Designation: F1323 – 14

An American National Standard

Standard Specification for Shipboard Incinerators[1]

This standard is issued under the fixed designation F1323; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This specification covers the design, manufacture, performance, operation, functioning, and testing of incinerators intended to incinerate garbage and other shipboard wastes generated during the ship's normal service (that is, maintenance, operational, domestic, and cargo-associated wastes).

1.2 This specification is a companion document to Guide F1322.

1.3 This specification applies to those incinerator plants with capacities up to 4000 kW per unit.

1.4 Additional information is given in Appendix X1 – Appendix X8.

1.5 This specification does not apply to systems on special incinerator ships, for example, for burning industrial wastes such as chemicals, manufacturing residues, and so forth.

1.6 This specification does not address the electrical supply to the unit nor the foundation connections and stack connections.

1.7 *It is possible that this standard will involve hazardous materials, operations, and equipment. 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. If an incinerator is to be operated in coastal regions, the strictest governing regulations for those countries in which the incinerator would potentially operate would form the requirement basis.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

F1166 Practice for Human Engineering Design for Marine Systems, Equipment, and Facilities

F1322 Guide for Selection of Shipboard Incinerators

2.2 *ASME Standard:*[3]

B31.1 Power Piping

B31.3 Process Piping

2.3 *ASME Boiler and Pressure Vessel Code:*[4]

Section I Power Boilers

Section IX Welding and Brazing Qualifications

2.4 *IMO Conventions:*[5]

SOLAS 74 International Convention for the Safety of Life at Sea (SOLAS), 1974, as amended

MARPOL 74 International Convention for the Prevention of Pollution from Ships (MARPOL), 1973, as amended

2.5 *Underwriter's Laboratory Standards:*[6]

UL 506 Standard for Specialty Transformers

UL 814 Standard for Gas-Tube Signs and Ignition Cables

2.6 *Other Documents:*[7]

NFPA No. 70 National Electrical Code (NEC)

NOTE 1—Incinerators designed and manufactured in accordance with alternative standards must show compliance with this specification.

3. Terminology

3.1 *Definitions:*

3.1.1 *administration, n*—means the Government of the State whose flag the ship is entitled to fly.

3.1.2 *cargo residues, n*—means the remnants of any cargo which are not covered by Annexes to MARPOL and which remain on the deck or in holds following loading or unloading, including loading and unloading excess or spillage, whether in wet or dry condition or entrained in wash water but does not

[1] This specification is under the jurisdiction of ASTM Committee F25 on Ships and Marine Technology and is the direct responsibility of Subcommittee F25.06 on Marine Environmental Protection.

Current edition approved Nov. 1, 2014. Published January 2015. Originally approved in 1990. Last previous edition approved in 2008 as F1323 – 08. DOI: 10.1520/F1323-14.

[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.

[3] Available from American Society of Mechanical Engineers (ASME), ASME International Headquarters, Two Park Ave., New York, NY 10016-5990, http://www.asme.org.

[4] Available from American Society of Mechanical Engineers (ASME), ASME International Headquarters, Three Park Ave., New York, NY 10016-5990, http://www.asme.org.

[5] Available from the International Maritime Organization, 4 Albert Embankment, London SE1 7SR, UK.

[6] Available from Underwriters Laboratories (UL), 333 Pfingsten Rd., Northbrook, IL 60062-2096, http://www.ul.com.

[7] Available from National Fire Protection Association (NFPA), 1 Batterymarch Park, Quincy, MA 02169-7471, http://www.nfpa.org.

include cargo dust remaining on the deck after sweeping or dust on the external surfaces of the ship.

3.1.3 *domestic waste, n*—all types of wastes not covered by Annexes to MARPOL that are generated in the accommodation spaces on board the ship.

3.1.3.1 *Discussion*—Domestic wastes does not include grey water.

3.1.4 *fishing gear, n*—any physical device or part thereof or combination of items that may be placed on or in the water or on the sea-bed with the intended purpose of capturing, or controlling for subsequent capture or harvesting marine or fresh water organisms.

3.1.5 *food wastes, n*—any spoiled or unspoiled food substances and includes fruits, vegetables, dairy products, poultry, meat products and food scraps generated aboard ship.

3.1.6 *garbage*—all kinds of food wastes, domestic wastes and operational wastes, all plastics, cargo residues, incinerator ashes, cooking oil, fishing gear, and animal carcasses generated during the normal operation of the ship and liable to be disposed of continuously or periodically except those substances which are defined or listed in Annexes to MARPOL.

3.1.6.1 *Discussion*—Garbage does not include fresh fish and parts thereof generated as a result of fishing activities undertaken during the voyage, or as a result of aquaculture activities which involve the transport of fish including shellfish for placement in the aquaculture facility and the transport of harvested fish including shellfish from such facilities to shore for processing.

3.1.7 *graywater, n*—drainage from dishwater, galley sink, showers, laundries, baths, and handbasins as long as it is not mixed with sewage.

3.1.8 *incinerator or shipboard incinerator, n*—a shipboard facility designed for the primary purpose of incineration.

3.1.9 *oily rags, n*—rags that have been saturated with oil as controlled in Annex I to MARPOL.

3.1.9.1 *Discussion*—Contaminated rags are rags that have been saturated with a substance defined as a harmful substance in Annexes to MARPOL.

3.1.10 *oil residue (sludge), n*—the residual waste oil products generated during the normal operation of a ship such as those resulting from the purification of fuel or lubricating oil for main or auxiliary machinery, separated waste oil from oil filtering equipment, waste oil collected in drip trays, and waste hydraulic and lubricating oils.

3.1.11 *operational wastes, n*—all solid wastes (including slurries) not covered by Annexes to MARPOL that are collected on board during normal maintenance or operations of a ship, or used for cargo stowage and handling.

3.1.11.1 *Discussion*—Operational wastes also include cleaning agents and additives contained in cargo hold and external wash water. Operational wastes do not include grey water, bilge water or other similar discharges essential to the operation of a ship.

3.1.12 *plastic, n*—a solid material that contains as an essential ingredient one or more high molecular mass polymers and which is formed (shaped) during either manufacture of the polymer or the fabrication into a finished product by heat and/or pressure.

3.1.12.1 *Discussion*—Plastics have material properties ranging from hard and brittle to soft and elastic. For the purpose of this standard, plastic means all garbage that consists of or includes plastic in any form, including synthetic ropes, synthetic fishing nets, plastic garbage bags and incinerator ashes from plastic products.

3.1.13 *recognized classification society, n*—American Bureau of Shipping (ABS) or other classification society that is a participating member of the International Association of Classification Societies (IACS).

3.1.14 *sewage, n*—drainage and other wastes from any form of toilets and urinals; drainage from medical premises (dispensary, sick bay etc.) via wash basins, wash tubs and scuppers located in such premises; drainage from spaces containing living animals; or other waste waters when mixed with drainages defined as sewage.

3.1.15 *ship, n*—a vessel of any type operating in the marine environment and includes hydrofoil boats, air-cushion vehicles, submersibles, floating craft, and fixed or floating platforms.

3.1.16 *waste*—useless, unneeded, or superfluous matter which is to be discarded.

4. Ordering Information

4.1 Orders shall include the following information, in accordance with Guide F1322:

4.1.1 Sizing requirements.

4.1.2 Processing rate requirements.

4.1.3 Additional control requirements.

4.1.4 All applicable requirements contained in the supplemental requirements section.

4.1.5 Any additional requirements required by the purchaser to meet special needs.

5. Materials and Manufacture

5.1 Metal parts of the incinerator exposed to the combustion process shall be made of materials listed in Section I of the ASME Boiler and Pressure Vessel Code.

5.2 Where welded construction is used, welded joint design details, welding, and nondestructive testing of the combustion chamber shall be in accordance with Section I of the ASME Code. Welders and weld procedures shall be qualified in accordance with Section IX of the ASME Code. Alternatively, design, welding (including welders and weld procedures), and testing are permitted to be in accordance with rules of a recognized classification society.

5.3 Piping and piping components associated with incinerators for fuel, sludge, and liquid cargo residues shall comply with ASME B31.1 or ASME B31.3 for design and material requirements.

5.3.1 Fuel oil pressure piping between service pumps and burners shall have a relief valve fitted which will discharge into the suction line or back into the tank.

5.3.2 Pressure piping shall be of seamless steel with a thickness of at least Schedule 80. Short lengths of steel tubing, or annealed copper nickel, nickel copper, or copper pipe and tubing are acceptable for use at the burners for flexibility.

5.3.3 The use of nonmetallic materials for fuel lines is prohibited.

5.3.4 Valves and fittings shall not be threaded in sizes over 2-in. nominal pipe size (NPS) (60-mm outside diameter).

5.3.5 Threaded unions shall not be used on pressure lines in sizes 1-in. NPS (33-mm outside diameter) and over.

5.3.6 Gaskets in fuel piping shall be fire resistant and suitable for the fuel type

5.4 If equipped with an electrically, hydraulically, or pneumatically activated valve, the valve shall be designed to fail closed or in the safe position on loss of power whichever is more appropriate to the applicable system.

5.5 All rotating or moving mechanical and exposed electrical parts shall be protected against accidental contact. All electrical devices shall be enclosed in drip-proof or watertight enclosures.

5.6 The coatings or paints shall not contain any heavy metals, such as, chromium, lead, tin, and so forth, or other materials banned by federal, state, or local authorities.

5.7 Asbestos, mercury, cadmium, polychlorinated biphenyls (PCBs), and chlorinated plastics shall not be used in the construction of the incinerator or any subsystem, including gaskets or lagging materials.

5.8 Refractory shall be resistant to thermal shocks and resistant to normal ship's vibration. The refractory design temperature shall be equal to the combustion chamber design temperature plus 20 % (see 6.1).

5.9 Incinerating systems shall be designed such that corrosion will be minimized on the inside of the systems.

5.10 In systems equipped for incinerating liquid wastes, safe ignition and maintenance of combustion shall be ensured, for example, by a supplementary burner using gas oil/diesel oil or equivalent.

5.11 The incinerating furnace shall be designed so that when it is charged with solid waste either by hand or automatically, the fire dangers shall be avoided and charging is performed without danger to the operating personnel.

5.11.1 For instance, where charging is carried out by hand, except as provided for in 5.11.2, a charging lock shall be provided which ensures that the charging space is isolated from the fire box as long as the filling hatch is open.

5.11.2 Where charging is not affected through a charging lock, an interlock shall be installed to prevent the charging door from opening while the incinerator is in operation or while the furnace temperature is above 220°C (428°F).

5.12 Incinerators equipped with a feeding sluice shall ensure that the material charged will move from the sluice to the combustion chamber. Examples for accomplishing this are the use of a clear path down or a mechanical pusher.

5.13 Interlocks shall be installed to prevent ash removal doors from opening while burning is in progress or while the furnace temperature is above 220°C (428°F).

5.14 The incinerator shall be provided with a safe observation port of the combustion chamber to provide visual control of the burning process and waste accumulation in the combustion chamber. Neither heat, flame, nor particles shall be able to pass through the observation port. An example of a safe observation port is high-temperature glass with a metal closure.

5.15 The outside surface of the combustion chamber(s) shall be shielded from contact such that people would not be exposed to extreme heat (maximum 20°C (68°F) above ambient temperature) or direct contact of surface temperatures exceeding 60°C (140°F). Examples for alternatives to accomplish this are a double jacket with airflow in between or an expanded metal jacket.

5.16 Safety interlocks shall be provided to ensure that the incinerator cannot be operated if the shock cooling subsystem is not functioning properly.

5.17 *Electrical Requirements:*

5.17.1 *General*—Installation requirements shall apply to controls, safety devices, and burners on incinerators.

5.17.1.1 A disconnecting means capable of being locked in the open position shall be installed at an accessible location at the incinerator so that the incinerator can be disconnected from all sources of electrical potential. This disconnecting means shall be an integral part of the incinerator or adjacent to it (see 7.1).

5.17.1.2 All rotating or moving parts that have the potential to cause injury shall be guarded to avoid accidental contact.

5.17.1.3 The electrical equipment shall be so arranged so that failure of this equipment will cause the fuel supply to be shut off.

5.17.1.4 The power supply to the electrical control system shall be from a two-wire branch circuit that has a grounded conductor; otherwise, an isolation transformer with a two-wire secondary shall be provided. When an isolation transformer is provided, one side of the secondary winding shall be grounded.

5.17.1.5 One side of all coils shall be electrically located in the grounded side of the circuit. All switches, contacts, and overcurrent devices shall be electrically located in the ungrounded or "hot" side of the circuit. All electrical contacts of every safety device installed in the same control circuit shall be electrically connected in series. However, special consideration shall be given to arrangements when certain devices are wired in parallel.

5.17.1.6 All electrical components and devices shall have a voltage rating commensurate with the supply voltage of the control system.

5.17.1.7 All electrical devices shall be at least NEMA Type 2 (Drip tight). Electric equipment exposed to the weather shall be at least NEMA Type 4.

5.17.1.8 All electrical and mechanical control devices shall be of a type tested and accepted by a nationally recognized testing agency.

5.17.1.9 The design of the control circuits shall be such that limit, and primary safety controls shall directly open a circuit that functions to interrupt the supply of fuel to combustion units.

5.17.2 *Overcurrent Protection:*

5.17.2.1 Conductors for interconnecting wiring that is smaller than the supply conductors shall be provided with overcurrent protection based on the size of the smallest interconnecting conductors external to any control box.

5.17.2.2 Overcurrent protection for interconnecting wiring shall be located at the point where the smaller conductors connect to the larger conductors. However, overall overcurrent protection is acceptable if it is sized on the basis of the smallest conductors of the interconnecting wiring.

5.17.2.3 Overcurrent protection devices shall be accessible and their function shall be identified.

5.17.3 *Motors:*

5.17.3.1 Motors exposed to dripping or spraying oil or water shall be of drip-proof construction. All motors shall be fully guarded as installed.

5.17.3.2 Motors shall be provided with a corrosion-resistant nameplate specifying information in accordance with NFPA No. 70, Article 430-7.

5.17.3.3 Motors shall be provided with running protection by means of integral thermal protection, or by overcurrent devices, or a combination thereof, in accordance with the manufacturer's instructions that shall be based on the requirements of NFPA No. 70.

5.17.3.4 Motors shall be rated for continuous duty and shall be designed for an ambient temperature of 50°C (122°F) or higher.

5.17.3.5 All motors shall be provided with terminal leads or terminal screws in terminal boxes integral with, or secured to, the motor frames.

5.17.4 *Ignition System:*

5.17.4.1 When automatic electric ignition is provided, it shall be accomplished by means of either a high-voltage electric spark, a high-energy electric spark, or a glow coil.

5.17.4.2 Ignition transformers shall conform to requirements of the UL 506.

5.17.4.3 Ignition cable shall conform to requirements of the UL 814.

5.17.5 *Wiring:*

5.17.5.1 All wiring for incinerators shall be rated for the maximum operating temperature to which it will potentially be exposed. Such wiring shall be in accordance with NFPA No. 70. All wiring between components shall have copper conductors and be constructed in accordance with the NFPA No. 70.

5.17.5.2 All electrical wiring shall have a voltage rating commensurate with the voltage of the power supply.

5.17.5.3 Conductors shall be protected from physical damage where appropriate.

5.17.5.4 Conductors shall be sized on the basis of the rated current of the load they supply.

5.17.6 *Bonding and Grounding:*

5.17.6.1 Means shall be provided for grounding the major metallic frame or assembly of the incinerators.

5.17.6.2 Noncurrent carrying enclosures, frames, and similar parts of all electrical components and devices shall be bonded to the main frame or assembly of the incinerator. Electrical components that are bonded by their installation do not require a separate bonding conductor.

5.17.6.3 When an insulated conductor is used to bond the grounding system for electrical components and devices, it shall show a continuous green color, with or without a yellow stripe.

5.18 Fasteners for components susceptible to vibration shall use self-locking nuts.

5.19 Shredder Requirements (if shredder is used):

5.19.1 The shredder and downstream conveyor/stoker system shall have access ports to enable the operator to access areas where trash is likely to jam.

5.19.2 Interlocks shall be installed on the access ports that enable them to be opened only when the shredder and conveyor/stoker system is de-energized. Access ports that have an open path to the furnace shall be interlocked to prevent them from being opened when the furnace temperature is above 220°C (428°F)

5.19.3 The shredder and downstream conveyor system (if there is no open path from the conveyor to the furnace) shall be capable of being de-energized independently for routine maintenance without having to de-energize the entire incinerator system. The shredder and downstream conveyor system shall be isolated by separate power switches so that they can be locked opened without having to access any other control panel that would have to remain energized to maintain incinerator operation.

6. Operating Requirements

6.1 The incinerator system shall be designed and constructed for operation with the following conditions:

Maximum combustion chamber temperature	1200°C (2158°F)
Minimum combustion chamber temperature	850°C (1560°F)
Preheat temperature of combustion chamber	650°C (1200°F)

For batch-loaded incinerators, there are no preheating requirements. However, the incinerator shall be so designed that the temperature in the actual combustion space shall reach 600°C (1110°F) within 5 min after start.

Prepurge, before ignition	at least 4 air changes in the chamber(s) and stack, but not less than 15 s
Time between restarts	at least 4 air changes in the chamber(s) and stack, but not less than 15 s
Postpurge, after shutoff of fuel oil	not less than 15 s after the closing of the fuel oil valve

6.2 Incinerating systems shall be operated with underpressure (negative pressure) in the combustion chamber such that no gases or smoke can leak out to the surrounding areas (see 7.3.1.3).

6.3 The incinerator shall have warning plates attached in a prominent location on the unit, warning against unauthorized opening of doors to combustion chamber(s) during operation and against overloading the incinerator with waste.

6.4 The incinerator shall have instruction plate(s) attached in a prominent location on the unit that clearly addresses the following:

6.4.1 Cleaning ashes and slag from the combustion chamber(s) and cleaning of combustion air openings before starting the incinerator (where applicable).

6.4.2 Operating procedures and instructions. These shall include system diagrams (combustion/cooling air, fuel,

electrical, and waste processing), and procedures for proper start-up, normal operation, normal shutdown, and emergency shutdown.

6.5 The flue gas shall be shock cooled to a maximum 350°C (660°F) within 2.5 metres from the combustion chamber flue gas outlet.

7. Operating Controls

7.1 The entire unit shall be capable of being disconnected from all sources of electricity by means of one disconnect switch located near the incinerator (see 5.17.1.1).

7.2 There shall be an emergency stop switch located outside the compartment that stops all power to the equipment. The emergency stop switch shall also be able to stop all power to the fuel pumps. If the incinerator is equipped with an induced draft fan, the fan shall be capable of being restarted independently of the other equipment on the incinerator.

7.3 The control equipment shall be so designed that any failure of the following equipment will prevent continued operations and cause the fuel supply to be cut off.

7.3.1 *Safety Thermostat/Draft Failure:*

7.3.1.1 A flue gas temperature controller, with a sensor(s) placed in the flue gas duct, shall be provided that will shut down the burner, and lock out feeder system operation and/or signal the operator not to feed waste if the flue gas temperature exceeds the temperature set by the manufacturer for the specific design. A sensor shall be placed in the flue gas duct within 2.5 metres from the combustion chamber flue gas outlet that will shut down the burner if the flue gas temperature exceeds 350°C (660°F).

7.3.1.2 A combustion temperature controller, with a sensor placed in the combustion chamber, shall be provided that will shut down the burner, and lock out feeder system operation and/or signal the operator not to feed waste if the combustion chamber temperature exceeds the maximum temperature.

7.3.1.3 A negative pressure switch shall be provided to monitor the draft and the negative pressure in the combustion chamber. The purpose of this negative pressure switch is to ensure that there is sufficient draft in the incinerator during operations. The circuit to the program relay for the burner shall be opened and an alarm activated before the negative pressure rises to atmospheric pressure. This is applicable to incinerators fitted with induced draft fans.

7.3.2 *Flame Failure/Fuel Oil Pressure:*

7.3.2.1 The incinerator shall have a flame safeguard control consisting of a flame-sensing element and associated equipment for shutdown of the unit in the event of ignition failure and flame failure during the firing cycle. The flame safeguard control shall be so designed that the failure of any component will cause a safety shutdown and prevent automatic restarting.

7.3.2.2 The flame safeguard control shall be capable of closing the fuel valves in not more than 4 s after a flame failure.

7.3.2.3 The flame safeguard control shall provide a trial-for-ignition period of not more than 10 s during which fuel is to be supplied to establish flame. If flame is not established within 10 s, the fuel supply to the burners shall be immediately shut off automatically. Where a light oil pilot is used, the flame safeguard control shall provide a trial-for-ignition period for the pilot of not more than 10 s. If flame is not established within 10 s, the fuel supply to the pilot shall be immediately shut off automatically.

7.3.2.4 Whenever the flame safeguard control has operated because of failure of ignition, flame failure, or failure of any component, manual reset of the flame safeguard control shall be required for restart.

7.3.2.5 Flame safeguard controls of the thermostatic type, such as stack switches and pyrostats operated by means of an open bimetallic helix, are prohibited.

7.3.2.6 If fuel oil pressure drops below that set by the manufacturer, a failure and lockout of the program relay shall result. This also applies to a sludge oil used as a fuel. (Applies where pressure is important for the combustion process or where a pump is not an integral part of the burner.)

7.3.3 *Motor Overload*—All motors shall be protected in all phases by a thermal overload relay or circuit breaker with thermal overload protection that must be reset manually (see 5.17.3.3).

7.3.4 If there is a loss of power to the incinerator control/alarm panel (not remote alarm panel), the system shall shut down.

7.4 *Fuel Supply*—Two fuel control solenoid valves shall be provided in series in the fuel supply line to each burner. On multiple burner units, a valve on the main fuel supply line and a valve at each burner will satisfy this requirement. The valves shall be connected electrically in parallel so that both operate simultaneously.

7.5 *Alarms:*

7.5.1 When a failure occurs, an audible alarm shall be automatically sounded. A visible indicator shall show what caused the failure. (It is acceptable for the alarm to be provided by the user and for the indicator to cover more than one fault condition.)

7.5.2 Means shall be provided to silence the audible alarm. The visible indicators shall be designed so that, where failure is a safety related shutdown, manual reset is required.

7.6 After shutdown of the oil burner, the exhaust fan or ejector must continue to run until the combustion chamber has cooled sufficiently. This does not apply in the case of an emergency manual trip.

8. Other Requirements

8.1 *Documentation*—A complete operations and maintenance manual with drawings, electric diagrams, spare parts list, and so forth shall be furnished with each incinerator. The combustion air supply requirements shall be specified.

8.2 *Installation*—All devices and components shall, as fitted in the ship, be designed to operate when the ship is upright and when inclined at any angle of list up to and including 15° either way under static conditions and 22.5° under dynamic conditions (rolling) either way and simultaneously inclined dynamically (pitching) 7.5° by bow or stern.

8.3 *Incinerator:*

8.3.1 Incinerators shall be fitted with a pilot burner or spark ignition with sufficient energy to ensure a safe ignition and

combustion. The combustion shall take place at sufficient negative pressure in the combustion chamber(s) to ensure no gases or smoke leaking out to the surrounding areas (see 7.3.1.3).

8.3.2 A drip tray is to be fitted under each burner and under any pumps, strainers, and so forth that require occasional examination.

9. Tests

9.1 *Prototype Tests*—An operating test for the prototype of each design shall be conducted, with a test report completed indicating results of all tests. The tests shall be conducted to ensure that all of the control components have been properly installed and that all parts of the incinerator, including controls and safety devices, are in satisfactory operating condition. Tests shall include those described in 9.3 and 9.4.

9.2 *Factory Tests*—For each unit, if preassembled, an operating test shall be conducted to ensure that all of the control components have been properly installed and that all parts of the incinerator, including controls and safety devices, are in satisfactory operating condition. Tests shall include those described in 9.3.

9.3 *Installation Tests*—An operating test after installation shall be conducted to ensure that all of the control components have been properly installed and that all parts of the incinerator, including controls and safety devices, are in satisfactory operating condition. The requirements for prepurge and time between restarts referred to in 6.1 shall be verified at the time of the installation tests.

NOTE 2—Installation tests shall be conducted by the manufacturer or other engineering personnel familiar with the incinerator operation, or both.

9.3.1 *Flame Safeguard*—The operation of the flame safeguard system shall be verified by causing flame and ignition failures. Operation of the audible alarm and visible indicator shall be verified. The shutdown times shall be verified.

9.3.2 *Limit Controls*—Shutdown as a result of the operation of the limit controls shall be verified.

9.3.2.1 *Oil Pressure Limit Control*—The lowering of the fuel oil pressure below the value required for safe combustion shall initiate a safety shutdown.

9.3.2.2 *Air Pressure Limit Control*—Systems using compressed air-oil atomization shall be tested to verify that the air pressure is above the minimum required for proper atomization.

9.3.2.3 *Other Interlocks*—Other interlocks provided shall be tested for proper operation as specified by the unit manufacturer.

9.3.3 *Combustion Controls*—The combustion control shall be stable and operate smoothly.

9.3.4 *Programming Controls*—Programming controls shall be verified as controlling and cycling the unit in the intended manner. Proper pre-purge, ignition, post-purge, and modulation shall be verified. A stopwatch shall be used for verifying intervals of time.

9.3.5 *Fuel Supply Controls*—The satisfactory operation of the two fuel control solenoid valves for all conditions of operation and shutdown shall be verified.

9.3.6 *Low-Voltage Test*—A low-voltage test shall be conducted on the incinerator unit to demonstrate satisfactorily that the fuel supply to the burners will be automatically shut off before an incinerator malfunction results from the low voltage.

9.3.7 *Switches*—All switches associated with the unit shall be tested to verify proper operation.

9.4 *Emission Requirements:*

9.4.1 *Each incinerator* shall be designed and built to meet the IMO emission limits specified below. Each model shall go through a specified type approval test at the factory or an approved test facility. An IMO Type Approval Certificate shall be permitted to be issued, under the responsibility of the administration, for each model designed, built and tested to this specification.

9.4.2 *The Type Approval Test* shall include measuring of the following parameters:

Maximum capacity	kW or kcal/h kg/h of specified waste kg/h per burner
Pilot fuel consumption	kg/h per burner
O_2 average in combustion chamber/zone	%
CO average in flue gas	mg/MJ
Soot number average	Bacharach or Ringelman Scale
Combustion chamber flue gas outlet temperature average	°C
Amount of unburned components in ashes	% by weight

9.4.3 *Duration of Type Approval Test:*

For sludge oil and solid waste burning	6 to 8 h

9.4.4 *Fuel/Waste Specification for Type Approval Test (% by Weight):*

Sludge oil consisting of:	75 % sludge oil from heavy fuel oil
	5 % waste lubricating oil
	20 % emulsified water
Solid waste (Class 2) consisting of:	50 % food waste
	50 % rubbish containing approximately 30 % paper, 40 % cardboard, 10 % rags, and 20 % plastic. This mixture will have up to 50 % moisture and 7 % incombustible solids.

Classes of Waste:[8]

Class 2 Refuse, consisting of approximately even mixture of rubbish and garbage by weight. This type waste is common to passenger ships' occupancy, consisting of up to 50 % moisture, 7 % incombustible solids, and has a heating value of about 10 000 kJ/kg as fired.

Calorific values	kJ/kg	kcal/kg
Vegetable and putrescibles	5 700	1360
Paper	14 300	3415
Rag	15 500	3700
Plastics	36 000	8600
Oil sludge	36 000	8600
Sewage sludge	3 000	716

Densities	kg/m^3
Paper (loose)	50
Refuse (75 % wet)	720
Dry rubbish	110
Scrap wood	190
Wood sawdust	220

Density of loose general waste generated on board ship will be about 130 kg/m^3.

[8] Waste classification from Incinerator Institute of America.