



Standard Specification for Selection and Application of Field-Installed Cryogenic Pipe and Equipment Insulation Systems on Liquefied Natural Gas (LNG)-Fueled Ships¹

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1. Scope

1.1 This specification provides requirements for the design of thermal insulation systems for cryogenic piping and equipment for liquefied natural gas (LNG)-fueled ship applications. Methods and materials for installation, including jacketing and vapor retarders, are also detailed.

1.2 The pipe and equipment operating temperature range addressed by this specification is from a temperature no warmer than -259°F (-162°C) to all temperatures colder.

1.3 These types of piping systems typically have a small diameter: 3 in. (80 mm) NPS and smaller. However, this specification is not limited to pipes that small.

1.4 This specification does not address the thermal insulation on either LNG fuel tanks or factory installed, pre-insulated pipe insulation assemblies.

1.5 The design of removable/reusable insulation systems is not addressed in this specification.

1.6 Structural design and physical strength of insulation systems are not addressed in this specification. However, the securement of jacketing systems is addressed.

1.7 For above ambient pipe and equipment not carrying LNG, see Practice F683 for insulation practices.

1.8 Insulation system weight is not a design criterion considered in this specification.

1.9 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

1.10 *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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

¹ This specification is under the jurisdiction of ASTM Committee F25 on Ships and Marine Technology and is the direct responsibility of Subcommittee F25.02 on Insulation/Processes.

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1.11 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 ASTM Standards:²

- C165 Test Method for Measuring Compressive Properties of Thermal Insulations
- C168 Terminology Relating to Thermal Insulation
- C177 Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded-Hot-Plate Apparatus
- C680 Practice for Estimate of the Heat Gain or Loss and the Surface Temperatures of Insulated Flat, Cylindrical, and Spherical Systems by Use of Computer Programs
- C835 Test Method for Total Hemispherical Emittance of Surfaces up to 1400°C
- C1136 Specification for Flexible, Low Permeance Vapor Retarders for Thermal Insulation
- C1729 Specification for Aluminum Jacketing for Insulation
- C1767 Specification for Stainless Steel Jacketing for Insulation
- C1809 Practice for Preparation of Specimens and Reporting of Results for Permeance Testing of Pressure Sensitive Adhesive Sealed Joints in Insulation Vapor Retarders
- D696 Test Method for Coefficient of Linear Thermal Expansion of Plastics Between -30°C and 30°C with a Vitreous Silica Dilatometer
- D1621 Test Method for Compressive Properties of Rigid Cellular Plastics
- E84 Test Method for Surface Burning Characteristics of Building Materials
- E96 Test Methods for Water Vapor Transmission of Materials

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.

E136 Test Method for Assessing Combustibility of Materials Using a Vertical Tube Furnace at 750°C

E228 Test Method for Linear Thermal Expansion of Solid Materials With a Push-Rod Dilatometer

E831 Test Method for Linear Thermal Expansion of Solid Materials by Thermomechanical Analysis

F683 Practice for Selection and Application of Thermal Insulation for Piping and Machinery

2.2 Other Standards:

IGF Code International Code of Safety for Ships using Gases or Other Low-Flashpoint Fuels³

Fire Test Procedures Code IMO Resolution MSC 307 (88) Annex 1 Part 1 and Part 5 and Annex 2³

IMO SOLAS 1974 as amended through 2014, Chapter II-2 Regulations 5 and 6³

ISO 8497 Determination of steady-state thermal transmission properties of thermal insulation for circular pipes⁴

MSC 1-Circ 1558 Unified Interpretations of The IGF Code⁵
Title 46 CFR Part 38 Subpart 38.05-2 Design and Construction of Cargo Tanks⁶

Title 46 CFR Part 164 Subpart 164.109 Non-Combustible Materials (SOLAS)⁶

3. Terminology

3.1 Definitions:

3.1.1 For definitions of terms relating to insulating materials used in this specification, refer to Terminology **C168**.

3.2 Definitions of Terms Specific to This Standard:

3.2.1 *rubber membrane vapor retarder, n*—relatively thick, flexible material acting as a vapor retarder, the primary component of which is a rubber or rubberized material such as rubberized asphalt, nitrile rubber, or butyl rubber, combined with one or more secondary components such as aluminum foil, plastic film, and mesh or nonwoven reinforcement.

4. Materials and Manufacture

4.1 Insulation and jacketing material specifications describe those materials that are intended for use in the indicated temperature ranges. The specifications and requirements outlined herein are not intended to prevent the use of materials provided that sufficient technical data are submitted to demonstrate that the proposed material is comparable in quality, effectiveness, durability, and safety to that prescribed by this specification.

4.2 All materials and material properties shall be verified for applicability for use at cryogenic temperatures.

NOTE 1—The metal materials used for construction of the pipe and equipment are usually austenitic stainless steel (see IGF Code).

NOTE 2—The heat transmission studies for a liquefied natural gas (LNG) cargo tank includes a maximum ambient still air temperature of

115°F (46°C) (see 46 CFR 38.05-2) and this design condition is being adopted in this specification for the LNG piping.

NOTE 3—Nitrogen gas at high flow rates, pressures, and temperatures will substantially reduce plant and pipelines downtime by providing efficient purging/blanketing, drying, pressure testing, leak testing, and product displacement solutions in a safe, inert manner. Heated nitrogen gas for purging or cleaning LNG piping and equipment is to be maintained in temperatures equal to or lower than the maximum temperature of 115°F (46°C) (see 46 CFR 38.05-2).

5. General Requirements

5.1 All safety requirements as applicable to ships such as those from the relevant flag administration, the International Convention for the Safety of Life at Sea (SOLAS), and the IGF Code are applicable to the insulation materials and systems described in this specification.

5.2 LNG fuel piping shall be considered a cold service system for both open deck and enclosed spaces. Insulation and the associated vapor retarders, adhesives, as well as insulation pipe fittings shall comply with one of the following flammability requirements:

5.2.1 Be non-combustible by virtue of complying with the criteria of one of the following three: (1) Test Method **E136**, (2) Part 1 of the MO Fire Test Procedures (FTP) Code, or (3) 46 CFR 164.109.

5.2.2 Have a low-flame spread characteristic as determined by IMO FTP Code, Annex 1, Part 5, by exhibiting a critical flux at extinguishment (CFE) not less than 20 kW/m², a heat of sustained burning (Qsb) not less than 1.5 MJ/m², a total heat released (Qt) not exceeding 0.7 MJ, a peak heat release rate (Qp) not exceeding 4.0 kW, and not generating burning droplets.

5.2.3 Exhibit a flame spread index not exceeding 25 as determined by Test Method **E84**.

5.3 All piping and fittings, such as elbows and tees, which carry LNG, shall be insulated and protected by an abuse-resistant protective jacketing or protective finish with an emittance determined by Test Method **C835**; for use in design calculations, see **5.7.1**. Unless otherwise specified, all associated flanges and valves shall also be insulated and jacketed. For more detailed information, see Section 8.

5.4 All insulation systems shall be sealed against water vapor intrusion resulting from sustained high vapor pressure differences between the cold surfaces and the ambient air with a vapor retarder system (details addressed in this specification are found in Section 7). Vapor retarder systems shall have a permeance ≤0.01 perm (0.575 ng/(s·m²·Pa)).

NOTE 4—The designer is to consider the heat gain into the insulated pipes between the LNG fuel tank and the master gas valves (MGVs) when designing the safety system for the LNG fuel tank (see MSC 1-Circ 1558).

5.5 The mechanical insulation system designer shall determine and state whether pipe and equipment insulation are necessary for personnel protection, condensation control, or other design criteria. For design purposes, the warmest LNG temperature shall be −259°F (−162°C).

5.5.1 For personnel protection, the insulation thickness shall be designed to maintain the outer surface of the insulation system above 0°F (−17.7°C) at a chosen set of harsh ambient conditions. For other personnel protection design criteria,

³ Available from International Maritime Organization (IMO), 4, Albert Embankment, London SE1 7SR, United Kingdom, <http://www.imo.org>.

⁴ Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, <http://www.ansi.org>.

⁵ Available from ics.org.ir.

⁶ Available from U.S. Government Printing Office, Superintendent of Documents, 732 N. Capitol St., NW, Washington, DC 20401-0001, <http://www.access.gpo.gov>.