Ultraviolet microbiological water treatment systems

NSF International Standard/ American National Standard

NSF/ANSI 55 – 2002

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NSF International Standard/
American National Standard
for Drinking Water Treatment Units –

Ultraviolet microbiological water treatment systems

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Foreword[2]

It is the purpose of this Standard to establish minimum requirements for the reduction of microorganisms using ultraviolet radiation (UV). UV water treatment systems covered by this Standard are intended for water that may be either microbiologically safe or microbiologically unsafe. This Standard also specifies the minimum product literature and labeling information that a manufacturer shall supply to authorized representatives and system owners, as well as the minimum service-related obligations that the manufacturer shall extend to system owners. Systems covered by this Standard are in keeping with the *Report of Task Force on Guide Standard and Protocol for Testing Microbiological Water Purifiers***,** April, 1987.[3]

It is recognized that the federal, state and local objectives are to provide safe water supplies without user treatment. However, many users are faced with the presence of contaminants of both aesthetic and health concern in their water supplies and need guidance as to the availability of tested and certified point-of-entry and point-of-use ultraviolet water treatment systems. This Standard will help to meet this need but cannot be expected to address claims beyond those covered in this Standard.

Since it was not economically feasible to mount a routine testing program using all of the target microorganisms, e.g., bacteria, viruses, and protozoan cysts, an equivalent "disinfection" set of tests and requirements was developed for point-of-use and point-of-entry ultraviolet disinfection systems.

A virus reduction of 4 log against a poliovirus and rotavirus challenge and a bacteriological reduction of 6 logs against a challenge of a coliform bacteria (*Klebsiella terrigena*) has been recommended by Schaub and an expert task force (1987).[4]

The technical and health protection problems (laboratory staff) and the inherent cost of establishing and maintaining a live virus test program preclude its routine application in a multipurpose standards testing laboratory. Consequently, an alternate means of assuring virus efficacy was developed.

Survival data for poliovirus and rotavirus (Chang, 1985)[5] show between a 3- to 4-log reduction in both poliovirus and rotavirus may be accomplished by a UV dosage of 30,000 μW-sec/cm^2 while a greater than 6-log reduction of *Escherichia coli* may be projected. Additional data (Harris, 1986)[6] shows a 5-log reduction of poliovirus at 40,000 μw-sec/cm^2. In NSF/ANSI 55 2000, a minimum UV dosage of 38,000 μW-sec/cm^2 at the failsafe setpoint was set as an equivalent 4-log virus reduction requirement. To be consistent with International Standards, the minimum UV dose in NSF/ANSI 55 2002 has been changed to 40 mJ/cm2 (40,000 μw-sec/cm^2) at the alarm set point.

Prior to the late 1990's it was thought ultraviolet light had limited cysticidal ability, which required information for the user as to the need for a prefilter complying with NSF/ANSI 53: *Drinking water treatment units – Health effects* for cyst reduction. Survival data for *Cryptosporidium* (Clancy, 2000)[7] and *Giardia* (Craik,

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[3] *Guide Standard and Protocol for Testing Microbiological Water Purifiers***,** Report of Task Force, submitted by Steven A. Schaub to the USEPA, April 1987.

[4] Ibid., p. 7.

[5] "UV Inactivation of Pathogenic and Indicator Microorganisms," Chang, J.C., Johnson, J. Doald, et al. *Journal of Applied Environmental Microbiology*, Vol. 49, pp. 1361–1365, 1985.

[6] "UV Inactivation of Selected Bacteria and Viruses With Photoreactivation of the Bacteria," Harris, D. George, Adams, Dean, et al., *Water Resources*, Vol. 21, pp. 687–692, 1986.

[7] "Using UV to Inactivate *Cryposporidium*," Clancy, J. L., et al. *Journal of American Water Works*, Vol 92, Issue 9, pp. 97-104, 2000.

2000)[8] show minimum 3- to 4-log reduction in both *Cryptosporidium* and *Giardia* may be accomplished by a UV dosage of 10 mJ/cm^2.

Where drinking water is considered to be free of disease causing pathogenic organisms and has a turbidity level within acceptable drinking water standards, ultraviolet treatment may be useful for the supplemental treatment of this drinking water. It would be suitable for the reduction of normally occurring microbiological flora (non-spore forming heterotrophic bacteria) commonly found in drinking water. Survival data (Chang, 1985)[9] show a greater than 2-log reduction of non-spore forming heterotrophic bacteria may be accomplished by an ultraviolet dosage of 16,000 μW-sec/cm^2. The yeast organism *Saccharomyces cerevisiae* was chosen as the test challenge to allow for a reasonable influent concentration and an easily measured reduction in the effluent. Most vegetative bacteria including coliform species are too susceptible to UV radiation at the dose range of 16,000 μW-sec/cm^2 to allow for measurable testing.

Water contact materials in Drinking Water Treatment Units listed under NSF/ANSI 42, 44, 53, 55, 58 and 62 are tested and evaluated under a separate protocol from NSF/ANSI 61 with criteria that were developed specifically for the intended end use. NSF/ANSI 61 listing should not be additionally required for acceptance of these listed units for water contact application.

This version of the Standard contains the following revisions:

– NSF/ANSI 55 covers two types of UV treatment systems: Class A systems are intended for the inactivation of pathogenic bacteria and viruses; Class B systems are intended for the reduction of nonpathogenic, nuisance organisms. This edition of the Standard increases the scope of Class A systems claims to include *Cryptosporidium* and *Giardia*. In addition, Class A systems may make a general cyst claim when supplied with a device that has been tested against a NSF/ANSI Standard for cyst reduction/inactivation.

– In order to verify systems claims, the Standard historically has used a "surrogate" organism to determine the UV dose applied based on log reduction curves. This edition of the Standard continues with that mode of testing, but the Class A challenge organism now is MS-2 Coliphage, not *Bacillus subtilis*.

– A quality assurance/quality control section for the collimated beam and challenge organism (MS-2 Coliphage) was drafted (see 6.3.4.1). The intent of this section is to provide assurance that the propagation, harvest, and preparation of the challenge stock produce a homogenous, monodispersed suspension of the challenge organism prior to the suspension's introduction to the UV system.

– In step H of the challenge organism bioassay – dose response, the sampling requirement has been increased to three data points (see 6.3.1.3.1).

– In step G of the microbiological test method for flow through systems, language has been added to clarify that five unit void volumes will pass through the unit before the sample is taken (see 6.3.2.7).

– Section 4 has been editorially revised to clarify the intent of the materials evaluation testing procedures. New language has been added to detail the follow-up actions when a contaminant's advisory concentration is exceeded in the extractant water. A new health concern contaminant category, "Maximum Contaminant Concentration" (MCC), has been created. Current MDWL values, which are numbers set by a recognized regulatory agency, have been relocated under the MCC headings in Tables 1 and 2.

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[8] "Inactivation of *Giardia Muris* Cysts Using Medium-Pressure Ultraviolet Radiation in Filtered Drinking water," Craik, S. A., et al. *Water Resources*, Vol. 34, No. 18, pp 4325-4332, 2000.

[9] Ibid., p. 1362.

– Pressure testing requirements and materials testing requirements are now consistent with the methods of other NSF Drinking Water Treatment Unit Standards.

– Other revisions to the Standard not detailed above generally aim to further clarify the Standard's intent or to be consistent with the stable of NSF DWTU Standards.

This Standard and the accompanying testing program will provide assurance to the user and the regulatory officials that point-of-entry and point-of-use ultraviolet water treatment systems will perform, with proper operation and maintenance, in accordance with the claims made under the Standard. However, final acceptance of systems for any application covered under governmental regulation will be subject to the approval of the appropriate federal, state, and/or local regulatory agency having jurisdiction.

This Standard was developed by the NSF Joint Committee on Drinking Water Treatment Units using the consensus process described by the American National Standards Institute.

Suggestions for improvement of this Standard are welcome. Comments should be sent to Chair, Joint Committee on Drinking Water Treatment Units, c/o NSF International, Standards Department, PO Box 130140, Ann Arbor, Michigan 48113-0140, USA.

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NSF/ANSI Standard
for Drinking Water Treatment Units –

Ultraviolet microbiological water treatment units

1 General

1.1 Purpose

It is the purpose of this Standard to establish minimum requirements for the reduction of microorganisms using ultraviolet radiation (UV). UV water treatment systems covered by this Standard are intended for water that may be either microbiologically safe or microbiologically unsafe. This Standard also specifies the minimum product literature and labeling information that a manufacturer shall supply to authorized representatives and system owners as well as the minimum service-related obligations that the manufacturer shall extend to system owners.

1.2 Scope

This Standard covers ultraviolet microbiological water treatment systems and components for point-of-use and point-of-entry applications. Systems are intended to be used under the following specific conditions.

1.2.1 Class A systems

Class A point-of-entry and point-of-use systems covered by this Standard are designed to inactivate and/or remove microorganisms, including bacteria, viruses, *Cryptosporidium* oocysts, and *Giardia* cysts, from contaminated water. Systems covered by this Standard are not intended for the treatment of water that has an obvious contamination or intentional source, such as raw sewage, nor are systems intended to convert wastewater to drinking water. The systems are intended to be installed on visually clear water (not colored, cloudy, or turbid).

Class A systems not installed downstream of a device tested for cyst reduction/inactivation in conformance with the appropriate NSF/ANSI Standard may claim *Cryptosporidium* oocysts and *Giardia* cysts only. Class A systems installed downstream of a device tested for cyst reduction/inactivation in conformance with the appropriate NSF/ANSI standard may make a general cyst claim when used on untreated surface waters and/or ground water under the direct influence of surface water.

NOTE – Current data supports that *Cryptosporidium* oocysts and *Giardia* cysts are inactivated by ultraviolet treatment

1.2.2 Class B systems or components

Class B point-of-entry and point-of-use systems covered by this Standard are designed for supplemental bactericidal treatment of disinfected public drinking water or other drinking water that has been tested and deemed acceptable for human consumption by the state or local health agency having jurisdiction. The system is designed to reduce normally occurring nonpathogenic nuisance microorganisms only. The Class B system is not intended for the disinfection of microbiologically unsafe water and may not make individual or general cyst claims. Class B systems shall not make microbiological health effects claims.

1.3 Variance from minimum requirements

Variations from the minimum requirements specified in 4, 5, 6 and 7 may be permitted provided they give the system or component the same or greater resistance to corrosion, wear, and physical damage, or if they improve the general operation or performance of the system or component. Proposed variations shall be accepted by the testing agency prior to use. Sys-

tems with components or functions covered under existing NSF standards or criteria shall comply with those applicable requirements.

1.4 Alternate materials

If specific materials are mentioned, other materials that provide at least equal performance and sanitation shall be acceptable.

2 Normative references

The following reference documents contain provisions that constitute requirements of this Standard. At the time of publication, the indicated editions were valid. All documents are subject to revision, and it is the responsibility of the user of this specification to determine the applicability of the most recent editions of these documents.

ANSI/NFPA 70, 1999, *National Electric Code*[10]

APHA, *Standard Methods for the Examination of Water and Wastewater*, twentieth edition[11]

NSF/ANSI 53 – 2001, *Drinking water treatment units – Health effects*

NSF/ANSI 58 – 2001, *Reverse osmosis drinking water treatment systems*

NSF/ANSI 61 – 2001, *Drinking water system components – Health effects*

NSF/ANSI 62 – 1999, *Drinking water distillation systems*

USEPA 600/479020, *Methods for the Chemical Analysis of Water and Wastes*, March 1983[12]

USEPA 600/R94/111, *Methods for the Determination of Metals in Environmental Samples*, Supplement 1, May 1994[12]

USEPA 600/488/039, *Methods for the Determination of Organic Compounds in Drinking Water*, December 1988[12]

USEPA 600/490/020, *Methods for the Determination of Organic Compounds in Drinking Water* – Supplement 1, July 1990[12]

USEPA *National Primary Drinking Water Regulations*, 40 CFR Part 143[13]

USEPA *National Secondary Drinking Water Regulations*, 40 CFR Part 143[13]

USFDA Code of Federal Regulations, Title 21, (*Food and Drugs) Direct Food Additive Substances Parts 170 through 199,* April 1, 1992[13]

3 Definitions

3.1 accessible: Fabricated to be exposed for cleaning and inspection using simple tools (screwdriver, pliers, open-end wrench).

3.1.1 readily accessible: Fabricated to be exposed for cleaning and inspection without using tools.

3.2 advisory concentration: The minimum concentration attainable for a given substance using good manufacturing practices and appropriate process controls. In some cases the advisory concentration is equal to the limit of detection of the preferred analytical method for the substance.

3.3 alarm set point: The conditions under which the UV sensor activates the alarm.

3.4 challenge water: The water used to test the performance of a component, system, or process.

3.5 Class A system: A system capable of delivering a UV dose at a wavelength of 254 nm at least equivalent to 40 mJ/cm^2 at the alarm set point.

NOTE – 40 mJ/cm^2 is equal to 4.0 x 10^4 μW-sec/cm^2.

[10] National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02269

[11] American Public Health Association (APHA), 800 I Street, NW, Washington, DC 20001

[12] U.S. Environmental Protection Agency, Environmental Monitoring and Support Laboratory, Cincinnati, OH 45268

[13] Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402

3.6 Class B system: A system capable of delivering a UV dose at a wavelength of 254 nm at least equivalent to 16 mJ/cm^2 at 70% of the UV lamp normal output or at the alarm set point.

NOTE – 16 mJ/cm^2 is equal to 1.6 x 10^4 μW-sec/cm^2.

3.7 corrosion resistant: Capable of maintaining original surface characteristics under prolonged contact with the intended end use environment and exposure to cleaning or sanitizing procedures according to the manufacturer's recommendation.

3.8 cyst: The infectious stage in the life cycle of waterborne protozoa when the organism is typically most resistant to disinfection. Cyst includes oocysts of *Cryptosporidium* and *Toxoplasma* and cysts of *Giardia* and *Entamoeba.*

3.9 disinfection: The act of eliminating disease-causing microorganisms from contaminated water either by physical removal or by killing/inactivating them.

3.10 drinking water: Water intended for human consumption.

3.11 effluent : The treated water at the outlet of a unit, system, component, or process.

3.12 influent challenge: The mixture of water and contaminants entering a system.

3.13 irradiance: The measure of light "intensity" at a surface. The radiant power arriving at a point on a surface, per unit area (mW/cm^2).

3.14 joining material: Any substance used to produce a tight joint, e.g., solvent cements, adhesives, or elastomeric seals.

3.15 maximum contaminant concentration (MCC): The maximum permissible concentration of a contaminant in drinking water as established by a recognized regulatory agency such as USEPA and Health Canada.

3.16 maximum contaminant level (MCL): The maximum permissible concentration of a contaminant in drinking water as established in the USEPA *National Primary Drinking Water Regulations.*

3.17 maximum drinking water level (MDWL): The maximum concentration of a contaminant in drinking water that a system is allowed to contribute to the product water as established in this Standard.

3.18 microbiologically unsafe water: Water that (1) is known to contain disease-causing bacteria, viruses, protozoa, or other disease-causing microbiological agents, (2) shows a positive test for a fecal indicator organism or infectious protozoa, (3) is determined unsafe by an appropriate health or regulatory agency, or (4) has not been shown to meet appropriate health agency microbiological guidelines.

3.19 normal output (Class B system): The UV irradiance delivered by the UV lamp after a 100-hour conditioning period.

3.20 point-of-entry system: A system used to treat all or part of the water for the facility at the point where drinking water comes into the facility. For Class A systems, a single-family dwelling shall be considered a facility.

3.21 point-of-use system: A system used to treat the water at a single tap or multi-taps but not for the entire facility.

3.22 removable: Fabricated to be taken away from the system or component using simple tools (screwdriver, pliers, open-end wrench).

3.23 readily (or easily) removable: Fabricated to be taken away from the main system or component without using tools.

3.24 system: A complete water treatment device, including all components needed to connect it to a potable water supply.

3.25 turbidity: A condition caused by the presence of suspended and/or colloidal matter, which results in the scattering of light rays.

3.26 UV absorbance: The fraction of irradiance at 254 nm that is absorbed or scattered in a solution. UV absorbance is expressed as a fraction per cm.

3.27 UV dose: The product of irradiance at 254 nm and time over a given area expressed as mJ/cm^2.

3.28 UV sensitivity: A measurement of or-

ganism inactivation at a specified ultraviolet radiation dose. The measurement is expressed as the negative logarithm base 10 (log_{10}) of the fraction of the challenge organism remaining after the UV dose.

3.29 UV sensor: A device used to measure the UV irradiance.

3.30 unit void volume: Total water holding volume with the filter medium or components or both in place.

3.31 watertight: A condition existing in equipment and material of such precision of construction and fit as to be impermeable to water.

3.32 weepage: The formation of bubbles or droplets of water on the outside of a fiber glass tank during the initial phase of a pressure test due to the expression of water which was trapped between the tank liner and the fiber glass wrap during the tank manufacturer's testing.

3.33 working pressure: Feedwater or inlet water pressure to a system.

3.33.1 maximum working pressure: The maximum operating pressure recommended by the manufacturer.

3.34 wastewater: Blackwaste and greywaste generated from residences, commercial buildings, industrial plants, and institutions, and the water or medium used to transport it.

3.34.1 blackwaste: Human and/or animal body waste, toilet paper, and any other material intended to be deposited in and discharged from a receptacle designed to receive urine and/or feces.

3.34.2 greywaste: Materials, exclusive of urine, feces, or industrial waste, deposited in and discharged from plumbing fixtures found in residences, commercial buildings, industrial plants, and institutions.

4 Materials

4.1 Materials in contact with drinking water

Materials in contact with drinking water shall not impart levels of extractable contaminants that exceed the MCC or MDWL values specified in tables 1 and 2 when evaluated and tested in accordance with 4.2.

4.1.1 Complete formulation information on any material not certified as specifically compliant with the sections of the U.S. Code of Federal Regulations, Title 21, listed in table 3, shall be reviewed to determine whether the material presents a health effects concern in contact with drinking water and to assess the material's potential for contributing contaminants to the drinking water.

NOTE – As a minimum for those materials requiring submission of formulation information, the complete chemical identity or proportion by weight (in some cases approximate weights or proportions may suffice), ingredient sources of supply, documentation regarding the health effects concern of each ingredient in the material, and documentation regarding the suitability of each ingredient for use in potable-water-contact material shall be provided.

4.1.2 The product shall be tested in accordance with 4.2.3. If the product does not impart a concentration of an extractable contaminant at a level that exceeds either the MCC, MDWL, or advisory concentrations in tables 1, 2, or 4, the product shall be deemed to have met the requirements of 4. If the product does impart a concentration of an extractable contaminant at a level that exceeds the advisory concentration, but not the MCC or MDWL, the product shall be deemed to have met the requirements of 4, but the manufacturer shall be notified of the concentration of the extractable contaminant, and a new product sample shall be immediately retested in accordance with 4.2.3.6. For the parameters in table 4, the required follow-up analyses shall also be performed after the product has been exposed according to 4.2.3.6, if they were not performed as part of the initial exposure under 4.2.3.2.

4.1.3 Whole-system extraction testing may be waived if components, when separately tested, meet the requirements of this Standard and are assembled in a manner that does not introduce any new components, increase the surface

area-to-volume ratio of previously evaluated components, or present potential concern based on cumulative factors.

4.2 Materials evaluation

4.2.1 Analytical methods

All analyses shall be conducted in accordance with the applicable method(s) referenced in 2.

4.2.2 Exposure water

Systems and components shall be exposed to locally available tap water that has been adjusted to contain 50 ± 5 mg/L total dissolved solids, 0.5 ± 0.05 mg/L free available chlorine, and have a pH of 6.75 ± 0.25. Exposure water used to evaluate systems or components shall be 23 ± 2 °C (73 ± 3 °F). Any existing concentrations of extraction testing parameters listed in tables 1, 2, and 4 found to be present in the exposure water shall be subtracted from the values obtained in the analysis of the extractant water.

4.2.3 Exposure

NOTE – The lamp shall be on during exposure testing, when appropriate.

4.2.3.1 The system or component(s) of a system shall be installed, flushed, and conditioned in accordance with the manufacturer's instructions using the exposure water specified in 4.2.2 at an initial inlet static pressure of 340 kPa (50 psig).

4.2.3.2 The system or component(s) shall be refilled with exposure water specified in 4.2.2 and maintained for 24 h at an ambient temperature of 23 ± 2 °C (73 ± 3 °F). A 2-L water sample shall then be collected in accordance with 4.2.3.3. The system or component(s) shall be flushed according to the manufacturer's instructions, refilled, and maintained for another 24 h at an ambient temperature of 23 ± 2 °C (73 ± 3°F). A second 2-L water sample shall be collected in accordance with 4.2.3.3. The system or component(s) shall again be flushed according to the manufacturer's instructions, refilled, and maintained for a third period of 24 h at an ambient temperature of 23 ± 2 °C (73 ± 3 °F). A third 2-L water sample shall be collected in accordance with 4.2.3.3.

4.2.3.3 A minimum sample volume of 2 L shall be collected at each sample point. If the water holding volume of the product is greater than 2 L, the entire volume shall be collected in a suitable collection vessel, and a 2-L subsample obtained from this volume. If the water holding volume of the product is less than 2 L, sufficient products shall be exposed to provide the required 2-L volume of extractant water

4.2.3.4 All samples collected shall be composited and analyzed in accordance with 4.2.1.

4.2.3.5 Systems with adsorptive or absorptive media shall be tested with and without the media.

4.2.3.6 If the level of an extractable contaminant exceeds an advisory concentration in tables 1, 2, or 4, the 72-h test exposure sequence in 4.2.3.2 shall be repeated three times using a new product sample. The extractant water from the third 24-h exposure of the third 72-h exposure sequence shall be analyzed to determine if the concentration of the extractable contaminant has been reduced to a concentration less than or equal to the advisory concentration.

5 Design and construction

5.1 General

A system or component evaluated under this standard shall be designed and constructed so that its intended purpose will be accomplished when installed and operated according to the manufacturer's instructions. Systems and components shall be designed to prevent UV exposure to humans when operated and serviced according to manufacturer's recommendation.

Materials used in the construction of systems or components shall be capable of withstanding exposure to the intended use environment. Materials exposed to UV irradiation shall not impart hazardous chemicals to the water upon irradiation.

NOTE – Materials exposed to UV irradiation should be formulated to resist deterioration over the service life of the unit.

5.2 Working pressure

5.2.1 The pressure vessel(s) and all other components of a water treatment system that are subject to line pressure shall be designed and constructed to maintain structural integrity at a pressure of 690 kPa (100 psig) or the maximum working pressure, whichever is greater. Testing shall be conducted in accordance with 6.2.

5.2.2 Portable systems not designed for direct connection to a pressurized supply line shall be designed and constructed to maintain structural integrity under the maximum pressure of the intended end-use. Testing shall be conducted in accordance with 6.2.

5.3 Performance indication

5.3.1 Class A systems

Class A systems shall be equipped with a UV sensor to indicate when the UV irradiance at the sensor is below the minimum required by the Standard. One or more of the following means shall be used to indicate ineffective operation:

- a visual alarm;
- an audible alarm; or
- a system that terminates discharge of water.

The alarm or shut off system shall be evaluated in accordance with 6.4.

5.3.2 Class B systems

Class B systems shall be exempt from performance indication requirements. If a UV sensor is provided on a Class B system to measure the UV transmission, the alarm or shut off system shall be evaluated in accordance with 6.4.

5.4 Elements

Cartridges, filters, and similar replacement components shall be removable.

5.5 Flow control

An automatic fixed flow rate control shall be provided to prevent flow above the manufacturer's maximum rated flow over the manufacturer's recommended operating pressure range.

5.6 Waste connections

Waste connections or drain outlets, if provided, shall be designed and constructed to provide for connection to the sanitary waste system through an air gap of 2 pipe diameters or 25 mm (1 in), whichever is larger.

5.7 Product water dispensing outlets

Product water dispensing outlets, if provided, shall be designed, constructed, and located so the discharge orifice is directed downward and the lower edge of the outlet shall be at an elevation not less than 51 mm (2 in) above the flood rim of the waste receptacle.

5.8 Hazards

All component parts shall be free of nonfunctional rough or sharp edges or other hazards that may cause injury to persons adjusting, servicing, or using the system.

5.9 Lamp operation indication

The UV system or component shall be provided with a visual means to verify electrical operation of all lamps.

5.10 Electrical requirements

Electrical systems and components shall comply with the requirements of the *National Electrical Code*, or equivalent, where appropriate. Certification of conformance shall be provided by the manufacturer.

5.11 Lamp replacement

The recommended lamp replacement intervals for Class B systems shall be verified by submittal of irradiance vs. time curves. The irradiance shall be measured at 254 nm at a distance of 1.0 m (3.3 ft) from the lamp. Lamp replacement shall be recommended to occur prior to the time 70% of the initial irradiance is reached.

5.12 Maintenance

The system or component shall be designed to be accessible for cleaning and required maintenance. The product literature or label shall include instructions for the prevention of UV expo-

sure to users during cleaning and maintenance, or the system shall be designed to prevent UV exposure to users while the system is being cleaned and maintained.

5.13 Temperature resistance

Systems and/or components should be constructed of materials suitable to withstand temperatures generated during sustained periods of no water use.

5.14 Corrodible materials

Corrodible materials should be provided with a corrosion resistant protective coating completely covering all wetted surfaces.

5.15 Gaskets, o-rings, shaft seals, and packing materials

Gaskets, o-rings, shaft seals, and packing materials shall conform to the applicable requirements of 5.1.

5.16 Dissimilar metals

Dissimilar metals not normally considered compatible on the electromotive scale shall not be in direct contact.

5.17 Insulating fittings

Insulating fittings should be provided when materials are not compatible with adjoining fittings or parts.

5.18 Plastics

The manufacturer shall provide information to substantiate that plastic components exposed to UV will not lose structural integrity after prolonged exposure to the extent that the performance of the system is adversely affected.

5.19 Welding

Welded seams and deposited weld material shall meet the requirements of 5.1 and 5.16.

6 Performance

6.1 General

Systems and components covered under this Standard shall be designed to meet the microbiological and structural performance requirements at the manufacturer's recommended operating pressures and flow rates.

6.2 Structural integrity

6.2.1 General

The purpose for testing structural integrity performance is to evaluate the materials, design and fabrication quality of the complete water treatment system.

6.2.2 Acceptance

Each test of structural integrity (cyclic pressure, hydrostatic pressure, and burst pressure) shall be performed on a separate system. If the complete water treatment system is tested, a separate test of the system pressure vessel is not required.

Complete systems, pressure vessels, and components shall be tested for structural integrity in accordance with 6.2.3 at the pressures specified in table 5. When more than one pressure is specified in table 5, testing shall be done at the higher pressure.

Complete systems, pressure vessels, and components shall be water tight when tested for structural integrity under 6.2.3.

NOTE – Weepage (see 3.32) shall be considered acceptable at the beginning of a test, but weepage shall not begin in the middle of a test.

6.2.3 Structural integrity test methods

6.2.3.1 Apparatus

An enclosure shall be provided for each system tested to prevent injury to personnel or property damage if the system fails. An apparatus that may be used for the cyclic and hydrostatic test is shown schematically in figure 1. Pressure measuring instruments shall have a precision and accuracy of 2% at the point of measurement.

6.2.3.2 Hydrostatic pressure test – complete systems

Systems designed to operate only at atmospheric pressure shall be exempt from the hydrostatic pressure test but shall be watertight in normal use. Components downstream of the system on/off valve that are not subject to pressure under the off mode and contain no media subject to plugging or are not designed to contain media shall be exempt from the hydrostatic pressure test but shall be watertight in normal use. Components that are downstream of the system on/off valve but upstream of the media subject to clogging shall meet the requirements of this section. The following procedure shall be used for the hydrostatic pressure testing of other complete systems:

a) A water temperature of 13 to 24 °C (55 to 75 °F) shall be used. The test water shall be adjusted to a temperature at which condensation will not form on the surface of the test unit.

b) Connect the inlet of the test system to the apparatus shown in figure 1. The system shall be in conformance with its normal state of use, with the option of plugging drain lines.

c) Fill the test system with water. Flush to purge air from the system. Close the system outlet and place the control valve in the service position. All parts of the unit, including inlet and outlet fittings that may be subject to line pressure in normal operation, shall be pressurized.

d) Raise the hydrostatic pressure at a constant rate so that the test pressure specified in table 5 is reached within 5 min. The rate of pressure increase shall not be more than 690 kPa (100 psig) per second.

e) Maintain the test pressure for 15 min. The system shall be inspected periodically through the end of the test period to check if the system is watertight.

6.2.3.3 Hydrostatic pressure test – metallic pressure vessels

The permanent increase in the circumference of the pressure vessel shall not be more than 0.2% of the original circumference when the vessel is tested in accordance with the procedures below. The circumference shall be measured at the midpoint of the side wall of the vessel and at 30 cm (12 in) intervals. The top or bottom head deflection of the pressure vessel shall not exhibit a permanent deflection exceeding 0.5% of the vessel diameter.

The test rig for metal tanks shall allow the installation of instrumentation required to measure the change in tank circumference and the deflection of the top and bottom heads. This may require elevating the tank. Distance measuring instruments or methods shall be accurate to 0.0025 cm (0.001 in).

The following procedure shall be used for the hydrostatic pressure testing of metallic pressure vessels:

a) Install the unit on the elevated rack or stand. Prepare and fill the test unit as specified in 6.2.3.2, steps a), b), and c).

b) An appropriate measuring device, such as an extensometer or dial micrometer, shall be installed vertically against the tank bottom head and either the tank top head, top-mounted control valve, or other component solidly mounted to the tank top.

c) An appropriate measuring device, such as an extensometer or periphery tape, shall be installed around the tank perpendicular to its axis and 15 cm (6 in) above its bottom. Additional measurement devices shall be placed, vertically spaced not more than 30 cm (12 in) apart, up the side sheet of the tank. The uppermost device shall be within 30 cm (12 in) of the tank top head. If the tank length is less than 61 cm (24 in), a measuring device should be placed at the midsection. When using extensometers, the flexible wire shall be wrapped once around the tank perpendicular to its axis and 15 cm (6 in) above its bottom. One end of the wire shall be fastened to a solid post at the same elevation. The other end shall be fastened to a second post at the same elevation by means of a spring so as to maintain the wire taut. The blocks shall be fastened to each end of the wire, adjacent to the tank, such that they are spaced 15 to 20 cm (6 to 8 in) apart. For larger tanks, the spacing shall be permitted to be increased to avoid contact between the blocks and the tank. Blocks

shall be attached to each wire wrap as previously specified.

d) Take initial readings from the measurement devices before pressurizing the test unit. When using extensometers, measure the distance between the blocks on each wire with a micrometer caliper.

e) Pressurize the test unit as specified in 6.2.3.2, steps d) and e).

f) Take final readings from the extensometers or measurement devices with no pressure on the unit.

g) The difference between the readings of each measurement device is the measure of permanent deformation of either the tank bottom or top head. The difference in measurement around the tank is the increase in tank circumference.

6.2.3.4 Burst test – nonmetallic pressure vessels

The following procedure shall be used for the burst testing of nonmetallic pressure vessels:

a) A water temperature of 13 to 24 °C (55 to 75 °F) shall be used. The test water shall be adjusted to a temperature at which condensation will not form on the surface of the test unit.

b) Assemble a complete unit, as normally installed and operated.

c) Connect the pressure vessel to a water supply through a pump system with a pressure measurement device that has a method of indicating maximum pressure during a test, a check valve, a shut-off valve, and a drain valve. Threaded fittings are to be used for the system subject to the high pressure.

d) Close all remaining pressure vessel openings by using threaded fittings, where possible. Fill the entire system with water and flush to purge air from the unit.

e) Raise the hydrostatic pressure until the burst pressure specified in table 5 is reached or the vessel fails at a lower pressure. The rate of pressure increase shall be no more than 690 kPa (100 psig) per second and shall be sufficient to reach the burst pressure within 70 s of the start of the test. Maintain the desired pressure for an instant and release.

6.2.3.5 Cycle test

The following procedure shall be used for the cyclic testing:

a) A water temperature of 20 ± 3 °C (68 ± 5 °F) shall be used throughout the test. The test water shall be adjusted to a temperature at which condensation will not form on the surface of the test unit.

b) Connect the inlet of the test system to the test apparatus as shown in figure 1. The system shall be in conformance with its normal state of use, with the option of plugging drain lines.

c) Fill the test system with water. Flush to purge air from the system. Close the system outlet and place the control valve in the service position. All parts of the unit, including inlet and outlet fittings that may be subject to line pressure in normal operation, shall be pressurized.

d) Set the counter to zero, or record its initial reading, and initiate pressure cycling. The pressure rise shall be ≥ 1 s and the pressure in the test unit shall return to 14 kPa (2 psig) before the initiation of another cycle.

e) The pressure shall be cycled as specified in table 5. The system shall be inspected periodically through the end of the test period to check if the system is watertight.

6.3 Microbiological performance

6.3.1 UV sensitivity of challenge organisms

6.3.1.1 General

Calibration is performed to determine the UV sensitivity of the MS-2 Coliphage ATCC # 15597-BI (Class A) or *Saccharomyces cere*

visiae ATCC # 18824 challenges (Class B) used in the performance test methods outlined in 6.3.2.

Microbiological methods for stock culture preparation, enumeration/analysis, and storage for MS-2 Coliphage and *S. cerevisiae* shall be performed as specified in annex A.

6.3.1.2 Apparatus

Assemble an apparatus in which a small stirred sample can be irradiated in a nearly collimated beam. A radiometer meeting specification in 6.3.1.2.1 can then be used to measure the incident irradiance (E_o).

A low-pressure mercury vapor UV lamp shall be wired to a ballast and a voltage regulator (figure 2). Use a solution contained in a small dish equal to or smaller in diameter than that of the collimated tube. The solution shall be 1 cm deep. Measure E_o at the surface of the liquid by removing the dish and stirrer and placing the radiometer at the corresponding position from which the dish was removed. The UV irradiance at each point of the surface shall be within ± 5% of the average irradiance across the solution surface.

6.3.1.2.1 Radiometer specifications

A radiometer with the following specification shall be used:

– linearity: ± 0.5%;

– spectral response: visible-blind detector with narrow band-pass filter centered at 254 nm, full width at half maximum = 20 nm or less;

– spatial response: cosine response ± 5%;

– calibration: Radiometer calibration (including optics, transducer and electronics) shall be traceable to NIST or other national standards laboratory. Calibration shall be performed annually or at interval specified by manufacturer, whichever is more frequent;

– uncertainty: The calibration documentation provided with each radiometer (including optics, transducer and electronics) shall include both calibration uncertainties (transfer uncertainty to customer) and the uncertainty associated with the calibration standard. The NIST (or other national laboratory) uncertainty is added the transfer uncertainty to customer to yield total uncertainty; and

– maximum total uncertainty: ± 9 % at 254 nm.

6.3.1.3 Challenge organism bioassay – dose response method

a) Prior to the bioassay – dose response of the appropriate challenge organism, prepare the challenge suspension (see annex A).

b) On the day of the bioassay – dose response, properly prepare the agar plates. Turn on UV source for 30 min to equilibrate the UV output. Multiple measurements of the UV output shall be taken over the 30-min time period of the equilibration to verify non-fluctuation of the UV source to ± 5% of the UV output.

c) Dilute aliquots of the harvested challenge organism suspension using appropriate dilution solution to yield a concentration of 5 $x10^4$ to 5 x 10^5 organisms per milliliter.

d) Determine the UV absorbance of the suspension at 254 nm with 1 cm path length using *Standard Methods for the Examination of Water and Wastewater,* method 5910 UV-Absorbing Organic Constituents.

e) Measure the UV lamp irradiance of the collimating beam at the level of the top of suspension (E_o).

f) Calculate the average irradiance in the stirred solutions from 6.3.1.3 c) by using the radiometer E_o measurement and the following equation. The calculation requires use of the UV absorbance of the suspension that is irradiated at 254 nm (as determined in 6.3.1.3 d).

$$E_{ave} = 0.98 \left[\frac{E_0}{L} \left(\frac{(T)^L - 1}{\ln[T]} \right) \right]$$

where:

T = 1 – A;

A = UV absorbance for a pathlength of 1 cm;

L = depth of solution irradiated in a collimated beam (cm);

E_o = incident irradiance (mW/cm^2); and

E_{ave} = average irradiance in water (mW/cm^2).

NOTE – Calculation of the doses is made by assuming the 2% of the measured E_o is reflected from the water surface. The average intensity multiplied by exposure time is used as the dose. The concentration of the challenge organism is such that the UV absorbance of the solution is very small and hence any error in calculation of UV absorbance is almost negligible.

g) Determine the dose at the following percentage(s) of the minimum dose requirement: 0, 15%, 30%, 45%, 60%, 75%, 90%, 105%, 120%, 135% and 150%. The exposure time at each dose shall be determined using the following formula:

exposure time = dose/E_{ave}

h) Prepare 33 sterile 60 x 20 mm petri dishes with 10 x 3 mm sterile stir bars. Add sufficient diluted challenge suspension (to a depth of 1 cm) to each sterile 60 x 20 mm petri dish. Irradiate three petri dishes per dose as determined in 6.3.1.3 g).

i) Handle irradiated samples aseptically. Analysis shall be initiated within 1 h of exposure. Prior to analysis, store samples in the dark. Make serial dilutions of exposed samples (10^0-10^{-5}) using sterile dilution solution. Plate dilutions on agar plates in triplicate. Rock the plates to spread inoculum evenly. After the agar has solidified, invert and incubate at appropriate temperature and time.

j) Select plates containing 25 to 250 distinct colony forming units (CFU)/plaque forming units (PFU) using a colony counter. Calculate the concentration of the challenge organism suspension by multiplying the number of CFU/PFU obtained by the inverse of the dilution factor. Express results as the number of CFU/mL or PFU/mL.

NOTE – All log reductions shall be established using only plates containing 25 to 250 CFU/PFU.

k) The final dose used at each point of exposure shall be adjusted based upon the E_{ave} using the following formula:

final dose = E_{ave} x exposure time

l) Calculate the log survival of organisms by using the following equation for log survival:

Log survival of organisms = Log(N_s/N_o)

where

N_o = geometric mean of non-irradiated sample concentrations at dose zero; and

N_s = geometric mean value of irradiated sample concentrations at each dose.

m) The bioassay – dose response curve is produced by plotting the log survival values for the exposed organism suspension on the y-axis and the final UV dose mJ/cm^2 (μW-sec/cm^2) values on the x-axis.

n) Perform a linear regression on the data to obtain an equation for the dose response relationship. Calculate the log reduction at the required minimum UV dose.

6.3.1.4 Quality assurance/quality control (QA/QC)[14]

6.3.1.4.1 General

The QA/QC for the collimated beam and challenge organism shall be performed to provide assurance that the propagation, harvest and preparation of the challenge stock produce a homogenous, monodispersed suspension of the challenge organisms prior to the suspensions introduction to the UV system.

[14] American Water Works Association Research Foundation, National Water Research Institute. December 2000. Ultraviolet Disinfection *Guidelines for Drinking Water and Water Reuse*

6.3.1.4.2 QA/QC

Plot the following lines on the graph produced in 6.3.1.3 m).

$-\log_{10}(N_s/N_o) = 0.040*[\text{UV dose, mJ/cm}^2] + 0.64$

$-\log_{10}(N_s/N_o) = 0.033*[\text{UV dose, mJ/cm}^2] + 0.20$

6.3.1.4.3 Specifications

All data points in the specified UV dose ranges shall be included in the regression analysis. The final regression and 80% of the data points shall lie inside the defined area in 6.3.1.4.2 in the appropriate UV dose range.

NOTE – The results that are outside of the limits specified in 6.3.1.4.3 shall be reported but shall not be used to determine the bioassay – dose response curve or verify the UV system.

6.3.2 Microbial performance testing

Component filters or other media that may interfere with the testing of a system shall be removed or bypassed during the test.

Microbiological methods for stock culture preparation, enumerations/analysis, storage and stock challenge concentration for challenge test for MS-2 Coliphage and *S. cerevisiae* shall be performed as specified in annex A.

6.3.2.1 Class A systems

A Class A system shall deliver a UV dose at least equivalent to 40 mJ/cm^2 [4.0 x 10^4 μW-sec/cm^2] at the alarm set point when the system is tested in accordance with 6.3.2.7 or 6.3.2.8 as applicable. The equivalence of the UV dose shall be determined by comparing the system's inactivation of MS-2 Coliphage to the inactivation obtained in accordance with 6.3.1.3.

6.3.2.2 Class B systems

A Class B system shall deliver a UV dose at least equivalent to 16 mJ/cm^2 [1.6 x 10^4 μW-sec/cm^2] at a UV lamp output that is 70% of normal or at the alarm set point when the system is tested in accordance with 6.3.2.7 or 6.3.2.8 as applicable. The equivalence of the UV dose shall be determined by comparing the system's inactivation of *S. cerevisiae* cells to the inactivation obtained in accordance with 6.3.1.3.

6.3.2.3 Apparatus

The test units shall be installed and operated using the test apparatus shown in figure 3. The test systems shall be plumbed in parallel to simulate normal installation. Manifolds shall be representative of household plumbing (2.0 to 6.5 cm [0.75 to 2.5 in] pipe sizes).

6.3.2.4 Test water

6.3.2.4.1 General test water

A chlorine free water with the following characteristics shall be used:

pH	7.5 ± 0.5
UV transmittance	98 ± 2% (prior to adding PHBA)
turbidity	< 1.0 NTU
temperature	20 ± 2.5 °C (68 ± 5 °F)
TDS	200 – 500 mg/L

6.3.2.4.2 Challenge organism

The appropriate organism shall be added to the above water:

MS-2 Coliphage ATCC # 15597-B	5 x 10^4 to 5 x 10^5 PFU/mL
S. cerevisiae ATCC # 18824	5 x 10^4 to 5 x 10^5 CFU/mL

6.3.2.5 Determination of test operating conditions

UV devices not equipped with an alarm set point mechanism shall use 6.3.2.5.2 to determine the normal output.

6.3.2.5.1 Systems with UV sensor and alarm set point

Sufficient parahydroxybenzoic acid (PHBA) shall be added to reduce UV light transmission to the alarm set point in the device. No less than the quantity of PHBA required to give a mean UV absorption of 0.3 per cm at 254 nm shall be used.

NOTE – Reference *Standard Methods for the Examination of Water and Wastewater,* method

5910 UV-Absorbing Organic Constituents.

6.3.2.5.2 Measurement of normal output for Class B systems

The following procedure shall be used to measure the normal output:

a) Install two bulb and ballast components identical to the system's bulb and ballast component into a container coated with material that does not reflect UV radiation. The container shall be large enough to allow for measurement of the UV intensity at 1.0 m (3.3 ft).

b) A regulated voltage source shall be set at the manufacturer's minimum recommended voltage.

c) Operate the lamp for 100 h and record the intensity at 1.0 m (3.3 ft).

d) Reduce the voltage to the lamps until the irradiance reaches 70% of normal output measured at 100 h. Record the voltage and intensity.

e) The lower of the two voltage reductions shall be used to adjust the system to 70% of its normal output.

f) Test shall be conducted with lamps conditioned for 100 h.

NOTE – Alternative methods may be used to reduce the irradiance by 70%.

6.3.2.6 Analytical methods

The analytical methods shall be as specified in 2. All bacteriological samples shall be collected aseptically in sterile bottles without neutralizer.

6.3.2.7 Microbiological test method – flow through systems

The following procedure shall be used as the disinfection test method for flow through systems:

a) Install two systems as shown in figure 3 and condition each system in accordance with the manufacturer's instructions using the general test water without the challenge organism. If a pre-filter or post-filter is supplied with the system, the filter shall be removed before testing. Determine the flow rate of the test system by subjecting the system to inlet pressures of 140 kPa (20 psig), 210 kPa (30 psig), 280 kPa (40 psig), 340 kPa (50 psig), 410 kPa (60 psig), 480 kPa (70 psig), 550 kPa (80 psig), 620 kPa (90 psig), 690 kPa (100 psig), and the system's maximum working pressure ± 5% and measuring the flow rate at each sample point. The maximum flow rate observed shall be the evaluation service flow. The UV lamp shall be disabled during influent sampling.

b) Before starting the test, the influent and effluent waters shall be analyzed for pH, total dissolved solids, turbidity, residual chlorine, and temperature. Other parameters may be used for purposes of future comparison and for documentation.

c) Use appropriate techniques of dilution and adequate mixing to prepare the general test water in 6.3.2.4.1.

d) Obtain 70% of the lamp's normal output as determined in 6.3.2.5.2, or if a performance indicating device is provided, reduce the intensity to the alarm set point by the use of PHBA as determined in 6.3.2.5.1.

e) Flush the system with the general test water. Start an operating cycle of 50% on / 50% off cycle with a 15 to 40 min cycle. This cycle shall be continued for 8 h per 24-h period. The test program shall cover a 10-d period.

f) Begin injection feeding the challenge organism used in the calibration method in 6.3.1 a minimum of 2 cycles prior to the sampling cycle to ensure organisms are evenly distributed throughout the test apparatus.

g) Collect samples of influent and effluent water at the times specified in table 6 at a sample point immediately following the test unit as shown in figure 3. Collect all samples in duplicate from the flowing water during the sampling "on" portion of the cycle. Samples will be one unit void volume (or of appropriate quantity for analysis). Samples shall not be composited. Effluent samples shall be collected first. Immediately after col-

lecting the effluent and during the same "on" portion of the cycle, shut the UV lamp off and allow 5 unit void volumes to pass through the unit. Collect the effluent sample downstream of the test unit to represent the influent.

h) Influent and effluent samples are to be collected aseptically in sterile bottles with no neutralizer. Samples shall be stored in the dark prior to analysis. For all microbiological samples, analysis should be initiated within 1 h. See annex A for methods.

6.3.2.8 Batch treatment systems

The following procedure shall be used as the disinfection test method for batch systems:

a) Two systems shall be tested. Condition each system prior to the start of the test in accordance with the manufacturer's instructions utilizing the general test water. The UV lamp shall be on throughout the test.

b) Adjust the voltage to the system to obtain 70% of the lamp's normal output as determined in 6.3.2.5.2, or if a performance indicating device is provided, reduce the intensity to the alarm set point by the use of PHBA as determined in 6.3.2.5.1.

c) Add the challenge organism used in the calibration method in 6.3.1 a minimum of 2 treatment cycles prior to the sampling treatment cycle to ensure organisms are evenly distributed throughout the test device.

NOTE – Treatment cycle is one full operating batch.

6.3.2.8.1 Sampling

NOTE – Influent samples shall be collected by removing an aliquot from the midpoint of the raw water reservoir by pipette.

Day 1 – Start the system and operate for the recommended treatment time specified by the manufacturer. Collect the complete batch for analysis. Refill the system with the general test water.

Days 2 to 4 – Spike the system with challenge organism into the general test water in the system from the previous day. Restart system and generate a batch for sampling. Turn systems off and fill with general test water for next day's testing.

Days 5 to 6 – The systems are to remain stagnant for 48 h with challenge water remaining in the system.

Days 7 to 9 – Repeat method used for Days 2 to 4.

6.3.2.8.2 Acceptance

6.3.2.8.2.1 Class A systems

For Class A systems, the geometric mean of all MS-2 Coliphage plaques on influent samples minus the geometric mean of counts on all effluent samples shall demonstrate a log reduction equal to or greater than the reduction caused by a dose of 40 mJ/cm^2 [4.0 x 10^4 μW-sec/cm^2] as calibrated in 6.3.1.

6.3.2.8.2.2 Class B systems

For Class B systems or components, the geometric mean of all *S. cerevisiae* cell counts on influent samples minus the geometric mean of counts on all effluent samples shall demonstrate a log reduction equivalent to or greater than the reduction caused by a dose of 16 mJ/cm^2 [1.6 x 10^4 μW-sec/cm^2] as calibrated in 6.3.1.

6.4 UV alarm performance

6.4.1 Purpose

This test is performed to determine that the UV alarm provided with the system will activate 100 consecutive times in response to decreased UV intensity. This test is performed after the microbiological test method specified in 6.3.

6.4.2 Apparatus

The apparatus described in figure 3 shall be used.

6.4.3 Procedure

The following procedure shall be used to evaluate alarm performance:

a) Conduct all testing at the system's maximum flow rate.

b) Prepare the test system by cleaning it in accordance with the manufacturer's instructions.

c) For continuous flow units, warm the system up according to manufacturers' instructions. For systems with an instant on, no warm up shall be conducted.

d) Determine the injection pump setting that will deliver a dose of PHBA into the feed stream sufficient to activate the alarm system. This is the "dose volume." Measure the UV absorbance, as referenced in 6.3.1.3 d), of the resulting challenge water.

e) Reset the alarm and resume feeding clean general test water in 6.3.2.4.1.

f) Activate the injection pump to deliver one "dose volume" of PHBA solution. Verify alarm activation.

g) Repeat steps d) and e) until the alarm has been activated 100 consecutive times.

NOTE – If the alarm fails to activate during the test, verify that there has been no increase in power to the unit and the challenge water UV absorbance has not changed. If these conditions have changed, restart from step b), if not, terminate the test.

6.4.4 Acceptance

The sensor/alarm system, as supplied with the system, shall activate 100 consecutive times in response to decreasing UV intensity.

7 Instruction and information

Class A systems not installed downstream of a device tested for cyst reduction/inactivation in conformance with the appropriate NSF/ANSI standard may claim *Cryptosporidium* oocysts and *Giardia* cysts only. Class A systems installed downstream of a device tested for cyst reduction/inactivation in conformance with the appropriate NSF/ANSI standard may make a general cyst claim when used on untreated surface waters and/or ground water under the direct influence of surface water. Class B systems may not make individual or general cyst claims.

The units evaluated in this Standard shall not make claims of reduction or inactivation of MS-2 Coliphage and *S. cerevisiae*.

7.1 Installation, operation, and maintenance instruction

7.1.1 Information setting forth complete, detailed instructions for installation, operation, and maintenance shall be provided with each system. Specific information shall include:

– model number and class designation;

– complete name, address and telephone number of manufacturer;

– flushing and conditioning procedures;

– rated service flow in L/min or L/d (gpm or gpd)

– maximum working pressure in kPa (psig)

– maximum operating temperature in degrees C (degrees F);

– detailed installation instructions including an explanation or schematic diagram of proper connections to the plumbing system;

– general operation and maintenance requirements including, but not limited to, service to the system, user responsibility, and parts and service availability;

– sources of supply for replaceable components;

– statement noting the system and installation shall comply with applicable state and local regulations;

– use limitations;

– model number of UV lamp;

– required replacement intervals of ultraviolet lamp(s) in accordance with the manufacturer's instructions;

– for Class A systems, a warning to boil water in a failure situation;

– for Class A systems, a procedure to disinfect the system and plumbing during instal-

lation and after a system failure;

– cleaning instructions; and

– statement of applications:

– Class A systems:

This Class A system conforms to NSF/ANSI 55 for the disinfection of microbiologically contaminated water that meets all other public health standards. The system is not intended to convert wastewater or raw sewage to drinking water. The system is intended to be installed on visually clear water.

NSF/ANSI 55 defines wastewater to include human and/or animal body waste, toilet paper, and any other material intended to be deposited in a receptacle designed to receive urine and/or feces (blackwaste); and other waste materials deposited in plumbing fixtures (greywaste).

– Class A system without a general cyst inactivation/reduction device in conformance to the appropriate NSF/ANSI Standard:

If this system is used for the treatment of untreated surface waters or ground water under the direct influence of surface water, a device found to be in conformance for cyst reduction under the appropriate NSF/ANSI Standard shall be installed upstream of the system.

– Class B systems:

This Class B system or component conforms to NSF/ANSI 55 for the supplemental bactericidal treatment disinfected public drinking water or other drinking water which has been tested and deemed acceptable for human consumption by the state or local health agency having jurisdiction. The system is only designed to reduce normally occurring nonpathogenic nuisance microorganisms. Class B Systems are not intended for treatment of contaminated water.

7.1.2 Where applicable and appropriate, the following information shall also be included:

– model number of replacement components;

– rated capacity/rated service life in L (gal);

– minimum working pressure in kPa (psig);

– minimum operating temperature in degrees C (degrees F);

– electrical requirements;

– diagram showing proper air gap installation to waste connections;

– explicit instructions explaining how the performance indicator functions; and

– disinfection or cleaning instructions for Class A systems.

7.2 Data plate

7.2.1 A permanent plate or label shall be affixed in a readily accessible location on the system and shall contain, at a minimum, the following information:

– model number and class designation;

– name and address of manufacturer;

– maximum working pressure in kPa (psig);

– maximum operating temperature in degrees C (degrees F);

– model number of UV lamps;

– maximum operating feed water temperature in degrees C (degrees F);

– applicable warning signs;

– use limitations statement: “See instruction manual for use conditions.”;

– maximum flow rate in L/min (gpm or

gpd);

– operational volts, amperage, and Hertz of the system;

– required replacement intervals of ultraviolet lamp(s);

– the following applicable statement:

– Class A system:

The system or component conforms to NSF/ANSI 55 for the disinfection of microbiologically contaminated water that meets all other public health standards. The system is not intended for the treatment of water that has an obvious contamination or intentional source, such as raw sewage, nor is the system intended to convert wastewater to microbiologically safe drinking water.

– Class A system without a general cyst inactivation/reduction device in conformance to the appropriate NSF/ANSI Standard:

If this system is used for the treatment of untreated surface waters or ground water under the direct influence of surface water, a device found to be in conformance for cyst reduction under the appropriate NSF/ANSI Standard shall be installed upstream of the system.

– Class B system:

The system or component conforms to NSF/ANSI 55 for the supplemental bactericidal treatment of disinfected public drinking water or other drinking water that has been tested and deemed acceptable for human consumption by the state or local health agency having jurisdiction. The system is only designed to reduce normally occurring nonpathogenic, nuisance microorganisms. Class B Systems are not intended for the disinfection of contaminated water.

Components that have been evaluated only for design and construction, materials, or both, shall be exempt from this requirement.

7.2.2 Where applicable and appropriate, the following information shall also be included:

– model number of replacement components;

– electrical requirements;

– recommended frequency for the replacement of UV lamps (Class B systems);

– maintenance schedule; and

– for Class A systems, a warning to boil water in a failure situation.

7.3 Replacement components

7.3.1 The packaging of replacement components shall be labeled with the following information:

– model number and name of component;

– model number of system(s) in which the component is to be used; and

– name and address of manufacturer.

7.3.2 Where applicable, the following information shall also be stated:

– component rated capacity/rated service life in L (gal);

– operating or exchange steps; and

– required replacement intervals of ultraviolet lamp(s) in accordance with the manufacturer's instructions.

7.4 Performance data sheet

7.4.1 A performance data sheet shall be available to potential buyers for each system and shall include the following information:

– model number and class designation;

– complete name, address, and telephone number of manufacturer;

– rated service flow in L/min or L/d (gpm

or gpd);.

– rated capacity/rated service life in L (gal);

– maximum working pressure in kPa (psig);

– maximum operating temperature in degrees C (degrees F);

– general installation conditions and needs;

– general operation and maintenance requirements including, but not limited to: suggested frequency of component replacement or service to the system, user responsibility, and parts and service availability;

– statement of applications:

  – Class A systems:

    This Class A system conforms to NSF/ANSI 55 for the disinfection of microbiologically contaminated water that meets all other public health standards. The system is not intended to convert wastewater or raw sewage to drinking water. The system is intended to be installed on visually clear water.

    NSF/ANSI 55 defines wastewater to include human and/or animal body waste, toilet paper, and any other material intended to be deposited in a receptacle designed to receive urine and/or feces (blackwaste); and other waste materials deposited in plumbing fixtures (greywaste).

  – Class A system without a general cyst inactivation/reduction device in conformance to the appropriate NSF/ANSI Standard:

    If this system is used for the treatment of untreated surface waters or ground water under the direct influence of surface water, a device found to be in conformance for cyst reduction under the appropriate NSF/ANSI Standard shall be installed upstream of the system.

  – Class B systems:

    This Class B system or component conforms to NSF/ANSI 55 for the supplemental bactericidal treatment of disinfected public drinking water or other drinking water, which has been tested and deemed acceptable for human consumption by the state or local health agency having jurisdiction. The system is only designed to reduce normally occurring nonpathogenic, nuisance microorganisms. Class B systems are not intended for treatment of contaminated water.

– electrical characteristics, volts, amperage, and Hertz;

– recommended service life of UV lamps;

– maximum operating feed water temperature in degrees C (degrees F); and

– use limitations.

7.4.2 Where applicable, the following information shall also be included:

– model number of replacement components;

– pressure drop of new system in kPa (psig) at rated flow (point-of-entry systems only);

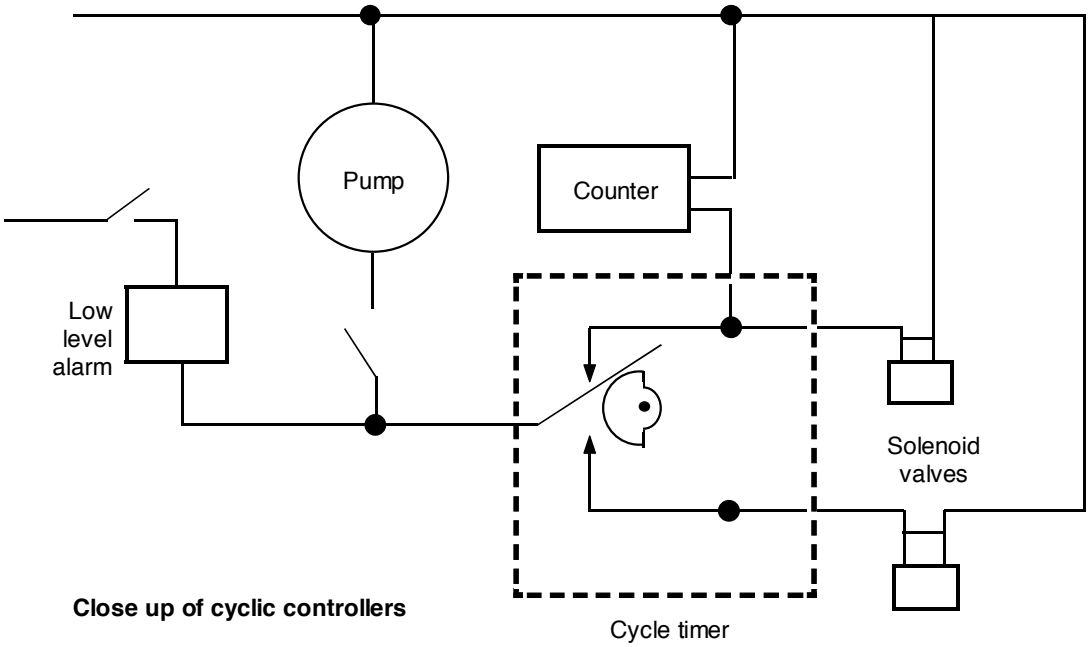
– minimum working pressure in kPa (psig);

– minimum operating temperature in degrees C (degrees F);

– electrical requirements;

– recommended frequency for the replacement of UV lamps (Class B systems); and

– explanation of how the performance indicator functions.



Close up of cyclic controllers

Basic hydrostatic and cyclic testing

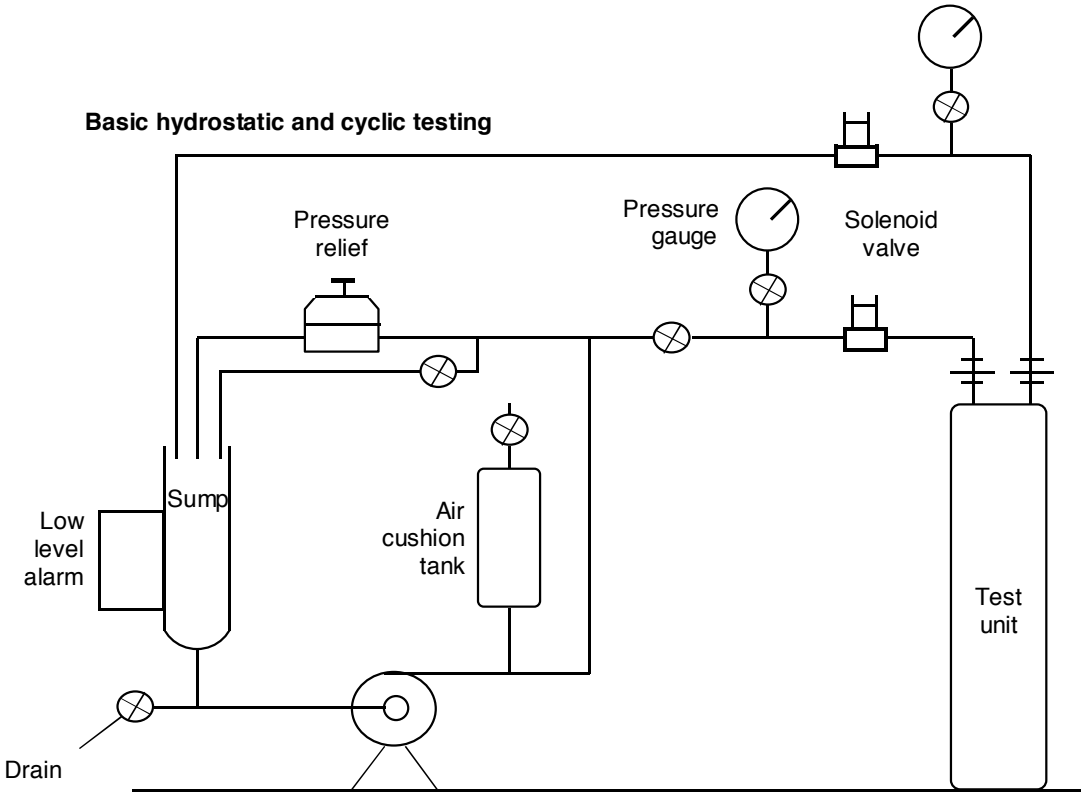
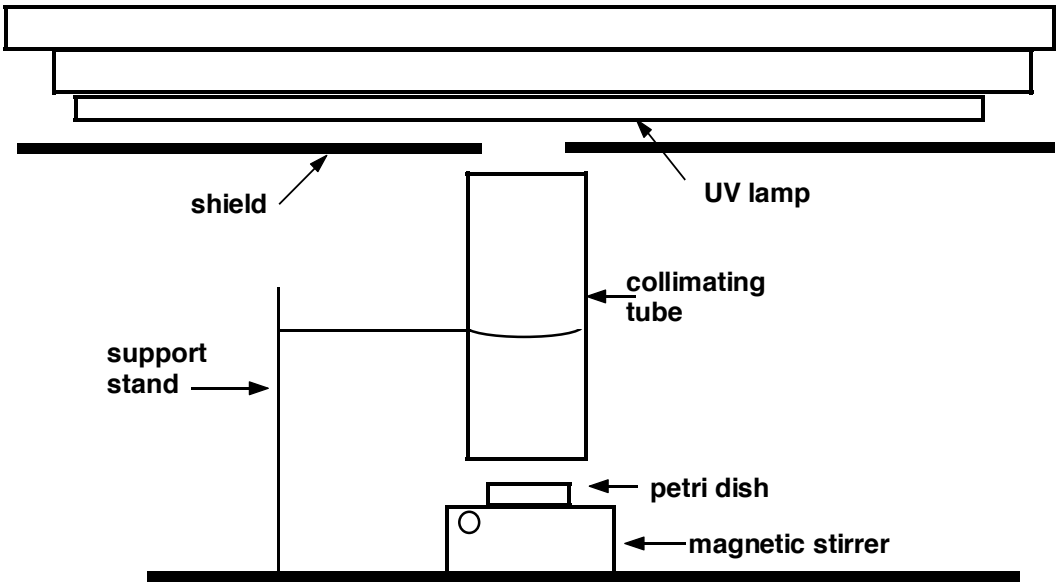


Figure 1 – Structural testing apparatus



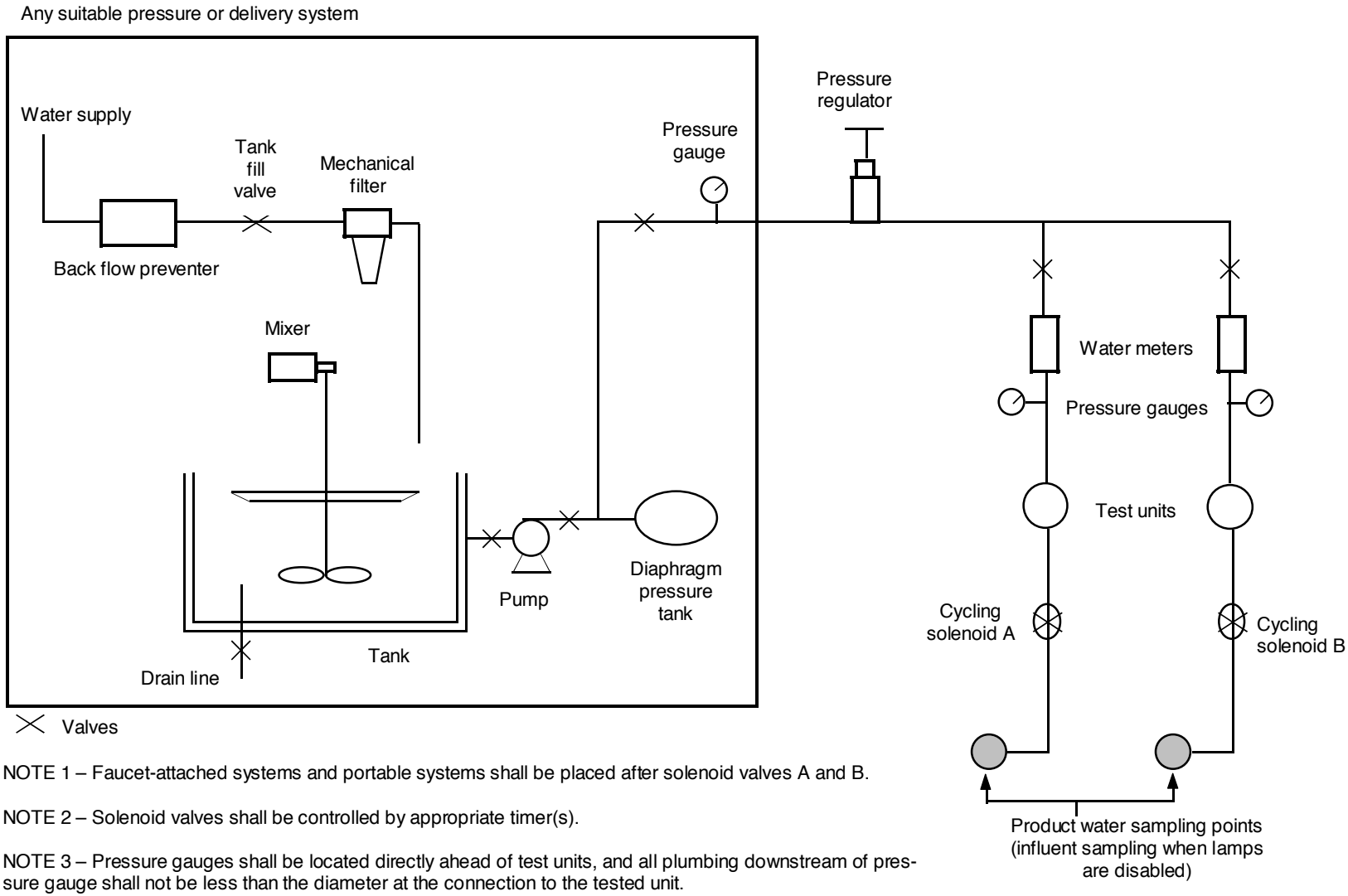
NOTE 1 – The collimating tubes shall be a minimum of 53 cm (21 in) in length and the interior shall be painted flat black.

NOTE 2 – The support stand, if used, shall be adjustable to raise or lower the collimating tube to the surface of the petri dish.

NOTE 3 – The petri dish shall be set so the surface of the liquid is at the same level as the radiometer.

NOTE 4 – Measurement of the UV dose must be done at the same point at which the petri dish surface is exposed.

Figure 2 – Collimated beam apparatus



NOTE 1 – Faucet-attached systems and portable systems shall be placed after solenoid valves A and B.

NOTE 2 – Solenoid valves shall be controlled by appropriate timer(s).

NOTE 3 – Pressure gauges shall be located directly ahead of test units, and all plumbing downstream of pressure gauge shall not be less than the diameter at the connection to the tested unit.

NOTE 4 – Diameter of plumbing and equipment after test units shall not be less than the diameter at the connection to the tested unit.

Figure 3 - Example test apparatus

Table 1 – Extraction testing parameters
(This was table A1 in NSF/ANSI 55 – 2000)

Parameter	Maximum contaminant concentration (MCC) mg/L	Maximum drinking water level (MDWL) mg/L	Advisory concentration mg/L	USEPA method(s)
aluminum	—	0.5	0.05 – 0.2[1]	200.7, 200.8
antimony	0.006	—	—	200.8, 200.9
arsenic	0.025	—	—	200.8, 200.9
barium	2.0	—	0.05[2]	200.7, 200.8
beryllium	0.004	—	detected[3]	200.7, 200.8, 200.9
cadmium	0.005	—	detected[3]	200.8, 200.9
chromium	0.1	—	—	200.7, 200.8, 200.9
copper	1.3	—	0.05[2, 4]	200.7, 200.8
lead	0.015	—	0.005[2, 3, 4, 5]	200.8, 200.9
manganese	—	0.3	0.05[1]	200.7, 200.8
mercury	0.002	—	detected[3]	200.8, 245.1
nickel	—	0.1	0.05[2]	200.7, 200.8
selenium	0.05	—	—	200.8, 200.9
thallium	0.002	—	detected[3]	200.8, 200.9
volatile organic compounds (includes)[6]				
total	—	—	0.010[2]	502.2
benzene	0.005	—	detected[3, 5]	502.2
carbon disulfide	—	0.05	—	GC/PID
carbon tetrachloride	0.005	—	detected[3]	502.2
1,2-dichloroethane	0.005	—	detected[5]	502.2
1,1-dichloroethylene	0.007	—	—	502.2
dichloromethane	0.005	—	detected[5]	502.2
1,2-dichloropropane	0.005	—	detected[5]	502.2
ethylbenzene	0.7	—	0.005[2]	502.2
styrene	0.1	—	0.005[2]	502.2
tetrachloroethylene	0.005	—	detected[5]	502.2
toluene	1.0	—	0.005[2]	502.2
total trihalomethanes	0.080	—	—	502.2
bromodichloromethane	—	—	0.005[2, 5]	502.2
bromoform	—	—	0.005[2, 5]	502.2
chlorodibromomethane	—	—	0.005[2, 5]	502.2

Table 1 – Extraction testing parameters
(This was table A1 in NSF/ANSI 55 – 2000)

Parameter	Maximum contaminant concentration (MCC) mg/L	Maximum drinking water level (MDWL) mg/L	Advisory concentration mg/L	USEPA method(s)
chloroform	—	—	0.005[2, 5]	502.2
1,1,1-trichloroethane	0.2	—	0.005[2]	502.2
1,1,2-trichloroethane	0.005	—	—	502.2
trichloroethylene	0.005	—	—	502.2
vinyl chloride	0.002	—	detected[2, 5]	502.2
o-,m-,p-xylene	10	—	0.005[2]	502.2

[1] Based on the final USEPA Secondary Maximum Contaminant Level published in 56FR3573. For aluminum, the high level of 0.2 mg/L is shown to allow for products such as activated aluminum media.

[2] Contaminant potentially contributed by other sources in the distribution and plumbing system.

[3] Contaminant should not be intentionally present in drinking water treatment unit systems.

[4] Subpopulations exist that are sensitive to exposure to this contaminant.

[5] Contaminant has a Maximum Contaminant Level Goal (MCLG) of zero.

[6] The referenced method includes approximately 60 chemicals. Testing for the chemicals as specifically listed is required. Others, if detected, shall be treated as having a 0.005 mg/L advisory concentration. An advisory concentration of 0.010 mg/L applies to total organic compounds.

– concluded –

Table 2 – Formulation dependent extraction testing parameters

Parameter	Maximum contaminant concentration (MCC) mg/L	Maximum drinking water level (MDWL) mg/L	Advisory concentration mg/L	USEPA method(s)
tin	—	—	0.05	200.8, 200.9
zinc	—	—	5.0[1]	200.7, 200.8
nitrate (as N)	10.0	—	1.0[2, 3]	300
nitrite (as N)	1.0	—	0.1[2, 3]	300
nitrate plus nitrite (as N)	10.0	—	1.0[2, 3]	—
sulfate	—	—	40[2]	300
sulfite	—	—	0.5[2]	377.1
acrylonitrile	—	—	0.005[2]	524.2
1,4-dioxane	—	0.07	0.005[2]	524.2
dimethylformamide	—	0.050	0.030	
melamine	—	3.0	0.3	HPLC/UV
formaldehyde	—	1	0.1[2, 3]	—
di-2-ethylhexyl adipate	0.4	—	—	525.2
phthalate scan (includes):				625
butyl benzyl phthalate	—	0.05	0.010[2]	
di(2-ethylhexyl) phthalate	0.006	—	—	
di-n-butyl phthalate	—	0.05	0.010[2]	
di-n-octyl phthalate	—	—	0.010[2]	
diethyl phthalate	—	0.05	0.010[2]	
dimethyl phthalate	—	—	0.010[2]	
polynuclear aromatics (includes):				550.1
naphthalene	—	0.05	0.001[2]	
acenaphthylene	—	—	0.002[2]	
acenaphthene	—	—	0.001[2]	
fluorene	—	—	detected[2]	
phenanthrene	—	—	detected[2]	
anthracene	—	—	detected[2]	
fluoranthene	—	—	detected[2]	
pyrene	—	—	detected[2]	
benzo(a)anthracene	—	—	detected[2]	
chrysene	—	—	detected[2]	

Table 2 – Formulation dependent extraction testing parameters

Parameter	Maximum contaminant concentration (MCC) mg/L	Maximum drinking water level (MDWL) mg/L	Advisory concentration mg/L	USEPA method(s)
benzo(b)fluoranthene	—	—	detected[2]	550.1
benzo(k)fluoranthene	—	—	detected[2]	
benzo(a)pyrene	0.0002	—	—	
dibenzo(a,h)anthra-cene	—	—	detected[2]	
benzo(g,h,i)perylene	—	—	detected[2]	
indeno(1,2,3-cd)pyrene	—	—	detected[2]	
nitrosamines (includes):				625
n-nitroso-di-n-butyl amine	—	0.00006	detected[2]	
n-nitrosodimethyl-amine	—	0.000007	detected[2]	
n-nitrosodiphenyl-amine	—	0.07	detected[2]	
n-nitroso-di-npropylamine	—	0.0005	detected[2]	
acetone	—	1	0.1[2, 3]	GC/FID or PID[5]
cyclohexanone	—	0.05	0.005[2, 3]	GC/FID or PID[5]
methyl ethyl ketone	—	1	0.1[2, 3]	502.2
methanol	—	4	0.4[2, 3]	GC/FID[5]
tetrahydrofuran	—	1	0.1[2, 3]	GC/FID or PID[5]

[1] Based on the final USEPA Secondary Maximum Contaminant Level published in 56 FR 3573.

[2] Contaminant potentially contributed by other sources in the distribution and plumbing system.

[3] Advisory concentration set at 10% of the MDWL value.

[4] Gas chromatography with mass spectrometry.

[5] Gas chromatography, with detection by flame ionization or photoionization.

NOTE – Formulation-dependent extraction testing parameters not listed in this table shall have a corresponding MDWL established in accordance with the procedures in NSF/ANSI 61, annex A.

– concluded –

Table 3 – Materials listed in U.S. Code of Federal Regulations, Title 21, not requiring formulation review

Sections	Material
172.880 178.3700	petrolatum
172.888 178.3720	synthetic petroleum wax
172.878	white mineral oil
172.884	odorless white petroleum hydrocarbons
172.886 178.3710	petroleum wax
173.25	ion exchange resins – provided that the sub-section stating the composition of the resin is specified
173.65	divinyl benzene copolymer
178.3620	mineral oil
Part 184	Direct food substances affirmed as generally recognized as safe – when used in accordance with any conditions of use specified for the substance.
solvents	Solvents which may be considered for solvent bonding without review are limited to acetone, methyl ethyl ketone, cyclohexanone, and tetrahydrofuran. Mixtures such as solvent cements shall be evaluated against NSF/ANSI 61 or shall be subject to formulation review. NOTE - Solvent bonding is not recommended, as solvents soak into synthetic materials and leach back out into water at relatively high levels for long periods of time. In addition, solvents can contaminate the work area and can be adsorbed by carbon in the work area. Solvents which have been reprocessed or recycled shall not be used.

Table 4 – Non-specific extraction testing parameters

Required parameter	Advisory concentration (mg/L)	USEPA method(s)	Follow-up testing[1]
phenolics	0.05	420.4	analysis for specific phenolic compound(s) in material formulations, Base/Neutral/Acid scan by GC/MS[2]
total organic carbon (TOC)	1.0	415.2	analysis for specific compound(s) in material formulations, GC/MS scan[2] (for non-polar compounds), LC/MS[3] (for target polar compounds)
Formulation dependent parameter	**Advisory concentration (mg/L)**	**USEPA method(s)**	**Follow-up testing[1]**
total dissolved solids (TDS)	50	160.1	no follow-up recommended
total kjeldahl nitrogen (TKN)	0.5	351.2	analysis for specific compound(s) in material formulations, ammonium analysis, Base/Neutral scan by GC/MS[2)](for non-polar compounds), LC/MS[3)](for target polar compounds)

[1] Follow-up testing may include one or more analyses.

[2] Gas chromatography with mass spectroscopy (GC/MS).

[3] Liquid chromatography with mass spectroscopy (LC/MS).

Table 5 – Structural integrity testing requirements

Complete systems	Hydrostatic pressure test[1]	Burst pressure test[1]	Cyclic pressure test[1]
Complete systems with pressure vessels having a diameter < 203 mm (8 in)	2.4 x maximum working pressure or 1654 kPa (240 psig)	none	none
Complete systems with pressure vessels having a diameter of 203 mm (8 in)	1.5 x maximum working pressure or 1,040 kPa (150 psig)	none	none
Complete systems designed for open discharge[2]	1.2 x maximum working pressure or 867 kPa (120 psig)	none	10,000 cycles at 0 to 345 kPa (0 to 50 psig)
Complete portable systems pressurized by user[3]	1.5 x maximum working pressure	none	none
Components	**Hydrostatic pressure test**	**Burst pressure test**	**Cyclic pressure test**
Permanent metallic pressure vessels having a diameter< 203 mm (8 in)[4]	2.4 x maximum working pressure or 1654 kPa (240 psig)	none	none
Permanent metallic pressure vessels having a diameter of 203 mm (8 in)[4]	1.5 x maximum working pressure or 1,040 kPa (150 psig)	none	none
Permanent nonmetallic pressure vessels having a diameter < 203 mm (8 in)	2.4 x maximum working pressure or 1654 kPa (240 psig)	4 x maximum working pressure or 2,760 kPa (400 psig)	none
Permanent nonmetallic pressure vessels having a diameter of 203 mm (8 in)	none	4 x maximum working pressure or 2,760 kPa (400 psig)	100,000 cycles at 0 to 1,040 kPa (0 to 150 psig) or maximum working pressure
Disposable metallic pressure vessels and components	2.4 x maximum working pressure or 1654 kPa (240 psig)	none	10,000 cycles at 0 to 1,040 kPa (0 to 150 psig) or maximum working pressure
Disposable nonmetallic pressure vessels and components	2.4 x maximum working pressure or 1654 kPa (240 psig)	none	10,000 cycles at 0 to 1,040 kPa (0 to 150 psig) or maximum working pressure
Valves and controls[5]	none	none	100,000 cycles at 0 to 1,040 kPa (0 to 150 psig) or maximum working pressure

[1] When a choice is given in the table, testing shall be done at the greater pressure.

[2] Components downstream of the system on/off valve that are not subject to pressure under the off mode and contain no media subject to plugging or are not designed to contain media shall be exempt from the hydrostatic pressure test, but shall be watertight in normal use.

[3] Portable systems designed to utilize only atmospheric pressure or gravity flow shall be exempt from the hydrostatic pressure test but shall be watertight in normal use.

[4] Permanent metallic pressure vessels require measurement of permanent circumference and head deflection. The pressure vessel circumference shall not exhibit a permanent increase of more than 0.2% when measured at the midsection and at 30 cm (12 in) intervals. The top and bottom head deflection of the pressure vessel shall not exhibit a permanent deflection exceeding 0.5% of the vessel diameter.

[5] Subject to line pressure and tested as separate components.

Table 6 – Sampling for disinfection performance
(This was tables C1 and D1 in NSF/ANSI 55 – 2000)

Sampling point		Influent	Effluent
day 0	condition system	no sample	no sample
day 1	start up	x	x[1]
	4 h	x	x[2]
day 2	start up	x	x[1]
	4 h	x	x[2]
day 3	start up	x	x[1]
	4 h	x	x[2]
day 4	start up	x	x[1]
	4 h	x	x[2]
days 5, 6	48 to 72-h stagnation	no sample	no sample
day 7	start up	x	x[1]
	4 h	x	x[2]
day 8	start up	x	x[1]
	4 h	x	x[2]
day 9	start up	x	x[1]
	4 h	x	x[2]

[1] Samples shall be collected at the start-up of each day following a 16-h stagnation according to the sampling requirements in 6.3.2.7 and 6.3.2.8. Samples shall be of the first unit void volumes from the system or component.

[2] Samples shall be collected after a minimum of 5 unit void volumes have passed through the system or component.

Annex A
(normative)

Ultraviolet water treatment systems microbial reduction

A.1 Summary

MS-2 Coliphage and *Saccharomyces cerevisiae* are used as biological surrogates to determine the average UV dose output of UV water treatment systems. The methods that are used for suspension preparation, titration and analysis of the challenge organisms for use in the sensitivity calibration and testing are presented in this annex.

A.2 Equipment

– autoclave;

– radiometer (International light IL-700);

– UV collimating beam apparatus and 254 nm photo detector;

– incubator, 35 ± 1 °C (95 ± 1 °F);

– refrigerator, 5 ± 3 °C (41 ± 3 °F);

– water bath 50 ± 1 °C (122 ± 1 °F);

– freezer;

– microwave;

– vortex mixer;

– UV-vis spectrophotometer;

– pH meter;

– hemocytometer;

– colony counter; and

– centrifuge.

A.3 Microorganisms

All organisms shall be obtained from: American Type Culture Collection, 19301 Parklawn Drive, Rockville, Maryland 20852-1776

– *Saccharomyces cerevisiae* (ATCC #18824);

– MS-2 Coliphage (ATCC # 15597-Bl); and

– *Escherichia coli* host strain (ATCC # 15597).

A.4 Supplies

– Petri dishes, 20 x 60 mm and 15 x 100 mm: sterile;

– pipettes, 1 mL and 10 mL; sterile;

– sterile centrifuge tubes, 10 mL and 50 mL;

– sample bottles, 125 mL sterile screw cap;

– test tubes, 16 x 125 mm;

– sterile inoculating loop;

– sterile filtration apparatus;

– sterile 0.22 μm polycarbonate membrane filters;

– Whatman #1 filter;

– chlorine detection kit; and

– disposable sterile 250 mL polypropylene container.

A.5 Reagents

– Sterile buffered dilution water (SBDW) shall be prepared according to the *Standard Methods for the Examination of Water and Wastewater* (dilution water: buffered water);

– Phosphate buffer saline (PBS) – a stock solution shall be prepared by dissolving 80 g sodium chloride (NaCl), 2 g potassium dihydrogen phosphate (KH_2PO_4), 29 g hydrated disodium hydrogen phosphate

($Na_2HPO_4 \cdot 12H_2O$) and 2 g potassium chloride (KCl) in water to a final volume of 1 L. A working solution shall be prepared from the stock solution by diluting 1 volume of the stock with 9 volumes of water. The pH shall be adjusted using a pH meter to 7.4 with 0.1 N HCl or 0.1 N NaOH before use;

– Ethylenediaminetetraacetic acid (EDTA), Sigma # ED2SS; and

– Lysozyme, Boehringer Mannheim, #1 243004. Store at 2 to 8 °C (35 to 46 °F).

A.6 Safety precautions and hazards

A.6.1 Steam sterilized samples and equipment are to be handled with protective gloves when being removed from the autoclave.

A.6.2 Cryogenic culture vials are handled with cryoprotective gloves.

A.6.3 Ultraviolet light is used to expose the organism during calibration. This light can result in skin cancer and retinal damage; hence personnel must be protected from exposure.

A.6.4 All microbiological samples and contaminated test supplies are steam sterilized to 121 ± 1 °C (250 ± 1 °F) at 15 psi for a minimum of 20 min prior to being discarded.

A.7 Growth medium

NOTE 1 – Common bacteriological mediums may be purchased from bacteriological medium manufacturers and prepared according to the manufacturer's instructions.

NOTE 2 – The quality of the growth media shall be monitored by examining growth promotion and sterility prior to use.

A.7.1 Formula for YM medium to be used when *Saccharomyces cerevisiae* is chosen for microbiological agent

A.7.1.1 YM medium nutrient broth

yeast extract	3 g
malt extract	3 g
peptone	5 g
dextrose	10 g
DI water	1 L
pH	6.2 ± 0.2

Dissolve by boiling, adjust to final pH, and dispense 10 mL aliquots into 16 x 150 mm test tubes and two 2-L flasks. Autoclave at 121 ± 1 °C (250 ± 1 °F) at 15 psi for 20 min. Store cooled broth at 5 ± 3 °C (41 ± 1 °F).

A.7.1.2 YM medium agar

yeast extract	3 g
malt extract	3 g
peptone	5 g
dextrose	10 g
Bacto-agar	15 g
DI water	1 L
pH	6.2 ± 0.2
antibiotic stock solution[1]	2 mL/100 mL agar

[1] antibiotic stock solution ingredients per 100 mL of distilled or deionized water:

chlortetracycline 0.5 g
chloramphenicol 0.5 g

NOTE – Do not autoclave antibiotic stock solution.

Dissolve by boiling, adjust to final pH and autoclave at 121 ± 1 °C (250 ± 1 °F) at 15 psi for 20 min. Add antibiotic stock solution aseptically after autoclaved and YM agar has cooled to approximately 45 to 50 °C (113 to 122 °F). Pour tempered media into sterile petri dishes. Store agar plates at 5 ± 3 °C (41 ± 1 °F). Allow plates to warm to room temperature before use.

A.7.2 Formula to be used when MS-2 Coliphage is chosen for microbiological agent

A.7.2.1 TSB (Tryptic Soy Broth)

tryptone	1.7 g
soytone	0.3 g
dextrose	0.25 g
sodium chloride	0.5 g
dipotassium phosphate	0.25 g
DI water	100 mL
pH	7.3 ± 0.2

Dissolve by boiling, adjust to final pH, and dispense 8 mL aliquots into 16 x 150 mm test tubes. Autoclave at 121 ± 1 °C (250 ± 1 °F) at 15 psi for 20 min. Store cooled broth at 5 ± 3 °C (41 ± 1 °F).

A.7.2.2 1.5% TSA (Tryptic Soy Agar)

tryptone	7.5 g
soytone	2.5 g
sodium chloride	2.5 g
bacto-agar	7.5 g
DI water	500 mL
pH	7.3 ± 0.2

Dissolve by boiling, adjust to final pH and autoclave at 121 ± 1 °C (250 ± 1 °F) at 15 psi for 20 min. Pour tempered media into sterile petri dishes. Store agar plates at 5 ± 3 °C (41 ± 1 °F). Allow plates to room temperature before use.

A.7.3.3 Phage top agar 1% TSA (Tryptic Soy Agar)

tryptone	7.5 g
soytone	2.5 g
sodium chloride	2.5 g
agar	5.0 g
DI Water	500 mL
pH	7.3 ± 0.2

Dissolve by boiling, adjust to final pH, and autoclave at 121 ± 1 °C (250 ± 1 °F) at 15 psi for 20 min. Store agar at 5 ± 3 °C (41 ± 1 °F). On the day of testing, liquefy and place in the 45 ± 1 °C (113 ± 1 °F) water bath. It is very important to keep the MS-2 Coliphage top agar at 45 ± 1 °C (113 ± 1 °F) to prevent agar solidification.

A.8 Culture of challenge organisms

A.8.1 *Saccharomyces cerevisiae*

A.8.1.1 Stock culture preparation of *S. cerevisiae*

a) Four days prior to preparing *S. cerevisiae* cells stock, inoculate a 10 mL tube of YM broth and incubate on a shaker water bath at 25 ± 1 °C (77 ± 1 °F) and approximately 225 rpm for 24 ± 2 h.

b) Perform this initial passing of the culture for three successive passes, each 24 ± 2 h, transferring to a fresh broth tube.

c) After incubation time has elapsed on the third transfer, uniformly suspend the yeast cells in the tube and pipet 5 mL each to two 2-L flasks containing 1 L of YM broth in each. Incubate the inoculated flasks on a shaker water bath at 25 ± 1 °C (77 ± 1 °F) and approximately 225 rpm for 24 ± 2 h.

d) Centrifuge the suspension at 2320 *xg* for 15 min. Carefully remove the supernatant. Pool all the cells from the 2 L of centrifuged suspension.

e) Wash the cells 3 times using 99 mL aliquots of buffered water for each wash. Centrifuge the suspension at 2320 *xg* for 15 min between washes and carefully decant supernatant.

f) After removal of the supernatant on the third wash, resuspend the cells in 50 mL of buffered water.

g) This final suspension shall be used for UV exposures in calibration and in testing of the treatment units. These cells must be used within 24 ± 2 h of harvest and stored at room temperature during this time.

h) Titrate the *S. cerevisiae* cells as in A.8.1.2. The concentration of *S. cerevisiae* cells should be 10^7 to 10^8 CFU/mL. Use a hemocytometer to verify the appropriate concentration of *S. cerevisiae* cells.

A.8.1.2 Enumeration of *S. cerevisiae* cells

a) Determine the viable concentration of cells using a pour plate technique. Plate 10^{-5}

to 10^{-9} dilutions in triplicate on YM agar plates. Incubate plates at 25 ± 1 °C (77 ± 1 °F) for 48 to 72 h prior to reading.

b) After incubation, enumerate plates containing 25 to 250 distinct cells using a colony counter. Calculate the titer of the *S. cerevisiae* cell suspension by multiplying the number of cells obtained by the inverse of the dilution factor. Express results as the number of cells per milliliter. The concentration of *S. cerevisiae* cells should be 10^7 to 10^8 CFU/mL.

A.8.2 MS-2 Coliphage

A.8.2.1 Stock culture preparation of MS-2 Coliphage

NOTE – This section describes the propagation and harvesting methods for stock suspensions of MS-2 Coliphage for use as a challenge suspension for low flow (< 1 gpm) water treatment units. If units possessing a flow rate greater than 1 gpm are to be tested, the stock preparation procedure may have to be repeated multiple times to achieve the required volume of MS-2 Coliphage. This method should also be repeated when cryogenic stocks are low.

a) One day prior to preparing MS-2 Coliphage stock, thaw a cryogenically frozen *E. coli* host strain and inoculate one TSB tube with 0.1 mL of the stock suspension. Incubate at 35 ± 1°C (95 ± 1 °F) for 18 ± 2 h.

b) On the day of preparing MS-2 Coliphage stock, liquefy 1% TSA and temper the media in a 45 ± 1 °C (113 ± 1 °F) water bath. 1.5% TSA plates shall be room temperature prior to use.

c) Make serial dilutions of MS-2 Coliphage suspension (10^{-1} to 10^{-12}) using sterile PBS. Plate 10^{-5} to 10^{-12} dilutions in triplicate on 1.5% TSA plates. In a sterile tube transfer 1 mL of diluted MS-2 Coliphage, quickly add 0.1 mL of *E. coli* host and ~ 5 mL of melted 1% TSA. Vortex and pour. Rock the plate to spread inoculum evenly. After the 1% TSA layer has solidified, invert and incubate at 35 ± 1°C (95 ± 1 °F) for 18 ± 2 h.

d) Select the plates, which show complete lysis of host cells by the MS-2 Coliphage. Flood the surface of each plate with 3 mL of TSB and gently remove the 1% TSA layer using a cell scraper. Pour the contents into two sterile 50 mL centrifuge tubes and bring the total volume to 40 mL with TSB. Add 0.2 g EDTA and 0.026 g lysozyme to each tube. Incubate at room temperature for 2 h, mixing every 15 min.

e) After the 2 h incubation, centrifuge the tubes at 9280 *xg* for 5 min, or 2320 *xg* for 20 min, at 20 ± 1 °C (68 ± 1 °F). Remove the resulting supernatant while avoiding the pellet. Aseptically construct a sterile 47 mm filtration assembly using a 0.22-μm polycarbonate filter. Pretreat the filter with 10 mL of TSB broth just prior to the filtration to minimize MS-2 Coliphage adsorption to the filter. Filter the supernatant.

f) For long-term storage (greater than 28 d), add $^1/_{10}$ volume of sterile glycerol to suspension, dispense into 1 mL and 3 mL aliquots in cryovials, and store at -70° ± 1 °C (-94 ± 1 °F).

g) Titrate the MS-2 Coliphage suspension as in A.8.2.2. The concentration of MS-2 Coliphage should be 10^{10} to 10^{12} PFU/mL.

A.8.2.2 Enumeration of MS-2 Coliphage plaques

a) Thaw a cryogenically frozen *E. coli* host strain and inoculate one TSB tube with 0.1 mL of the stock suspension. Incubate at 35 ± 1 °C (95 ± 1 °F) for 18 ± 2 h.

b) Liquefy 1% TSA and temper the media in a 45 ± 1 °C (113 ± 1 °F) water bath. Allow 1.5% TSA plates to warm to room temperature.

c) Make serial dilutions of MS-2 Coliphage suspension (10^{-1} to 10^{-12}) using sterile PBS. Plate 10^{-7} to 10^{-12} dilutions in triplicate on 1.5% TSA plates. In a sterile tube transfer 1 mL of diluted MS-2 Coliphage, quickly add 0.1 mL of *E. coli* host and ~ 5 mL of 1% TSA. Vortex and pour. Rock the plate to spread inoculum evenly. After the 1% TSA layer has solidified, invert and incubate at 35 ± 1°C (95 ± 1 °F) for 18 ± 2 h.

d) After incubation, enumerate plates containing 25 to 250 distinct plaque forming units (PFU) using a colony counter. Calcu-

late the titer of the MS-2 Coliphage suspension by multiplying the number of PFU obtained by the inverse of the dilution factor. Express results as the number of PFU/mL. The concentration of MS-2 Coliphage should be 10^{10} to 10^{12} PFU/mL.

A.9 Drinking water treatment unit challenge organism suspension preparation

A.9.1 Determination of the concentration of challenge organism

This determination will be based upon the unit flow rates, injection feed pump rate, suspension density, and the final challenge organism concentration for the unit challenge. The suspension will have to be of adequate volume to deliver the challenge organism to two complete on/off cycles at each sample point (see 6.3.2).

Example:

– unit flow rate: 1.0 gpm; duplicate units tested so total of 2.0 gpm (7560 mL/min);

– injection rate: 10 mL/min;

– suspension density: 1 x 10^9/mL;

– final concentration: 7.0 x 10^4/mL; and

– on/off cycle: 10 min / 10 min (20 min on for two complete cycles).

a) To challenge for 20 min at two 10 min intervals, a total of 200 mL of suspension is needed to challenge 151,200 mL of water (7560 min x 20 min):

– (7.0 x 10^4/mL)(151,200 mL) = (injection feed conc.)(200 mL); and

– injection feed concentration = 5.3 x 10^7/mL.

b) To prepare this from the stock suspension:

– (200 mL)(5.3 x 10^7/mL) = (mL of suspension density)(1.0 x 10^9/mL);

– mL of suspension density = 10.6 mL; and

– add 10.6 mL of suspension to 189.4 mL of PBS.

Once suspension has been made, mix the suspension using a magnetic stirrer.

Remove a 10-mL aliquot from the challenge suspension and set aside for density verification according to *Standard Methods for the Examination of Water and Wastewater.*

A.10 Analysis of influent and effluent samples

A.10.1 Enumeration of *S. cerevisiae* cells

a) Make serial dilutions of the influent and effluent samples (10^0 to 10^{-5}) using SBDW. Plate 10^0 to 10^{-5} dilutions in duplicate on YM agar plates. Incubate plates at 25 ± 1 °C (77 ± 1 °F) for 48 to 72 h prior to reading.

b) After incubation, enumerate plates containing 25 to 250 distinct cells using a colony counter. Calculate the titer of the *S. cerevisiae* cells suspension by multiplying the number of CFU obtained by the inverse of the dilution factor. Express results as the number of CFU/mL.

A.10.2 Enumeration of MS-2 Coliphage plaques

a) Make serial dilutions of the influent and effluent samples (10^0 to 10^{-5}) using sterile PBS. Plate 10^0 to 10^{-5} dilutions in duplicate on 1.5% TSA plates. In a sterile tube, transfer 1 mL of diluted MS-2 Coliphage, quickly add 0.1 mL of *E. coli* host and ~ 5 mL of melted 1% TSA. Vortex and pour. Rock the plate to spread inoculum evenly. After the 1% TSA layer has solidified, invert and incubate at 35 ± 1°C (95 ± 1 °F) for 18 ± 2 h.

b) After incubation, enumerate plates containing 25 to 250 distinct plaque forming units (PFU) using a colony counter. Calculate the titer of the MS-2 Coliphage suspension by multiplying the number of PFU obtained by the inverse of the dilution factor.

Express results as the number of PFU/mL.

A.11 Challenge verification

After the appropriate incubation period for MS-2 Coliphage or *S. cerevisiae*, count colonies on all of the density determination plates. Calculate the mean number of microorganisms per milliliter for plates with 25 to 250 colonies/plaques. This is to verify that challenge organism was present in the challenge test water at the optimum concentration before being added to test apparatus.

Annex B[15]

Key elements of a certification program for drinking water treatment systems and components

A certification program for drinking water treatment systems and components should contain the following program elements:

B.1 Marking the product

Requirements for product marking including:

– Certified systems should bear a registered trademark of the certifying organization.

– Certified components intended to be used with other components to make a complete functional system, as defined by NSF/ANSI Standard 55, should bear a component mark.

– Each system should have a model designation.

– Each system should bear a statement of claims verified through the certifying organization and substantiated by test data.

B.2 Listing certified companies

A published listing of all certified systems and components. The listing format should include at least the following information:

– company name and address;

– product description;

– trademark/model designation;

– flow rate;

– rated capacity or service cycle; and

– each substance reduction claim that has been successfully evaluated and is supported by test data.

B.3 Annual audits

Actual physical audits of all facilities and production locations of the certified company at least annually.

B.4 Testing

Testing in accordance with all applicable NSF/ANSI Standard 55 requirements prior to certification.

– A retest program that includes reevaluation and retesting at least once every five years.

B.5 Toxicological evaluation of materials formulations

Formulation information of each material used in the fabrication of the system and/or components shall be provided to and maintained on file by the certifying organization. The formulation information should include, at a minimum:

– the complete chemical identity or proportion by weight;

– ingredient sources of supply

– documentation regarding the health effects concern of each ingredient in the material; and

– documentation regarding the suitability of each ingredient for use in potable-water-contact material.

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B.6 Corrective action

Corrective action for all items of noncompliance found during audits and reevaluation including:

– provisions for review and authorization for modifications to designs;

– modifications to certified system and/or components; and

– documentation and authorization of the modification maintained on file.

B.7 Enforcement

To preserve the integrity of the registered trademark of the certifying organization and protect public health, enforcement action should be taken by the certifier for the following:

– use of the registered trademark of the certifying organization on a non-certified product;

– general noncompliance;

– unauthorized change to a certified product;

– unauthorized shipment or disposal of product placed on hold; and

– bribes.

B.8 Administrative review

Provisions for an administrative review as requested by any party directly affected by a decision or action of the certifier.

B.9 Appeals

Provisions for an appeals process as requested by any party directly affected by a decision or action of the certifier resulting from an administrative review.

B.10 Complaints

Provisions for investigation of complaints related to certified products, misuse of the registered trademark of the certifying organization by a certified company, or use/misuse of the registered trademark of the certifying organization by a non-certified company.

– certified company retention and disclosure of complaint records and remedial actions for certified products.

B.11 Advertising

Requirement of proper use of the registered trademark of the certifying organization on sales literature, technical publications, promotional materials, packaging, catalogs, and advertising.

B.12 Records

Provisions for verification of complete certified company records, including:

– installation and service for fabricators and distributors;

– purchased materials and components; and

– production, shipment, and inventory.

B.13 Public notice

Provisions for issuing a public notice for noncompliance with any requirement of certification.

B.14 Confidentiality

A strict policy of non-disclosure of any confidential information supplied to the certifier by the company regarding the product, including formulations, components, processes, ingredients, or the identity of the company's suppliers and distributors.

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NSF®

THE STRONGEST MARK IN THE WATER TREATMENT BUSINESS!

The Public Health and Safety Company™

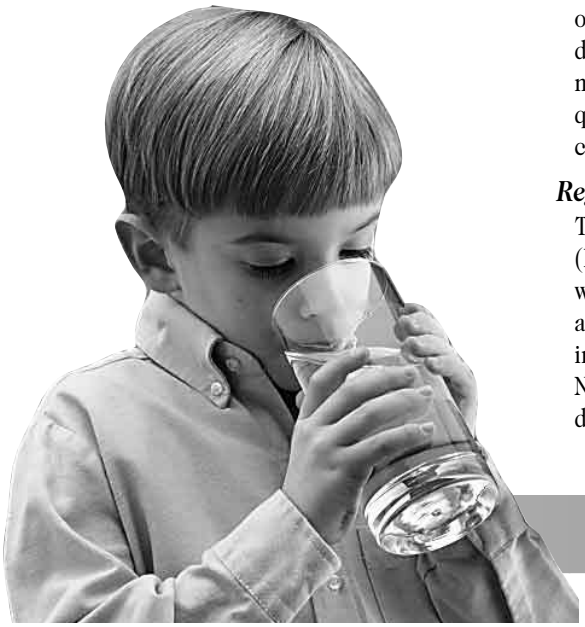

NSF's state-of-the-art testing facility.

Firm Foundation

For nearly 60 years, NSF has developed and maintained consensus standards and certification programs in public health, safety and the environment. During that time, NSF has become the premier, independent, global third-party certifier of products.

Beginning in 1968, the Conference of Local Environmental Health Administrators and the USEPA along with NSF International began development of NSF Drinking Water Treatment Unit (DWTU) Standards. Over the past thirty years, with the help of Federal and state regulators, user representatives and manufacturers, there are now six NSF/ANSI DWTU Standards covering most point-of-use and point-of-entry treatment technologies and contaminant reduction claims.

Millions of drinking water treatment units now bear the NSF Mark, providing consumer confidence in the products they purchase. NSF has the world's largest number of DWTU certified companies, bringing global recognition to the NSF Mark.



Consumer Benefits

Product Listings

NSF-certified drinking water treatment units are listed in our publication *NSF Listings and Consumer Guide,* as well as online. NSF's online Certified Product Listings at **www.nsf.org** are updated daily and are accessible 24 hours a day.

Consumer Affairs Office

Information regarding certified NSF products is also provided to consumers toll-free at 1-877-8-NSF-HELP (1-877-867-3435).

Media Attention (Public Relations)

National and international news media have publicized NSF's role as a trusted, independent testing and certification organization for water treatment devices. Monthly, more than four million subscribers read about water quality concerns and the value of NSF certification to NSF/ANSI Standards.

Regulatory Referrals

The Environmental Protection Agency's (EPA) Drinking Water Hotline, along with local public health departments, and utilities refer callers interested in drinking water treatment units to NSF for information and advice on drinking water products.

Market Benefits

NSF third-party testing and certification provides:

Market Access

Manufacturers enter new markets faster and easier with the ultimate certification in the water treatment industry. The NSF Mark is a powerful marketing tool that opens doors throughout the world.

In addition to recognition in North America, NSF certification can bridge the gap between countries and certification marks. For example, through NSF global partners, NSF certification can help in Europe to obtain the French CSTBat Mark, in Asia to deliver the Japan Water Mark, and in the Middle East to access the Israeli SII Mark.

Product Acceptance

NSF certification demonstrates to regulatory officials, retailers and consumers that products have obtained one of the most respected and accepted conformity assessment Marks in the industry.

Consumer Confidence

Customers have more confidence in products that are independently certified by a recognized, accredited third-party organization.

Credibility

NSF certification programs are accredited to the international standards for third-party product certifiers through the American National Standards Institute (ANSI) and the Standards Council of Canada, assuring the highest level of integrity, quality and acceptance.

Full Capabilities

The NSF professional staff includes chemists, engineers, microbiologists and toxicologists. Each has the experience and background needed to assure proper compliance with the applicable standards.

NSF maintains state-of-the-art, in-house DWTU testing laboratories in Ann Arbor, Michigan and Sacramento, California. In the past five years, NSF has more than quadrupled the testing capacity in order to provide fast turnaround times for both certification and R&D testing.

The Six NSF/ANSI Standards

- *Standard 42:* Drinking Water Treatment Units – Aesthetic Effects
- *Standard 53:* Drinking Water Treatment Units – Health Effects
- *Standard 44:* Residential Cation Exchange Water Softeners
- *Standard 55:* Ultraviolet Microbiological Water Treatment Systems
- *Standard 58:* Reverse Osmosis Drinking Water Treatment Systems
- *Standard 62:* Drinking Water Distillation Systems

Standard 42 and 53 cover carbon and mechanical filtration type systems. Standard 42 includes aesthetic claims such as chlorine, taste and odor, particulate and bacteriostasis. Standard 53 covers health claims such as lead, VOC's, pesticides, herbicides, cyst and the gasoline additive MTBE.

Standard 44 addresses water softeners, testing for hardness reduction, efficiency rating as well as radium and barium reduction. Standard 55 covers ultraviolet disinfection systems for bacterial and viral claims. Standard 58 covers reduction claims for reverse osmosis, such as fluoride, hexavalent and trivalent chromium, TDS and nitrate/nitrite reduction. Finally, Standard 62 covers the evaluation of distillation systems and reduction claims like mercury, nitrate/nitrite, arsenic and bacteria.

Component Certification

In addition to product certification of complete treatment systems, individual components are also NSF Certified to the NSF/ANSI DWTU standards. The process is very similar but offers the following benefits:

Faster

Turnaround times are reduced for certification of systems using certified components, as NSF already has on file all of the required material formulations for the component.

Cost-Effective

The cost is reduced for certification of components, as no contaminant reduction claims testing is necessary. In addition, systems using certified components will not need to repeat certain steps and evaluations.

Compliance Confidence

Systems that use certified components have the assurance that the materials extraction and structural integrity requirements of the standard are not compromised.

Fully Certified and Listed

Certified components appear in NSF listing under the applicable standard, the same as certified systems. This provides other companies a directory of components to assist with system manufacturing and certification.

Component certification is a fast and cost-efficient way to promote your components as leaders in the water filtration market.

Four Easy Steps to Certification

Our professional staff is trained to assist product manufacturers in completing the certification process in a timely manner.

Through our easy three-step process, NSF International evaluates products against the applicable NSF/ANSI Standard.

Application

The manufacturer provides information on the product and materials of construction. Following review, NSF requests product be submitted.

Product Evaluation

Structural Integrity. Structural evaluation of the drinking water treatment unit or pressure-bearing component is required, and may include cyclic, hydrostatic, and burst evaluations, depending on the product type.

Material Evaluation. Toxicological assessment and acceptance of all materials used in the fabrication of the product is required. In addition, extraction testing and health effects assessments are performed for all materials coming into contact with the water. This ensures the product is not adding any substance of toxicological significance to the drinking water.

Performance Testing. Selection of contaminant reduction claims is made by the manufacturer. Testing is then performed according to the test methodology and criteria of the applicable standard.

Literature. Review and acceptance of all labeling and sales literature used with the product is required.

Plant Audit

An inspection of the production facility, which may take place at any point in the process, verifies manufacturer compliance with the applicable product specifications. Annual monitoring and follow-up services are conducted to ensure continued compliance.

Certification

NSF Certification is issued after all requirements have been successfully completed. Products are listed in the NSF's Consumer Book as well as on our web sight, **www.nsf.org**.

Standards and Criteria[16]

The following standards and criteria established and adopted by NSF as minimum voluntary consensus standards are used internationally:

2 Food equipment
3 Commercial warewashing equipment
4 Commercial cooking, rethermalization, and powered hot food holding and transport equipment
5 Water heaters, hot water supply boilers, and heat recovery equipment
6 Dispensing freezers
7 Commercial refrigerators and freezers
8 Commercial powered food preparation equipment
12 Automatic ice making equipment
13 Refuse processors and processing systems
14 Plastics piping system components and related materials
18 Manual food and beverage dispensing equipment
20 Commercial bulk milk dispensing equipment
21 Thermoplastic refuse containers
24 Plumbing system components for manufactured homes and recreational vehicles
25 Vending machines for food and beverages
29 Detergent and chemical feeders for commercial spray-type dishwashing machines
35 High pressure decorative laminates (HPDL) for surfacing food service equipment
36 Dinnerware
37 Air curtains for entranceways in food and food service establishments
40 Residential wastewater treatment systems
41 Non-liquid saturated treatment systems
42 Drinking water treatment units – Aesthetic effects
44 Residential cation exchange water softeners
46 Evaluation of components and devices used in wastewater treatment systems
49 Class II (laminar flow) biohazard cabinetry
50 Circulation system components and related materials for swimming pools, spas/hot tubs
51 Food equipment materials
52 Supplemental flooring
53 Drinking water treatment units – Health effects
55 Ultraviolet microbiological water treatment systems
58 Reverse osmosis drinking water treatment systems
59 Mobile food carts
60 Drinking water treatment chemicals – Health effects
61 Drinking water system components – Health effects
62 Drinking water distillation systems
75 Non-potentially hazardous foods
116 Non-food compounds used in food processing facilities – Food grade lubricants (draft standard for trial use)
173 Dietary supplements (draft standard for trial use)
184 Residential dishwashers
14159 Safety of machinery – Hygiene requirements for the design of machinery
14159-1 Hygiene requirements for the design of meat and poultry processing equipment
C-2 Special equipment and/or devices

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***THE HOPE OF MANKIND** rests in the ability of man to define and seek out the environment which will permit him to live with fellow creatures of the earth, in health, in peace, and in mutual respect.*

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