Montana Department of
ENVIRONMENTAL QUALITY

CIRCULAR DEQ 1

STANDARDS
FOR
WATER WORKS

February 24, 2006 Edition

FOREWORD

The Board of Environmental Review of the State of Montana as authorized by 75-6-103(2)(f), MCA, hereby adopts the following standards for water works.

Preceding the standards are policy statements of the Board concerning water works design, practice, or resource protection. Those policy statements recommending an approach to the investigation of innovative treatment processes have not been included as part of the standards because sufficient confirmation has not yet been documented to allow the establishment of specific limitations or design parameters.

These standards, consisting of proven technology, are intended to serve as a guide in the design and preparation of plans and specifications for public water supply systems, to suggest limiting values for items upon which an evaluation of such plans and specifications may be made by the MDEQ, and to establish, as far as practicable, uniformity of practice.

The terms shall and must are used where practice is sufficiently standardized to permit specific delineation of requirements or where safeguarding of the public health justifies such definite action. These mandatory items serve as a checklist for the MDEQ. The terms should, recommended, and preferred are used to indicate desirable procedures or methods. These non-mandatory items serve as guidelines for designers.

The term " MDEQ" as used in these standards refers to the Montana Department of Environmental Quality or its authorized agents.

It is not possible to cover recently developed processes and equipment in a publication of this type. However, the policy is to encourage, rather than obstruct, the development of new processes and equipment. Recent developments may be acceptable if they meet at least one of the following conditions: 1) have been thoroughly tested in full scale comparable installations under competent supervision; 2) have been thoroughly tested as a pilot plant operated for a sufficient time to indicate satisfactory performance; or 3) a performance bond or other acceptable arrangement has been made so the owners or official custodians are adequately protected financially or otherwise in case of failure of the process or equipment, or 4) they meet generally accepted industry standards that have not yet been adopted by the Board of Environmental Review.

These standards are based on the "Recommended Standards for Water Works" (2003 Edition), prepared by the Great Lakes Upper Mississippi River Board of State Sanitary Engineers. The Board of Environmental Review acknowledges this basis and expresses its appreciation to the Great Lakes Upper Mississippi River Board of State Sanitary Engineers for its contribution to public health.

POLICY ON PRE-ENGINEERED WATER TREATMENT PLANTS FOR PUBLIC WATER SUPPLIES

Pre-engineered water treatment plants are becoming available and being used for production of potable water at public water systems. Many applications being proposed are for small systems that have relatively clean surface water sources and that are now being required to provide filtration under the federal Safe Drinking Water Act.

Pre-engineered water treatment plants are normally modular process units, which are pre-designed for specific process applications and flow rates and purchased as a package. Multiple units may be installed in parallel to accommodate larger flows.

Pre-engineered treatment plants have numerous applications but are especially applicable at small systems where conventional treatment may not be cost effective. As with any design the proposed treatment must fit the situation and assure a continuous supply of safe drinking water for water consumers. MDEQ may accept proposals for pre-engineered water treatment plants on a case-by-case basis where they have been demonstrated to be effective in treating the source water being used.

Factors to be considered include:

1. Raw water quality characteristics under normal and worst case conditions. Seasonal fluctuations must be evaluated and considered in the design.

2. Demonstration of treatment effectiveness under all raw water conditions and system flow demands. This demonstration may be on-site pilot or full scale testing or testing off-site where the source water is of similar quality. On-site testing is required at sites having questionable water quality or applicability of the treatment process. The proposed demonstration project must be approved by MDEQ prior to starting.

3. Sophistication of equipment. The reliability and experience record of the proposed treatment equipment and controls must be evaluated.

4. Unit process flexibility allowing for optimization of treatment.

5. Operational oversight that is necessary. At surface water sources full-time operators are necessary, except where MDEQ has approved an automation plan. See Policy Statement on Automated/Unattended Operation of Surface Water Treatment Plants.

6. Third party certification or approvals such as National Sanitation Foundation (NSF), for treatment equipment and materials that will be in contact with the water.

7. Suitable pretreatment based on raw water quality and the pilot study or other demonstration of treatment effectiveness.

8. Factory testing of controls and process equipment prior to shipment.

9. Automated troubleshooting capability built into the control system.

10. Start-up and follow-up training and troubleshooting to be provided by the manufacturer or contractor.

11. Operation and maintenance manual. This manual must provide a description of the treatment, control and pumping equipment, necessary maintenance and maintenance schedule, and a troubleshooting guide for typical problems.

12. On-site and contractual laboratory capability. The on-site testing must include all required continuous and daily testing as specified by MDEQ. Contract testing may be considered for other parameters.

13. Manufacturer's warranty and replacement guarantee. Appropriate safeguards for water supplier must be included in contract documents. MDEQ may consider interim or conditional project approvals for innovative technology when there is sufficient demonstration of treatment effectiveness and contract provisions to protect the water supplier should the treatment not perform as claimed.

14. Water supplier revenue and budget for continuing operations, maintenance and equipment replacement in the future.

15. Additional information on this topic is given in the "State Alternative Technology Approval Protocol," dated June 1996, which was developed by the Association of State Drinking water Administrators, U.S. Environmental Protection Agency and various industry groups.

POLICY ON AUTOMATED/UNATTENDED OPERATION OF SW TREATMENT PLANTS.

Recent advances in computer technology, equipment controls and Supervisory Control and Data Acquisition (SCADA) Systems have brought automated and off-site operation of surface water treatment plants into the realm of feasibility. Coincidentally, this comes at a time when renewed concern for microbiological contamination is driving optimization of surface water treatment plant facilities and operations and finished water treatment goals are being lowered to levels of < 0.1 NTU turbidity and < 20 total particle counts per milliliter.

MDEQ encourages any measures, including automation, which assist operators in improving plant operations and surveillance functions.

Automation of surface water treatment facilities to allow unattended operation and off-site control presents a number of management and technological challenges, which must be overcome before an approval, can be considered. Each facet of the plant facilities and operations must be fully evaluated to determine what on-line monitoring is appropriate, what alarm capabilities must be incorporated into the design and what staffing is necessary. Consideration must be given to the consequences and operational response to treatment challenges, equipment failure and loss of communications or power.

An engineering report must be developed as the first step in the process leading to design of the automation system. The engineering report to be submitted to review authorities must cover all aspects of the treatment plant and automation system including the following information/criteria:

1. Identify all critical features in the pumping and treatment facilities that will be electronically monitored, have alarms and can be operated automatically or off-site via the control system. Include a description of automatic plant shutdown controls with alarms and conditions that would trigger shutdowns. Dual or secondary alarms may be necessary for certain critical functions.

2. Automated monitoring of all critical functions with major and minor alarm features must be provided. Automated plant shutdown is required on all major alarms. Automated startup of the plant is prohibited after shutdown due to a major alarm. The control system must have response and adjustment capability on all minor alarms. Built-in control system challenge test capability must be provided to verify operational status of major and minor alarms.

3. The plant control system must have the capability for manual operation of all treatment plant equipment and process functions.

4. A plant flow diagram that shows the location of all critical features, alarms and automated controls to be provided.

5. A description of off-site control station(s) that allow observation of plant operations, that receive alarms and that have the ability to adjust and control operation of equipment and the treatment process.

6. A certified operator must be on "standby duty" status at all times with remote operational capability and must be located within a reasonable response time of the treatment plant.

7. A certified operator must conduct an on-site check at least once per day to verify proper operation, chemical supply levels, and plant security.

8. Description of operator staffing and training planned or completed in both process control and the automation system.

9. Operations manual, which gives operators, step-by-step procedures for understanding and using the automated control system under all water quality conditions. Emergency operations during the power or communication failures or other emergencies must be included.

10. A plan for a 6 month or greater demonstration period to prove the reliability of producers, equipment and surveillance system. A certified operator must be on-duty at all times of operation during the demonstration period. The final plan must identify and address any problems and alarms that occurred during the demonstration period. Challenge testing of each critical component of the overall system must be included as part of the demonstration project.

11. Schedule for maintenance of equipment and critical parts replacement.

12. Sufficient finished water storage must be provided to meet system demands and CT requirements whenever normal treatment production is interrupted as the result of automation system failure or plant shutdown.

13. Sufficient staffing must be provide to carry out daily on-site evaluations, operational functions and needed maintenance and calibration of all critical treatment components and monitoring equipment to ensure reliability of operations.

14. Plant staff must perform, at a minimum, weekly checks on the communication and control system to ensure reliability of operations. Challenge testing of such equipment should be part of normal maintenance routines.

15. Provisions must be made to ensure security of the treatment facilities at all times. Appropriate intrusion alarms must be provided so that alarms are effectively communicated to the operator in charge.

POLICY ON USE OF CHLORAMINE DISINFECTANT FOR PUBLIC WATER SUPPLIES

Ammonia can be used to convert chlorine in drinking water into the longer lasting but less powerful disinfectant chloramine. Possible advantages and disadvantages of the use of chloramine rather than free chlorine include:

Use of chloramine may reduce total trihalomethane concentrations reaching consumers. This is because chloramine does not form trihalomethanes on contact with natural organic matter in the water, although it may form other by-products.

Use of chloramine may reduce the need for high disinfectant concentrations to be added at the plant and/or at booster stations. This can be an advantage during the warmer seasons of the year for protection of the water and mains system, from bacterial overgrowth. Although they may contribute to other problems, the lowered disinfectant requirements also can reduce complaints due to unacceptable chlorine taste/odor problems from consumers located close to water plants.

The use of chloramine may provide less protection from contamination of the distribution system through cross connections, water main breaks and other causes.

Unlike most substances added to water for treatment purposes, chloramine cannot be prepared at high concentrations. It can be made only by adding ammonia to lightly prechlorinated water or by adding chlorine to water containing low concentrations of ammonia. Contact between high concentrations of chlorine and ammonia or ammonium salts must be avoided because the sensitive and violently explosive substance, nitrogen trichloride, may be formed.

Operating authorities who wish to modify disinfectant practices by using chloramine must show MDEQ clear evidence that bacteriological and chemical protection of consumers will not be compromised in any way and that aspects of chloramination mentioned below have been considered in any permit application.

1. Chloramine, which is less powerful than free chlorine, may be suitable for disinfection of some ground water supplies but it is inadequate in strength for primary disinfection of surface waters.

2. Chloramine can be suitable for protecting potable water in distribution systems against bacterial contamination. The chloramine tends to remain active for longer periods and at greater distances from the plant than free chlorine. Chloramine concentrations should be maintained higher than chlorine to avoid nitrifying bacterial activity. A range of 1-2 mg/L, measured as combined chlorine, on entry to the distribution system and greater than 1 mg/L at the system extremities is recommended. Chloramine can be less odorous than chlorine so these concentrations may be tolerated well by consumers.

3. Suitable commercial sources of ammonia for chloramine production are either ammonia gas or water solutions of ammonia or ammonium sulphate. Ammonia gas is supplied as compressed liquid in cylinders that must be stored in separate facilities designed for chlorine gas. Ammonia solutions must be stored in containment with adequate cooling to prevent gas release from storage and gas release must be handled with pressure relief systems. Absorption/neutralization systems for ammonia gas leaks/spills must be designed specially for ammonia. Ammonium sulphate is available as a free flowing powdered solid that must be stored in cool dry conditions and dissolved in water for use.

4. Thorough and reasonably rapid mixing of chlorine and ammonia in the main plant stream must be arranged to avoid formation of odorous dichloramine. Sufficient ammonia must be added to provide at least a small excess (more than one part of ammonia to 4 parts of chlorine) over that required to convert all the free chlorine present to chloramine.

5. Addition of ammonia gas or ammonia solution will increase the pH of the water and addition of ammonium sulphate depresses the pH. The actual pH shift may be small in well-buffered water but the effects on disinfectant power and corrosiveness of the water may require consideration. Ammonia gas forms alkaline solutions, which may cause local plugging by lime deposition. Where hard water is to be treated, a side stream of pre-softened water may be needed for ammonia dilution to reduce plugging problems.

6. The use of chloramine in distribution systems that are not well maintained by flushing, swabbing and other regular routine maintenance activities, can lead to local loss of disinfectant residual, nitrifying bacterial activity and, possibly, over a period of time, to persistent high coliform bacterial counts, which may not respond to reversion to the use of free chlorine. Early detection of nitrifying bacteria activity may be made by checking for reduced dissolved oxygen and elevated nitrite levels.

7. Chloramine in water is considerably more toxic than free chlorine to fish and other aquatic organisms. Consideration must therefore be given to the potential for leaks to contaminate and damage natural watercourse ecosystems. Kidney dialysis treatment can be upset by use of chloraminated water. Medical authorities, hospitals and commercial and domestic aquarium keepers should be notified so they can arrange for precautions to be taken.

POLICY ON CONTROL OF ORGANIC CONTAMINATION FOR PUBLIC WATER SUPPLIES

Although standards and advisories for organics are being developed, there have been numerous cases or organic contamination of public water supply sources. In all cases, public exposure to organic contamination must be minimized. There is insufficient experience to establish design standards, which would apply to all situations. Controlling organic contamination is an area of design that requires pilot studies and early consultation with MDEQ. Where treatment is proposed, best available technology must be provided to reduce organic contaminants to the lowest practical levels. Operations and monitoring must also be considered in selecting the best alternative. The following alternatives may be applicable:

1. Alternate Source Development

2. Existing Treatment Modifications

3. Air Stripping for Volatile Organics

Consideration should be given to:

a. materials for tower, packing and piping that are acceptable for use in contact with potable water,

b. providing a moisture barrier (demister),

c. metering the water flow to the tower,

d. metering the air flow to the tower,

e. providing influent and effluent sampling taps,

f. disinfecting the water passing through the tower,

g. designing the tower to reduce the critical contaminants to the lowest practical levels,

h. the air discharge meeting the air quality standards,

i. provisions for easy access to allow inspection, media replacement, maintenance and cleaning of the packing materials. Iron and manganese precipitation, carbonate deposition and biological fouling are potential problems,

j. chemical stability of the finished water, and

k. acceptable supply during periods of maintenance and operation interruptions.

l. allow the tower to be extended in height without major reconstruction.

4. Granular Activated Carbon

Consideration should be given to:

a. using contact units rather than replacing a portion of existing filter media;

b. series and parallel flow piping configurations to minimize the effect of breakthrough without reliance on continuous monitoring;

c. providing at least two units. Where only two units are provided, each must be capable of meeting the plant design capacity (normally the projected maximum daily demand) at the approved rate. Where more than two units are provided, the contactors must be capable of meeting the design capacity at the approved rate with one or more (as determined in conjunction with MDEQ) units removed from service;

d. using virgin carbon; this is the preferred media. Although reactivated carbon may eventually present an economic advantage at large water treatment plants, such an alternative may be pursued only with the preliminary endorsement of MDEQ. Regenerated carbon using only carbon previously used for potable water treatment can be used for this purpose. Transportation and regeneration facilities must not have been used for carbon put to any other use;

e. acceptable means of spent carbon disposal.

Except for temporary, emergency treatment conditions, particular attention must be given to developing an engineering report, which, in addition to the normal determinations, includes the following:

1. For organic contaminants found in surface water sources:

    a. type of organic chemicals, sources, concentration, frequency of occurrence, water pollution abatement schedule, etc.,

    b. possible existing treatment plant modifications to lower organic chemical levels. Results of bench, pilot or full scale testing demonstrating treatment alternatives, effectiveness and costs,

    c. a determination of the quality and/or operational parameters which serve as the best measurement of treatment performance, and a corresponding monitoring and process control program.

2. For organic contamination found in groundwater sources:

    a. types of organic chemicals, sources, concentration, estimate of residence time within the aquifer, flow characteristics, water pollution abatement schedule, etc.,

    b. results of bench or pilot studies demonstrating treatment alternatives, effectiveness, and costs,

    c. a determination of the quality and/or operational parameters that serve as the best measure of treatment performance, and a corresponding monitoring and process control program.

The collection of this type of data is often complicated and lengthy. Permanent engineering solutions will take significant time to develop. The cost of organic analyses and the availability of acceptable laboratories may further complicate both pilot work and actual operation.

Alternative source development or purchase of water from nearby unaffected systems may be a more expedient solution for contaminated groundwater sources.

POLICY ON INTERNAL CORROSION CONTROL FOR PUBLIC WATER SUPPLIES

Internal and external corrosion of a public water supply distribution system is a recognized problem that cannot be completely eliminated but can be effectively controlled. Aside from the cost of labor and materials for pipe replacement, the possible adverse health effects of corrosion products must be considered. A major corrosion failure in the distribution system mains or service connections could lead to the gross contamination of the water being delivered to the public, as well as service interruption and operation.

Control of corrosion is a function of the design, maintenance, and operation of a public water supply. These functions must be considered simultaneously in order for the corrosion control program to function properly. Corrosion problems must be solved on an individual basis depending on the materials used in the distribution system, and soil and water characteristics. Some specific information can be obtained from Section 4.8 (Stabilization) and from publications of technical societies such as the American Water Works Association, the National Association of Corrosion Engineers, and the American Society for Testing Materials. Broad areas of consideration for a corrosion control program follow.

Internal Corrosion

1. Provide for a system of records by which the nature and frequency of corrosion problems are recorded. On a plan map of the distribution system, show the location of each problem so that follow-up investigations and improvements can be made when a cluster of problems is identified.

2. When complaints are received from a customer, follow up with an inspection by experienced personnel or consultant experienced in corrosion control. Where advisable, obtain samples of water for chemical and microbiological analyses and piping and plumbing material samples. Analyses should be made to determine the type and, if possible, the cause of the corrosion.

3. Establish a program whereby a determination of the stability of the water in representative parts of the distribution system can be made. Analysis for alkalinity, pH, and corrosion products (such as lead, cadmium, copper, and iron) should be performed on water samples collected at the treatment plant or wellhead and at representative points on the distribution system. In comparing the analyses of the source water with the distribution system water, significant changes in alkalinity, pH, or corrosion products would indicate that corrosion is taking place and thereby indicate that corrective steps need to be taken.

4. Where possible, especially when corrosion has been detected in the determination of water stability, provide a program that will measure both the physical and chemical aspects of the corrosion phenomena. Physical measurement of the rate of corrosion can be made by the use of coupons, easily removed sections of pipe, connected flow-through pipe test sections or other piping arrangements. At the same site, measure the relative degree of corrosivity on a routine basis by using corrosion indices such as the Langelier Index, Ryznar Index, or Aggressiveness Index (AWWA C400). Correlation of the data from the physical measurement, with the data from the selected corrosion index, will provide information to determine the type of corrective treatment needed and may allow for the subsequent use of the corrosion index alone to determine the degree of corrosivity in select areas of the distribution system.

5. If corrosion is found to exist throughout the distribution system, corrective measures at the treatment plant, pump station or wellhead should be initiated. A chemical feed can be made to provide a stable to slightly depositing water. In calculating the stability index and the corresponding chemical feed adjustments, consideration must be given to items such as the water temperature. If it varies with the season and within various parts of the distribution system; the velocity of flow within various parts of the distribution system; the degree of stability needed by the individual customer; and the dissolved oxygen content of distributed water, especially in waters having low hardness and alkalinity. Threshold treatment involving the feeding of a polyphosphate or a silicate to control corrosion may be considered for both ground and surface water supplies.

6. Additional control of corrosion problems can be obtained by a regulation or ordinance for the materials used in or connected to a distribution system. Careful selection of materials compatible with the physical system or the water being delivered can aid in reduction of corrosion product production.

Note: Adjustment of pH for corrosion control must not interfere with other pH dependent processes (e.g., color removal by alum coagulation) or aggravate other water quality parameters (e.g. THM formation). In addition, the use of ortho or blended phosphates must not aggravate distribution microbial concerns or adversely impact wastewater facilities.

POLICY ON TRIHALOMETHANE REMOVAL AND CONTROL FOR PUBLIC WATER SUPPLIES

Trihalomethanes (THMs) are formed when free chlorine reacts with organic substances, most of which occur naturally. These organic substances (called "precursors"), are a complex and variable mixture of compounds. Formation of THMs is dependent on such factors as amount and type of chlorine used, temperature, concentration of precursors, pH, and contact time. Approaches for controlling THMs include:

1. Control of precursors at the source.

    a. Selective withdrawal from reservoirs -- varying depths may contain lower concentrations of precursors at different times of the year.

    b. Plankton Control -- Algae and their by-products have been shown to act as THM precursors.

    c. Alternative sources of water may be considered, where available.

2. Removal of THM precursors and control of THM formation.

    a. Moving the point of chlorination to minimize THM formation.

    b. Removal of precursors prior to chlorination by optimizing:

        (1) Coagulation/flocculation -- sedimentation -- filtration

        (2) Precipitative softening/filtration

        (3) Direct filtration

    c Adding oxidizing agents such as potassium permanganate, ozone or chlorine dioxide to reduce or control THM formation potential.

    d. Adsorption by powdered activated carbon (PAC).

    e. Lowering the pH to inhibit the reaction rate of chlorine with precursor materials. Corrosion control may be necessary.

3. Removal of THM.

    a. Aeration - by air stripping towers.

    b. Adsorption by:

        (1) Granular Activated Carbon (GAC)

        (2) Synthetic Resins

4. Use of Alternative Disinfectants -- Disinfectants that react less with THM precursors may be used as long as bacteriological quality of the finished water is maintained. Alternative disinfectants may be less effective than free chlorine, particularly with viruses and parasites. Alternative disinfectants, when used, must be capable of providing an adequate distribution system residual. Possible health effects of by-products that may be produced by using alternative disinfectants must be taken into consideration. The following alternative disinfectants may be considered:

a. Chlorine Dioxide

b. Chloramines

c. Ozone

Using various combinations of THM controls and removal techniques may be more effective than a single control or treatment method.

Any modifications to existing treatment process must be approved by MDEQ. Pilot plant studies are desirable.

POLICY ON ULTRA VIOLET LIGHT FOR TREATMENT OF PUBLIC WATER SUPPLIES

General:

Ultraviolet (UV) Light treatment devices may be used to treat bacteriologically unsafe ground water from drinking water wells. However, MDEQ expects water system owners to take all steps possible to obtain a naturally safe water source before considering treatment. A naturally safe water source provides the best long-term public health protection and there is no need for reliance on a treatment device to assure safe water. There must be a determination that the bacteriologically unsafe water is not due to the influence of surface water.

Recent research has demonstrated the effectiveness of UV as a primary disinfectant for inactivation of pathogens. MDEQ must be contacted regarding use of UV treatment for these applications.

The Environmental Protection Agency (EPA) is expected to finalize the Long Term 2 Enhanced Surface Water Treatment Rule and make available the Ultraviolet Disinfection Guidance Manual (UVDGM) in the Spring of 2006. MDEQ is reluctant to approve UV application to sources where known contamination exists until EPA sets dosage requirements for individual pathogens. Therefore, until EPA publishes the final rule and guidance manual setting dosage rates for log inactivation of target organisms, the use of UV treatment will be provisional and limited in most cases to those that fit into generally accepted capabilities. Approvals of UV systems will contain conditional statements that dosage, hydraulic flow rates and other operating characteristics may change once EPA rules are finalized, requiring retrofits to bring the system into compliance with new regulations.

1.0 Criteria

There are two basic scenarios under which UV treatment may be applied.

1.1 UV used as a primary disinfectant for inactivation of a pathogen(s)

Systems may use UV as the primary disinfectant for inactivation of a pathogen(s). MDEQ must be consulted for this application. Validation either on-site or at an off-site validation center in accordance with Section 6.0 must be conducted in order to verify log inactivation achieved for the pathogen(s) of concern.

1.1.1 Design Requirements

a. The design must address all requirements in this policy.
b. Pre-treatment will be required to achieve the water quality criteria in Section 4.0.
c. Systems will be required to provide post UV disinfection that provides a measurable residual of at least 0.2 mg/l free or total chlorine at the most distant end of the system.

1.2 Systems using UV for purposes other than primary disinfection for inactivation of a pathogen(s)

1.2.1 UV is acceptable for the following applications when it is not being used as a primary disinfectant for inactivation of a pathogen(s):

a. Ground water sources with no history of positive bacteriological results or other circumstances that would require disinfection.
b. Ground water systems with small or no distribution system that require disinfection due to addition of a treatment process will be considered for UV application.
c. Other applications as allowed by MDEQ on a case-by-case basis.

1.2.2 Design Criteria

a. UV radiation at a wavelength of 253.7 nanometers must be applied at a minimum dose of 40 millijoules per square centimeter (mJ/cm^2) at the failsafe set point at the end of lamp life.
b. The design must address all requirements in this policy with the exception of Section 6.0: Validation Testing. MDEQ may require validation testing on a case-by-case basis depending on the specific UV application.

2.0 Engineering Report:

All plans and specifications for the UV system must be signed and submitted by a professional engineer. Engineer reports must address, at a minimum, the following design components:

a. Goals of disinfection to include target organisms and corresponding log inactivations.
b. Integration of UV equipment in the over-all treatment process. The need for redundant components for emergencies or scheduled maintenance must be addressed.
c. Water quality assessment to include, at a minimum, the factors in Section 4.0: Water Quality.
d. Hydraulic assessment and design to identify minimum and maximum flow rates. Surge or water hammer assessment must be analyzed.
e. An assessment to verify adequate pressure is maintained at all times for proper UV performance. Adequate pressure must also be maintained on the downstream side of the UV reactor such that downstream treatment processes and distribution system pressures are adequate for proper operation.
f. Electric power to include, at a minimum, reliability, quality, need for backup or uninterruptible power supply (UPS).
g. Operation and Maintenance requirements that address at a minimum the following:

    1. when the treatment system is “off-spec” or “down”,
    2. lamp breakage,
    3. response to both High and Low priority alarms,
    4. monitoring program,
    5. lamp cleaning and replacement frequency,
    6. calibration, maintenance, and replacement of UV sensors, transmittance monitors, and other devices used to monitor UV performance.

3.0 Design:

3.1 Technical Requirements for UV Water Treatment Devices:

a. UV water treatment devices must comply with criteria approved by MDEQ and Class A criteria under ANSI/NSF Standard 55-Ultraviolet Microbiological Water Treatment Systems. Each UV water treatment device must meet the following standards:

    1. The UV device must be fitted with a light sensor to safely verify that UV light at the minimum required dose is being delivered into the reactor.

    3. The UV light assembly must be insulated from direct contact with the influent water by a quartz (or high silica glass with similar optical and strength characteristics) lamp jacket to maintain proper operating lamp temperature.

    4. The design and installation of the UV reactor must ensure that the manufacturer’s maximum rated flow cannot be exceeded.

    5. The UV assemblies must be accessible for visual observation, cleaning and replacement of the lamp, lamp jackets and sensor window/lens.

6. A narrow band UV monitoring device must be provided that is sensitive to germicidal UV light. It must be accurately calibrated so that it indicates the true irradiance (mJ/cm^2) at 253.7 nanometers and be installed at the location critical for that unit. Other devices that accurately monitor UV performance may be allowed. The device must trigger an audible alarm in the event the sensor or lamp fails or if insufficient dosage is detected.

7. An automatic shutdown valve must be installed in the water supply line ahead of the UV treatment system that will be activated whenever the water treatment system loses power or is tripped by a monitoring device when the dosage is below its alarm point. When power is not being supplied to the UV unit the valve must be in a closed (fail-safe) position.

8. The UV housing must be stainless steel 304 or 316L.

b. A flow or time delay mechanism must be provided to permit a sufficient time for tube warm-up per manufacturer's recommendations before water flows from the unit upon startup. Where there are extended no-flow periods and fixtures are located a short distance downstream of the UV unit, consideration should be given to UV shutdown between operating cycles to prevent heat build-up in the water due to the UV lamp.

c. A sufficient number (required number plus one if UV is used as a primary disinfectant for pathogens) of parallel UV treatment systems must be provided to assure a continuous water supply when one unit is out of service.

d. No bypasses shall be installed if UV is used as a primary disinfectant for pathogens. All water must be treated if UV is used as a primary disinfectant.

e. All UV applications must include a water flow meter capable of determining instantaneous flow rates and total accumulated flow.

4.0 Water Quality:

The water to be treated by the UV device must be analyzed for the water quality parameters in Table 4-1 and the results must be included in the submittal. The range of water quality parameters to be treated by the UV reactor must be addressed as a result of raw water quality changes or pretreatment. Pretreatment is required for UV installations if the water quality exceeds any of the limits listed in Table 4-1. If chemicals are used in the pretreatment process, the affect of these chemicals on the UV performance must be addressed. Water systems considering UV treatment must propose a sampling program for each of the parameters identified below during pilot testing and after final MDEQ approval. MDEQ may require pilot testing of installed UV systems to verify adequacy and adjustment of pre and post treatment.

Table 4-1. Water Quality Parameters

Parameter	Maximum
UV 254 nm Absorption	20 percent at 1 cm
Dissolved Iron	0.3 mg/L
Dissolved Manganese	0.05 mg/L
Hardness	120 mg/L*
Hydrogen Sulfide (if odor is present)	Non-Detectable
Iron Bacteria	None
pH	6.5 to 9.5
Suspended Solids	10 mg/L
Turbidity	1.0 NTU
Total Coliform	1,000/100 mL
E. Coli	**

Fecal coliform	**

* A higher hardness may be acceptable to MDEQ if experience with similar water quality and reactors shows there are no treatment problems or excessive maintenance required.
** E. coli and fecal coliforms must be absent in all water quality samples where UV is used for purposes other than primary disinfection.

5.0 Operation and Maintenance:

5.1 Water systems utilizing UV treatment must keep a monitoring log of operating parameters and maintenance performed. MDEQ will determine, on a case-by-case basis, which parameters are to be monitored along with frequency and reporting procedures. Parameters and frequency can be selected from Table 5-I. Systems using UV as a primary disinfectant for inactivation of a pathogen(s) must submit completed logs to MDEQ on a monthly basis. System using UV for purposes other than primary disinfection of pathogens must keep a log available for review during scheduled sanitary surveys.

Table 5-I. UV System Monitoring

Parameter	Frequency
UV Absorbance or Transmittance	As needed if UV Intensity readings are low
pH, iron, manganese, hardness	Measure only if sleeve fouling becomes an issue
Turbidity	Measure if chemicals are added prior to UV
Electric Power (Amps & volts)	Measure to ensure adequate power
Water Temperature	TBD by type of system
Water Flow	TBD by type of system
Intensity Meter	TBD by type of system
Intensity Meter Status	Yearly calibration
Irradiance	TBD by type of system
Sleeve cleaning	Intensity Meter readings < 80% Transmittance
Intensity Meter readings < 80% Transmittance	TBD by type of system
Lamp Operating Time	Monthly
Lamp change	As occurs, yearly minimum
Alarms	As occur
Water quality parameters listed in Table 4-1	As determined by MDEQ based on information provided in Section 4.0

5.2 Certified operators must receive documented training on UV equipment or the water system must have a maintenance agreement with an entity, such as the equipment supplier, that is qualified to maintain UV equipment. Water systems without certified operators must have a maintenance agreement. Maintenance agreements must include at least the following items:

a. Sleeve cleaning to be accomplished when Intensity meter readings indicate a drop in Transmittance below 80%.

b. Lamp replacement when lamp status indicates 50% power or after one year equivalent of operation.

c. Yearly calibration of the intensity meter.

5.3 Process Control Water Quality Monitoring

Water quality monitoring parameters and frequency of monitoring will be determined by MDEQ based on information provided in Section 4.0. Water quality information will be used to evaluate UV treatment effectiveness.

5.4 Online Monitoring, Replacement Parts

UV light intensity of each installed unit must be monitored continuously. Treatment units and the water system components must automatically shutdown if the UV sensors, transmittance monitors, or other monitoring device indicate the UV reactor is not delivering the required dose. Each system must have available on site at least one replacement lamp and any other components or equipment necessary to keep the treatment system in service.

5.5 Seasonal Operations

UV water treatment devices that are operated on a seasonal basis must be inspected and cleaned prior to use at the start of each operating season. The UV water treatment system including the filters must be disinfected prior to placing the water treatment system back into operation. A procedure for shutting down and starting up the UV treatment system must be developed for or by each system based upon manufacturer's recommendations and submitted to MDEQ.

5.6 Record Keeping and Access

A record must be kept of the water quality test data, maintenance information, dates of lamp replacement and cleaning, a record of when the device was shutdown and the reason for shutdown, and other maintenance, calibration, or replacement activities that occurred.

MDEQ shall have access to the UV water treatment system and records upon request.

6.0 Validation

Systems using UV for primary disinfection for inactivation of a pathogen(s) must perform validation testing either on-site or at an off-site validation center. Validation testing must demonstrate the operating conditions under which the reactor can deliver the UV dose required to achieve the necessary level of log inactivation. Validation must include the following:

a. The range of operating conditions that can be monitored by the system and under which the reactor delivers the required dose. Operating conditions must include flow rate, UV intensity as measured by a UV sensor, and UV lamp status.

b. The validated operating conditions must account for:

    1. UV absorbance of the water,
    2. lamp fouling and aging,
    3. measurement uncertainty of on-line sensors,
    4. UV dose distribution arising from the velocity profiles through the reactor,
    5. failure of UV lamps or other critical system components, and
    6. inlet and outlet piping or channel configuration of the UV reactor.

c. Validation testing must include full scale testing of a reactor that conform uniformly to the UV reactors used by the system and inactivation of a test microorganism whose dose response characteristics have been quantified with a low pressure mercury vapor lamp.

POLICY FOR APPLICATION OF POU/POE TECHNOLOGY TO TREAT FOR MCL VIOLATIONS

1.0 Policy Justification

Centrally managed Point-of-Use (POU) and Point-of Entry (POE) treatment strategies have proven to be cost-effective and technically feasible in meeting the requirements of the National Primary Drinking Water Rules (NPDWRs) for systems serving 10,000 and fewer people.

2.0 Applicability

POU or POE technologies may not be used for treatment of nitrate, nitrite, VOCs, microbials, microbial indicators, or any treatment technique for Surface water and ground water under the direct influence of surface water systems. POU and POE technologies must not be used by new or proposed water systems as a means to achieve compliance with an MCL. Where POU is used, all water with the potential for human consumption, including all bathroom sources (hot and cold), refrigerator water dispensers, and icemakers, must be treated.

3.0 Procedure for Submittal, Review and Approval of Proposals

All proposed POU/POE treatment systems must obtain conditional approval of plans and specifications to undergo one year of verification operation and pilot testing prior to final approval. Pilot testing must be conducted on at least 10 percent of the households or 4 households, whichever is greater, for a community water system. Documentation of successful pilot testing in conjunction with submission of plans and specifications meeting MDEQ requirements will result in obtaining final approval. The pilot testing program approach must be done in accordance with Section 7 of this policy and submitted for MDEQ review and approval. The pilot testing results must be summarized in progress reports from the engineer or qualified professional to MDEQ at 3 months and 6 months, and at 1 year, and a final report must be submitted with final plans and specifications for the treatment system for which final approval is sought.

Plans and specifications meeting the requirements of DEQ-1 or DEQ-3 must be provided to MDEQ for review and approval prior to alteration or construction of any public water supply. Specifically, all submittals must include:

a. Plans & specifications meeting general requirements of DEQ-1, Chapters 1 and 2 for CWSs, or DEQ-3, Chapters 1 and 2 for NTNCs. Disposal of liquid waste streams (spent backwash, reject water, and regenerant streams), spent media, spent membranes, and spent cartridges must be addressed.
b. Design of treatment meeting general requirements of DEQ-1, Chapters 4 and 5, and this guidance.
c. Certification by owner that a professional engineer will be hired to provide:
    1. An Operation and Maintenance (O&M) Manual with information on system components, controls, monitoring, maintenance and troubleshooting.
    2. Homeowner and operator training at startup, documented and submitted to the MDEQ.
    3. Construction inspection at sufficient frequency to ensure that the systems are constructed as approved.
    4. Certified as-built plans of the treatment systems as constructed.
d. MDEQ requires the plans and specifications to be prepared by, and installation to be inspected by a professional engineer due to the complexity of POU/POE systems.
e. If POU or POE devices are used under variance or exemption, the PWS must comply with the appropriate sections for 40 CFR 142.62 and 40 CFR 142.66.
f. The PWS owner must retain a certified operator adequately certified by MDEQ for the level of treatment installed.

4.0 Special Design Criteria

a. Only treatment devices independently certified against American National Standards Institute (ANSI) or National Sanitation Foundation (NSF) product standards, where they exist, can be used.

b. Units must be sized to minimize replacement/regeneration frequency based on a comparison of the lifecycle cost of equipment, maintenance and sampling/analytical costs, as well as avoidance of generating hazardous wastes.
c. Each treatment device installed as part of a compliance strategy must be equipped with a warning device that will alert users when their unit is no longer adequately treating their water. Alternatively, devices may be fitted with an automatic shut-off mechanism that will not allow water to flow until the problem is fixed.

5.0 Requirements for all systems - POU:

a. Equipment Ownership

All POU equipment must remain under the ownership and control of the PWS. That means the PWS or an entity under contract with the PWS is responsible for installation, monitoring, maintenance and replacement.

b. 100 percent participation

Systems proposing use of POU to meet MCL requirements must demonstrate 100 percent participation via the following:

1. Provide a map showing every service connection and the location of every unit, along with the name of the owner or person responsible for the connection/tap.
2. For community systems, provide a notarized, signed letter from every homeowner/user stating they are aware of the health issue surrounding drinking untreated water, that they support the use of POU as a compliance strategy, and that they will allow system representatives to enter their home to install and maintain the POU unit.

c. Public Education

Systems must specify a program of public education to ensure that all people served by POU devices understand the health risks of drinking from other than the treated tap. Public Education may consist of written material distributed at regular frequencies, public forums where speakers address an audience, newspaper or radio public service announcements, and any other medium approved by MDEQ. Homeowners must attend one training session when their POU unit is installed or they assume occupancy of a home with a POU device. The system must track attendance and retain records including the trainer's and trainees' signatures.

d. Community or Local Ordinances

The PWS proposing POU must ensure ongoing access to each home where a POU device is installed through a local ordinance or other means. The PWS must obtain the authority to shut off water to any user who refuses access to, bypasses, removes, or disables the POU device. The PWS must submit a copy of the proposed ordinance to MDEQ for its review and approval prior to enacting the ordinance. A copy of the published ordinance must be provided before approval will be issued.

e. Routine Monitoring

Raw and treated water sample taps must be provided as part of every installation. The PWS proposing POU must propose a routine monitoring program for MDEQ review and approval. Each installation must be monitored during the first year of being installed, and then once every three years thereafter such that one-third of the households/buildings are sampled each year. Sample results must be submitted to MDEQ for review.

Systems must notify the State immediately in the event of an MCL exceedance. In the event of an MCL exceedance, the system must replace the unit immediately and commence with quarterly monitoring at the location where the exceedance occurred in accordance with 40 CFR 141.23 for inorganics, 40 CFR 141.24 for organics, or 40 CFR 141.26 for radionuclides.

f. Routine Maintenance and Replacement Frequency

The PWS proposing POU must propose a maintenance and replacement program for MDEQ review and approval that identifies critical components of the unit and specifies maintenance activity and frequency.

Replacement frequencies must be based on pilot test results that demonstrate replacement occurs prior to the contaminant level in the treated water exceeding one-half the MCL. Replacement must be based on one of the following:

1. Gallons treated. A flow meter must be included as part of the installed device.
2. TDS levels for reverse osmosis units. An in-line TDS monitor must be included as part of the installed device.

An alarm or shut-off valve must be activated once the designated gallons treated or TDS level for reverse osmosis unit is reached.

A routine maintenance schedule must be developed at the time of plan and specification review and approval, based on equipment treatment capacity.

Copies of routine maintenance logs must be available on site upon request. The PWS must keep detailed records documenting installation date, and dates and types of all further maintenance activity, including sampling dates and who performed the work. MDEQ may request access to records at any time, and failure to keep sufficient records will constitute operating outside the conditions of approval, and effectively revoke system approval.

g. Compliance

Each POU device will be considered an entry point. If one device results in an MCL violation based on monitoring conducted in accordance with 40 CFR 141.23 for inorganics, 40 CFR 141.24 for organics, or 40 CFR 141.26 for radionuclides, then the entire system is in violation.

6.0 Requirements for all systems - POE:

a. The PWS must comply with all requirements in 40 CFR 141.100 if POE is used for compliance with an MCL.

b. All POE equipment must remain under the ownership and control of the PWS. That means the PWS or an entity under contract with the PWS is responsible for installation, monitoring, maintenance and replacement.

c. 100 % participation

Systems proposing use of POE to meet MCL requirements must demonstrate 100 % participation via the following:

1. Provide a map showing every service connection and the location of every unit, along with the name of the owner or person responsible for the connection/tap.
2. For community systems, provide a notarized, signed letter from every homeowner/user stating they are aware of the health issue surrounding drinking untreated water, that they support the use of POE as a compliance strategy, and that they will allow system representatives to enter their home to install and maintain the POE unit.

Systems unable to attain documented 100% participation will not have POE treatment approved. MDEQ must have 100% participation per 40 CFR 141.100 and 40 CFR 142.62.

d. Public Education

Systems must specify a program of public education to ensure that all people served by POE devices understand the health risks of drinking from other than the treated tap. Public Education may consist of written material distributed at regular frequencies, public forums where speakers address an audience, newspaper or radio public service announcements, and any other medium approved by MDEQ. Homeowners must attend one training session when their POE unit is installed or they assume occupancy of a home with a POE device. The system must track attendance and retain records including the trainer’s and trainees’ signatures.

e. Community or Local Ordinances

The PWS proposing POE must ensure ongoing access to each home where a POE device is installed through a local ordinance or other means. The PWS must obtain the authority to shut off water to any user who refuses access to, bypasses, removes, or disables the POE device. The PWS must submit a copy of the proposed ordinance to MDEQ for its review and approval prior to enacting the ordinance. A copy of the published ordinance must be provided before approval will be issued.

f. Routine Monitoring

Raw and treated water sample taps must be provided as part of every installation. The PWS proposing POE must propose a routine monitoring program for MDEQ review and approval. Each POE installation must be monitored during the first year of being installed, and then once every three years thereafter such that one-third of the households/buildings are sampled each year. Sample results must be submitted to MDEQ for review.

Systems must notify the State immediately in the event of an MCL exceedance. In the event of an MCL exceedance, the system must replace the unit immediately and commence with quarterly monitoring at the location where the exceedance occurred in accordance with 40 CFR 141.23 for inorganics, 40 CFR 141.24 for organics, or 40 CFR 141.26 for radionuclides.

g. Routine Maintenance

The PWS proposing POE must propose a maintenance and replacement program for MDEQ review and approval that identifies critical components of the unit and specifies maintenance activity and frequency.

Replacement frequencies must be based on pilot test results that demonstrate replacement occurs prior to the contaminant level in the treated water exceeding one-half the MCL. Replacement must be based on one of the following:

1. Gallons treated. A flow meter must be included as part of the installed device.
2. TDS levels for reverse osmosis units. An in-line TDS monitor must be included as part of the installed device.

An alarm or shut-off valve must be activated once the designated gallons treated or TDS level for reverse osmosis unit is reached.

Copies of routine maintenance logs must be available on site upon request. The PWS must keep detailed records documenting installation date, and dates and types of all further maintenance activity, including sampling dates and who performed the work. MDEQ may request access to records at any time, and failure to keep sufficient records will constitute operating outside the conditions of approval, and effectively revoke system approval.

h. Compliance

Each POE device will be considered an entry point. If one device results in an MCL violation based on monitoring conducted in accordance with 40 CFR 141.23 for inorganics, 40 CFR 141.24 for organics, or 40 CFR 141.26 for radionuclides, then the entire system is in violation.

The system must ensure the microbiological safety of the water at all times.

7.0 Elements of Pilot Testing

Pilot testing must be conducted to identify and resolve technical or operational issues that may affect the use of the device for meeting the treatment requirement. The following items must be adequately addressed:

a. Raw water quality under normal and peak conditions, including seasonal variation must be evaluated. The type of technology proposed will dictate the testing required. Appropriate parameters including competing or interfering parameters must be identified. The range of raw water quality observed must be adequately addressed by the design.

b. Monitoring of treated water for the parameter requiring treatment during the pilot testing period is required. The minimum frequency is one time immediately after installation and startup and once monthly for the remainder of the pilot testing period.
c. Quantity and quality of waste generated through reject streams, backwash/regeneration cycles, and ultimate disposal of media or membranes.
    1. Determine whether waste from treatment process results in exceeding the capacity of the wastewater collection and disposal system.
    2. Determine whether batch or continuous discharge will impact biological treatment.
    3. Determine compatibility with waste receiving system.
    4. Maintenance and sampling costs and requirements of automatically regenerating media systems should be compared with those of disposable media systems.
d. Maintenance requirements and maintenance roles and responsibilities must be clearly specified in the program outline.
e. Potential corrosivity of treated water. System design must consider corrosion control when POE is used, particularly POE RO.
f. Type of treatment to be used and potential for treatment failure. The replacement frequency of components must be such that replacement occurs prior to the contaminant exceeding one-half the MCL in the treated water.
g. The design engineer or qualified professional must propose a method of evaluation for the potential for microbial colonization and disinfection requirements for each system where POU/POE is proposed.
h. Systems that provide chemical disinfection prior to the POU/POE treatment must indicate that the POU/POE device specified provides effective treatment in that environment.

8.0 Use of Case Studies

MDEQ may accept case study information from other systems that address items in Section 7.0 on a case-by case basis.

9.0 General Considerations

a. Failure to maintain the system in compliance with the MCL requirements may result in reevaluation of treatment requirements or enforcement action.

b. MDEQ reserves the right to conduct unannounced inspections and sample at reasonable times.

c. MDEQ reserves the right to invoke additional requirements on a case-by case basis as necessary to ensure that treatment provided by POU/POE is equally protective as central treatment.

CHAPTER 1 - SUBMISSION OF PLANS

1.0 GENERAL

All reports, final plans and specifications must be submitted at least 60 days prior to the date on which action by MDEQ is desired. Permits for construction, for waste discharges, for stream crossings, etc., may be required from other federal, state, or local agencies. No approval for construction can be issued until final, complete, detailed plans and specifications have been submitted to MDEQ and found to be satisfactory. Three copies of the final plans and specifications signed and stamped by the engineer must be submitted. An approved set will be returned to the applicant. Documents submitted for formal approval must include but are not limited to:

a. a summary of the basis of design,

b. operation requirements, where applicable,

c. general layout,

d. detailed plans,

e. specifications, and

f. documentation that owner is committed to providing as-built drawings of the project by a registered professional engineer and the certification letter required in ARM 17.38.101.

1.1 ENGINEER'S REPORT

The engineer's report for new water works and for existing water systems, where pertinent, must present the following information:

1.1.1 General information, including:

a. description of the existing water works and sewerage facilities,

b. identification of the municipality or area served,

c. name and mailing address of the owner, developer and official custodian, and

d. information requested in Appendix A.

1.1.2 Extent of water works system, including

a. description of the nature and extent of the area to be served,

b. provisions for extending the water works system to include additional areas, and

c. appraisal of the future requirements for service, including existing and potential industrial, commercial, institutional, and other water supply needs.

1.1.3 Alternate plans

Where two or more solutions exist for providing public water supply facilities, each of which is feasible and practicable, discuss the alternate plans. Give reasons for selecting the one recommended, including financial considerations, and a comparison of the minimum classification of water works operator required for operation of each alternative facility.

1.1.4 Site Conditions

Soil and groundwater conditions, including a description of the character of soil through which water mains are to be laid and the approximate elevation and flow direction of groundwater in relation to subsurface structures.

1.1.5 Water use data, including:

a. a description of the population trends as indicated by available records, and the estimated population which will be served by the proposed water supply system or expanded system, a minimum of 20 years in the future in five year intervals or over the useful life of the critical structures and equipment,

b. present water consumption and the projected average and maximum daily demands, including fire flow demand (see Section 1.1.6),

c. present and/or estimated yield of the sources of supply, and

d. unusual occurrences.

1.1.6 Flow requirements, including:

a. hydraulic analyses based on flow demands and pressure requirements (See Section8.2.1), and

b. fire flows, when fire protection is provided, meeting the recommendations of the fire protection agency in which the water system is being developed, or in the absence of such a recommendation, the fire code adopted by the State of Montana. Documentation from the fire protection agency may be required if the flow requirements vary significantly from typical values.

1.1.7 Sewage system available

Describe the existing or proposed sewage collection system and sewage treatment works, with special reference to their relationship to existing or proposed water works structures which may affect the operation of the water supply system, or which may affect the quality of the supply.

1.1.8 Sources of water supply

Describe the proposed source or sources of water supply to be developed, the reasons for their selection, and provide information as follows:

1.1.8.1 Surface water sources, including:

a. hydrological data, stream flow and weather records,

b. safe yield, including all factors that may affect it,

c. maximum flood flow, together with approval for safety features of the spillway and dam from the appropriate reviewing authority,

d. summarized quality of the raw water with special reference to fluctuations in quality, changing meteorological conditions, etc.

e. documentation that an application for water rights has been filed with the Department of Natural Resources, when applicable. Final System approval will be conditioned on the ability to obtain water rights, and

f. a source water assessment report for surface water sources.

1.1.8.2 Groundwater sources including:

a. sites considered,

b. advantages of the site selected,

c. elevations with respect to surroundings,

d. probable character of formations through which the source is to be developed through nearby well logs,

e. geologic conditions affecting the site, such as anticipated interference between proposed and existing wells,

f. summary of source exploration, test well depth, and method of construction; placement of liners or screen; test pumping rates and their duration; water levels and specific yield; water quality,

g. documentation that an application for water rights has been filed with the Department of Natural Resources, when applicable. Final System approval will be conditioned on the ability to obtain water rights,

h. a preliminary assessment for proposed groundwater sources that may be under the direct influence of surface water, prepared in accordance with PWS-5, "Assessment of Groundwater Sources Under the Direct Influence of Surface Water,"

i. a source water protection plan prepared in accordance with PWS-6, and

j. a description of any wellhead protection measures being considered.

1.1.9 Proposed treatment processes

Summarize and establish the adequacy of proposed processes and unit parameters for the treatment of the specific water under consideration. Alternative methods of water treatment and chemical use should be considered as a means of reducing waste handling and disposal problems. Bench scale tests, Pilot studies or demonstrations will generally be required to establish adequacy for some water quality standards.

1.1.10 Waste disposal

Discuss the various wastes from the water treatment plant, their volume, proposed treatment and disposal locations. If discharging to a sanitary sewerage system, verify that the system including any lift stations, is capable of handling the flow to the sewage treatment works and that the treatment works is capable and will accept the additional loading.

1.1.11 Automation

Provide supporting data justifying automatic equipment, including the servicing and operator training to be provided. Manual override must be provided for any automatic controls. Highly sophisticated automation may put proper maintenance beyond the capability of the plant operator, leading to equipment breakdowns or expensive servicing. Adequate funding must be assured for maintenance of automatic equipment.

1.1.12 Project sites, including:

a. discussion of the various sites considered and advantages of the recommended ones, and

b. the proximity of residences, industries, and other establishments,

1.1.13 Financing

Provide financial information for new systems or significant improvements with economic impacts as required in Appendix A.

1.1.14 Future extensions

Summarize planning for future needs and services.

1.2 PLANS

Plans for waterworks improvements must be legible and must provide the following:

1.2.1 General layout, including:

a. suitable title,

b. name of municipality, or other entity or person responsible for the water supply,

c. area or institution to be served,

d. scale, in feet,

e. north point,

f. datum used,

g. boundaries of the municipality or area to be served,

h. date, and name of the designing engineer,

i. ink imprint of registered professional engineer's seal and signature,

j. location and size of existing water mains, and

k. location and nature of any existing water works structures and appurtenances affecting the proposed improvements noted on one sheet.

1.2.2 Detailed plans, including, where pertinent:

a. stream crossings, providing profiles with elevations of the streambed and the normal and extreme high and low water levels,

b. profiles having a horizontal scale of not more than 100 feet to the inch and a vertical scale of not more than 10 feet to the inch, with both scales clearly indicated,

c. location and size of the property to be used for the groundwater development with respect to known references such as roads, streams, section lines, or streets,

d. topography and arrangement of present or planned wells or structures, with contour intervals not greater than two feet,

e. elevations of the highest known flood level, floor of the structure, upper terminal of protective casings and outside surrounding grade, using United States Coast and Geodetic Survey, United States Geological Survey or equivalent elevations where applicable as reference,

f. plan and profile drawings of well construction, showing diameter and depth of drill holes, casing and liner diameters and depths, grouting depths, elevations and designation of geological formations, water levels and other details to describe the proposed well completely,

g. location, size and length of existing or proposed streets; water sources, including ponds, lakes and drains; storm, sanitary, combined and house sewers; septic tanks, disposal fields and cesspools; and abandoned wells,

h. schematic flow diagrams and hydraulic profiles showing the flow through various plant units,

i. piping in sufficient detail to show flow through the plant, including waste lines,

j. locations of all chemical storage areas, feeding equipment and points of chemical application (see Chapter 5),

k. 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/or water works structures,

l. locations of sanitary or other facilities, such as lavatories, showers, toilets, and lockers,

m. locations, dimensions, and elevations of all proposed plant facilities,

n. locations of all sampling taps, and

o. adequate description of any features not otherwise covered by the specifications.

1.3 SPECIFICATIONS

Complete, detailed technical specifications must be supplied for the proposed project, including

a. a program for keeping existing water works facilities in operation during construction of additional facilities so as to minimize interruption of service,

b. laboratory facilities and equipment,

c. the number and design of chemical feeding equipment (see Section 5.1),

d. materials or proprietary equipment for sanitary or other facilities including any necessary backflow or back-siphonage protection, and

e. procedures for flushing, disinfection and testing, as needed, prior to placing the project in service.

1.4 DESIGN CRITERIA

A summary of complete design criteria must be submitted for surface water treatment projects, containing but not limited to the following:

a. reservoir surface area, volume, and a volume-versus-depth curve, if applicable,

b. area of watershed, if applicable,

c. flash mix, flocculation and settling basin capacities,

d. retention times,

e. unit loadings,

f. filter area and the proposed filtration rate,

g. backwash rate,

h. feeder capacities and ranges, and

i. minimum and maximum chemical application rates.

1.5 REVISIONS TO APPROVED PLANS

Any changes to approved plans or specifications affecting capacity, hydraulic conditions, operating units, the functioning of water treatment processes, or the quality of water to be delivered, must be re-approved by MDEQ before such changes are implemented. Revised plans or specifications must be submitted in time to permit the review and approval of such plans or specifications before any construction work, which will be affected by such changes, is begun.

1.6 ADDITIONAL INFORMATION REQUIRED

MDEQ may require additional information that is not part of the construction drawings, such as head loss calculations, proprietary technical data, copies of deeds, copies of contracts, etc.

1.7 DEVIATIONS FROM STANDARDS

The Department, on a case-by-case basis for specific projects, may grant deviations from the mandatory requirements of these standards.

1.7.1 Procedure

a. A person desiring a deviation must make a request in writing on the *Department of Environmental Quality Deviation Form*. The request must identify the specific section and deviation of the standards to be considered. Adequate justification for the deviation must be provided. "Engineering judgment" or "professional opinion" without supporting data is not considered adequate justification.

b. A panel of three persons from the Department shall review the request, and make a final determination on whether or not a deviation may be granted.

c. A file of all deviations will be maintained by the Department.

CHAPTER 2 - GENERAL DESIGN CONSIDERATIONS

2.0 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.

2.1 DESIGN BASIS

The system including the water source and treatment facilities must be designed for maximum day demand and the design year, except that the capacity of each well and pump in a hydropneumatic system must be at least equal to the peak instantaneous demand for the design year.

2.2 PLANT LAYOUT

Design must consider

a. functional aspects of the plant layout,

b. provisions for future plant expansion,

c. provisions for expansion of the plant waste treatment and disposal facilities,

d. access roads,

e. site grading,

f. site drainage,

g. walks,

h. driveways, and

i. chemical delivery.

2.3 BUILDING LAYOUT

Design must provide for:

a. adequate ventilation,

b. adequate lighting,

c. adequate heating,

d. adequate drainage,

e. dehumidification equipment, if necessary,

f. accessibility of equipment for operation, servicing and removal,

g flexibility of operation,

h. operator safety,

i. convenience of operation, and

j. safe chemical storage and feed equipment in a separate room to reduce safety and health hazards to prevent contact between incompatible substances and to minimize facility damage in the event of chemical spill or container rupture.

2.4 LOCATION OF STRUCTURES

The appropriate regulating authority must be consulted regarding any structure that is so located that normal or flood streams flows may be impeded.

2.5 ELECTRICAL CONTROLS

Main switch gear controls must be located above grade, in areas not subject to flooding. All electric work must conform to the requirements of the National Electric Code or to relevant state and local codes.

2.6 STANDBY POWER

Dedicated standby power is required so that water may be treated and pumped to the distribution system during power outages to meet the average day demand. Alternatives to dedicated standby power may be considered with proper justification.

Carbon monoxide detectors are recommended when fuel-fired generators are housed.

2.7 SHOP SPACE AND STORAGE

Adequate facilities should be included for shop space and storage consistent with the designed facilities.

2.8 LABORATORY FACILITIES

Each public water supply must have its own equipment and facilities for routine laboratory testing necessary to ensure proper operation. Laboratory equipment selection must be based on the characteristics of the raw water source, anticipated time spent on-site by the operator, and the complexity of the treatment process involved. Laboratory test kits, which simplify procedures for making one or more tests may be acceptable. An operator or chemist qualified to perform the necessary laboratory tests is essential. Analyses conducted to determine compliance with drinking water regulations, except control testing, must be performed in a Department of Public Health and Human Services certified laboratory in accordance with Standard Methods for the Examination of Water and Wastewater or approved alternative methods. Persons designing and equipping laboratory facilities must confer with the reviewing authority before beginning the preparation of plans or the purchase of equipment.

2.8.1 Testing equipment

As a minimum, the following laboratory equipment must be provided:

a. Surface water supplies must provide the necessary facilities for microbiological testing of water for both the treatment plant and the distribution system.

b. Surface water supplies must have a nephelometric turbidimeter meeting the requirements of Standard Methods for the Examination of Water and Wastewater, and must have appropriate equipment and supplies to calibrate the turbidimeter against a primary standard on no less than quarterly intervals.

c. Each surface water treatment plant utilizing coagulation and flocculation including those which lime soften, must have a pH meter, equipment and laboratory supplies for performing jar tests, and titration equipment for both hardness and alkalinity.

d. Each ion-exchange softening plant, and lime-softening plant treating only groundwater must have a pH meter and titration equipment for both hardness and alkalinity.

e. Each iron or manganese removal plant must have test equipment capable of accurately measuring iron to a minimum of 0.1 milligrams per liter, and test equipment capable of accurately measuring manganese to a minimum of 0.05 milligrams per liter.

f. Public water supplies that chlorinate must have test equipment for determining both free and total chlorine residual by methods in Standard Methods for the Examination of Water and Wastewater.

g. Public water supplies that fluoridate must have test equipment for determining fluoride by methods in Standard Methods for the Examination of Water and Wastewater.

h. Public water supplies that feed poly or orthophosphates must have test equipment capable of accurately measuring phosphates from 0.1 to 20 milligrams per liter.

2.8.2 Physical facilities

Sufficient bench space, adequate ventilation, adequate lighting, storage room, laboratory sink, and auxiliary facilities must be provided. Air conditioning may be necessary.

2.9 MONITORING EQUIPMENT

Water treatment plants must be provided with continuous monitoring equipment (including recorders) to monitor water being discharged to the distribution system as required in Chapter 4 of these Standards.

2.10 SAMPLE TAPS

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

2.11 FACILITY WATER SUPPLY

The facility water supply service line and the plant finished water sample tap must be supplied from a source of finished water at a point where all chemicals have been thoroughly mixed, and the required disinfectant contact time has been achieved (see Section 4.3.2). There may not be any cross-connections between the facility water supply service line and any piping, troughs, tanks, or other treatment units containing wastewater, treatment chemicals, raw or partially treated water.

2.12 WALL CASTINGS

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

2.13 METERS

All water supplies must have an acceptable means of metering the finished water.

2.14 PIPING COLOR CODE

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

<u>Water Lines</u>	
Raw	Olive Green
Settled or Clarified	Aqua
Finished or Potable	Dark Blue
<u>Chemical Lines</u>	
Alum or Primary Coagulant	Orange
Ammonia	White
Carbon Slurry	Black
Caustic	Yellow with Green Band
Chlorine (Gas and Solution)	Yellow
Fluoride	Light Blue with Red Band
Lime Slurry	Light Green
Ozone	Yellow with Orange Band
Phosphate Compounds	Light Green with Red Band
Polymers or Coagulant Aids	Orange with Green Band
Potassium Permanganate	Violet
Soda Ash	Light Green with Orange Band
Sulfuric Acid	Yellow with Red Band
Sulfur Dioxide	Light Green with Yellow Band
<u>Waste Lines</u>	
Backwash Waste	Light Brown
Sludge	Dark Brown
Sewer (Sanitary or Other)	Dark Gray
<u>Other</u>	
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 of contrasting color should be on one of the pipes at approximately 30-inch intervals. The name of the liquid or gas should also be on the pipe. In some cases it may be advantageous to provide arrows indicating the direction of flow.

2.15 DISINFECTION

All wells, pipes, tanks, and equipment that can convey or store potable water must be disinfected in accordance with current AWWA procedures. Plans or specifications must outline the procedure and include the disinfection dosage, contact time, and method of testing the results of the procedure.

2.16 OPERATION AND MAINTENANCE MANUAL

An operation and maintenance manual including a parts list and parts order form, operator safety procedures and an operational trouble-shooting section, must be supplied to the water works as part of any proprietary unit installed in the facility.

2.17 OPERATOR INSTRUCTION

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

2.18 SAFETY

Consideration must be given to the safety of water plant personnel and visitors. The design must comply with all applicable safety codes and regulations that may include the Uniform Building Code, Uniform Fire Code, National Fire Protection Association Standards, and state and federal OSHA standards. Items to be considered include noise arresters, noise protection, confined space entry, protective equipment and clothing, gas masks, safety showers and eye washes, handrails and guards, warning signs, smoke detectors, toxic gas detectors and fire extinguishers.

2.19 SECURITY

Security measures must be considered. Such measures, as a minimum, must include means to lock all exterior doorways, windows, gates and other entrances to source, treatment and water storage facilities. Other measures may include fencing, signage, close circuit monitoring, real time water quality monitoring, and intrusion alarms.

2.20 FLOOD PROTECTION

Other than surface water intakes, all water supply facilities and water treatment plant access roads must be protected to at least the 100-year flood elevation or maximum flood of record. A freeboard factor may also be required by MDEQ.

2.21 CHEMICALS AND WATER CONTACT MATERIALS

Chemicals and water contact materials must be approved by MDEQ or meet the appropriate ANSI/AWWA or ANSI/NSF standards.

2.22 OTHER CONSIDERATIONS

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 handicapped, plumbing and electrical codes, construction in the flood plain, etc. All equipment must be designed to operate within manufacturer’s recommended range.

CHAPTER 3 - SOURCE DEVELOPMENT

3.0 GENERAL

In selecting the source of water to be developed, the designing engineer, must prove to the satisfaction of MDEQ, that an adequate quantity of water will be available, and that the water which is to be delivered to the consumers will meet the current requirements of MDEQ with respect to microbiological, physical, chemical and radiological qualities. Each water supply should take its raw water from the best available source that is economically reasonable and technically possible.

3.1 SURFACE WATER

A surface water source includes all tributary streams and drainage basins, natural lakes and artificial reservoirs or impoundments above the point of water supply intake.

3.1.1 Quantity

The quantity of water at the source must

a. be adequate to meet or exceed the design maximum day demand for the service area as shown by calculations based on a one in fifty year drought or the extreme drought of record, and must include consideration of multiple year droughts. Storage must comply with the provisions of Section 7.0.1 or Section 7.2.2, as appropriate. Requirements for flows downstream of the inlet must comply with the requirements of the appropriate reviewing authority,

b. provide a reasonable surplus for anticipated growth,

c. be adequate to compensate for all losses such as silting, evaporation, seepage, etc., and

d. be adequate to provide ample water for other legal users of the source.

3.1.2 Quality

A sanitary survey and study must be made of the factors, both natural and man made, which may affect quality. Such survey and study must include, but not be limited to

a. determining possible future uses of impoundments or reservoirs,

b. determining degree of control of watershed by owner,

c. assessing degree of hazard to the supply by accidental spillage of materials that may be toxic, harmful or detrimental to treatment processes,

d. obtaining samples over a sufficient period of time to assess the microbiological, physical, chemical and radiological characteristics of the water,

e. assessing the capability of the proposed treatment process to reduce contaminants to applicable standards, and

f. consideration of currents, wind and ice conditions, and the effect of confluencing streams.

3.1.3 Minimum treatment

a. The design of the water treatment plant must consider the worst conditions that may exist during the life of the facility.

b. The Department will determine the minimum treatment required to ensure compliance with Title 17, Chapter 38, Sub-chapter 2, ARM.

c. Filtration preceded by appropriate pretreatment must be provided for all surface waters.

3.1.4 Structures

3.1.4.1 Design of intake structures must provide for:

a. withdrawal of water from more than one level if quality varies with depth,

b. separate facilities for release of less desirable water held in storage,

c. where frazil ice may be a problem, holding the velocity of flow into the intake structure to a minimum, generally not to exceed 0.5 feet per second,

d. inspection manholes every 1000 feet for pipe sizes large enough to permit visual inspection,

e. occasional cleaning of the inlet line,

f. adequate protection against rupture by dragging anchors, ice, etc.,

g. ports located above the bottom of the stream, lake or impoundment, but at sufficient depth to be kept submerged at low water levels,

h. where raw water pumping wells are not provided, a diversion device capable of keeping large quantities of fish or debris from entering an intake structure, and

i. when buried surface water collectors are used, sufficient intake opening area must be provided to minimize inlet headloss. Selection of backfill material must be chosen in relation to the collector pipe slot size and gradation of the native material over the collector system.

3.1.4.2 Raw water pumping wells must

a. have motors and electrical controls located above grade, and protected from flooding,

b. be accessible,

c. be designed against flotation,

d. be equipped with removable or traveling screens before the pump suction well,

e. provide for introduction of chlorine or other chemicals in the raw water transmission main if necessary for quality control,

f. have intake valves and provisions for back-flushing or cleaning by a mechanical device and testing for leaks, where practical, and

g. have provisions for withstanding surges where necessary.

3.1.4.3 Off-Stream raw water storage reservoir is a facility into which water is pumped during periods of good quality and high stream flow for future release to treatment facilities. Off-Stream raw water storage reservoirs must be constructed to assure that

a. water quality is protected by controlling runoff into the reservoir,

b. dikes are structurally sound and protected against wave action and erosion,

c. intake structures and devices meet requirements of Section 3.1.4.1,

d. point of influent flow is separated from the point of withdrawal, and

e. separate pipes are provided for influent to and effluent from the reservoir.

3.1.5 Impoundments and reservoirs

3.1.5.1 Site preparation must provide where applicable:

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

b. protection from floods during construction, and

c. abandonment of all wells that will be inundated, in accordance with ARM 36.21.669-678.

3.1.5.2 Construction may require:

a. approval from the appropriate regulatory agencies of the safety features for stability and spillway design, and

b. a permit from an appropriate regulatory agency for controlling stream flow or installing a structure on the bed of a stream or interstate waterway.

3.1.5.3 Water Supply Dams

Water supply dams must be designed and constructed in accordance with federal and state regulations.

3.2 GROUNDWATER

A groundwater source includes all water obtained from dug, drilled, bored or driven wells, and infiltration lines. Prior to construction of a well intended to serve a public water supply, the proposed location and the plans and specifications must be approved by MDEQ in accordance with the requirements of this section. To assess the available water quality and quantity, MDEQ may require construction and testing of the source in accordance with the approved plans and specifications and at the approved location prior to approval of other system components. All wells must be constructed by a licensed water well contractor in accordance with Title 37, Chapter 43, MCA and Title 36, Chapter 21, ARM, current edition, (Water Well Contractor rules) with the following additional requirements.

3.2.1 Quantity

3.2.1.1 Source capacity

a. The total developed groundwater source capacity for systems utilizing gravity storage or pumped storage, unless otherwise specified by MDEQ must equal or exceed the design maximum day demand with the largest producing well out of service. Storage must comply with the requirements of Section 7.0.1.

b. The total developed groundwater source capacity for systems utilizing hydropneumatic storage tanks as the only storage facility must be sufficient to equal or exceed the peak instantaneous demand with the largest producing well out of service. For systems serving 50 or less equivalent dwelling units, MDEQ may allow a reduction in total required system capacity provided the system can maintain the minimum pressures required in section 8.2.1 with the largest producing well out of service.

3.2.1.2 Number of sources

A minimum of two sources of groundwater must be provided

3.2.1.3 Auxiliary power

a. When power failure would result in cessation of minimum essential service, sufficient power must be provided to meet average day demand through

   1. connection to at least two independent public power sources, or

   2. portable or in-place auxiliary power.

b. Auxiliary power is not required when

   1. documentation is submitted that shows power outages are infrequent and of short duration, and

   2. fire protection is not diminished by power failure.

c. When automatic pre-lubrication of pump bearings is necessary, and an auxiliary power supply is provided, the pre-lubrication line must be provided with a valved by-pass around the automatic control, or the automatic control must be wired to the emergency power source.

3.2.2 Quality

The Department will determine, on a case-by-case basis, the minimum treatment required for a groundwater source to ensure compliance with Title 17, Chapter 38, Sub-Chapter 2, ARM.

3.2.2.1 Microbiological quality

a. Disinfection of every new, modified or reconditioned groundwater source

   1. must be provided in accordance with ARM 36.21.662(1) prior to placement of permanent pumping equipment, and

   2. must be provided after placement of permanent pumping equipment.

b. More than 72 hours after disinfection, two or more water samples must be submitted to a laboratory certified by the Department of Public Health and Human Services for microbiological analysis with satisfactory results reported to MDEQ prior to placing the well into service.

c. If MDEQ determines from the required application materials that the source may be groundwater under the direct influence of surface water in accordance with PWS-5, further assessment or treatment may be required.

3.2.2.2 Physical, chemical, and radiological quality

a. Every new, modified or reconditioned groundwater source must be examined for applicable physical and chemical characteristics by tests of a representative sample in a laboratory certified by the Department of Public Health and Human Services, with the results reported to MDEQ.

b. Samples must be collected at the conclusion of the test pumping procedure prior to disinfection and examined as soon as practical. Sample results for the constituents of ARM 17.38.216 must be submitted to MDEQ for review and approval to demonstrate compliance with Title 17, Chapter 38, Sub-Chapter 2, ARM, prior to placing the well into service.

c. Field determinations of physical and chemical constituents or special sampling procedures, may be required by MDEQ.

3.2.3 Location

3.2.3.1 Well location

MDEQ must be consulted prior to design and construction regarding a proposed well location as it relates to required separation between existing and potential sources of contamination and groundwater development. Wells must be located at least 100 feet from sewer lines, septic tanks, holding tanks, and any structure used to convey or retain industrial, storm or sanitary waste. Well location(s) must be based on a source water protection assessment conducted in accordance with Section 1.1.8.2 of this circular.

3.2.3.2 Continued protection

Continued protection of the well site from potential sources of contamination must be provided either through ownership, zoning, easements, leasing or other means acceptable to MDEQ. Such protection must extend for a radius of at least 100 feet around the well. Also, separation distances between proposed wells and potential sources of contamination must be defined and justified by the design engineer in accordance with Section 1.1.8.2 of this circular. The zone of influence of a proposed or existing well must not be in a groundwater mixing zone as defined in ARM 17.30.517. Fencing of the site may be required.

3.2.4 Testing and records

3.2.4.1 Yield and drawdown tests must:

a. be performed on every production well after construction or subsequent treatment and prior to placement of the permanent pump,

b. have the test methods clearly indicated in the project specifications,

c. have a test pump capacity, at maximum anticipated drawdown, at least 1.5 times the quantity anticipated, and

d. provide for continuous constant rate pumping at 1.5 times the design pump capacity for at least 24 hours. Data collection must begin at time zero. The test may be terminated if stabilized drawdown occurs for at least six hours during the test. If the design pumping rate is 35 gpm or greater, the minimum stabilized drawdown period must be at least eight hours.

e. provide the following data:

1. static water level,

2. time of starting and ending each test cycle,

3. pumping rate,

4. test pump capacity-head characteristics,

5. depth of test pump setting,

6. maximum drawdown,

7. pumping water levels taken so as to provide at least 10 evenly spaced data points per log cycle of time (in minutes) on a time-drawdown plot, and

8. water recovery levels taken so as to provide at least 10 evenly spaced data points per log cycle of time (in minutes) on a time-drawdown plot.

Test results must be reported to MDEQ. To demonstrate adequate water quantity, MDEQ may require that pump test results be submitted for review and approval prior to construction of the system.

3.2.4.2 Plumbness and alignment requirements

a. Every well must be tested for plumbness and alignment in accordance with AWWA A100.

b. The test method and allowable tolerance must be clearly stated in the specifications.

c. If the well fails to meet these requirements, it may be accepted by the engineer if it does not interfere with the installation or operation of the pump or uniform placement of grout.

3.2.4.3 Geological data must

a. be determined in accordance with ARM 36.21.667 except that samples must be collected at intervals of five feet or less. Upon completion, a copy of the well log must be submitted to MDEQ, and

b. be supplemented with a driller's log, and accurate geological location such as latitude and longitude or GIS coordinates as determined by GPS to an accuracy of +/- 25 feet.

3.2.5 General well construction

3.2.5.1 Drilling fluids and additives

must be approved by the National Sanitation Foundation (NSF) or a similar ANSI accredited laboratory/organization.

3.2.5.2 Minimum protected depths

a. Minimum protected depths of drilled wells must provide watertight construction to such depth as may be required by MDEQ, to

1. exclude contamination, and

2. seal off formations that are, or may be, contaminated or yield undesirable water.

b. Wells must have unperforated casing to a minimum depth of 25 feet or continuous disinfection with chlorine must be provided.

c. Full time disinfection is required where the water source is an aquifer with a water table that is within 25 feet of the ground surface. A deviation of this standard may be granted by MDEQ in accordance with the procedures of Section 1.7.

3.2.5.3 Permanent steel casing pipe must:

a. be in accordance with ARM 36.21.640,

b. when driven, be equipped with a drive shoe in accordance with ARM 36.21.644, and

c. have joints in accordance with ARM 36.21.642.

3.2.5.4 Nonferrous casing materials

Plastic well casing must be in accordance with ARM 36.21.645 and ARM 36.21.646.

3.2.5.5 Packers

Packers must be of material that will not impart taste, odor, toxic substance or bacterial contamination to the well water. Lead packers must not be used.

3.2.5.6 Screens must:

a. be constructed of materials resistant to damage by chemical action of groundwater or cleaning operations,

b. have size of openings based on sieve analysis of formation and/or gravel pack materials,

c. have sufficient length and diameter to provide adequate specific capacity and low aperture entrance velocity. The entrance velocity must not exceed 0.1 feet per second,

d. be installed so that the pumping water level remains above the screen under all operating conditions,

e. where applicable, be designed and installed to permit removal or replacement without adversely affecting water-tight construction of the well, and

f. be provided with a bottom plate or washdown bottom fitting of the same material as the screen.

3.2.5.7 Grouting requirements

a. All permanent well casing must be sealed in accordance with ARM 36.21.654 through ARM 36.21.660.

b. The casing must be provided with centralizers in accordance with ARM 36.21.649.

3.2.5.8 Upper terminal well construction

a. Permanent casing for all groundwater sources must be in accordance with ARM 36.21.647.

b. Where a well house is constructed, the floor surface must be at least six inches above the final ground elevation.

c. Sites subject to flooding must be provided with an earth mound surrounding the casing and terminating at an elevation at least two feet above the 100-year flood level or highest known flood elevation.

d. The top of the well casing at sites subject to flooding must terminate at least three feet above the 100 year flood level or the highest known flood elevation, whichever is higher .

e. Protection from physical damage must be provided.

3.2.5.9 Development

a. Every well must be developed in accordance with ARM 36.21.653.

b. Where chemical conditioning is required, the specifications must include provisions for the method, equipment, chemicals, testing for residual chemicals, and disposal of waste and inhibitors.

c. Where blasting procedures may be used, the specifications must include the provisions for blasting and cleaning. Special attention must be given to assure that the blasting does not damage the grouting and casing.

3.2.5.10 Capping requirements

Temporary capping must be in accordance with ARM 36.21.661

3.2.5.11 Well abandonment

All wells that have no further use must be abandoned in accordance with ARM 36.21.670 through ARM 36.21.678.

3.2.6 Aquifer types and construction methods -- Special conditions

3.2.6.1 Sand or gravel wells

a. If clay or hardpan is encountered above the water bearing formation, the well must be constructed in accordance with ARM 36.21.657.

b. If a sand or gravel aquifer is overlaid only by permeable soils, the well must be constructed in accordance with ARM 36.21.656.

3.2.6.2 Gravel pack wells

a. Gravel pack must be well rounded particles, 95 per cent siliceous material, that are smooth and uniform, free of foreign material, properly sized, washed and then disinfected immediately prior to or during placement.

b. Gravel pack must be placed in one uniform continuous operation.

c. Gravel refill pipes, when used, must be Schedule 40 steel pipe incorporated within the pump foundation and terminated with screwed or welded caps at least 12 inches above the pump house floor or concrete apron.

d. Gravel refill pipes located in the grouted annular opening must be surrounded by a minimum of 1 1/2 inches of grout.

3.2.6.3 Radial water collector

a. Locations of all caisson construction joints and porthole assemblies must be indicated.

b. The caisson wall must be reinforced to withstand the forces to which it will be subjected.

c. Radial collectors must be in areas and at depths approved by MDEQ.

d. Provisions must be made to assure that radial collectors are essentially horizontal.

e. The top of the caisson must be covered with a watertight floor.

f. All openings in the floor must be curbed and protected from entrance of foreign material.

g. The pump discharge piping may not be placed through the caisson walls.

3.2.6.4 Infiltration lines

a. Infiltration lines may be considered only where geological conditions preclude the possibility of developing an acceptable drilled well.

b. The area around infiltration lines must be under the control of the water purveyor for a distance acceptable to MDEQ.

c. Flow in the lines must be by gravity to the collecting well.

d. Water from infiltration lines will be considered groundwater under the direct influence of surface water unless demonstrated otherwise to the satisfaction of MDEQ.

3.2.6.5 Dug wells

a. Dug wells may be considered only where geological conditions preclude the possibility of developing an acceptable drilled well.

b. A watertight cover must be provided.

c. Minimum protective lining and grouted depth, must be at least ten feet below original or final ground elevation, whichever is lower.

d. Openings must be curbed and protected from entrance of foreign material.

e. Pump discharge piping may not be placed through the well casing or wall.

3.2.6.6 Consolidated formation wells

Drilled wells that penetrate an aquifer either within or overlain by a consolidated formation must be grouted in accordance with ARM 36.21.655.

3.2.6.7 Naturally flowing wells

must be sealed in accordance with ARM 36.21.658.

3.2.7 Well pumps, discharge piping and appurtenances

3.2.7.1 Line shaft pumps

Wells equipped with line shaft pumps must

a. have the casing firmly connected to the pump structure or have the casing inserted into a recess extending at least one-half inch into the pump base,

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

c. avoid the use of oil lubrication at pump settings less than 400 feet. Lubricants must meet ANSI/NSF Standard 61.

3.2.7.2 Submersible pumps

Where a submersible pump is used

a. the top of the casing must be effectively sealed against the entrance of water under all conditions of vibration or movement of conductors or cables, and

b. the electrical cable must be firmly attached to the riser pipe at 20-foot intervals or less.

3.2.7.3 Discharge piping and appurtenances

a. The discharge piping and appurtenances must

   1. be designed so that the friction loss will be low,

   2. have control valves and appurtenances located above the pumphouse floor when an aboveground discharge is provided,

   3. be protected against the entrance of contamination,

   4. be equipped with a check valve in or at the well, a shutoff valve, a pressure gauge, a means of measuring flow, and a smooth nosed sampling tap located at a point where positive pressure is maintained,

   5. where applicable, be equipped with an air release-vacuum relief valve located upstream from the check valve, with exhaust/relief piping terminating in a down-turned position at least 18 inches above the floor and covered with a 24 mesh corrosion resistant screen. Air release vacuum relief valves located in valve pits must meet the relief valve piping requirements in Section 8.5.2,

   6. be valved to permit test pumping and control of each well,

   7. have all exposed piping, valves and appurtenances protected against physical damage and freezing,

8. be properly anchored to prevent movement, and

9. be protected against surge or water hammer.

b. The discharge piping must be provided with a means of pumping to waste, but may not be directly connected to a sewer.

3.2.7.4 Pitless well units

a. Pitless units and pitless adapters submitted as a part of a system need to be specified using manufacturer's name and model number.

b. Pitless units must

1. be shop-fabricated from the point of connection with the well casing to the unit cap or cover,

2. be threaded or welded to the well casing,

3. be of watertight construction throughout,

4. be of materials and weight at least equivalent and compatible to the casing,

5. have field connection to the lateral discharge from the pitless unit of threaded, flanged or mechanical joint connection, and

6. terminate at least 18 inches above final ground elevation or three feet above the 100-year flood level or the highest known flood elevation, whichever is higher.

c. The design of the pitless unit must make provision for

1. access to disinfect the well,

2. a properly constructed casing vent meeting the requirements of Section 3.2.7.5,

3. facilities to measure water levels in the well (see Section 3.2.7.6),

4. a cover at the upper terminal of the well that will prevent the entrance of contamination,

5. a contamination-proof entrance connection for electrical cable,

6. an inside diameter as great as that of the well casing, up to and including casing diameters of 12 inches, to facilitate work and repair on the well, pump, or well screen,

7. at least one check valve within the well casing, and

8. re-sealing the disturbed casing seal to prevent downward movement of both surface water and water and in the pipeline trench.

d. If the connection to the casing is by field weld, the shop-assembled unit must be designed specifically for field welding to the casing. The only field welding permitted will be that needed to connect a pitless unit to the casing.

3.2.7.5 Casing vent

a. Provisions must be made for venting the well casing to atmosphere. Venting must be provided by factory manufactured vented well cap or fabricated vent assembly. All vents must be screened with corrosion resistant material to prevent entry of insects and oriented so as to prevent entry of rainwater.

b. Fabricated vents must terminate in a down turned position, at or above the top of the casing or pitless unit in a minimum 1 1/2 inch diameter opening covered with a 24-mesh screen. The pipe connecting the casing to the vent must be of adequate size to provide rapid venting of the casing. Where vertical turbine pumps are used, vents into the side of the casing may be necessary to provide adequate well venting. Fabricated vent assemblies must be of such design and strength as to be vandal resistant.

3.2.7.6 Water level measurement

a. Provisions (i.e. probe access tube or air line) must be made for periodic measurement of water levels in the completed well.

b. Where pneumatic water level measuring equipment is used it must be made using corrosion resistant materials attached firmly to the drop pipe or pump column and in such a manner as to prevent entrance of foreign materials.

3.2.7.7 Observation wells must be:

a. constructed in accordance with the requirements for permanent wells if they are to remain in service after completion of a water supply well, and

b. protected at the upper terminal to preclude entrance of foreign materials.

3.2.7.8 Well houses

must be designed to meet the pertinent sections of Chapter 6.

CHAPTER 4 - TREATMENT

4.0 GENERAL

The design of treatment processes and devices depends on evaluation of the nature and quality of the particular water to be treated, the desired quality of the finished water and the mode of operation planned. At installations where treatment is used for removal of contaminants for compliance purposes, testing equipment, where commercially available, subject to Department approval, must be provided for treatment process monitoring.

All equipment must be designed to be operated within manufacturers recommended parameters.

4.1 CLARIFICATION

Plants designed for processing surface water must

a. provide a minimum of two units each for rapid mix, flocculation and sedimentation,

b. permit operation of the units in series or parallel where softening is performed and should permit series or parallel operation where plain clarification is performed,

c. 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,

d. provide multiple-stage treatment facilities when required by MDEQ,

e. be started manually following shutdown,

f. minimize hydraulic head losses between units to allow future changes in processes without the need for re-pumping.

4.1.1 Presedimentation

Waters containing high turbidity may require pretreatment, usually sedimentation either with or without the addition of coagulation chemicals.

a. Basin design -- Presedimentation basins must have hopper bottoms or be equipped with continuous mechanical sludge removal apparatus, and provide arrangements for dewatering.

b. Inlet -- Incoming water must be dispersed across the full width of the line of travel as quickly as possible; short-circuiting must be prevented.

c. Bypass - Provisions for bypassing presedimentation basins must be included.

d. Detention time -- Three hours detention is the minimum period recommended; greater detention may be required.

4.1.2 Rapid mix

a. Rapid mix must rapidly disperse chemicals throughout the water to be treated, usually by violent agitation. The engineer must submit the design basis for the velocity gradient (G value) selected, considering the chemicals to be added and water temperature, color and other related water quality parameters. The engineer must also submit the design basis for the type of mixer selected. Whenever pilot studies are required, mixer designs must be based upon the results of the study.

b. Equipment – Basins must be equipped with devices capable of providing adequate mixing for all treatment flow rates. Static mixing may be considered if treatment flow is not variable and can be adjusted by the design engineer.

c. Mixing – The detention period must be not more than thirty seconds.

d. Location - The rapid mixer and the flocculation basin must be as close together as possible.

4.1.3 Flocculation

Flocculation means the agitation of water at low velocities for long periods of time.

a. Basin Design -- Inlet and outlet design must prevent short-circuiting and destruction of floc. A drain and/or pumps must be provided to handle dewatering and sludge removal. Three stage flocculation must be provided for conventional complete treatment plants.

b. Detention -- The flow-through velocity may not be less than 0.5 nor greater than 1.5 feet per minute, with a detention time for floc formation of at least 30 minutes.

c. Equipment -- Agitators must be driven by variable speed drives with the peripheral speed of paddles ranging from 0.5 to 3.0 feet per second.

d. Piping -- Flocculation and sedimentation basins must be as close together as possible. The velocity of flocculated water through pipes or conduits to settling basins may not be less than 0.5 nor greater than 1.5 feet per second. Allowances must be made to minimize turbulence at bends and changes in direction.

e. Other designs -- Baffling may be used to provide for flocculation in small plants only after consultation with MDEQ. The design should be such that the velocities and flows noted above will be maintained.

f. Superstructure -- A superstructure over the flocculation basins may be required.

4.1.4 Sedimentation

Sedimentation must follow flocculation, except in direct filtration facilities. The detention time for effective clarification is dependent upon a number of factors related to basin design and the nature of the raw water. The following criteria apply to conventional sedimentation units:

a. Detention time -- Detention time must provide a minimum of four hours of settling time. This may be reduced to two hours for lime-soda softening facilities treating only groundwater. Reduced sedimentation time may also be approved when equivalent effective settling is demonstrated.

b. Inlet devices -- Inlets must be designed to distribute the water equally and at uniform velocities. Open ports, submerged ports, and similar entrance arrangements are required. A baffle should be constructed across the basin close to the inlet end and should project several feet below the water surface to dissipate inlet velocities and provide uniform flows across the basin.

c. Outlet devices -- Outlet devices must 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.

d. Overflow rate -- The rate of flow over the outlet weir or through the submerged orifices may not exceed 20,000 gallons per day per foot of weir length. Where submerged orifices are used as an alternate for overflow weirs, they should be not lower than three feet below the flow line with flow rates equivalent to weir loadings. The entrance velocity through the submerged orifices must not exceed 0.5 feet per second.

e. Velocity -- The velocity through settling basins may not exceed 0.5 feet per minute. The basins must be designed to minimize short-circuiting. Fixed or adjustable baffles must be provided as necessary to achieve the maximum potential for clarification.

f. Overflow -- An overflow weir (or pipe) should be installed which will establish the maximum water level desired on top of the filters. It must discharge by gravity with a free fall at a location where the discharge will be noted.

g. Superstructure -- A superstructure over the sedimentation basins may be required. If there is no mechanical equipment in the basins and if provisions are included for adequate monitoring under all expected weather conditions, a cover may be provided in lieu of a superstructure.

h. Sludge collection -- Mechanical sludge collection equipment must be provided.

i. Drainage -- Basins must be provided with a means for dewatering. Basin bottoms must slope toward the drain not less than one foot in twelve feet where mechanical sludge collection equipment is not required.

j. Flushing lines -- Flushing lines or hydrants must be provided and must be equipped with backflow prevention devices acceptable to MDEQ.

k. Safety -- Permanent ladders or handholds must be provided on the inside walls of basins above the water level. Guardrails must be included.

l. Sludge removal -- Sludge removal design must provide that

    1. sludge pipes must be not less than three inches in diameter and so arranged as to facilitate cleaning,

    2. entrance to sludge withdrawal piping must prevent clogging,

    3. valves must be located outside the tank for accessibility,

    4. the operator may observe and sample sludge being withdrawn from the unit.

m. Sludge disposal -- Facilities are required by MDEQ for disposal of sludge. (See Section 4.11.) Provisions must be made for the operator to observe and sample sludge being withdrawn from the unit.

4.1.5 Solids contact unit

Units are generally acceptable for combined softening and clarification where water characteristics, especially temperature, do not fluctuate rapidly, flow rates are uniform and operation is continuous. Before such units are considered as clarifiers without softening, specific approval of MDEQ must be obtained. Clarifiers must be designed for the maximum uniform rate and should be adjustable to changes in flow that are less than the design rate and for changes in water characteristics. A minimum of two units are required for surface water treatment.

4.1.5.1 Installation of equipment

Supervision by a representative of the manufacturer must be provided with regard to all mechanical equipment at the time of

a. installation, and

b. initial operation.

4.1.5.2 Operating equipment

The following must be provided for plant operation:

a. a complete outfit of tools and accessories,

b. necessary laboratory equipment,

c. adequate piping with suitable sampling taps so located as to permit the collection of samples of water from critical portions of the units.

4.1.5.3 Chemical feed

Chemicals must be applied at such points and by such means as to ensure satisfactory mixing of the chemicals with the water.

4.1.5.4 Mixing

A rapid mix device or chamber ahead of solids contact units may be required by MDEQ to assure proper mixing of the chemicals applied. Mixing devices employed must be so constructed as to

a. provide good mixing of the raw water with previously formed sludge particles, and

b. prevent deposition of solids in the mixing zone.

4.1.5.5 Flocculation

Flocculation equipment

a. must be adjustable (speed and/or pitch),

b. must provide for coagulation in a separate chamber or baffled zone within the unit,

c. should provide the flocculation and mixing period to be not less than 30 minutes.

4.1.5.6 Sludge concentrators

a. The equipment must provide either internal or external concentrators in order to obtain a concentrated sludge with a minimum of wastewater.

b. Large basins must have at least two sumps for collecting sludge with one sump located in the central flocculation zone.

4.1.5.7 Sludge removal

Sludge removal design must provide that

a. sludge pipes must be not less than three inches in diameter and so arranged as to facilitate cleaning,

b. entrance to sludge withdrawal piping must prevent clogging,

c. valves must be located outside the tank for accessibility, and

d. the operator may observe and sample sludge being withdrawn from the unit.

4.1.5.8 Cross-connections

a. Blow-off outlets and drains must terminate and discharge at places satisfactory to MDEQ.

b. Cross-connection control must be included for the potable water lines used to backflush sludge lines.

4.1.5.9 Detention period

The detention time must be established on the basis of the raw water characteristics and other local conditions that affect the operation of the unit. Based on design flow rates, the detention time should be

a. two to four hours for suspended solids contact clarifiers and softeners treating surface water, and

b. one to two hours for the suspended solids contact softeners treating only groundwater.

MDEQ may alter detention time requirements.

4.1.5.10 Suspended slurry concentrate

Softening units should be designed so that continuous slurry concentrates of one per cent or more, by weight, can be satisfactorily maintained.

4.1.5.11 Water losses

a. Units must be provided with suitable controls for sludge withdrawal.

b. Total water losses should not exceed

    1. five per cent for clarifiers,

    2. three per cent for softening units.

c. Solids concentration of sludge bled to waste should be

    1. three per cent by weight for clarifiers,

    2. five per cent by weight for softeners.

4.1.5.12 Weirs or orifices

The units should be equipped with either overflow weirs or orifices constructed so that water at the surface of the unit does not travel over 10 feet horizontally to the collection trough.

a. Weirs must be adjustable, and at least equivalent in length to the perimeter of the tank.

b. Weir loading may not exceed

1. 10 gallons per minute per foot of weir length for units used for clarifiers,

2. 20 gallons per minute per foot of weir length for units used for softeners.

c. Where orifices are used the loading per foot of launder rates should be equivalent to weir loadings. Either must produce uniform rising rates over the entire area of the tank.

4.1.5.13 Upflow rates

Unless supporting data is submitted to MDEQ to justify rates exceeding the following, rates may not exceed

a. 1.0 gallon per minute per square foot of area at the sludge separation line for units used for clarifiers,

b. 1.75 gallons per minute per square foot of area at the slurry separation line, for units used for softeners.

4.1.6 Tube or plate settlers

Proposals for settler unit clarification may be required to include pilot plant and/or full-scale demonstration satisfactory to MDEQ prior to the preparation of final plans and specifications for approval. Settler units consisting of variously shaped tubes or plates which are installed in multiple layers and at an angle to the flow may be used for sedimentation, following flocculation.

4.1.6.1 General Criteria

a. Inlet and outlet considerations -- Design to maintain velocities suitable for settling in the basin and to minimize short-circuiting.

b. Drainage -- Drain piping from the settler units must be sized to facilitate a quick flush of the settler units and to prevent flooding other portions of the plant.

c. Protection from freezing -- Although most units will be located within a plant, outdoor installations must provide sufficient freeboard above the top of settlers to prevent freezing in the units. A cover or enclosure is strongly recommended.

d. Application rate -- A maximum rate of 2 gal/ft^2/min of cross-sectional area for tube settlers (based on 24-inch long 60^o tubes or 39.5-inch long 7 1/2^o tubes), unless higher rates are successfully shown through pilot or plant or in-plant demonstration studies.

e. Application rates for plates – A maximum plate loading rate of 0.5 gpm per square foot (1.2 m/hr), based on 80 percent of the projected horizontal plate area.

f. Flushing lines -- Flushing lines must be provided to facilitate maintenance and must be properly protected against backflow or back siphonage.

4.1.7 High Rate clarification processes

High rate clarification processes may be approved upon demonstrating satisfactory performance under on-site pilot plant conditions or documentation of full-scale plant operation with similar raw water quality conditions as allowed by MDEQ. Reductions in detention times and/or increases in weir loading rates must be justified. Examples of such processes may include dissolved air flotation, ballasted flocculation/sedimentation, contact flocculation/clarification, and helical upflow, solids contact units.

4.2 FILTRATION

Acceptable filters are limited to, upon the discretion of MDEQ, the following types:

a. rapid rate gravity filters,

b. rapid rate pressure filters,

c. diatomaceous earth filtration,

d. slow sand filtration,

e. direct filtration

f. deep bed rapid rate gravity filters

g. biologically active filters

h. membrane filtration

i. bag and cartridge filters

The application of any one type must be supported by water quality data representing a reasonable period of time to characterize the variations in water quality. Experimental treatment studies may be required to demonstrate the applicability of the method of filtration proposed. Filter media must meet the requirements of ANSI/NSF Standard 61 or otherwise be acceptable to MDEQ.

4.2.1 Rapid rate gravity filters

4.2.1.1 Pretreatment

The use of rapid rate gravity filters requires pretreatment.

4.2.1.2 Rate of filtration

The rate of filtration must be determined through consideration of such factors as raw water quality, degree of pretreatment provided, filter media, water quality control parameters, competency of operating personnel, and other factors as required by MDEQ. In any case, the filter rate must be proposed and justified by the designing engineer to the satisfaction of MDEQ prior to the preparation of final plans and specifications.

4.2.1.3 Number

At least two units must be provided. Where only two units are provided, each must be capable of meeting the plant design capacity (normally the projected maximum daily demand) at the approved filtration rate. Where more than two filter units are provided, the filters must be capable of meeting the plant design capacity at the approved filtration rate with one filter removed from service. Where declining rate filtration is provided, the variable aspect of filtration rates, and the number of filters must be considered when determining the design capacity for the filters.

4.2.1.4 Structural details and hydraulics

The filter structure must be designed to provide for

a. vertical walls within the filter,

b. no protrusion of the filter walls into the filter media,

c. cover by superstructure as determined necessary under local climate,

d. head room to permit normal inspection and operation,

e. minimum depth of filter box of 8-1/2 feet,

f. minimum water depth over the surface of the filter media of three feet,

g. trapped effluent to prevent backflow of air to the bottom of the filters,

h. prevention of floor drainage to the filter with a minimum 4-inch curb around the filters,

i. prevention of flooding by providing overflow,

j. maximum velocity of treated water in pipe and conduits to filters of two feet per second,

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

l. wash water drain capacity to carry maximum flow,

m. walkways around filters, to be not less than 24 inches wide,

n. safety handrails or walls around filter areas adjacent to normal walkways,

o. construction to prevent cross connections and common walls between potable and non-potable water.

4.2.1.5 Wash water troughs

Wash water troughs must be constructed to have,

a. the bottom elevation above the maximum level of expanded media during washing,

b. a two-inch freeboard at the maximum rate of wash,

c. the top edge level and all at the same elevation,

d. spacing so that each trough serves the same number of square feet of filter area,

e. maximum horizontal travel of suspended particles to reach the trough not to exceed three feet.

4.2.1.6 Filter material

The media must be clean silica sand or other natural or synthetic media approved by MDEQ, having the following characteristics:

a. a total depth of not less than 24 inches and generally not more than 30 inches,

b. an effective size range of the smallest material no greater than 0.45 mm to 0.55 mm,

c. a uniformity coefficient of the smallest material not greater than 1.65,

d. a minimum of 12 inches of media with an effective size range no greater than 0.45 mm to 0.55 mm, and a specific gravity greater than other filtering materials within the filter.

e. Types of filter media:

    1. Anthracite - Clean crushed anthracite, or a combination of anthracite and other media may be considered on the basis of experimental data specific to the project, and must have

        a. effective size of 0.45 mm - 0.55 mm with uniformity coefficient not greater than 1.65 when used alone,

        b. effective size of 0.8 mm - 1.2 mm with a uniformity coefficient not greater than 1.85 when used as a cap,

        c. effective size for anthracite used on potable groundwater for iron and manganese removal only must be a maximum of 0.8 mm (effective sizes greater than 0.8 mm may be approved based upon onsite pilot plant studies).

    2. Sand - sand must have

        a. effective size of 0.45 mm to 0.55 mm,

        b. uniformity coefficient of not greater than 1.65.

    3. Granular activated carbon (GAC) - Granular activated carbon media may be considered only after pilot or full scale testing and with prior approval of MDEQ. The design must include the following:

        a. The media must meet the basic specifications for filter media as given in Section 4.2.1.6.a. through d. except that larger size media may be allowed by MDEQ where full scale tests have demonstrated that treatment goals can be met under all conditions.

        b. There must be provisions for a free chlorine residual and adequate contact time in the water following the filters and prior to distribution (See 4.3.2.d. and 4.3.3).

        c. There must be means for periodic treatment of filter material for control of bacterial and other growth.

        d. Provisions must be made for frequent replacement or regeneration if GAC is used for filtration.

    4. Other media -- Other media will be considered based on experimental data and operating experience.

5. 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, and

   b. uniformity coefficient not greater than 1.7.

6. Gravel -- Gravel, when used as the supporting media must consist of hard, durable, rounded silica particles and may not include flat or elongated particles. The coarsest gravel must be 2 1/2 inches in size when the gravel rests directly on the strainer system, and must extend above the top of the perforated laterals. Not less than four layers of gravel must be provided in accordance with the following size and depth distribution when used with perforated laterals:

Size	Depth
2 1/2 to 1 1/2 inches	5 to 8 inches
1 1/2 to 3/4 inches	3 to 5 inches
3/4 to 1/2 inches	3 to 5 inches
1/2 to 3/16 inches	2 to 3 inches
3/16 to 3/32 inches	2 to 3 inches

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

4.2.1.7 Filter bottoms and strainer systems

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

a. minimize loss of head in the manifold and laterals,

b. assure even distribution of wash water and even rate of filtration over the entire area of the filter,

c. provide the ratio of the area of the final openings of the strainer systems to the area of the filter at about 0.003,

d. provide the total cross-sectional area of the laterals at about twice the total area of the final openings,

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

f. Lateral perforations without strainers must be directed downward.

4.2.1.8 Surface wash or 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 revolving-type apparatus. All devices must be designed with

a. provision for water pressures of at least 45 psi,

b. a properly installed vacuum breaker or other approved device to prevent back siphonage if connected to the treated water system,

c. 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,

d. air wash can be considered based on experimental data and operating experiences.

4.2.1.9 Air scouring

Air scouring can be considered in place of surface wash

a. air flow for air scouring the filter must be 3-5 standard cubic feet per minute per square foot of filter area(0.9 – 1.5 $m^3/min/m^2$) when the air is introduced in the underdrain; a lower air rate must be used when the air scour distribution system is placed above the underdrains,

b. concurrent wash water rates must not exceed 8 gallons per minute per square foot unless a method of retaining the filter media is provided,

c. air scouring must be followed by a fluidization wash sufficient to restratify the media,

d. air must be free from contamination,

e air scour distribution systems must be placed below the media and supporting bed interface; if placed at the interface the air scour nozzles must be designed to prevent media from clogging the nozzles or entering the air distribution system.

f. piping for the air distribution system must not be flexible hose that will collapse when not under air pressure, and must not be a relatively soft material that may erode at the orifice opening with the passage of air at high velocity.

g. air delivery piping must not pass through the filter media nor shall there be any arrangement in the filter design that would allow short-circuiting between the applied unfiltered water and the filtered water.

h. Consideration must be given to maintenance and replacement of air delivery piping.

i. The backwash water delivery system must be capable of 15 gallons per minute per square foot of filter surface area (37 m/hr); however, when air scour is provided the backwash water rate must be variable and must not exceed 8 gallons per minute per square foot (20 m/hr) unless operating experience shows that a higher rate is necessary to remove scoured particles from filter media surfaces.

j. The filter underdrains must be designed to accommodate air scour piping when the piping is installed in the underdrain, and

k. provisions of Section 4.2.1.11 must be followed

4.2.1.10 Appurtenances

a. The following must be provided for every filter:

1. influent and effluent sampling taps,

2. an indicating loss of head gauge,

3. an indicating rate-of-flow meter. A modified rate controller, which limits the rate of filtration to a maximum rate may be used. However, equipment that simply maintains a constant water level on the filters is not acceptable, unless the rate of flow onto the filter is properly controlled. A pump or a flow meter in each filter effluent line may be used as the limiting device for the rate of filtration only after consultation with MDEQ,

4. where used for surface water , provisions for filtering to waste with appropriate measures for backflow prevention

5. A continuous monitoring and recording turbidimeter for each individual filter and the combined filter effluent in surface water treatment plants. If there are two or fewer filters, than combined filter effluent may be monitored instead.

b. It is recommended the following be provided for every filter:

1. wall sleeves providing access to the filter interior at several locations for sampling or pressure sensing,

2. a 1 to 1 1/2 inch pressure hose and storage rack at the operating floor for washing filter walls,

3. particle monitoring equipment as a means to enhance overall treatment operations where used for surface water.

4.2.1.11 Backwash

Provisions must be made for washing filters as follows:

a. a minimum rate of 15 gallons per minute per square foot, consistent with water temperatures and specific gravity of the filter media. A rate of 20 gallons per minute per square foot or a rate necessary to provide for a 50 percent expansion of the filter bed is recommended. A reduced rate of 10 gallons per minute per square foot may be acceptable for full depth anthracite or granular activated carbon filters,

b. filtered water provided at the required rate by wash water tanks, a wash water pump, from the high service main, or a combination of these,

c. wash water pumps in duplicate unless an alternate means of obtaining wash water is available,

d. not less than 15 minutes wash of one filter at the design rate of wash,

e. a wash water regulator or valve on the main wash water line to obtain the desired rate of filter wash with the wash water valves on the individual filters open wide,

f. a rate-of-flow indicator, preferably with a totalizer, on the main wash water line, located so that the operator can easily read it during the washing process,

g. design to prevent rapid changes in backwash water flow.

h. Backwash may be operated initiated. Automated systems must be able to be adjusted by the operator.

4.2.1.12 Miscellaneous

Roof drains may not discharge into the filters or basins and conduits preceding the filters.

4.2.2 Rapid rate pressure filters

The normal use of these filters is for iron and manganese removal. Pressure filters may be used in the filtration of surface or other polluted waters or following lime-soda softening with the approval of MDEQ. Pilot studies must be conducted to justify the use of pressure filters to treat surface water or other polluted waters.

4.2.2.1 General

Minimum criteria relative to number, rate of filtration, structural details and hydraulics, filter media, etc., provided for rapid rate gravity filters also apply to pressure filters where appropriate.

4.2.2.2 Rate of filtration

The rate may not exceed three gallons per minute per square foot of filter area except where in-plant testing or pilot testing as approved by MDEQ has demonstrated satisfactory results at higher rates.

4.2.2.3 Details of design

The filters must be designed to provide for

a. loss of head gauges and sample access on the inlet and outlet pipes of each filter,

b. an easily readable meter or flow indicator on each battery of filters. A flow indicator is recommended for each filtering unit,

c. filtration and backwashing of each filter individually with an arrangement of piping as simple as possible to accomplish these purposes,

d. 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,

e. the top of the wash water collectors to be at least 18 inches above the surface of the media,

f. the underdrain system to efficiently collect the filtered water and to uniformly distribute the backwash water at a rate not less than 15 gallons per minute per square foot of filter area,

g. backwash flow indicators and controls that are easily readable while operating the control valves,

h. an air release valve on the highest point of each filter,

i. an accessible manhole to facilitate inspection and repairs,

j. means to observe the wastewater during backwashing,

k. construction to prevent cross-connection.

4.2.3 Diatomaceous earth filtration

The use of these filters may be considered for application to surface waters with low turbidity and low bacterial contamination, and may be used for iron removal for groundwaters providing the removal is effective and the water is of satisfactory sanitary quality before treatment.

4.2.3.1 Conditions of use

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

a. bacteria removal,

b. color removal,

c. turbidity removal where either the gross quantity of turbidity is high or the turbidity exhibits poor filterability characteristics,

d. filtration of waters with high algae counts.

4.2.3.2 Pilot plant study

Installation of a diatomaceous earth filtration system must be preceded by a pilot plant study on the water to be treated.

a. Conditions of the study such as duration, filter rates, head loss accumulation, slurry feed rates, turbidity removal, bacteria removal, etc., must be approved by MDEQ prior to the study.

b. Satisfactory pilot plant results must be obtained prior to preparation of final construction plans and specifications.

c. The pilot plant study must demonstrate the ability of the system to meet applicable drinking water standards at all times.

4.2.3.3 Types of filters

Pressure or vacuum diatomaceous earth filtration units will be considered for approval. However, the vacuum type is preferred for its ability to accommodate a design which permits observation of the filter surfaces to determine proper cleaning, damage to a filter element, and adequate coating over the entire filter area.

4.2.3.4 Treated water storage

Treated water storage capacity in excess of normal requirements must be provided to:

a. allow operation of the filters at a uniform rate during all conditions of system demand at or below the approved filtration rate, and

b. guarantee continuity of service during adverse raw water conditions without bypassing the system.

4.2.3.5 Number of units

See Section 4.2.1.3

4.2.3.6 Precoat

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

b. Quantity - Diatomaceous earth in the amount of 0.1 pounds per square foot of filter area or an amount sufficient to apply a 1/16 inch coating should be used with recirculation. When precoating is accomplished with a filter-to-waste system, 0.15 - 0.2 pounds per square foot of filter area is recommended.

4.2.3.7 Body feed

A body feed system to apply additional amounts of diatomaceous earth slurry during the filter run is required to avoid short filter runs or excessive head losses.

a. Quantity - Rate of body feed is dependent on raw water quality and characteristics and must be determined in the pilot plant study.

b. Operation and maintenance can be simplified by providing accessibility to the feed system and slurry lines.

c. Continuous mixing of the body feed slurry is required.

4.2.3.8 Filtration

a. Rate of filtration - The recommended nominal rate is 1.0 gallon per minute per square foot of filter area with a recommended maximum of 1.5 gallons per minute per square foot. The filtration rate must be controlled by a positive means.

b. Head loss - The head loss may not exceed 30 psi for pressure diatomaceous earth filters, or a vacuum of 15 inches of mercury for a vacuum system.

c. Recirculation - A recirculation or holding pump must 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. A minimum recirculation rate of 0.1 gallon per minute per square foot of filter area must be provided.

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

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

4.2.3.9 Backwash

A satisfactory method to thoroughly remove and dispose of spent filter cake must be provided.

4.2.3.10 Appurtenances

The following must be provided for every filter:

a. sampling taps for raw and filtered water,

b. loss of head or differential pressure gauge,

c. rate-of-flow indicator, preferably with totalizer,

d. a throttling valve used to reduce rates below normal during adverse raw water conditions,

e. evaluation of the need for body feed, recirculation, and any other pumps, in accordance with Section 6.3.

f. provisions for filtering to waste with appropriate measures for backflow prevention (see Chapter 9.6)

4.2.3.11 Monitoring

a. A continuous monitoring turbidimeter with recorder is required on each filter's effluent for plants treating surface water, unless there are two or fewer filters, in which case combined filter effluent may be monitored

b. Particle monitoring equipment should be provided as a means to enhance overall treatment operations for plants treating surface water.

4.2.4 Slow sand filters

The use of these filters will require prior engineering studies to demonstrate the adequacy and suitability of this method of filtration for the specific raw water supply.

4.2.4.1 Quality of raw water

Slow sand filtration must be limited to waters having maximum turbidities of 10 units and maximum color of 15 units; such turbidity must not be attributable to colloidal clay. Raw water quality data must include examinations for algae.

4.2.4.2 Number

At least two units must be provided. Where only two units are provided, each must be capable of meeting the plant design capacity (normally the projected maximum daily demand) at the approved filtration rate. Where more than two filter units are provided, the filters must be capable of meeting the plant design capacity at the approved filtration rate with one filter removed from service.

4.2.4.3 Structural details and hydraulics

Slow rate gravity filters must be so designed as to provide:

a. a cover,

b. headroom to permit normal movement by operating personnel for scraping and sand removal operations,

c. adequate manholes and access ports for handling of sand,

d. filtration to waste,

e. an overflow at the maximum filter water level.

f. protection from freezing.

4.2.4.4 Rates of filtration

The permissible rates of filtration must be determined by the quality of the raw water and experimental data derived from the water to be treated. The nominal rate may be 45 to 150 gallons per day per square foot of sand area, with somewhat higher rates acceptable when demonstrated to the satisfaction of MDEQ.

4.2.4.5 Underdrains

Each filter unit must be equipped with a main drain and an adequate number of lateral underdrains to collect the filtered water. The underdrains must be so spaced that the maximum velocity of the water flow in the underdrain will not exceed 0.75 feet per second. The maximum spacing of laterals may not exceed 3 feet if pipe laterals are used.

4.2.4.6 Filter material

a. Filter sand must be placed on graded gravel layers for a minimum depth of 30 inches.

b. The effective size must be between 0.15 mm and 0.30 mm. Larger sizes may be considered by MDEQ; a pilot study may be required.

c. The uniformity coefficient may not exceed 2.5.

d. The sand must be clean and free from foreign matter.

e. The sand must be rebedded when scraping has reduced the bed depth to no less than 19 inches. Where sand is to be reused in order to provide biological seeding and shortening of the ripening process, rebedding must utilize a “throw over” technique whereby new sand is placed on the support gravel and existing sand is replaced on top of the new sand.

4.2.4.7 Filter gravel

The supporting gravel must conform to the size and depth distribution provided for rapid rate gravity filters. See 4.2.1.6.e.5,6.

4.2.4.8 Depth of water on filter beds

Design must provide a depth of at least three feet of water over the sand. Influent water may not scour the sand surface.

4.2.4.9 Control appurtenances

Each filter must be equipped with:

a. loss of head gauge,

b. an orifice, Venturi meter, or other suitable metering device installed on each filter to control the rate of filtration,

c. an effluent pipe designed to maintain the water level above the top of the filter sand,

d. an influent and effluent sample tap.

4.2.4.10 Ripening

After scraping or rebedding, slow sand filters must be operated to waste during a ripening period until the filter effluent turbidity falls to consistently below the regulated drinking water standard established for the system.

4.2.5 Direct filtration

Direct filtration, as used herein, refers to the filtration of a surface water following chemical coagulation and possibly flocculation but without prior settling. The nature of the treatment process will depend upon the raw water quality. A full-scale direct filtration plant may not be constructed without prior pilot studies, which are acceptable to MDEQ. In-plant demonstration studies may be appropriate where conventional treatment plants are converted to direct filtration. Where direct filtration is proposed, an engineering report must be submitted prior to conducting pilot plant or in-plant demonstration studies.

4.2.5.1 Engineering report

In addition to the items considered in Section 1.1, "Engineering Report," the report must include a historical summary of meteorological conditions and of raw water quality with special reference to fluctuations in quality, and possible sources of contamination. The following raw water parameters must be evaluated in the report:

a. color,

b. turbidity,

c. bacterial concentration,

d. microscopic biological organisms, including algae,

e. temperature,

f. total solids,

g. general inorganic chemical characteristics,

h. additional parameters as required by MDEQ,

i. disinfection byproduct precursors.

The report must also include a description of methods and work to be done during a pilot plant study or, where appropriate, an in-plant demonstration study.

4.2.5.2 Pilot plant studies

After approval of the engineering report, a pilot study or in-plant demonstration study must be conducted. The study must be conducted over a sufficient time to treat all expected raw water conditions throughout the year. The study must emphasize but not be limited to, the following items:

a. chemical mixing conditions including shear gradients and detention periods,

b. chemical feed rates,

c. use of various coagulants and coagulant aids,

d. flocculation conditions,

e. filtration rates,

f. filter gradation, types of media and depth of media,

g. filter breakthrough conditions, and

h. adverse impact of recycling backwash water due to solids, algae, disinfection byproduct formation and similar problems.

Prior to the initiation of design plans and specifications, a final report including the engineer's design recommendations must be submitted to MDEQ.

The pilot plant filter must be of a similar type and operated in the same manner as proposed for full-scale operation.

The pilot plant must demonstrate the minimum contact time necessary for optimal filtration for each coagulant proposed.

4.2.5.3 Pretreatment -- Rapid mix and flocculation

The final rapid mix and flocculation basin design should be based on the pilot plant or in-plant demonstration studies augmented with applicable portions of Section 4.1.2, "Rapid Mix" and Section 4.1.3, "Flocculation."

4.2.5.4 Filtration

a. Filters must be rapid rate gravity or pressure filters with dual or mixed media. The final filter design must be based on the pilot plant or in-plant demonstration studies augmented by applicable portions of Section 4.2.1, "Rapid Rate Gravity Filters." Single media sand filters may not be used.

b. Surface wash, subsurface wash or air scour must be provided for the filters in accordance with 4.2.1.8 and 4.2.1.9.

c. Provisions for filtration to waste with appropriate measures for backflow prevention may be required by MDEQ.

4.2.5.5 Control and operation

a. A continuous monitoring and recording turbidimeter must be installed on each filter effluent line. Effluent sample taps must be available whether or not turbidimeters are installed.

b. Additional continuous monitoring equipment to assist in control of coagulant dose may be required by MDEQ.

4.2.5.6 Siting requirements

The plant design and land ownership surrounding the plant must allow for the installation of conventional sedimentation basins should it be found that such are necessary.

4.2.6 Deep bed rapid rate gravity filters

4.2.6.1 Definition

Deep bed rapid rate gravity filters, as used herein, generally refers to rapid rate gravity filters with filter material depths equal to or greater than 48 inches. Filter media sizes are typically larger than those listed in Section 4.2.1.6 (e).

4.2.6.2 Pilot Studies

Deep bed rapid rate filters may be considered based on pilot studies pre approved by MDEQ.

4.2.6.3 Final Design

The final filter design must be based on the pilot plant studies and must comply with all applicable portions of Section 4.2.1. Careful attention must be paid to the design of the backwash system which usually includes simultaneous air scour and water backwash at subfluidization velocities.

4.2.7 Biologically active filters

4.2.7.1 Definition

Biologically active filtration, as used herein, refers to the filtration of a surface water (or a ground water with iron, manganese or significant natural organic material) which includes the establishment and maintenance of biological activity within the filtration media.

Objectives of biologically active filtration may include control of disinfection byproduct precursors, increased disinfectant stability, reduction of substrates for microbial regrowth, breakdown of small quantities of synthetic organic chemicals, reduction of ammonia-nitrogen, and oxidation of iron and manganese. Biological activity can have an adverse impact on turbidity, particle and microbial pathogen removal, disinfection practices; head loss development; filter run times and distribution system corrosion. Design and operation must ensure that aerobic conditions are maintained at all times. Biologically active filtration often includes the use of ozone as a pre-oxidant/disinfectant which breaks down natural organic materials into biodegradable organic matter and granular activated carbon filter media which may promote denser biofilms.

4.2.7.2 Pilot Studies

Biologically active filters may be considered based on pilot studies pre-approved by MDEQ. The study objectives must be clearly defined and must ensure the microbial quality of the filtered water under all anticipated conditions of operation. The pilot study must be of sufficient duration to ensure establishment of full biological activity; often greater than three months is required. Also, the pilot study must establish empty bed contact time, biomass loading, and/or other parameters necessary for successful operation as required by MDEQ.

4.2.7.3 Final Design

The final filter design must be based on the pilot plant studies and must comply with all applicable portions of Section 4.2.1.

4.2.8 Membrane Filtration: Reverse Osmosis And Nanofiltration

Overall treatment requirements and disinfection credits must be discussed with and approved by MDEQ. Disinfection is required with membrane filtration for additional pathogen control. The system must be properly disinfected and water must be run to waste each time the vessels are opened for maintenance.

4.2.8.1 Selection and Design Considerations:

The following items must be considered in evaluating the applicability of reverse osmosis (RO) and nanofiltration (NF):

a. Membrane Selection: Two types of membranes are typically used. These are Cellulose Acetate and Polyamide/Composite. Membrane configurations include tubular, spiral wound and hollow fine fiber. Operational conditions and useful life vary depending on type of membrane selected, quality of feedwater, and process operating parameters.

b. Useful Life of the Membrane: The membrane represents a major cost component in the overall water system. Membrane replacement frequency can significantly affect the overall cost of operating the treatment facility. Power consumption may also be a significant cost factor for RO/NF plants.

c. Pretreatment Requirements: Acceptable feedwater characteristics are dependent on the type of membrane and operational parameters of the system. Without pretreatment or acceptable feedwater quality, the membrane may become fouled or scaled, resulting in a shortened useful life. Pretreatment is usually needed for turbidity reduction, iron or manganese removal, stabilization of the water to prevent scale formation, microbial control, chlorine removal, and pH adjustment, and must be addressed by the design engineer

d. Treatment Efficiency: Reverse osmosis is highly efficient in removing metallic salts and ions from the raw water. Efficiencies, however, do vary depending on the ion being removed and the membrane utilized. For most commonly encountered ions, removal efficiencies will range from 85% to over 99%. Organics removal is dependent on the molecular weight, the shape of the organic molecule and the pore size of the membrane utilized. Removal efficiencies may range from as high as 99% to less than 30%, depending on the membrane type and treatment objective.

e. Bypass Water: Reverse osmosis permeate will be virtually demineralized. The design must provide for a portion of the raw water to bypass the unit to maintain a stable water within the distribution system and to improve process economics as long as the raw water does not contain unacceptable levels of contaminants. Use of split treatment/bypass water as a compliance strategy is subject to the approval of MDEQ.

f. Post Treatment: Post treatment typically includes degasification for carbon dioxide and hydrogen sulfide removal (if present), pH and hardness adjustment for corrosion control and disinfection as a secondary pathogen control and for distribution system protection. Post treatment must be addressed by the design engineer in the design report.

g. Reject Water: Reject water may range from 10% to 50% of the raw water pumped to the reverse osmosis unit. This may present a problem both from the standpoint of source availability and from the standpoint of waste treatment capabilities. The amount of reject water from a unit may be reduced to a limited extent by increasing the feed pressure to the unit; however, this may result in a shorter membrane life. Acceptable methods of waste disposal include discharge to the municipal sewer system, or to an evaporation pond. Reject water disposal, including quantity and quality, must be addressed by the design engineer in the design report. The method of waste disposal must be approved by MDEQ.

h. Cleaning the Membrane: The membrane must be periodically cleaned with acid, detergents and possibly disinfectants, or replaced. Method of cleaning and chemicals used must be approved by MDEQ. Care must be taken in the acid cleaning process to prevent contamination of both the raw and finished water system. Cleaning chemicals, frequency and procedure must follow membrane manufacturer's guidelines. Chemicals must meet AWWA standards and ANSI/NSF Standard 60, where applicable.

i. Pilot Plant/Verification Study: Prior to initiating the design of a reverse osmosis or nanofiltration treatment facility, MDEQ must be contacted to determine if a pilot plant or verification study will be required. In most cases, a pilot plant study will be required to determine the best membrane to use, the type of pretreatment, type of post treatment, the bypass ratio, the amount of reject water, process efficiency and other design criteria.

j. Operator Training and Startup: The ability to obtain qualified operators must be evaluated in selection of the treatment process. The necessary operator training must be provided prior to plant start-up. Systems that do not have certified operators must have third party maintenance contracts.

4.2.9 Microfiltration And Ultrafiltration

Chemicals used for cleaning and the method of and procedures for cleaning must be acceptable to the membrane manufacturer and approved by MDEQ. Chemicals must meet AWWA standards and ANSI/NSF Standard 60, where applicable.

Overall treatment requirements and disinfection credits must be discussed with and approved by MDEQ. Disinfection is required with membrane filtration for additional pathogen control and distribution system protection. The system must be properly disinfected and water must be run to waste each time the vessels are opened for maintenance.

4.2.9.1 Selection and Design Considerations:

The following items must be considered in evaluating the applicability of microfiltration (MF) and ultrafiltration (UF):

a. A review of source raw water quality data, including turbidity or particle counts, seasonal changes, organic loading, microbial activity, temperature differentials, as well as other inorganic and physical parameters, must be conducted to determine feasibility and cost of the system. The degree of pre-treatment required, if any must be addressed by the design engineer. Design considerations and membrane selection at this phase must also address the issue of target removal efficiencies versus acceptable trans-membrane pressure differentials. On surface water supplies, pre-screening or cartridge filters may be required.

b. Prior to initiating the design of a MF or UF treatment facility, MDEQ must be contacted to determine if a pilot plant or verification study will be required. In most cases, a pilot plant study will be necessary to determine the best membrane to use, particulate/organism removal efficiencies, cold and warm water flux, the need for pre-treatment, fouling potential, operating and transmembrane pressure and other design considerations. Any virus removal credit must also be documented through an appropriate piloting process. MDEQ must be contacted prior to conducting the pilot study to establish the protocol to be followed.

c. The life expectancy of a particular membrane under consideration must be evaluated during the pilot study or from other relevant available data. Membrane replacement frequency is a significant factor in operation and maintenance cost comparisons in the selection of the process.

d. Some membrane materials are incompatible with certain oxidants. If the system must rely on pretreatment oxidants for other purposes, for example, zebra mussel control, taste and odor control, and iron and manganese oxidation, the selection of the membrane material becomes a significant design consideration. The design engineer must address compatibility in the design report.

e. The source water temperature can significantly impact the flux of the membrane under consideration. At low water temperatures the flux can be reduced appreciably(due to higher water viscosity and resistance of the membrane to permeate), possibly impacting process economics by the number of membrane units required for a full-scale facility. Seasonal variation of design flow rates may be based on documented lower demand during cold weather.

f. Back flushing volumes can range from 5-15 percent of the permeate flow, depending upon the frequency of flushing/cleaning and the degree of fouling and this must be considered in the treatment system sizing and the capacity of the raw water source.

g. An appropriate level of finished water monitoring as well as periodic integrity testing must be provided to routinely evaluate membrane and housing integrity and overall filtration performance. Monitoring options may include particle counters, manual and/or automated pressure testing or air diffusion tests, sonic testing, and biological testing. Consult MDEQ regarding process monitoring requirements.

h. Cross connection considerations must be incorporated into the system design, particularly with regard to chemical feeds and waste piping used for membrane cleaning, waste stream and concentrate.

i. Redundancy of critical control components including but not limited to valves, air supply, and computers shall be required as per MDEQ.

j. Other post-membrane treatment requirements must be evaluated in the final design to address other contaminants of concern such as color and disinfection by-product precursors.

k. Operator Training and Startup: The ability to obtain qualified operators must be evaluated in selection of the treatment process. The necessary operator training must be provided prior to plant start-up.

l. The system must be properly disinfected and water must be run to waste each time the vessels are opened for maintenance.

4.2.10 Bag and Cartridge Filters

With this type of treatment there is no alteration of water chemistry. So, once the technology has demonstrated the 2-log removal efficiency, no further pilot demonstration is necessary. The demonstration of filtration is specific to a specific housing and a specific bag or cartridge filter. Any other combinations of different bags, cartridges, or housings will require additional demonstration of filter efficiency.

Treatment of a surface water must include source water protection, filtration, and disinfection. The following items must be considered in evaluating the applicability of bag or cartridge filtration.

4.2.10.1 Pre-design/Design

a. The filter housing and bag/cartridge filter must demonstrate a minimum filter efficiency of 2-log reduction in particles size 2 microns and above. MDEQ will decide whether or not a pilot demonstration or verification study is necessary for each installation. This filtration efficiency may be accomplished by:

1. Microscopic particulate analysis, including particle counting, sizing and identification, which determines occurrence and removals of micro-organisms and other particles across a filter or system under ambient raw water source conditions, or when artificially challenged.

2. *Giardia/Cryptosporidium* surrogate particle removal evaluation in accordance with procedures specified in NSF Standard 53 or equivalent procedures. These evaluations may be conducted by NSF or by another third-party whose certification would be acceptable to MDEQ.

3. "Particle Size Analysis Demonstration for *Giardia* Cyst Removal Credit" procedure presented in Appendix M of the EPA Surface Water Treatment Rule Guidance Manual

4. "Nonconsensus" live *Giardia* challenge studies that have been designed and carried out by a third-party agent recognized and accepted by MDEQ for interim evaluations. Presently, uniform protocol procedures have not been established for live *Giardia* challenge studies. If a live *Giardia* challenge study is performed on site there must be proper cross-connection control equipment in place and the test portion must be operated to waste.

5. Methods other than these that are approved by MDEQ.

b. System components such as housing, bags, cartridges, membranes, gaskets, and O-rings must be evaluated under NSF Standard 61, or an equivalent method, for leaching of contaminants. Additional testing may be required by MDEQ.

c. The source water or pre-treated water must have a turbidity of less than 5 NTU.

d. The flow rate through the treatment process must be monitored with a flow valve and meter. The flow rate through the bag/cartridge filter must not exceed 20 gpm, unless documentation at higher flow rates demonstrates that it will meet the requirements for removal of particles.

e. Pretreatment may be required by MDEQ. This is to provide a more constant water quality to the bag/cartridge filter. Examples of pretreatment include media filters, larger opening bag/cartridge filters, infiltration galleries, and beach wells. Location of the water intake must be considered in the pretreatment evaluation.

f. Particle count analysis may be used to determine the level of pretreatment necessary. It should be noted that particulate counting is a "snap shot" in time and that there can be seasonal variations such as algae blooms, lake turnover, spring runoff and heavy rainfall events that will give varied water quality.

g. It is recommended that chlorine or another disinfectant be added at the head of the treatment process to reduce/eliminate the growth of algae, bacteria, etc., on the filters. The impact on disinfection-byproduct formation must be considered and addressed. The impact of disinfection on other unit processes in the treatment system must be considered and addressed. Disinfection may not be compatible with other treatment processes.

h. A filter to waste component is strongly recommended for any pretreatment pressure sand filters. At the beginning of each filter cycle and/or after every backwash of the prefilters a set amount of water should be discharged to waste before water flows into the bag/cartridge filter. Filter to waste must be provided for the final filters and a set amount of water must be discharged to waste after changing the filters. The design engineer must determine the appropriate amount of filter to waste for each installation on a case-by-case basis.

i. If pressure media filters are used for pretreatment they must be designed according to Section 4.2 2.

j. Sampling taps must be provided before and after any treatment so water samples can be collected.

k. Pressure gages, isolation valves and sampling taps must be installed before and after the media filter and before and after each bag/cartridge filter.

l. An automatic air release valve must be installed on top of the filter housing.

m. Frequent start and stop operation of the bag or cartridge filter should be avoided. To avoid this frequent start and stop cycle the following options are recommended.

    1. install a slow opening and closing valve ahead of the filter to reduce flow surges

    2. reduce the flow through the bag or cartridge filter to as low as possible to lengthen filter run times.

    3. install a re-circulating pump that pumps treated water back to a point ahead of the bag or cartridge filter. Care must be taken to make sure there is no cross connection between the finished water and raw water.

n. A minimum of two bags or cartridge filter housings in parallel must be provided for water systems that must provide water continuously.

o. A pressure relief valve must be incorporated into either the bag or cartridge filter housing or immediately upstream of the assembly, but downstream of the shutoff valve.

p. Complete automation of the treatment system is not required. Automation of the treatment plant should be incorporated into the ability of the water system to monitor the finished water quality. Where required, a qualified water operator must be available to run the treatment plant.

q. A plan of action must be in place if the water quality parameters fail to meet EPA or MDEQ standards.

4.2.10.2 Operations

a. The filtration and backwash rates must be monitored so that the prefilters are being optimally used.

b. The bag and cartridge filters must be replaced when a pressure difference of 30 psi or other pressure difference recommended by the manufacturer is observed. It should be noted that bag filters do not load linearly. Additional observation of the filter performance is required near the end of the filter run.

c. Maintenance (o-ring replacement) must be performed in accordance with the manufacturer's recommendations.

d. Sterile rubber gloves and disposable face mask covering the nose and mouth must be worn when replacing or cleaning the cartridge or bag filters.

e. The filter system must be properly disinfected and water must be run to waste each time the cartridge or bag filter vessels are opened for maintenance.

f. The following parameters must be monitored: instantaneous flow rate, total flow rate, operating pressure, pressure differential, and turbidity.

4.3 DISINFECTION

Chlorine is the preferred disinfecting agent. Chlorination may be accomplished with liquid chlorine, calcium or sodium hypochlorites or chlorine dioxide. Other disinfecting agents will be considered, providing reliable application equipment is available and testing procedures for a residual, where applicable, are recognized in "Standard Methods for the Examination of Water and Wastewater," latest edition. Disinfection is required at all surface water supplies and at any groundwater supply of questionable sanitary quality, or where any other treatment, i.e., chemical addition, is provided. Continuous disinfection is recommended for all water supplies. The potential for formation of unacceptable levels of disinfection by-products must be addressed. Results of physical and chemical analyses for pH, alkalinity, hardness, conductance, iron, manganese, hydrogen sulfide, and total organic carbon (TOC) must be provided with all submittals for chlorination systems. The need for pretreatment must be addressed where the following levels are exceeded:

1. iron > 0.3 mg/L,
2. manganese > 0.05 mg/L,
3. hydrogen sulfide > 0.5 mg/L,
4. total organic carbon > 10 mg/L, and
5. Total Dissolved Solids > 500 mg/L

Estimates of associated chlorine demand must be provided, and dose calculations adjusted accordingly.

4.3.1 Chlorination equipment

4.3.1.1 Type

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

4.3.1.2 Capacity

The chlorinator capacity must be such that a free chlorine residual as estimated under 4.3.2. of at least 2 milligrams per liter can be maintained in the water after contact time when maximum flow rate coincides with anticipated maximum chlorine demand. Higher free chlorine residuals and longer chlorine contact times may be required. The equipment must be of such design that it will operate accurately over the desired feeding range.

4.3.1.3 Standby equipment

Where chlorination is required for protection of the supply, standby equipment of sufficient capacity must be available to replace the largest unit. Spare parts must be made available to replace parts subject to wear and breakage. If there is a large difference in feed rates between routine and emergency dosages, a gas metering tube should be provided for each dose range to ensure accurate control of the chlorine feed.

4.3.1.4 Automatic switchover

Where necessary to protect the public health, automatic switchover of chlorine cylinders must be provided to assure continuous disinfection.

4.3.1.5 Automatic proportioning

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

4.3.1.6 Eductor

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

4.3.1.7 Injector/diffuser

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

4.3.2 Contact time and point of application

a. Due consideration must be given to the contact time of the chlorine in water with relation to pH, ammonia, taste-producing substances, temperature, bacterial quality, disinfection byproduct formation potential and other pertinent factors. The disinfectant must be applied at a point that will provide adequate contact time. All basins used for disinfection must be designed to minimize short circuiting. Additional baffling can be added to new or existing basins to minimize short circuiting and increase contact time. Baffling factors must be determined in accordance with Appendix E of the EPA document, "Guidance Manual for Compliance with the Filtration and Disinfection Requirements for Public Water Systems Using Surface Water Sources", March 1991 Edition. The baffling factor used must be approved by MDEQ.

b. At plants treating surface water, provisions should be made for applying chlorine to the raw water, settled water, filtered water, and water entering the distribution system. The contact time as required in 4.3.2.d must be provided after filtration unless otherwise approved by MDEQ.

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

d. Free residual chlorination is the preferred practice. **A contact time as required by MDEQ must be provided.** Contact time must be based on tables in Appendix E of the EPA document, "Guidance Manual for Compliance with the Filtration and Disinfection Requirements for Public Water Systems Using Surface Water Sources", March 1991 Edition. Contact times for inactivation of both *Giardia* cysts and viruses must be considered, where applicable. The contact time will depend upon water pH and temperature, the design of the contact basin, method of filtration, the proposed disinfectant, minimum disinfectant residual at the exit of the contact basin and treatment process control.

e. If primary disinfection is accomplished using ozone or some other method that does not provide a residual disinfectant, then chlorine may be required to provide a residual disinfectant as discussed in 4.3.3. Disinfection for groundwaters will be determined by MDEQ under ARM 17.38.229.

f. Smooth-nose sample taps must be provided before and after the point of disinfectant application in accordance with Chapter 2.

4.3.3 Residual chlorine

Minimum free chlorine residual at distant points in a water distribution system should be 0.2 to 0.5 milligrams per liter. Combined chlorine residuals, if appropriate, should be 1.0 to 2.0 milligrams per liter at distant points in the distribution system.

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

4.3.4 Testing equipment

a. Chlorine residual test equipment, recognized in the latest edition of Standard Methods for Examination of Water and Wastewater, must be provided and must be capable of measuring residuals to the nearest 0.1 milligrams per liter in the range below 0.5 milligrams per liter, to the nearest 0.3 milligrams per liter between 0.5 milligrams per liter and 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. All systems must use an instrument using the DPD colorimetric method with a digital readout and a self contained light source, or amperometric titration.

b. All surface water treatment plants must be equipped with recording chlorine analyzers monitoring water entering the distribution system, except as allowed by the MDEQ. (See Section 2.8.)

c. MDEQ must be contacted to determine if automatic chlorine residual recorders will be required for groundwater systems having a capacity of 0.5 million gallons per day or greater or where the chlorine demand varies appreciably over a short period of time

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

4.3.5 Chlorinator piping

4.3.5.1 Cross-connection protection

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

4.3.5.2 Pipe material

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

4.3.6 Housing

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

4.3.7 Ozone

4.3.7.1 Design considerations

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

Following the use of ozone, the application of a disinfectant may be required in order to ensure a bacteriologically safe water is carried throughout the distribution system. The ability to obtain qualified operators must be evaluated in selection of the treatment process. The necessary operator training must be provided prior to plant startup.

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

4.3.7.2 Feed Gas Preparation

a. General

1. Feed gas can be air, oxygen enriched air, or high purity oxygen. Sources of high purity oxygen include purchased liquid oxygen; on site generation using cryogenic air separation; or temperature, pressure or vacuum swing (adsorptive separation) technology. For high purity oxygen-feed systems, dryers typically are not required.

2. Air handling equipment on conventional low pressure air feed systems must consist of an air compressor, water/air separator, refrigerant dryer, heat reactivated desiccant dryer, and particulate filters. Some "package" ozonation systems for small plants may work effectively operating at high pressure without the refrigerant dryer and with a "heat-less" desiccant dryer. In all cases the design engineer must ensure that the maximum dew point of -76°F (-60°C) will not be exceeded at any time.

b. Air Compression

1. Air compressors must be of the liquid-ring or rotary lobe, oil-less, positive displacement type for smaller systems or dry rotary screw compressors for larger systems.

2. The air compressors must have the capacity to simultaneously provide for maximum ozone demand, provide the air flow required for purging the desiccant dryers (where required) and allow for standby capacity.

3. Air feed for the compressor must be drawn from a point protected from rain, condensation, mist, fog and contaminated air sources to minimize moisture and hydrocarbon content of the air supply.

4. A compressed air after-cooler and/or entrainment separator with automatic drain must be provided prior to the dryers to reduce the water vapor.

5. A back-up air compressor must be provided so that ozone generation is not interrupted in the event of a break-down.

c. Air Drying

1. Dry, dust-free and oil-free feed gas must be provided to the ozone generator. Dry gas is essential to prevent formation of nitric acid, to increase the efficiency of ozone

generation and to prevent damage to the generator dielectrics. Sufficient drying to a maximum dew point of -76°F (-60°C) must be provided at the end of the drying cycle.

2. Drying for high pressure systems may be accomplished using heatless desiccant dryers only. For low pressure systems, a refrigeration air dryer in series with heat-reactivated desiccant dryers must be used.

3. A refrigeration dryer capable of reducing inlet air temperature to 40°F (4°C) must be provided for low pressure air preparation systems. The dryer can be of the compressed refrigerant type or chilled water type.

4. For heat-reactivated desiccant dryers, the unit must contain two desiccant filled towers complete with pressure relief valves, two four-way valves and a heater. In addition, external type dryers must have a cooler unit and blowers. The size of the unit must be such that the specified dew point will be achieved during a minimum adsorption cycle time of 16 hours while operating at the maximum expected moisture loading conditions.

5. Multiple air dryers must be provided so that the ozone generation is not interrupted in the event of dryer breakdown.

6. Each dryer must be capable of venting "dry" gas to the atmosphere, prior to the ozone generator, to allow start-up when other dryers are "on-line".

d. Air Filters

1. Air filters must be provided on the suction side of the air compressors, between the air compressors and the dryers and between the dryers and the ozone generators.

2. The filter before the desiccant dryers must be of the coalescing type and be capable of removing aerosol and particulates larger than .0.3 microns in diameter. The filter after the desiccant dryer must be of the particulate type and be capable of removing all particulates greater than 0.1 microns in diameter, or smaller if specified by the generator manufacturer.

e. Preparation Piping

Piping in the air preparation system can be common grade steel, seamless copper, stainless steel or galvanized steel. The piping must be designed to withstand the maximum pressures in the air preparation system.

4.3.7.3 Ozone Generator

a. Capacity

1. The production rating of the ozone generators must be stated in pounds per day and kWhr per pound at a maximum cooling water temperature and maximum ozone concentration.

2. The design must ensure that the minimum concentration of ozone in the generator exit gas will not be less than 1 percent (by weight).

3. Generators must be sized to have sufficient reserve capacity so that the system does not operate at peak capacity for extended periods of time. This can result in premature breakdown of the dielectrics.

4. The production rate of ozone generators will decrease as the temperature of the coolant increases. If there is to be a variation in the supply temperature of the coolant throughout the year, then pertinent data must be used to determine production changes due to the temperature change of the supplied coolant. The design must ensure that the generators can produce the required ozone at maximum coolant temperature.

5. Appropriate ozone generator backup equipment must be provided.

b. Specifications must require that the transformers, electronic circuitry and other electrical hardware be proven, high quality components designed for ozone service.

c. Adequate cooling must be provided. The required water flow to an ozone generator varies with the ozone production. Normally unit design provides a maximum cooling water temperature rise of 5°F (2.8°C). The cooling water must be properly treated to minimize corrosion, scaling and microbiological fouling of the water side of the tubes. A closed loop cooling water system is often used to insure proper water conditions are maintained. Where cooling water is treated, cross connection control must be provided to prevent contamination of the potable water supply in accordance with Section 8.8.2.

d. To prevent corrosion, the ozone generator shell and tubes must be constructed of Type 316L stainless steel.

4.3.7.4 "A"- Ozone Contactors

The selection or design of the contactor and method of ozone application depends on the purpose for which the ozone is being used.

a. Bubble Diffusers

1. Where disinfection is the primary application a minimum of two contact chambers each equipped with baffles to prevent short circuiting and induce countercurrent flow must be provided. Ozone must be applied using porous-tube or dome diffusers. A design employing counter and co-current flow may be considered by MDEQ.

2. The minimum contact time shall be 10 minutes. A shorter contact time may be approved by MDEQ if justified by appropriate design and "CT" considerations.

3. For ozone applications in which precipitates are formed, such as with iron and manganese removal, porous diffusers should be used with caution.

4. Where taste and odor control is of concern, multiple application points and contactors should be considered.

5. Contactors should be separate closed vessels that have no common walls with adjacent rooms. The contactor must be kept under negative pressure and sufficient ozone monitors must be provided to protect worker safety. Placement of the contactor where the entire roof is exposed to the open atmosphere is recommended.

6. Large contact vessels should be made of reinforced concrete. All reinforcement bars must be covered with a minimum of 1.5 inches of concrete. Smaller contact vessels can be made of stainless steel, fiberglass or other material which will be stable in the presence of residual ozone and ozone in the gas phase above the water level.

7. Where necessary a system shall be provided between the contactor and the off-gas destruct unit to remove froth from the air and return the other to the contactor or other location acceptable to MDEQ. If foaming is expected to be excessive, then a potable water spray system must be placed in the contactor head space.

8. All openings into the contactor for pipe connections, hatchways; etc. must be properly sealed using welds or ozone resistant gaskets such as Teflon or Hypalon.

9. Multiple sampling ports must be provided to enable sampling of each compartment's effluent water and to confirm "CT" calculations.

10. A pressure/vacuum relief valve must be provided in the contactor and piped to a location where there will be no damage to the destruction unit.

11. The diffusion system should work on a countercurrent basis such that the ozone is fed at the bottom of the vessel and water is fed at the top of the vessel.

12. The depth of water in bubble diffuser contactors should be a minimum of 18 feet. The contactor should also have a minimum of 3 feet of freeboard to allow for foaming.

13. All contactors must have provisions for cleaning, maintenance and drainage of the contactor. Each contactor compartment must also be equipped with an access hatchway.

14. Aeration diffusers must be fully serviceable by either cleaning or replacement.

b. Other contactors, such as the venturi or aspirating turbine mixer contactor, may be approved by MDEQ provided adequate ozone transfer is achieved and the required contact times and residuals can be met and verified.

4.3.7.5 Ozone Destruction Unit

a. A system for treating the final off-gas from each contactor must be provided in order to meet safety and air quality standards. Acceptable systems include thermal destruction and thermal/catalytic destruction units.

b. In order to reduce the risk of fires, the use of units that operate at lower temperatures is encouraged, especially where high purity oxygen is the feed gas.

c. The maximum allowable ozone concentration in the discharge is 0.1 ppm (by volume).

d. At least two units must be provided which are each capable of handling the entire gas flow.

e. Exhaust blowers must be provided in order to draw off-gas from the contactor into the destruct unit.

f. The catalyst and heating elements must be located where they can easily be reached for maintenance.

g. Catalysts must be protected from froth, moisture and other impurities that may harm the catalyst.

4.3.7.6 Piping Materials

Only low carbon 304L and 316L stainless steels shall be used for ozone service with 316L preferred.

4.3.7.7 Joints and Connections

a. Connections on piping used for ozone service are to be welded where possible.

b. Connections with meters, valves or other equipment are to be made with flanged joints with ozone resistant gaskets, such as Teflon of Hypalon. Screwed fittings must not be used because of their tendency to leak.

c. A positive closing plug or butterfly valve plus a leak-proof check valve must be provided in the piping between the generator and the contactor to prevent moisture reaching the generator.

4.3.7.8 Instrumentation

a. Pressure gauges must be provided at the discharge from the air compressor, at the inlet to the refrigeration dryers, at the inlet and outlet of the desiccant dryers, at the inlet to the ozone generators and contactors and at the inlet to the ozone destruction unit.

b. Electric power meters should be provided for measuring the electric power supplied to the ozone generators. Each generator must have a trip that shuts down the generator when the wattage exceeds a certain preset level.

c. Dew point monitors must be provided for measuring the moisture of the feed gas from the desiccant dryers. Because it is critical to maintain the specified dew point, it is recommended that continuous recording charts be used for dew point monitoring which will allow for proper adjustment of the dryer cycle. Where there is potential for moisture entering the ozone generator from downstream of the unit or where moisture accumulation can occur in the generator during shutdown, post-generator dew point monitors must be used.

d. Air flow meters must be provided for measuring air flow from the desiccant dryers to each of other ozone generators, air flow to each contactor and purge air flow to the desiccant dryers.

e. Temperature gauges must be provided for the inlet and outlet of the ozone cooling water and the inlet and outlet of the ozone generator feed gas, and, if necessary, for the inlet and outlet of the ozone power supply cooling water.

f. Water flow meters must be installed to monitor the flow of cooling water to the ozone generators and, if necessary, to the ozone power supply.

g. Ozone monitors must be installed to measure zone concentration in both the feed-gas and off-gas from the contactor and in the off-gas from the destruct unit. For disinfection systems, monitors must also be provided for monitoring ozone residuals in the water. The number and location of ozone residual monitors must be such that the amount of time that the water is in contact with the ozone residual can be determined.

4.3.7.9 Alarms

The following alarm/shutdown systems must be included at each installation:

a. Dew point shutdown/alarm - This system must shut down the generator in the event the system dew point exceeds - 76°F (-60°C).

b. Ozone generator cooling water flow shutdown/alarm - This system must shut down the generator in the event that cooling water flows decreases to the point that generator damage could occur.

c. Ozone power supply cooling water flow shutdown/alarm - This system must shut down the power supply in the event that cooling water flow decreases to the point that damage could occur to the power supply.

d. Ozone generator cooling water temperature shutdown/alarm - This system must shutdown the generator if either the inlet or outlet cooling water exceeds a certain preset temperature.

e. Ozone power supply cooling water temperature shutdown/alarm - This system must shutdown the power supply if either the inlet or outlet cooling water exceeds a certain preset temperature.

f. Ozone generator inlet feed-gas temperature shutdown/alarm - This system must shutdown the generator if the feed-gas temperature is above a preset value.

g. Ambient ozone concentration shutdown/alarm - The alarm must sound when the ozone level in the ambient air exceeds 0.1 ppm or a lower value chosen by the water supplier. Ozone generator shutdown must occur when ambient ozone levels exceed 0.3 ppm (or a lower value) in either the vicinity of the ozone generator or the contactor.

h. Ozone destruct temperature alarm - The alarm must sound when temperature exceeds a preset value.

4.3.7.10 Safety

a. The maximum allowable ozone concentration in the air to which workers may be expose must not exceed 0.1 ppm (by volume).

b. Noise levels resulting from the operating equipment of the ozonation system must be controlled to within acceptable limits by special room construction and equipment isolation.

c. High voltage and high frequency electrical equipment must meet current electrical and fire codes.

d. Emergency exhaust fans must be provided in the rooms containing the ozone generators to remove ozone gas if leakage occurs.

e. A portable purge air blower that will remove residual ozone in the contactor prior to entry for repair or maintenance must be provided.

f. A sign must be posted indicating "No smoking, oxygen in use" at all entrances to the treatment plant. In addition, no flammable or combustible materials shall be stored within the oxygen generator areas.

4.3.7.11 Construction Considerations

a. Prior to connecting the piping from the desiccant dryers to the ozone generators the air compressors must be used to blow the dust out of the desiccant.

b. The contactor must be tested for leakage after sealing the exterior. This can be done by pressurizing the contactor and checking for pressure losses.

c. Connections on the ozone service line must be tested for leakage using the soap-test method

4.3.8 Chlorine dioxide

Chlorine dioxide may be considered as a primary and residual disinfectant, a pre-oxidant to control tastes and odors, to oxidize iron and manganese, and to control hydrogen sulfide and phenolic compounds. It has been shown to be a strong disinfectant which does not form THMs or HAAs. When choosing chlorine dioxide, consideration must be given to formation of the regulated byproducts, chlorite and chlorate.

4.3.8.1 Chlorine dioxide generators

Chlorine dioxide generation equipment must be factory assembled pre-engineered units with a minimum efficiency of 95 percent. The excess free chlorine must not exceed three percent of the theoretical stoichiometric concentration required.

4.3.8.2 Feed and storage facilities

Chlorine gas and sodium chlorite feed and storage facilities must comply with sections 5.4.1 and 5.4.4, respectively. Sodium hypochlorite feed and storage facilities must comply with section 5.4.5.

4.3.8.3 Other design requirements

a. The design must comply with all applicable portions of sections 4.3.

b. The maximum residual disinfectant level has been set at 0.8 mg/l, even for short term exposures. The minimum residual disinfectant level shall be established by MDEQ.

4.3.8.4 Public notification

Notification of a change in disinfection practices and the schedule for the changes must be made known to the public; particularly to hospitals, kidney dialysis facilities and fish breeders, as chlorine dioxide and its byproducts may have similar effects as chloramines.

4.3.9 Ultraviolet light

See Policy Statement On Ultraviolet Light For Treatment Of Public Water Supplies.

4.3.10 Other disinfecting agents

Proposals for use of disinfecting agents other than those listed shall be approved by MDEQ prior to preparation of final plans and specifications. Pilot studies may be required.

4.4 SOFTENING

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 must be demonstrated.

4.4.1 Lime or lime-soda process

Design standards for rapid mix, flocculation and sedimentation are in Section 4.1. Additional consideration must be given to the following process elements.

4.4.1.1 Hydraulics

When split treatment is used, the bypass line must be sized to carry total plant flow, and an accurate means of measuring and splitting the flow must be provided.

4.4.1.2 Aeration

Determinations should be made for the carbon dioxide content of the raw water. When concentrations exceed 10 milligrams per liter, the economics of removal by aeration as opposed to removal with lime should be considered if it has been determined that dissolved oxygen in the finished water will not cause corrosion problems in the distribution system. (See Section 4.5.)

4.4.1.3 Chemical feed point

Lime and recycled sludge should be fed directly into the rapid mix basin.

4.4.1.4 Rapid mix

Rapid mix basins must provide not more than 30 seconds detention time with adequate velocity gradients to keep the lime particles dispersed.

4.4.1.5 Stabilization

Equipment for stabilization of water softened by the lime or lime-soda process is required. (See Section 4.8.)

4.4.1.6 Sludge collection

a. Mechanical sludge removal equipment must be provided in the sedimentation basin.

b. Sludge recycling to the rapid mix should be provided.

4.4.1.7 Sludge disposal

Provisions must be included for proper disposal of softening sludges. (See Chapter 9.)

4.4.1.8 Disinfection

The use of excess lime is not an acceptable substitute for disinfection. (See Section 4.3.)

4.4.1.9 Plant start-up

The plant processes must be manually started following shut-down.

4.5 AERATION

Aeration may be used to help remove offensive tastes and odors due to dissolved gases from decomposing organic matter, or to reduce or remove objectionable amounts of carbon dioxide, hydrogen sulfide, etc., and to introduce oxygen to assist in iron and/or manganese removal. The following design criteria are not intended for organics removal facilities.

4.5.1 Natural draft aeration

Design must provide

a. perforations in the distribution pan 3/16 to 1/2 inches in diameter, spaced 1 to 3 inches on centers to maintain a six inch water depth,

b. for distribution of water uniformly over the top tray,

c. discharge through a series of three or more trays with separation of trays not less than 12 inches,

d. loading at a rate of 1 to 5 gallons per minute for each square foot of total tray area,

e. trays with slotted, heavy wire (1/2 inch openings) mesh or perforated bottoms,

f. construction of durable material resistant to aggressiveness of the water and dissolved gases,

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

h. protection from insects by 24-mesh screen.

4.5.2 Forced or induced draft aeration

Devices must be designed to

a. include a blower with weatherproof motor in a tight housing and screened enclosure,

b. insure adequate counter current of air through the enclosed aerator column,

c. exhaust air directly to the outside atmosphere,

d. include a down-turned and 24-mesh screened air outlet and inlet,

e. be such that air introduced in the column must be as free from obnoxious fumes, dust, and dirt as possible,

f. 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,

g. provide loading at a rate of 1 to 5 gallons per minute for each square foot of total tray area,

h. insure that the water outlet is adequately sealed to prevent unwarranted loss of air,

i. discharge through a series of five or more trays with separation of trays not less than six inches,

j. provide distribution of water uniformly over the top tray,

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

4.5.3 Spray aeration

Design must provide

a. A hydraulic head of between 5 to 25 feet,

b. nozzles, with the size, number, and spacing of the nozzles being dependent on the flowrate, space, and the amount of head available,

c. nozzle diameters in the range of 1 to 1.5 inches to minimize clogging,

d. an enclosed basin to contain the spray. Any openings for ventilation, etc. must be protected with a 24-mesh screen.

4.5.4 Pressure aeration

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

a. give thorough mixing of compressed air with water being treated,

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

4.5.5 Packed tower aeration

Packed tower aeration (PTA) which is also known as air stripping involves passing water down through a column of packing material while pumping air counter-currently up through the packing. PTA is used for the removal of volatile organic chemicals, trihalomethanes, carbon dioxide, and radon. Generally, PTA is feasible for compounds with a Henry's Constant greater than 100 (expressed in atm mol/mol) - at 12°C, but not normally feasible for removing compounds with a Henry's Constant less than 10. For values between 10 and 100, PTA may be feasible but should be extensively evaluated using pilot studies. Values for Henry's Constant should be discussed with MDEQ prior to final design.

4.5.5.1 Process design

a. Process design methods for PTA involve the determination of Henry's Constant for the contaminant, the mass transfer coefficient, air pressure drop and stripping factor. The applicant must provide justification for the design parameters selected (i.e. height and diameter of unit, air to water ratio, packing depth, surface loading rate, etc.). Pilot plant testing may be required.

b. The pilot test must evaluate a variety of loading rates and air to water ratios at the peak contaminant concentration. Special consideration should be given to removal efficiencies when multiple contaminations occur. Where there is considerable past performance data on the contaminant to be treated and there is a concentration level similar to previous projects, MDEQ may approve the process design based on use of appropriate calculations without pilot testing. Proposals of this type must be discussed with MDEQ prior to submission of any permit applications.

c. The tower must be designed to reduce contaminants to below the maximum contaminant level (MCL).

d. The ratio of the column diameter to packing diameter should be at least 7:1 for the pilot unit and at least 10:1 for the full scale tower. The type and size of the packing used in the full scale unit must be the same as that used in the pilot work.

e. The minimum volumetric air to water ratio at peak water flow should be 25:1. The maximum air to water ratio for which credit will be given is 80:1

f. The design should consider potential fouling problems from calcium carbonate and iron precipitation and from bacterial growth. It may be necessary to provide pretreatment. Disinfection capability must be provided prior to and after PTA.

g. The effects of temperature should be considered since a drop-in water temperature can result in a drop in contaminant removal efficiency.

h. Redundant capacity may be required by MDEQ.

4.5.5.2 Materials of construction

a. The tower can be constructed of stainless steel, concrete, aluminum, fiberglass or plastic. Uncoated carbon steel is not recommended because of corrosion. Towers constructed of light-weight materials should be provided with adequate support to prevent damage from wind.

b. Packing materials must be resistant to the aggressiveness of the water, dissolved gases and cleaning materials and must be suitable for contact with potable water.

4.5.5.3 Water flow system

a. Water should be distributed uniformly at the top of the tower using spray nozzles or orifice type distributor trays that prevent short-circuiting. For multi-point injection, one injection point for every 30 in^2 of tower cross-sectional area is recommended

b. A mist eliminator must be provided above the water distributor system,

c. A side wiper redistribution ring must be provided at least every 10 feet in order to prevent water channeling along the tower wall and short-circuiting.

d. Sample taps must be provided in the influent and effluent piping.

e. The effluent sump, if provided, must have easy access for cleaning purposes and be equipped with a drain valve. The drain must not be connected directly to any storm or sanitary sewer.

f. A blow-off line should be provided in the effluent piping to allow for discharge of water/chemicals used to clean the tower.

g. The design must prevent freezing of the influent riser and effluent piping when the unit is not operating. If piping is buried, it must be maintained under positive pressure.

h. The water flow to each tower must be metered.

i. An overflow line must be provided which discharges 12 to 14 inches above a splash pad or drainage inlet. Proper drainage must be provided to prevent flooding of the area.

j. Butterfly valves may be used in the water effluent line for better flow control, as well as to minimize air entrainment.

k. Means must be provided to prevent flooding of the air blower.

I. The water influent pipe should be supported separately from the tower's main structural support.

4.5.5.4 Air flow system

a. The air inlet to the blower and the tower discharge vent must be downturned and protected with a noncorrodible 24-mesh screen to prevent contamination from extraneous matter. It is recommended that a 4-mesh screen also be installed prior to the 24-mesh screen on the air inlet system.

b. The air inlet must be in a protected location.

c. An air flow meter must be provided on the influent airline or an alternative method to determine the air flow must be provided.

d. A positive air flow sensing device and a pressure gauge must be installed on the air influent line. The positive air flow sensing device must be a part of an automatic control system that will turn off the influent water if positive air flow is not detected. The pressure gauge will serve as an indicator of fouling buildup.

e. A backup motor for the air blower must be readily available.

4.5.5.5 Other features that must be provided

a. A sufficient number of access ports with a minimum diameter of 24 inches to facilitate inspection, media replacement, media cleaning and maintenance of the interior.

b. A method of cleaning the packing material when iron, manganese, or calcium carbonate fouling may occur.

c. Tower effluent collection and pumping wells constructed to clearwell standards.

d. Provisions for extending the tower height without major reconstruction.

e. An acceptable alternative supply must be available during periods of maintenance and operation interruptions. No bypass shall be provided unless specifically approved by MDEQ.

f. Disinfection application points both ahead of and after the tower to control biological growth.

g. Disinfection and adequate contact time after the water has passed through the tower and prior to the distribution system.

h. Adequate packing support to allow free flow of water and to prevent deformation with deep packing heights.

i. Operation of the blower and disinfectant feeder equipment during power failures.

j. Adequate foundation to support the tower and lateral support to prevent overturning due to wind loading.

k. Fencing and locking gate to prevent vandalism.

I. An access ladder with safety cage for inspection of the aerator including the exhaust port and de-mister.

m. Electrical interconnection between blower, disinfectant feeder and well pump.

4.5.5.6 Environmental factors

a. The applicant must contact the appropriate air quality office to determine if permits are required under the Clean Air Act.

b. Noise control facilities should be provided on PTA systems located in residential areas.

4.5.6 Other methods of aeration

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

4.5.7 Protection of aerators

All aerators except those discharging to lime softening or clarification plants must be protected from contamination by birds, insects, wind borne debris, rainfall and water draining off the exterior of the aerator.

4.5.8 Disinfection

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

4.5.9 Bypass

A bypass should be provided for all aeration units except those installed to comply with maximum contaminant levels.

4.5.10 Corrosion control

The aggressiveness of the water after aeration should be determined and corrected by additional treatment, if necessary. (See Section 4.8.)

4.6 IRON AND MANGANESE CONTROL

Iron and manganese control, as used herein, refers solely to treatment processes designed specifically for this purpose. The treatment process used will depend upon the character of the raw water. The selection of one or more treatment processes must meet specific local conditions as determined by engineering investigations, including chemical analyses of representative samples of water to be treated, and receive the approval of MDEQ. 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. Testing equipment and sampling taps must be provided as outlined in Chapter 2.

4.6.1 Removal by oxidation, detention and filtration

4.6.1.1 Oxidation

Oxidation may be by aeration, as indicated in Section 4.5, or by chemical oxidation with chlorine, potassium permanganate, ozone or chlorine dioxide.

4.6.1.2 Detention

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

b. Sedimentation - Sedimentation basins must be provided when treating water with high iron and/or manganese content, or where chemical coagulation is used to reduce the load on the filters. Provisions for sludge removal must be made.

4.6.1.3 Filtration

Filters must be provided and must conform to Section 4.2.

4.6.2 Removal by the lime-soda softening process

See Section 4.4.1.

4.6.3 Removal by manganese greensand filtration

This process consists of a continuous feed of potassium permanganate to the influent of a manganese greensand filter.

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

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

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

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

e. Normal wash rate is 8 to 10 gallons per minute per square foot.

f. Air washing should be provided.

g. Sample taps must be provided prior to application of permanganate, immediately ahead of filtration, at the filter effluent, and should be provided at points between the anthracite media and the manganese greensand media, and halfway down the manganese greensand media.

4.6.4 Removal by ion exchange

This 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.

4.6.5 Biological removal

Biofiltration to remove manganese or iron requires on-site piloting to establish effectiveness. The final filter design must be based on the on-site pilot plant studies and must comply with all portions of section 4.2.7.

4.6.6 Sequestration by polyphosphates

Where phosphate treatment is used, a minimum chlorine residual of 0.2 milligrams per liter must be maintained in the distribution system.

a. Feeding equipment must conform to the applicable sections of Chapter 5.

b. Stock phosphate solutions must be received, stored and dispensed from covered shipping drums. Disinfection of the solution beyond that provided by the manufacturer is not required.

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

d. Liquid polyphosphates must meet the requirements of ANSI/NSF Standard 60. The total phosphate applied may not exceed the maximum concentration allowed by NSF Standard 60.

4.6.7 Sequestration by sodium silicates

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 the minimum feed needed. Rapid oxidation of the metal ions such as by chlorine or 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.

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

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

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

d. Feeding equipment must conform to the requirements of Chapter 5.

e. Sodium silicate may not be applied ahead of iron or manganese removal treatment.

f. Liquid sodium silicate must meet AWWA Standard B404.

4.6.8 Sampling taps

Smooth-nosed sampling taps must be provided for control purposes. Taps must be located on each raw water source, each treatment unit influent and each treatment unit effluent.

4.6.9 Testing equipment

must be provided for all plants.

a. The 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.

b. Where polyphosphate sequestration is practiced, appropriate phosphate testing equipment must be provided.

4.7 FLUORIDATION

Sodium fluoride, sodium silicofluoride and hydrofluosilicic acid must conform to the applicable AWWA standards and ANSI/NSF Standard 60. Other fluoride compounds, which may be available, must be approved by MDEQ. The proposed method of fluoride feed must be approved by MDEQ prior to preparation of final plans and specifications.

4.7.1 Fluoride compound storage

Fluoride chemicals should be isolated from other chemicals to prevent contamination. Compounds must be stored in covered or unopened shipping containers and should be stored inside a building. Unsealed storage units for hydrofluosilicic acid should be vented to the atmosphere at a point outside any building. Bags, fiber drums and steel drums should be stored on pallets.

4.7.2 Chemical feed equipment and methods

In addition to the requirements in Chapter 5, fluoride feed equipment must meet the following requirements:

a. scales, loss of weight recorders or liquid level indicators, as appropriate, accurate to within five percent of the average daily change in reading must be provided for chemical feeds,

b. feeders must be accurate to within five percent of any desired feed rate,

c. fluoride compound may not be added before lime-soda softening, ion exchange softening, or filtration,

d. the point of application of hydrofluosilicic acid, if into a horizontal pipe, must be in the lower half of the pipe,

e. a fluoride solution must be applied by a positive displacement pump having a stroke rate not less than 20 strokes per minute,

f. anti-siphon devices must be provided for all fluoride feed lines and dilution water lines,

g. a device to measure the flow of water to be treated is required,

h. the dilution water pipe must terminate at least two pipe diameters above the solution tank,

i. water used for sodium fluoride dissolution must be softened if hardness exceeds 75 mg/l as calcium carbonate,

j. fluoride solutions may not be injected to a point of negative pressure,

k. the electrical outlet used for the fluoride feed pump should have a nonstandard receptacle and must be interconnected with the well or service pump,

l. saturators must be of the upflow type and be provided with a meter and backflow protection on the makeup water line.

m. Consideration must be given to providing a separate room for fluorosilicic acid storage and feed.

4.7.3 Secondary controls

Secondary control systems for fluoride chemical feed devices may be required by MDEQ as a means of reducing the possibility of overfeed; these may include flow or pressure switches or other devices.

4.7.4 Protective equipment

Protective equipment, as outlined in Section 5.3.4, must be provided for operators handling fluoride compounds. Deluge showers and eye wash devices must be provided at all fluorosilicic acid installations.

4.7.5 Dust control

a. 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 must be provided with an exhaust fan and dust filter that place the hopper under negative pressure. Air exhausted from fluoride handling equipment must discharge through a dust filter to the outside atmosphere of the building.

b. Provision must be made for disposing of empty bags, drums or barrels in a manner that will minimize exposure to fluoride dusts. A floor drain should be provided to facilitate the hosing of floors.

4.7.6 Testing equipment

Equipment must be provided for measuring the quantity of fluoride in the water. Such equipment is subject to the approval of MDEQ.

4.8 STABILIZATION

Water that is unstable due either to natural causes or to subsequent treatment must be stabilized. The expected treated water quality must be evaluated to determine what, if any, treatment is necessary.

4.8.1 Carbon dioxide addition

a. Recarbonation basin design should provide

    1. a total detention time of twenty minutes

    2. two compartments, with a depth that will provide a diffuser submergence of not less than 7.5 feet nor greater submergence than recommended by the manufacturer as follows:

        a. a mixing compartment having a detention time of at least three minutes,

        b. a reaction compartment.

b. The practice of on-site generation of carbon dioxide is discouraged.

c. Where liquid carbon dioxide is used, adequate precautions must be taken to prevent carbon dioxide from entering the plant from the recarbonation process.

d. Recarbonation tanks must be located outside or be sealed and vented to the outside with adequate seals and adequate purge flow of air to ensure worker safety.

e. Provisions must be made for draining the recarbonation basin and removing sludge.

4.8.2 Acid addition

a. Feed equipment must conform to Chapter 5.

b. Adequate precautions must be taken for operator safety, such as not adding water to the concentrated acid. (See Sections 5.3 and 5.4.)

4.8.3 Phosphates

The feeding of phosphates may be applicable for sequestering calcium in lime-softened water, corrosion control, and in conjunction with alkali feed following ion exchange softening.

a. Feed equipment must conform to Chapter 5.

b. Phosphate must meet the requirements of ANSI/NSF Standard 60.

c. Stock phosphate solution must be kept covered and disinfected by carrying approximately 10 mg/l free chlorine residual unless the phosphate is not able to support bacterial growth and the phosphate is being fed from the covered container. Phosphate solutions having a pH of 2.0 or less may also be exempted from this requirement by MDEQ.

d. Where phosphate treatment is used, a minimum chlorine residual of 0.2 milligrams per liter must be maintained in the distribution system.

4.8.4 "Split treatment"

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 prior to secondary clarification and filtration. Treatment plants designed to utilize "split treatment" should also contain facilities for further stabilization by other methods. Split treatment is subject to the approval of MDEQ.

4.8.5 Alkali feed

Unstable water created by ion exchange softening must be stabilized by an alkali feed. An alkali feeder must be provided for all ion exchange water softening plants except when exempted by MDEQ.

4.8.6 Carbon dioxide reduction by aeration

The carbon dioxide content of an aggressive water may be reduced by aeration. Aeration devices must conform to Section 4.5.

4.8.7 Other treatment

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 MDEQ before use. Chemical feeders must be as required in Chapter 5.

4.8.8 Unstable Water

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 sulfides should be prevented by the maintenance of a free chlorine residual throughout the distribution system.

4.8.9 Control

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

4.9 TASTE AND ODOR CONTROL

Provision must be made for the control of taste and odor at all surface water treatment plants. Chemicals must be added sufficiently ahead of other treatment processes to assure adequate contact time for an effective and economical use of the chemicals. Where severe taste and odor problems are encountered, in-plant and/or pilot plant studies are required. If a disinfectant is to be used to control taste and odors, the potential for formation of unacceptable levels of disinfection by-products must be considered.

4.9.1 Flexibility

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

4.9.2 Chlorination

Chlorination can be used for the removal of some objectionable odors. Adequate contact time must be provided to complete the chemical reactions involved. Excessive potential trihalomethane production through this process should be avoided by adequate bench-scale testing prior to design.

4.9.3 Chlorine dioxide

Chlorine dioxide has been generally recognized as a treatment for tastes caused by industrial wastes, such as phenols. However, chlorine dioxide can be used in the treatment of any taste and odor that is treatable by an oxidizing compound. Provisions must be made for proper storing and handling of the sodium chlorite, so as to eliminate any danger of explosion. (See Section 5.4.3.)

4.9.4 Powdered activated carbon

a. Powdered activated carbon should be added as early as possible in the treatment process to provide maximum contact time. Flexibility to allow the addition of carbon at several points is preferred. Activated carbon should not be applied near the point of chlorine application or other oxidant application.

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

c. Continuous agitation or resuspension equipment is necessary to keep the carbon from depositing in the slurry storage tank.

d. Provision must be made for adequate dust control.

e. 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 adding from 0.1 milligrams per liter to at least 40 milligrams per liter.

f. Powdered activated carbon must be handled as a potentially combustible material. It should be stored in a building or compartment as nearly fireproof as possible. Other chemicals should not be stored in the same compartment. A separate room should be provided for carbon feed installations. Carbon feeder rooms should be equipped with explosion-proof electrical outlets, lights and motors.

4.9.5 Granular activated carbon

Replacement of anthracite with GAC may be considered as a control measure for geosmin and methyl isoborneol (MIB) taste and odors from algae blooms. Demonstration studies may be required by MDEQ.

See Section 4.2.1.6 for application within filters.

4.9.6 Copper sulfate and other copper compounds

Continuous or periodic treatment of water with copper compounds to kill algae or other growths must be controlled to prevent copper in excess of 1.0 milligrams per liter as copper in the plant effluent or distribution system. Care must be taken to assure an even distribution of the chemical within the treatment area. Necessary approval and/or permits must be obtained prior to application, if required. Consult the responsible Regulatory Agencies (e.g., Fish and Wildlife agencies or Department of Natural Resources) before making applications to public waters.

4.9.7 Aeration

See Section 4.5.

4.9.8 Potassium permanganate

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

4.9.9 Ozone

Ozonation can be used as a means of taste and odor control. Adequate contact time must be provided to complete the chemical reactions involved. Ozone is generally more desirable for treating water with high threshold odors. (See section 4.3.7.)

4.9.10 Other methods

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 on consultation with MDEQ.

4.10 MICROSCREENING

A microscreen is a mechanical supplement of treatment capable of removing suspended matter from the water by straining. It may be used to reduce nuisance organisms and organic loadings. It may not be used in place of

a. filtration, when filtration is necessary to provide a satisfactory water, or

b. coagulation, in the preparation of water for filtration.

4.10.1 Design

a. must give due consideration to

   1. nature of the suspended matter to be removed,

   2. corrosiveness of the water,

   3. effect of chlorination, when required as pre-treatment,

   4. duplication of units for continuous operation during equipment maintenance;

5. automated backflushing operation when used in conjunction with microfiltration treatment.

b. must provide

1. a durable, corrosion-resistant screen,

2. by-pass arrangements,

3. protection against back-siphonage when potable water is used for washing,

4. proper disposal of wash waters. (See Chapter 9.)

4.11 ION EXCHANGE- ANION AND CATION EXCHANGE

4.11.1 Pilot Testing

A pilot study may be required to identify and resolve technical or operational issues that may affect the use of the device for meeting the treatment requirement. The following items must be adequately addressed if pilot testing is conducted:

a. Raw water quality under normal and peak conditions, including seasonal variation must be evaluated. The range of raw water quality observed must be adequately addressed by the design. Raw water quality parameters to be monitored include competing ions, the contaminant(s) being removed, and any other parameters identified by the resin manufacturer.
Testing must be performed to determine concentrations of interfering and competing ions. For anion exchange, TDS and sulfate must be analyzed at a minimum. For cation exchange, iron and manganese must be analyzed at a minimum.

b. Monitoring of treated water for the design contaminant during the pilot test period is required. The minimum frequency is one time immediately after installation and startup, once immediately before and after each scheduled resin change or regeneration cycle, and once quarterly for the remainder of the verification testing period unless conditions indicate that additional process control monitoring is needed or a correlation between gallon throughput and exhaustion is established.

c. Regeneration duration and frequency. Resin regeneration must occur prior to the contaminant concentration in the treated water exceeding 75 percent of the MCL.

d. Quantity and quality of waste generated through reject streams, backwash/regeneration cycles, and ultimate disposal of resin.

i. Determine whether waste from treatment process results in exceeding the capacity of the wastewater collection and disposal system.

ii. Determine whether batch or continuous discharge will impact disposal.

iii. Determine compatibility with waste receiving system.

e. Maintenance and sampling costs and requirements of automatically regenerating resin systems should be compared with those of disposable resin systems.

f. Maintenance requirements and maintenance roles and responsibilities must be clearly specified in the program outline. A third party maintenance contract will be required for the life of the system for systems without certified operators.

g. Potential corrosivity of treated water must be addressed. Corrosion control or blending of raw and treated water may be required.

h. Type of resin to be used and potential for chromatographic peaking at failure must be addressed.

4.11.2 Pre-treatment requirements

Pre-treatment is required when the content of competing ions reduces treatment efficiency or if other parameters that cause fouling are present. Pretreatment must provide adequate treatment such that the water entering the ion exchange unit complies with manufacturer's recommendations.

4.11.3 Post-treatment requirements

Disinfection must be provided in accordance with DEQ-1 and ARM 17.38.229. Additional post-treatment must be provided if the treated water is corrosive.

4.11.4 Design

The units may be of pressure or gravity type, of either an upflow or downflow design. Automatic regeneration based on volume of water treated or other measurable parameter must be used unless manual regeneration is justified and is approved by MDEQ. Resin regeneration must occur prior to the contaminant concentration in the treated water exceeding 75 percent of the MCL. A manual override must be provided on all automatic controls. A minimum of two ion exchange units must be provided such that one unit is always on-line and treating water while the other unit is being regenerated or out of service.

4.11.5 Exchange capacity

The design capacity for contaminant removal must not exceed manufacturer's recommendations or as demonstrated through a pilot test study.

4.11.6 Depth of resin

The depth of the exchange resin must be in accordance with manufacturer's recommendations and must allow adequate resin expansion and cleaning within the vessel during backwash.

4.11.7 Flow rates

Loading rates onto the resin and backwash rates must be in accordance with manufacturer's recommendations. Rate-of-flow controllers or the equivalent must be installed for the above purposes.

4.11.8 Freeboard

Freeboard must be provided in accordance with manufacturer's recommendations. The freeboard will depend upon the specific gravity of the resin and the direction of water flow. Generally, the wash water collector should be 24 inches above the top of the resin on downflow units.

4.11.9 Underdrains and supporting gravel

The bottoms, strainer systems and support for the exchange resin must conform to criteria provided for rapid rate gravity filters. (See Sections 4.2.1.6 and 4.2.1.7.)

4.11.10 Brine distribution

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

4.11.11 Cross-connection control

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

4.11.12 Bypass piping and equipment

A bypass may be allowed around the ion exchange units to produce a blended water of desirable water quality. Totalizing meters must be installed on the bypass line and on each ion exchange unit. The bypass line must have a shutoff valve and should have an automatic proportioning or regulating device.

4.11.13 Additional limitations

Resin limitations must be addressed. Items to consider include, but are not limited to, chlorine concentration and pH.

4.11.14 Sampling taps

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

4.11.15 Brine and salt storage tanks

a. Salt dissolving or brine tanks and wet salt storage tanks must be covered and must be corrosion-resistant.

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

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

d. Overflows, where provided, must be protected with corrosion resistant screens and must terminate with either a turned downed bend having a proper free fall discharge or a self-closing flap valve.

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

f. The salt must be supported on graduated layers of gravel placed over a brine collection system.

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

4.11.16 Salt and brine storage capacity

Total salt storage should have sufficient capacity to provide for at least 30 days of operation.

4.11.17 Brine pump or eductor

An eductor may be used to transfer brine from the brine tank to the ion exchange unit. If a pump is used, a brine measuring tank or means of metering should be provided to obtain proper dilution.

4.11.18 Stabilization

Refer to Section 4.8

4.11.19 Waste disposal

Suitable disposal must be provided for brine waste (See Section 9). Where the volume of spent brine must be reduced, consideration may be given to using part of the spent brine for subsequent regeneration.

4.11.20 Construction materials

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

4.11.21 Housing

Bagged salt and dry bulk salt storage must be enclosed and separated from other operating areas in order to prevent damage to equipment.

4.11.22 Hydraulic Analysis

An hydraulic analysis must be performed to verify adequate pressure when ion exchange pressure vessels are used. An hydraulic analysis must also be performed to verify adequate distribution pressures are maintained post-treatment in accordance with Section 8 of DEQ-1.

4.12 ADSORPTIVE MEDIA – GRANULAR FERRIC HYDROXIDE & ACTIVATED ALUMINA

4.12.1 Pilot Testing

A pilot study may be required to identify and resolve technical or operational issues that may affect the use of the device for meeting the treatment requirement. The following items must be adequately addressed if pilot testing is conducted:

a. Raw water quality under normal and peak conditions, including seasonal variation must be evaluated. The range of raw water quality observed must be adequately addressed by the design. Raw water quality parameters to be monitored include competing ions, the contaminant(s) being removed, and any other parameters identified by the media manufacturer. Testing must be performed to determine concentrations of interfering and competing ions.

b. Monitoring of treated water for the design contaminant during the pilot test period is required. The minimum frequency is one time immediately after installation and startup, once immediately before and after each scheduled media change or regeneration (if media is regenerated), and once quarterly for the remainder of the verification testing period unless conditions indicate that additional process control monitoring is needed or a correlation between gallon throughput and exhaustion is established.

c. Media backwash, regeneration (if media is regenerated), and replacement frequency. Media regeneration (if practiced) or replacement must occur prior to the contaminant concentration in the treated water exceeding 75 percent of the MCL.

d. Quantity and quality of waste generated through reject streams, backwash/regeneration cycles, and ultimate disposal of exhausted media.

   i. Determine whether waste from the treatment process results in exceeding the capacity of the wastewater collection and disposal system.

   ii. Determine whether batch or continuous discharge will impact disposal.

   iii. Determine compatibility with waste receiving system.

e. Maintenance and sampling costs.

f. Maintenance requirements and maintenance roles and responsibilities must be clearly specified in the program outline. A third party maintenance contract will be required for the life of the system for systems without certified operators.

g. Potential corrosivity of treated water must be addressed. Corrosion control or blending of raw and treated water may be required.

h. Type of media to be used and potential for chromatographic peaking at failure must be addressed.

i. Requirements of automatically regenerating media systems should be compared with those of disposable media systems.

4.12.2 Pre-treatment requirements

Pre-treatment is required when the content of competing ions reduces treatment efficiency or if other parameters that cause fouling are present. Pretreatment must provide adequate treatment such that the water entering the adsorptive media unit complies with manufacturer's recommendations. If pH adjustment is needed for adequate contaminant removal, the method of pH adjustment and pH control must be presented.

4.12.3 Post-treatment requirements

Disinfection must be provided in accordance with DEQ-1 and ARM 17.38.229. Additional post-treatment must be provided if the treated water is corrosive or requires pH adjustment.

4.12.4 Design

The units may be of pressure or gravity type, of either an upflow or downflow design. If media is regenerated, automatic regeneration based on volume of water treated or other measurable parameter must be used unless manual regeneration is justified and is approved by MDEQ. Media regeneration (if practiced) or media replacement must occur prior to the contaminant concentration in the treated water exceeding 75 percent of the MCL. A manual override must be provided on all automatic controls. A minimum of two adsorptive media units must be provided such that one unit is always on-line and treating water while the other unit is being regenerated or out of service.

4.12.5 Adsorptive capacity

The design capacity for contaminant removal must not exceed manufacturer's recommendations or as demonstrated through a pilot test study.

4.12.6 Depth of media

The depth of adsorptive media must be in accordance with manufacturer's recommendations and must allow adequate media expansion and cleaning within the vessel during backwash.

4.12.7 Flow rates

Loading rates onto the media and backwash rates must be in accordance with manufacturer's recommendations. Rate-of-flow controllers or the equivalent must be installed for the above purposes.

4.12.8 Freeboard

Freeboard must be provided in accordance with manufacturer's recommendations. The freeboard will depend upon the specific gravity of the media and the direction of water flow. Generally, the wash water collector should be 24 inches above the top of the media on downflow units.

4.12.9 Underdrains and supporting gravel

The bottoms, strainer systems and support for the media must conform to criteria provided for rapid rate gravity filters. (See Sections 4.2.1.6 and 4.2.1.7.)

4.12.10 Cross-connection control

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

4.12.11 Bypass piping and equipment

A bypass may be allowed around the adsorptive media units to produce a blended water of desirable water quality. Totalizing meters must be installed on the bypass line and on each adsorptive media unit. The bypass line must have a shutoff valve and should have an automatic proportioning or regulating device.

4.12.12 Sampling taps

Smooth-nose sampling taps must be provided for the collection of representative samples. The taps must be located to provide for sampling of the influent, effluent and blended water. The sampling taps for the blended water must be at least 20 feet downstream from the point of blending. Petcocks are not acceptable as sampling taps.

4.12.13 Waste disposal

Suitable disposal must be provided for all waste streams (See Section 9).

4.12.14 Media regeneration

If media is regenerated, all equipment and chemicals used for regeneration must be addressed and designed in accordance with manufacturer's recommendations.

4.12.15 Hydraulic Analysis

A hydraulic analysis must be performed to verify adequate pressure when pressure media vessels are used. A hydraulic analysis must also be performed to verify adequate distribution pressures are maintained post-treatment in accordance with Section 8 of DEQ-1.

CHAPTER 5 - CHEMICAL APPLICATION

5.0 GENERAL

No chemicals may be applied to treat drinking waters unless specifically permitted by MDEQ.

5.0.1 Plans and specifications

Plans and specifications must be submitted for review and approval, as provided for in Chapter 2, and must include

a. descriptions of feed equipment, including maximum and minimum feed ranges,

b. location of feeders, piping layout and points of application,

c. storage and handling facilities,

d. specifications for chemicals to be used,

e. operating and control procedures including proposed application rates, and

f. descriptions of testing equipment and procedures.

5.0.2 Chemical application

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

a. assure maximum efficiency of treatment,

b. assure maximum safety to consumer,

c. provide maximum safety to operators,

d. assure satisfactory mixing of the chemicals with the water,

e. provide maximum flexibility of operation through various points of application, when appropriate, and

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

5.0.3 General equipment design

General equipment design must be such that

a. feeders will be able to supply, at all time, the necessary amounts of chemicals at an accurate rate, throughout the range of feed,

b. chemical-contact materials and surfaces are resistant to the aggressiveness of the chemical solution,

c. corrosive chemicals are introduced in such a manner as to minimize potential for corrosion,

d. chemicals that are incompatible are not stored or handled together,

e. all chemicals are conducted from the feeder to the point of application in separate conduits,

f. chemical feeders are as near as practical to the feed point,

g. chemical feeders and pumps operate at no lower than 20 percent of the feed range unless two fully independent adjustments mechanisms such as pump pulse rate and stroke length are fitted when the pump operates at no lower than 10 percent of the rated maximum, and

h. chemicals are fed by gravity where practical.

5.1 FACILITY DESIGN

5.1.1 Number of feeders

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

   1. a minimum of two feeders must be provided, and

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

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

b. A separate feeder must be used for each chemical applied.

c. Spare parts must be available for all feeders to replace parts that are subject to wear and damage.

5.1.2 Control

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

b. At automatically operated facilities, chemical feeders must be electrically interconnected with the well or service pump and should be provided a non-standard electrical receptacle.

c. Chemical feed rates must be proportional to flow.

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

e. Provisions must be made for measuring the quantities of chemicals used.

f. Weighing scales

   1. must be provided for weighing cylinders, at all plants utilizing chlorine gas,

   2. may be required for fluoride solution feed,

   3. should be provided for volumetric dry chemical feeders, and

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

g. Where conditions warrant, for example with rapidly fluctuating intake turbidity, coagulant and coagulant aid addition may be made according to turbidity, stream current or other sensed parameter.

5.1.3 Dry chemical feeders

Dry chemical feeders must

a. measure chemicals volumetrically or gravimetrically,

b. provide adequate solution water and agitation of the chemical in the solution pot,

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

5.1.4 Positive displacement solution pumps

Positive displacement type solution feed pumps must be used to feed liquid chemicals, but shall not be used to feed chemical slurries. Pumps must be capable of operating at the required maximum rate against the maximum head conditions found at the point of injection. Calibrations tubes that allow for direct physical checking of actual feed rates must be fitted.

5.1.5 Liquid chemical feeders - Siphon control

Liquid chemical feeders must be such that chemical solutions cannot be siphoned into the water supply, by

a. assuring discharge at a point of positive pressure, or

b. providing vacuum relief, or

c. providing a suitable air gap, or

d. other suitable means or combinations as necessary.

5.1.6 Cross-connection control

Cross-connection control must be provided to assure that

a. the service water lines discharging to solution tanks must be properly protected from backflow as required by MDEQ,

b. liquid chemical solutions cannot be siphoned through solution feeders into the water supply as required in Section 5.1.5, and

c. 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.

5.1.7 Chemical feed equipment location

Chemical feed equipment must

a. be located in a separate room to reduce hazards and dust problems,

b. be conveniently located near points of application to minimize length of feed lines,

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

5.1.8 In-Plant water supply

In-Plant water supply must be:

a. ample in quantity and adequate in pressure,

b. provided with means for measurement when preparing specific solution concentrations by dilution,

c. properly treated for hardness, when necessary,

d. properly protected against backflow, and

e. obtained from a location sufficiently downstream of any chemical feed point to assure adequate mixing.

5.1.9 Storage of chemicals

a. Space should be provided for

   1. at least 30 days of chemical supply,

   2. convenient and efficient handling of chemicals,

   3. dry storage conditions, and

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

b. Storage tanks and pipelines for liquid chemicals must be specified for use with individual chemicals and not used for different chemicals. Offloading areas must be clearly labeled to prevent accidental cross-contamination.

c. Chemicals must be stored in covered or unopened shipping containers, unless the chemical is transferred into an approved storage unit.

d. Liquid chemical storage tanks must

   1. have a liquid level indicator, and

   2. have an overflow and a receiving basin or drain capable of receiving accidental spills or overflows without uncontrolled discharge; a common receiving basin may be provided for each group of compatible chemicals, that provides sufficient containment volume to prevent accidental discharge in the event of failure of the largest tank.

5.1.10 Solution tanks

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

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

c. Means must be provided to measure the solution level in the tank.

d. Chemical solutions must be kept covered. Large tanks with access openings must have such openings curbed and fitted with overhanging covers.

e. Subsurface locations for solution tanks must

  1. be free from sources of possible contamination, and

  2. assure positive drainage for groundwaters, accumulated water, chemical spills and overflows.

f. Overflow pipes must

  1. be turned downward, with the end screened,

  2. have a free fall discharge, and

  3. be located where noticeable.

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

h. Each tank must be provided with a valved drain, protected against backflow in accordance with Sections 5.1.5 and 5.1.6.

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

5.1.11 Day tanks

a. Day tanks must be provided where bulk storage of liquid chemical is provided.

b. Day tanks must meet all the requirements of Section 5.1.10.

c. Day tanks should hold no more than a 30 hour supply.

d. Day tanks must 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.

e. 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-driven transfer pumps are provided, a liquid level limit switch and an over-flow from the day tank, must be provided.

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

g. Tanks and tank refilling line entry points must be clearly labeled with the name of the chemical contained.

5.1.12 Feed lines

a. should be as short as possible, and

   1. of durable, corrosion-resistant material,

   2. easily accessible throughout the entire length,

   3. protected against freezing, and

   4. readily cleanable;

b. should slope upward from the chemical source to the feeder when conveying gases;

c. must be designed consistent with scale-forming or solids depositing properties of the water, chemical, solution or mixtures conveyed; and

d. should be color coded.

5.1.13 Handling

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

b. Provisions must be made for disposing of empty bags, drums or barrels by an approved procedure that will minimize exposure to dusts.

c. 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. Control should be provided by use of

   1. vacuum pneumatic equipment or closed conveyor systems,

   2. facilities for emptying shipping containers in special enclosures, and/or

   3. exhaust fans and dust filters that put the hoppers or bins under negative pressure.

d. Provision must be made for measuring quantities of chemicals used to prepare feed solutions.

5.1.14 Housing

a. Floor surfaces must be smooth and impervious, slip-proof and well drained.

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

5.2 CHEMICALS

5.2.1 Shipping containers

Chemical shipping containers must be fully labeled to include

a. chemical name, purity and concentration, and

b. supplier name and address.

5.2.2 Specifications

Chemicals must meet AWWA standards and ANSI/NSF Standard 60, where applicable.

5.2.3 Assay

Provisions may be required for assay of chemicals delivered.

5.3 OPERATOR SAFETY

5.3.1 Ventilation

Special provisions must be made for ventilation of chlorine feed and storage rooms.

5.3.2 Respiratory protection equipment

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

5.3.3 Chlorine leak detection

A bottle of ammonium hydroxide, 56 per cent ammonia solution, must be available for chlorine leak detection; where ton containers are used, a leak repair kit approved by the Chlorine Institute must be provided. Continuous chlorine leak detection equipment is recommended. Where a leak detector is provided it must be equipped with both an audible alarm and a warning light.

5.3.4 Protective equipment

a. At least one pair of rubber gloves, a dust respirator of a type certified by NIOSH for toxic dusts, an apron or other protective clothing and goggles or face mask must be provided for each operator as required by the reviewing authority. A deluge shower and eye washing device must be installed where strong acids and alkalis are used or stored.

b. A water holding tank that will allow water to come to room temperature must be installed in the water line feeding the deluge shower and eye washing device. Other methods of water tempering will be considered on an individual basis.

c. Other protective equipment should be provided as necessary.

5.4 SPECIFIC CHEMICALS

5.4.1 Chlorine gas

a. Chlorine gas feed and storage must be enclosed and separated from other operating areas. The chlorine room must be

   1. provided with a shatter resistant inspection window installed in an interior wall,

   2. constructed in such a manner that all openings between the chlorine room and the remainder of the plant are sealed, and

   3. provided with doors equipped with panic hardware, assuring ready means of exit and opening outward only to the building exterior.

b. Full and empty cylinders of chlorine gas should be

   1. isolated from operating areas,

   2. restrained in position to prevent upset,

   3. stored in rooms separate from ammonia storage, and

   4. stored in areas not in direct sunlight or exposed to excessive heat.

c. Where chlorine gas is used, the room must be constructed to provide the following:

   1. each room must have a ventilating fan with a capacity which provides one complete air change per minute when the room is occupied, where this is not appropriate due to the size of the room a lesser rate may be considered.

   2. the ventilating fan must take suction near the floor as far as practical from the door and air inlet, with the point of discharge so located as not to contaminate air inlets to any rooms or structures,

   3. air inlets should be through louvers near the ceiling,

   4. louvers for chlorine room air intake and exhaust must facilitate airtight closure,

   5. separate switches for the fan and lights must be located outside of the chlorine room and at the inspection window. Outside switches must be protected from vandalism. A signal light indicating fan operation must be provided at each entrance when the fan can be controlled from more than one point,

   6. vents from feeders and storage must discharge to the outside atmosphere, above grade,

   7. the room location should be on the prevailing downwind side of the building away from entrances, windows, louvers, walkways, etc.,

   8. floor drains are discouraged. Where provided, the floor drains must discharge to the outside of the building and may not be connected to other internal or external drainage systems.

   9. where deemed necessary by MDEQ, provisions must be made to chemically neutralize chlorine gas before discharge from the water treatment plant building into the environment. Such equipment must be designed as part of the chlorine gas storage and feed areas to automatically engage in the event of any measurable chlorine release. The

equipment must be sized to treat the entire contents of the largest storage container on site.

d. Chlorinator rooms should be heated to 60^0F and be protected from excessive heat. Cylinders and gas lines should be protected from temperatures above that of the feed equipment.

e. Pressurized chlorine feed lines may not carry chlorine gas beyond the chlorinator room.

5.4.2 Locker-type chlorine enclosure for a small pump house

This section applies to small systems that wish to avoid the cost of a large chlorine room by installing a small locker-type enclosure to a pump house.

a. The enclosure must be sized such that it is just big enough to house the chlorination equipment. Under no circumstances may it be big enough for a person to get into.

b. Chlorine gas feed equipment and storage must be enclosed and separated from other operating areas

c. Because the enclosure is sized to prevent the entrance of humans, the ventilation (5.3.1), inspection window (5.4.1 a.1) and panic hardware (5.4.1.a.3) requirements of this section are not applicable to the locker type enclosure.

d. The enclosure must be heated.

e. The access doors must be properly secured to prevent unauthorized access and labeled with an appropriate chlorine warning placard.

5.4.3 Acids and caustics

a. Acids and caustics must be kept in closed corrosion-resistant shipping containers or storage units.

b. Acids and caustics must 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.

5.4.4 Sodium chlorite for chlorine dioxide generation

Proposals for the storage and use of sodium chlorite must be approved by MDEQ prior to the preparation of final plans and specifications. Provisions must be made for proper storage and handling of sodium chlorite to eliminate any danger of fire or explosion associated with its powerful oxidizing nature.

a. Storage

1. Sodium chlorite must be stored by itself in a separate room and preferably should be stored in an outside building detached from the water treatment facility. It must be stored away from organic materials because many materials will catch fire and burn violently when in contact with chlorite.

2. The storage structures must be constructed of non-combustible materials.

3. If the storage structure must be located in an area where a fire may occur, water must be available to keep the sodium chlorite area cool enough to prevent heat induced explosive decomposition of the chlorite.

b. Handling

1. Care should be taken to prevent spillage.

2. An emergency plan of operation should be available for the clean up of any spillage.

3. Storage drums must be thoroughly flushed prior to recycling or disposal.

c. Feeders

1. Positive displacement feeders must be provided.

2. Tubing for conveying sodium chlorite or chlorine dioxide solutions must be Type 1 PVC, polyethylene or materials recommended by the manufacturer.

3. Chemical feeders may be installed in chlorine rooms if sufficient space is provided or facilities meeting the requirements of subsection 5.4.1 must be provided.

4. Feed lines must be installed in a manner to prevent formation of gas pockets and must terminate at a point of positive pressure.

5. Check valves must be provided to prevent the backflow of chlorine into the sodium chlorite line.

5.4.5 Sodium hypochlorite

Sodium hypochlorite storage and handling procedures must be arranged to minimize the slow natural decomposition process either by contamination or by exposure to more extreme storage conditions. In addition, feed rates must be regularly adjusted to compensate for this progressive loss in chlorine content.

a. Storage

1. Sodium hypochlorite must be stored in the original shipping containers or in sodium hypochlorite compatible containers.

2. Storage containers or tanks must be sited out of the sunlight in a cool area and must be vented to the outside of the building.

3. Wherever reasonably feasible, stored hypochlorite must be pumped undiluted to the point of addition. Where dilution is unavoidable, deionized or softened water should be used.

4. Storage areas, tanks, and pipe work must be designed to avoid the possibility of uncontrolled discharges and a sufficient amount of appropriately selected spill absorbent must be stored on-site.

5. Reusable hypochlorite storage containers must be reserved for use with hypochlorite only and must not be rinsed out or otherwise exposed to internal contamination.

b. Feeders

1. Positive displacement pumps with hypochlorite compatible materials for wetter surfaces must be used.

2. To avoid air locking in small installations, small diameter suction lines must be used with foot valves and degassing pump heads.

3. In larger installations flooded suction must be used with pipe work arranged to ease escape of gas bubbles.

4. Calibrations tubes or mass flow monitors that allow for direct physical checking of actual feed rates must be fitted.

5. Injectors must be removable for regular cleaning where hard water is to be treated.

5.4.6 Ammonia

Ammonia for chloramine formation may be added to water either as a water solution of ammonium sulfate, or as aqua ammonia (ammonia gas in water solution), or as anhydrous ammonia (purified 100% ammonia in liquid or gaseous form). Special provisions required for each form of ammonia are listed below.

5.4.6.1 Ammonium Sulfate

A water solution is made by addition of ammonium sulfate solid to water with agitation. The tank and dosing equipment contact surfaces should be made of corrosion resistant non-metallic materials. Provisions should be made for removal of the agitator after dissolving the solid. The tank should be fitted with a lid and vented outdoors. Injection of the solution should take place in the center of treated water flow at a location where there is a high velocity movement

5.4.6.2 Aqua ammonia (ammonium hydroxide)

Aqua ammonia feed pumps and storage must be enclosed and separated from other operating areas. The aqua ammonia room must be equipped as in Section 5.4.1 with the following changes:

a. A corrosion resistant, closed, unpressurized tank must be used for bulk storage, vented through an inert liquid trap to a high point outside and an incompatible connector or lockout provisions be made to prevent accidental addition of other chemicals to the storage tank.

b. The storage tank must be fitted either with cooling/refrigeration and/or with provision without opening the system to dilute and mix the contents with water to avoid conditions where temperature increases cause the ammonia vapor pressure over the aqua ammonia to exceed atmospheric pressure.

c. An exhaust fan must be installed to withdraw air from high points in the room and makeup air must be allowed to enter at a low point.

d. The aqua ammonia feed pump, regulators, and lines must be fitted with pressure relief vents discharging outside the building away from any air intake and with water purge lines leading back to the headspace of the bulk storage tank.

e. The aqua ammonia must be conveyed direct from storage to the treated water stream injector without the use of a carrier water stream unless the carrier stream is softened.

f. The point of delivery of the main water stream must be placed in a region of rapid, preferably turbulent, water flow.

g. Provisions should be made for easy access for removal of calcium scale deposits from the injector.

h. Provision of a modestly-size scrubber capable of handling occasional minor emissions should be considered.

5.4.6.3 Anhydrous ammonia

Anhydrous ammonia is readily available as a pure liquefied gas under moderate pressure in cylinders or as a cryogenic liquid boiling at –15 Celsius at atmospheric pressure. The liquid causes severe burns on skin contact.

a. Anhydrous ammonia and storage feed systems (including heaters where required) must be enclosed and separated from other work areas and constructed of corrosion resistant materials.

b. Pressurized ammonia feed lines must be restricted to the ammonia room.

c. An emergency air exhaust system, as in Section 5.4.1c but with an elevated intake, must be provided in the ammonia storage room.

c. Leak detection systems must be fitted in all areas though which ammonia is piped.

e. Special vacuum breaker/regulator provisions must be made to avoid potentially violent results of backflow of water into cylinders or storage tanks.

f. Carrier water systems of soft or pre-softened water may be used to transport ammonia to the finished water stream and to assist in mixing.

g. The ammonia injector must use a vacuum eductor or must consist of a perforated tube fitted with a closely fitting flexible rubber tubing seal punctured with a number of small slits to delay fouling by lime deposits.

h. Provision must be made for the periodic removal of scale/lime deposits from injectors and carrier piping.

i. Consideration must be given to the provision of an emergency gas scrubber capable of absorbing the entire contents of the largest ammonia storage unit whenever there is a risk to the public as a result of potential ammonia leaks.

CHAPTER 6 - PUMPING FACILITIES

6.0 GENERAL

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

6.1 LOCATION

The pumping station must 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.

6.1.1 Site protection

The station must be

a. elevated to a minimum of three feet above the 100-year flood elevation, or three feet above the highest recorded flood elevation, whichever is higher, or protected to such elevations,

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

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

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

6.2 PUMPING STATIONS

Both raw and finished water pumping stations must

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

b. be of durable construction, fire and weather resistant and with outward-opening doors,

c. have floor elevation of at least six inches above finished grade,

d. have underground structure waterproofed,

e. have all floors drained in such a manner that the quality of the potable water will not be endangered. All floors must slope to a suitable drain,

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

6.2.1 Suction well

Suction wells must

a. be watertight,

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

c. be covered or otherwise protected against contamination.

d. have two pumping compartments or other means to allow the suction well to be taken out of service for inspection, maintenance or repair.

6.2.2 Equipment servicing

Pump stations must be provided with

a. crane-ways, hoist beams, eyebolts, or other adequate facilities for servicing or removal of pumps, motors or other heavy equipment,

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

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

6.2.3 Stairways and ladders

Stairways or ladders must

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

b. have handrails on both sides, and treads of non-slip material. Stairs are preferred in areas where there is frequent traffic or where supplies are transported by hand. They must have risers not exceeding nine inches and treads wide enough for safety.

6.2.4 Heating

Provisions must be made for adequate heating for

a. the comfort of the operator,

b. the safe and efficient operation of the equipment

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

6.2.5 Ventilation

Ventilation must conform to existing local and state codes. Adequate ventilation must be provided for all pumping stations for operator comfort and dissipation of excess heat from the equipment. Forced ventilation of at least six changes of air per hour must be provided for

a. all confined rooms, compartments, pits and any enclosures below ground floor,

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

6.2.6 Dehumidification

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

6.2.7 Lighting

Pump stations must be adequately lighted throughout. All electrical work must conform to the requirements of the National Electrical Code and to the relevant state and local codes.

6.2.8 Sanitary and other conveniences

All pumping stations that are manned for extensive periods should be provided with potable water, lavatory and toilet facilities. Plumbing must be installed so as to prevent contamination of a public water supply. Wastes must be discharged in accordance with Chapter 9.

6.3 PUMPS

At least two pumping units must be provided. With any pump out of service, the remaining pump or pumps must be capable of providing the maximum daily pumping demand of the system. Additional capacity may be required if storage for the pump station service area is inadequate per Section 7.0.1.b of this circular. If only hydropneumatic storage is provided for the pump station service area, the pumping units must be sufficient to equal or exceed the peak instantaneous demand with the largest pump out of service. For hydropneumatic pumping stations serving 50 or less equivalent dwelling units, MDEQ may allow a reduction in total pumping capacity provided the system can maintain the minimum pressures required in Section 8.2.1 with the largest pump out of service. The pumping units must

a. have ample capacity to supply the peak demand against the required distribution system pressure without dangerous overloading,

b. be driven by prime movers able to operate against the maximum horsepower condition of the pumps ,

c. have spare parts and tools readily available,

d. be served by control equipment that has proper heater and overload protection for air temperature encountered.

6.3.1 Suction lift

Suction lift must

a. be avoided, if possible, or

b. if not possible, be within allowable limits, preferably less than 15 feet.

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

6.3.2 Priming

Prime water must not be of lesser sanitary quality than that of the water being pumped. Means must be provided to prevent either backpressure or backsiphonage. When an air-operated ejector is used, the screened intake must 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 MDEQ. Vacuum priming may be used.

6.4 BOOSTER PUMPS

In addition to the applicable sections of 6.3, booster pumps must be located or controlled so that:

a. they will not produce negative pressure in their suction lines,

b. the intake pressure is in accordance with section 8.2.1 when the pump is in normal operation,

c. automatic cutoff pressure must be at least 20 psi in the suction line, under all operating conditions, unless otherwise acceptable to the MDEQ. Pumps taking suction from ground storage tanks must be equipped with automatic shutoffs or low pressure controllers as recommended by the pump manufacturer.

d. automatic or remote control devices must have a range between the start and cutoff pressure that will prevent excessive cycling,

e. a bypass is available.

f. pumps installed in the distribution system must maintain inlet pressure as required in Section 8.2.1 under all operating conditions. Pumps taking suction from storage tanks must be provided adequate net positive suction head.

6.4.1 Duplicate pumps

Each booster pumping station must contain not less than two pumps with capacities such that peak demand can be satisfied with the largest pump out of service.

6.4.2 Metering

All booster pumping stations must be fitted with a flow rate indicating and totalizing meter.

6.4.3 Inline booster pumps

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

6.4.4 Service line booster pumps

Booster pumps are not allowed for any individual residential service lines from the public water supply main. Booster pumps may be allowed for multi story public buildings provided the distribution system pressures required under Section 8.2.1 are maintained and adequate backflow protection is provided.

6.5 AUTOMATIC AND REMOTE CONTROLLED STATIONS

All automatic stations must be provided with automatic signaling apparatus, which will report when the station is out of service. All remote controlled stations must be electrically operated and controlled and must have signaling apparatus of proven performance. Installation of electrical equipment must conform with the applicable state and local electrical codes and the National Electrical Code.

6.6 APPURTENANCES

6.6.1 Valves

Pumps must be adequately valved to permit satisfactory operation, maintenance and repair of the equipment. If foot valves are necessary, they must have a net valve area of at least 2 1/2 times the area of the suction pipe and they must be screened. Each pump must have a positive-acting check valve on the discharge side between the pump and the shut-off valve.

6.6.2 Piping

In general, piping must

a. be designed so that the friction losses will be minimized,

b. not be subject to contamination,

c. have watertight joints,

d. be protected against surge and water hammer,

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

f. have a pressure and leakage test performed in accordance with AWWA standards.

6.6.3 Gauges and meters

Each pump

a. must have a standard pressure gauge on its discharge line,

b. should have a compound gauge on its suction line, and must have a threaded port for this gauge if it is not installed.

c. must have recording gauges in the larger stations,

d. should have a means for measuring the discharge.

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

6.6.4 Water seals

Water seals may 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 must

a. be provided with either an approved reduced pressure principle backflow preventer or a break tank open to atmospheric pressure,

b. where a break tank is provided, have an air gap of at least six inches or two pipe diameters, whichever is greater, between the feeder line and the flood rim of the tank.

6.6.5 Controls

Pumps, their prime movers and accessories, must be controlled in such a manner that they will operate at rated capacity without dangerous overload. Where two or more pumps are installed, provision must be made for alternation. Provision must be made to prevent energizing the motor in the event of a backspin cycle. Electrical controls must be located above grade. Equipment must be provided or other arrangements made to prevent surge pressures from activating controls, which switch on pumps or activate other equipment outside the normal design cycle of operation.

6.6.6 Standby power

a. When power failure would result in cessation of minimum essential service, sufficient power must be provided to meet average day demand through

1. connection to at least two independent public power sources, or

2. portable or in-place auxiliary power.

b. If standby power is provided by onsite generators or engines, the fuel storage and fuel line must be designed to protect the water supply from contamination. (See Section 2.6)

c. Auxiliary power is not required when

1. documentation is submitted that shows power outages are infrequent and of short duration, and

2. fire protection is not diminished by power failure.

Carbon monoxide detectors are required when generators are housed within pump stations.

6.6.7 Water pre-lubrication

When automatic pre-lubrication of pump bearings is necessary and an auxiliary direct drive power supply is provided, the pre-lubrication line must be provided with a valve bypass around the automatic control so that the bearings can, if necessary, be lubricated manually before the pump is started or the pre-lubrication controls must be wired to the auxiliary power supply.

CHAPTER 7 - FINISHED WATER STORAGE

7.0 GENERAL

The materials and designs used for finished water storage structures must provide stability and durability as well as protect the quality of the stored water. Steel, concrete, fiberglass-reinforced plastic, and flexible membrane water storage facilities must follow current AWWA Standards. Other materials of construction are acceptable when properly designed to meet the requirements of Chapter 7. Porous material, including wood and concrete block, are not suitable for potable water contact applications.

7.0.1 Sizing

Storage facilities must be sufficient, as determined from engineering studies, to supplement source capacity to satisfy all system demands occurring on the maximum day, plus fire flow demands where fire protection is provided.

a. Fire flow requirements recommended by the fire protection agency in which the water system is being developed, or in the absence of such a recommendation, the fire code adopted by the State of Montana, must be satisfied where fire protection is provided.

b. The minimum allowable storage must be equal to the average daily demand for a 24-hour period plus fire flow demand where fire protection is provided. A Storage Sizing Engineering Analysis must support any deviation requests from this standard. Large non-residential demands must be accompanied by a Storage Sizing Engineering Analysis and may require additional storage to meet system demands.

c. Each pressure zone of systems with multiple pressure zones must be analyzed separately and provided with sufficient storage to satisfy the above requirements.

d. Excessive storage capacity should be avoided to prevent water quality deterioration and potential freezing problems.

7.0.2 Location of ground-level reservoirs

a. Consideration should be given to maintaining water quality when locating water storage facilities.

b. The bottom of reservoirs and standpipes should be placed at the normal ground surface and must be above the 100 Year Flood or the highest flood of record.

c. If the bottom must be below normal ground surface, it must be placed above the groundwater table. At least 50 per cent of the water depth should be above grade. Sewers, drains, standing water, and similar sources of possible contamination must be kept at least fifty feet from the reservoir. Gravity sewers constructed of water main quality pipe, pressure tested in place without leakage, may be used for gravity sewers at distances greater than 20 feet and less than 50 feet.

d. The top of a partially buried storage structure must 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.

7.0.3 Protection

All finished water storage structures must have suitable watertight roofs, which exclude birds, animals, insects, and excessive dust. The installation of appurtenances, such as an antenna, must be done in a manner that ensures no damage to the tank, coatings or water quality, or corrects any damage that occurred.

7.0.4 Protection from trespassers

Locks on access manholes and other necessary precautions must be provided to minimize the potential for vandalism and sabotage.

7.0.5 Drains

No drain on a water storage structure may have a direct connection to a sewer or storm drain. The design must allow draining the storage facility for cleaning or maintenance without causing loss of pressure in the distribution system. Outlets must discharge over a drainage inlet structure or a splash plate and should be designed to minimize erosion.

7.0.6 Stored Water Turnover

The system should be designed to facilitate turnover of the water in the reservoir. Consideration should be given to separate inlet and outlet pipes, baffle walls or other acceptable means to avoid stagnation.

7.0.7 Overflow

All water storage structures must be provided with an overflow that is brought down to an elevation between 12 and 24 inches above the ground surface, and discharges over a drainage inlet structure or a splash plate. No overflow may be connected directly to a sewer or a storm drain. All overflow pipes must be located so that any discharge is visible.

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 storage reservoir must open downward and be screened with twenty-four mesh non-corrodible screen. The screen must be installed within the overflow pipe at a location least susceptible to damage by vandalism. If a flapper valve is used, a twenty-four mesh non-corrodible screen must be provided inside the valve.

c. The overflow of an elevated tank must open downward and be screened with a four mesh, non-corrodible screen. The screen must be installed within the overflow pipe at a location least susceptible to damage by vandalism. If a flapper valve is used, a four mesh, non-corrodible screen must be provided inside the valve.

d. Screens must be visible for inspection and readily accessible for replacement.

e. The overflow pipe must be of sufficient diameter to permit waste of water in excess of the filling rate.

7.0.8 Access

Finished water storage structures must be designed with reasonably convenient access to the interior for cleaning and maintenance. At least two (2) manways must be provided above the waterline at each water compartment where space permits.

7.0.8.1 Elevated Storage Structures

At least one of the manways:

a. must be framed at least four inches, above the surface of the roof at the opening, must be fitted with a solid watertight cover which overlaps the framed opening and extends down around the frame at least two inches, must be hinged at one side, and must have a locking device.

b. All other manways or access ways must be bolted and gasketed, or must meet the requirements of (a).

7.0.8.2 Ground Level Structures

a. Each manway must be elevated at least 24 inches above the top of the tank or covering sod, whichever is higher.

b. Each manway must be fitted with a solid watertight cover, which overlaps a framed opening and extends down around the frame at least two inches. The frame must be at least four inches high. Each cover must be hinged on one side, and must have a locking device.

7.0.9 Vents

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

a. must prevent the entrance of surface water and rainwater,

b. must exclude birds and animals,

c. should exclude insects and dust, as much as this function can be made compatible with effective venting, and

d. must, on ground-level structures, open downward with the opening at least 24 inches above the roof or sod and be covered with twenty-four mesh non-corrodible screen. The screen must be installed within the pipe at a location least susceptible to vandalism.

7.0.10 Roof and sidewall

The roof and sidewalls of all water storage structures must be watertight with no openings except properly constructed vents, manholes, overflows, risers, drains, pump mountings, control ports, or piping for inflow and outflow. Particular attention must be given to the sealing of roof structures, which are integral to the tank body.

a. Any pipes running through the roof or sidewall of a metal storage structure must be welded, or properly gasketed. In concrete tanks, these pipes must be connected to standard wall castings, which were poured in place during the forming of the concrete. These wall castings must have seepage rings imbedded in the concrete when located below the water surface.

b. Openings in the roof of a storage structure designed to accommodate control apparatus or pump columns, must be curbed and sleeved with proper additional shielding to prevent contamination from surface or floor drainage.

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. The roof of the storage structure must be well drained. Downspout pipes may 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.

e. The roof of concrete reservoirs with earthen cover must be sloped to facilitate drainage. Consideration should be given to installation of an impermeable membrane roof covering.

f. Reservoirs with pre-cast concrete roof structures must be made watertight with the use of a waterproof membrane or similar product.

7.0.11 Safety

Safety must be considered in the design of the storage structure. The design must 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 must be provided where applicable.

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

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

d. Confined space entry requirements must be considered.

7.0.12 Freezing

Finished water storage structures and their appurtenances, especially the riser pipes, overflows, and vents, must be designed to prevent freezing which will interfere with proper functioning. Equipment used for freeze protection that will come in contact with potable water must meet ANSI/NSF Standard 61 or be approved by MDEQ. If a water circulation system is used, it is recommended that the circulation pipe be located separately from the riser pipe.

7.0.13 Internal catwalk

Every catwalk over finished water in a storage structure must have a solid floor with raised edges, designed to prevent contamination from shoe scrapings and dirt.

7.0.14 Silt stop

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

7.0.15 Grading

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

7.0.16 Painting and cathodic protection

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

a. Paint systems must meet the requirements of ANSI/NSF Standard 61 and be acceptable to the MDEQ. Interior paint must be applied, cured, and used in a manner consistent with ANSI/NSF approval. After curing, the coating must not transfer any substance to the water, which will be toxic or cause tastes or odor~~s~~ problems. Prior to placing in service, an analysis for volatile organic compounds is advisable to establish that the coating is properly cured. Consideration should be given to 100% solids coatings.

b. Wax coatings for the tank interior should not be used on new tanks. Recoating with a wax system is discouraged. Old wax coating must be completely removed before using another tank coating.

c. Cathodic protection must be designed, installed and maintained by competent technical personnel and a maintenance contract must be provided or provision for adequate training must be included in the specifications.

7.0.17 Disinfection

a. Finished water storage structures must be disinfected in accordance with current AWWA Standard C652. Two or more successive sets of samples, taken at 24-hour intervals, must indicate microbiologically satisfactory water before the facility is placed into operation.

b. Disposal of heavily chlorinated water from the tank disinfection process must be in accordance with the requirements of the MDEQ.

c. The disinfection procedure (AWWA chlorination method 3, section 4.3 C652), which allows use of the chlorinated water held in the storage tank for disinfection purposes, is not recommended. The chlorinated water may contain various disinfection by-products, which should be kept out of the distribution system. When the chlorinated water is allowed to enter the distribution, the free chlorine residual must not exceed 4.0 mg/l.

7.1 TREATMENT PLANT STORAGE

The applicable design standards of Section 7.0 must be followed for plant storage.

7.1.1 Filter wash water tanks

Filter wash water tanks must be sized, in conjunction with available pump units and finished water storage, to provide the backwash water required by Section 4.2.1.11. Consideration must be given to the backwashing of several filters in rapid succession.

7.1.2 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 contact time for chlorine (see Section 4.3.2) special attention must be given to size and baffling. (See Section 7.1.2.b below.)

b. To ensure adequate chlorine contact time, sizing of the clearwell should include extra volume to accommodate depletion of storage during the nighttime for intermittently operated filtration plants with automatic high service pumping from the clearwell during non-treatment hours.

c. An overflow and vent must be provided meeting the requirements of Sections 7.0.7 and 7.0.9.

d. A minimum of two clearwell compartments must be provided.

7.1.3 Adjacent compartments

Finished or treated water must not be stored or conveyed in a compartment adjacent to untreated or partially treated water when the two compartments are separated by a single wall, unless approved by MDEQ.

7.1.4 Other treatment plant storage tanks

Unless otherwise allowed by MDEQ, other treatment plant storage tanks/basins such as detention basins, backwash reclaim basins, receiving basins and pump wet-wells for finished water must be designed as finished water storage structures.

7.2 HYDROPNEUMATIC TANK SYSTEMS

Hydropneumatic (pressure) tanks, when provided as the only storage facility, are acceptable only in very small water systems. Systems serving more than 50 living units should have ground or elevated storage designed in accordance with Section 7.1 or 7.3. Hydropneumatic tank storage is not permitted for fire protection purposes. Pressure tanks must meet applicable ASME code requirements. Pressure tanks for which the ASME code does not apply (i.e., those with nominal water containing capacity of 120 gallons or less) must meet ASME code requirements or must satisfactorily pass a hydrostatic test of one and one-half (1.5) times the maximum allowable working pressure of the tank. The maximum allowable working pressure must be marked on each tank.

7.2.1 Location

Captive air hydropneumatic tanks must be located above normal ground surface and be completely housed. Conventional tanks (i.e., without an air-water separator) may be partially buried and must be provided with ground level access to the appurtenances required in section 7.2.4.

7.2.2 Sizing

a. The capacity of the sources and pumps in a hydropneumatic system must have capacity sufficient to satisfy the requirements in section 3.1.1. or 3.2.1.1.b.

b. The active storage volume of the hydropneumatic tanks must be sufficient to limit pump cycling to manufacturer's and industry recommendations. Maximum cycling frequency for pumps not using a variable speed drive must be determined for each pump and for any combination of pumps operated by the same pressure switch when consumer demand is equal to one-half (0.5) of the pump(s) capacity. Maximum cycling frequency for pumps using a variable speed drive programmed to either maintain constant pressure, constant flow, or match the system design curve, must be determined when the customer demand is one-half (.5) of the minimum pumping rate. Reduction of required tank volume for systems with alternating pump controls will not be allowed.

c. Sizing of hydropneumatic storage tanks must consider the need for chlorine contact time, as applicable, independent of the requirements in 7.2.2.a above. Tanks with a common inlet and outlet will not be given any credit for chlorine contact time.

7.2.3 Piping

Each tank must have bypass piping or valves to permit operation of the system while it is being repaired or painted.

7.2.4 Appurtenances

a. Each tank must have means of draining, automatic or manual air blow-off, and means for adding air. In addition, each conventional tank (i.e., without an air-water separator) must have a water sight glass and an access manhole. Where practical the access manhole should be at least 24 inches in diameter.

b. Control equipment consisting of a pressure gage, pressure relieving device, and pressure operated start-stop controls for the pumps must be provided for the hydropneumatic tank system. Installing a shut-off valve between the pump and the pressure operated start-stop controls must be avoided when possible.

c. The pressure relieving device must prevent the pressure from rising more than 10 percent above the maximum allowable working pressure. The discharge capacity of the pressure relieving device must be adequately sized. Pressure gages must have a range of no less than 1.2 times the pressure at which the pressure relieving device is set to function.

7.3 DISTRIBUTION STORAGE

The applicable design standards of Section 7.0 must be followed for distribution system storage.

7.3.1 Pressures

The maximum variation between high and low levels in storage structures providing pressure to a distribution system should not exceed 30 feet. The minimum working pressure in the distribution system should be 35 psi (240 kPa) and the normal working pressure should be approximately 60 to 80 psi (410-550 kPa). When static pressures exceed 100 psi(690 kPa),, pressure reducing devices should be provided on mains in the distribution system.

7.3.2 Drainage

Storage structures that provide pressure directly to the distribution system, must 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 must discharge to the ground surface with no direct connection to a sewer or storm drain.

7.3.3 Level controls

Adequate controls must 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.

7.4 CISTERNS

Cisterns designed according to CIRCULAR DEQ 17, Montana Standards for Cisterns (Water Storage Tanks) for Individual Non-public Systems, and provided with an appropriate air gap on the service line discharge, may be used on individual service connections.

CHAPTER 8 –TRANSMISSION MAINS, DISTRIBUTION SYSTEMS, PIPING & APPURTENANCES

8.0 GENERAL

Transmission mains and water distribution systems must be designed to maintain treated water quality. Special consideration should be given to distribution main sizing, providing for design of multidirectional flow, adequate valving for distribution system control, and provisions for adequate flushing. Systems should be designed to maximize turnover and to minimize residence times.

8.1 MATERIALS

8.1.1 Standards, materials selection

a. All materials including pipe, fittings, valves and fire hydrants must conform to the latest standards issued by the AWWA and ANSI/NSF, where such standards exist, and be acceptable to MDEQ.

b. In the absence of such standards, materials meeting applicable Product Standards and acceptable to MDEQ may be selected.

c. Special attention must be given to selecting pipe materials, which will protect against both internal and external corrosion.

d. Pipes and pipe fittings containing more than 8% lead must not be used. All products must comply with ANSI/NSF standards.

e. All materials used for the rehabilitation of water mains must meet ANSI/NSF standards.

f. Where lines are to be slip-lined, slip-lining material must be approved for potable water applications, be installed in accordance with the manufacturer's guidelines, and be installed in a manner that minimizes service interruption.

8.1.2 Permeation of system by organic compounds

Where distribution systems are installed in areas of groundwater contaminated by organic compounds:

a. pipe and joint materials that are not subject to permeation of the organic compounds must be used.

b. non-permeable materials must be used for all portions of the system including water main, pipe joint material, service connections and hydrant leads.

8.1.3 Used materials

Water mains, which have been previously used for conveying potable water, may be reused provided they meet the above standards and have been restored practically to their original condition.

8.1.4 Joints

Packing and jointing materials used in the joints of pipe must meet the standards of the AWWA and MDEQ. Pipe having mechanical joints or slip-on joints with rubber gaskets is preferred. Gaskets containing lead must not be used. Repairs to lead-joint pipe must be made using alternative methods. Manufacturer approved transition joints must be used between dissimilar piping materials.

8.2 WATER MAIN DESIGN

8.2.1 Pressure

All water mains, including those not designed to provide fire protection, must be sized after a hydraulic analysis based on flow demands and pressure requirements. The system must be designed to maintain a minimum normal working pressure of 35 psi. Minimum pressure under all conditions of flow (e.g. fire flows, hydrant testing, and water main flushing) must be 20 psi. Water main pressures must be sufficient to provide the required minimum pressures at ground level at the highest building sites served by the proposed water mains excluding service line head losses. (i.e. water main pressure must be equal to or greater than the required minimum pressure plus the elevation difference between the highest building site and ground level at the service connection). Maximum normal working pressure should be approximately 60 to 80 psi. Transmission mains and water lines directly serving reservoirs are exempt from the minimum pressure requirements where the line pressures are controlled by the reservoir water surface elevation.

8.2.2 Diameter

The minimum size of water main for providing fire protection and serving fire hydrants must 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 8.2.1.

The minimum size of water main in the distribution system where fire protection is not to be provided should be a minimum of three (3) inch diameter. Any departure from minimum requirements must be justified by hydraulic analysis and future water use, and can be considered only in special circumstances.

8.2.3 Fire protection

When fire protection is to be provided, system design must be such that fire flows and facilities are in accordance with the recommendations of the fire protection agency in which the water system is being developed, or in the absence of such a recommendation, the fire code adopted by the State of Montana. Water mains not designed to carry fire-flows may not have fire hydrants connected to them.

8.2.4 Dead ends

a. dead ends must be minimized by making appropriate tie-ins whenever practical, in order to provide increased reliability of service and reduce head loss.

b. Where dead-end mains occur, they must be provided with a fire hydrant if flow and pressure are sufficient, or with an approved flushing hydrant or blow-off for flushing purposes. Flushing devices should be sized to provide flows, which will give a velocity of at least 2.5 feet per second in the water main being flushed, and must be sized to provide at least the minimum pressure of 20 psi. required in section 8.2.1, when the flushing device is fully open. Flushing devices may not be directly connected to any sewer.

8.3 VALVES

Sufficient valves must 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 intervals in commercial districts and at not more than one block or 800 foot intervals in other districts. Where systems serve widely scattered customers and where future development is not expected, the valve spacing should not exceed one mile.

8.4 HYDRANTS

8.4.1 Location and spacing

Hydrants should be provided at each street intersection and at intermediate points between intersections and must be provided as recommended by the fire protection agency in which the water system is being developed, or in the absence of such a recommendation, the fire code adopted by the State of Montana.

8.4.2 Valves and nozzles

Fire hydrants must have a bottom valve size of at least five inches, one 4-1/2 inch pumper nozzle and two 2-1/2 inch nozzles. Other bottom valve and nozzle sizes may be acceptable when compatible with the existing fire hydrants and fire fighting equipment.

8.4.3 Hydrant leads

The hydrant lead must be a minimum of six inches in diameter. Auxiliary valves must be installed in all hydrant leads.

8.4.4 Hydrant drainage

a. Hydrant drains should be plugged. When the drains are plugged the barrels must be pumped dry after use during freezing weather.

b. Where hydrant drains are not plugged, a gravel pocket or dry well must be provided unless the natural soils will provide adequate drainage.

c. Hydrant drains must not be connected to or located within 10 feet of sanitary sewers, or storm drains.

8.5 AIR RELIEF, VACUUM RELIEF, AND COMBINATION AIR/VACUUM RELIEF VALVES

8.5.1 Air relief valves

At high points in water mains where air can accumulate provisions must be made to remove the air by means of hydrants or air relief valves. Automatic air relief valves may not be used in situations where flooding of the manhole or chamber may occur. Use of manual air relief valves is recommended wherever practical.

8.5.2 Relief valve piping

a. The open end of an air relief pipe from a manually operated valve must be extended to the top of the pit and provided with a screened, downward-facing elbow if drainage is provided for the manhole.

b. The open end of relief pipe from automatic valves must be extended to at least one foot above grade and be provided with a screened, downward-facing elbow. Where the potential for freezing of trapped water in the relief pipe is a concern, a drain protected by two single check valves may be installed in the relief pipe. Air relief piping with a screened downward facing elbow may terminate near the top of chamber if a drain to daylight is provided.

c. Discharge piping from relief valves must not connect directly to any storm drain, storm sewer, or sanitary sewer.

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

8.6 VALVE, METER, AND BLOW-OFF CHAMBERS

Wherever possible, chambers, pits or manholes containing valves, blow-offs, meters, or other such appurtenances to a distribution system, must not be located in areas subject to flooding or in areas of high groundwater. Such chambers or pits should drain to the ground surface, or to absorption pits underground. The chambers, pits, and manholes must not connect to any storm drain or sanitary sewer.

8.7 INSTALLATION OF MAINS

8.7.1 Standards

Specifications must incorporate the provisions of the AWWA standards and manufacturer's recommended installation procedures. Where AWWA standards are not available MDEQ may allow installation per manufacturer's and industry standards on a case-by-case basis.

8.7.2 Bedding

A continuous and uniform bedding must be provided in the trench for all buried pipe. Backfill material must 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 must be removed for a depth of at least six inches below the bottom of the pipe.

8.7.3 Cover

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

8.7.4 Blocking

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

8.7.5 Pressure and leakage testing

All types of installed pipe must be pressure tested and leakage tested in accordance with the appropriate AWWA Standards.

8.7.6 Disinfection

All new, cleaned or repaired water mains must be flushed, disinfected and tested in accordance with AWWA Standard C651. The specifications must include detailed procedures for adequate flushing, disinfection, and microbiological testing of all water mains. In an emergency or unusual situation, the disinfection procedure must be discussed with MDEQ.

8.7.7 External Corrosion

a. Where external corrosion may be a concern, a system of records by which the nature and frequency of corrosion problems are recorded must be provided. On a plat map of the distribution system, show the location of each problem so that follow-up investigations and improvements can be made when a cluster of problems is identified.

b. If needed, perform a survey to determine the existence of facilities or installations that would provide the potential for stray, direct electric currents. Also, determine whether problems are caused by the use of water pipes as grounds for the electrical system.

c. In areas where aggressive soil conditions are suspect, or in areas where there are known aggressive soil conditions, analyses must be performed to determine the actual aggressiveness of the soil.

d. If soils are found to aggressive, take necessary action to protect the water main such as by encasement of the water main in polyethylene, provision of cathodic protection (in very severe instances), or using corrosion resistant water main materials.

8.8 SEPARATION OF WATER MAINS, SANITARY SEWERS AND STORM SEWERS

8.8.1 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.

8.8.2 Parallel installation

Water mains must be laid at least 10 feet horizontally from any existing or proposed gravity sewer, septic tank, or subsoil treatment system. The distance must be measured edge to edge.

8.8.3 Crossings

a. Water mains crossing sewers must be laid to provide a minimum vertical distance of 18 inches between the outside of the water main and the outside of the sewer. This must be the case where the water main is either above or below the sewer.

b. At crossings, one full length of water pipe must 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.

8.8.4 Exception

When it is impossible to obtain the minimum specified separation distances, MDEQ must specifically approve, through the deviation process, any variance from the requirements of Sections 8.8.2 and 8.8.3. Where sewers are being installed and Section 8.8.2 and 8.8.3 cannot be met, the following methods of installation may be used:

a. Such deviation may allow installation of the water main closer to a gravity sewer, provided that the water main is laid in a separate trench or on an undisturbed earth shelf located on one side of the sewer at such an elevation that the bottom of the water main is at least 18 inches above the top of the gravity sewer.

b. The sewer must be in compliance with the requirements of DEQ-2, Chapter 30, Section 38 Protection of Public Water Supplies.

8.8.5 Force mains

There must be at least a 10 foot horizontal separation between water mains and sanitary sewer force mains. There must be an 18 inch vertical separation at crossings as required in Section 8.8.3.

8.8.6 Sewer manholes

No water pipe may pass through or come in contact with any part of a sewer manhole. Water main should be located at least 10 feet from sewer manholes.

8.8.7 Separation of water mains from other sources of contamination

Design engineers should exercise caution when locating water mains at or near certain sites such as sewage treatment plants or industrial complexes. Subsurface sewage systems must be located and avoided. The engineer must contact MDEQ to establish specific design requirements for locating water mains near any source of contamination.

8.9 SURFACE WATER CROSSINGS

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

8.9.1 Above-water crossings

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

8.9.2 Underwater crossings

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

a. pipe pulled or floated and lowered into position must be of special construction, having flexible watertight joints; pipe assembled in place may have mechanical or welded watertight joints in lieu of flexible water tight joints.

b. valves must be provided at both ends of water crossings so that the section can be isolated for testing or repair; the valves must be easily accessible, and not subject to flooding.

c. means of applying pressure for leakage tests on the isolated section must be provided.

8.10 CROSS-CONNECTIONS AND INTERCONNECTIONS

8.10.1 Cross-connections

There may not be unprotected cross-connections between the distribution system and any pipes, pumps, hydrants, or tanks whereby unsafe water or other contaminating materials may be discharged or drawn into the system. Cross-connections must be eliminated in conformity with Title 17, Chapter 38, Sub-Chapter 3, ARM.

8.10.2 Cooling water

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

8.10.3 Interconnections

The approval of MDEQ must be obtained for interconnections between potable water supplies. Consideration should be given to differences in water quality.

8.11 WATER SERVICES AND PLUMBING

8.11.1 Plumbing

Water services and plumbing must conform to relevant local and state plumbing codes, or to the Uniform Plumbing Code as amended by ARM 8.70.302. Solders and flux containing more than 0.2% lead and pipe fittings containing more than 8% lead must not be used.

8.11.2 Booster pumps

Individual booster pumps are not allowed for any individual residential service from the public water supply mains. Where permitted for multi story public building services, booster pumps must be designed in accordance with Sections 6.4 through 6.4.4.

8.12 SERVICE METERS

Each service connection should be individually metered. New water systems should individually meter each service connection.

8.13 WATER LOADING STATIONS

Water loading stations present special problems since the fill line may be used for filling both potable water vessels and other tanks or contaminated vessels. To prevent contamination of both the public supply and potable water vessels being filled, the following principles must be met in the design of water loading stations:

a. there may not be any backflow to the public water supply.

b. the piping arrangement must prevent contaminant being transferred from a hauling vessel to others subsequently using the station,

c. hoses may not be contaminated by contact with the ground.

8.14 WATER MAIN ABANDONMENT

Water mains must be abandoned in a manner that prevents cross connections and must be entirely or partially removed to prevent future connection to the abandoned main.

8.15 TEMPORARY WATER DISTRIBUTION

All pipes including service lines and all appurtenances for temporary distribution of water during construction of replacement projects must be approved by the MDEQ. The plans and specifications must, at a minimum, satisfy the following requirements:

a. All materials must comply with ANSI/NSF, where such standards exist, and be acceptable to MDEQ.

b. No component of the temporary distribution system can be in contact with or at risk of being in contact with sources of contamination.

c. The temporary system must be designed to maintain a minimum working pressure of 35-psi at all points in the distribution system including the service lines.

d. Where accumulation of air could diminish the flow capacity of the system, air relief must be provided.

e. All piping and valves must be adequately restrained where necessary and protected from physical damage to the extent practicable.

f. Each temporary setup of distribution piping must be visually inspected for leaks at full pressure prior to use and daily during use. Visual leaks occurring during use must be reported to the project engineer and repaired immediately.

g. Each temporary setup of distribution piping must be flushed, disinfected, and microbiologically tested in accordance with AWWA Standard C651.

h. There may not be any potential cross-connections to the temporary distribution system.

i. A double check assembly backflow prevention valve, at a minimum, must be installed to protect the municipal supply connection to the temporary distribution system. Backflow prevention valves must conform to standards issued by AWWA.

CHAPTER 9 – WASTE RESIDUALS

9.0 GENERAL

Provisions must be made for proper disposal of water treatment plant waste such as sanitary, laboratory, clarification sludge, softening sludge, iron sludge, filter backwash water, and brines. All waste discharges are governed by regulatory agency requirements. The requirements outlined herein must, therefore, be considered minimum requirements as state water pollution control authorities may have more stringent requirements. In locating waste disposal facilities, due consideration must be given to preventing potential contamination of the water supply. Alternative methods of water treatment and chemical use should be considered as a means of reducing waste volumes and the associated handling and disposal problems. Appropriate backflow prevention must be provided on waste discharge piping as needed to protect the public water supply.

9.1 SANITARY WASTE

The sanitary waste from water treatment plants, pumping stations, and other waterworks installations must receive treatment. Waste from these facilities must be discharged directly to a sanitary sewer system, when available and feasible, or to an adequate on-site waste treatment facility approved by MDEQ. However, initiation of this practice will depend on obtaining approval from the owner of the sewerage system as well as from the MDEQ before final designs are made.

9.2 BRINE WASTE

Waste from ion exchange plants, demineralization plants, or other plants that produce a brine, may be disposed of by controlled discharge to a stream if adequate dilution is available. Surface water quality requirements of MDEQ will control the rate of discharge. Except when discharging to large waterways, a holding tank of sufficient size must be provided to allow the brine to be discharged over a twenty-four hour period. Where discharging to a sanitary sewer, a holding tank may be required to prevent the overloading of the sewer and/or interference with the waste treatment process. The effect of brine discharge to sewage lagoons may depend on the rate of evaporation from the lagoons.

9.3 PRECIPITATIVE SOFTENING SLUDGE

Sludge from plants using precipitative softening varies in quantity and in chemical characteristics depending on the softening process and the chemical characteristics of the water being softened. Recent studies show that the quantity of sludge produced is much larger than indicated by stoichiometric calculations. Methods of treatment and disposal are as follows:

a. Lagoons

   1. Temporary storage lagoons which must be cleaned periodically must be designed on the basis of 0.7 acres per million gallons per day per 100 milligrams per liter of hardness removed based on usable lagoon depth of five feet. This should provide about 2 1/2 years storage. At least two but preferably more lagoons must be provided in order to give flexibility in operation. An acceptable means of final sludge disposal must be provided. Provisions must be made for convenient cleaning.

   2. Permanent lagoons must have a volume of at least four times the volume of temporary lagoons.

   3. The design of both temporary lagoons and permanent lagoons must provide for:

      a. location free from flooding,

b. dikes, deflecting gutters or other means of diverting surface water must be provided so that it does not flow into the lagoons,

c. a minimum usable depth of five feet,

d. adequate freeboard of at least two feet,

e. adjustable decanting device,

f. effluent sampling point,

g. adequate safety provisions,

h. parallel operation, and

i. subsurface infiltration may be acceptable if approved by MDEQ.

b. The application of liquid lime sludge to farm land can be considered as a method of ultimate disposal. Approval from MDEQ must be obtained. When this method is selected, the following provisions must be made:

1. Transport of sludge by vehicle or pipeline must incorporate a plan or design, which prevents spillage or leakage during transport.

2. Interim storage areas at the application site must be kept to a minimum and facilities must be provided to prevent washoff of sludge or flooding.

3. Sludge must not be applied at times when washoff of sludge from the land could be expected.

4. Sludge must not be applied to sloping land where washoff could be expected unless provisions are made, for suitable land, to immediately incorporate the sludge into the soil.

5. Trace metals loading must be limited to prevent significant increases in trace metals in the food chain, phytotoxicity or water pollution.

6. Each area of land to receive lime sludge must be considered individually and a determination made as to the amount of sludge needed to raise soil pH to the optimum for the crop to be grown.

c. Discharge of lime sludge into sanitary sewers should be avoided since it may cause both liquid volume and sludge volume problems at the sewage treatment plant. This method must only be used when the sewerage system has the capability to adequately handle the lime sludge, and the applicant has obtained written approval from the owner of the sewerage system before final designs are made.

d. Mixing of lime sludge with activated sludge waste may be considered as a means of co-disposal.

e. Disposal at the landfill can be done as either a solid or liquid if the landfill can accept such waste, depending on individual state requirements.

f. Mechanical dewatering of sludge may be considered. Pilot studies on a particular plant waste are required.

g. Calcination of sludge may be considered. Pilot studies on a particular plant waste are required.

h. Lime sludge drying beds are not recommended.

9.4 ALUM SLUDGE

Lagoons may be used as a method of handling alum sludge. Lagoon size can be calculated using total chemicals used plus a factor for turbidity. Mechanical concentration may be considered. A pilot plant study is required before the design of a mechanical dewatering installation. Freezing changes the nature of alum sludge so that it can be used for fill. Acid treatment of sludge for alum recovery may be a possible alternative. Alum sludge can be discharged to a sanitary sewer. However, initiation of this practice will depend on obtaining approval from the owner of the sewerage system as well as from the MDEQ before final designs are made.

9.4.1 Lagoons

Lagoons must be designed to produce an effluent satisfactory to the MDEQ and must provide for:

a. location free from flooding,

b. dikes, deflecting gutters or other means of diverting surface water must be provided so that it does not flow into the lagoon,

c. a minimum usable depth of five feet,

d. adequate freeboard of at least two feet,

e. adjustable decanting device,

f. effluent sampling point,

g. adequate safety provisions, and

h. a minimum of two cells each with appropriate inlet/outlet structures to facilitate independent filling/dewatering operations.

9.4.2 Mechanical Dewatering

a. The successful use of mechanical dewatering depends on the characteristics of the alum sludge produced, as determined by site specific studies.

b. Mechanical dewatering must be preceded by sludge concentration and chemical pre-treatment.

9.4.3 Land Application

Alum sludge may be disposed of by land application either alone, or in combination with other wastes where an agronomic value has been determined and disposal has been approved by MDEQ.

9.5 "RED WATER" WASTE

Waste filter wash water from iron and manganese removal plants can be disposed of as follows:

9.5.1 Sand filters

Sand filters must have the following features:

a. Total filter area, regardless of the volume of water to be handled, must be no less than 100 square feet. Unless the filter is small enough to be cleaned and returned to service in one day, two or more cells are required.

b. The "red water" filter must have sufficient capacity to contain, above the level of the sand, the entire volume of wash water produced by washing all of the production filters in the plant, unless the production filters are washed on a rotating schedule and the flow through the production filters is regulated by true rate of flow controllers. Then sufficient volume must be provided to properly dispose of the wash water involved.

c. Sufficient filter surface area must be provided so that, during any one filtration cycle, no more than two feet of backwash water will accumulate over the sand surface.

d. The filter may not be subject to flooding by surface runoff or flood waters. Finished grade elevation must be established to facilitate maintenance, cleaning and removal of surface sand as required. Flash boards or other non-watertight devices may not be used in the construction of filter side walls.

e. The filter media must consist of a minimum of twelve inches of sand, three to four inches of supporting small gravel or torpedo sand, and nine inches of gravel in graded layers. All sand and gravel must be washed to remove fines.

f. Filter sand must have an effective size of 0.3 to 0.5 mm and a uniformity coefficient not to exceed 3.5.

g. The filter must have an adequate under-drainage collection system to permit satisfactory discharge of filtrate.

h. Provision must be made for the sampling of the filter effluent.

i. Overflow devices from "red water" filters are not permitted.

j. Where freezing is a problem, provisions must be made for covering the filters during the winter months.

k. "Red water" filters must comply with the common wall provisions contained in Sections 7.1.3 and 8.10.1, which pertain to the possibility of contaminating treated water with an unsafe water.

l. MDEQ must be contacted for approval of any arrangement where a separate structure is not provided.

9.5.2 Lagoons

Lagoons must have the following features:

a. be designed with volume 10 times the total quantity of wash water discharged during any 24-hour period,

b. a minimum usable depth of three feet,

c. length four times width, and the width at least three times the depth, as measured at the operating water level,

d. outlet to be at the end opposite the inlet,

e. a weir overflow device at the outlet end with weir length equal to or greater than depth,

f. velocity to be dissipated at the inlet end, and

g. subsurface infiltration lagoons may be acceptable if approved by MDEQ.

9.5.3 Discharge to community sanitary sewer

Red water can be discharged to a community sewer. However, approval of this method will depend on obtaining approval from the owner of the sewerage system as well as MDEQ before final designs are made. A holding tank must be provided to prevent overloading the sewers. Design must prevent cross connections and there must be no common walls between potable and non-potable water.

9.5.4 Recycling "Red Water" Wastes

Recycling of supernatant or filtrate from "red water" waste treatment facilities to the head end of an iron removal plant are not allowed except as approved by MDEQ .

9.6 WASTE FILTER WASH WATER

Waste filter wash water from surface water treatment or lime softening plants must have suspended solids reduced to a level acceptable to MDEQ before being discharged. Many plants have constructed holding tanks and returned this water to the inlet end of the plant. The holding tank must be sized to contain the anticipated volume of waste wash water produced by the plant when operating at design capacity. A plant that has two filters must have a holding tank that will contain the total waste wash water from both filters calculated by using a 15-minute wash at 20 gallons per minute per square foot. In plants with more filters, the size of the holding tank will depend on the anticipated hours of operation. It is recommended that waste filter wash water be returned at a rate of less than 10 percent of the raw water entering the plant. Filter backwash water must not be recycled when the raw water contains excessive algae, when finished water taste and odor problems are encountered, or when trihalomethane levels in the distribution system exceed allowable levels.

9.7 RADIOACTIVE MATERIALS

Radioactive materials include, but are not limited to, GAC used for radon removal; ion exchange regeneration waste from radium removal; and manganese greensand backwash solids from manganese removal systems, precipitive softening sludges, and reverse osmosis concentrates where radiological constituents are present. The buildup of radioactive decay products of radon must be considered, and adequate shielding and safeguards must be provided for operators and visitors. These materials may require disposal as radioactive waste in accordance with Nuclear Regulatory Commission Regulations. Approval must be obtained from MDEQ prior to disposal of all wastes.

APPENDIX A

A.1 General

In addition to the information required in the circular, information on management, operation, maintenance, and financing of the system must be submitted. The purpose of this information is to allow evaluation of a new system for proper system management, operation and maintenance (O&M), and financial planning that provides long-term stability of the new system. The 1996 Safe Drinking Water Act provides for State development of strategies to ensure the managerial, technical, and financial capacity for new community water systems.

The fundamental goals of capacity development are:

to protect public health by ensuring consistent compliance with drinking water standards,

to enhance performance beyond compliance through measures that improve efficiency, effectiveness, and service excellence,

to promote continuous improvement through monitoring, assessment, and strategic planning.

Capacity terms are defined as follows based on definitions in Title 36, Chapter 23, Sub-chapter 1, ARM:

Managerial capability (capacity) means the management structure of the water system, including but not limited to ownership accountability, staffing, and organization.

Technical capability (capacity) means the physical infrastructure of the water system, including but not limited to the source water adequacy, infrastructure adequacy, and technical knowledge based on information provided.

Financial capability (capacity) means the financial resources of the water system, including but not limited to the revenue sufficiency, credit worthiness, and fiscal controls.

The Department is granted the authority in 75-6-103(2)(f), MCA, to ensure financial viability of proposed public water supply systems (and public sewage systems) as necessary to ensure the capability of the system to meet the requirements of Title 75, Chapter 6, Part 1, MCA.

A separate application form with appropriate guidance is available from the Department to assist in providing information. All new public water supplies and existing systems making modifications must submit a capacity development inventory and self-assessment form.

A.2 Managerial Capacity

Provide the following information:

1. Name, address, and telephone number of the owner(s). If ownership or control of the system is to change in the near future, such as in a subdivision where the developer will eventually relinquish control to the homeowners' association, provide a projected time line for change of ownership.

2. Administrative and management organizational charts. Define the functions and responsibilities of the organization and each administrative/managerial position. For example, if the organization has a secretary, provide a brief description of the secretary's responsibilities.

Plans for staffing the system with a certified operator and back-up operator. Provide the name of the operator if an operator has been selected. An operator should be available to operate the system even if the system has not yet become public. If the system is to be operated under contracted services, provide a copy of the contract.

4. A system or plan for maintaining records (including records of operation, service maintenance, and repairs), plans and specifications for construction, as-built drawings, O&M manuals, and compliance information. Preferably, an office space should be dedicated for storing all information that is readily accessible by the operator, manager(s), and owner(s) of the system.

5. A copy of the articles of incorporation, by-laws, or similar documents that:

a. Define the purpose of the responsible entity.

b. Describe the procedures for compliance with the requirements of the Secretary of State's Office for creating and maintaining a non-profit association.

c. List membership and define membership rights (all lot owners should automatically

d. Define the format and schedule for meetings and requirements for quorums.

e. Describe the powers and duties of the board of directors.

f. Describe the process for transferring control of the system from the developer to the lot owners, where applicable.

g. Explain the procedures for amendment of the by-laws.

h. Confer authority to assess and collect fees for O&M, monitoring, personnel, capital improvements and equipment replacement.

i. Establish the service area of the responsible entity.

j. Confer authority to require water conservation practices, including metering.

k. Confer authority to require installation of water meters, and to own and maintain water meters, and the authority to bill according to water usage.

l. Confer authority to require installation of backflow prevention devices, and to own and maintain such devices.

m. Confer authority and define procedures for disconnection of service (nonpayment, refusal to provide meters or backflow devices or to allow access for maintenance of this equipment).

Also, provide policies on how delinquent accounts, system violations, fee changes, and customer complaints will be addressed. Please note that homeowners' associations must file their articles of incorporation with the Secretary of State.

6. In the event that the responsible entity becomes insolvent, how will perpetuation of the system be maintained? Has a second party been considered for future ownership in the event that the responsible entity becomes insolvent?

The managerial plan must allow for:

a. Efficient operation of the system.

b. Adequate control of and accountability for the system by the owner(s), manager(s), and operator(s).

c. Adequate resources and accountability for regulatory compliance by the owner(s), manager(s) and operator(s).

d. Dissemination of appropriate information to all customers and regulatory agencies.

A.3 Technical, Operational, and Maintenance Capacity

Provide the following information in the form of an O&M manual that will be available to the operator, owner(s), and manager(s):

1. An explanation of startup and normal operation procedures. Startup should address operation of the system throughout system buildout if applicable (i.e., a subdivision will experience varying demands as the subdivision develops and builds out).

2. Will any equipment be leased or rented? Are easement or lease agreements necessary for any portion of the system? If applicable, provide pertinent information (i.e., copy of easement or lease agreement). Are changes in local zoning necessary to protect the proposed source(s)?

3. Record keeping method and system for reporting to the Department.

4. Sampling and analyses program to demonstrate compliance with drinking water standards (Title 17, Chapter 38, Sub-Chapter 2, ARM) for all sources, entry points, treatment, and distribution systems.

5. Staffing and training requirements to operate the system to maintain compliance with drinking water standards (Title 17, Chapter 38, Sub-Chapter 2, ARM).

6. Documentation of a safety program.

7. Documentation of an emergency plan and emergency operating procedures (e.g., in the event of a chemical spill or loss of power).

8. Manufacturer's manuals for all equipment and contact names for service. A routine maintenance program and maintenance schedules must also be included. Forms for recording routine maintenance checks per manufacturer's guidelines should be provided, including frequency of maintenance and anticipated replacement dates for major equipment.

Items 1 through 5 must be submitted in the form of an O&M manual prior to approval of the system.

A letter from the applicant must be provided prior to system use indicating that the system (or portion of the system that has been completed to date) was constructed per the approved plans and specifications. As-built, record drawings for the system (or portion of the system that has been completed to date) must be provided within 90 days after the system has become operational. The as-built, record drawings must include an O&M manual addressing items 1 through 8 and must contain manufacturer's manuals and other pertinent information to complete the O&M manual.

9. The system must be operated in a manner that:

a. Maintains compliance with drinking water standards (Title 17, Chapter 38, Sub-Chapter 2, ARM).

b. Allows effective operation of the system in accordance with the approved plans and specifications.

c. Supplies adequate water, both in terms of quantity and quality.

d. Complies with operating conditions presented in the engineer's report.

A.4 Financial Capacity

The following financial information must be submitted in order to receive system approval:

1. The financial information in Table A-1 must be completed for a 5-year period.

2. O&M rates and capital improvement/replacement rates must be developed based on the information in Table A-1. A capital improvement/replacement plan must be developed for a 20-year period and the rate set accordingly. A reserve fund must be established and maintained to address future replacement of equipment based on anticipated replacement dates.

3. Customers should be metered. If customers are metered, demonstrate how the rates account for metering (cost of meters, cost of operator to read/maintain meters, how rates correspond to meter readings).

4. Connection/system development fee and basis for fee, if applicable.

5. A description of the owner(s) or responsible entity's access to financial capital. If a large sum of money is necessary for replacement, improvement, or expansion, can the owner(s) or responsible entity obtain a loan or grant?

6. Budgetary controls and audit schedule.

7. If the system is privately owned, has the Department of Public Service Regulation been contacted?

8. Provide a financial plan that demonstrates how all improvements will be constructed per the proposed plans and specifications. If bonding or other financial assurance has been provided for improvements with a regulating entity (such as the county), provide information on the bonded improvements.

The financial plan must demonstrate that:

a. Revenues match or exceed expenses.

b. Adequate funds will be maintained for replacement of equipment.

c. Appropriate reserve accounts will be maintained.

d. The budget will be controlled, preferably by audits every 3 to 5 years.

e. The 5-year cash flow presented in Table A-1 is sufficient to properly operate the system.

All proposed improvements will be constructed completely and in accordance with the approved plans and specifications.

GLOSSARY

Active Storage Volume: The volume of water available in a hydropneumatic pressure tank between the ON-OFF pressure settings. The effective volume is limited to approximately 25 - 30% of the total volume of the tank. More accurate percentages can be obtained from tables utilizing pump ON-OFF settings and tank pre-charge. Manufacturers' information on captive air tanks give the effective volume for different operating pressure ranges and pre-charges.

Average-Day Demand: Annual water consumption divided by 365 days in a year. Average-Day Demand normally includes the following components for design of new systems. Average-Day Demand from actual use records for existing systems that provide fire Protection may also include some Fire Demands that have occurred. However, separate Fire Demand must always be added to the components listed below for new systems or to the actual average use for existing systems when designing for fire storage.

1. Domestic demand: Volume of water required by the average household for drinking, cooking, laundry, bathing and sanitation.
2. Commercial/Industrial: Volume of water required by users other than residential. Such as restaurants, offices, institutions, shops.
3. Irrigation Demand: Volume of water used to irrigate lawns and gardens. The total seasonal demand over 180 days is averaged for the entire year.

Design Pump Capacity: Anticipated production rate based on pump selection from manufacturer's pump performance curves. Pump selections, within recommended efficiency ranges, are made using water system Total Dynamic Head (TDH) and desired production capacity.

Discharge piping: Water line from the source to the pressure control assembly. Includes the piping to which the pressure control appurtenances are attached. Discharge piping would normally begin at a well pitless unit or adaptor.

Fire-flow Demand: Volume of water required to fight structural fires, expressed as flow rate times duration. The proposed fire flows must be as recommended by the fire protection agency in which the water system is being developed, or in the absence of such a recommendation, the fire code adopted by the State of Montana. Fire flow demand must be added to the maximum day demand during the hours of peak demand when designing a system.

Hydraulic analysis: An evaluation of the distribution system to determine if adequate pressure is maintained under all flow conditions in accordance with DEQ-1, Section 8.2.1. The analysis can be performed using a calibrated model or established empirical equations, such as Darcy-Weisbach or Hazen-Williams.

Maximum Day Demand: The highest volume of water consumed on any day in a year.

Network analysis: The process of analyzing water distribution systems through the use of mathematical computer models.

Peak Instantaneous Demand: The highest flow rate on the hydrographic curve. Expressed as a volume per unit of time. Calculated from a Fixture Unit analysis per the UPC, AWWA Fixture Value Method, or by applying a peaking factor to the Average Day Demand in gallons per minute, or other means acceptable to MDEQ.

Service connection: A line that provides water service to one building or living unit.

Storage Sizing Engineering Analysis: A detailed engineering study that includes hourly water usage demands for the maximum day, operational storage volume requirements, reserve standby storage requirements, dead storage volume, and extended time reservoir mass flow analysis for the maximum day demand with the required fire flow, when fire protection is provided, occurring during the hours of peak demand. The required design storage volume must be determined with the largest well, largest treatment train, and largest booster pump out of service and must include provisions for auxiliary power.

Water main: Any line providing water to two or more service connections.