles when manual cleaning is used.

### 4.3 COAGULATION (CHEMICAL ADDITION AND RAPID MIX)

4.3.1 Rapid mix shall mean the rapid dispersion of chemicals throughout the water to be treated through violent agitation, and the imparting of energy to the water to cause destabilization of the suspended particulate. Chemical addition and rapid mix are an integral part of rapid rate filtration and must always be used when this type of filtration is used. The coagulation process must be designed to handle the critical raw water conditions encountered by the plant, i.e., the cold low turbidity (1 NTU) winter condition and high turbidity spring runoff conditions.

4.3.2 The following are acceptable methods: basins with mechanical mixers, in-line mechanical mixers, in-line hydraulic (static) mixers, and hydraulic jumps. Basins with mechanical mixers are recommended because they impart a constant known energy to the water over all flow ranges.

4.3.3 The design of the mixing unit must be appropriate for the type of coagulation employed, i.e., absorption-destabilization or sweep coagulation, for the particular raw water conditions. Velocity gradient, or "G" values and detention times for the rapid mixes chosen must be justified when submitted. If hydraulic mixers are proposed, "G" values and detention times must be submitted for the range of flows expected in the plant. In lieu of "G" values and detention times, other mixing calculations may be justified.

4.3.4 Coagulants should be injected at the optimum location ahead of the mixer. This location will vary depending on mixer type.

4.3.5 The rapid mix and flocculation basins shall be as close together as possible.

## 4.4 FLOCCULATION

4.4.1 Flocculation shall mean the physical agitation of water at low intensities over a period of time causing collisions of destabilized particles and the subsequent formation of larger aggregated, called floc. Flocculation is required for systems using direct or conventional rapid rate filtration.

4.4.2 The design of the flocculation system should be based on critical mixing conditions encountered by the facility, i.e., spring runoff, high turbidity conditions and cold, (winter) low turbidity water.

4.4.3 Inlet and outlet design shall prevent short-circuiting and destruction of the floc.

4.4.4 Baffling should be provided to uniformly distribute flow across the basin.

4.4.5 The in-basin velocity shall not be less than 0.5 nor greater than 1.5 feet per minute.

4.4.6 Flocculation and sedimentation basins shall be as close together as possible.

4.4.7 The velocity of flocculated water through pipes or conduits to settling basins shall not be less that 0.5 nor greater than 1.5 feet per second. Turbulence at bends and changes in direction shall be minimized.

4.4.8 A minimum of 3 mixing compartments should be provided. A detention time of 20-30 minutes shall be provided for complete floc formation.

4.4.9 Hydraulic gradient, or "G" values shall fall in the range from 10 to 70. Tapered agitation mechanical flocculators should be used.

4.4.10 Agitators shall be driven by variable speed drives with the tip speed of paddles ranging from 0.5 to 2.0 feet per second.

## 4.5 SEDIMENTATION

4.5.1 Sedimentation shall mean the process of settling out particulate matter (floc) in order to decrease the sediment load onto the filters and shall follow flocculation when

conventional rapid rate filtration is used. Other methods of floc removal, such as upflow and contact clarifiers, may be approved on case-by-case basis.

The following criteria apply to conventional sedimentation units:

4.5.2 Inlet Zone - inlet zones shall be designed to distribute the water equally and at uniform velocities before entering the settling zone. Open ports, submerged ports, baffles, etc. should be used to provide proper hydraulic flows;

4.5.3 Settling Zone - surface overflow (or loading) rate governs the design of the settling zone. Surface overflow (or loading) rate shall not exceed 0.7 gpm/$ft^2$ (1000 gpd/$ft^2$);

4.5.4 Outlet Zone - the outlet zone shall be designed to maintain velocities suitable for settling in the basin and to minimize short-circuiting. The use of submerged orifices is recommended in order to provide a volume above the orifices for storage when there are fluctuations in flow;

4.5.5 Weir Overflow (or Loading) Rate - the rate of flow over the outlet weir shall not exceed 12 gpm/ft (17,000 gal. per day per foot) of weir length. Where submerged orifices are used as an alternate for over-flow weirs, they should not be lower than three feet below the flow line with flow rates equivalent to weir loadings;

4.5.6 Velocity - the velocity through settling basins shall not exceed 0.5 feet per minute. The basins must be designed to minimize short-circuiting;

4.5.7 Overflow - an overflow weir (or pipe) should be installed which will establish the maximum water level desired on top of the filter. It shall discharge with a free fall at a location where the discharge will be noted;

4.5.8 Sludge collection - mechanical sludge collection equipment should be provided;

4.5.9 Drainage - basins must be provided with a means for dewatering;

4.5.10 Flushing lines - flushing lines or hydrants shall be provided and must be equipped with backflow prevention devices acceptable to the Department;

4.5.11 Sludge disposal - facilities are required to specify a method for disposal of sludge. Sludge shall be disposed of in accordance with all applicable regulations (See Section 8.9).

The following criteria apply to tube or plate settler units:

4.5.12 Inlet Zone - inlet zones shall be designed to distribute the water equally and at uniform velocities before entering the settling zone. Open ports, submerged ports, baffles, etc., should be used to provide proper hydraulic flows;

4.5.13 Settling Zone - hydraulic loading (overflow) rate shall not exceed 2.5 gpm/$ft^2$ of total tube face area (area of the plane containing the open end of all the tubes, as well as, the tube material) for tubes inclined $60^o$ from the horizontal;

4.5.14 Outlet Zone - the outlet zone shall be designed to maintain velocities suitable for settling in the basin and to minimize short-circuiting. When effluent launders are utilized, the spacing between the launders shall not exceed 2 times the distance from the water surface to top of tubes. When submerged orifices are utilized, they must be located in the top quarter of the distance between the water surface and the top of the tubes;

4.5.15 Tube Cleaning - a method for periodic cleaning of the tubes shall be specified;

4.5.16 Sludge Collection - mechanical sludge collection equipment should be provided;

4.5.17 Drainage - basins must be provided with a means for dewatering;

4.5.18 Flushing lines - flushing lines or hydrants shall be provided and must be equipped with reduced pressure principle backflow prevention devices acceptable to the Department;

4.5.19 Sludge disposal - facilities are required to specify a method for disposal of sludge. Sludge shall be disposed of in accordance with all applicable current regulations.

## PART 5 - FILTRATION

### 5.0 GENERAL

5.0.1 All surface water treatment must be sufficient to achieve at least 99.9 percent (3 log) inactivation and/or removal of Giardia lamblia cysts (relies primarily on the filter) and at least 99.99 (4-log) inactivation and/or removal of viruses (relies primarily on the disinfection concentration and contact time). Acceptable filtration methods include properly designed:

a. rapid rate gravity filtration;

b. rapid rate vertical pressure filtration;

c. diatomaceous earth filtration;

d. slow sand filtration;

e. cartridge/bag filtration;

f. other.

5.0.2 The use of horizontal rapid rate pressure filters will not be approved by this Department.

5.0.3 The type of filtration chosen must be supported by raw water quality data representing the full range of water quality conditions to be encountered at the treatment plant. Pilot plant studies may be required to demonstrate the applicability of the proposed filtration method.

5.0.4 The use of direct filtration is generally discouraged since it provides less treatment than conventional filtration. Due to this concern, evaluation of direct filtration processes will be more closely scrutinized for treatment efficiency to determine compliance and need for longer chlorine detention times.

5.0.5 Innovative filtration methods are acceptable if properly justified through pilot plant testing, performance testing of field scale plants, etc.

5.0.6 Bypasses - Bypasses of the final filtration process shall not be allowed. Filter bypass lines will not be approved under any circumstance.

5.0.7 Number of Units - At least two units shall be provided. Where only two units are provided, each should be capable of meeting the projected average daily demand at the approved filtration rate. Where more than two filter units are provided, the filters shall be capable of meeting the plant design capacity at the approved filtration rate with one filter removed from service.

5.0.8 One unit will be approved if 3 days finished water storage is provided or an alternative approved water source is available.

5.0.9 A microscopic particulate analysis shall be performed on the product water following start-up of all surface water treatment systems. These results will be submitted to this Department for final determination of the compliance with the removal efficiency of the filters.

## 5.1 RAPID RATE GRAVITY FILTRATION

The following raw water turbidity threshold values determine the extent of pre-treatment necessary prior to rapid rate filtration:

5.1.1 "straining," defined as the use of no chemical coagulants, is not acceptable to this office unless followed by additional filtration;

5.1.2 "in line filtration" may be considered if the raw water turbidity never exceeds 5 NTU. In line filtration consists of coagulation (chemical addition and rapid mix) followed by filtration;

5.1.3 "direct filtration" may be considered if the raw water turbidity never exceeds 10 NTU. Direct filtration consists of coagulation (chemical addition and rapid mix), flocculation, and filtration;

5.1.4 "conventional filtration" shall be used if the raw water turbidity ever exceeds 10 NTU. Conventional filtration consists of presedimentation (for high turbidity condition), coagulation, flocculation, sedimentation, and filtration;

5.1.5 After each backwash cycle is complete the first water filtered shall be wasted (filter-to-waste) to lessen the probability of turbidity breakthrough and to allow conditioning of the filter. Water to be wasted shall be a minimum of 2 filter volumes. Filter-to-waste, or a justified alternative, is required by this Department;

## 5.2 RATE OF FILTRATION (HYDRAULIC LOADING RATE)

The proper filtration rate is dependent upon such factors as raw water quality, media depth, media type, water quality control parameters, etc. The filter hydraulic loading rate shall not exceed 5 $gpm/ft^2$. A method of flow control which prevents the filtration rate from exceeding the maximum allowed shall be provided. Proposals for declining rate filtration will be considered on a case-by-case basis.

## 5.3 STRUCTURAL DETAILS AND HYDRAULICS

The filter structure shall be designed to provide for:

5.3.1 vertical walls within the filter;

5.3.2 no protrusion of the filter walls into the filter media

5.3.3 minimum depth of filter box of 8 ½ feet, (2.6m);

5.3.4 minimum water depth over the surface of the filter media of three feet (1M);

5.3.5 trapped effluent to prevent backflow of air to the bottom of the filters;

5.3.6 prevention of floor drainage to the filter with a minimum 4-inch (10c) curb around the filters;

5.3.7 prevention of filter water flooding floor by providing overflow;

5.3.8 maximum velocity of unfiltered water in pipe and conduits to filters of two feet per second;

5.3.9 cleanouts and straight alignment for influent pipes or conduits where solids loading is heavy, or following lime-soda softening;

5.3.10 washwater drain capacity to carry maximum flow.

## 5.4 WASHWATER TROUGHS

Washwater troughs shall be designed to provide the following:

5.4.1 the bottom of the trough shall be above the maximum level of expanded media during washing;

5.4.2 a two-inch water depth above the trough weir at the maximum rate of wash;

5.4.3 the top edge shall be level;

5.4.4 spacing so that each trough serves the same number of square feet of filter area;

5.4.5 troughs shall not cover greater than 25 per cent of filter surface area;

5.4.6 trough spacing shall not exceed 2 times the distance from the top of filter media to top of trough and in no case shall exceed six feet, center line to center line.

## 5.5 FILTER MATERIAL

The media shall be clean silica sand, anthracite or other natural or synthetic media approved by the reviewing authority. A total media depth of not less than 24 inches and generally not greater than 30 inches shall be provided.

The following media types are acceptable under the listed conditions:

5.5.1 Anthracite;

a. effective size - 0.45 mm to 1.2 mm

b. uniformity coefficient - not greater than 1.85

c. specific gravity - shall be less than the specific gravity of the sand used.

5.5.2 Sand;

a. effective size - 0.45 mm to 0.55 mm

b. uniformity coefficient - not greater than 1.65

c. depth - the combined sand and high density sand layers must have a minimum 12 inch depth.

5.3.3 High-density Sand (or Garnet);

a. effective size - 0.25 mm to 0.35 mm

b. uniformity coefficient - not greater than 2.2

c. depth - minimum of 3 inches

d. specific gravity - the specific gravity of the high density sand must be greater than the specific gravity of the sand.

5.5.4 Other media;

Filters consisting of materials or configurations not described in this section will be considered on a case-by-case basis. Pilot plant studies or documented operational experience may be required. Media such as monomedia, manganese green sand and granular activated carbon are included in this category.

5.6 SUPPORT MEDIA

5.6.1 Torpedo sand - a three-inch layer of torpedo sand should be used as a supporting media for filter sand, and should have:

a. effective size of 0.8 mm to 2.0 mm;

b. uniformity coefficient not greater than 1.7

5.6.2 Gravel - Gravel, when used as the supporting media, shall consist of hard, rounded particles and shall not include flat or elongated particles. The coarsest gravel shall be 2 ½ inches in size when the gravel rests directly on the strainer system, and must extend above the top of the perforated laterals. No less than four layers of gravel shall be provided in accordance with the following size and depth distribution when used with perforated laterals:

| Size | Depth |
|---|---|
| 2 ½ to 3/4 inches | 5 to 8 inches |
| 1 ½ to 3/4 inches | 3 to 5 inches |
| 3/4 to ½ inches | 3 to 5 inches |
| ½ to 3/16 inches | 2 to 3 inches |

Reduction of gravel depths may be considered upon justification to the reviewing authority when proprietary filter bottoms are specified.

## 5.7 FILTER BOTTOMS AND STRAINER SYSTEM

Departures from these standards may be acceptable for high rate filters and for proprietary bottoms. Porous plate bottoms shall not be used where iron or manganese may clog them or with waters softened by lime. The design of manifold-type collection systems shall be such as to:

5.7.1 minimize loss of head in the manifold and laterals;

5.7.2 assure even distribution of washwater and even rate of filtration over the entire area of the filter;

5.7.3 provide the ratio of the area of the final openings of the strainer systems to the area of the filter at about 0.003;

5.7.4 provide the total cross-sectional area of the laterals at about twice the total area of the final openings;

5.7.5 provide the cross-sectional area of the manifold at 1 ½ to 2 times the total area of the laterals.

## 5.8 SURFACE WASH AND SUBSURFACE WASH

Surface or subsurface wash facilities are required except for filters used exclusively for iron or manganese removal, and may be accomplished by a system of fixed nozzles or a revolving type apparatus. All devices shall be designed with:

5.8.1 provisions for water pressures of at least 45 psi;

5.8.2 a properly installed reduced pressure zone backflow preventer to prevent back-siphonage if connected to the treated water system;

5.8.3 rate of flow of 2.0 gallons per minute per square foot of filter area with fixed nozzles or 0.5 gallons per minute per square foot with revolving arms.

5.8.4 Air scour is an acceptable alternative when properly justified and designed.

## 5.9 APPURTENANCES

The following shall be provided for every filter:

5.9.1 piping for a filter-to-waste cycle must be provided. Appropriate measures for backflow prevention must be also be included.

5.9.2 a continuous monitoring turbidity recording device for the finished water from the surface water treatment plant;

5.9.3 influent and effluent sampling taps;

5.9.4 an indicating loss of head gauge;

5.9.5 drains shall be diverted away from all treatment processes and finished water.

## 5.10 BACKWASH

Provisions shall be made for washing filters as follows:

5.10.1 a flow rate necessary to provide for a 50 percent expansion of the filter bed is recommended. The system should be capable of providing a rate up to 20 gallons per minute per square foot for 20 minutes.

5.10.2 a reduced rate of 10 gallons per minute per square foot may be acceptable for full depth anthracite or granular activated carbon filters;

5.10.3 an air scour phase will be considered on a case-by-case basis, as justified by submittal of calculations for flow rates, bed expansion, etc;

5.10.4 filtered water provided at the required rate by washwater tanks, a washwater pump, from the high service main, or a combination of these;

5.10.5 washwater pumps in duplicate unless an alternate means of obtaining washwater is available;

5.10.6 not less than 15 minutes wash of one filter at the design rate of wash;

5.10.7 a washwater regulator or valve on the main washwater line to obtain the desired rate of filter wash with the washwater valves on the individual filters open wide;

5.10.8 sufficient backwash storage volume shall be provided;

5.10.9 a rate-of-flow indicator, preferable with a totalizer, on the main washwater line, located so that it can be easily read by the operator during the washing process;

5.10.10 design to prevent rapid changes in backwash water flow. The backwash cycle should begin with a gradual rate of flow increase, followed by a constant design

rate, and end with a gradual decrease to zero flow to allow uniform resettling of the filter bed.

## 5.11 RAPID RATE VERTICAL PRESSURE FILTRATION

5.11.1 The use of rapid rate vertical pressure filtration for surface waters may be allowed if the special conditions described below are met. The use of vertical pressure filters may be considered for iron and manganese removal for groundwater sources.

5.11.2 Minimum criteria required for rapid rate gravity filters also apply to pressure filters where appropriate. (See 5.2 - 5.10)

5.11.3 Physical inspections of the filter media for new filter designs shall be performed quarterly the first year of filter operations, and semi-annually thereafter. The semi-annual inspections should be conducted in March and September.

5.11.4 Written reports shall be submitted to the Department after each inspection. The inspections and reports should address the following:

a. initial appearance of sand after backwash (level surface, holes, etc.);

b. depth from a reference point to original media surface ( detect loss of media);

c. anthracite searched for mudballs down to interface (describe quantity and size of mudballs, if any);

d. measured depth of anthracite;

e. comments on interface;

f. relative indication of raw and finished water characteristics for the quarter;

g. approximate filtration rate;

h. indication of backwash frequency.

Rapid rate pressure filters shall also be designed to provide:

5.11.5 backwash collection piping designed to provide efficient collection of backwash waste water above filter media;

5.11.6 minimum side wall shell height of five feet. A corresponding reduction in side wall height is acceptable where proprietary bottoms permit reduction of the gravel depth;

5.11.7 an air release valve on the highest point of each filter;

5.11.8 an accessible manhole to facilitate inspections and repairs;

5.11.9 means to observe the wastewater during backwashing.

## 5.12 DIATOMACEOUS EARTH FILTRATION

5.12.1 The use of diatomaceous earth filtration may be considered for surface waters of generally less than 10 NTU raw water turbidity. Proper diatomaceous earth filtration consists of precoating the filter septum. During the filter run, body feed is continuously added to the raw water in order to maintain the permeability of the filter cake. Alum may or may not be used to precoat the filter media.

5.12.2 Diatomaceous earth filters are excluded from consideration for the following conditions:

a. raw water turbidities greater than 10 NTU;

b. color removal;

c. filtration of raw waters with high algae counts.

5.12.3 Types of Diatomaceous Earth Filters

Pressure or vacuum diatomaceous earth filtration units will be considered for approval. They should be designed so that the internal mechanism of the filter is readily accessible for inspection and maintenance. It should contain no dead areas in which settling can occur or filter cake can be inadequately removed. The use of vacuum units is discouraged for low temperature raw waters with a high dissolved oxygen level.

Treated water storage capacity shall be provided to:

5.12.4 allow operation of the filters at a uniform rate during all condition of system demand at or below the approved filtration rate, and;

5.12.5 guarantee continuity of service during adverse raw water conditions without by-passing the system.

5.12.6 Precoat:

a. Application - A uniform precoat shall be applied hydraulically to each septum by introducing a slurry to the tank influent line and employing a recirculation system;

b. Quantity - Diatomaceous earth in the amount of 0.2 pounds per square foot of filter area shall be applied to the filter as precoat.

5.12.7 Body feed - A body feed system to apply additional amounts of diatomaceous earth slurry during the filter run is required. Continuous slow speed mixing of the body feed slurry is also required.

5.12.8 Rate of filtration (filter loading rate) - The maximum filtration rate shall not exceed 1.5 gallons per minute per square foot. The filtration rate shall be controlled by a positive means such as an acceptable rate of flow control device.

5.12.9 Recirculation - A recirculation or holding pump may be employed to maintain differential pressure across the filter when the unit is not in operation in order to prevent the filter cake from dropping off the filter elements.

5.12.10 Septum or filter element - The filter elements shall be structurally capable of withstanding maximum pressure and velocity variations during filtration and backwash or cleaning cycles, and shall be spaced such that no less than one inch is provided between elements or between any element and a wall.

5.12.11 Inlet design - The filter influent shall be designed to prevent scour of the diatomaceous earth from the filter element.

The following shall be provided for every filter:

5.12.12 continuous monitoring effluent turbidity recording device;

5.12.13 sampling taps for raw and filtered water;

5.12.14 loss of head or differential pressure gauge;

5.12.15 rate-of-flow indicator, preferably with totalizer, and recorded flow indicator.

## 5.13 SLOW SAND FILTRATION

5.13.1 Slow sand filtration may be considered for surface waters if raw water turbidity never exceeds 10 ntu. Proper filtration using the slow sand method requires "curing" of the filter before placing the filter on-line.

5.13.2 Sand depth - a minimum depth of 30 inches shall be provided for raw filters. Filters may be scraped to a minimum depth of 24 inches before the sand must be replaced.

5.13.3 The sand size shall have:

a. effective size of 0.15 to 0.35 mm;

b. uniformity coefficient less than or equal to 3.

5.13.4 Filtration rate (filter loading rate) - the maximum filtration rate shall not exceed 0.1 $gpm/ft^2$ (6 mgd/acre). A method of flow control which prevents the filtration rate from exceeding the maximum allowed shall be provided.

5.13.5 Underdrains - each filter unit shall be equipped with a main drain and an adequate number of lateral underdrains to collect the filtered water. The underdrains shall be spaced so the maximum velocity of the water in the lateral underdrain will not

exceed 0.75 feet per second. The maximum spacing of the laterals shall not exceed 12 feet.

5.13.6 Support Media - the support gravel shall conform to the size and depth distribution provided for rapid rate gravity filters. (See Section 5.6).

5.13.7 Curing Period - the filter beds should be sized to allow a curing period of 5 to 7 weeks to allow development of a biopopulation before the filter is placed on-line.

5.13.8 Overflow - an overflow shall be provided at the maximum filter water level.

5.13.9 Inlet Design - shall prevent media scouring.

5.13.10 Covers provided for temperature or sunlight control - they must provide adequate access ports and adequate headroom above top of sand to facilitate cleaning.

5.13.11 Minimum and maximum water depth above media in filter will be justified.

The following shall be provided for every filter:

5.13.12 Piping for a filter-to-waste cycle. Appropriate measures for backflow prevention must be included;

5.13.13 Continuous monitoring effluent turbidity recording device;

5.13.14 Influent and effluent sampling taps;

5.13.15 Effluent pipe designed to maintain water level above top of filter sand.

## 5.14 CARTRIDGE AND BAG FILTRATION

5.14.1 Filters may be considered if they have a third party certification for a 3-log removal efficiency for the removal giardia lamblia cysts. All filter manufactures will obtain pre-approval by the Department.

5.14.2 The filter and housing must be tested for giardia lamblia removal efficiency.

5.14.3 Filter rate - cartridge: the flow rate shall not exceed 2 gpm per 10 inches of filter cartridge. Bag: the flow rate shall not exceed 25 gpm per bag.

5.14.4 A method of flow control shall be provided.

5.14.5 Filter housing units shall have a drain.

5.14.6 A list of approved filters will be provided by the Department upon written requests.

## 5.15 INNOVATIVE TECHNOLOGIES

Innovative technologies will require independent third party performance testing. In addition, the Division may require pilot testing and follow-up evaluation of the process. Systems that install such technologies are requested to obtain a performance guarantee from the manufacturer.

## 5.16 OTHER FILTRATION

The use of other filtration methods such as granular activated carbon, low head rapid rate, manganese greensand, etc., will be considered on a case-by-case basis and may require pilot testing, performance data, etc.

# PART 6 - DISINFECTION

## 6.0 GENERAL

The disinfection of water supplies serves to destroy or inactivate disease-producing microorganisms. A secondary benefit is to prevent a biological regrowth within the distribution system.

## 6.1 CHLORINATION

6.1.1 Chlorine is required for all surface water treatment systems and is the preferred disinfecting agent for groundwater systems. Chlorination may be accomplished with liquid chlorine, calcium or sodium hypochlorites, or chlorine dioxide. Other disinfecting agents will be considered, providing the equipment and testing procedures are recognized in "Standard Methods for the Examination of Water and Wastewater", latest edition. Continuous disinfection is required for all public water supplies.

6.1.2 Solution-feed-gas-type chlorinators or hypochlorite feeders of the positive displacement type must be provided. (See Part 7).

6.1.3 The chlorinator capacity shall be such that a free chlorine residual of at least 2 milligrams per liter for groundwater and 5 milligrams per liter for surface water can be attained in the water after contact time of at least 30 minutes when maximum flow rates coincide with anticipated maximum chlorine demands. If a storage tank is used in lieu of a clear well, the criteria in Appendix I, Part 1, shall apply.

6.1.4 Where chlorination is required for protection of the supply, standby equipment of sufficient capacity shall be available to replace the largest unit during shut-down.

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

6.1.6 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, and other pertinent factors.

6.1.7 At plants treating surface water, provisions should be made for applying chlorine to the raw water, applied water, and filtered water.

6.1.8 At plants treating groundwater, provisions should be made for applying chlorine to at least the detention basin inlet and water entering the distribution system. The chlorine solution should not be injected directly into the well casing.

6.1.9 Tablet type chlorinators should not be installed due to the inconsistent concentrations of chlorine supplied to the finished water.

6.1.10 A minimum of 30 minutes of actual chlorine contact time must be provided before the first tap for all public water systems. However, groundwater systems may apply for waivers from contact time and/or chlorination.

6.1.11 In those instances where combined residual chlorination is approved by the reviewing authority, two hours contact time must be provided.

6.1.12 Determination of actual detention time for clear wells and/or storage tanks may be calculated by either: using a tracer study, or the ratio between actual and theoretical detention times associated with various baffling designs. The types of baffling designs and their descriptions include:

a. Unbaffled (mixed flow). No baffling, agitated basin, very low length to width ratio, and high inlet and outlet flow velocities receives an actual to theoretical (A/T) credit of 0.1.

b. Poor. Single or multiple unbaffled inlets and outlets with no intra-basin baffles receives an A/T credit of 0.3.

c. Average. Baffled inlet or outlet with some intra-basin baffles receives an A/T credit of 0.5.

d. Superior. Perforated inlet baffle, serpentine or perforated intra-basin baffles and outlet weirs or perforated launders has an A/T of 0.7.

e. Perfect (plug flow). Very high length to width ratio, perforated inlet, outlet, and intra-basin baffles receives an A/T of 1.0. The detention time for water in pipes will have a ratio of 1.0.

6.1.13 The minimum residual chlorine concentration, after the clear well (after 30 minutes of detention time), shall not be less than 0.2 mg/l. The residual chlorine concentration at distant points in a water distribution system shall have a measurable trace of chlorine present.

6.1.14 The combined chlorine residuals, when used, after the clear well (after 120 minutes of detention time), shall not be less than 2.0 mg/l. The residual chlorine concentration at distant points in a water distribution system shall have a measurable trace of chlorine present.

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

6.1.16 Excessively high chlorine residuals are undesirable due to the potential formation of THM's.

6.1.17 All system shall have a portable chlorine analyzer. The chlorine analyzers or continuous monitors shall be capable of measuring residuals to the nearest 0.1 milligrams per liter in the range of 0 to 1.0 milligrams per liter and to the nearest 0.5 milligrams per liter between 1.0 milligrams per liter and 2.0 milligrams per liter.

6.1.18 Continuous chlorine residual monitors and recorders must be provided for all surface water systems that serve more than 3300 persons or for systems where the chlorine demand varies appreciably over a short period of time. Systems serving 3300 or fewer persons may take grab samples in lieu of providing continuous monitoring, see regulations for the minimum number of samples required per day.

6.1.19 Adequate housing must be provided for the chlorination equipment and for storing the chlorine. A separate house or room at or above ground level must be provided exclusively for gas chlorination purposes. No other chemicals will be stored or fed in the chlorine room.

6.1.20 The chlorine room shall be large enough for all necessary equipment plus room to store an additional month's supply of chlorine, or one change of tanks.

6.1.21 The door to the chlorination area shall be outward opening. If the chlorination space is part of a larger building, the door shall open to the outside of the building.

6.1.22 The door lock shall be of a type such that the door is locked at all times from the outside and unlocked at all times from the inside. If possible, the door should be opened from the inside using a push bar.

6.1.23 All openings between the chlorine room and the remainder of the plant shall be sealed including joints around walls.

6.1.24 The door shall have tight fitting weather stripping around all edges.

6.1.25 The door shall have a waist height square or narrow vertical strip of Shatter-Proof Window, which must allow observance of conditions in the room prior to entering.

6.1.26 The window must provide a clear view of the floor, and have an area of one square foot minimum.

6.1.27 A sign warning of chlorine gas danger shall be mounted by the entrance.

6.1.28 Floor surfaces should be smooth, impervious, and slip-proof. Floor drains will not be allowed in chlorine rooms unless properly trapped.

6.1.29 Chlorine gas is pale green and settles to the floor, therefore, floors should be a contrasting color such as white.

6.1.30 Sufficient ventilation shall be provided to allow one complete air change in the chlorination room every two minutes.

6.1.31 The exhaust duct intake must be located within six inches above finished floor level so that it draws air from the floor of the room.

6.1.32 The exhaust duct shall discharge to the open air above grade, above anticipated snow level, and away from the inlets (doors, windows, etc.) to other rooms or structures.

6.1.33 The duct shall also be located as far as practical from the chlorine room entrance, and other doors, windows, vents, or where it is likely that persons will be, such as parking lots.

6.1.34 An ideal design for exhaust ventilation is where the exhaust fan is located between 3 and 6 feet above finished floor level, with an air duct going down to within six inches of the floor. In this manner, if a chlorine leak did occur, the exhaust fan would not be damaged by the chlorine gas.

6.1.35 A louvered fresh air intake must be provided to serve as a make-up air supply when the fan is operating. This intake should be located in the ceiling or near the ceiling level such that no short-circuiting directly to the exhaust duct will occur.

6.1.36 A signal light indicating fan operation should be at each entrance if the fan can be controlled from more than one point.

6.1.37 Separate on-off switches shall be provided for the exhaust fan and lighting in the room and be located outside of the chlorine room door.

6.1.38 An additional switch should be located in the door to the chlorination room which will activate the light and the exhaust fan automatically when the door is opened.

6.1.39 Under no circumstances shall the exhaust fan be turned on by an automatic sensor or timer.

6.1.40 A locked storage space, located outside of the chlorine gas room, shall be provided and must contain:

a. respiratory protection equipment meeting NIOSH Standards with 30 minutes capacity of compressed air, or the same units used by the fire department responsible for the treatment plant;

b. a 56% Ammonium Hydroxide Solution for chlorine leak detection. If an automatic chlorine leak detector is used it must be wired to an alarm light or telemetry device. It cannot be wired such that it will turn on the exhaust fan;

c. chlorine leak repair kit approved by the Chlorine Institute for gas cylinders or ton containers, as appropriate;

d. other protective equipment such as rubber gloves, protective clothing, and goggles.

6.1.41 Two alternatives for chlorine piping in the chlorine room are suggested:

a. an arrangement where the water pipe to be injected with chlorine enters and exits the chlorine room. The water pump delivering water through the pipe can either be installed in the pump room or the chlorine room. All chlorine equipment, including the vacuum ejector are located in the chlorine room;

b. an arrangement where the water pipe to be injected with chlorine does not enter the chlorine room. Rather, the chlorine vacuum ejector gas tubing leaves the chlorine room, enclosed the full length in schedule 80 PVC conduit, to where it will be injected into the water pipe. Special care must be taken in this design to insure safety. THE CHLORINE EJECTOR-CL TUBING MUST NOT LEAVE THE CHLORINE ROOM UNLESS IT IS ENCLOSED IN SEALED SCHEDULE 80 PVC CONDUIT.

c. Pressure type chlorine injector design is strongly discouraged.

6.1.42 A heater shall be provided to maintain the chlorine room temperature at 60$^{o}$ F. The room, the feed lines, and the chlorine cylinders/containers should be protected from excessive head to avoid failure of the 158$^{o}$ F fusible plugs located in bottles or ton cylinders. Chlorine tanks shouldn't be exposed to direct sunlight.

6.1.43 Individual safety bracket devices shall be provided for all tanks, full or empty, to prevent upset. Chains are not considered adequate.

6.1.44 A scale must be provided to measure chlorine usage for each chlorine tank in use or for one tank in each bank.

6.1.45 A poster giving chlorine handling instructions and precautions should be posted in a conspicuous place in the chlorination room. Detailed chlorine manuals are available from the various manufacturers and should be available for reference.

6.1.46 Additional design considerations are included in Section 7 - Chemical Applications

## 6.2. ULTRAVIOLET

6.2.1 The use of ultraviolet disinfection (UV) will be considered for approval on a case by case basis for ground water systems serving less than 100 people. Since there is no residual disinfectant present with UV, the approval will require special conditions to verify the water is safe.

## 6.3 IODINE

6.3.1 The use of iodine as a disinfectant in drinking water will not be approved by the Division.

## 6.4 OTHER DISINFECTING AGENTS

6.4.1 The use of other disinfectants, such as chlorine dioxide, ozone, or pre-formed chloramines, will be reviewed on a case by case basis.

# PART 7 - CHEMICAL APPLICATION

## 7.0 GENERAL

No chemicals shall be applied to treat drinking waters unless specifically permitted by the reviewing authority. Extreme care must be taken to assure that chemicals are compatible if mixed or stored on site.

## 7.1 PLANS AND SPECIFICATIONS

Plans and specifications shall be submitted for review and approval, as provided for in Part 1, and shall include:

7.1.1 descriptions of feed equipment, including maximum and minimum feed ranges;

7.1.2 location of feeders, piping layout and points of application;

7.1.3 storage and handling facilities including any safety concerns;

7.1.4 specifications for chemicals to be used;

7.1.5 operating and control procedures including proposed application rates;

7.1.6 descriptions of testing equipment and procedures.

## 7.2 CHEMICAL APPLICATION

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

7.2.1 assure maximum efficiency of treatment;

7.2.2 assure maximum safety to consumers;

7.2.3 provide maximum safety to operators;

7.2.4 assure satisfactory mixing of the chemicals with the water;

7.2.5 provide maximum flexibility of operation through various points of application, when appropriate;

7.2.6 prevent backflow or back-siphonage between multiple points of feed through common manifolds.

## 7.3 EQUIPMENT DESIGN

Chemicals shall be applied to the water at such points and by such means as to assure:

7.3.1 feeders will be able to supply, at all times, the necessary amounts of chemicals at an accurate rate, throughout the range of feed;

7.3.2 chemical-contact materials and surfaces are resistant to the aggressiveness of the chemical solution;

7.3.3 corrosive chemicals are introduced in such a manner as to minimize potential for corrosion;

7.3.4 chemicals that are incompatible are not fed, stored or handled together.

## 7.4 CHEMICAL FEEDERS

Where chemical feed is necessary for the protection of the supply, such as chlorination, coagulation or other essential processes:

7.4.1 a minimum of two feeders shall be provided;

7.4.2 a standby unit or a combination of units of sufficient capacity should be available to replace the largest unit during shut-downs;

7.4.3 where a booster pump is required, duplicate equipment should be provided and, when necessary, standby power;

7.4.4 a separate feeder shall be used for each chemical applied;

7.4.5 spare parts shall be available for all feeders to replace parts which are subject to wear and damage.

## 7.5 CONTROLS

7.5.1 Feeders may be manually or automatically controlled, with automatic controls being designed so as to allow override by manual controls.

7.5.2 Chemical feed rates shall be proportioned to flow.

7.5.3 A means to measure water flow must be provided in order to determine chemical feed rates.

7.5.4 Provisions shall be made for measuring the quantities of chemicals used.

## 7.6 WEIGHING SCALES

Scales:

7.6.1 shall be provided for weighing cylinders, at all plants utilizing chlorine gas;

7.6.2 may be required for fluoride solution feed;

7.6.3 should be provided for volumetric dry chemical feeders;

7.6.4 should be accurate to measure increments of 0.5 per cent of load.

## 7.7 DRY CHEMICAL FEEDERS

Dry chemical feeders shall:

7.7.1 measure chemical volumetrically and/or gravimetrically;

7.7.2 provide adequate solution water and agitation of the chemical in the solution pot;

7.7.3 provide gravity feed from solution pots;

7.7.4 completely enclose chemicals to prevent emission of dust to the operating room.

## 7.8 POSITIVE DISPLACEMENT SOLUTION PUMPS

Positive displacement type solution feed pumps should be used to feed liquid chemicals, but shall not be used to feed chemical slurries.

## 7.9 LIQUID CHEMICAL FEEDERS - SIPHON CONTROL

Liquid chemical feeders shall be protected against cross-connection with chemical solutions into the water supply, by:

7.9.1 assuring discharge at a point of positive pressure, or

7.9.2 providing vacuum relief, or

7.9.3 providing a suitable air gap, or

7.9.4 other suitable means or combinations as necessary.

## 7.10 CROSS CONNECTION CONTROL

Cross-connection control must be provided to assure that:

7.10.1 the service water lines discharging to solution tanks shall be properly protected from backflow by use of either an air gap of at least six inches or two pipe diameters, whichever is greater, or a reduced pressure principle backflow device;

7.10.2 liquid chemical solutions cannot be siphoned through solution feeders into the water supply (Section 7.9 );

7.10.3 no direct connection exists between any sewer and a drain or overflow from the feeder, solution chamber or tank by providing that all drains terminate at least six inches or two pipe diameters, whichever is greater, above the overflow rim of a receiving sump, conduit or waste receptacle, which must daylight.

## 7.11 CHEMICAL FEED EQUIPMENT LOCATION

Chemical feed equipment shall:

7.11.1 be located in a separate room to reduce hazards and dust problems;

7.11.2 be conveniently located near points of application to minimize length of feed lines;

7.11.3 be readily accessible for servicing, repair, and observation of operation.

## 7.12 SERVICE WATER SUPPLY

Service water supply shall be:

7.12.1 ample in supply and adequate in pressure;

7.12.2 provided with means for measurement when preparing specific solution concentrations by dilution;

7.12.3 properly treated for hardness, when necessary;

7.12.4 properly protected against backflow.

## 7.13 STORAGE OF CHEMICALS

Space should be provided for:

7.13.1 at least 30 days of chemical supply;

7.13.2 convenient and efficient handling of chemicals;

7.13.3 dry storage conditions;

7.13.4 a minimum storage volume of 1 1/2 truck loads where purchase is by truck load lots.

7.13.5 Storage tanks and pipelines for liquid chemicals shall be specific to the chemicals and not for alternates.

7.13.6 Chemicals shall be sorted in covered or unopened shipping containers, unless the chemical is transferred into an approved-covered storage unit.

Liquid chemical storage tanks must:

7.13.7 have a means of indicating liquid levels;

7.13.8 have an overflow and a receiving basin or drain capable of receiving accidental spills or overflows;

7.13.9 be properly protected against backflow.

## 7.14 SOLUTION TANKS

7.14.1 A means which is consistent with the nature of the chemical solution shall be provided in a solution tank to maintain a uniform strength of solution. Continuous agitation shall be provided to maintain slurries in suspension.

7.14.2 Two solution tanks of adequate volume may be required for a chemical to assure continuity of supply in servicing a solution tank.

7.14.3 Means shall be provided to measure the solution level in the tank.

7.14.4 Chemical solutions shall be kept covered. Large tanks with access openings shall have such openings curbed and fitted with tight overhanging covers.

Subsurface locations for solution tanks shall:

7.14.5 be approved by the Underground Storage Tank (UST) Program of the Hazardous Materials and Waste Management Division of this Department, if hazardous;

7.14.6 be free from sources of possible contamination;

7.14.7 assure positive drainage.

Overflow pipes, when provided, should:

7.14.8 be turned downward, with the end screened;

7.14.9 have a freefall discharge;

7.14.10 be located where noticeable.

7.14.11 Acid storage tanks must be vented to the outside atmosphere, but not through vents in common with day tanks.

7.14.12 Each tank shall be provided with a valved drain, protected against backflow in accordance with Section 7.9 and 7.10.

7.14.13 Solution thanks shall be located and protective curbings provided so that chemicals from equipment failure, spillage or accidental drainage shall not enter the water in conduits, treatment or storage basins.

## 7.15 DAY TANKS

7.15.1 shall be provided where bulk storage of liquid chemical is provided;

7.15.2 shall meet all the requirements of Section 7.14;

7.15.3 should hold no more than a 30 hour supply;

7.15.4 shall be scale-mounted, or have a calibrated gauge painted or mounted on the side if liquid level can be observed in a gauge tube or through translucent sidewalls of the tank. In opaque tanks, a gauge rod extending above a reference point at the top of the tank, attached to a float may be used. The ratio of the area of the tank to its height must be such that unit readings are meaningful in relation to the total amount of chemical fed during a day.

7.15.5 Hand pumps may be provided for transfer from a carboy or drum. A tip rack may be used to permit withdrawal into a bucket from a spigot. Where motor-driver transfer pumps are provided, a liquid level limit switch and an over-flow from the day tank, which will drain by gravity back into the bulk storage tank, must be provided.

7.15.6 A means which is consistent with the nature of the chemical solution shall be provided to maintain uniform strength of solution in a day tank. Continuous agitation shall be provided to maintain chemical slurries in suspension.

7.15.7 Tanks shall be properly labeled to designate the chemical contained.

## 7.16 FEED LINES

All feed lines should be:

7.16.1 as short as possible in length of run;

7.16.2 of durable, corrosion resistant material;

7.16.3 easily accessible throughout the entire length;

7.16.4 protected against freezing;

7.16.5 readily cleanable;

7.16.6 slope upward from the chemical source to the feeder when conveying gases;

7.16.7 should be color coded;

7.16.8 designed to prevent scale-forming or solids deposition.

## 7.17 CHEMICAL HANDLING

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

7.17.2 Provisions shall be made for disposing of empty bags, drums or barrels by an approved procedure which will minimize exposure to dust.

7.17.3 Provision 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.

7.17.4 Provision shall be made for measuring quantities of chemicals used to prepare feed solutions.

7.18 HOUSING

7.18.1 Floor surfaces shall be smooth and impervious, slip-proof and well drained with a minimum slope of 3" in 10'.

7.18.2 Vents from feeders, storage facilities and equipment exhaust shall discharge to the outside atmosphere above grade and remote from air intakes.

7.19 SHIPPING CONTAINERS

Chemical shipping containers shall be fully labeled to include:

7.19.1 chemical name, purity and concentration;

7.19.2 supplier name and address.

7.20 SPECIFICATIONS

Chemicals shall meet AWWA specifications, where applicable.

7.21 ACIDS

7.21.1 Acids shall be kept in closed acid-resistant shipping containers or storage units.

7.21.2 Acids shall 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.

7.22 SAFETY

7.22.1 Safety protection equipment, meeting the requirements of the National Institute for Occupational Safety and Health (NIOSH), shall be available in a convenient location for use by the operators.

7.22.1 The fire department shall be notified of the chemicals used or stored on site.

# PART 8 - OTHER TREATMENT

## 8.1 SOFTENING

8.1.1 The softening process selected must be based upon the mineral qualities of the raw water and the desired finished water quality in conjunction with requirements for disposal of sludge or brine waste, cost of plant, cost of chemicals and plant location. Applicability of the process chosen shall be demonstrated.

Lime or lime-soda process:

8.1.2 Design standards for rapid mix, flocculation and sedimentation are in Sections 4.3, 4.4, and 4.5, respectively.

8.1.3 Mechanical sludge removal equipment shall be provided in the sedimentation basin.

8.1.4 Equipment for stabilization of water softened by the lime or lime-soda process may be required and must be address. (See Section 7.7).

8.1.5 Provisions must be included for proper disposal of softening sludges. (See Section 8.9).

## 8.2 ION EXCHANGE

8.2.1 Alternative methods of hardness reduction should be investigated when the sodium content and dissolved solids concentration is of concern. Iron, manganese, or a combination of the two, should not exceed 0.3 milligrams per liter in the water as applied to the ion exchange resin. Pre-treatment is required when the content of iron, manganese, or a combination of the two, is one milligram per liter or more.

8.2.2 The units may be of pressure or gravity type, of either an upflow or downflow design. Automatic regeneration based on volume of water softened should be used unless manual regeneration is justified and is approved by the reviewing authority. A manual override shall be provided on all automatic controls.

8.2.3 The design capacity for hardness removal should not exceed 20,000 grains per cubic foot (46 mg. per cubic cm.) when resin is regenerated with 0.3 pounds of salt per kilograin of hardness removed.

8.2.4 The depth of the exchange resin should not be less than three feet.

8.2.5 The rate of softening should not exceed seven gallons per minute per square foot of bed area and the backwash rate should be six to eight gallons per minute per square foot of bed area.

8.2.6 The freeboard will depend upon the specific gravity of the resin and the direction of water flow.

8.2.7 The bottoms, strainer systems and support for the exchange resin shall conform to criteria provided for rapid rate gravity filters. (See Section 5.6 and 5.7).

8.2.8 Facilities should be included for even distribution of the brine over the entire surface of both upflow and downflow units.

8.2.9 Backwash, rinse and air relief discharge pipes should be installed in such a manner as to prevent any possibility of a cross-connection.

8.2.10 A bypass must be provided around softening units to produce a blended water of desirable hardness. Totalizing meters must 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.

8.2.11 Smooth-nose sampling taps must be provided for the collection of representative samples. The taps shall be located to provide for sampling of the softener influent, effluent and blended water. The sampling taps for the blended water shall be at least 20 (6.1m) feet downstream from the point of blending.

8.2.12 Brine measuring or salt dissolving tanks and wet salt storage facilities must be covered and must be constructed of corrosion-resistant material. The make-up water inlet must have a free fall discharge of two pipe diameters above the maximum liquid level of the unit or be otherwise 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 salt shall be supported on graduated layers of gravel under which is a suitable means of collecting the brine. Wet salt storage basins must be equipped with manhole or hatchway openings having raised curbs and watertight covers having overhanging edges similar to those required for finished water reservoirs. Overflow, where provided, must be turned down, have a proper free fall discharge and be protected with corrosion-resistant screens or self-closing flap valves.

8.2.13 Salt storage should have sufficient capacity to store in excess of 1 ½ carloads or truckloads of salt, and provide for at least 30 days of operations.

8.2.14 Stabilization for corrosion control shall be provided. (See Section 6.7).

8.2.15 Suitable disposal must be provided for brine waste. (See Section 6.10).

8.2.16 Pipes and contact materials must be resistant to the aggressiveness of salt.

8.2.17 Salt storage shall be enclosed and separated from other operating areas in order to prevent damage to equipment.

8.2.18 The ion exchange process of iron and manganese removal should not be used for water containing more than 0.3 milligrams per liter of iron, manganese, or combination thereof. This process is not acceptable where either the raw water or wash water contains dissolved oxygen.

8.2.19 Radium removal by ion exchange will be reviewed on a case-by-case basis. Special considerations must be given to proper shielding and disposal problems.

8.2.20 Removal of specific contaminants other than those listed above will be reviewed on a case-by-case basis.

## 8.3 AERATION

Aeration may be used to help remove offensive tastes and odors due to dissolved gases from decomposing organic matter, or to reduce of remove objectionable amounts of carbon dioxide, hydrogen sulphide, etc., and to introduce oxygen to assist in iron and/or manganese removal.

Natural draft aeration shall provide:

8.3.1 perforations in the distribution pan 3/16 to ½ inches in diameter, spaced 1 to 3 inches on centers to maintain a six inch water depth;

8.3.2 for distribution of water uniformly over the top tray;

8.3.3 discharge through a series of three or more trays with separation of trays not less than 12 inches;

8.3.4 loading at a rate of 1 to 5 gallons per minute for each square foot of total tray area;

8.3.5 trays with slotted, heavy wire (1.2 inch openings) mesh or perforated bottoms;

8.3.6 construction of durable material resistant to aggressiveness of the water and dissolved gases;

8.3.7 protection from loss of spray water by wind carriage by enclosure with louvers sloped to the inside at an angle of approximately 45 degrees;

8.3.8 protection from insects by 24-mesh non-corrodible screen.

Forced or induced draft aeration shall:

8.3.9 include a blower with a weatherproof motor in a tight housing and screened enclosure;

8.3.10 insure adequate counter current of air through the enclosed aerator column;

8.3.11 exhaust air directly to the outside atmosphere;

8.3.12 include a down-turned and 24-mesh screened air outlet and inlet;

8.3.13 be such that air introduced in the column shall be as free from obnoxious fumes, dust, and dirt as possible;

8.3.14 be such that sections of the aerator can be easily reached or removed for maintenance of the interior or installed in a separate aerator room;

8.3.15 provide loading at a rate of 1 to 5 gallons per minute for each square foot of total tray area;

8.3.16 insure that the water outlet is adequately sealed to prevent unwarranted loss of air;

8.3.17 discharge through a series of five or more trays with separation of trays not less than six inches;

8.3.18 provide distribution of water uniformly over the top tray;

8.3.19 be of durable material resistant to the aggressiveness of the water and dissolved gases.

8.3.20 Noise control and/or off gas treatment may be required on a case-by-case basis.

Pressure aeration:

8.3.21 may be used for oxidation purposes only if pilot plant study indicates the method is applicable; it is not acceptable for removal of dissolved gases. Filters following pressure aeration must have adequate exhaust devices for release of air;

8.3.22 must give thorough mixing of compressed air with water being treated;

8.3.23 must provide screened and filtered air, free of obnoxious fumes, dust, dirt and other contaminants.

8.3.24 Other methods of aeration may be used if applicable to the treatment needs. Such methods include but are not restricted to spraying, diffused air, cascades 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 reviewing authority.

8.3.25 All aerators, except those discharging to lime softening or clarification plants, shall be protected from contamination from birds and insects.

8.3.26 Groundwater supplies exposed to the atmosphere by aeration must receive chlorination as the minimum additional treatment.

8.3.27 A by-pass should be provided for all aeration units.

## 8.4 IRON AND MANGANESE CONTROL

8.4.1 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 analyses of representative samples of water to be treated, and receive the approval of the reviewing authority. It may be necessary to operate a pilot plant in order to gather all information pertinent to the design. Consideration should be given to adjusting pH of the raw water to optimize the chemical reaction.

8.4.2 Oxidation may be by aeration, as indicated in Section 8.3, or by chemical oxidation with chlorine, potassium permanganate, ozone or chlorine dioxide.

8.4.3 Reaction - A minimum detention of 20 minutes shall be provided following aeration in order to insure that the oxidation reactions are as complete as possible. This minimum detention shall be omitted only where a pilot plant study indicates no need for detention. The detention basin shall be designed as a holding tank with no provisions for sludge collection but with sufficient baffling to prevent short-circuits.

8.4.4 Sedimentation - Sedimentation basins shall be provided when treating water with high iron and/or n\manganese content, or where chemical coagulation is used to reduce the load on the filters.

8.4.5 Filters shall be provided and shall conform to Part 5.

8.4.6 Removal by manganese greensand filtration, consisting of a continuous feed of potassium permanganate to the influent of a manganese greensand filter, is applicable to the removal of manganese and iron.

8.4.7 Provisions should be made to apply the permanganate as far ahead of the filter as practical and to a point immediately before the filter.

8.4.8 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.

8.4.9 Anthracite media cap of at least six inches (15cm) should be provided over manganese greensand.

8.4.10 Normal filtration rate is three gallons per minute per square foot.

8.4.11 Normal back wash rate is 10 to 12 gallons per minute per square foot.

8.4.12 Air scouring should be provided.

8.4.13 The Design Standards for ion exchange are in Section 8.2.

8.4.14 Sequestration by polyphosphates shall not be used when iron, manganese or combination thereof exceeds 1.0 milligrams per liter.

8.4.15 The total phosphate applied shall not exceed 10 milligrams per liter as $PO_4$.

8.4.16 Where phosphate treatment is used, satisfactory chlorine residuals shall be maintained in the distribution system.

8.4.17 Feeding equipment shall conform to the requirements of Part 7.

8.4.18 Stock phosphate solution must be kept covered and disinfected by carrying approximately 10 milligrams per liter free chlorine residual.

8.4.19 Polyphosphates shall not be applied ahead of iron and manganese removal treatment. The point of application shall be prior to any aeration, oxidation or disinfection if no iron or manganese removal treatment is provided.

8.4.20 Phosphate chemicals must be food grade.

8.4.21 Where applicable, phosphate contribution to a wastewater treatment plant must be addressed.

8.4.22 Testing equipment shall be provided for all plants.

8.4.23 Testing equipment should have the capacity to accurately measure the iron content to a minimum of 0.1 milligrams per liter and the manganese content to a minimum of 0.05 milligrams per liter.

8.4.24 Where polyphosphate sequestration is practiced, appropriate phosphate testing equipment shall be provided.

8.4.25 Sodium silicate sequestration of iron and manganese is appropriate only for groundwater supplies prior to air contact. On-site pilot tests are required to determine the suitability of sodium silicate for the particular water and minimum feed needed. Rapid oxidation of the metal ions such as by chlorine and chlorine dioxide must accompany or closely precede the sodium silicate addition. Injection of sodium silicate more than 15 seconds after oxidation may cause detectable loss of chemical efficiency. Dilution of feed solutions much below five per cent silica as $SiO_2$ should also be avoided for the same reason.

8.4.26 Sodium silicate addition is applicable to waters containing up to 2 mg/l of iron, manganese or combination thereof.

8.4.27 Chlorine residuals shall be maintained throughout the distribution system to prevent biological breakdown of the sequestered iron.

8.4.28 The amount of silicate added shall be limited to 20 mg/l as $SiO_2$, but the amount of added and naturally occurring silicate shall not exceed 60 mg/l as $SiO_2$.

8.4.29 Feeding equipment shall conform to the requirements of Part 7.

8.4.30 Sodium silicate shall not be applied ahead of iron or manganese removal treatment.

8.4.31 Liquid sodium silicate shall meet AWWA standards.

## 8.5 FLUORIDATION

8.5.1 Commercial sodium fluoride, sodium silicofluoride and hydrofluosilicic acid shall conform to the applicable AWWA standards. Other fluoride compounds which may be available must be approved by the reviewing authority.

The proposed method of fluoride feed must be approved by the reviewing authority prior to preparation of final plans and specifications.

In addition to the requirements in Part 7, fluoride feed equipment shall meet the following requirements:

8.5.3 scales or loss-of-weight recorders shall be provided for dry chemical feeds;

8.5.4 feeders shall be accurate to within five percent of any desired feed rate;

8.5.5 to avoid precipitation of fluoride, the fluoride compound should not be added before lime-soda softening and shall not be added before ion exchange softening;

8.5.6 the point of application of hydrofluo silicicacid, if into a horizontal pipe, shall be in the lower half of the pipe;

8.5.7 a fluoride solution shall be applied by a positive displacement pump having a stroke rate not less than 10 strokes per minute;

8.5.8 adequate anti-siphon devices shall be provided for all fluoride feed lines.

8.5.9 At least one pair of rubber gloves, a respirator of a type certified by the National Institute for Occupational Safety and Health for toxic dusts or acid gas (as necessary), an apron or other protective clothing, and goggles or face masks shall be provided. Other protective equipment must be provided as necessary.

8.5.10 Provision must be made for the 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 which may enter the room in which the equipment is installed. The enclosure shall be provided with an exhaust fan and dust filter which places the hopper under a negative pressure.

8.5.11 Air exhausted from fluoride handling equipment shall discharge through a dust filter to the outside atmosphere of the building.

8.5.12 Provision shall be made for disposing of empty bags, drums or barrels in a manner which will minimize exposure to fluoride dusts.

8.5.13 A floor drain should be provided to facilitate the hosing of floors. The floor drain shall not be returned to any raw water plumbing.

8.5.14 Equipment shall be provided for measuring the quantity of fluoride in the water. Such equipment shall be subject to the approval of the reviewing authority.

## 8.6 STABILIZATION

8.6.1 Water that is unstable due either to natural causes or to treatment given the water should be stabilized.

Carbon dioxide addition should provide:

8.6.2 a total detention time of twenty minutes;

8.6.3 a mixing compartment having a detention time of at least three minutes, with a minimum depth of eight feet;

8.6.4 a reaction compartment with a minimum depth of eight feet.

8.6.5 Adequate precautions must be taken to prevent the possibility of carbon monoxide entering the plant from recarbonation compartments.

8.6.6 Provisions shall be made for draining the recarbonation basin and removing sludge.

Acid addition shall provide:

8.6.7 feed equipment conforming to Part 7;

8.6.8 adequate precautions for safety, such as not adding water to the concentrated acid.

Polyphosphate addition shall provide that:

8.6.9 feed equipment conforming to Part 7;

8.6.10 phosphate be of food grade;

8.6.11 stock phosphate solution be kept covered and disinfected by carrying approximately 10 milligrams per liter free chlorine residual;

8.6.12 satisfactory chlorine residuals be maintained in the distribution system when phosphates are used.

8.6.13 Under some conditions, a lime-softening water treatment plant can be designed using "split treatment" in which raw water is blended with lime-softened water to partially stabilize the water. Treatment plants designed to utilize "split treatment" should also contain facilities for further stabilization by other methods.

8.6.14 The carbon dioxide content of an aggressive water may be reduced by aeration. Aeration devices shall conform to Section 8.3.

8.6.15 Other treatment for controlling corrosive waters by the use of sodium silicate and sodium bicarbonate may be used where necessary. Any proprietary compound must receive the specific approval of the reviewing authority before use. Chemical feeders shall be as required in Part 7.

8.6.16 Unstable water resulting from the bacterial decomposition of organic matter in water (especially in dead end mains), the biochemical action within tubercles, and the reduction of sulfates to sulphides, should be prevented by the maintenance of a minimum free chlorine residual of .2 mg/l throughout the distribution system.

8.6.17 Laboratory equipment shall be provided for determining the effectiveness of stabilization treatment.

## 8.7 TASTE AND ODOR CONTROL

8.7.1 Provision should be made for the addition of taste and odor control chemicals at all surface water treatment plants. These chemicals should be added sufficiently ahead of other treatment processes to assure adequate contact time for an effective and economical use of the chemicals.

8.7.2 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.

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

8.7.4 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 and odor that is treatable by an oxidizing compound. Provisions shall be made for proper storing and handling of the sodium chlorite, so as to protect against the danger of explosion.

8.7.5 Powdered activated carbon may be added prior to coagulation to provide maximum contact time. Facilities to allow the addition at several points is preferred. Activated carbon should not be applied near the point of chlorine application.

8.7.6 The carbon can be added as a pre-mixed slurry of by means of a dry-feed machine as long as the carbon is properly wetted.

8.7.7 All materials in contact with activated carbon shall be PVC, stainless steel, or otherwise protected against corrosion.

8.7.8 Agitation is necessary to keep the carbon from depositing in the slurry storage tank.

8.7.9 Provision shall be made for adequate dust control.

8.7.10 The required rate of feed of carbon in a water treatment plant depends upon the tastes and/or odors involved, but provision should be made for a wide range of feed rates.

8.7.11 Slurry feed lines shall be sized to keep the PAC in suspension, and shall have provisions for line flushing.

8.7.12 Use of granular activated carbon media for organics removal will be considered on a case-by-case basis. The following is a partial list of items to be address and justified:

a. media specifications;

b. filter housing and appurtenances;

c. control of bacteria and other growths on the media;

d. regeneration or media replacement;

e. empty bed contact time;

f. retardation factors;

g. distribution coefficients;

h. depth of media;

I. estimated bed life;

j. effects of other contaminants;

k. backwashing details.

8.7.13 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 milligrams per liter as copper in the plant effluent or distribution system. Care shall be taken to assure an even distribution.

8.7.14 Aeration shall conform with Section 6.4.

8.7.15 Application of potassium permanganate may be considered, providing the treatment shall be designed so that the products of the reaction are not present in the finished water.

8.7.16 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.

8.7.17 The decision to use any other methods of taste and odor control should be made only after careful laboratory and/or pilot plant tests and consultation with the reviewing authority.

## 8.8 MICROSCREENING

8.8.1 A microscreen is a mechanical supplement of treatment capable of removing suspended matter from the water by straining. It shall not be used in place of filtration, when filtration is necessary to provide a satisfactory water, or in place of coagulation, in the preparation of water for filtration.

Microscreening shall:

8.8.2 consider the nature of the suspended matter to be removed;

8.8.3 consider the corrosiveness of the water;

8.8.4 consider the effect of chlorination, when required as pre-treatment;

8.8.5 provide a durable, corrosion-resistant screen;

8.8.6 provide by-pass arrangements;

8.8.7 provide protection against back-siphonage when potable water is used for washing;

8.8.8 provide proper disposal of wash waters. (See Section 8.9).

## 8.9 WASTE DISPOSAL

8.9.1 This section applies to sanitary wastes, brine wastes, lime softening sludges, "red water" wastes, alum sludges, filter backwash wastes, and any other waste produced by treatment which must be disposed of.

8.9.2 All methods of disposal are regulated by one or more agencies, depending upon the method of disposal being used. The following is a list of the agencies most commonly involved, but not all agencies may be listed:

a. Hazardous Materials / Waste Management, CDPHE, 692-3300,

b. Permit Section, WQCD, CDPHE, 692-3500

c. various county and local government agencies.

8.9.3 All applicable regulations for waste disposal must be addressed at the time of plans submittal.

8.9.4 It is the responsibility of the water treatment entity to contact the regulating agencies and apply for the necessary permits.

8.9.5 Backwash treatment ponds designed for water reuse to the water plant will be designed for adequate settling and sludge storage so as to assure effluent suitable for use as raw water. An emergency discharge permit may be required by this Department.

8.9.6 Systems designed to be non-discharging shall conform with Wastewater Treatment Design Criteria for non-discharging ponds.

# PART 9 - PUMPING FACILITIES

## 9.0 GENERAL

9.0.1 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.

9.0.2 No pumping station shall be built in the 100 year flood plain without adequate flood protection to the 100 year flood plain level.

## 9.1 LOCATION

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

## 9.2 SITE PROTECTION

The station shall be:

9.2.1 elevated to a minimum of one foot above the highest recorded flood elevation, or protected to such elevation;

9.2.2 readily accessible at all times unless permitted to be out of service for the period of inaccessibility;

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

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

## 9.3 PUMPING STATIONS

Both raw and finished water pumping stations shall:

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

9.3.2 be of durable construction, fire and weather resistant and with outward-opening doors;

9.3.3 have floor elevation of at least six inches (15cm) above finished grade;

9.3.4 have underground structure waterproofed according to A.W.W.A. waterproofing criteria;

9.3.5 have all floors drained in such a manner that the quality of the potable water will not be endangered. All floors shall slope at least three inches (7.6cm) in every 10 feet (3m) to a suitable drain or sump and automatic sump pump;

9.3.6 provide a suitable outlet for drainage from pump glands without discharging onto the floor;

9.3.7 be watertight;

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

9.3.9 be covered or otherwise protected against contamination.

9.3.10 In areas where excess moisture could cause hazards to safety or damage to equipment, means for dehumidification should be provided.

9.3.11 Pump stations shall be adequately lighted throughout. All electrical work shall conform to the requirements of the National Electric Code and related agencies and to the relevant State and/or local codes.

9.3.12 Except in the cases of small automatic stations or where such facilities are otherwise available, all pumping stations should 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 6.10.

## 9.4 PUMPS

At least two pumping units shall be provided. With any pump out of service, the remaining pump or pumps shall be capable of providing the maximum daily pumping demand of the system. The pumping units shall:

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

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

9.4.3 have spare parte and tools readily available.

## 9.5 SUCTION LIFT

Suction lift shall:

9.5.1 be avoided, if possible;

9.5.2 be within allowable limits, preferably less than 15 feet;

9.5.3 be made with self-priming pumps using automatic shutdown for loss of prime.

9.5.4 If suction lift is necessary, provision shall be made for priming the pumps.

## 9.6 PRIMING

Prime water must not be of lesser sanitary quality than that of the water being pumped. Means shall be provided to prevent backsiphonage. When an air-operated ejector is used, the screened intake shall draw clean air from a point at least 10 feet above the ground or other source of possible contamination, unless the air is filtered by an apparatus approved by the reviewing authority. Vacuum priming may be used.

## 9.7 BOOSTER PUMPS

Booster pumps shall be located or controlled so that:

9.7.1 they will not produce negative pressure in their suction lines;

9.7.2 the intake pressure shall be at least 20 psi when the pump is in normal operation;

9.7.3 automatic cutoff pressure shall be at least 10 psi in the suction line;

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

9.7.5 a bypass is available.

9.7.6 In addition to the other requirements of this section, inline booster pumps shall be accessible for servicing and repairs.

## 9.8 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 applicable State and local electrical codes and the National Electrical Code.

## 9.9 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 2 ½ 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 the shut-off valve.

## 9.10 PIPING

In general piping shall:

9.10.1 be designed so that the friction losses will be minimized;

9.10.2 not be subject to contamination;

9.10.3 have watertight joints;

9.10.4 be protected against surge or water hammer;

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

9.11. GAUGES AND METERS

Each pump:

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

9.11.2 shall have a compound gauge on its suction line;

9.11.3 should have recording gauges in the larger stations;

9.11.4 should have a means for measuring the discharge.

9.11.5 The station should have indicating, totalizing, and recording metering of the total water pumped.

9.12 WATER SEALS

Water seals shall not be supplied with water of a lesser sanitary quality than that of the water being pumped. Where pumps are sealed with potable water and are pumping water of lesser sanitary quality the seal shall:

9.12.1 be provided with a break tank open to atmospheric pressure, or a reduced pressure principle backflow preventer;

9.12.2 have an air gap of at least six inches or two pipe diameters, whichever is greater, between the feeder line and the spill line of the tank, or a reduced pressure principle backflow preventer.

9.13 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 pimps are installed, provision shall be made for alteration. Provision shall be made to prevent energizing the motor in the event of a backspin cycle. Electrical controls shall be located above grade.

9.14 POWER

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

## 9.15 WATER PRE-LUBRICATION

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 bypass around the automatic control so that the bearings can, if necessary be lubricated manually before the pump is started.

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APPENDIX I

# STATE OF COLORADO

# DESIGN CRITERIA

for

# POTABLE WATER SYSTEMS

# DISTRIBUTION AND STORAGE

REVISED MARCH 31, 1997

Prepared by:

Colorado Department of Health and Environment

Water Quality Control Division

DISTRIBUTION AND STORAGE CRITERIA
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# WATER STORAGE

## 1.0 GENERAL

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

### 1.0.1 Sizing

Storage facilities should have sufficient capacity, as determined from engineering studies, to meet domestic demands and, where fire protection is provided, fire flow demands.

a. Fire flow requirements established by the state Insurance Services Office should be satisfied where fire protection is provided.

b. The minimum one day storage capacity (or equivalent capacity) for systems not providing fire protection and less than a 5000 population with meters should be as follows:

| POPULATION | STORAGE (Gallons) | POPULATION | STORAGE (Gallons) |
|---|---|---|---|
| 50 | 10,000 | 1,500 | 320,000 |
| 100 | 20,000 | 2,000 | 440,000 |
| 200 | 40,000 | 2,500 | 550,000 |
| 300 | 60,000 | 3,000 | 675,000 |
| 500 | 100,000 | 3,500 | 800,000 |
| 750 | 150,000 | 4,000 | 925,000 |
| 1,000 | 200,000 | 5,000 | 1,150,000 |

Those systems without water meters should provide a one day storage of 300 gallons (1,135 1) per capita.

The minimum storage capacity (or equivalent capacity) for systems with a population greater than 5,000 not providing fire protection should be equal to the average daily consumption.

These requirements may be reduced when the source and treatment facilities have sufficient capacity with standby power capability to supplement peak demands of the system.

### 1.0.2 Location of ground-level reservoirs

a. The bottom of the reservoirs and standpipes should be placed at the normal ground surface and shall be above the 100-year flood plain.

b. Sewers, drains, standing water, and similar sources of possible contamination must be kept at least fifty (50) feet (15 m) from the reservoir. Water main pipe, pressure tested in place to 50 psi (3.51 kg/cm$^2$) without leakage, may be used for gravity sewers at distances greater than 20 feet (6 m) and less than 50 feet (15 m).

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

d. Access to the reservoir must be protected against surface contamination.

e. Shall be located above the 100 year flood plain.

1.0.3 Protection

All finished water storage structures should have impervious watertight roofs which exclude birds, animals, insects, and be dust-proof.

1.0.4 Protection from trespassers

A sign, fencing, locks on access manholes, and other necessary precautions should be provided to prevent trespassing, vandalism and sabotage.

This criteria may be waived for remote areas on a case by case basis.

1.0.5 Drains

No drain on a water storage structure may have a direct connection to any sewer or storm drain.

Adequate energy dissipation must be provided in order to prevent soil erosion at the outfall.

Discharge shall be such as to disallow flow into State waters.

A 24 mesh screen shall be installed on the end of any open drain.

1.0.6 Overflow

All water storage structures should be provided with an overflow which is brought down to an elevation 12 to 24 (30 to 60 cm) inches above the ground surface, and discharges over a drainage inlet structure or a splash plate. No overflow may be connected directly to any sewer or storm drain. All overflow pipes should be located so any discharge is visible. Discharge shall be such as to disallow flow into State waters.

a. When an internal overflow pipe is used on elevated tanks, it should be located in the access tube. For vertical drops on other types of storage facilities, the overflow pipe should be located on the outside of the structure.

b. The overflow of a ground-level structure should open downward and be screened with number twenty-four mesh non-corrodible screen installed within the pipe at a location least susceptible to damage by vandalism. Flap valves are an acceptable alternative.

c. The overflow pipe should be of a sufficient diameter to permit waste of water in excess of the filling rate.

d. Should exclude insects, birds and animals by a number twenty-four mesh non-corrodible screen.

1.0.7 Access

Finished water storage structures should be designed with reasonable convenient access to the interior for cleaning and maintenance. Manholes above the waterline:

a. should be framed at least four inches, and preferably six inches, above the surface of the roof at the opening; on ground-level structures, manholes should be elevated 24 to 36 inches (61 to 91 cm) above the top or covering sod;

b. should be fitted with a solid impervious watertight cover which overlaps the framed opening and extends down around the frame at least two inches (5 cm);

c. should be hinged at one side;

d. should have a locking device;

e. should be materials of a non-corrodible and non-biodegradable nature.

1.0.8 Vents

Finished water storage structures should be vented. Overflows shall not be considered as vents. Open construction between the sidewall and roof is not permissible. Vents

a. should prevent the entrance of surface water and rainwater;

b. shall have a 24 mesh screen to exclude insects, 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, twenty-four mesh non-corrodible screen may be used; and

d. should, on ground level structures, terminate in an inverted U construction with the opening 12 inches (30.5 cm) above the average annual snow depth and covered with twenty-four mesh non-corrodible screen installed within the pipe at a location least susceptible to vandalism.

1.0.9 Roof and sidewall

The roof and sidewalls of all structures must be of an impervious watertight material 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. In concrete tanks, these pipes should be connected to standard wall castings which were poured in place during the forming of the concrete. These wall castings should have seepage rings imbedded int he concrete.

b. Openings in a storage structure roof or top, designed to accommodate control apparatus or pump columns, should be curbed and sleeved with proper additional shielding to prevent the access of surface or floor drainage water into the structure.

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

d. Any superstructure should be two feet (0.6 m) above the high water level.

e. Structure should be in compliance with local building codes for all snow loads.

f. For any roof of wood construction, a plastic underlining must be provided.

1.0.10 Drainage of roof

The roof of the storage structure should be well drained. 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 unless adequate waterproofing and drainage are provided.

1.0.11 Safety

The safety of employees must be considered in the design of storage structure. As a minimum, such matters should conform to pertinent laws and regulations of the area where the reservoir is constructed.

a. Ladders, ladder guards, balcony railings, and safely located entrance hatches should be provided where applicable.

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

c. Railings or handholds should be provided on elevated tanks where persons must transfer from the access tube to the water compartment.

1.0.12 Freezing

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

1.0.13 Internal catwalk

Every catwalk over finished water in a storage structure should have a solid, no slip surface floor with raised edges so designed that shoe scrapings and dirt will not fall into the water. Railings should also be provided for the catwalk.

1.0.14 Silt stop

The discharge pipes from all reservoirs shall be located in a manner that will prevent the flow of sediment into the distribution system. Removable silt stops should be provided where feasible.

1.0.15 Grading

The area surrounding a ground-level structure should be graded in a manner that will prevent surface water from standing within 75 feet (23 m) of it.

1.0.16 Painting and/or cathodic protection

Proper protection shall be given to metal surfaces by paints or other protective coatings, by cathodic protective devices, or by both.

a. Paint systems shall be in accordance with NSF Standard 61 or equivalent. After proper curing, the coating shall not transfer any substance to the water which will be toxic or cause tastes or odors.

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

1.0.17 Disinfection

Finished water storage structures shall be disinfected in accordance with AWWA Standard C-652. These methods are as follows:

1.) The water storage structures shall be filled to the overflow level with potable water to which enough chlorine is added to provide a free chlorine residual in the full facility of not less that 10 mg/1 at an appropriate period of time as specified in the Standard.

2.) A solution of 200 mg/1 available chlorine shall be applied directly to the surfaces of all parts of the storage facility which would be in contact with the water when the storage facility is full to the overflow elevation. Two or more successive sets of samples, taken at 24-hour intervals, shall indicate microbiologically satisfactory water before the facility is placed into operation.

## 1.1 PLANT STORAGE

The applicable design standards of Section 1.0 should be followed for plant storage.

1.1.1 Washwater tanks

Washwater tanks should be sized, in conjunction with available pump units and finished water storage, to provide the backwash water required by Part I, Section 5.10. Consideration must be given to the backwashing of several filters in rapid succession.

1.1.2 Clearwell

Clearwell storage should be sized, in conjunction with distribution system storage, to relieve the filters from having to follow fluctuations in water use.

a. When finished water storage is used to provide the contact time for chlorine (see Part I Section 6), special attention must be given to size and baffling to prevent short-circuiting.

b. An overflow shall be provided with a 24 mesh screen on the end.

c. There should be no piping within the clearwell with the exception of feed or disinfection piping.

d. There shall be no sanitary sewer facilities or floor drains directly above the clearwell.

1.1.3 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.

1.1.4 Basins and wet-wells

Receiving basins and pump wet wells for finished water should be designed as finished water storage structures, and be constructed of a non-corrosive material.

## 1.2 PRESSURE TANKS

Hydro-pneumatic (pressure) tanks, when provided as the only storage facility, are acceptable only in small water systems. When serving more than 50 homes, ground or elevated storage designed in accordance with Section 1.0.1 should be provided. Pressure tank storage is not to be considered for fire protection purposes. Pressure tanks should meet ASME code requirements or an equivalent requirement of state and local laws and regulations for the construction and installation of unfired pressure vessels.

1.2.1 Location

The tanks should be located above normal ground surface and be completely housed.

The floor around the tank shall have positive drainage to daylight, or a sump pump to discharge at ground surface level. Controls for the sump pump must be located above the 100 year flood plain level.

1.2.2 Sizing

The capacity of the wells and pumps in a hydro-pneumatic system should be at least ten times the average daily consumption rate. The gross volume of the hydro-pneumatic tank in gallons, should be at least ten time the capacity of the largest pump, rated in gallons per minute, and designed for a minimum 30 minute chlorine contact detention time.

1.2.3 Piping

The tank should have bypass piping to permit operation of the system while it is out of service for maintenance.

1.2.4 Appurtenances

Each tank should have an access manhole, a drain, and control equipment consisting of pressure gage, water sight glass, automatic or manual air blow-off, means for adding air, and pressure operated start-stop controls for the pumps. Where practical, the access manhole should be 24 inches (61 cm)

in diameter for tanks over 1000 gallons (3,875 1) capacity. These systems should also be provided with a water level sight glass.

## 1.3 DISTRIBUTION STORAGE

The applicable design standards of Section 1.0 should be followed for distribution system storage.

### 1.3.1 Pressures

The maximum variation between high and low levels in storage structures providing pressure in the distribution system should be 35 psi (2.46 kg/cm$^2$) and the normal working pressure should be approximately 60 psi or 4.22 kg/cm$^2$) acceptable to the local code. When static pressures exceed 100 psi, (7.03 kg/cm$^2$) pressure reducing devices should be provided on mains in the distribution system.

### 1.3.2 Drainage

Storage structures which provide pressure directly to the distribution system should be designed so they can be isolated from the distribution system and drained for cleaning or maintenance without necessitating loss of pressure in the distribution system. The drain shall discharge to the ground surface with no direct connection to any sewer or storm drain.

### 1.3.3 Level Controls

Adequate controls should be provided to maintain levels in distribution system storage structures. Level indicating devices should be provided at a central location.

a. Pumps should be controlled from tank levels with the signal transmitted by telemetering equipment when 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 24 hours a day.

# DISTRIBUTION SYSTEMS

## 2.0 MATERIALS

### 2.0.1 Standards

Pipe, fittings, valves and fire hydrants should conform to the latest standards issued by the AWWA, if such standards exist, and be acceptable to the reviewing authority. In the absence of such standards, materials meeting applicable Product Standards and acceptable to the reviewing authority may be selected.

2.0.2 Used materials

Water mains which have been used previously for conveying potable water may be reused provided they meet the above standards and have been thoroughly cleaned and restored to their original condition. Pipe utilized for conveying any other material shall not be reused.

2.0.3 Joints

Packing and jointing materials used in the joints of pipe shall meet the standards of the AWWA and the reviewing authority. Pipe having mechanical joints or slip-on joints with rubber gaskets is preferred.

## 2.1 WATER MAIN DESIGN

The normal working pressure in the distribution system should be approximately 60 psi, (4.22 kg/cm$^2$) and not less than 35 psi (2.46 kg/cm$^2$).

2.1.1 Pressure

All water mains, including those not designed to provide fire protection, should 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 (1.41 kg/cm$^2$) at ground level at all points in the distribution system under all conditions of flow.

2.1.2 Diameter

The minimum size of water main for providing fire protection and serving fire hydrants shall be six inch diameter. Larger size mains will be required if necessary to allow the withdrawal of the required fire flow while maintaining the minimum residual pressure specified in Section 2.1.1.

2.1.3 Fire protection

When fire protection is to be provided, system design should be such that fire flows and facilities are in accordance with the requirements of the Insurance Service Office at Denver, Colorado.

2.1.4 Small mains

Any departure from minimum requirements should be justified by hydraulic analysis and future water use, and can be considered only in special circumstances.

2.1.5 Hydrants

Water mains not designed to carry fire-flows should not have fire hydrants connected to them.

Hydrants designed to carry fire-flows should conform with the National Fire Protection Association standards.

2.1.6 Dead ends

Dead ends should be minimized by looping of all mains whenever practical.

2.1.7 Flushing

Where dead-end mains occur they should be provided with a fire hydrant if flow and pressure are sufficient, or with an approved flushing hydrant or blow-off for flushing purposes. No flushing device shall be directly connected to any sewer.

## 2.2 VALVES

Sufficient shut-off valves shall be provided on water mains so that inconvenience and sanitary hazards will be minimized during repairs. Valves should be located at not more than 500 foot (152 m) intervals in commercial districts and at not more than one block or 800 foot (244 m) intervals in other districts. Rural systems required to meet this criteria will be reviewed on a case by base basis.

## 2.3 HYDRANTS

2.3.1 Location and spacing

Hydrants should be provided at each street intersection and at intermediate points between intersections as recommended by the State Insurance Services Office. Generally, hydrant spacing may range from 350 to 600 feet (107 to 183 m) depending on the area being served.

2.3.2 Valves and nozzles

Fire hydrants should have a bottom valve size of at least five inches, one 4 ½ inch pumper nozzle and two 2 ½ inch nozzles.

2.3.3 Hydrant leads

The hydrant lead shall be a minimum of six inches (15.2 cm) in diameter. Auxiliary valves should be installed in all hydrant leads.

2.3.4 Drainage

Hydrant drains should be plugged. When the drains are plugged the barrels should be pumped dry during freezing weather. Where hydrant drains are not plugged, a gravel pocket or dry well should be provided unless the natural soils will provide adequate drainage. Hydrant drains shall not be connected to or located within 10 feet (3.05 m) of sanitary sewers or storm drains.

2.3.5 Freeze protection

Propylene glycol shall be the only antifreeze utilized for freeze protection of hydrants.

## 2.4 AIR RELIEF VALVES: VALVE, METER AND BLOW-OFF CHAMBERS

2.4.1 Air relief valves

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.

2.4.2 Air relief valve piping

The open end of an air relief pipe from automatic valves shall be extended to at least one foot (30 cm) above grade and provided with a 24 mesh non-corrodible screened, downward-facing elbow. The pipe from a manually operated valve should be extended to the top of the pit.

2.4.3 Chamber drainage

Chambers, pits or manholes 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, not shall blow-offs or air relief valves be connected directly to any sewer. Such chambers or pits should be drained to the surface of the ground where they are not subject to flooding by surface water, or to absorption pits underground.

## 2.5 INSTALLATION OF MAINS

2.5.1 Standards

Specifications shall incorporate the provisions of the AWWA standards.

2.5.2 Bedding

A continuous and uniform bedding should be provided in the trench for all buried pipe. Backfill material should be tamped in layers around the pipe

and to a sufficient height above the pipe to adequately support and protect the pipe. Stones found in the trench should be removed for a depth of at least six inches (15 cm) below the bottom of the pipe. Provisions should be made to prevent water logging of the bedding material during installation.

2.5.3 Cover

All water mains should be covered with sufficient earth or other insulation to prevent freezing.

2.5.4 Blocking

All tees, bends, plugs and hydrants shall be provided with reaction blocking, tie rods or joints designed to prevent movement.

2.5.5 Pressure and leakage testing

The installed pipe should be pressure tested and leakage tested in accordance with AWWA Standard C600.

2.5.6 Disinfection

All new, cleaned or repaired water mains shall be disinfected in accordance with AWWA Standard C601. The specifications shall include detailed procedures for the adequate flushing, disinfection, and microbiological testing of all water mains, and provisions for disposal of the chlorinated water which must be acceptable to the Division

## 2.6 SEPARATION OF WATER MAINS AND SEWERS

2.6.1 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.

2.6.2 Parallel installation

Water mains shall be laid at least 10 feet horizontally from any existing or proposed sewer. The distance shall be measured edge to edge. Sewers shall be defined as both sanitary and storm sewers.

2.6.3 Crossings

Water mains crossing sewers should be laid to provide a minimum vertical distance of 18 inches (46 cm) between the outside of the water main and the outside of the sewer. This should be the case where the water main is above the sewer. At crossings, one full length of 18 foot (5.5 m) water pipe should be located so both joints will be as far from the sewer as possible. Special structural support for the water and sewer pipes may be required.

2.6.4 Exception

The reviewing authority must specifically approve any variance from the requirements of Sections 2.6.2 and 2.6.3 when it is impossible to obtain the specified separation distances.

2.6.5 Force mains

There shall be at least a 10 foot (3.05 m) horizontal separation between water mains and sanitary sewer force mains. There shall be an 18 inch (46 cm) vertical separation at crossings as required in Section 2.6.3.

2.6.6 Sewer manholes

No water pipe shall pass through or come within ten feet (3.05 m) of a sewer manhole unless adequate protection is provided.

## 2.7 SURFACE WATER CROSSINGS

Surface water crossings, whether over or under water, present special problems. The reviewing authority should be consulted before final plans are prepared.

2.7.1 Above-water crossings

The pipe should be adequately supported and anchored, protected from damage and freezing, and accessible for repair or replacement.

2.7.2 Underwater crossings

A minimum cover of two feet should be provided over the pipe. When crossing water courses which are greater than 15 feet in width, the following shall be provided:

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

b. valves shall be provided at both ends of water crossings so that the section can be isolated for testing or repair; the valves shall be easily accessible, and not subject to flooding; and the valve closest to the supply source shall be in a manhole;

c. permanent taps shall be made on each side of the valve within the manhole to allow insertion of a small meter for testing to determine leakage and for sampling purposes;

d. pipe lengths shall be centered on crossings of small rivers or streams;

e. structural protection must be provided in unstable alluvial basins.

## 2.8 CROSS CONNECTIONS AND INTERCONNECTIONS

### 2.8.1 Cross connections

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

### 2.8.2 Cooling water

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

### 2.8.3 Interconnections

The approval of the reviewing authority shall be obtained for interconnections between potable water supplies.

## 2.9 WATER SERVICES AND PLUMBING

### 2.9.1 Plumbing

Water services and plumbing should conform to relevant local plumbing codes and the Colorado state Plumbing Code.

### 2.9.2 Booster pumps

Individual home booster pumps should not be considered or required for any individual service from the public water supply mains.

## 2.10 SERVICE METERS

Each service connection should be individually metered.

## 2.11 WATER LOADING STATIONS

Water dispensing units present special problems when the fill line may be used for filling both potable water vessels and other tanks or contaminated vessels. To prevent contamination of the public supply, the following criteria shall be met:

2.11.1 Air break

A device shall be installed on the fill line to provide an air break and prevent a submerged discharge line (see Figure 1).

2.11.2 Hose length

The fill hose and cross connection control device must be constructed so that t\when hanging freely it will terminate at least two feet (61 cm) above the ground surface.

2.11.3 Fill line terminus

The discharge end of the fill line must be unthreaded and constructed to prevent the attachment of additional hose, piping or other appurtenances.

## 2.12 DUAL DISTRIBUTION SYSTEMS

Any dual distribution system will be reviewed by the Department on a case by case basis.