R309-520. Facility Design and Operation: Disinfection

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R309-520. Facility Design and Operation: Disinfection.

R309-520-1. Purpose.

This rule specifies requirements for facilities that disinfect public drinking water. It is to be applied in conjunction with rules R309-500 through R309-550, Drinking Water Facility Construction, Design, and Operation. Collectively, these Rules govern the design, construction, and operation and maintenance of public drinking water system facilities. These Rules are intended to assure that such facilities are reliably capable of supplying adequate quantities of water that consistently meet applicable drinking water quality requirements and do no harm to general public health.

R309-520-2. Authority.

This rule is promulgated by the Drinking Water Board as authorized by Title 19, Environmental Quality Code, Chapter 4, Safe Drinking Water Act, Subsection 104(1)(a)(ii) of the Utah Code and in accordance with Title 63G, Chapter 3 of the same, known as the Administrative Rulemaking Act.

R309-520-3. Definitions.

Definitions for certain terms used in this rule are given in R309-110 but may be further clarified herein.

R309-520-4. Primary Disinfectants.

Primary disinfection is the means to provide adequate levels of inactivation of pathogenic microorganisms within the treatment process. The effectiveness of chemical disinfectants is measured as CT, a function of disinfectant residual concentration and contact time. The effectiveness of UV disinfection is determined through validation testing of each model and specific configuration of UV reactor proposed in the design, as described in R309-520-8.

Four disinfectants: chlorine, ozone, ultraviolet light, and chlorine dioxide are approved as primary disinfectants of drinking water.

Guidance: Iodine disinfection is no longer allowed because of adverse health implications for the public.

R309-520-5. Secondary Disinfectants.

Secondary disinfection provides an adequate disinfectant residual in the distribution system to maintain the quality of treated water by controlling microbiological contamination.

Secondary chemical disinfection is achieved by maintaining a detectable disinfectant residual throughout the distribution system. Allowable secondary disinfectants are chlorine and chloramine.

R309-520-6. General.

(1) Continuous Disinfection

(a) Continuous disinfection is required of all ground water sources that do not otherwise continuously meet microbiological standards. Intermittent or batch disinfection, such as adding hypochlorite tablets or concentrated hypochlorite solution to a tank, is not acceptable for ongoing operation if continuous disinfection is required.

(b) Disinfection is not an acceptable remedy to physical deficiencies or sources susceptible to surface water influence. Disinfection shall not be used to mask ongoing contamination and shall not be used as a substitute for correcting deficiencies.

(c) Where continuous disinfection is required, the design shall provide a means to isolate or service the disinfection equipment without allowing untreated water to enter the distribution system. If the untreated water is to be discharged, it shall not cause environmental or property damage.

(2) ANSI/NSF Standard 60 Certification

All chemicals added to drinking water, including chlorine (i.e., gas, hypochlorite solution, hypochlorite tablets, granules, and powder), chloramines, and chemicals used to generate hypochlorite solutions and chlorine dioxide, shall be certified as complying with ANSI/NSF Standard 60, Drinking Water Treatment Chemicals.

Guidance: Third-party organizations, such as NSF, UL, and the Water Quality Association, are accredited to provide product certification to ANSI/NSF Standard 60.

Hypochlorite tablets for swimming pools are not approved for use in drinking water. Swimming pool grade hypochlorite tablets contain chemicals to retard the photodecomposition of hypochlorite and typically lack approval for use in drinking water.

(3) Required Disinfection

(a) Surface water, or groundwater under the direct influence of surface water, shall be filtered by conventional surface water treatment or alternative surface water treatment methods and disinfected to meet the requirements of R309-200-7.

(b) Where microbiological treatment is required for a ground water source that is not under the influence of surface water, disinfection without filtration may be considered adequate.

(4) Point of Application and CT

A combination of disinfectant residual and contact time is defined as disinfection CT in R309-110-4. The following requirements apply to disinfectant point of application and CT:

(a) Consideration shall be given to the contact time of the disinfectant in water with relation to pH, ammonia, taste-producing substances, temperature, biological quality, and other pertinent factors.

(b) Where possible, the design shall minimize the formation of disinfection byproducts.

(c) Treatment of ground water sources shall provide sufficient CT to achieve a minimum of 4-log virus inactivation and/or removal.

(d) Point of application of disinfectants shall be at a location that will achieve the required disinfection CT prior to the first service connection.

(5) Site Selection

Disinfection installations shall be sited to permit convenient access during the operation period. These installations shall be sited with due consideration of possible danger to nearby population and of possible jeopardy from seismic fault zones.

Guidance: Public water systems should work closely with local fire code officials to evaluate hazards associated with chorine gas when subdivisions or other populations encroach upon previously remote facilities or when new geologic hazards are identified.

R309-520-7. Chlorine.

(1) General Requirements for all Chlorination Installations.

(a) Chemical Types.

Disinfection by chlorination shall be accomplished by gaseous chlorine or hypochlorite solutions. Hypochlorite solutions can be purchased, generated on site, or prepared by dissolving solids.

Guidance: For small supplies requiring less than four pounds per day, liquid hypochlorite feed systems are advised.

(b) Feed Equipment.

Solution-feed gas type chlorinators, direct-feed gas type chlorinators or hypochlorite liquid feeders of a positive displacement type shall be provided. Solution-feed gas type chlorinators are preferred. Use caution when selecting direct-feed gas type chlorinators.

(c) Chlorine Feed Capacity.

(i) The capacity of the chlorine feed equipment shall be sized to provide at least 2 mg/L during peak demand.

(ii) The feed equipment shall operate accurately over the design feeding range.

(iii) The feed equipment shall be designed to maintain a detectable residual at all times, at all points within the intended area in the distribution system.

(d) Automatic Proportioning.

Automatic proportioning chlorinators shall be required where the rate of flow of the water to be treated or chlorine demand of the water to be treated is not reasonably constant.

Guidance: Chlorine gas chlorinators that respond to a 4-20 milliamp signal from an electronic flow meter are recommended for flow-proportioning. Chlorine gas chlorinators that respond to on-line chlorine residual concentration feedback signal are recommended for dose-proportioning.

(e) Injector, Eductor, or Diffuser.

(i) Chlorine shall be added at a point that allows rapid and thorough mixing. The center of a pipeline is the preferred application point.

(ii) The selection of equipment shall consider the point of application, the quantity of chlorine to be added, the size and flow of the chlorine solution line, the back pressure of the to-be-treated water flow, and the equipment operating pressure.

(iii) A suitable strainer to prevent small debris from clogging chlorine feed equipment shall be provided. Provision for flushing the strainer is required.

(f) Disinfection Point of Application for Surface Water.
The design of plants treating surface water or ground water under the direct influence of surface water shall make provisions to add chlorine at various process points as needed.

Guidance: Consider adding chlorine to raw water, settled water, filtered water, and water entering the distribution system.

(g) Minimization of Chlorinated Overflow.

The design shall minimize the release of chlorinated water into the environment, for example, the discharge of chlorinated water from tank overflows. Such releases must comply with rules of Division of Water Quality that pertain to discharge of pollution.

(h) Prevention of Cross Connections.

(i) The design shall prevent contamination of the treated water supply by make-up water of lesser quality.

(ii) All chlorine solution make-up water shall be at least of equal quality to the water receiving the chlorine solution. At surface water treatment facilities, pre-chlorination and post-chlorination processes shall be independent to prevent cross connections where pre-chlorination make-up water is not finished water.

(i) Flow Measurement.

The design of the chlorination system shall provide a means to measure the flow rate of treated water as a basis for dosing.

Guidance: In most circumstances, a commercial flow meter will be necessary to satisfy this requirement. In unusual circumstances, for example, where the availability of electrical power may be problematic, an exception-to-rule may be warranted to allow the use of a calibrated staff gauge or a calibrated v-notch weir, in an appropriate hydraulic structure such as a surface water intake box or a spring collection box outlet wall.

(j) Residual Testing Equipment.

The water system shall have chlorine residual test equipment capable of measuring residuals to the nearest 0.1 mg/L in the range below 0.5 mg/L, to the nearest 0.3 mg/L between 0.5 mg/L and 1.0 mg/L and to the nearest 0.5 mg/L above 1.0 mg/L.

Guidance: Automatic chlorine residual recorders should be provided where the chlorine demand varies appreciably over a short period of time. The N,N-Diethyl-p-phenylendiamine (DPD) method of chlorine residual or other EPA-approved method determination is recommended.

(k) Standby and Backup Equipment.

(i)A spare parts kit shall be provided and maintained for all chlorinators to repair parts subject to wear and breakage. If there could be a large difference in feed rates between routine and emergency dosages, multiple gas metering tubes shall be provided, at least one for each dose range, to assure accurate control of the chlorine feed under both routine and emergency conditions.

(ii) Where chlorination is required for disinfection of a water supply, standby equipment of sufficient capacity shall be available to replace the largest unit in the event of its failure.

(iii) Standby power shall be available, during power outages, for operation of chlorinators where disinfection of the water supply is required unless operation of the chlorinator does not require power.

(l) Heating, Lighting, Ventilation.

Chlorinator buildings shall be heated, lighted and ventilated as necessary to assure proper operation of the equipment and safety of the operators.

(m) Incompatible Chemicals.

The design shall ensure that incompatible chemicals that may damage or deteriorate chlorination facilities are stored separately from chlorination equipment and chemicals.

(2) Additional Requirements for Gas Chlorinators.

(a) Automatic Switch over.

Automatic Switch over of chlorine cylinders shall be provided if continuous disinfection is required.

(b) Gas Scrubbers.

One-ton chlorine cylinder operating areas shall be equipped with a gas scrubber per the International Fire Code capable of treating the release of chlorine gas from the largest single cylinder at its maximum flow rate. Furthermore, local toxic gas ordinances shall be complied with if they exist.

(c) Heat.

The design of the chlorination room shall assure that the temperature in the room will not fall below 32 degrees F or the temperature required for proper operation of the chlorinator, whichever is greater.

Guidance: Chlorinator rooms should be heated to 50 degrees F, and be protected from room temperatures in excess of 70-80 degrees F. Where space heaters are used, the cylinders should be protected from direct heat. Care should be taken to avoid chlorine condensation in feed lines caused by the feed equipment being cooler than the chlorine cylinder.

(d) Ventilation.

(i) Chlorination equipment rooms which contain chlorine cylinders, tanks, equipment and gaseous chlorine lines under pressure shall have at least one exhaust fan.

Guidance: For the safety of the operators, chlorination facility should not be located in a vault that has inadequate ventilation or in a location that is considered a confined space.

(ii) Chlorine room exhaust fan(s), when operating, shall provide at least one complete room air change per minute.

(iii) Chlorine room exhaust fan(s) shall take suction inside the chlorine room near the floor, as far as practical from the door and air inlet, and discharge air outside of the building away from air inlets.

(iv) Chlorine room air inlets shall be through wall louvers near the ceiling.

(v) Separate switches for the chlorine room fans and lights shall be located near the entrance to the room and shall be protected from vandalism. The switches shall be located outside the chlorine room if housed in a water treatment plant.

(vi) The ventilation system for one-ton chlorine cylinder operating areas shall be designed to operate independently from the ventilation system for the rest of the treatment plant. One-ton chlorine cylinder operating areas shall be designed to maintain negative pressure per the International Fire Code.

(e) Chlorine Vent Line.

The chlorine vent line shall discharge outside, above grade, at a point least susceptible to vandalism, and shall have the end covered with a No. 14 mesh non-corrodible screen.

(f) Housing.

(i) Housing shall be provided for chlorination equipment and storage to ensure proper function and security.

(ii) Chlorine cylinders shall not be stored in direct sunlight or exposed to excessive heat.

(g) Housing at Water Treatment Plants.

A separate chlorine room, for chlorine cylinders and feed equipment, shall be provided at all water treatment plants with multiple processes and operating areas.

(i) The chlorine room shall have shatter resistant inspection window(s) installed in an interior wall preferably located so that an operator may read the weighing scales without entering the chlorine room.

(ii) All openings between the chlorine room and the remainder of the plant shall be sealed.

(iii) Outward-opening doors shall be equipped with panic bars to allow rapid exit.

(iv) Floor drains are discouraged but, where provided, shall discharge to the outside of the building and shall not be connected to other internal or external drain systems.

(v) Chlorine feed lines shall not carry pressurized chlorine gas beyond the chlorine room. Only vacuum lines may be routed to other portions of the building outside the chlorine room. Any openings for these lines must be adequately sealed.

(vi) The design of operating areas for one-ton cylinders shall allow full and empty cylinders to be stored in separate areas.

(h) Cylinder Security.

Chlorine cylinders shall be restrained in position to prevent upset.

(i) Weighing Scales.

Scales shall be provided for determining chlorine cylinder weight. Scales shall be of a corrosion resistant material and shall be placed in a location remote from any moisture. Scales shall be accurate enough to indicate loss of weight to the nearest one pound for 150 pound cylinders and to the nearest 10 pounds for one ton cylinders.

(j) Pressure Gauges.

Pressure gauges shall be provided on the inlet and outlet of each chlorine eductor.

(k) Gas Masks.

(i) Where chlorine gas in one-ton cylinders is handled, respiratory protection equipment, meeting the requirements of the National Institute for Occupational Safety and Health (NIOSH) shall be available 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 units used by the fire department responsible for the plant.

(ii) Where 150 pound chlorine cylinders are used, a respirator recommended by the National Institute for Occupational Safety and Health must be available.

(l) Chlorine Leak Detection and Repair.

(i) A bottle of Ammonium Hydroxide, 56% ammonia solution, shall be available for chlorine leak detection.

(ii) Where one-ton cylinders are used, a leak repair kit approved by the Chlorine Institute shall be provided.

(iii) Continuous chlorine leak detection equipment is required for one-ton cylinders.

(iv) Where a continuous leak detector is provided, it shall be equipped with both an audible alarm and a warning light to ensure operator safety.

(3) Additional Requirements for Hypochlorite Systems.

(a) General Requirements.

(i) Emergency Eyewash and Safety Showers.

Emergency eyewash stations and safety showers shall be provided at all hypochlorite installations where concentrated hypochlorite solutions, containing 5% or greater available chlorine by volume, are handled in containers greater than 55 gallons. Where hypochlorite solutions are used at remote locations or in quantities of 55 gallons or less on site, safety showers are not required and alternative emergency eyewash may be provided.

(ii) Storage of Liquid Hypochlorite to Prevent Decay.

Storage and injection areas shall be designed to minimize the decay in strength of concentrated hypochlorite solutions from excessive heat or direct sunlight.

(iii) Feed Equipment – Chemical Addition.

Hypochlorite feed equipment shall generally conform with R309-525-11, Chemical Addition.

Guidance: Hypochlorite feed equipment should conform with the following regulations as applicable R309-525-11(6) for storage and safe handing; with R309-525-11(7) for feeder design, location, and control; with R309-525-11(8) for feeder appurtenances such as pumps, day tanks, bulk storage tanks, and feed lines; and R309-525-11(9) for make-up water supply and protection.

(iv) Feed Equipment - Certification

The hypochlorite feed equipment for drinking water treatment shall be certified to meet ANSI/NSF Standard 61.

(b) Concentrated Hypochlorite Solutions.

The water system shall provide an operational means to avoid the injection of significantly decayed hypochlorite solutions, for example by keeping records on site of the delivery date of the hypochlorite solution.

Guidance: Non-NSF-certified, over-the-counter household bleach is not approved for normal use in drinking water principally because of trace metal contamination.

(c) On-Site Generation of Hypochlorite Solutions.

(i) The on-site hypochlorite generation systems used for drinking water treatment shall be certified as meeting the NSF/ANSI Standard 61.

(ii) Manufacturer recommendations for safety with respect to equipment and electrical power shall be followed.

(iii) The make-up water used in on-site generation shall be of drinking water quality.

(iv) The hydrogen gas generated in the electrolytic cell of the on-site generation system shall be vented upward to the outside of the building in a dedicated, unobstructed line.

(d) Hypochlorite Tablets.

(i) Before selecting a hypochlorite tablet disinfection process, water hardness, solubility of hypochlorite tablets, water temperature, and other water quality factors shall be taken into consideration.

(ii) The hypochlorite dissolution equipment for drinking water treatment shall be certified as meeting the ANSI/NSF Standard 61.

(iii) The design shall allow the hypochlorite tablets to be stored in accordance with the manufacturer's safety guidelines and in their original containers in a cool, dry, well-ventilated area. The hypochlorite tablets shall not be stored near combustible materials or acids to avoid fire or the release of toxic gases.

R309-520-8. Ultraviolet Light.

(1) General Requirements

This rule shall apply to the public drinking water systems that use ultraviolet (UV) disinfection for inactivation of *Cryptosporidium*, *Giardia*, and virus. The Director may reduce the requirements of monitoring and reporting on a case by case basis for the water systems that use UV as ancillary means of disinfection and do not claim credit for UV disinfection, or for water systems using UV without a SCADA system and treating less than 30 gallons per minute.

Terminology used in this rule is based on the definitions in the EPA Ultraviolet Disinfection Guidance Manual for the Final Long Term 2 Enhanced Surface Water Treatment Rule (2006 Final UVDGM).

(a) Water systems using surface water or ground water under the influence of surface water shall not use UV as the sole means of disinfection. For these types of water systems, at least one alternative primary disinfectant must be used for virus disinfection, and a secondary disinfectant shall be provided to maintain a disinfectant residual in the distribution system.

(b) The following requirements apply to the water systems that wish to receive credit for UV disinfection:

(i) The water system shall submit a UV plan which clearly identifies the dose monitoring strategy, such as the UV intensity setpoint approach, the calculated dose approach or an alternative approach.

(ii) The water system shall identify the goals for the UV facility as part of a comprehensive disinfection strategy, including target pathogens, target log inactivation, and corresponding required UV dose per Table 215-5 in R309-215-15(19)(d).

(iii) The water system shall submit a UV reactor validation report in accordance with R309-520-8(2), to the Director for review prior to obtaining approval for installation of UV facility.

(iv) The water system must demonstrate that the reactor is delivering the required UV dose using a validated dose monitoring system and continue to comply with the monitoring and reporting requirements specified in R309-215-15(19) and (20).

(2) Validation Testing

Validation testing must conform to the guidelines in Chapter 5 Validation of UV Reactors of the EPA Ultraviolet Disinfection Guidance Manual for the Final Long Term 2 Enhanced Surface Water Treatment Rule (2006 Final UVDGM).

The Director may accept a validation report that was conducted based on the 2003 draft UV Disinfection Guidance Manual on a case-by-case basis.

(a) Each model and specific configuration of UV reactor must undergo off-site, full-scale validation testing by an independent third party test facility prior to being approved for use. The validation testing shall be conducted in qualified test facilities that are deemed acceptable by NSF, EPA, or the Director.

(b) Validation testing results shall provide data, including calculations and tables or graphical plots, on dose delivery by the UV reactor under design conditions of flow rate, UV transmittance (UVT), UV intensity, lamp status, power ballast setting, as well as consideration of lamp aging and lamp fouling. The validation report shall demonstrate that the monitoring algorithm is valid over the range expected with the application. The data is used to define the dose monitoring algorithm for the UV reactor and the operating conditions that can be monitored by a utility to ensure that the UV dose required for a given pathogen inactivation credit is delivered.

(c) The UV reactor validation report shall include:

(i) Description of the reactor and validation test set-up, including general arrangement and layout drawings of the reactor and validation test piping arrangement.

(ii) Description of the methods used to empirically validate the reactor.

(iii) Description of the dose monitoring equation for the reactor to achieve the target pathogen inactivation credit and related graphical plots showing how the equation was derived from measured doses obtained through validation testing under varying test conditions.

(iv) Range of validated conditions for flow, UVT, UV dose, and lamp status.

(v) Description and rationale for selecting the challenge organism used in validation testing, and analysis to define operating dose for pathogen inactivation credit.

(vi) Tabulated data, analysis, and quality assurance/quality control (QA/QC) measures during validation testing.

(vii) A licensed professional engineer's third party oversight certification indicating that the testing and data analyses in the validation report are conducted in a technically sound manner and without bias.

(viii) The validation report shall be accompanied with completed Checklists 5.1 through 5.5 included in the EPA Ultraviolet Disinfection Guidance Manual for the Final Long Term 2 Enhanced Surface Water Treatment Rule (2006 Final UVDGM).

(3) Design Criteria

(a) A water system considering UV disinfection shall gather sufficient water quality data prior to design. The water samples shall be representative of the source water to be treated by the UV facility. Frequent testing may be required if significant variation or seasonal trending in water quality is expected.

(b) The following water quality parameters shall be considered in UV facility planning:

(i) UV Transmittance or UV Absorbance

(ii) Calcium

(iii) Alkalinity

(iv) Hardness

(v) Iron

(vi) Manganese

(vii) Turbidity

(viii) pH

(ix) Oxidation-Reduction Potential (ORP)

(x) Particle content and algae

(c) The design flow rate and UVT used to size the UV system shall be selected to provide the required dose at least 95 percent of the time, accounting for seasonal variations of flow and UVT combinations. Specifying a matrix of flow and UVT conditions for the UV reactors may be necessary.

(d) The water system may consider increasing the delivered dose beyond the required UV dose listed in Table 215-5 in R309-215-15(19)(d) to provide flexibility and conservatism.

(e) UV reactor inlet and outlet configurations shall meet the validated hydraulic distribution of flow conditions or be more hydraulically conservative. This can be achieved using one of the following approaches:

(i) The inlet and outlet configuration shall meet one of the conditions specified in Section 3.6.2 of the 2006 Final UVDGM.

(ii) Computational fluid dynamics (CFD)-based modeling may be used to demonstrate that the given conditions of inlet and outlet piping with the UV installation provides equal or greater dose delivery. The CFD modeling shall be conducted at the minimum and maximum values of the validated range of flow, UVT, and lamp status.

(f) The UV disinfection system shall be capable of applying the required design dose with a failed or out-of-service reactor. The design shall account for an on-line backup UV reactor or an operating scheme to apply the design dose with one reactor out of service.

(g) It shall be possible to isolate each reactor for maintenance.

(h) Signals and alarms shall be provided for the operation of the UV facility for the parameters necessary for dose monitoring algorithm, such as low UV dose, high flow rate, low UVT, UVT monitoring failure, UV sensor failure, off specification event, Ground Fault Interrupt (GFI), high water temperature, and low water level.

(i) All materials used in constructing or coating the UV reactors that come in contact with water shall be certified NSF Standard 61 - Drinking Water System Components – Health Effects.

(j) Any chemicals used in the cleaning of the UV reactor components in contact with the drinking water such as quartz sleeves shall be certified as meeting the ANSI/NSF Standard 60 – Drinking Water Treatment Chemicals – Health Effects.

(k) A flow or time delay shall be provided to permit a sufficient time for tube warm-up, per manufacturer recommendations, before water flows from the unit upon start up. The flow or time delay shall be included in the design so they do not result in excessive off specification conditions.

(l) To ensure a continuous supply of power, a backup power supply of sufficient capacity shall be provided for the UV disinfection system. If power quality problems, such as frequent power interruptions or brownouts, or remote location with unknown power quality, are anticipated, power conditioning equipment, such as uninterruptible power supply (UPS), shall be included in the design.

(m) The design shall include a redundant disinfection mechanism that will apply an approved primary disinfectant to achieve the CT or log removal/inactivation required for compliance if a UV facility is off specification or offline within a maximum response time of 15 minutes. One example of such response is to shut down the off- specification UV train and either bring a parallel UV train on line or initiate a back-up primary disinfection system within 15 minutes, so the continuous duration of an off- specification event is limited to no more than 15 minutes.

(n) UV disinfection units rated at 30 gallons per minute or less shall be certified as meeting the ANSI/NSF Standard 55, Class A, or other equivalent or more stringent validation or certification standards that are deemed acceptable by the Director.

(o) The dose monitoring approach used for UV facility must be reviewed and accepted by the Director. Typically the calculated dose approach is suitable for large systems or systems with significant flow variation, and the UV intensity setpoint approach is for small systems or systems with fixed flow rate. The dose monitoring approaches need to be consistent with the guidelines stated in the 2006 Final UVDGM.

(p) If Programmable Logic Controller (PLC) or SCADA interface is used for UV reactor's process control, the programming shall be in accordance with the validated dose monitoring algorithm and the validated conditions. The algorithm shall use inputs of flow, UV intensity sensor readings, lamps status, and/or UVT equal to or more conservative than values measured during the operation of the UV system. If the measured UVT is above the validated range, the maximum validated UVT shall be used as the input to the dose algorithm. If the measured flow rate is below the validated range, the minimum validated flow rate shall be used as the input to the dose algorithm. If the dose algorithm uses relative lamp output determined from the UV intensity sensor readings as an input, the relative lamp output shall be based on the measured UVT, even if it exceeds the maximum validated UVT.

(q) The UV reactor's PLC or microprocessor shall be programmed to record off specification events for the following conditions:

(i) Delivered UV dose less than the required dose,

(ii) Flow greater than the validated range,

(iii) UVT less than the validated range,

(iv) Lamp status outside the validated range,

(v) Failure of UV sensors, flow meters, or on-line UVT monitors used in the dose calculation. Laboratory measurements of UVT may be used temporarily in the program until the on-line UVT monitor is repaired.

(4) Operation and Maintenance

The operation and maintenance tasks and the frequency of performing them can be specific to the UV equipment installed. The water systems with approved UV installations shall follow the manufacturer's recommendation or the operation & maintenance guidelines stated in Section 6.2 through 6.5 of the *2006 Final UVDGM.*

(a) Startup testing.

(i) The UV reactor manufacturer must provide a site-specific operation and maintenance manual, which shall include the procedure for starting up and shutting down the UV treatment system.

(ii) Provide schedules and performance standards for start-up testing and initial operation. Schedules shall include anticipated start-up date and proposed testing duration. Performance standards shall reference applicable regulations and specific equipment capabilities.

(iii) Operators shall receive site-specific training on the operation of the UV disinfection system.

(b) An incident plan shall be developed to address lamp breakage and release of mercury, response to alarms, power supply interruptions, activation of standby equipment, failure of systems, etc.

(c) To verify that the UV reactors are operated within the validated limits, selected parameters shall be monitored. The routine operation and maintenance shall include the monitoring and calibration requirements listed in R309-215-15(19) and (20) and are in accordance with the monitoring and reporting protocol approved by the Director. For very small UV systems, the Director may consider granting exception to allow reduced monitoring and reporting on a case-by-case basis.

R309-520-9. Ozone.

(1) General Requirements

(a) Ozone is approved as a primary disinfectant, but is not approved as a secondary disinfectant for the distribution system because of its rapid decomposition in aqueous solution. A different disinfectant approved for secondary disinfection must be used if a minimum disinfection residual is required in the distribution system. Ozone may also be used for taste and odor control, oxidation of inorganic and organic compounds and for enhanced performance of other water treatment processes such as microflocculation and filtration. Some of the requirements of this section may not be applicable if ozone is used only for reasons other than primary disinfection.

(b) Pilot studies or bench scale studies shall be conducted for all surface waters unless there is sufficient data available from other studies performed on the same water source. The studies shall determine the initial ozone demand, the rate of ozone decay, the minimum and maximum ozone dosages for the range of water conditions for disinfection "CT" compliance, and the ozone dosage required for other desired benefits. Pilot studies or bench scale studies shall take into account the seasonal and other variations of the source water. Plans for pilot studies or bench scale studies shall be reviewed and accepted by the Director prior to commencement of the studies.

(2) Ozone Generation

(a) The ozone system shall be designed with backup capability such that required inactivation can be achieved with one generator out of service.

(b) The ozone generators shall be housed in an enclosed temperature controlled building for protection. Adequate ventilation shall be provided in the building, and be capable of providing six or more air changes per hour when needed in case of an ozone leak.

(c) The ozone generators shall be of the medium or high frequency type.

(d) The power supply units for the ozone generators shall have a backup electrical power source, normally an emergency generator, or the system shall have an alternate primary disinfection system that may be used in case of an electrical power outage.

(e) The ozone generators shall be water-cooled with a maximum increase in cooling water temperature of 10 ^{o}F (5.6 ^{o}C). If necessary, the cooling water shall be treated to minimize corrosion, scaling, and microbiological fouling of the water side of the tubes. A closed-loop cooling water system may be used to assure proper water conditions are maintained. The power supply units to the ozone generators may also be water cooled.

(f) The ozone generators shall comply with Section 3705 of Chapter 37, "Ozone Gas Generators," of the 2006 International Fire Code.

(3) Ozone Generator Feed Gas

(a) Feed gas may be air, vaporized high purity liquid oxygen, or oxygen enriched air. Oxygen may be generated on-site or delivered in bulk. Oxygen-enriched air is typically generated on-site.

(b) The design of the feed gas system must ensure that the maximum dew point of the feed gas of -76 ^{o}F (-60 ^{o}C) is not exceeded at any time.

(c) Liquid Oxygen Feed Gas Systems

(i) Liquid oxygen storage tanks shall be sized to provide a minimum of a 7-day supply to the ozone generators at the maximum operating rate.

(ii) There shall be two or more vaporizers to convert liquid oxygen to the gaseous form. Vaporizers must be capable of maintaining oxygen flow at the minimum design air temperature with one unit on standby.

(iii) Liquid oxygen storage tanks and system shall comply with Chapters 40, “Oxidizers,” of the 2006 International Fire Code.

(d) Air or Oxygen Enriched Air Feed Gas Systems

(i) There shall be two or more air compressors to supply air. The capacity of the compressors shall be such that the demand during maximum ozone production and for other compressed air uses at the treatment plant can be met when the largest compressor is out of service.

(ii) Entrainment separators, refrigeration dryers, desiccant dryers, and filters shall be used as necessary to provide a sufficiently dried, dust-free, and oil-free feed gas to the ozone generators. Multiple units of this equipment shall be used so that the ozone generation is not interrupted in the event of a breakdown.

(4) Ozone Contactors

(a) An ozone contactor shall consist of two or more chambers to provide for introduction of ozone into the water and contact time. In a water treatment plant, ozone may be introduced in the raw water, or ozone may be introduced later in the process, such as to settled water after solids have been removed. An ozone contactor must be a closed vessel that is kept under less than atmospheric pressure to prevent escape of ozone gas. The materials of construction must be ozone-resistant to prevent premature failure of the contactor.

(b) Ozone gas may be injected into the water under positive pressure through bubble diffusers using porous-tube or dome diffusers. Alternatively, ozone gas may be injected into the water using side stream injection. This is where ozone gas is drawn into the side stream using negative pressure, which is generated in a pipe section with a venturi.

(c) An ozone contactor shall be designed to achieve a minimum transfer efficiency of 85 percent.

(d) Multiple sampling points shall be provided in an ozone contactor to enable sampling of treated water for purposes of determining an accurate measure of the concentration to be used in the “CT” disinfection calculation.

(e) A recommended minimum disinfection contact time is ten minutes.

(f) Ozone contactors shall have provision for cleaning, maintenance, and drainage of the contactor. Each contactor chamber shall be equipped with an access hatchway or other means of entry.

(g) An ozone contactor shall have an emergency off-gas pressure/vacuum relief system to prevent damage to the unit.

(h) A system must be provided for worker safety at the end of the ozone contactor for compliance with OSHA standards. Specifically, ozone levels in the gas space above treated water that has exited the contactor must not exceed the established OSHA 8-hour exposure limit of 0.1 ppm. This system may be an ozone residual quenching system where a chemical is used to destroy remaining ozone in the water, or this system may be a monitoring system that provides sufficient time to lower the residual ozone level in the water by natural decay to an acceptable level. Any chemical used to quench residual ozone shall comply with ANSI/NSF Standard 60.

(5) Off-Gas Destruction Units

(a) A system for treating the final off-gas from each ozone contactor must be provided in order to meet safety standards. Systems using thermal destruction or catalytic destruction may be used. At least two units shall be provided which are each capable of handling the entire off-gas flow.

(b) Exhaust blowers shall be provided in order to draw off-gas from the contactor into the destruction units.

(c) Provisions must be made to drain water from condensation in the off-gas piping and to protect the destruction units and piping from moisture and other impurities that may cause damage.

(d) The maximum allowable ozone concentration in the gas discharge from a destruction unit is 0.1 ppm by volume. Provisions may be made for temporary transient concentration spikes that may exceed this limit.

(6) Piping and Connections

(a) Because ozone is a strong oxidant, consideration shall be given to piping materials used in ozone service. Generally, only low carbon 304L and 316L stainless steel shall be used for ozone gas service.

(b) Connections on piping used for ozone service shall be welded where possible. Threaded connections shall be avoided for ozone gas piping because of their tendency to leak. Connections with meters, valves, or other equipment shall be made with flanged joints with ozone-resistant gaskets.

(c) A positive-closing 90-degree turn isolation valve, or other equivalent means, shall be provided in the piping between an ozone generator and a contactor to prevent moisture from reaching the ozone generator during shutdowns.

(7) Instrumentation and Monitoring

(a) A flow meter shall be provided to measure the flow rate of the water being treated. A temperature gauge or transmitter shall also be provided to measure the temperature of the water being treated. The pH shall also be measured to indicate changes in the water being treated.

(b) An ozone gas analyzer, a flow meter, and a temperature measurement shall be provided on the gaseous ozone feed line going to the ozone injection point.

(c) Ozone aqueous residual analyzers shall be provided to measure the ozone residual concentration in the water being treated in order to determine "CT" credit.

(d) An ozone gas analyzer shall be provided on the gas discharge of each ozone destruction unit, or combined vent gas discharge, to determine the exiting ozone concentration.

(e) Ambient ozone monitors shall be installed in the vicinity of the ozone generators, the ozone contactors, the ozone destruction units, and other areas where ozone gas may accumulate.

(f) A continuous dew point monitor shall be provided on the feed gas line to the ozone generators.

(g) Instrumentation such as pressure gauges, temperature gauges, flow meters, and power meters shall be provided as necessary to monitor the feed gas system, ozone generators, power supply units, and cooling water to protect the equipment and monitor performance.

(8) Alarms and Shutdowns

(a) An ambient ozone monitor shall be provided.

(b) The design shall include alarms and shutdowns.

(9) Safety

(a) Training shall be provided to the operators of ozone systems by the manufacturers of the ozone equipment, or other professionals with experience in ozone treatment, to promote the safe operation of the systems.

(b) Appropriate signs shall be installed around ozone and liquid oxygen equipment to warn operators, emergency responders, and others of the potential dangers.

(c) A means shall be provided, such as portable purge air blowers and portable monitors, to reduce residual ozone levels in an ozone contactor or other equipment to safe levels prior to entry for repair, maintenance, or emergency.

(10) Operation and Maintenance

(a) An ambient ozone monitor shall activate an alarm when the ozone level exceeds 0.1 ppm. Because the natural ozone levels can exceed 0.1 ppm under certain atmospheric conditions, it is permissible to set the alarm level at a slightly higher level to avoid nuisance alarms. Ozone generator shutdown shall occur when ambient levels exceed 0.3 ppm in the vicinity of an ozone generator or a contactor. Operators of the water treatment system may set the alarm level and the shutdown level lower at their discretion. It is recommended that an ozone ambient monitor activates a local audible alarm and/or flashing light warning, in addition to an alarm at the operator control system panel.

(b) There shall be an alarm/shutdown to prevent the dew point of the feed gas exceeding the maximum of -76 ^{o}F (-60 ^{o}C).

(c) Alarms and shutdowns shall be programmed based on the pressure gauges, temperature gauges, flow meters, and power meters, to protect the feed gas system, ozone generators, power supply units, and cooling water system.

R309-520-10. Chlorine Dioxide.

Public water systems must take into consideration that chlorine dioxide and its byproducts may have similar effects as chloramines on sensitive populations. Chlorine dioxide shall not be intentionally used as a secondary disinfectant. The water system must monitor the chlorine dioxide residuals and byproducts in the distribution system. If the chlorine dioxide residual in the distribution system may affect sensitive populations, the public water system shall notify the public of the change. Sensitive populations include hospital and kidney dialysis patients. Sensitive industries include fisheries.

(1) Pre-design Proposal

Proposals for the use of chlorine dioxide shall be discussed with the Division prior to the preparation of final plans and specifications. A water system must submit a detailed written proposal to the Director for review, including:

(a) The make, model, and specifications for proposed chlorine dioxide generator

(b) References of other U.S. potable water installations of the proposed unit

(c) Information on the operational and maintenance training program

(d) The expected total applied dosage of chlorine dioxide and other disinfectants as well as the points of application for all disinfectants and the type and amount of residuals and by-products expected in the distribution system

Guidance: It is recommended that the plans, specifications, operating procedures, and emergency response plans be reviewed by a certified safety consultant. Individuals which meet these requirements should maintain and supervise safety programs and procedures.

(2) Chlorine dioxide generators

(a) Chlorine dioxide generation shall be designed to be efficient compared to industry standard, and production of excess chlorine shall be minimized.

Guidance: Concentrations of chlorine dioxide and chlorite in the plant effluent need to be considered in design and operation to avoid exceeding the MRDL and MCL respectively.

Guidance: Typically a well-run generator can operate at more than 95% yield $([ClO_2]/\{[ClO_2] + [ClO_2^-] + 67.45/83.45[ClO_3^-]\})$***. Maximizing yield will minimize chlorite demand and the possibility of exceeding the chlorite MCL. Discharge of free chlorine from the generator can typically be limited to less than 2% by weight. Free chlorine can contribute to DBP formation.***

(b) The generator shall not produce a solution with chlorine dioxide concentration more than 6,000 mg/L to minimize the explosion hazard.

(c) The design shall include capability to measure concentrations of chlorine dioxide, chlorite, chlorate, and free chlorine of the solution leaving the generator.

(d) The chlorine dioxide generator shall be equipped with a chlorine dioxide analyzer to measure the strength of the solution leaving the generator.

(e) Generators which use solid chlorite will not be allowed.

(3) Chlorine Dioxide Feed and Storage System

(a) Chlorine Dioxide Feed system.

(i) Use fiberglass reinforced vinyl ester plastic (FRP) or high density linear polyethylene (HDLPE) tanks with no insulation.

(ii) If centrifugal pumps are used, provide Teflon packing material. Pump motors must be totally enclosed, fan-cooled, equipped with permanently sealed bearings, and equipped with double mechanical seals or other means to prevent leakage.

(iii) Provide chlorinated PVC, vinyl ester or Teflon piping material. Do not use carbon steel or stainless steel piping systems.

(iv) Provide glass view ports for the reactor if it is not made of transparent material.

(v) Provide flow monitoring on all chemical feed lines, dilution water lines, and chlorine dioxide solution lines.

(vi) Provide a means to verify calibrated feed flow to each application feed point.

(vii) Control air contact with chlorine dioxide solution to limit potential for explosive concentrations building up within the feed facility.

(viii) All chlorite solutions shall have concentrations less than 30%. Higher strength solutions are susceptible to crystallization and stratification.

(b) Chlorine Dioxide Storage and Operating Area. The following requirements apply to the chlorite storage and chlorine dioxide day tank area.

(i) The chlorine dioxide facility shall be physically located in a separate room from other water treatment plant operating areas.

(ii) The chlorine dioxide area shall have a ventilation system separate from other operating areas.

(iii) Provision shall be made to ventilate the chlorine dioxide facility area and maintain the ambient air chlorine dioxide concentrations below the Permissible Exposure Limit (PEL).

(A) The ventilating fan(s) 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 of any rooms or structures.

(B) Air inlets are provided near the ceiling.

(C) Air inlets and outlets shall be louvered.

(D) Separate switches for the fans are outside and near the entrance of the facility.

Guidance: Chlorine dioxide has a permissible exposure limit (PEL) in air based on 8 hour work day of 0.1 ppm and a short term exposure limit (STEL) of 0.3 ppm. The odor threshold of chlorine dioxide is about 0.1 ppm. Special measures are needed to protect treatment plant personnel.

(iv) The area housing chlorine dioxide facility shall be constructed of non-combustible materials such as concrete.

(v) There shall be an ambient air chlorine dioxide sensor in the vicinity of the chlorine dioxide operating area. The ambient air chlorine dioxide readouts and alarm or warning light shall be audible and visible in the operating area and on the outside of the door to the operating area. The design shall include distinguishing audible alarms that are triggered by the ambient air chlorine dioxide sensor readings.

(vi) There shall be observation windows through which the operating area can be observed from outside the room to ensure operator safety.

(vii) Manual switches to the light in the operating area shall be located outside the door to the room.

(viii) There shall be an emergency shower and eyewash outside and close to the door to the operating area.

(ix) An emergency shutoff control to shut flows to the generator shall be located outside the operating area.

(x) The design shall minimize the possibility of chlorite leaks.

(xi) The chlorite tank and chlorine dioxide solution tank shall be vented to the outdoors away from any operating areas.

(xii) Gaseous chlorine feed to the chlorine dioxide generator shall enter the chlorine dioxide facility area through lines which can only feed to vacuum.

(xiii) The floor of the chlorine dioxide facility area shall slope to a sump.

(xiv) There shall not be any open drains in the chlorine dioxide operating area.

(xv) Provide secondary containments with sumps for chlorine dioxide storage, and chlorine dioxide solutions which can hold the entire volume of these vessels. This containment shall prevent these solutions from entering the rest of the operating area.

(xvi) Provide wash-down water within the operating area.

(xvii) The operating area shall be designed to avoid direct exposure to sunlight, UV light, or excessive heat.

(4) Other Design Criteria

(a) Provide secondary containment, a sump, wash-down water, and a shower and eyewash at the bulk delivery transfer point.

(b) Finished water shall be used for chlorine dioxide generation.

(c) The finished water line to the chlorine dioxide generator shall be protected with a high hazard assembly.

(d) Provide a water supply near the storage and handling area for cleanup.

(e) The parts of the chlorine dioxide system in contact with the strong oxidizing or acid solutions shall be of inert material.

(f) The design shall provide the capability to shut off the chlorine dioxide operation remotely, i.e., from a location that is outside of the chlorine dioxide operating area.

(5) Operation and Maintenance

(a) Do not store or handle combustible or reactive materials, such as acids, reduced metals, or organic material, in the chlorine dioxide operating area.

(b) Store chemicals in clean, closed, non-translucent containers.

(c) Personal protective equipment and first aid kits shall be stored at a nearby location that is outside the chlorine dioxide facility area.

(d) The temperature of the chlorine dioxide operating area shall be maintained between 60 and 100 °F.

(e) After delivery allow chlorite solutions to equalize with the ambient temperature of the operating area to avoid stratification.

(f) The Operating and Maintenance manual shall include operator safety and emergency response procedures. Personnel shall have ongoing training for operator safety and emergency response procedures.

(g) All wastes shall be disposed of in accordance to any existing solid and hazardous waste regulations.

(h) The operating area shall be inspected daily for chlorite spills and solid chlorite buildup. The daily inspections shall be logged.

(i) Chlorite leaks and solid chlorite buildup shall be cleaned up and disposed of immediately.

(j) Solid chlorite shall be washed down before removal.

Guidance: Solid chlorite is an explosion hazard. Solid chlorite should be handled with care.

(k) The ventilation system in the chlorine dioxide facility area shall be operated to maintain the ambient air chlorine dioxide concentrations below the Permissible Exposure Limit (PEL).

(l) Audible alarms shall be programmed to alert water treatment plant personnel when the ambient air chlorine dioxide sensor in the vicinity of the chlorine dioxide operating area detects the chlorine dioxide concentration above the Permissible Exposure Limit (PEL) and the Short Term Exposure Limit (STEL).

R309-520-11. Chloramines.

Proposals for the use of Chloramines as a disinfectant shall be discussed with the Division prior to the preparation of final plans and specifications.

Guidance: Chloramines are a much weaker oxidant than free chlorine, ozone or chlorine dioxide and therefore the "CT" values for inactivation of Giardia cysts by chloramines are

extremely high and may not be achievable for some systems. Chloramines may be utilized only for secondary disinfection, as necessary to maintain required disinfectant residual concentrations in water entering, or throughout, the distribution system. Chlorine may be added prior to ammonia in producing chloramines, or ammonia prior to chlorine, or even ammonia and chlorine added concurrently. The order of application of chlorine and ammonia to form chloramines is important and source waters must be evaluated to determine which method is most effective.

KEY: drinking water, primary disinfectants, secondary disinfectants, operation and maintenance
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