

Standard Specification for Sewage and Graywater Flow Through Treatment Systems¹

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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.*

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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

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 breakers⁵
- ANSI/ASSE 1013** Performance requirements for reduced pressure principle backflow preventers and reduced pressure principle fire protection backflow preventers⁵
- 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 generators⁵
- DoD 4715.6-R1** Regulations on vessels owned or operated by the Department of Defense⁷
- 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 designation⁸
- IEC 60092-350** Electrical installations in ships—Part 350: General construction and test methods of power, control, and instrumentation cables for shipboard and offshore applications⁸
- 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 kV⁸
- 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 platforms⁹
- MIL-S-167-1** Test method standard for mechanical vibrations of shipboard equipment¹⁰
- MIL-S-901** Requirements for shock tests: High-impact shipboard machinery, equipment, and systems¹⁰
- NFPA 70** National Electrical Code¹¹
- SNAME T&R Bulletin 3-37** Design guide for shipboard airborne noise control¹²
- SM 4600-Cl** Chlorine (residual)—Standard methods for the examination of water and wastewater¹³
- UL 913** Intrinsically safe apparatus and associated apparatus for use in class I, II, and III, division 1, hazardous (classified) locations¹⁴
- UL 1203** Explosion-proof and dust-ignition-proof electrical equipment for use in hazardous (classified) locations¹⁴
- UL 1309** Marine shipboard cables¹⁴

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 Varembe, 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 *n*th 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	...	...	...	...	...	...

^AAmounts 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.

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.

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

^ASubstance list may vary by treatment system type, ship type, etc.

^B"X" indicates the listed substance is common.