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An American National Standard

Standard Specification for Sewage and Graywater Flow Through Treatment Systems[1]

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INTRODUCTION

Shipboard treatment of wastewater has evolved over the years from systems using maceration and chlorination techniques to more advanced biological systems that are designed to treat a single wastestream of sewage followed more recently by complex bio-reactor systems employing advanced oxidation and high-powered UV systems that are designed to remove organic and inorganic materials from a combined wastestream of sewage and graywater.

Advancements in treatment technologies have been fueled, in part, by shipping companies wanting to adopt more environmentally friendly practices as well as by regulatory bodies imposing more stringent standards on wastewater discharges from ships.

This standard is a consolidated source of sewage and graywater treatment system requirements that combines international requirements in MARPOL Annex IV with requirements of other regulatory bodies and overlays industry best practices.

1. Scope

1.1 This specification covers the design, manufacture, performance, operation, and testing of flow through treatment systems intended to process sewage or graywater, or both, generated during a ship's normal service. This specification is intended for use by designers, manufacturers, purchasers, and operators of shipboard environmental pollution control equipment to determine the requirements for equipment design, manufacture, purchase, and in-service operation.

1.2 The treatment system shall be capable of meeting the effluent requirements detailed in Section 4 with respect to a ship's operational area.

1.3 The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in non-conformance with the standard.

1.4 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

A307 Specification for Carbon Steel Bolts, Studs, and Threaded Rod 60 000 PSI Tensile Strength
A563 Specification for Carbon and Alloy Steel Nuts
B117 Practice for Operating Salt Spray (Fog) Apparatus
B165 Specification for Nickel-Copper Alloy (UNS N04400) Seamless Pipe and Tube
D1253 Test Method for Residual Chlorine in Water
E11 Specification for Woven Wire Test Sieve Cloth and Test Sieves
F906 Specification for Letters and Numerals for Ships
F992 Specification for Valve Label Plates
F993 Specification for Valve Locking Devices
F998 Specification for Centrifugal Pump, Shipboard Use
F1030 Practice for Selection of Valve Operators
F1098 Specification for Envelope Dimensions for Butterfly Valves—NPS 2 to 24
F1122 Specification for Quick Disconnect Couplings (6 in. NPS and Smaller)
F1155 Practice for Selection and Application of Piping System Materials
F1166 Practice for Human Engineering Design for Marine Systems, Equipment, and Facilities
F1298 Specification for Flexible, Expansion-Type Ball

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

Joints for Marine Applications
F1323 Specification for Shipboard Incinerators
F1387 Specification for Performance of Piping and Tubing Mechanically Attached Fittings
F1510 Specification for Rotary Positive Displacement Pumps, Ships Use
F1511 Specification for Mechanical Seals for Shipboard Pump Applications
F2044 Specification for Liquid Level Indicating Equipment, Electrical

2.2 *ASME Standards:*[3]
B16.1 Gray iron pipe flanges and flanged fittings: Classes 25, 125, and 250
B16.5 Pipe flanges and flanged fittings: NPS ½ through NPS 24 metric/inch standard
B16.11 Forged fittings, socket-welding and threaded
B16.24 Cast copper alloy pipe flanges and flanged fittings: Classes 150, 300, 600, 900, 1500, and 2500
B16.34 Valves flanged, threaded, and welding end

2.3 *IMO Regulations:*[4]
MARPOL Annex IV Regulations for the prevention of pollution by sewage from ships
MEPC.159(55) Guidelines on implementation of effluent standards and performance tests for sewage treatment plants

2.4 *ISO Standards:*[5]
ISO 5815-1 Water quality–Determination of biochemical oxygen demand after n days (BOD_n)–Part 1: Dilution and seeding method with allylthiourea addition
ISO 15705 Water quality–Determination of the chemical oxygen demand index (ST-COD)–Small-scale sealed-tube method

2.5 *US Laws and Regulations:*[6]
33 CFR Part 159 Marine sanitation devices
33 CFR 159.301 Subpart E–Discharge of effluents in certain Alaskan waters by cruise vessel operations
40 CFR Part 136 Guidelines establishing test procedures for the analysis of pollutants

2.6 *Other Standards:*
ANSI/ASSE 1001 Performance requirements for atmospheric type vacuum breakers[5]
ANSI/ASSE 1013 Performance requirements for reduced pressure principle backflow preventers and reduced pressure principle fire protection backflow preventers[5]
ANSI/ISA 60079-1 Explosive atmospheres–Part 1: Equipment protection by flameproof enclosures *d*[5]
ANSI/ISA 60079-11 Explosive atmospheres–Part 11: Equipment protection by intrinsic safety *i*[5]
ANSI/NEMA 250 Enclosures for electrical equipment (1000 Volts Maximum)[5]
ANSI/NEMA MG 1 Motors and generators[5]
DoD 4715.6-R1 Regulations on vessels owned or operated by the Department of Defense[7]
IEC 60079-1 Explosive atmospheres–Part 1: Equipment protection by flameproof enclosures *d*[8]
IEC 60079-11 Explosive atmospheres–Part 11: Equipment protection by intrinsic safety *I*[8]
IEC 60085 Electrical insulation–Thermal evaluation and designation[8]
IEC 60092–350 Electrical installations in ships–Part 350: General construction and test methods of power, control, and instrumentation cables for shipboard and offshore applications[8]
IEC 60092–353 Electrical installations in ships–Part 353: Single and multicore non-radial field power cables with extruded solid insulation for rated voltages 1 kV and 3 kV[8]
IEC 60529 Degrees of protection provided by enclosures (IP Code)[8]
IEEE 1580 Recommended practice for marine cable for use on shipboard and fixed or floating platforms[9]
MIL-S-167-1 Test method standard for mechanical vibrations of shipboard equipment[10]
MIL-S-901 Requirements for shock tests: High-impact shipboard machinery, equipment, and systems[10]
NFPA 70 National Electrical Code[11]
SNAME T&R Bulletin 3-37 Design guide for shipboard airborne noise control[12]
SM 4600-Cl Chlorine (residual)–Standard methods for the examination of water and wastewater[13]
UL 913 Intrinsically safe apparatus and associated apparatus for use in class I, II, and III, division 1, hazardous (classified) locations[14]
UL 1203 Explosion-proof and dust-ignition-proof electrical equipment for use in hazardous (classified) locations[14]
UL 1309 Marine shipboard cables[14]

3. Terminology

3.1 *Definitions:*
3.1.1 *blackwater*—see *sewage*.

[3] Available from American Society of Mechanical Engineers (ASME), ASME International Headquarters, Three Park Ave., New York, NY 10016-5990, http://www.asme.org.
[4] Available from the International Maritime Organization, 4 Albert Embankment, London SE1 7SR, United Kingdom, http://www.imo.org.
[5] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, http://www.ansi.org.
[6] Available from U.S. Government Printing Office Superintendent of Documents, 732 N. Capitol St., NW, Mail Stop: SDE, Washington, DC 20401, http://www.access.gpo.gov.
[7] Available from the Under Secretary of Defense (AT&L), Department of Defense, 3400 Defense Pentagon, Washington, DC 20301-3400, USA, http://www.dtic.mil/whs/directives/corres/pub1.html.
[8] Available from the International Electrotechnical Commission, 3 rue de Varembé, PO Box 131, CH-1211 Geneva 20, Switzerland, http://www.iec.ch.
[9] Available from Institute of Electrical and Electronics Engineers, Inc. (IEEE), 445 Hoes Ln., Piscataway, NJ 08854, http://www.ieee.org.
[10] Available from the Document Automation and Production Service, Department of Defense, Bldg 4/D, 700 Robbins Ave, Philadelphia, PA 19111, USA, http://dodssp.daps.dla.mil/
[11] Available from National Fire Protection Association (NFPA), 1 Batterymarch Park, Quincy, MA 02169-7471, http://www.nfpa.org.
[12] Available from the Society of Naval Architects and Marine Engineers, 601 Pavonia Ave, Jersey City, NJ 07306, USA, www.sname.org.
[13] Available from American Public Health Association, 800 I St N.W., Washington, DC 20001-3710, USA, www.standardmethods.org.
[14] Available from Underwriters Laboratories (UL), 2600 N.W. Lake Rd., Camas, WA 98607-8542, http://www.ul.com.

3.1.2 *chlorine, n*—residual disinfectant or byproducts associated with the use of chlorine or its compounds.

3.1.3 *coliform, n*—thermotolerant coliform bacteria which produce gas from lactose in 48 h at 44.5°C [112.1°F].

3.1.4 *cruise ship, n*—ship, including submersible craft, carrying at least one passenger for hire for whom consideration is contributed as a condition of carriage, whether directly or indirectly flowing to the owner, charterer, operator, agent, or any other person having an interest.

3.1.5 *deleterious effect, n*—cracking, softening, deterioration, displacement, breakage, leakage, or damage of components or materials that affects the operation or safety of a treatment system.

3.1.6 *dilution, n*—process water added to the treatment system.

3.1.7 *discharge, n*—spilling, leaking, pumping, pouring, emitting, emptying, or dumping, however caused.

3.1.8 *effluent, n*—liquid containing sewage, graywater, or other wastes, whether treated or untreated, flowing out of the treatment system or holding tank usually to be discharged.

3.1.9 *flushwater, n*—transport medium used to carry sewage or other wastes from toilets or urinals to the treatment system.

3.1.10 *geometric mean, n*—the nth root of the product of n numbers.

3.1.11 *graywater, n*—(*1*) drainage from galley sink and dishwater drains; (*2*) drainage from laundry facilities; or (*3*) drainage from bath, shower, and washbasin drains.

3.1.12 *holding tank, n*—tank for collecting or storing of sewage or graywater, whether treated or untreated, having suitable design, construction, fittings, and coatings for the intended purpose as designated by the certifying body.

3.1.12.1 *Discussion*—The terms sludge tank, bioreactor tank, collection tank, receiving tank, and flow equalization tank are synonymous with holding tank, but for a different purpose.

3.1.13 *influent, n*—liquid containing sewage, graywater, or other wastes, whether treated or untreated, flowing into the treatment system or holding tank.

3.1.14 *international voyage, n*—voyage from a port or place in one country to a port or place outside such country, or conversely.

3.1.15 *operational, adj*—(*1*) quality of performance or quality of effluent, a treatment system that continually processes, treats, and discharges wastewater to the applicable treatment standard, or is ready to do so following an individual use; (*2*) functional area, a description of the ship's route, duration of voyage, and distance from nearest land; (*3*) daily routine, a schedule of events, meal times, and work hours for the ship's crew.

3.1.16 *passenger ship*—see *cruise ship*.

3.1.17 *process water, n*—seawater or other liquid added to the treatment process.

3.1.18 *residual chlorine*—see *chlorine*.

3.1.19 *retention tank, n*—auxiliary tank, pressure vessel, container, reservoir, or similar component for storing liquids, solids, or gasses used or capable of being used during the treatment process.

3.1.20 *sewage, n*—(*1*) drainage and other wastes from any form of toilets and urinals; (*2*) drainage from medical premises (for example, dispensary, sick bay, etc.) by means of wash basins, wash tubs, and scuppers located in such premises; (*3*) drainage from spaces containing living animals; or (*4*) other wastewater when mixed with the drainages defined above.

3.1.21 *ship, n*—every description of watercraft, other than a seaplane on the water, used or capable of being used as a means of transportation in water.

3.1.21.1 *Discussion*—The terms ship and vessel are interchangeable and synonymous.

3.1.22 *thermotolerant coliform*—see *coliform*.

3.1.23 *tonnage, n*—a function of the moulded volume of enclosed spaces on the ship, gross or net, as indicated on the ship's international tonnage certificate.

3.1.24 *wastestream*—see *wastewater*.

3.1.25 *wastewater, n*—liquid containing sewage, graywater, or other similar wastes, including flushwater.

3.1.25.1 *Discussion*—Wastes do not include industrial wastes, such as from fixed or floating platforms engaged in exploration, exploitation, and associated offshore processing of seabed mineral resources.

3.1.26 *vessel*—see *ship*.

4. Classification

NOTE 1—Concentration limit for solids is ≤10 % of calculated TSS. See 11.14.1.

4.1 *Type I marine sanitation device* is a flow-through sewage treatment system certified by the U.S. Coast Guard for installation on a U.S. flagged vessel ≤19.7 m [65 ft] in length and designed to meet the requirements in 33 CFR Part 159. This treatment system is typically a small device that is designed to be used for processing, treating, and discharging sewage "on demand" following each individual use. In the United States, vessels are able to discharge through this device while operating within three nautical miles (nm) of land, except where otherwise prohibited.

4.2 *Type II-A marine sanitation device* is a flow-through sewage treatment system certified by the U.S. Coast Guard for installation on a U.S. flagged vessel of any length to meet the

TABLE 1 Treatment Standards by Type of System[A]

Type	Coliform, CFU/100 mL	TSS, mg/L	BOD_5, mg/L	COD, mg/L	Chlorine, µg/L	pH
I	≤1000	(see Note 1)	...	...	...	...
II-A	≤200	≤150	...	...	...	...
II-B	≤100	≤35	≤25	≤125	<500	6–8.5
II-C	≤20	≤30	≤30	...	≤10	6–9
III	...	...	...	...	...	...

[A]Amounts presented in this table are for comparison purposes only. For detailed requirements, consult the regulatory standard cited in 4.1 through 4.6, as appropriate.

requirements in 33 CFR Part 159. For U.S. flagged vessels that engage in international voyages, Type II-A devices fitted with holding tank for the temporary storage of treated sewage meet the requirements of regulation 9.1.2 of MARPOL Annex IV as a sewage comminuting and disinfecting system. This treatment system is typically a large device that is designed to be used for processing, treating, and discharging sewage continuously between individual uses. In the United States, vessels are able to discharge through this device while operating within 3 nm of land, except where otherwise prohibited. However, while operating on an international voyage, such discharges are at a distance of >3 nm from nearest land.

4.3 *Type II-B sewage treatment plant* is a flow-through treatment system of a type approved by the flag Administration for installation on a ship engaged in international voyages of 400 gross tonnage (GT) and above, and ships of <400 GT which are certified to carry >15 persons, to meet the requirements of regulation 9.1.1 of MARPOL Annex IV as amended by MEPC.159(55). This treatment system is typically a large device that is designed to be used for processing, treating, and discharging sewage or graywater, or both, continuously between individual uses. While on an international voyage, vessels are able to discharge through this treatment system while operating within 3 nm of land, except where otherwise prohibited.

4.4 *Type II-C advanced wastewater treatment system* are Type II-B sewage treatment plants that are designed to treat a combined sewage and graywater influent to a more stringent standard for installation on a cruise ship authorized to carry ≥500 passengers operating in certain Alaskan waters to meet the requirements Subpart E to 33 CFR 159.301 et seq. Cruise ships are able to discharge through this treatment system while operating in certain Alaskan waters.

4.5 *Type III-A marine sanitation device* certified by the U.S. Coast Guard for installation on a U.S. flagged vessel of any length designed to prevent the overboard discharge of treated or untreated sewage to meet the requirements in 33 CFR Part 159. Typically this holding tank is used solely for the storage of wastewater (for example, sewage, graywater, flushwater) at ambient air pressure and temperatures. In the United States, vessels are able to discharge from a holding tank while operating outside of 3 nm of land, except where otherwise prohibited. However, while operating on an international voyage, such discharges occur at a distance of >12 nm from nearest land and while the vessel is en route proceeding at ≥4 kts.

4.6 *Type III-B sewage holding tank* constructed to the satisfaction of the flag Administration and having capacity for the retention of all sewage, with visual means to indicate the amount of its contents, taking into account the operation of the ship, the number of persons on board, and other relevant factors, to meet the requirements of regulation 9.1.3 of MARPOL Annex IV. Discharges are similar to Type III-A.

5. Ordering Information

5.1 *General:*

5.1.1 Purchaser shall provide treatment system manufacturer with all pertinent acquisition requirements, including items shown in 5.2.

5.2 *Acquisition Requirements:*

5.2.1 Title, number, and date of this specification.

5.2.2 Type of treatment system (for example, Type II-B) from Section 4.

5.2.3 Whether treatment system is designed to process or retain sewage or graywater, or combined sewage and graywater.

5.2.4 Maximum number of persons, including non-crew members.

5.2.5 *Design Sizing Requirements:*

5.2.5.1 Hydraulic loading for both graywater and sewage in accordance with Table 2, including method of collection, whether gravity or vacuum feed.

5.2.5.2 When specifying growth margin, it is important to consider the potential for increases in the number of crew and passengers over the life of the ship.

NOTE 2—If vacuum collection is used for graywater, then design generation rate is expected to be the same as for gravity collected graywater.

5.2.6 Organic loading for both graywater and sewage in accordance with Table 3.

5.2.7 Thermal loading for both graywater and sewage influent temperature taking into account management of variations in influent temperature.

5.2.7.1 Consideration should include the addition of a temperature or flow equalization tank, or other means to adjust temperature.

5.2.8 Treatment system start-up and stabilization periods.

5.2.9 Space, weight, and service restrictions, if any.

5.2.10 Doorway, hatch, and compartment dimensions, including clearance restrictions for access to parts for service.

5.2.11 Operational profile of ship.

5.2.12 Additional control requirements.

5.2.13 Any additional requirements as required by purchaser to meet special needs.

5.2.14 Level of operator interfacing as determined by purchaser consistent with ship operational and maintenance procedures.

5.2.15 Supplementary requirements, if any, from Section 17.

6. Materials and Manufacture

6.1 *Material Deterioration, Prevention, and Control:*

TABLE 2 Hydraulic Loading Design Flow per Capita by Collection Method

Collection Method	Sewage, L/day [gal/day]	Graywater, L/day [gal/day]
Gravity	23 – 125 [6 – 33]	34 – 189 [9 – 50]
Vacuum,		
with urinals	2.3 – 13 [0.6 – 3.3]	(see Note 2)
without urinals	4.2 – 23 [1.1 – 6.1]	(see Note 2)

TABLE 3 Organic Loading Design Rate per Capita by Influent

Influent	TSS, kg/day [lb/day]	BOD_5, kg/day [lb/day]
Sewage	0.044 – 0.073 [0.096 – 0.161]	0.016 – 0.035 [0.036 – 0.078]
Graywater	0.033 – 0.061 [0.072 – 0.134]	0.118 – 0.156 [0.259 – 0.343]

6.1.1 Treatment system shall be fabricated from compatible materials, inherently corrosion resistant or treated to provide protection against corrosion and deterioration for the service life of the treatment system from the following:

6.1.1.1 Internal exposure to wastestreams, chemicals, and other substances commonly found in treatment systems or as part of the treatment process; and

6.1.1.2 External exposure to petroleum products, cleaning compounds, and other substances commonly used on ships in the compartment where a treatment system will be installed.

6.1.2 A listing of common substances that a treatment system may be exposed to is provided in Table 4.

6.1.3 Manufacturer should develop a list of specific substances considered in the design of a particular treatment system.

6.1.4 Dissimilar metals shall not be used in intimate contact with each other unless protected against galvanic corrosion.

6.1.5 Treatment system shall not be damaged nor shall subsequent operational performance be degraded:

6.1.5.1 As a result of exposure to salt fog in accordance with ASTM Practice B117; and

6.1.5.2 When in a non-operating state, such as when secured for winter layup.

6.1.6 Components, such as valves, fittings, pumps, and motors shall be of corrosion resistant material suitable for the intended service and shall be standard items such as those complying with ASME B16.34, Practice F1030 and Specifications A307, A563, F992, F993, F998, F1098, F1122, F1298, F1387, F1510, and F1511, which are easy to maintain and replace.

6.1.7 Component design shall be compatible with treatment system materials.

TABLE 4 Common Substances by Exposure Type[A]

Substance	Internal[B]	External[B]
Sewage, graywater, flushwater incl intermediate process fluids, vapors	X	X
Toilet bowl cleaners, pipe scale prevention chemicals incl bleach, citric acid tablets, acid-based & biological substances	X	X
Disinfectants incl solid, liquid or gas, in quantity specified by manufacturer	X	X
Fuel oils or other fuels incl diesel fuel, marine fuel oil		X
Lubricating oils incl synthetic & petroleum-based oils		X
Cleaning agents incl mineral spirits, methyl alcohol, petroleum-based solvents		X

[A]Substance list may vary by treatment system type, ship type, etc.
[B]"X" indicates the listed substance is common.

6.1.8 Metallic holding and retention tanks shall be provided with cathodic protection, or by insulation of the galvanic coupling, to minimize corrosion due to galvanic reactions.

6.1.9 Fasteners shall be of corrosion resistant material.

6.2 *Design for Human Interface and Safety:*

6.2.1 Practice F1166 shall be used for the design, construction, and layout of the treatment system, controls, displays, equipment, and labels.

6.2.1.1 Warning and operating labels shall be affixed to treatment system where necessary in accordance with Practice F1166.

6.2.2 All rotating or moving parts with the potential to cause injury shall be guarded to avoid accidental contact.

6.2.3 Equipment requiring routine maintenance shall be easily accessible.

6.3 *Features:*

6.3.1 *Vents*—Vents shall be designed and constructed to minimize clogging by either contents of holding and retention tanks or climatic conditions such as snow or ice.

6.3.2 *Baffles*—Baffles in holding and retention tanks, if any, shall have openings to allow contents to flow freely across the top and bottom of the tank.

6.3.3 *Level Indicator*—Holding and retention tanks, if any, shall have a means of indicating tank level that complies with Specification F2044.

6.3.4 *Chemical Level Indicator*—If the treatment system uses one or more chemicals for its effective operation, then the system shall be fitted with one of the following:

6.3.4.1 means of indicating the amount of the chemical in the retention and holding tanks; or

6.3.4.2 Means of indicating when chemicals need to be added to the retention and holding tanks for the proper continued operation of the treatment system.

6.3.5 *Independent Support*—Treatment system shall have provisions for support that are independent from connecting pipes.

6.3.5.1 Piping shall not be used to support the treatment system or its major components.

6.3.6 *Backflow Prevention*—Treatment system shall be protected from backflow of wastewater through supply and discharge piping.

6.3.6.1 Manufacturer may specify in the installation instructions backflow prevention requirements as part of ship's piping.

6.3.6.2 Where pressurized backflow is not possible, atmospheric type vacuum breaker conforming to ANSI/ASSE 1001 shall be used.

6.3.6.3 Treatment system using ship supplied potable water shall be fitted with a reduced pressure principle sanitary backflow preventer conforming to ANSI/ASSE 1013 in order to protect the ship's potable water from cross-contamination.

6.3.7 *Sampling ports*—Treatment system shall provide for manually collecting representative samples of influent and effluent without opening tanks, voids, or vents.

6.3.7.1 Ports shall be located in: (*1*) influent line, or receiving and collection tank, for sampling influent; and (*2*) effluent line immediately downstream of treatment system for sampling effluent.

6.3.7.2 Manufacturer may specify in installation instructions additional sampling port requirements as part of ship piping.

6.3.7.3 If a sludge collection tank or discharge line is included in the treatment system design, then a sampling port is required.

6.3.7.4 For biological treatment systems, provisions shall be made on the bioreactor tank for assessing the condition of the biomass.

6.3.8 *Removal Fittings*—Standard discharge fittings, if provided with treatment system, shall be in accordance with Table 5.

6.3.8.1 Flange in Table 5 is designed to accept pipes up to a maximum internal diameter of 100 mm [3.9 in] and shall be of steel or other equivalent material having a flat face. This flange, together with a gasket, shall be suitable for a service pressure of 6 kg/cm^2 [85.3 psi].

6.3.8.2 For ships having a molded depth ≤ 5 m [16.4 ft], the inner diameter of the discharge connection may be 38 mm [1.5 in.].

6.3.8.3 For ships in dedicated trades, that is, passenger ferries, alternatively the ship discharge pipeline may be fitted with a discharge connection which can be accepted by the flag Administration, such as quick connection couplings.

6.4 *Piping:*

6.4.1 Piping shall be compatible with treatment system materials.

6.4.2 Piping selection and application shall be in accordance with Practice F1155.

6.4.3 Pipe bends, if any, shall have minimum 3:1 bend radius to diameter.

6.4.4 Inlet and outlet connections shall be in accordance with ASME B16.1, B16.5, or B16.11, or ASME B16.24 or equivalent ISO or DIN standards.

6.4.5 Piping shall be clamped to prevent damage or unintended discharge due to stress or vibration.

6.4.6 If copper-nickel alloy piping is used, then it shall meet the requirements in Specification B165.

6.4.7 If alternate materials are used other than those listed in Practice F1155, then the manufacturer shall obtain buyer approval for use.

6.5 *Electrical:*

6.5.1 *Components and installation:*

TABLE 5 Standard Dimensions for Flanges for Discharge Connections

Description	Dimension
Outside diameter	210 mm [8.3 in.]
Inner diameter	According to pipe outside diameter
Bolt circle diameter	170 mm [6.7 in.]
Slots in flange	4 holes 18 mm [0.7 in.] in diameter equidistantly placed; on a bolt circle of the above diameter, slotted to the flange periphery. The slot width to be 18 mm [0.7 in.]
Flange thickness	16 mm [0.6 in.]
Bolts and nuts, quantity and diameter	4, each of 16 mm [0.6 in.] in diameter and of suitable length

6.5.1.1 Interior electrical equipment and enclosures for treatment system used in a machinery space, a location normally exposed to splashing, or another space with similar moisture levels shall be at least IEC 60529 IP 44 or an appropriate ANSI/NEMA 250 Type for the intended service.

6.5.1.2 Exterior electrical equipment and enclosures for treatment system exposed to weather, water washdown, or similar moisture conditions shall be at least IEC 60529 IP 65 or ANSI/NEMA 250 Type 4 or Type 4X.

6.5.1.3 Electrical equipment and installations shall be suitable for roll, pitch, and vibration of a ship while underway.

6.5.1.4 Electrical equipment for treatment system, including switches, fuses, lamp holders, etc., shall be suitable for the voltage and current utilized.

6.5.1.5 Electrical equipment and circuits for treatment system shall be clearly marked and identified on wiring diagram in 15.3.1.4 and 15.5.1.14.

6.5.1.6 Any cabinet, panel, box, or other enclosure containing more than one source of power shall be fitted with a sign warning persons of this condition and identifying the circuits to be disconnected.

6.5.1.7 Electrical equipment exposed to corrosive environments shall be corrosion resistant and of suitable construction.

6.5.1.8 Electrical equipment shall be protected from accidental contact by personnel operating or routinely servicing the equipment.

6.5.2 *Control systems and conductors:*

6.5.2.1 Wiring for treatment system shall be rated for the maximum operating temperature to which it has the potential to be exposed.

6.5.2.2 All control wiring between components shall have stranded copper conductors of ≥No. 18 AWG or shall have stranded copper conductors with a current-carrying capacity of ≥125 % of the expected current. Communications and radio frequency (RF) cables, such as USB, ribbon, coaxial, telephone twisted-pairs, Ethernet, or similar cables do not have to meet this requirement.

6.5.2.3 Internal wiring of cabinets or enclosures shall be of NEC or equivalent type insulated wires suitable for at least dry and damp locations.

6.5.2.4 Internal wiring within enclosure or cabinet shall terminate on terminal blocks when connection to external wiring is necessary.

6.5.2.5 When individual insulated wires are used, rather than cable, outside cabinets or enclosures on systems of >50 V, wires shall be in conduit.

6.5.2.6 Cables shall be secured with metallic band strapping such that they remain tight without damage to armor or insulation.

6.5.2.7 Metallic band strapping used for cable support shall be fabricated from steel and corrosion treated if not of a corrosion-resistant material.

6.5.2.8 Cable supports for all horizontal runs shall prevent undue sag.

6.5.2.9 Cable retention devices shall be installed on vertical and horizontal runs, as applicable.

6.5.2.10 Power cables and external control cables shall meet construction and testing standards of IEEE 1580, UL 1309, IEC 60092-350, or IEC 60092-353 with amendment 1.

6.5.2.11 When a Type metal-clad (MC) cable is used it shall be a continuous corrugated metal-clad cable.

6.5.2.12 Portable cables or flexible cords may be used for external connections of moving parts or where frequent interchange or disconnection is necessary due to calibration or maintenance of field connected devices.

6.5.2.13 Overcurrent protection shall be in accordance with Article 240 of NFPA 70 or equivalent standard as determined by the certifying body.

6.5.2.14 Electrical equipment in spaces containing machinery powered by, or fuel tanks containing, gasoline or other fuels having a flashpoint of ≤43.3°C [110°F] shall be explosion-proof or ignition-protected or be part of an intrinsically safe system.

6.5.3 *Motors:*

6.5.3.1 Motors shall be rated to operate at 50.0°C [122°F] ambient air temperature, unless it can be shown that a 40.0°C [104°F] or 45.0°C [113°F] ambient temperature will not be exceeded.

6.5.3.2 Motors shall be constructed with a minimum of Class F insulation in accordance with IEC 60085 or ANSI/NEMA MG 1.

6.5.3.3 Motors exposed to splashing or spraying oil or water shall be at least IEC 60529 IP 44 or an equivalent ANSI/NEMA 250 type for the service intended.

6.5.3.4 Motors shall be provided with a corrosion resistant nameplate specifying: (*1*) manufacture's name; (*2*) rated horsepower; (*3*) rated voltage and full-load current; (*4*) rated frequency and number of phases; (*5*) rated RPM; (*6*) rated temperature; (*7*) the Code letter; and (*8*) thermal protection, if used. For IEC motors, manufacturer shall certify the rated temperature by signed letter or other equivalent means.

6.5.3.5 Motor branch circuits, motor feeder conductors and their protection, motor overload protection, motor control circuits, motor controllers, and motor control centers shall be in accordance with Article 430 of NFPA 70 or equivalent standard as determined by the certifying body.

6.5.3.6 Motor controllers shall have a power rating in accordance with Part IV of Article 430 of NFPA 70 or equivalent standard as determined by the certifying body.

6.5.3.7 Motors shall be provided with motor running protection in accordance with Part IV of Article 430 of NFPA 70 or equivalent standard as determined by the certifying body.

6.5.3.8 Thermal protection of the motor shall be in accordance with Part III of Article 430 of NFPA 70 or equivalent standard as determined by the certifying body.

6.5.3.9 Conductors of a motor remote control, interlock, and indicator circuits shall be protected against overcurrent in accordance with Part VI of Article 430 of NFPA 70 or equivalent standard as determined by the certifying body.

6.5.3.10 Motors shall be provided with terminal leads or terminal screws in terminal boxes integral with or secured to the motor frame.

6.5.3.11 Motor terminal housing shall be in accordance with Article 430 of NFPA 70 or equivalent standard as determined by the certifying body.

6.5.4 *Pumps:*

6.5.4.1 Pumps, if fitted to a treatment system, shall be in accordance with Specifications F998 or F1510 or equivalent standard as determined by the certifying body.

6.5.4.2 Positive displacement pumps, if any, shall have a relief valve to direct flow back to the tank from which the pump takes suction. Piping to pump inlet is prohibited.

6.5.4.3 Positive displacement pumps having rubber stators shall be fitted with run dry protection.

6.6 *Hazardous locations:*

6.6.1 Components to be installed in hazardous location shall be certified as being:

6.6.1.1 Intrinsically safe in accordance with UL 913, ANSI/ISA 60079-11, or IEC 60079-11;

6.6.1.2 Explosion proof in accordance with UL 1203, ANSI/ISA 60079-1, or IEC 60079-1 for Class I, Group D hazardous locations; or

6.6.1.3 Other equivalent standards as determined by the certifying body.

6.7 *Power Interruption:*

6.7.1 Treatment system control and motor control circuit shall provide low voltage release (LVR) feature to ensure automatic restarting of the system and system motor occurs after a momentary loss of power during operation.

6.8 *Accessibility:*

6.8.1 Treatment system shall be constructed and arranged so that major system assemblies, attachments, and any non-hull integrated holding or retention tanks are accessible for maintenance, repair, or replacement without requiring removal of major assemblies or attachments.

6.8.2 Access to any filter membranes, electrodes, or other treatment system components that require scheduled maintenance, repair, or replacement shall be provided without the need to remove major system components.

6.9 *Dilution:*

6.9.1 Dilution shall not be a substitute for the treatment process.

7. Performance Requirements

7.1 *General:*

7.1.1 Treatment system shall process or retain sewage or graywater, or combined sewage and graywater, in the manner for which it is designed and shall be tested in accordance with the procedures in Section 11 to verify it meets the performance requirements in this section and the required treatment standards in Section 4.

7.1.2 *Exceptions*—Type III-A and Type III-B holding tanks only retain and do not process wastewater therefore are not subject to wastewater processing or operational tilt performance requirements in this section or test procedures in Section 11.

7.2 *Temperature and Humidity:*

7.2.1 Treatment system, while empty and in a non-operating state, shall be capable of withstanding without any deleterious effect conditions of:

7.2.1.1 Ambient air pressure;

7.2.1.2 Ambient temperature from 5.0 to 50.0°C [41 to 122°F]; and

7.2.1.3 Relative humidity from 5 to 95 % non-condensing.

7.2.2 Treatment system shall be capable of operating and processing water under conditions of:

7.2.2.1 Ambient air pressure;

7.2.2.2 Ambient temperature from 5.0 to 50.0°C [41 to 122°F];

7.2.2.3 Relative humidity from 5 to 95 % non-condensing; and

7.2.2.4 Either: (*1*) a controlled range of influent temperature as specified by manufacturer and accepted by the certifying body; or (*2*) for systems that do not control for potential variations in influent temperature, an influent temperature range varying from 2 to 40°C [35.6 to 104.0°F].

7.2.3 Refer to test procedures in 11.2 and 11.9.

7.3 *Salt Fog:*

7.3.1 Treatment system shall withstand without any deleterious effect exposure to salt fog mist for 48 h in accordance with 11.3.

7.4 *Vibration:*

7.4.1 Treatment system shall withstand without any deleterious effect sinusoidal vibration for a period of 2 h at the resonant frequency of the system or at 30 Hz with an acceleration of ±0.7 g [22.5 ft/s^2] in accordance with 11.4.

7.5 *Shock:*

7.5.1 Treatment system shall withstand without any deleterious effect vertical shocks ten times the force of gravity (10 g) [98.07 m/s^2, 321.7 ft/s^2] in accordance with 11.5.

7.6 *Rolling:*

7.6.1 Treatment system shall withstand without any deleterious effect rolling to 15° on any side of the vertical plane during 80 % of the test in 11.6 and to 22.5° or the maximum angle specified by the manufacturer, whichever is greater, for 20 % of the test in 11.6.

7.6.2 Treatment system shall be fabricated to prevent unintentional escape of gases and liquids under rolling conditions.

7.7 *Hydrostatic Integrity:*

7.7.1 Holding and retention tanks, if any, designed to operate under pressure shall be capable of withstanding a pressure head of 2.13 m [7 ft] or 150 % of the maximum pressure specified by the manufacturer, whichever is greater, in accordance with 11.7.

7.8 *Chemical Resistance:*

7.8.1 Materials used in fabrication of treatment system shall be compatible, with no evidence of deleterious effect, for both internal and external exposure over the service life of the treatment system, to common substances listed in Table 4, or to specific substances identified by treatment system manufacturer.

7.8.2 Test facility shall examine the bill of materials provided by treatment system manufacturer for compatibility in accordance with 7.8.1. Any material that, in the view of the test facility, may not be compatible shall be tested in accordance with 11.8.

7.9 *Wastewater Processing:*

7.9.1 Treatment system, except Type III holding tank, shall be capable of processing sewage or graywater, or both, in accordance with 11.10 through 11.18.

7.10 *Tilt or List:*

7.10.1 Treatment system, except Type III holding tank, shall be capable of processing sewage or graywater, or both while operating under conditions of tilt or list at an angle 22.5° or the maximum angle specified by the manufacturer, whichever is greater, in accordance with 11.19.

7.11 *Discharged Vapor and Gas:*

7.11.1 Treatment system shall be capable of being vented to the atmosphere or provided with a means to prevent an explosion or over-pressurization as a result of an accumulation of gases.

7.11.2 Treatment system vents shall be designed and constructed to minimize clogging caused by tank contents, seawater, or other similar conditions.

7.12 *Control and Operation:*

7.12.1 Treatment system shall be fully automatic and shall be fitted with a control system that automatically performs the following functions:

7.12.1.1 Monitors and controls operation;

7.12.1.2 Activates alarms;

7.12.1.3 Acquires system data;

7.12.1.4 Provides visual display of system data; and

7.12.1.5 Precludes operation that are harmful to the crew.

7.12.2 Control system shall interface with ship control system to provide remote monitoring and condition assessment.

7.12.3 Treatment system shall have visual and audible alarms to alert the crew of escaping vapors, gases, or liquids.

7.12.4 In the event of failure, treatment system machinery, sub-systems, equipment, and fixtures shall automatically fail to a safe mode.

7.13 *Accessibility:*

7.13.1 Treatment system shall be accessible for maintenance, repair, or replacement, without requiring removal of major assemblies or attachments, including for access to any filter membranes, electrodes, or other treatment system components.

8. Number of Tests and Retests

8.1 *General:*

8.1.1 For each discrete model number of treatment system to be tested, manufacturer shall provide test facility:

8.1.1.1 one production-quality treatment system; and

8.1.1.2 samples of each material from which the treatment system is constructed, as required by 7.8.2.

8.2 *Equivalency:*

8.2.1 Alternative testing procedures equivalent to the requirements in Section 12 may be considered for approval on a case-by-case basis by the certifying body when a treatment

system is not able to be tested due to size (for example, very large or very small) or other unique design factors.

8.2.2 See 11.1.3 for alternatives to temperature, humidity, salt fog, vibration, shock, and rolling.

8.2.3 Approved alternative procedures, if any, shall be clearly documented in the treatment system certification.

8.3 *Scaling:*

8.3.1 Only full-scale treatment systems should be accepted for testing purposes.

8.3.2 Certifying body may certify a defined range of manufacturer's equipment sizes based on results from actual testing performed on a production-quality treatment system employing the same marine engineering design principles and treatment technology, but due consideration shall be given to limitations on performance which might arise from scaling up or scaling down.

8.4 *Retesting:*

8.4.1 Testing facility may retest in cases where a material or treatment system fails to pass a specification, provided any such retest is performed in accordance with Section 11 and in the prescribed order of the test procedures.

8.4.2 Retesting shall be performed in accordance with Section 11 following any changes or improvements to a material or treatment system.

8.4.3 Test report shall include failed test results and subsequent changes made to the treatment system or test conditions, if any.

TEST METHODS

9. Scope

9.1 This test method uses performance-based quantitative procedures for evaluation, inspection, and testing of sewage or graywater flow through treatment systems.

9.2 After being evaluated for design and loading in Section 5, and then inspected for materials and manufacture in Section 6, treatment system is then subjected to series of performance tests in Sections 7 and 11 that are designed to simulate installation on board a ship.

9.3 Environmental tests (for example, shock, vibration, etc.) are followed by wastewater processing tests for treatment systems that process sewage or graywater, or both, where samples of effluent are collected and analyzed to determine the composition and quality meets the requirements in Section 4.

10. Hazards

10.1 *Safety:*

10.1.1 Treatment system shall present no uncontrolled safety or health hazard to operating or maintenance personnel during operation or when secured.

10.1.2 Treatment system shall safely hold and transfer all malodors, gases, smoke, and toxic substances, including collected wastewater, minimizing risk of contamination or exposure to operating or maintenance personnel.

10.1.3 Leaks shall be minimized using overflow alarms intra-system, drain funnels under sampling points, and self-closing valves at the sampling points.

10.1.4 Any fluid transfer subsystem shall prevent splatter, spillage, or other loss of liquids from any treatment system component during operation or when secured.

10.1.5 Treatment system shall remain safe and sanitary, and shall not create dangerous or unsanitary conditions during normal operation.

10.1.6 There shall be no sewage, graywater, or treatment chemicals remaining on surfaces or in crevices that could come in contact with a person using or servicing the treatment system in accordance with manufacturer's instructions.

10.2 *Safety Concerns:*

10.2.1 Design of treatment system shall minimize potential for human error during operation and maintenance under routine, non-routine, and emergency conditions.

10.2.2 Each treatment system shall:

10.2.2.1 Be free of design defects: (*1*) having rough or sharp edges with potential to cause bodily injuries; or (*2*) that will allow toxic substances to escape into the interior of the ship with the potential to be a hazard to humans;

10.2.2.2 Be vented to the atmosphere or provided with a means to prevent an explosion or over pressurization as a result of an accumulation of gases;

10.2.2.3 Include warnings for: (*1*) toxic, hazardous, flammable, explosive, or malodorous vapors produced by the treatment system to not be vented or allowed to escape into any shipboard space; (*2*) any vapors that are produced to be removed, diluted with air, or otherwise rendered safe before being discharged to the vent; (*3*) hazardous vapors produced by any loss of aeration to a bioreactor; and (*4*) any vapor or gaseous discharges from the treatment system to be compatible with ventilation exhaust system to prevent deleterious effect; and

10.2.2.4 Meet all other safety requirements applicable to the type of vessel for which it will be installed.

10.3 *Chemical Hazards:*

10.3.1 Manual handling of hazardous materials by users shall be limited as far as possible.

10.3.2 Chemicals designated as hazardous materials provided by the manufacturer for use in operation of the treatment system shall be labeled as required by applicable regulations and shall have corresponding material safety data sheets provided to the purchaser.

10.3.3 If chlorine is used to disinfect the wastestream, a means to detect chlorine gas shall be provided in the operating space for safety of crew and other persons.

10.3.4 Warning labels shall be affixed to the treatment system indicating that wastewater and biosludge are infectious and may be harmful to human health.

11. Procedure

11.1 *General:*

11.1.1 *Initial Setup*—Treatment system shall be:

11.1.1.1 The same treatment system used for all tests of this section;

11.1.1.2 Set up in a manner simulating installation on a ship in accordance with manufacturer's instructions in particular with respect to mounting, water supply, and discharge fittings; and

11.1.1.3 Tested in the order given below for each test procedure.

11.1.2 *Objectives*—Treatment system shall:

11.1.2.1 Meet performance requirements in Section 7 as well as materials and manufacture in Section 6;

11.1.2.2 Meet operational constraints and environmental requirements of this section, without deleterious effect; and

11.1.2.3 Remain operational following temperature and humidity operating test in 11.9.

11.1.3 *Alternatives*—Treatment systems of large size or mass, which exceed capacity of the test equipment used for 11.2 through 11.6 (temperature, humidity, salt fog, vibration, shock, rolling) shall instead undergo the following:

11.1.3.1 Control and sensor components shall be discretely tested in accordance with 12.2 through 12.5; and

11.1.3.2 Structural analysis shall be performed on holding and retention tanks, pressure vessels, and other similar components, which are part of the treatment system, using deep tank design criteria and assuming: (*1*) loads imposed on the treatment system by a roll with a 4 s period; (*2*) axis of rotation in the plane of the base of the treatment system offset 121.9 cm [4 ft] from centerline; and (*3*) variables listed in 11.2 through 11.6.

11.2 *Temperature and Humidity Non-operating Test:*

11.2.1 Treatment system shall be empty, in a non-operating state, for a period of ≥2 h each under conditions of:

11.2.1.1 Low temperature held at 5.0 ± 2°C [41 ± 3.6°F] in an atmosphere with a relative humidity of 5 %; and

11.2.1.2 high temperature held at 50.0 ± 2°C [122 ± 3.6°F] in an atmosphere with a relative humidity of 95 %.

11.3 *Salt Fog Test:*

11.3.1 Treatment system shall be empty, in a non-operating state, and continuously exposed to salt spray in accordance with Practice B117 for 48 h at a temperature of 35.0°C [95.0°F] followed by drying period of 48 h.

11.3.2 At the end of the test period, treatment system shall be switched on and operate using water for 1 h with no evidence of deleterious effect.

11.4 *Vibration Test:*

11.4.1 Search shall be made for resonance over the following range of frequencies and amplitudes of acceleration:

11.4.1.1 From 2 to 13.2 Hz with an amplitude of ±1 mm [0.04 in.]; and

11.4.1.2 From 13.2 to 80 Hz with an acceleration of ±0.7 g [22.5 ft/s^2].

11.4.2 This search shall be made in each of the 3 planes at a rate sufficiently low to permit detection of resonance.

11.4.3 Treatment system shall be vibrated in the planes at each major resonant frequency for a period of 2 hours.

11.4.4 For treatment systems fitted with holding or retention tanks, vibration test shall be performed at 50 % volume using water.

11.4.5 If there is no resonant frequency, treatment system shall be vibrated in each of the planes at 30 Hz with an acceleration of ±0.7 g [22.5 ft/s^2] for a period of 2 hours.

11.4.6 After completion of the test, a search shall again be made for resonance and there should be no significant change in the vibration pattern.

11.5 *Shock Test:*

11.5.1 Treatment system shall be subjected to 1000 vertical shocks:

11.5.1.1 That are 98.07 m/s^2 [10 g, 321.7 ft/s^2]; and

11.5.1.2 Have a duration of 20 to 25 ms measured at the base of the half-sine shock envelope.

11.5.2 For treatment systems fitted with holding or retention tanks, shock test shall be performed at 50 % volume using water.

11.6 *Rolling Test:*

11.6.1 Treatment system shall be subjected to 100 cycles of motion with axis of rotation 121.92 cm [4 ft] from centerline of treatment system, ≤15.24 cm [6 in.] below the plane of the bottom of the treatment system, and parallel to any tank baffles as follows:

11.6.1.1 80 % of cycles shall be 15° on either side of the vertical at a cyclic rate of 3 to 4 seconds.

11.6.1.2 20 % of cycles shall be 22.5°, or the maximum angle specified by the manufacturer, whichever is greater, on either side of the vertical at a cyclic rate of 6 to 8 seconds.

11.6.2 Treatment system shall then be rotated 90° on its vertical axis and subjected to another 100 cycles of motion as above.

11.6.3 For treatment systems fitted with holding or retention tanks, rolling test shall be performed at 50 % volume and repeated at 100 % volume using water.

11.7 *Hydrostatic Test:*

11.7.1 Any holding or retention tanks designed to operate under pressure shall be capable of holding hydrostatic pressure for 1 h with no evidence of leaking at the greater of:

11.7.1.1 Pressure head of 2.13 m [7 ft]; or

11.7.1.2 150 % of maximum pressure specified by manufacturer for operation of tanks.

11.8 *Chemical Resistance Test:*

11.8.1 To test for compatibility in accordance with 7.8.2, a sample of material shall be partially submerged in the substance for 100 h at temperature of 22°C [71.6°F] and then visually examined for any signs of deleterious effects.

11.9 *Temperature and Humidity Operating Test:*

11.9.1 Treatment system shall operate and process water at median flow rates for a period of ≥2 h each at:

11.9.1.1 Ambient temperature of 5.0 ± 2°C [41 ± 3.6°F], relative humidity of 5 %, and inlet operating fluid temperature varying at a rate of ≤3°C/min [5°F/min] from either: (*1*) lowest to highest temperature as specified by manufacturer; or (*2*) from 2 to 40°C [35.6 to 104.0°F]; and

11.9.1.2 Ambient temperature of 50.0 ± 2°C [122 ± 3.6°F], relative humidity of 95 %, and inlet operating fluid temperature varying at a rate of ≤3°C/min [5°F/min] from either: (*1*) lowest to highest temperature as specified by manufacturer; or (*2*) from 2 to 40°C [35.6 to 104.0°F].

11.10 *Raw Influent Quality:*

11.10.1 Raw influent quality during wastewater processing tests for treatment systems that process sewage and graywater shall be composed of:

11.10.1.1 Fresh, domestic sewage, and graywater;

11.10.1.2 Primary sludge added, as necessary, for the number of persons and hydraulic loading in Table 2 for which treatment system will be certified, having a TSS concentration ≥500 mg/L for each sample collected.

11.11 *Sampling Test Plan:*

11.11.1 Sampling test period for treatment systems that process sewage and graywater shall be carried out in accordance with Table 6.

11.11.2 Influent and effluent samples of wastewater shall be taken on each test day during the test period.

11.11.2.1 A minimum of 40 influent and effluent samples shall be collected to allow a statistical analysis of the testing data (for example, geometric mean, maximum, minimum, and variance).

11.11.2.2 Influent and effluent samples shall be collected at the same time and in sufficient quantity to perform all required tests (that is, coliform, total suspended solids, biochemical oxygen demand, chemical oxygen demand, and pH).

11.11.2.3 Sampling frequency shall be in accordance with Fig. 1.

11.11.2.4 Minimum loading represents that generated by a minimum number of persons on a ship (for example, when alongside, in port) and average and maximum loadings represents those generated by an average and maximum number of persons, respectively, on a ship (for example, underway, at sea) taking into account meal times and watch rotations.

11.12 *Wastewater Processing Test:*

11.12.1 *Operations and Maintenance During Testing*—Treatment systems that process sewage or graywater, or both, shall be operated and maintained during the wastewater processing test period in accordance with the manufacturer's operations and maintenance manuals in 17.5.

11.12.2 *Stabilization Period*—After any initial start-up time specified by the manufacturer, treatment system shall be stabilized before the test period begins as follows:

11.12.2.1 Biological systems ≥14 days.

11.12.2.2 Physical/chemical systems ≥7 days.

11.12.2.3 Advanced oxidation systems ≥3 days.

11.12.3 During the stabilization period in 11.12.2, raw influent shall be used having a quality specified in 11.10 under average loading conditions in Fig. 1.

11.13 *Coliform Test:*

11.13.1 *Type I Treatment Systems*—Geometric mean of coliform in samples of effluent taken during the test period shall be ≤1000 coliform/100 mL using standard methods in 40 CFR Part 136.

TABLE 6 Sampling Period by Process Method

Treatment System Process Method	Test Period
On demand, following each individual use	≥10 days, in a 20-day period
Continuously	≥10 consecutive days

11.13.2 *Type II-A Treatment Systems*—Geometric mean of coliform in samples of effluent taken during the test period shall be ≤200 coliform/100 mL using standard methods in 40 CFR Part 136.

11.13.3 *Type II-B Treatment Systems*—Geometric mean of coliform in samples of effluent taken during the test period shall be ≤100 coliform/100 mL using:

11.13.3.1 Membrane filter;

11.13.3.2 Multiple tube fermentation; or

11.13.3.3 Equivalent analytical procedure as accepted by the certifying body.

11.13.4 *Type II-C Treatment Systems*—Geometric mean of coliform in samples of effluent taken during the test period shall be ≤20 coliform/100 mL using one of the methods specified for Type II-B treatment systems in 11.13.3.

11.14 *Total Suspended Solids Test:*

11.14.1 *Type I Treatment Systems*—Geometric mean of concentration of solids in samples of effluent taken during test period shall be ≤10 % of the calculated TSS for the same period, as follows:

11.14.1.1 By expeditiously passing 1 L of effluent through sieve No. 12, as specified by ASTM Specification E11, and then drying the retained material in an oven at 103°C [217.4°F] to a constant weight in order to determine concentration of solids, in terms of mg/L; and

11.14.1.2 By using a standard method in 40 CFR Part 136 to determine concentration of TSS.

11.14.2 *Type II-A Treatment Systems*—Geometric mean of total suspended solids in samples of effluent taken during test period shall be ≤150 mg/L using a standard method in 40 CFR Part 136.

11.14.3 *Type II-B Treatment Systems*—Geometric mean of total suspended solids in samples of effluent taken during test period shall be ≤35 mg/L using:

11.14.3.1 Filtration of representative sample through 0.45 µm filter membrane, drying at 105°C [221.0°F] and weighing;

11.14.3.2 Centrifuging of a representative sample for ≥5 min with mean acceleration of 2800 to 3200 g [90 087.3 to 102 957 ft/s^2], drying at 105°C [221.0°F] and weighing; or

11.14.3.3 Other equivalent test standard as accepted by the certifying body.

11.14.4 *Type II-C Treatment Systems*—Geometric mean of total suspended solids in samples of effluent taken during test period shall be ≤30 mg/L using one of the methods specified for Type II-B treatment systems in 11.14.3.

11.15 *Biochemical Oxygen Demand Test:*

11.15.1 *Type II-B or II-C Treatment Systems*—Geometric mean of five-day biochemical oxygen demand (BOD5) in samples of effluent taken during the test period shall be ≤25 mg/L using:

11.15.1.1 ISO 5815-1; or

11.15.1.2 Other equivalent test standards as accepted by the certifying body.

11.16 *Chemical Oxygen Demand Test:*

11.16.1 *Type II-B or II-C Treatment Systems*—Geometric mean of chemical oxygen demand (COD) in samples of effluent taken during the test period systems, shall be ≤125 mg/L using:

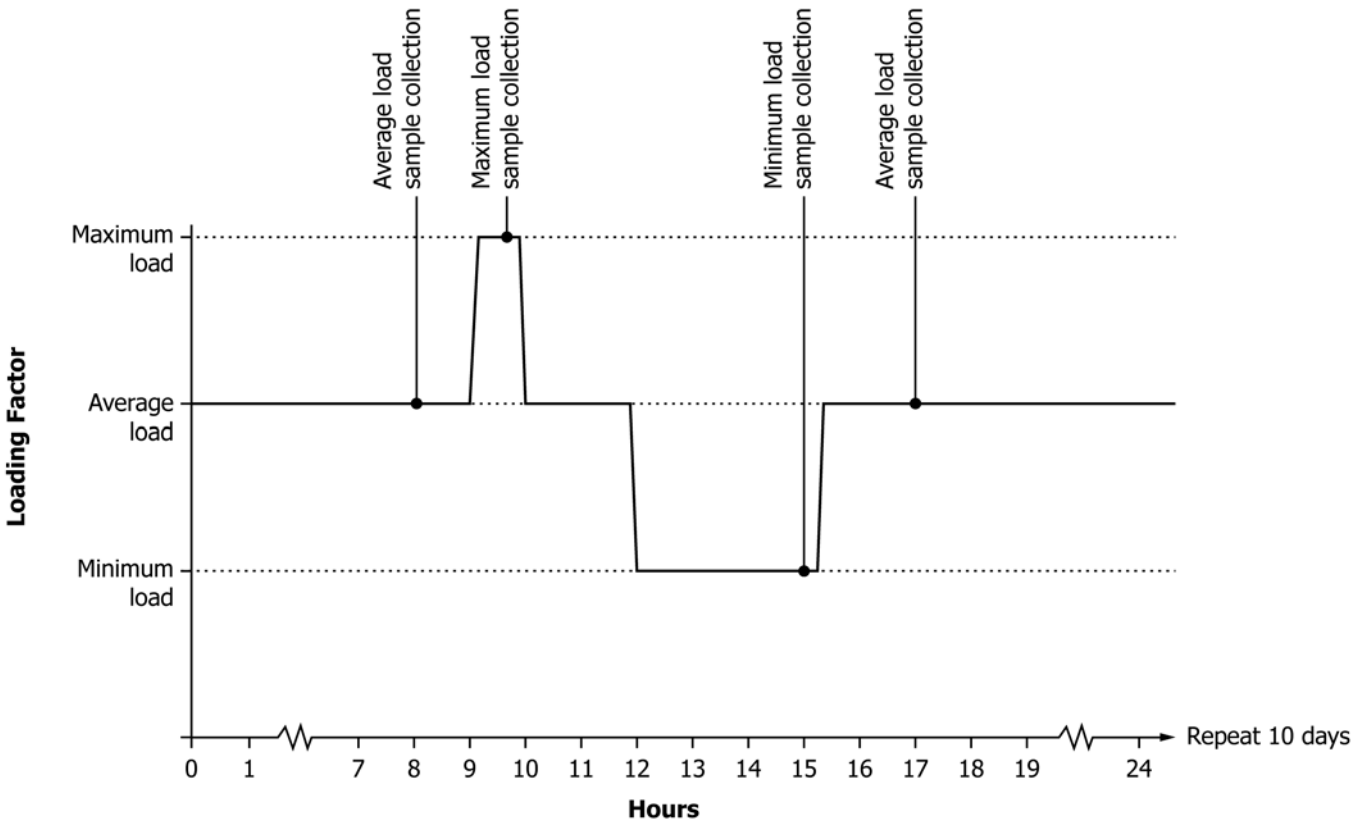

FIG. 1 Sampling Frequency for Testing Treatment Systems

11.16.1.1 ISO 15705; or

11.16.1.2 Other equivalent test standards as accepted by the certifying body.

11.17 *pH test:*

11.17.1 *Type II-B or II-C Treatment Systems*—pH in samples of effluent taken during the test period shall be between 6 and 8.5.

11.18 *Residual Chlorine Test:*

11.18.1 *Type II-B Treatment Systems*—Concentration of total residual chlorine in samples of effluent taken during test period shall be ≤500 µg/L using:

11.18.1.1 Direct amperometric titration in Test Method D1253;

11.18.1.2 DPD colorimetric method in SM 4600-Cl (G); or

11.18.1.3 Other equivalent test standard as accepted by the certifying body.

11.18.2 *Type II-C Treatment Systems*—Concentration of total residual chlorine in samples of effluent taken during test period shall be ≤10 µg/L by using one of the methods specified for Type II-B treatment systems in 11.18.1.

11.19 *Tilt Operating Test:*

11.19.1 *Type I, II-A, II-B or II-C Treatment Systems*—During wastewater processing test, treatment system shall operate for ≥1 h each test day at an angle of 22.5° or the maximum angle specified by manufacturer, whichever is greater. Over the course of the multi-day test period, treatment system shall be tilted at least twice in each of the cardinal directions in the vertical plane.

11.20 *Vapor and Gas Test:*

11.20.1 Treatment system shall be visually examined for compliance with the performance requirement in 7.11 for venting and over-pressurization.

11.21 *Control and Operation Test:*

11.21.1 During wastewater processing test, treatment system control system should be tested to demonstrate control and automation alarms in 7.12.

11.21.2 If not demonstrated during wastewater processing, then treatment system shall be filled with water and conditions simulated to demonstrate control and automation alarms.

11.22 *Accessibility Test:*

11.22.1 Treatment system shall be visually examined for accessibility in 7.13.

11.23 *Zero or Non-detected Values:*

11.23.1 For coliforms, zero values should be replaced with a value of 1 coliform/100 mL to allow for calculation of geometric mean.

11.23.2 For total suspended solids, biochemical oxygen demand, and chemical oxygen demand, values below the limit of detection should be replaced with one half the limit of detection to allow for calculation of geometric mean.

12. Inspection

12.1 Manufacturer shall afford purchaser's inspector all reasonable facilities necessary to satisfy him that the material is being furnished in accordance with this specification.

12.2 Inspection by the purchaser shall not interfere unnecessarily with manufacturer's operations.

12.3 All examinations and inspections shall be made at place of manufacture, unless otherwise agreed upon.

12.4 Treatment system manufacturer shall allow representatives from the certifying body and testing facility access to manufacturer's facilities and to all records required for treatment system certification.

13. Rejection and Rehearing

13.1 Manufacturer shall maintain production quality of treatment systems that are designed, tested, and marked in accordance with this specification.

13.2 Treatment systems that fail to conform to the requirements of this specification may be rejected.

13.2.1 Rejection should be reported to the producer or supplier promptly and in writing.

13.2.2 In case of dissatisfaction with the results of the test, producer or supplier may make claim for a rehearing.

13.3 At no time shall a treatment system be sold with this standard specification designation that does not meet the requirements herein. See Section 14.

14. Certification

14.1 Application for certification of treatment system shall be submitted in writing, signed by an authorized representative of the treatment system manufacturer, to a certifying body in Annex A1 and include the following:

14.1.1 *Design*—Drawings, specifications, and other design information that describes the materials, construction, and operation of the treatment system;

14.1.2 *Quality Assurance*—Description of manufacturer's production quality control and inspection methods, record keeping systems pertaining to the manufacture of treatment system, and testing procedures;

14.1.3 *Instructions*—Installation, operation, and maintenance instructions for the treatment system;

14.1.4 *Manufacturer*—Name and address of applicant and manufacturing facility;

14.1.5 *Prior Approvals*—Authorized deviations, exceptions, or equivalencies, if any, approved by the certifying body; and

14.1.6 *Test Rport*—Test report, prepared and signed by a representative of the independent laboratory, detailing the performance requirements in Section 7 and the results for each test in Section 11, including specific test methods, procedures, and standards used and any failed tests, as well as the following:

14.1.6.1 Name and address of independent laboratory that evaluated, inspected, and tested the treatment system for compliance with this standard;

14.1.6.2 Evaluation of treatment system design, materials, and manufacture for compliance with Section 6; and

14.1.6.3 Evaluation of manufacturer's quality control program and equipment instructions as described in 14.1.2 and 14.1.3.

14.2 *Changes:*

14.2.1 Changes to a certified treatment system shall be approved by the certifying body.

14.2.2 Manufacturer shall notify the certifying body in writing of any proposed change in design, materials, or manufacturer of a treatment system certified to this standard, including:

14.2.2.1 Description of the proposed change;

14.2.2.2 Reason for the proposed change, including advantages; and

14.2.2.3 Recommendation from the test facility as to whether the treatment system will remain in all material respects substantially the same as the original test unit.

14.2.3 Additional testing, in whole or in part, may be required by the certifying body.

15. Product Marking

15.1 *General:*

15.1.1 Markings and instructions shall withstand loss of legibility from normal wear and tear, exposure to water, salt spray, direct sunlight, heat, cold, and substances listed in Table 4.

15.1.2 Alteration, removal, or replacement of markings shall be obvious.

15.1.3 Typeface shall use alphabet of letters, numerals, and symbols of at least 3 mm [⅛ in.] in height in accordance with Specification F906 Type 1.

15.1.4 Language shall be at least in English, French, or Spanish.

15.2 *Nameplate:*

15.2.1 Treatment system shall be marked using fixed nameplate, stamped lettering, or other permanent marking containing the following information:

15.2.1.1 Name of manufacturer;

15.2.1.2 Name and model number;

15.2.1.3 Month and year of completion of manufacture;

15.2.1.4 Serial number;

15.2.1.5 Type, as described in Section 4;

15.2.1.6 Designed hydraulic loading, in m^3/day [gal/day];

15.2.1.7 Designed organic loading, in kg/day [lb/day] BOD;

15.2.1.8 ASTM F2363/F2363M-12 designation; and

15.2.1.9 Other internationally recognized standards, if applicable.

15.3 *Placards:*

15.3.1 Treatment system shall be marked using fixed placard, stamped lettering, or other permanent marking containing the following information:

15.3.1.1 Operating instructions;

15.3.1.2 Safety precautions;

15.3.1.3 Warnings; and

15.3.1.4 Wiring diagram inside control panel, cabinet door, or other suitable location.

15.4 *Piping:*

15.4.1 Treatment system piping shall be marked with service (for example, graywater, sewage, water, etc.) and direction.

15.4.2 Pressure and size of piping shall be provided to the purchaser.

15.5 *Instructions:*

15.5.1 Installation, operation, and maintenance instructions for treatment system shall be provided and shall include at least the following information:

15.5.1.1 Manufacturer name, address, telephone number, and other contact information;

15.5.1.2 Name and model number;

15.5.1.3 Type, as described in Section 4;

15.5.1.4 Designed hydraulic loading, in m^3/day [gal/day];

15.5.1.5 Designed organic loading, in kg/day [lb/day] BOD;

15.5.1.6 Designed thermal loading, in terms of minimum and maximum influent temperature in °C [°F];

15.5.1.7 Designed flow rate of flushwater, in L/h [gal/h];

15.5.1.8 Designed flow rate of process water and other added liquids, in L/h [gal/h];

15.5.1.9 ASTM F2363/F2363M-12 designation;

15.5.1.10 Other internationally recognized standards, if applicable;

15.5.1.11 Statement in 33 CFR 159.57(a)(17), if required;

15.5.1.12 Parts list;

15.5.1.13 Schematic, showing the relative location of each part;

15.5.1.14 Wiring diagram;

15.5.1.15 Power requirements, including voltage and current;

15.5.1.16 Electrical disconnect switch requirements;

15.5.1.17 Electrical lock out and tag out procedures;

15.5.1.18 Supply circuit overcurrent protection;

15.5.1.19 Piping and electrical connections;

15.5.1.20 Backflow prevention, including any additional requirements for backflow protection devices to be installed in ship's piping;

15.5.1.21 Sampling ports, including any additional requirements for sampling ports to be installed in ship's piping;

15.5.1.22 Clearance for safety and access to parts for service;

15.5.1.23 Ventilation requirements for treatment system, including installation of dedicated vent fan to manage ventilation pressure and fumes;

15.5.1.24 Ventilation requirements for compartment where treatment system will be installed, including: (*1*) number of air exchanges per hour of ambient air; and (*2*) installation of sensors and alarms for high level hydrogen sulfide and low level oxygen concentrations;

15.5.1.25 Whether treatment system is designed to operate using saltwater, freshwater, or both;

15.5.1.26 Chemicals required to operate treatment system, type and quantity;

15.5.1.27 Precautions for required chemicals, including handling, storage, and use;

15.5.1.28 Personnel protective equipment, including emergency eye wash station or bottle and hand cleaning basin with means for disinfection;

15.5.1.29 Description of maintenance for the user to perform without coming into contact with sewage, graywater, or chemicals;

15.5.1.30 Testing frequency of relief valves, if any, including a copy of the original testing certificate by pump manufacturer;

15.5.1.31 Cleaning procedures;

15.5.1.32 List of cleaning materials that will: (*1*) disrupt operations or damage treatment system; and (*2*) not disrupt operations or damage treatment system;

15.5.1.33 Sludge removal procedures;

15.5.1.34 Winter lay-up procedures;

15.5.1.35 Maximum angle of tilt during operation, in degrees;

15.5.1.36 Maximum hydrostatic pressure of holding and retention tanks, if any, that are designed to operate under pressure, in kPa [psig];

15.5.1.37 Maximum operating level of holding and retention tanks, if any; and

15.5.1.38 Minimum and maximum operating, layup, and storage temperatures, in °C [°F].

16. Keywords

16.1 sewage; graywater; flow-through treatment; marine sanitation device; MSD

17. Supplementary Requirements

17.1 *General:*

17.1.1 Supplementary requirements shall apply only when specified by the purchaser in the purchase order or contract.

17.1.2 When specified in the purchase order or contract, treatment system shall be certified in accordance with Section 14 and shall meet the additional supplementary requirements in this section.

17.2 *Human Engineering Design:*

17.2.1 Treatment system shall be designed and installed to conform to human engineering principles in accordance with Practice F1166 to the degree that it will be operated and maintained by a 152.4 cm [5 ft, 0 in.] tall male or female as well as 185.4 cm [6 ft, 1 in.] tall male or female.

17.2.2 Design shall also reflect personnel safety factors, including the elimination or minimization of the potential for human error during operation and maintenance of treatment system under routine, non-routine, or emergency conditions.

18. Special Government Requirements

18.1 *For U.S. government procurement only:*

18.1.1 *General*—Treatment system procured by the U.S. government (for example, for installation on US government vessels) shall be certified by the United States in accordance with Section 14 and shall meet the additional special government requirements in this section.

18.1.2 Except as otherwise specified in the contract:

18.1.2.1 Contractor is responsible for the performance of all inspection and test requirements specified herein; and

18.1.2.2 Contractor shall be permitted to use his own or any other suitable facilities for the performance of the inspection and test requirements specified herein, unless disapproved by the purchaser at time of purchase.

18.1.3 Purchaser shall have the right to perform any of the inspections and tests at the same frequency as set forth in this

Specification where such inspections are deemed necessary to assure that material conforms to prescribed requirements.

18.1.4 *Certification Testing:*

18.1.4.1 Treatment system shall be capable of passing one-time certification testing, either during construction of new surface ships, crafts, or boats, or during backfit, as provided for in DoD 4715.6-R1 for marine sanitation devices in public vessels owned or operated by the United States Department of Defense.

18.1.4.2 Recertification may be required when significant design changes occur to existing certified treatment systems, such as modification to piping or pumping systems, changes to the influent stream (for example, from sewage only to combined sewage and graywater) or other ship changes. Consult the relevant DoD component for details to determine recertification applicability.

18.1.5 *Design Considerations:*

18.1.5.1 Electrical power services available for the treatment system are: (*1*) 440 V, 60 Hz, 3 phase; and (*2*) 110 V, 60 Hz, 1 phase.

18.1.5.2 Seawater at 690 to 1207 kPa [100 to 175 psig]. Actual value will vary over time and depending on shipboard location.

18.1.5.3 Fresh water at 414 kPa [60 psig] up to 37.9 L/min [10 gpm] at 21.1°C [70°F].

18.1.5.4 Ship service compressed air at 862 kPa [125 psig].

18.1.5.5 Air supply to the space at a maximum 32.2°C [90°F] with a wet bulb of 27.2°C [81°F].

18.1.5.6 Compartment ventilation, as required.

18.1.5.7 Airborne noise shall meet SNAME T&R Bulletin 3-37.

18.1.5.8 Treatment systems that utilize incineration as a means of treatment technology shall comply with Specification F1323.

18.1.5.9 Chlorinated plastics shall not be used in the construction of the treatment system or any subsystem.

18.1.5.10 Hydrogen sulfide alarms and monitors shall be installed in the treatment system operating space to ensure crew safety.

18.1.6 *Human Engineering and Training:*

18.1.6.1 Human-machine interfaces shall minimize both the potential for and the consequence of human error.

18.1.6.2 Level of training required shall be: (*1*) ≤2 h for operating personnel; and (*2*) ≤5 h for maintenance personnel.

18.1.7 *Process Monitoring:*

18.1.7.1 Treatment system operation, performance monitoring, and operator intervention shall be through the use of a programmable logic controller (PLC), or equivalent, having automated controls necessary to maintain set point operating conditions. Set points to control treatment processes are to be determined by the manufacturer.

18.1.7.2 Operating (that is, logic) program for PLC, or equivalent, shall be tested for safety and reliability of the process monitoring system.

18.1.7.3 Operating program used for: (*1*) vital control, (*2*) alarm, or (*3*) monitoring systems shall be stored in non-volatile memory. In the event of power loss, PLC shall automatically operate after power is restored without the need for reloading the operating program.

18.1.7.4 PLC or equivalent shall provide for fail-safe control of all machinery, electric motors, drives, solenoids valves, and other devices that could cause personnel injury or equipment damage.

18.1.7.5 Low voltage electronics, including PLCs, shall be designed with due consideration for static discharge, electromagnetic interference, voltage transients, fungal growth, and contact corrosion.

18.1.7.6 Control interface shall clearly communicate all information to the operator that is required to ensure efficient and safe operation of the treatment system process.

18.1.8 *Treatment System Supportability:*

18.1.8.1 Reliability and maintainability characteristics of the treatment system shall be such to ensure that the crew of a ship can, with a high degree of confidence, consistently dispose of the waste stream as defined by purchaser.

18.1.8.2 Treatment system shall be designed for an operational life of ≥10 years, taking into account minimization of failures as well as scheduled maintenance and replacement of parts.

18.1.8.3 Treatment system shall be designed to allow for ease of routine cleaning and preventative maintenance.

18.1.8.4 Design of all components shall be consistent with an at sea working environment.

18.1.8.5 Treatment system shall have an operational availability a_0 of ≥0.90 over a six month operating profile.

18.1.8.6 For organizational level corrective maintenance, treatment system shall have a geometric mean time to repair ($MTTR_g$) of <4 h for 95 % of the time and a maximum repair time (M_{max}) of <12 h for 95 % of the time. Repair times do not include the time required to start up treatment system and produce satisfactory effluent. Organizational maintenance shall include any maintenance required during ship deployments, which are up to six months in duration.

18.1.8.7 Treatment system shall meet MIL-S-167-1 and shall be free from vibration that could result in damage or the potential of damage to the ship structure, machinery, equipment, and systems, or interfere with the operation of the ship, its cargo systems, or any ship component.

18.1.8.8 Treatment system shall have no resonant frequencies of its parts or structure below 40 Hz.

18.1.8.9 Treatment system shall meet Grade B, Class 1 for MIL-S-901, or as specified by ship requirements.

18.1.9 *Unacceptable Failures:*

18.1.9.1 Catastrophic failures that result in death or system loss and are of remote likelihood to occur.

18.1.9.2 Critical failures that cause severe injury, illness, or major system damage and are of probable likelihood to occur.

18.1.9.3 Marginal failures that cause minor injury or illness or system damage and are expected to occur frequently.

18.1.10 *Minimizing Failures*—The following failures shall be minimized to the greatest possible extent:

18.1.10.1 Catastrophic failures that are of improbable likelihood to occur.

18.1.10.2 Critical failures that are of occasional likelihood to occur.

18.1.10.3 Marginal failures that are of probable likelihood to occur.

ANNEX

(Mandatory Information)

A1. CERTIFYING BODIES

A1.1 Certifying bodies listed below have adopted this Specification for approval of treatment systems to be installed on ships flying the country's flag.

A1.1.1 *United States*—Application for certification of treatment systems meeting this standard are to be sent to the U.S. Coast Guard Marine Safety Center, 2100 2nd Street SW, Stop 7102, Washington DC, 20593-7102. For certification of equipment that will be installed on U.S. vessels, treatment system manufacturer shall use an independent laboratory accepted by the U.S. Coast Guard to perform the required evaluation, inspection, and testing listed in this standard. For U.S. vessels that engage in international voyages, use a qualified facility accepted by the U.S. Coast Guard instead. For a list of both recognized and qualified facilities, see http://cgmix.uscg.mil under approval series 159.015 for sewage pollution prevention equipment.