Guidance for Sanitizing Residential Drinking Water Treatment Systems

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Disclaimer

The foregoing considerations are provided for general informational purposes only and are not intended, and should not be relied upon, as specific scientific, operational, medical or legal advice. You are strongly encouraged to consult with qualified technical professionals for specific considerations applicable to your circumstances, to product manufacturers for specific instructions regarding their products and technologies and their operation, to qualified medical personal/public health officials for medical considerations in your reopening plans, to local, state, and federal orders, releases, regulations and/or laws for compliance and operational requirements, and to your legal counsel for legal considerations. If you use any suggested and informational guidance provided herein, you do so at your own risk and subject to this disclaimer and you specifically release from any and all liability Water Quality Association and its directors, officers, employees, volunteers, and agents in connection with your reliance on the enclosed considerations.

Introduction

It is neither necessary nor possible to maintain water treatment equipment and/or drinking water in a sterile condition or to completely eradicate or destroy one hundred percent of all microorganisms in drinking water. But the procedures and practices described here can effectively sanitize, maintain sanitary conditions, and disinfect the water treatment equipment. The term “sanitize” generally refers to the process of treating or cleaning inanimate objects (particularly water treatment equipment and associated installation and/or handling materials and tools). “Sanitary” implies a satisfactory condition of cleanliness in addition to a safe or controlled microbial level. “Disinfection” means to free the water or water contacting surfaces of harmful microorganisms as measured by the absence of pathogenic (disease-causing) and/or indicator coliform bacteria. It is important to note that the procedures discussed herein apply to potable water applications, and that other applications may require a different approach.

This document provides general guidance and information for water treatment professionals who may be called upon to sanitize drinking water treatment systems used within a home or business environment after a prolonged period of stagnation due to building vacancy, flooding, or similar potential contamination events. For example, this guidance would be appropriate when assisting customers who are bringing recently vacated buildings back online after COVID-19 “Shelter-In-Place” orders are lifted.

This guidance is not intended for sanitation of drinking water treatment systems which have been directly exposed to raw sewage such as during a backflow event or arising from the impact on water systems of other extraordinary events.

This guidance can also be used as a resource by building owners and operators. Examples include restaurant and coffee shop owners, small businesses and retail establishments, commercial facilities, industrial sites and manufacturing facilities that need to safely restore operations.

This sanitization procedures provided herein can be considered, evaluated and adapted by product manufacturers who are preparing detailed sanitation instructions for use with their own products, or can be used by water treatment dealers, i.e. those professionals who install, service and maintain systems when detailed sanitation instructions cannot be obtained from the product manufacturer and/or require confirmation or supplementation.

- Always follow the manufacturer's procedures for service, replacement of parts, and operating procedures;
- When detailed sanitation procedures are provided by the system manufacturer, the manufacturer’s procedures should be followed instead of the general procedures provided in this guidance;
- Choose a disinfection solution from the list approved under the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA), and certified for safe use with drinking water according to NSF/ANSI/CAN 60.
- Also review the limitations of disinfectants from the Centers for Disease Control (CDC);
- When using soap for the cleaning of wetted surfaces, use liquid dish soap; the simpler the better, and avoid types containing scents, whiteners, antibacterial agents, and other additives;
- Always follow the disinfectant manufacturer's safety precautions and refer to the Safety Data Sheet (SDS) for the particular disinfectant chemical being used when mixing and using disinfectant solutions (e.g., gloves and safety glasses may be recommended); and
- Water used for cleaning and rinsing must be potable and microbiologically safe.

The procedures in this guidance are based on sanitizing with chlorine. However, other chemical options are available as explained under *Disinfectant Sanitizers*.

Always read and understand the chemical manufacturer's instructions, and be aware that those instructions may or may not be appropriate for sanitizing water treatment equipment.

The surfaces to be sanitized must be clean. During the operation of the equipment, a biofilm may build up on the surfaces. Biofilms consist of a coating or cover of sticky and slimy polysaccharides, called glycocalyx, that can exude or release bacteria into the flowing water stream. This film must be removed using a brush with warm soapy water. Care must be taken not to damage sealing surfaces with scratches which could create leaks or bypass. Deep scratches or crevices in rough surfaces could also provide new sites for future biofilm growth.

Two factors must be considered when using chemicals to sanitize: 1) the concentration of the chemical; and 2) the time the equipment is exposed to the chemical solution. The higher the concentration, the shorter the time of exposure required (see *Disinfection Sanitizers* for more information).

Deterioration of some equipment components, such as O-rings and ion exchange resins, may result from high concentrations of chlorine. Some reverse osmosis membranes can also be damaged by chlorine. Thus, always consult with the system manufacturer even when following the general procedures provided in this guidance.

If chlorine was used to sanitize the premise plumbing or water treatment equipment, flush the equipment thoroughly with potable water after completing the sanitizing process. Flush water through the treatment system until the chlorine concentration drops below 1 part per million (ppm), or to the level of the influent supply, to ensure that excess chlorine has been flushed from the equipment.

In rare situations, raw sewage or highly contaminated water may have entered the resin bed or media from a flooded well or other event. In these cases, it is recommended that no attempt be made to clean the resin bed or media. The media in the tank should be removed and discarded, the tank and the control valve should be sanitized, and new media added.

General Sanitation Practices for Manufacturers and Water Treatment Dealers

Water treatment personnel involved in the manufacturing, transportation, installation, and servicing of water treatment products should observe basic sanitation practices. All products that come in contact with a potable water supply or product water (e.g. tubing, fittings, or other accessories) should be treated with the same sanitary practices as drinking water treatment equipment. In fact, the best mindset for maintaining sanitation is to think of water as food and apply the same type of consideration for anything that might contact potable water as one would for food about to be consumed.

Table 1 shows examples of microorganisms that are commonly found in water supplies, followed by typical sizes of the microorganisms and filtration techniques that can be effective for removing them.

Table 1
Microorganisms: Typical Sizes and Removal Techniques

Type	Example	Typical Size	Coarsest Filter Medium[f]
Protozoa	Cryptosporidium	4-6 μm[a]	Particulate Filtration
Mold Spore	Aspergillus	2-3.5 μm[b]	Particulate Filtration
Bacteria	E. coli	1-2 μm[c]	Micro Filtration
Virus	Retrovirus	0.1 μm[d]	Ultrafiltration
Pyrogen	Endotoxin	10,000[e] Dalton	Ultrafiltration

[a](World Health Organization [WHO], 2006)
[b](Mold & Bacteria Consulting Laboratories, n.d.)
[c](Riley, 1999)
[d](Ryu, 2017)
[e](“Cell Culture FAQs, n.d.)
[f](Hatch, Buteyn, & Kinsey, 2006)

General personnel responsibilities for the manufacturer and water treatment dealer are as follows:

- **Clothing**: Personnel shall wear clean, appropriate clothing and should practice good sanitation and health habits.
- **Disease Control**: Personnel, who by medical examination or supervisory observation, are shown to have, or appear to have, an illness, open lesions, including boils, sores, or infected wounds, or any other source of microbial contamination by which there is a reasonable possibility of the water treatment

device or components becoming contaminated by contact, should be excluded from participation in sanitation activities until medically cleared to do so. Personnel should be instructed to report to their supervisor such health conditions which they or their coworkers may appear to be presenting.

- **Personnel cleanliness**:
    - **Hand washing**. Personnel shall wash, and/or sanitize their hands thoroughly in an adequate hand washing facility before starting work, after each absence from the workstation, and at any other time when the hands may have become soiled or contaminated.
    - **Gloves**. Gloves (if they are used in the handling of a water treatment device or component) should be intact, clean, and not contaminated. The gloves should be of an impermeable material. Gloves should either be disposable or be cleaned and stored in such a way as to maintain a sanitary condition.
    - **Hair**. If appropriate, hair nets, hair bands, caps, beard covers, or other hair restraints should be worn. These items should either be disposable or be cleaned and stored in such a way as to maintain a sanitary condition.
    - **Food**. The eating of food in the assembly, testing, packaging, or service area of water treatment equipment manufacturing plant, or on the job site, should not be permitted.
    - **Smoking**. Because some of the water treatment equipment and components have adsorptive characteristics, smoking should not be permitted in the assembly, testing, and packaging area of the water treatment equipment manufacturing plant or on the job site.
- **Area**: Confining the area of manufacturing and service to a clean and controlled environment is necessary to prevent dust, dirt, fumes, and foreign matter from contaminating the water treatment equipment and components. Do not put items directly on the floor; use a clean piece of cardboard or other floor covering. If the cleanliness of the environment at the customer's site is of concern, sanitization can also be done offsite and the sanitized system returned to the customer at a later time.
- **Tools**: Tools that are used to assemble, test, package, and service the water treatment equipment should be kept in a clean environment. These tools should be dedicated to the use of assembling, testing, packaging, and servicing of the water treatment equipment, and regular cleaning and sanitizing of these tools should be a standard practice. To avoid contaminating drinking water, keep separate sets of tools for potable and non-potable applications.

- **Lubricants**: Only use lubricants which have been certified for safe use with drinking water (e.g., lubricants certified for material safety under NSF/ANSI/CAN standard 61) to lubricate gaskets or O-rings. Never use saliva or petroleum jelly. Lubricants need to be stored in a sanitary environment.

General Sanitation Practices Specific to the Water Treatment Dealer

The water treatment dealer plays an important role in preserving the integrity of the water treatment equipment, whether it is a point-of-use (POU) or point-of-entry (POE) system. It is the water treatment dealer who controls the good working condition, cleanliness, and sanitation of the equipment after receipt from the manufacturer.

Because water treatment equipment is susceptible to contamination from outside sources, special precautions must be taken not to contaminate the system and its components during the installation and servicing processes. Contamination can occur through airborne, waterborne, and human contact. Waterborne and human contact are the main sources for microbiological contamination. Bacteria contamination from the existing water lines can and will continue to grow after entering the water treatment equipment. Certain contaminants in water treatment equipment may produce complaints from the customer about the treated water quality. Some of the most common complaints are described as "earthy" and "musty" odors.

Sources that could result in potential microbiological contamination include, but are not limited to, feedwater biofilm originating in the plumbing, media in the water treatment equipment, improper installation, or improper service/maintenance procedures.

Most water treatment equipment is susceptible to "heterotrophic" (natural, non-disease-causing) microbiological growth. This type of microbial contamination can occur in systems with no disinfectant residual, at points in the system where water velocity is low, or on surfaces that are easily colonized by certain microbes. Storage tanks are an example of an area of low water movement. Examples of other easily colonized surface areas are gaskets and O-rings. These elastomeric surfaces are soft and porous which encourage microbial attachment. Microbial colonization is resistant to simple flushing or rinsing. Effective cleaning may require physical scrubbing of the parts or surface areas followed by flushing with a disinfectant solution.

Water treatment dealers need to be aware of the following recommendations, and their personnel need to be trained, equipped, and continuously cognizant of the importance of these recommendations.

Specific Best Practices for the Water Treatment Dealer

Unless specifically intended to provide primary disinfection, water treatment equipment should be installed on a potable and microbiologically safe water supply. If the potability of a publicly provided water supply is in doubt, contact the local water municipality or department of health and ask for its help to determine if the water supply is safe.

Make certain that the water treatment equipment is sized properly for the application. An oversized system may not have enough water flowing through it to keep stagnant areas in the equipment from developing excessive microbiological growth. Holding tanks and storage tanks are particularly vulnerable to this problem.

Prior to installing new water treatment equipment, flush the premise plumbing lines. It is common to have biofilms in existing plumbing. "Shock treating" the piping may be necessary to reduce the biofilm within older plumbing.

Advise the customer that drinking water treatment equipment should not remain dormant for extended periods of time. Otherwise sanitation of the water treatment system may be required.

Work with the customer to develop a periodic maintenance schedule for the water treatment equipment. Explain the importance of maintenance, and detail the steps required to ensure proper water quality from the system. Refer to the owners' manuals from the system manufacturer for maintenance procedures.

Water treatment equipment may be sanitized by several methods. These include the periodic exchange of equipment which has been sanitized at the dealership or sanitizing at the end user site with proper equipment and chemicals. Dealers should determine what method is appropriate for each situation.

When installing or servicing water treatment equipment, use only clean and sanitized tools. Thoroughly clean tools and equipment after each service or installation. Drills, cutters and other tools used on a waste or sewer line should not be used on potable water lines or drinking water treatment systems.

Hands must be washed prior to touching gloves, sanitized tools, or parts, since hands are a major source of microorganisms. The use of latex medical gloves and a breathing mask is encouraged when handling sanitized parts, filter cartridges, and membranes. If an unclean object has come in contact with a glove or sanitized part, the glove or part must be cleaned and sanitized again.

Replacement media, filter cartridges, and membranes are installed after the equipment and housing have been sanitized. Take precautions not to contaminate the replacement items during the installation process.

Personnel Responsibilities

Training and awareness are important for successful water treatment equipment sanitation. Discipline is required to avoid touching sanitized parts or filters with un-washed hands or touching unclean parts or tools with gloved or washed hands as cross-contamination could easily result.

The installation and service procedures must be thought out before the work begins. Tools used to do an installation or service should be sanitized before being used. If this cannot be done at the customer's site, a second set of clean tools should be available. Some dealers have one technician install the equipment, followed by a second who completes the sanitation work.

It is important to follow the equipment manufacturer's recommendations or procedures for sanitation. Each manufacturer or model of equipment may require a different procedure, and general guidelines may not be sufficient to ensure a properly sanitized system. To ensure the proper sanitation procedure for a particular water treatment system, contact the manufacturer.

Special Precautions due to the COVID-19 Pandemic

It is recommended that all personnel strictly follow these guidelines, adapted from OSHA and the CDC, to protect customers, employees and others from exposure to COVID-19. (Occupational Health and Safety Administration [OSHA], n.d.; Centers for Disease Control and Prevention [CDC], 2020)

- Frequently wash hands with soap and water for at least 20 seconds
- When handwashing is unavailable, use a hand sanitizer with at least 60% alcohol
- Avoid touching your eyes, nose, and mouth
- Avoid close contact with people who are sick
- Maintain a distance of at least 6 feet from other people
- Stay home and quarantined if you're sick, except to get medical care
- Cover coughs or sneezes with the inside of your elbow
- Wear a face mask on the job. It is meant to protect other people.
- Clean and disinfect surfaces you touch frequently with an EPA approved disinfectant for the COVID-19 virus

Disinfectant Sanitizers

This section provides information regarding various disinfectant sanitizers that are commonly used by the water treatment industry.

A broader list of disinfectants approved under the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA) for use against viral pathogens like the COVID-19 virus is available through the United States Environmental Protection Agency (USEPA):

https://www.epa.gov/pesticide-registration/list-n-disinfectants-use-against-sars-cov-2

A more comprehensive resource on limitations of various disinfectants is available through the Centers for Disease Control and Prevention (CDC):

https://www.cdc.gov/infectioncontrol/guidelines/disinfection/disinfection-methods/chemical.html

The information provided in this CDC link, along with CDC updates, should help the manufacturer and the water treatment dealer decide on the materials best for their applications. Information is included about some of the solutions and contact times required to be effective in obtaining positive desired results.

In all cases, the disinfectant manufacturer's recommendations and safety precautions must be followed. Be sure to obtain the Safety Data Sheet (SDS), and carefully follow the safety related instructions.

Disinfectants can be strongly reacting, reactive, and potentially dangerous chemicals, especially if mixed with certain other chemicals. For example, chlorine bleach and sodium hydrosulfite-based iron reducing agents, will produce a violent and dangerous reaction if allowed to come in direct contact. Always follow the chemical manufacturer's instructions for safe and effective use.

Only chemicals which are certified for use with potable water should be used on surfaces that will contact drinking water, such as the interior wetted surfaces of a drinking water treatment system. This is a mandatory requirement in some states. And all disinfectant chemicals, no matter where or how they are used, must be approved by and properly registered with the USEPA Office of Pesticides in accordance with FIFRA.

Control of Microorganisms in Water

Control of microorganisms falls into one of three categories.

1. Disinfection: A treatment process designed to remove or kill all disease-causing microorganisms in a water supply. Disinfected water will still have live microorganisms present. Disinfection is the category used to ensure the acceptable level of microbiological safety and potability of drinking water.
2. Sterilization: The kill or removal of all living microbes. This process is not employed for water intended for drinking.

3. Sanitization: A treatment of surfaces in contact with food or water that destroys microorganisms hazardous to health and reduces their concentration on those surfaces.

Processes to achieve sanitization of water treatment equipment are the primary focus of this guidance. To help understand how sanitization of equipment differs from disinfection of source water, a brief review of how a water supply and distribution system are disinfected is useful.

Control of microorganisms in water for the purpose of disinfection is approached from three different perspectives. Continuous disinfection processes are used when source water contains pathogens, i.e. disease-causing organisms. Public water systems that employ a chemical for continuous disinfection are required to maintain in the distribution system a relatively low concentration of that disinfectant, referred to as the disinfectant residual. For example, systems using chlorine as the disinfectant will aim for 1-2 ppm of free chlorine residual.

The disinfectant residual serves as an initial barrier to protect the water in the distribution system from microbiological contamination and helps reduce the growth of biofilm. However, when water stagnates in the distribution system and appliances, the disinfection residual dissipates. Flushing the distribution system with fresh, treated water, will help restore the disinfection residual, but it will do little to clean biofilm from water treatment equipment.

The second perspective, intermittent disinfection, is used when conditions may have resulted in the growth of biofilm because of water stagnation or increased water temperature, but the water supply does not have pathogens present. With intermittent disinfection, POU/POE treatment equipment is typically put in bypass where possible and all filter cartridges and membranes are usually removed from the path of the high disinfectant dosage and separately sanitized/replaced prior to being returned to service.

One example of this would be employing flushing of the distribution system, followed by the addition of a large concentration of disinfectant to the distribution system with several hours of contact time. The exact concentration will depend on the disinfectant used. Following the appropriate contact time, the disinfectant is flushed from the distribution system.

Finally, shock disinfection is intended to follow events that may have introduced pathogens into the source water or the distribution system. Examples of such events are a positive result of a coliform test either in the distribution system or in the source water, a break in a water distribution line, or a repair or replacement of a peripheral to the distribution system that requires cutting a pipe.

Following appropriate flushing to clean either the water source or the distribution system, a large concentration of disinfectant is added – larger than the concentration used for intermittent disinfection – and allowed to remain in contact with the source and/or distribution system for a specified time. The disinfectant is flushed from the system following the contact time and the water is retested for the presence of pathogens. The procedure may be repeated until water tests demonstrate the absence of pathogens.

As with intermittent disinfection, the dosages used for shock disinfection may damage treatment equipment and components. All POU/POE treatment equipment will usually be bypassed, or cartridges removed prior to the application of shock treatment. The equipment will need to be sanitized and cartridges replaced prior to being returned to service.

Understanding Dosage

Dosage of disinfectant for control of microbiological contamination, whether for disinfection or a sanitization process is a combination of the disinfectant concentration (irradiation, if UV lamp) and the time the disinfectant is in contact with the water or surface being treated.

Dosage is represented as CT, sometimes called the disinfection factor. Referring to CT as contact time is incorrect, as that leaves out the concentration of the disinfectant.

CT will differ based on the contaminant of interest; the temperature of the water; and for certain disinfectants, the pH of the water (Centers for Disease Control and Prevention [CDC] 2008).

CT does not consider other water quality or surface parameters that may interfere with the disinfection process such as the presence of oxidizable compounds of iron, manganese, and hydrogen sulfide; turbidity; or, depending on the disinfection method, hardness ions. Therefore, water and surfaces must be pretreated/precleaned to ensure contact between the disinfectant/sanitizer and the microbes.

The disinfectant residual is the concentration of the disinfectant remaining in a specific water sample after the disinfectant added has reacted with any substance in that sample that is capable of reacting with the disinfectant. Potential reactants include organic compounds and oxidizable inorganic compounds (e.g., compounds of iron, compounds of manganese, or hydrogen sulfide).

CT is defined by the following equation:

Equation 1.

$$CT = C \times T$$

Where:

T is the time in minutes that the water or surface being sanitized is in contact with the disinfectant residual

C is the concentration of the disinfectant residual in ppm

Disinfection factors are available for a variety of microbiological contaminants and disinfectants/sanitizers. The following table is a summary of CT values for chlorine for selected microorganisms (CDC n.d.).

Table 1: Selected CT factors for E. coli, rotavirus, cryptosporidium

Organism	Tolerance to chlorine	Concentration of chlorine (mg/L)	Time of chlorine exposure (min)	CT factor	Variables affecting CT factor: Temp (Celsius)	Variables affecting CT factor: pH
E. coli	Low	0.5	<0.5	<0.25	23	7.0
Rotavirus	Moderate	0.20	0.25	0.05	4.0	7.0
Cryptosporidium	High			15,300*	25	7.5

*Due to the high tolerance of Cryptosporidium and resulting high CT factor, the CDC recommends removing the oocysts with a 1-micron absolute filter (CDC n.d.).

As the data in Table 1 illustrated, CT is the product of the disinfectant concentration and the contact time. At a temperature of 4 °C and a pH of 7, the CT factor for Rotavirus kill is 0.05. That can be accomplished by using a solution of 0.2 ppm chlorine for 0.25 minutes as indicated in the table.

When the required CT and solution concentration is known, the contact time can be derived from equation 1.

Using the rotovirus example in Table 1, where CT is 0.05 and the disinfectant concentration is 0.2 ppm, the calculation for contact time is derived from equation 1:

$CT = T \times C$

$0.05 \text{ min}\cdot\text{mg/L} = T \text{ min} \times 0.2 \text{ ppm}$

$(0.05 \text{ min}\cdot\text{mg/L})/0.2 \text{ ppm} = T \text{ min}$

$0.25 \text{ min} = T \text{ min}$

Sanitization of Surfaces

The treatment of surfaces to reduce microbial contamination is called sanitizing by the U.S. Food and Drug Administration (FDA) and is considered an essential step after general cleaning of equipment. FDA defines "sanitize”:

> To adequately treat food-contact surfaces by a process that is effective in destroying vegetative cells of microorganisms of public health significance, and in substantially reducing numbers of other undesirable microorganisms, but without adversely affecting the product or its safety for the consumer. [FDA 2019:21 CFR § 110.3(o)]

Sanitizing Chemicals

Many of the common chemical sanitizers for water storage and dispensing equipment are the same chemicals used for disinfection. In sanitizing, however, the working concentration of the chemical is higher than that typically used for routine disinfection. For best effect, the surface to be sanitized must be thoroughly cleaned and rinsed prior to treatment with a chemical sanitizer.

Sanitizers commonly used in drinking water treatment and dispensing equipment include chlorine, iodine (iodophors), quaternary ammonium (quats), peracetic acid, and peracetic acid mixed with hydrogen peroxide.

Baking soda is not considered to be an effective sanitizer. Baking soda can be used to deodorize, but it has no disinfecting or antimicrobial activity.

Table 2 lists the sanitizers that are discussed in more detail below, and their working concentrations.

Table 2. Sanitizer Concentrations[a]

Sanitizer	Concentration Range for Sanitizing Food-Processing Equipment and Utensils and on other Food Contact Articles	Recommended Concentration
Chlorine	Solutions should not exceed 200 ppm as available chlorine and pH should be kept between 6.5 and 7.5 to be most effective[b]	**50 ppm**
Sodium dichloroisocyanurate (NaDCC)	100 ppm available chlorine[b]	**Follow manufacturer's instructions**
Iodine	12.5 – 25 ppm[b]	
Quaternary Ammonium (Quats)	150 – 400 ppm[b]	
Peracetic Acid	100 – 200 ppm[b]	
Peracetic Acid mixed with Hydrogen Peroxide	100 – 200 ppm peracetic acid plus 550 – 1100 ppm hydrogen peroxide[b]	

[a]Recommended concentrations are provided for reference, only, and are not intended to be prescriptive. Follow guidance from the disinfectant manufacturer and the equipment manufacturer.
[b][FDA 2019:21 CFR § 178.1010]

Chlorine

For sanitizing purposes, only the concentration of free chlorine is relevant. Free chlorine refers to three forms of chlorine that can be found in water: elemental chlorine, hypochlorous acid (HOCl), and hypochlorite ion (OCl-). Elemental chlorine is not present in sanitizing solutions under normal conditions. Hypochlorous acid is mainly responsible for the antimicrobial activity of chlorine and is the predominant form at lower pH levels. The hypochlorite ion is the less microbicidal form and is predominant at higher pH levels. In the pH range of most drinking water, 6.5-8.5, both species are present, and are in equilibrium at pH 7.5 (United States Environmental Protection

Agency [USEPA] n.d., Bowman & Mealy 2007). Chlorine is very effective against bacteria; however, it is not as effective as other agents in its biocidal action against viruses or cysts (World Health Organization [WHO] 2004). Typical sources of chlorine sanitizers are bleach (sodium hypochlorite solution) or calcium hypochlorite powders or tablets. Simple field test kits are available to measure the concentration of chlorine in sanitizing solutions. Chlorine sanitizers may damage certain materials such as metal, rubber, and plastic, and may cause staining and bleaching.

Chlorine sanitizing solutions are often made from sodium hypochlorite (bleach). Concentration of commercially available sodium hypochlorite solutions varies with manufacturer, so be sure to check the label and adjust the calculations respectively. The percent sodium hypochlorite is w/w, i.e. the amount of the solution, by weight, that is the sodium hypochlorite divided by the weight of the total solution.

For the purposes of this guidance, a target concentration of 50 mg/L of sodium hypochlorite is recommended for use in sanitizing drinking water treatment systems. An easy measurement and dilution procedure using 5.25% w/w sodium hypochlorite bleach is given in the Table 3 below and produces a 52.5 mg/L of sodium hypochlorite solution.

Table 3: Preparing a 52.5 ppm bleach solution from 5.25% sodium hypochlorite bleach

English Measurement	Metric Measurement
3/4 tsp. 5.25% w/w sodium hypochlorite in 1 U.S. gal. of water	1mL 5.25% sodium hypochlorite w/w in 1L of water

Combined Chlorine

One common form of combined chlorine is chloramine. Chloramine is chlorine combined with ammonia and ammonia compounds. Chloramine is commonly used for the disinfection of drinking water; however, it typically is not referenced for use as a sanitizer.

Another combined chlorine compound, sodium dichloro-S-triazinetrione, also known as sodium dichloroisocyanurate (NaDCC) historically has been used as a source of chlorine for the disinfection of swimming pools and in the food industry. Recently, it was approved by the EPA for the treatment of drinking water and drinking water equipment. NaDCC releases approximately 50% of its chlorine as free chlorine, and the rest remains as “reservoir chlorine” bound in the form of chlorinated isocyanurates which is released as the free available chlorine is used up. An advantage of NaDCC over sodium hypochlorite is that it has been found to have a slower decomposition rate and a lower corrosivity against plastic, metal, and rubber (Clasen & Edmondson 2006). This material is used at concentrations ranging from 47 – 4784 ppm (2-600 ppm for cooling towers) available chlorine, depending on the application (USEPA 1988).

Hydrogen Peroxide

Hydrogen Peroxide (H_2O_2) is an effective sanitizer (CDC 2008), but care must be taken to ensure it is food grade before use on surfaces in contact with food and water. Hydrogen peroxide is typically available as a 3% w/w solution, which is approximately 30,000 ppm. H_2O_2 is commercially available at concentrations of 35% (350,000 ppm) and 50% (500,000 ppm), but it is not recommended to be used because these can be extremely dangerous if not handled with great caution.

Iodine

Iodine is another common type of sanitizer. Compared to chlorine, iodine is more expensive, and at high concentrations can stain many materials (WHO 2000). Iodine can be a more effective sanitizer than chlorine depending on water chemistry. Iodine is stable across a wider pH range, reacts less with organic impurities, and works better for water of poor quality. However, the safety of long-term exposure to iodine when it is used as a drinking water disinfectant is not well established, and higher concentrations are required as compared to chlorine to achieve comparable disinfection efficacy (WHO 2018). Iodine sanitizers are not effective against protozoan cysts (CDC 2008).

Commercially available sanitizer concentrates are prepared as a water solution of iodine stabilized with an organic ether or isopropyl alcohol. These stabilized iodine sanitizers are commonly referred to as iodophors. Iodophors retain the germicidal efficacy of iodine but are generally non-staining and free of toxicity and irritancy (CDC 2009).

Quaternary Ammonia (Quats)

Quaternary ammonium-based sanitizers, also called quats, were developed for the food service industry as a noncorrosive, non-staining treatment, and are also commonly used in the healthcare industry for sanitizing noncritical surfaces such as floors and furniture FDA 2019:21 CFR § 178.1010, CDC 2008, Fisher 2003). Quaternary ammonium compounds are generally effective against bacteria, fungi, and enveloped viruses. However, they are not effective against spores or nonenveloped viruses (CDC 2008). Certain compounds have been registered with FIRFA for effectiveness against bacteria and viruses (USEPA 2020). Quats are used at concentrations ranging from 150 to 400 ppm, depending upon the application, however, for sanitizing water treatment equipment, a concentration of 200 ppm is recommended (FDA 2019:21 CFR § 178.1010, USEPA 2020).

Peracetic Acid

A more recent entrant to the pantheon of sanitizers is peracetic acid, also called peroxyacetic acid. Peracetic acid is a weak acid with strong bactericidal and fungicidal action. However, higher doses may be needed to deactivate viruses (CDC 2008). Peracetic acid is not as sensitive to organic matter presence as are chlorine and iodine. It can be corrosive to copper, brass, bronze, steel, and galvanized iron. However, this can be reduced by additives and pH modifications (Rutala & Weber 2015). As it ages, peracetic acid decomposes into water, oxygen, hydrogen peroxide, and acetic acid

(CDC 2008). Peracetic acid typically is used at a concentration of 200 ppm over a range of 100 to 200 ppm (FDA 2019:21 CFR § 178.1010). For some viruses, a concentration of up to 2250 ppm may be needed (Rutala & Weber 2015).

Peracetic Acid Mixed with Hydrogen Peroxide

Another type of sanitizer is peracetic acid mixed with hydrogen peroxide. This combination is an effective antimicrobial agent and has been shown to inactive a wide range of microorganisms, except bacterial spores, within 20 minutes (Alasri et al. 1992).

Effective Application of Sanitizer

The application of a sanitizer solution may be made by either immersion or spraying of parts. The effectiveness of sanitizing is dependent upon: (1) the cleanliness of the surface; (2) the concentration of sanitizer; (3) the temperature of the sanitizer solution; and (4) the sanitizer contact time. Sanitizers kill bacteria by direct contact. Dirt and biofilms can prevent the sanitizer from coming directly into contact with the microorganisms on a surface, thus allowing all such "hidden" or protected microbes to escape the bactericidal action of the sanitizer. During field sanitation, the amount of biofilm may be reduced by wiping or washing the surface with a clean paper towel or cloth.

Once the surface is clean, the effectiveness of a sanitizer is dependent upon the concentration, temperature, pH, and contact time. For example, if a two-minute contact time is adequate with a 50 ppm solution of chlorine, the contact time at the same temperature and pH could be cut to one minute by using 100 ppm solution of chlorine. (See Equation 1) The variation of sanitizer concentration and contact time is only valid within the acceptable concentration range for a sanitizer (see Table 2).

Water temperature has a dramatic effect on the speed with which a sanitizer kills microorganisms. For most disinfectants, the activity increases as the temperature increases (CDC 2008).

Dilution and Calculating Solution Strength

Most commercially available sanitizers will need to be diluted prior to use. The final solution strength should be based on recommendations from either the manufacturer of the equipment to be sanitized or the manufacturer of the sanitizer, specific to the equipment. Equation 2 below can be used to calculate how much water is needed to dilute a sanitizer for a specific solution volume. Table 4 lists helpful conversions.

Table 4: Useful unit conversions

Measurement Conversions
1 cup =8 fluid oz.
1 pint = 16 fluid oz.
1 quart = 32 fluid oz.
1 gallon = 128 fluid oz.
teaspoon (tsp.) = 1/6 fluid oz.

3 teaspoons = 1 tablespoon 1 tablespoon = 1/2 fluid oz. 1 fluid oz. = 29.6 ml 20 drops = 1 ml

The equation used to calculate concentration and volume is as follows:

$C_1V_1 = C_2V_2$ (Equation 2)

Where:

C_1 is the concentration of the solution to be diluted

V_1 is the volume of the solution to be diluted

C_2 is the concentration of the solution after dilution

V_2 is the volume of the diluted solution

The equation can be used to solve for any one unknown. For example, if 20 gallons of a 50 ppm sodium hypochlorite solution are needed, what volume of sodium hypochlorite bleach, 5.25% w/w, is needed?

The example provides three of the four variables used in the equation.

V_2 is 20 gallons and C_2 is 50 ppm. C_1 is 5.25% w/w, but that will need to be converted to ppm. The missing variable, and the one to solve for, is V_1; the volume of the 5.25% w/w solution needed.

To be able to work with the sodium hypochlorite concentration as C_1, first convert it from a percent by weight to parts per million, or ppm.

The percent by weight can be calculated using metric or imperial units. This example will use imperial.

The 5.25% means that in 100 pounds of solution, 5.25 pounds are sodium hypochlorite.

$$\frac{5.25}{100}$$

That's parts per hundred. To get the same as parts per million, multiply both the upper part of the fraction (numerator) and the bottom part of the fraction (denominator) to make the bottom number one million.

One hundred goes into one million ten thousand times:

1,000,000/100 = 10,000

Therefore, both the numerator and the denominator need to be multiplied by 10,000.

$$\frac{5.25}{100} \times \frac{10{,}000}{10{,}000} = \frac{52{,}500}{1{,}000{,}000} \text{ or } 52{,}500 \text{ parts per million (ppm)}$$

Equation 2 can now be used to find the volume of 5.25% sodium hypochlorite needed.

$C_1V_1 = C_2V_2$

$(52{,}500 \text{ ppm})V_1 = (50 \text{ ppm})(20 \text{ gallons})$

$$V_1 = \frac{(50 \text{ ppm})(20 \text{ gal})}{52{,}500 \text{ ppm}}$$

$$V_1 = 0.019 \text{ gallons}$$

0.019 gallons is difficult to measure. Ounces, cups, or teaspoons would be an easier measurement in the field. The conversions in Table 4 show that 1 gallon = 128 fl oz, and 1 cup = 8 fl oz.

To determine what 0.019 gallons is in teaspoons, set up the following conversion equation:

$$0.019 \text{ gal} \times \frac{128 \text{ fl oz}}{1 \text{ gal}} \times \frac{1 \text{ cup}}{8 \text{ fl oz}} = 0.3 \text{ cup}$$

About 1/3 of a cup of 5.25% w/w sodium hypochlorite is needed to make 20 gallons of 50 ppm solution. Since 0.019 gal in comparison to 20 gallons is negligible, the solution is made up by placing 1/3 of a cup of sodium hypochlorite into the solution storage tank and adding 20 gallons of water.

If a larger amount of sodium hypochlorite was needed, for example 1 gallon, then to make a 20 gallon solution, the remaining volume would be made up with water; 19 gallons of water, in this case.

Sanitation for Systems with Disposable Carbon Filters/ Media

The procedure below assumes that the user is starting with a 5.25% w/w sodium hypochlorite solution (chlorine bleach). Alternative concentrations of sodium hypochlorite solution may be used by adjusting the dose accordingly to result in a final concentration of approximately 50 mg/L sodium hypochlorite.

Federal law requires that the sodium hypochlorite brand be approved and properly registered through the U.S. EPA Office of Pesticides under the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA). State laws may also require that the brand of sodium hypochlorite solution be certified for safe use with drinking water according to NSF/ANSI/CAN 60.

For all other sanitizers, follow filter system manufacturer's and sanitizer manufacturer's instructions to obtain the correct dose for sanitization of the filter.

The procedure below also assumes that the filter housing can be disassembled, and the inside can be accessed for cleaning and sanitization. This may not be possible with some filter designs.

1. Remove and discard the used filter (or other media; referred to as "filter," herein).
2. Drain and wash the inside of the housing with detergent using a cloth or sponge.
    a. Any readily removable components should be removed, similarly washed, and then reassembled.
3. Add 1 mL of 5.25% sodium hypochlorite solution per liter of housing volume (there are approximately 20 drops in one mL) to the bottom canister/sump.
    a. This will create an approximate concentration of 50 mg/L sodium hypochlorite inside the housing once filled in step #5.
4. Reassemble the housing WITHOUT a new filter.
5. Turn on water very slowly and let the housing fill up with the water/bleach solution until water just begins to exit the system, then turn off the water and allow the system to soak for 10 minutes.
    a. For diverter valves (attached to existing faucet): Ensure valve is set to allow water flow through filter system housing until water just starts to exit, divert the water flow to direct faucet flow (slide or lever), then shut the water off at the faucet itself.
    b. For below sink units (standalone faucet): To disinfect the faucet spout where possible, remove the spout. Prepare a 50 mg/L bleach solution (1 mL, or approximately 20 drops, of 5.25% sodium hypochlorite solution added to 1 L of water will create a 52.5 mg/L bleach solution). Use a bottle brush or cotton swap soaked in the 50 mg/L bleach solution to physically

scrub the inside surface of the spout. Then submerge the spout in the 50 mg/L bleach solution, allow to soak for 10 minutes, then rinse thoroughly with water.

6. After the housing has soaked for 10 minutes, reconnect the faucet (if applicable), flush water through for 5 minutes, disassemble the housing, and dispose of the remaining water down the drain.
7. Follow the manufacturer's instructions to install a new filter, reassemble the housing, and flush/condition the new filter.
8. Flush at least two unit-volumes of water through the treatment system to remove any residual disinfectant.

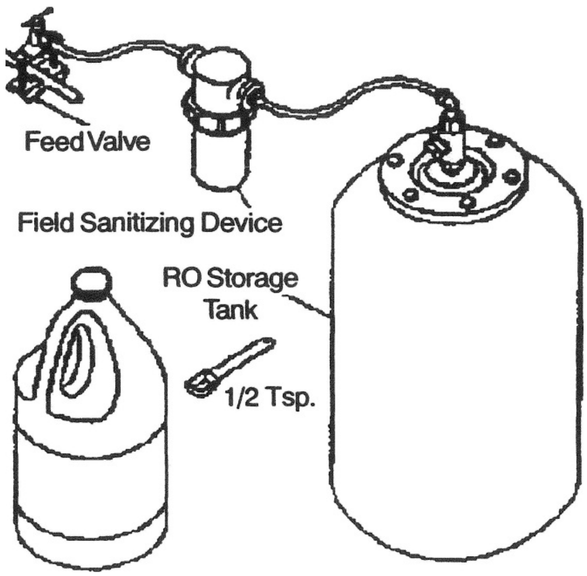
Sanitation Process for RO Systems

1. Shut off the source water supply to the RO system.
2. Open the purified water faucet and depressurize the RO system and holding tank.
3. Remove prefilter cartridges, postfilter cartridges, and the RO membrane(s). Discard the prefilter and postfilter cartridges. If the RO membrane element is to be reused, disinfectant solution should be introduced into the permeate tube outlet sufficient to remove biofilm in this vulnerable area before reinserting the membrane element into the housing.
4. Remove the existing O-rings. Discard O-rings or prepare for cleaning. Wash the internal housing areas with warm soapy water using a clean brush (do not scratch the surface of the housings). Be sure to clean O-ring grooves thoroughly.
5. Rinse off all housing pieces with clean water to remove soap.
6. Replace O-rings and lubricate per manufacturer's instruction.
7. Pour recommended amount of disinfection solution into each of the clean housings and replace housings on the RO system.
8. Disconnect RO holding tank from the system.
9. If a clean, disinfected holding tank is available, replace existing tank with the disinfected holding tank. Close the holding tank valve and proceed to step 11. If disinfection of the holding tank is required at the user's site, follow the RO holding tank cleaning procedure in Step 10.

Recommended items:

- Tank sanitizer feeder or small filter housing with fittings and tubing, see Figure 1
- Disinfectant solution (this example uses chlorine)
- Pressure gauge and air pump

Figure 1 Tank Sanitizer Feeder or Small Filter Housing with Fittings and Tubing



10. RO Holding Tank Cleaning Procedure: The procedure below uses chlorine as the disinfectant, but the same procedure could be adapted to other disinfectants by adjusting the dose accordingly.

    a. The tank should be empty. Check the air precharge pressure with an accurate gauge (low pressure type 0-12lbs.). The tank precharge pressure should be within the manufacturer's specifications for an empty precharged tank. Follow the manufacturer's instructions to adjust the air pressure if necessary.
    b. Fill the tank sanitizer feeder with the recommended disinfectant dosage (in the case of chlorine, a concentration of 50ppm is recommended) and connect the feeder to the water supply and RO holding tank.
    c. Turn on water supply and force water and disinfectant solution into the RO holding tank. Allow about three minutes of fill time at 50 psi line pressure for a standard 2-3 gallon tank. The holding tank should feel heavy when filled.
    d. Turn off the water supply valve and the RO holding tank valve. Disconnect the sanitizer feeder, and connect the RO holding tank to the RO system (the housing is still empty with no filters or membrane installed, and the holding tank valve should remain closed). The disinfectant solution should remain in the tank a minimum of 10 minutes.

11. With the cartridges and membrane still removed, install the sanitizer feeder between the source water supply valve and the RO system. Open the source water supply valve for the RO system, and open the pure water faucet until water flows freely from the spout. Close the RO faucet. Hold the disinfectant solution in

the RO system, including the tubing and faucet, for a minimum of 10 minutes. Open the valve on the RO holding tank.

12. Shut off the source water supply valve for the RO system, and open the RO faucet. Let water run out until the flow stops at the RO faucet.

13. Remove the sanitizer feeder. Rinse the system by opening the source water supply valve for the RO system. Let water flow freely from the faucet for three minutes. Shut off the water at the source water supply with the RO faucet open.

14. When the flow of water has stopped at the RO faucet, replace the filter cartridge(s) and membrane(s) per the manufacturer's recommendations.

15. With the system completely reassembled, open the source water valve and allow the water to flow from the faucet. Continue with recommended manufacturer's RO system start-up procedure.

16. Because some of the disinfectant may still be in the system, the system should be flushed prior to using the water for human consumption. It can take several hours (e.g., 3-6 hours) to fill a standard size RO tank. Therefore, the technician may need to leave and come back several times to complete this procedure. Alternatively, the customer can be provided with written instructions to perform this flushing procedure. The customer should not consume this water, but it may be used for non-potable uses such as watering plants, car windshield washer, etc.

    a. Allow the tank to refill completely, which may take several hours. Then with the water supply still on, open the dispensing valve until the flow reduces to a drip. This indicates the tank is empty again.

    b. Close the dispensing valve and allow the tank to refill again. Then with the water supply still on, open the dispensing valve and allow the tank to drain a second time.

    c. This procedure can be repeated a third time if the customer notices a chlorine taste remaining in the water.

Sanitation Process for Water Softeners

During normal use, a softener may become fouled with organic matter, or in some cases, with bacteria from stagnation, flooding, a main break which contaminated the water supply, or some other event.

Depending upon the conditions of use, the style of softener, the type of ion exchange media, and the disinfectant available, a choice can be made among the following sanitation methods.

Sodium hypochlorite or calcium hypochlorite solutions are satisfactory for use with polystyrene resins, synthetic gel zeolite, greensand, and bentonites. They are not recommended for use with phenolic resins or carbonaceous zeolites.

One fluid ounce of 5.25% sodium hypochlorite bleach per cubic foot of resin is recommended to yield approximately 50 ppm of sodium hypochlorite. (Note: One teaspoonful contains 1/6 fluid ounce, one tablespoonful contains ½ fluid ounce, and one cupful contains eight fluid ounces.)

Salt-in-Head Softeners:

1. Backwash the softener, open the top, and drain down the freeboard water to about 1/2" above the resin bed.
2. Pour in the required amount of sodium hypochlorite solution. Put the softener into backwash and refill the softener up flow (backwash procedure).
3. Close the softener and proceed with the normal down flow regeneration procedure.
4. Put the softener in rinse mode until the chlorine residual levels are below one ppm.

Brine Tank Softeners:

1. Confirm that the water supply in the brine tank is at the proper level to complete a regeneration cycle.
2. Backwash the softener and add the required amount of hypochlorite solution to the brine well of the brine tank.
3. Proceed with the normal regeneration. For extra disinfection, interrupt the cycle immediately after the brining step, before the rinse, and let the softener soak for one to eight hours.
4. Put the softener in rinse mode until the chlorine residual levels are below one ppm.

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