CHAPTER 6
Chemical Application

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6.0 General

No chemicals shall be applied to treat drinking waters unless specifically permitted by MassDEP. Refer to General Design Considerations, Chapter 2 for additional guidance on chemical application.

The public water supplier should evaluate the total sodium level of the water delivered to the customer when considering adding approved water works chemical. Chemicals that have not been previously used in Massachusetts' public drinking water supplies must receive written approval from MassDEP before use.

6.0.1 Plans and Specifications

MassDEP requests one hard copy and one electronic copy of the appropriate specifications and plans. The electronic copy must be submitted on a compact disk or other acceptable media and must be in PDF format.

Permit applications, plans and specifications shall be submitted for review and approval, as provided for in Chapter 1, and shall include:

1. Descriptions of feed equipment including maximum, average, and non-zero minimum feed ranges (expressed in daily/monthly use and gallons/volume/weight per hour);
2. Location of feeders, piping layout, and points of application;
3. Descriptions of storage and handling facilities;
4. Specifications for chemicals to be used;
5. Operating and control procedures including proposed application rates;
6. Descriptions of testing equipment and procedures;
7. A schematic of all chemical equipment, piping and appurtenances including sampling and monitoring locations;
8. A description of the Chemical Safety Control Strategy for Critical Chemical Feed Systems in section 6.1.3;
9. A description of the controls and instrumentation for the non-critical chemical feed systems;

6.0.2 Chemical Application

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

1. Assure maximum efficiency of treatment;

2. Provide maximum safety to consumer;

3. Provide maximum safety to operators;

4. Assure satisfactory mixing of the chemicals with the water;

5. Provide maximum flexibility of operation through various points of application, when appropriate;

6. Prevent backflow, prevent back-siphonage, prevent bypassing of treatment units, and eliminate multiple points of feed through common manifolds;

7. Provide a completed chemical injection point into a pipeline using an injection nozzle with a corporation stop, ball check (to prevent back flow), and safety chain/cable, or using a diffuser pipe into a basin unless otherwise approved by MassDEP.

6.0.3 General Equipment Design

The general equipment design shall conform to the following:

1. Feeders will be able to supply, at all times, the necessary amounts of chemicals at an accurate rate, throughout the range of feed.

2. Chemical-contact materials and surfaces are resistant to the aggressiveness of the chemical solution.

3. Corrosive chemicals are introduced in such a manner as to minimize potential for corrosion.

4. Chemicals that are incompatible are not fed, stored, or handled together.

5. All chemicals are conducted from the feeder to the point of application in separate conduits.

6. Chemical feeders are as near as practical to the feed point.

7. Feeders and pumps shall be sized in the specifications so they will operate at a point no lower than 10 percent setting on the feed range dial setting for greater metering accuracy. (If a motor driven pump or feeder with multiple step pulleys is provided, this requirement shall mean the maximum gallons or pounds per day on the smallest and slowest pulley size.) An example is a chemical dosage at optimum concentration of 15 gallons per day (gpd). This pump can not be sized in the specifications greater than 150 gpd (15 gpd divided by 0.10), but may be less.

8. For motor driven pumps with multiple step pulleys, feeders and pumps shall be sized in specifications so they will not deliver more than 2,000 percent of the optimal chemical dosage in mg/l to help prevent

potential overfeeds. This requirement shall mean maximum gallons or pounds per day on largest and fastest step pulley size[1].

9. Gravity may be used where practical.

6.1 Facility Design

6.1.1 Feeders and Metering Pumps

1. Chemical feed systems, when provided, shall include a minimum of two feeders. The standby unit or a combination of units of sufficient capacity should be available to replace the largest unit during shutdown. Each chemical feeder that is needed to comply with a treatment technique or MCL requirement should have a standby or reserve unit mounted and installed.

2. A separate feeder system shall be used for each chemical applied.

3. Spare parts shall be available for all feeders to replace parts which are subject to wear and damage, such as, anti-siphon valves, belts, tubing, etc.

6.1.2 Control of Feeders and Metering Pumps

1. Feeders and metering pumps may be manually or automatically controlled in setting stroke length, with automatic controls being designed so as to allow override by manual controls. To allow for routine service and testing of the metering pump, an HOA (hand, off, automatic) switch, or an internal (hand) and external (automatic pacing) switch may be used. Proper signage must be provided whenever the metering pump control is placed in “hand”, “manual” or “internal” mode to guard against any overfeeds.

2. Chemical feed rates shall be proportional, or automatically flow paced, to water flow.

3. A means to measure treated water flow in gpm and total gallons must be provided.

4. Provisions shall be made for measuring the daily net quantities of chemicals used in gallons, milliliters, or pounds.

5. The density in pounds/cubic foot for dry chemicals or pounds per gallon for liquid chemicals must be provided.

6. Chemical pumps or feeders shall be synchronized to start and stop (electrically interlocked with the appropriate upstream water pump motor or thermal type flow switch) with the flow of water being treated as the primary electrical interlock. The use of a pressure type switch as a primary electrical interlock is prohibited as unreliable.

[1] An example is optimal chemical dosage is 2.0 mg/l of chemical per day. The metering pump referenced in the specifications can not be capable of pumping more than (20 x 2.0 mg/l or) 40.0 mg/l of chemical at maximum strokes per minute setting and maximum 100 percent of full stroke setting, but may be less.

7. The use of a labeled twist type electrical plug for any metering pump and twist type interlock receptacle is recommended when the metering pump is not hardwired to help prevent overfeeds. A pilot light indicator with legend plate is desirable to tell the operator when the interlock circuit receptacle is energized.

8. Controls shall be configured such that chemical metering pumps are restarted only at the water treatment facility following an alarm initiated shutdown.

    a. The determination to resume operation of the chemical metering pumps following an alarm initiated shutdown shall be made by a certified operator.

9. Weighing scales:

    a. Shall be provided for weighing cylinders, at all plants using chlorine gas;

    b. Are required when hydrofluosilicic acid is used;

    c. Should be accurate to measure increments of 0.5 percent of load;

    d. Shall be graduated in pounds;

    e. Shall be required for volumetric dry chemical feeders;

    f. Are recommended for all other chemicals.

6.1.3 Chemical Safety Control Strategy for Critical Chemical Feed Systems

All critical chemical feed systems shall be equipped with controls and alarms to conform with this Chemical Safety Control Strategy. Critical chemical feed systems are considered to be those systems which may result in a threat to public health and safety in the event of an overfeed or underfeed of the chemical. MassDEP has identified the following chemicals as having critical chemical feed systems:

1. Most chemicals used for disinfection (i.e. gaseous or liquid chlorine, chloramines)

2. Hydrofluosilicic acid

3. Most chemicals used for pH adjustment (i.e. sodium hydroxide and potassium hydroxide)

4. Other chemicals as determined by MassDEP

MassDEP has also identified the following chemicals as not having critical chemical feed systems and therefore exempt from the Chemical Safety Control Strategy:

1. Sodium fluoride (as used in a fluoride saturator)

2. Lime contactor

3. Sodium bicarbonate

4. Potassium bicarbonate

6.1.3.1 Basic System

Each water pump or group of pumps discharging treated water into a distribution system must be monitored with a chemical analyzer for each critical chemical injected into the water system by a chemical metering pump, unless it can be demonstrated that such an analyzer is not needed. The analyzer may be specific to the chemical in use or a "surrogate" may be used (i.e. total chlorine analyzer for chloramines, pH analyzer for sodium hydroxide). Requests for a waiver from the requirement for a chemical analyzer shall be made in writing to MassDEP and shall include documentation to support that the analyzer is not needed. MassDEP shall review the request for a waiver and, if it concurs, grant approval for the waiver in writing.

The pump motor controller(s), chemical metering pump(s), and chemical analyzer(s) shall be interlocked so that no chemical is injected if the pump is not running. A flow meter or thermal type flow switch must also be installed and interlocked such that when no flow is detected, the chemical feed pumps shall not operate. If the analyzer detects a parameter that is out of range and the out of range condition could harm the public, the water pump(s) and metering pump(s) shall automatically shut down and an alarm shall be immediately sent to a properly certified operator. Following such an automatic shut down, a properly certified operator shall inspect the facility and insure system is returned to normal operating conditions prior to re-activating the supply. A facility that is staffed 24/7/365 is not required to have an automatic shut down, but properly certified staff shall be available to take proper action to prevent the plant from discharging water that may be harmful to the public.

Powering of all metering pumps shall be configured to prevent overriding of the safety shut down systems. Acceptable electrical configurations include:

1. Hard wiring with electrical interlocks that are tied to controls that must be satisfied in order for the pumps to operate. To allow for routine service and testing of the metering pump, the electrical configuration shall include an HOA (Hand-Off-Automatic) switch with a timer, or a spring loaded HOA switch, to insure that the metering pump, when in the hand mode, shall be automatically shut down after no more than 1 hour.

2. Connection to a duplex electrical receptacle that accepts only twist lock plugs where each outlet is energized only when approved controls are satisfied in order for the pumps to operate. One outlet, which will be used for routine operation of the pump, shall be interlocked with the safety shut down systems. To allow for routine service and testing of the metering pump, the other outlet shall have a separate power supply that is not interlocked with the safety shut down systems and is controlled by a timer to insure that the metering pump shall be automatically shut down after no more than 1 hour. Proper signage shall be provided for the use of the electrical receptacle.

3. Other configurations as approved by MassDEP.

6.1.3.2 Controls

Controls for protecting critical chemical feed systems depend on the complexity of the system. Controls can range from simple electromechanical relays to Programmable Logic Controllers (PLCs). In all but the most simple systems, PLCs should be considered because of the increased flexibility of control and the ability to perform control functions and communications. Any size system can benefit from the use of PLC technology and the cost should not be presumed to be prohibitive.

MassDEP recommends that controls be designed so that if a chemical feed pump is in the manual mode, the operator is notified locally by a visual and/or audible alarm and/or remotely by an autodialer.

For electrical configurations other than hard wiring or a duplex receptacle, as described under "Basic System", controls shall be required as determined by MassDEP.

6.1.3.3 Instrumentation

Unless a waiver from the requirement for a chemical analyzer is granted by MassDEP in accordance with the requirements under "Basic System", a chemical analyzer shall be used to detect and monitor critical chemicals injected into the water stream. Analyzers are commonly used to monitor and control chemical addition. Analyzers should have at least two alarm contacts that can be set for alarm conditions. These contacts may be used to interlock the chemical feed system with other system equipment to prevent overfeed or underfeed of critical chemicals.

All instrumentation shall be calibrated in accordance with the manufacturer's recommendations in order to insure a reliable and safe system. MassDEP recommends that the system implement a validation program to insure the reliability of all instrumentation.

6.1.3.4 Alarming

Where an uninterrupted supply of water is required, such as a single source, out of range operational conditions shall be alarmed immediately through an alarm device via phone line, radio or cellular means. Acceptable alarm devices include the following:

1. Phone line autodialer
2. Tone telemetry
3. Cellular alarm dialer
4. Cellular base system
5. SCADA based that communicates to a SCADA computer via radio or leased phone lines
6. Alarm company
7. Other devices approved by MassDEP.

6.1.3.5 Recording and Data Logging

Unless otherwise required by MassDEP, it is recommended that chemical feed system operational parameters be recorded so that the operators have information that tells them how the system is running. Recording or logging data will give the operators an indication of how well the system is operating and whether or not adjustments can be made to optimize the use of the chemicals being injected. The following are ways to record data:

1. Chart recorder

2. Electronic data logger

3. SCADA system

6.1.3.6 Testing Alarms and Controls

All alarms and controls installed to prevent the overfeed or underfeed of a critical chemical shall be tested quarterly, unless otherwise required by MassDEP, and logs shall be maintained to record the test results. The water supplier shall have written protocols for testing critical alarms, which include the following:

1. High and low critical alarms shall be tested using one of the following methods:

    a. Adjust alarm set points on the analyzer

    b. Change alarm sets points through the SCADA system

    c. Use a chemical standard if the system uses an analyzer probe

2. Interlocks shall be tested to insure chemical feed systems perform as expected using the following methods:

    a. *Interlock with Pump Starter* - Turn raw or finished water pump to off position and verify that corresponding critical chemical feed system is de-energized.

    b. *Interlock with Flow Meter or Flow Switch* - Create a low or no flow condition on the raw or finished water pump and verify that the corresponding critical chemical feed system is de-energized.

    c. *Interlock with Analyzer* – Create critical alarm condition, in accordance with the alarm testing protocols noted above, and verify that the corresponding critical chemical feed system and raw or finished water pump are de-energized.

3. If the system is required to use a remote notification device, such as an autodialer or software, the system shall test the device to insure that it notifies a properly certified operator on call. To test the device, the system shall trigger an alarm which requires a shut down and record the sequence in which the device contacts the certified operator authorized to respond. The system does not need to test all alarm systems, but the sequence should be checked for all critical alarms.

6.1.4 Controls and Alarms for Non-Critical Chemical Feed Systems

1. Non-critical chemicals are defined as any chemicals that are not defined as being critical chemicals in section 6.1.3. A chemical is classified as either critical or non-critical, and as determined by MassDEP.

2. Facility design for non-critical chemical feed systems shall be equipped with an electrical interlock(s) with the appropriate upstream production pump(s) or non mechanical type flow switch, such as, a thermal type flow switch.

3. Continuous chemical or pH analyzer with shut down capabilities is recommended.

4. Facility design for non-critical chemical feed systems may use equivalent devices as approved by MassDEP in writing. (The use of a pressure switch as a primary electrical interlock is prohibited as unreliable.)

5. Chemical feed systems must have audible and visual alarms when operating in manual mode. Manual mode assumes operating in manual override[2]. At a minimum or as otherwise approved in writing by MassDEP, manual override mode operation shall initially activate a visual alarm and after a set period of time an audible alarm would be triggered.

6. All alarms and interlocks on chemical feed systems shall be tested monthly or more frequently if so recommended by the manufacturers. This requirement must be covered in the SOP.

7. Only a certified operator or a designee under the direct supervision of the certified operator may set a pump, including chemical feed pumps, in manual mode.

8. Ensure that all alarms at a drinking water facility including alarms for pumps, high water, intrusion, etc. are transmitted to a location that is manually monitored continuously. If no such location is available, suitable alternative arrangements shall be made such as a programmable telephone dialer to an on-call person or persons. Telemetry systems, such as programmable telephone dialers, shall include a local alarm at the monitored location in case of loss of the telephone line or radio communications failure or other transmission failure**.** All requirements in this section must be satisfied unless otherwise approved by MassDEP in writing.

6.1.5 Dry Chemical Feeders

Dry chemical feeders shall:

1. Measure chemicals volumetrically or gravimetrically;

2. Provide adequate solution water and agitation of the chemical in the solution tank;

3. Provide gravity feed from solution tanks to point of application, if possible;

4. Completely enclose chemicals to prevent emission of dust to the operation room.

[2] A manual override is a procedure where an otherwise automatic system is switched to manual control, usually from a computer or other automatic control.

6.1.6 Positive Displacement Solution Pumps

1. Positive displacement type solution feed pumps shall be used to feed liquid chemicals, but shall not be used to feed chemical slurries, such as, lime and carbon. Use a special chemical type slurry pump or feeder to feed lime or powdered carbon solutions;

2. Pumps must be capable of operating at the required maximum rate against the maximum head conditions found at the point of chemical application;

3. Pressure relief valves shall be provided on the discharge line with the discharge piped or tightly tubed back into the respective day tank, solution tank, carboy shipping container or 1,000 ml calibration chamber used as a suction chamber to prevent chemical spillage, and for operator safety or other means as approved by MassDEP;

4. Clear calibration chambers (in ml) or mass flow meters should be mounted near feed pump to aid the operator in setting the pump rates and to allow for direct physical measurement of actual feed rates.

5. Chemicals should be fed in a manner that ensures a continuous dose of chemicals into the water. Pulsation dampeners or expansion chambers should be provided on the discharge side of the chemical feed pumps to minimize surges on long feed lines.

6.1.7 Liquid Chemical Feeders – Siphon Control

1. To prevent chemical solutions from being siphoned into the water supply, liquid chemical feeders shall provide:

   a. Discharge at a point of positive pressure or vacuum relief.

   b. A suitable air gap or anti-siphon device;

   c. Peristaltic pumps require installation of an anti-siphon or back-pressure valve.

   d. Other suitable means or combinations as necessary.

2. Anti-siphon devices shall be one diaphragm type spring loaded operated back-pressure or diaphragm type spring loaded operated anti-siphon valve located on the pump discharge line, easily accessible to operator, and located where noticeable. Such device is constructed so as to sit tight on increasing vacuum, and its positive pressure opening point is not less than 5 psig.

3. Wherever a flooded suction pump system is used, such as a sodium hypochlorite system, two anti- siphon or backpressure valves shall be installed in series as potential for siphoning increases.

4. Liquid chemical feeders should be located at an elevation not lower then the height of the chemical containment wall.

6.1.8 Cross Connection Control

1. Separate day tanks and feeders shall be provided for chemical feed systems that have feed points at both unfiltered and filtered water locations such that all unfiltered water feed points are fed from one day tank and feeder, and that all filtered water feed points are fed from another day tank and feeder;

2. Cross connection control must be provided in accordance with MassDEP Drinking Water Regulations (310 CMR 22.22).

6.1.9 Location of Chemical Feed Equipment

Chemical feed equipment should be:

1. Located in a separate room to reduce hazards, vapors, and dust problems;

2. Conveniently located near points of application to minimize length of feed lines;

3. Readily accessible with adequate space provided for servicing, repair, and observation of operation;

4. Located either above or inside the containment area.

6.1.10 In Plant Service Water Supply

Service water supply shall be:

1. Ample in quantity and adequate in pressure;

2. Provided with a means for measurement when preparing specific solution concentrations by dilution;

3. Softened if total hardness exceeds 75 mg/L for NaF saturator and NaF dry feeder;

4. Properly protected against backflow and back-siphonage.

6.1.11 Chemical Storage and Process Tanks

6.1.11.1 General Tank and Storage Facility Requirements

1. Space shall be provided for:

    a. At least 30 days of chemical supply to meet average treated water demand;

    b. Convenient and efficient handling of chemicals;

    c. Dry storage conditions;

    d. A minimum storage space capable of holding 150 percent of typical delivery volume (applies to packaged chemical deliveries such as drums, pallets, and carboys).

2. Storage tanks and pipelines for liquid chemicals shall be dedicated to the specific chemicals. However, with MassDEP written approval NaOH and KOH may be used in same chemical metering system using correct labels and after proper cleaning and flushing out as necessary. Offloading areas shall be clearly labeled to prevent accidental cross-contamination.

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

4. Storage and process containers shall be labeled to designate the chemical name contained.

5. Vents for liquid chemical tanks shall:

    a. Discharge outside buildings when vapors are potentially harmful or hazardous and remote from air intakes, parked cars, windows, and doors;

    b. Have a diameter equal to a minimum of 150 percent of fill pipe diameter to prevent excess pressures or vacuum (are only required for new construction);

    c. Not be connected to vents in common with another chemically dissimilar bulk, solution, or day tank (daytank venting for new construction only);

    d. Terminate in a manner to prevent entrance of contaminants, such as, a down turned position;

    e. Be covered with a 24 mesh corrosion resistant screen;

    f. If penetrating a roof, terminate at least 24 inches above the roof to prevent snowmelt from entering the tank;

    g. For new construction only, each chemical bulk, solution, or day tank be provided with an individual vent that does not connect to the vent any other tank.

6. Unless otherwise approved by MassDEP in writing, all liquid chemical tanks shall be provided with containment of not less than 110% of the total volume of the tanks within the containment area. Tank containment areas:

    a. Shall have a minimum 6-inch high containment curb;

    b. Must not be equipped with floor drains or sump pumps unless the discharge is directed to a separate containment area or tank;

    c. Should be sloped to a low area or sump to allow pumpage;

    d. Shall be provided with separate containment areas for chemicals that are not compatible such as acids and bases;

    e. Should be provided with a spill detection alarm device;

    f. Overflow from chemical process and storage tanks must discharge to the containment area unless one of the following provisions applies:

1) Overflow is discharged to a holding tank with a minimum volume equal to 25 percent of the tank with recommended high level audio and visual alarms; or

2) Overflow is discharged to a separate covered containment area with a minimum volume equal to 25 percent of the storage tank with recommended high level audio and visual alarms; or

3) The tank is sized and operated to provide a minimum overflow/overfill volume equal to 25 percent of the capacity of the tank and a high-level audio and visual alarm is provided and set at the full level, excluding the overflow volume.

7. All chemical storage and process tanks shall be provided with a means to empty the tank for routine inspection and cleaning. Drains where used, shall include ball valves provided with a threaded cap and shall discharge to containment area or holding tank.

8. All liquid chemical storage and process tanks shall be provided with a means to visually observe liquid level that is calibrated to indicate the liquid volume in the tank. Sight glass-type indicators that have direct contact with the chemical solution ("see level" sight gauges designed for direct observation) are not appropriate for chemicals that readily form precipitates (such as sodium hydroxide, soda ash, etc.) due to the masking effect of precipitate coating formed on the glass. Precipitate forming chemical tanks shall be provided with float-type liquid level sensors such as clock gauges or liquid level tape measures

9. All liquid chemical storage and process tanks shall be protected against backflow and siphonage in accordance with cross connection regulations and liquid chemical feeder's guidance.

10. Non-fluoride chemicals may be fed directly from a scale-mounted shipping container no larger than 30 gallons unless otherwise approved by MassDEP in writing.

6.1.11.2 Bulk Storage of Chemicals

1. Bulk tanks are chemical storage vessels that reside at the treatment facility and receive chemical deliveries from outside vendors.

2. Unless sized and alarmed to accommodate overfill volume as described in item [6.1.11.1]6.f.3 above, bulk tanks must be provided with an overflow pipe. The overflow pipe shall:

   a. Be sized to discharge by gravity at a rate that is equal to or greater than the anticipated filling rate;

   b. Be located where noticeable and directed downward into the containment area;

   c. Discharge 12 to 24 inches above the containment area floor;

   d. Be screened or otherwise protected to minimize the potential for contamination; and

   e. Be provided with a splash plate or other means to prevent overflow from dispersing outside the containment area or reaching sensitive equipment;

3. Bulk liquid chemical tanks shall:

a. Have high level liquid sensor(s) that activate audible and visual alarms mounted at locations that will alert both the treatment system operator and tank truck delivery driver prior to an overfilling of the bulk tank(s);

b. Have fill stations and fill pipe configurations that;

1) Are labeled with chemical name, chemical formula, and 4 digit UN number;

2) Have a ball shut off valve on inside fill pipe to prevent backflow of chemical when fill hose is disconnected, and to guard against any unauthorized fill ups;

3) Provide containment for minor releases during the fill process.

c. Have sturdy weatherproof locking hardware on outside fill pipe, or locking hardware on inside the building fill pipe;

d. Be coupled with day tanks that meet section 6.1.11.3 Day Tanks;

e. When provided with access openings, such openings shall be curbed and fitted with tight overhanging covers.

4. Unless otherwise approved by MassDEP in writing, bulk storage tanks must be installed indoors or above ground. Under certain circumstances, such as space constraints in densely developed areas, subsurface installation of bulk tanks may be allowed if the installation is a double-walled underground storage tank provided with automated leak detection or a conventional bulk tank installed in an underground vault that meets the following qualifications:

a. The vault is located in and area that is free from sources of possible contamination;

b. The vault itself can either meet all of the general containment requirements of section [6.1.11.1] 6 above or include a containment structure for the tank that meets these requirements; and

c. The vault or containment area inside the vault must be provided with alarmed spill detection.

6.1.11.3 Day Tanks

Day tanks are coupled with bulk tanks and:

1. Meet all of the General Tank and Storage Requirements in section 6.1.11.1 as applicable;

2. Are sized to contain a 30 - 60 hour chemical supply at the facility's average treated water demand rate;

3. Are provided with a means to measure the volume or weight of chemical fed that is precise enough to accurately register daily usage, such as, scale mounting, ultrasonic level sensing, gauge rods with floats, or visual calibration where the ratio of tank height to diameter are meaningful;

4. Are filled by a safe means. Day tanks shall be filled from the bulk tank by a manually controlled means unless otherwise authorized by MassDEP in writing;

5. Have a liquid level limit switch on day tank cover to automatically shut off motor or magnetic (seal-less) driven transfer pumps if provided.

6. Are only required for new construction or during substantial modifications requiring a permit or permit amendment.

6.1.11.4 Solution Tanks

1. Solutions tanks are liquid chemical processing/transfer vessels, excluding day tanks associated with bulk storage, which do not receive bulk deliveries. Examples include tanks used for phosphate mixing, sodium fluoride saturation, calcium carbonate slurry, etc.

2. A means that is consistent with the nature of the chemical solution shall be provided in a solution tank to maintain a uniform strength of solution. Continuous agitation shall be provided to maintain slurries, such as, lime or carbon in suspension.

3. A means to assure continuity of chemical supply while servicing a solution tank, such as installation of redundant solution tanks of adequate volume, shall be provided.

4. Chemical solutions shall be kept covered as practical to minimize the potential for contamination.

5. Solution tanks shall be located so that chemicals from equipment failure, spillage, or accidental drainage shall not enter the water-processing stream by means of conduits, treatment units or storage basins. Overflow pipes on solution tanks, when provided, shall meet the requirements listed for bulk storage tanks in section [6.1.11.2]2 above.

6.1.12 Feed Lines

1. Should be as short and straight as possible in length of run, and be:

   a. Of durable, corrosion resistant material

   b. Easily accessible

   c. Protected against freezing

   d. Readily cleanable

   e. Properly protected and secured

2. Shall slope upward without loops to prevent air or gas entrapment from the chemical source to the feeder when conveying gases, fluorides, and liquids using a suction metering pump foot valve.

3. Shall be designed consistent with scale-forming or solids depositing properties of the water, chemical, solution or mixture conveyed.

4. Shall be color coded (see Guidelines Piping Color Code Chapter 2.14) with flow direction arrows using ANSI/AWWA standards, labeled with chemical name as provided in Chapter 2.0 General Design Considerations. Caustic chemical feed lines, for example, use yellow with a green band as a color scheme.

5. Shall be placed in secondary containment when run underground outside of a building, and sloped to a location where any leaks are visually noticeable for new construction only.

6.1.13 Handling

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

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

3. Provision must be made for the proper transfer of dry chemicals from shipping containers to storage bins or hoppers, in such a way as to minimize the quantity of dust which may enter the room in which the equipment is installed. Control should be provided by use of one or more of the following:

    a. Vacuum pneumatic equipment or closed conveyor systems

    b. Facilities for emptying shipping containers in special enclosures

    c. Exhaust fans and dust filters which put the hoppers or bins under negative pressure

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

6.1.14 Housing

1. Floor surfaces shall be smooth, impervious, slip-proof and well drained.

2. Vents from feeders, storage facilities, and equipment exhaust shall discharge to the outside atmosphere above grade and remote from air intakes, parked cars, windows, and doors.

3. Chemical storage and feed facilities should be located in spaces that are weather-tight, and properly ventilated, and heated.

6.2 Chemicals

6.2.1 Shipping Containers

Chemical shipping containers shall be fully labeled to include:

1. Chemical name, purity, and concentration;

2. Supplier name and address.

6.2.2 Specifications

Chemicals shall meet latest ANSI/AWWA and NSF 60 specifications.

6.2.3 Assay

1. Provisions may be required for assay of chemicals delivered, such as, a labeled sampling tap on fill line to bulk tank to verify accuracy of chemical specifications.

2. MassDEP recommends operator's visual and chemical sampling of all chemicals during delivery to verify the correct chemical is being added. This recommendation should be included in the standard operating procedure (SOP).

6.3 Operator Safety

6.3.1 Chlorine Ventilation

Special provisions shall be made for ventilation of chlorine feed and storage rooms.

6.3.2 Respiratory Protection Equipment

Respiratory protection equipment that meets the requirements of the NIOSH (National Institute for Occupational Safety and Health) shall be available where chlorine gas is handled and shall be stored at a convenient location but not inside any room where chlorine is used or stored. The units shall 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.

6.3.3 Chlorine Gas Leak Detection

1. A small bottle of ammonium hydroxide, 56 percent ammonia solution, shall be available outside the chlorine room for chlorine leak detection.

2. Where 100-150 pound cylinders are used, a leak repair kit (type A for 100 and 150 pound cylinders) approved by the Chlorine Institute shall be provided.

3. Where ton containers are used, a leak repair kit (type B for one ton cylinders) approved by the Chlorine Institute shall be provided.

4. Where pressurized chlorine gas is present, continuous chlorine leak detection equipment is required and shall be equipped with both an audible alarm and a warning light.

6.3.4 Other Protective Equipment and Systems

1. At least one pair of gloves, a dust respirator for toxic dusts, an apron or other protective clothing, and splash goggles and face mask shall be provided for each operator as required by MSDS

(Material Safety Data Sheets) and OSHA (Occupational Safety and Health Administration) 29CFR1910;

2. Where sodium hydroxide (NaOH), potassium hydroxide (KOH), or other potentially dangerous liquids, strong alkalis or strong acids are stored or handled, a safety deluge shower (s) and eye washing device (s) shall be installed between the location of the hazard and the nearest means of egress. In addition whenever any bulk chemical feed system over 1,000 gallons is used, an ANSI Z358.1-2004 (Emergency Eyewash and Shower Equipment) approved safety deluge shower and piped eye-washing device shall be used. As a minimum all chemical feed systems must provide an eye-washing device;

3. A water holding tank that will allow water to come to room temperature must be installed in the water line feeding the safety deluge shower and piped eye washing device. Other methods of water tempering will be considered on an individual basis;

4. Consideration should be given to alarming the piped shower and eye wash water lines to a remote location such that a visual and audible alarm sounds when either is activated;

5. A sufficient amount of chemical spill absorbent shall be stored on site outside of each chemical room for emergency use and uncontrolled discharges;

6. Other protective equipment shall be provided as directed by MassDEP;

7. A standard operating procedure (SOP) summary must be posted in a protective shop envelope outside each chemical room or adjacent to chemical metering pump. The SOP will summarize the correct methods to properly receive, add, store, handle, and test the chemical in use;

8. Material Safety Data Sheets (MSDS) must be readily available on site for all employees for all chemicals used. These data sheets are supplied by the chemical manufacturer;

9. Consideration must be given to the safety of water plant personnel, operator, 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.

10. For ozone safety requirements see Guidelines Chapter 5.4.4 (16) Ozonation Safety and Training.

6.4 Specific Chemicals

6.4.1 Chlorine Gas

1. Chlorine gas feed and storage shall be enclosed and separated from other operating areas. In all installations using chlorine gas, the installation shall be as vandal proof as possible. The chlorine room shall be:

a. Provided with a shatter resistant inspection window installed in an interior wall;

b. Constructed in such a manner that all openings between the chlorine room and the remainder of the plant are sealed;

c. Provided with doors with panic type hardware assuring ready means of exit and opening only to the building exterior.

2. Full and empty cylinders of chlorine gas shall be:

a. Isolated from operating areas;

b. Restrained in position to prevent upset;

c. Stored in locked and secured rooms separate from ammonia and acid storage;

d. Stored in locked and secured areas not in direct sunlight or exposed to excessive heat.

3. When chlorine gas is used, the room shall be constructed to provide the following:

a. Each room shall have a ventilating fan with a capacity which provides at least 60 complete air changes per hour when the room is occupied; where this is not appropriate due to the size of the room a lesser rate may be considered.

b. The ventilating fan shall 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.

c. Air inlets shall be through corrosion resistant louvers near the ceiling.

d. Louvers for chlorine room intake and exhaust shall facilitate airtight closure.

e. Floor drains are discouraged. Where provided, the floor drains shall not be connected to other internal or external drainage systems. See Guidelines Chapter 5.10 titled: Waste Handling and Disposal.

f. Switches for fans and lights shall be outside of the room, at the entrance, and protected from vandalism. A signal light indicating fan operation should be provided at each entrance when the fan can be controlled from more than one point.

g. Vents from feeders and storage shall discharge to the outside atmosphere, above grade.

4. Chlorinator rooms should be heated to 60 degrees F and be protected from excessive heat. Any portion of non-pressurized chlorine gas line located outside the chlorination room should be protected from temperature below 60 degrees F and excessive heat.

5. Pressurized chlorine feed lines shall not carry chlorine gas beyond the chlorinator room. All piping carrying chlorine gas shall be kept as short as possible.

6.4.2 Acids and Caustics

1. Acids and caustics shall be kept in closed corrosion-resistant shipping containers or bulk liquid storage tanks.

2. Acids and caustics shall not be handled in open vessels, but should be pumped in undiluted form to and from bulk liquid storage tanks and covered day tanks or from shipping containers through suitable hoses, to the point of treatment.

6.4.3 Potassium Permanganate

1. General Information
   Potassium permanganate ($KMnO_4$) is used primarily to control taste and odors, remove color, control biological growth in treatment plants, and remove iron and manganese. Potassium permanganate is usually added ahead of chlorine and activated carbon for taste and odor control, and after chlorine for iron and manganese oxidation. In all cases, potassium permanganate is added prior to filtration.

2. Potassium permanganate addition

   a. A source of heated water should be available for dissolving potassium permanganate.

   b. Mechanical mixer(s) with overflow shall be provided.

   c. The feed rate shall be based on jar testing.

   d. If a sedimentation basin is used, a sample tap near end should be provided to test for presence of pink color which should disappear before filtration.

   e. Potassium permanganate storage must be in a cool and dry place away from heat and organic compounds to avoid potential explosions.

   f. A jar tester should be available in the lab for determining proper dosages.

6.4.4 Phosphate Compounds

1. The following types of phosphate have been approved for use in AWWA standards:

   a. Sodium polyphosphate, glassy (sodium hexamethaphosphate): The uses of sodium polyphosphate, glassy, include corrosion control, scale prevention, iron and manganese stabilization, and sequestering of metallic ions.

   b. Sodium Tripolyphosphate: Sodium tripolyphosphate is used to control scale and corrosion and to treat red water.

   c. Monosodium Phosphate, Anhydrous

   d. Disodium Phosphate, Anhydrous

e. Zinc Orthophosphate (ZOP): ZOP can be an effective chemical inhibitor of electrolytic corrosion in iron, steel, copper, and lead, which occurs in aggressive (low to moderate hardness and alkalinity) water. ZOP was originally used to suppress colored water caused by leaching tuberculation of iron pipe. This technology can be effective in waters without elevated concentrations of iron and manganese to sequester and where calcium precipitation and scaling are of minimal concern. ZOP can also reduce asbestos fiber counts and provide protection for asbestos– cement and concrete pipe. It prevents concrete pipe deterioration in aggressive waters because the zinc interacts with cement and forms a protective zinc carbonate barrier on the surface at zinc concentrations as low as 0.2 mg/L.

2. Phosphate requirements in addition to Chapter 5.6.5 (Sequestration by Phosphates) and Chapter 5.8.2 (Corrosion Inhibitors – Phosphates & Silicates):

   a. For maximum effectiveness, a source of non-heated water should be available for dissolving phosphate compound.

   b. Mechanical mixer(s) with overflow shall be provided.

   c. Phosphate compounds are considered acidic, and all wetted surfaces must be acid resistant.

   d. When chlorine is added to a phosphate solution it shall be AWWA and NSF 60 approved.

6.4.5 Ammonia (See Chapter 5.4.3.2 Forms of Ammonia)

6.4.6 Sodium Hypochlorite

1. General Information

   Sodium hypochlorite (NaOCl) storage and handling procedures should be arranged to minimize the slow natural decomposition process of sodium hypochlorite either by contamination or by exposure to more extreme storage conditions. In addition, feed rates should be regularly adjusted to compensate for this progressive loss in chlorine content.

2. Storage

   a. Sodium hypochlorite shall be stored in the original shipping container(s) or in sodium hypochlorite compatible bulk liquid storage tank(s) or suction calibration chamber.

   b. Storage containers or tanks shall be located out of the sunlight in a cool area and shall be vented to outside of building away from doors, windows, air intakes, or parked cars.

   c. Whenever reasonably feasible, stored sodium hypochlorite should be pumped undiluted to the point of addition. Where dilution is unavoidable, deionized or softened water should be used to avoid contamination.

   d. Reusable sodium hypochlorite storage containers shall be reserved for use with sodium hypochlorite only and shall not be rinsed out or otherwise exposed to internal contamination.

3. Metering Pumps or Feeders

a. Positive displacement pumps with sodium hypochlorite compatible materials for wetted surfaces shall be used, and

b. To help avoid air locking in smaller installations, small diameter suction lines shall be used with foot valves and degassing valve pump heads (to help prevent vapor lock),

c. In larger installations or wherever bulk tank(s) are used, flooded suction should be used with pipe work arranged to ease escape of gas bubbles. To help avoid siphoning in flooded suction systems, two anti-siphon or backpressure valves shall be installed in series on the pump discharge line.

d. Clear calibration tubes or chambers (in ml) or mass flow monitors (mounted on metering pump discharge line) which allow for direct physical checking of actual feed rates shall be provided.

4. Emergency disinfection at a groundwater source using bleach or NaOCl solution:

a. Consideration should be given that unforeseen circumstances may require a certified operator to quickly install a NaOCl emergency feed system upon order from MassDEP.

b. A spare calibrated minimum 10-32 gallon plastic translucent container with containment, metering pump, anti-siphon valve, tubing, injection nozzle, corporation stop, ball check, DPD chlorine test kit, and safety chain/cable should be installed and kept available for future needs and to save time. A labeled twist lock type electrical interlock receptacle and plug are also needed. MassDEP may not require a free chlorine analyzer in emergency conditions.

c. The installation of a spare bleach system above would not require other routinely used chemical systems, such as, fluoride or phosphate to be cannibalized when a boil order is issued.

d. In an emergency for short periods of time and with MassDEP approval in writing, a non NSF 60 and ANSI/AWWA approved type liquid chlorine solution, such as (5-6) % available chlorine that can be obtained from a local supermarket or pharmacy, may be used if necessary.

5. Occurrence of Perchlorate in Sodium Hypochlorite

a. To minimize the perchlorate occurrence risk in sodium hypochlorite and finished water, sodium hypochlorite should be:

1) Stored in the dark

2) Stored at cool temperatures

3) Used within a few weeks of manufacture if possible

b. Storage tanks and piping should be emptied of aged material and flushed to minimize the potential for perchlorate contamination.

c. Some applications, such as sodium hypochlorite pre-oxidation systems, may benefit from diluting their stored supply of sodium hypochlorite to reduce the potential for perchlorate formation.

6.4.7 Sodium Chlorite for Chlorine Dioxide Generation

Proposals for the storage and use of sodium chlorite must be approved by MassDEP in writing prior to the preparation of final plans and specifications. Provisions shall be made for proper storage and handling of sodium chlorite to eliminate any danger of fire or explosion associated with its powerful oxidizing nature.

1. Storage

   a. Sodium chlorite shall be stored by itself in a separate room and preferably shall be stored in an outside building detached from the water treatment facility. It shall be stored away from organic materials because many materials will catch fire and burn violently when in contact with sodium chlorite.

   b. The storage structures shall be constructed of noncombustible materials.

   c. 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 sodium chlorite.

2. Handling

   a. Care should be taken to prevent spillage.

   b. An emergency plan of operation should be available for the clean up of any spillage.

   c. Storage drums must be thoroughly flushed to an acceptable drain prior to recycling or disposal.

3. Feeders

   a. Positive displacement feeders shall be provided.

   b. Tubing for conveying sodium chlorite or chlorine dioxide solutions shall be Type 1 PVC, polyethylene or materials recommended by the manufacturer.

   c. Chemical feeders may be installed in chlorine rooms if sufficient space is provided or in separate rooms meeting the requirements of section 6.4.1 Chlorine Gas.

   d. Feed lines shall be installed in a manner to prevent formation of gas pockets and shall terminate at a point of positive pressure.

   e. Check valves shall be provided to prevent the backflow of chlorine into the sodium chlorite line.

6.4.8 Fluoride Chemicals (see Chapter 5.7 Fluoridation)