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Standard Specification for Prefabricated Reflective Insulation Systems for Equipment and Pipe Operating at Temperatures above Ambient Air[1]

This standard is issued under the fixed designation C 667; 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.

ε[1] NOTE—A referenced document was added and caveat updated editorially in September 1996.

1. Scope

1.1 This specification covers the requirements for all metal prefabricated, reflective insulation systems for equipment and piping operating at temperatures above ambient in air. Typical applications are in nuclear power-generating plants and industrial plants.

1.2 Reflective insulation is thermal insulation that reduces radiant heat transfer across spaces by the use of surfaces of high reflectance and low emittance.

1.3 The values stated in inch-pound units are to be regarded as the standard. The values given in parentheses are provided for information only.

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:*

C 168 Terminology Relating to Thermal Insulating Materials[2]

C 335 Test Method for Steady-State Heat Transfer Properties of Horizontal Pipe Insulation[2]

C 411 Test Method for Hot-Surface Performance of High-Temperature Thermal Insulation[2]

C 835 Test Method for Total Hemispherical Emittance of Surfaces from 20 to 1400°C[2]

C 854 Test for Resistance to External Loads on Metal Reflective Pipe Insulation[2]

C 1033 Test Method for Steady-State Heat Transfer Properties of Pipe Insulation Installed Vertically[2]

C 1061 Test Method for Thermal Transmission Properties of Non-Homogeneous Insulation Panels Installed Vertically[3]

3. Terminology

3.1 *Definitions:*

3.1.1 Terms relating to thermal insulation materials and testing are in accordance with Terminology C 168.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *convection stops*—seals used to reduce convection losses.

3.2.2 *end supports*—structural members placed at the end of a unit of insulation and fastened to both the inner and outer case. Their primary purpose is to increase the structural integrity of the unit.

3.2.3 *inner case*—the innermost sheet of the unit of insulation (closest to the hot surface). It may perform structural functions in addition to its thermal functions.

3.2.4 *insulation assembly*—an assembly of insulation units arranged and secured together in a prescribed order that comprises the complete insulation for a vessel, pump, pipeline, or other component for a single design objective.

3.2.5 *insulation system*—a collection of insulation assemblies, that when secured together in a prescribed order, comprises the complete insulation for a vessel, pump, pipeline, or other component for a single design objective.

3.2.6 *lap straps*—strips that overlap a longitudinal or circumferential joint in the insulation which aligns adjacent insulation units and may also serve to restrict air infiltration and convection losses and to shed external falling water. They may be integral with one piece of the outer case or separate strips secured to it.

3.2.7 *outer case*—the outermost sheet or the unit of insulation (farthest from the hot surface). It usually performs structural functions in addition to its thermal functions.

3.2.8 *penetrations*—openings in a unit of insulation from the cold surface through to the hot surface.

3.2.9 *reflective liners*—those reflective sheets or foil interposed between the inner and outer case to reflect radiant energy, to minimize emission of radiant energy, and to restrict internal convection.

3.2.10 *thickness*—(see Fig. 1).

3.2.11 *unit of insulation*—a single structurally independent assembly of inner case, outer case, reflective liners, and end supports (if required).

[1] This specification is under the jurisdiction of ASTM Committee C-16 on Thermal Insulation and is the direct responsibility of Subcommittee C16.21 on Reflective Insulation.

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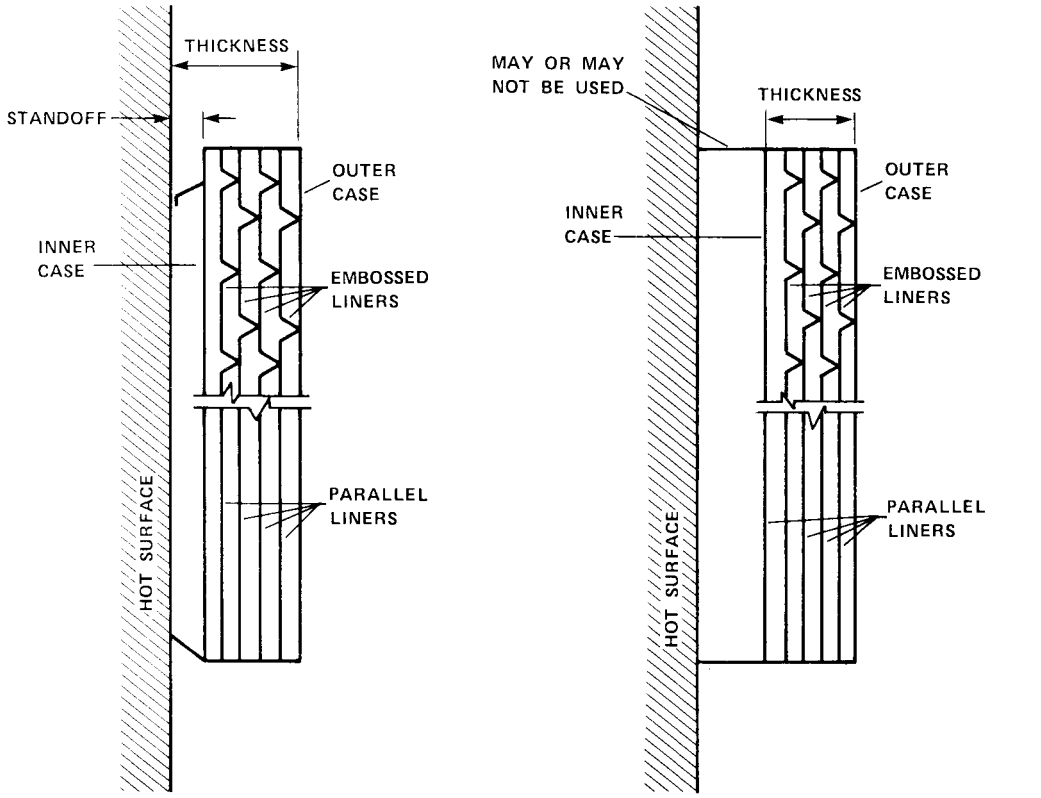
[2] *Annual Book of ASTM Standards*, Vol 04.06.

[3] Discontinued. See 1994 *Annual Book of ASTM Standard*, Vol 04.06.



(*a*) Reflective Insulation Applied to Piping

(*b*) Reflective Insulation Applied to Equipment

FIG. 1 Illustration of Terms Relating to Prefabricated Reflective Insulation Systems

4. Ordering Information

4.1 Ordering information should include the following:

4.1.1 Service requirements including operating hot surface temperature, expected ambient temperatures, and ambient air velocities,

4.1.2 Expected service life and any special environmental exposures,

4.1.3 Permitted average heat loss per unit of cold surface or as otherwise specified,

4.1.4 Personnel exposure surface temperature limitations,

4.1.5 Expected seismic, loading, and vibration exposures,

4.1.6 Purchaser's systems and equipment drawings,

4.1.7 Limits, if any, on size, maximum thickness, weight, or number of insulation units requiring removal for inspection,

4.1.8 Location of components or maintenance, or both, and systems requiring removal of units for inspections,

4.1.9 Any unusual operating or test conditions, and

4.1.10 Cleanliness level required.

5. Materials and Manufacture

5.1 Each insulation unit is a rigid, self-contained, prefabricated metal construction comprised of an inner casing and an outer casing, and if needed, one or more reflective liners supported and spaced so as to minimize internal convection and conduction. These parts are arranged to form a durable rigid assembly with separated air spaces between the inner and outer casing and the individual reflective liners.

5.2 The reflective insulation described herein is limited to systems of insulating units, designed by the manufacturer to fit the equipment or piping to be insulated, and engineered for the purchaser's service requirements.

5.3 All parts of reflective insulation units should be made of metals that meet the thermal, physical, and chemical requirements not only of the insulation as a unit, but also as an assembly of units forming the insulation system. The materials shall perform their functions for the service life specified and be compatible with the environment in which they will be used.

6. Temperature Limitations

6.1 Each insulation unit must effectively limit the flow of heat through the insulation by radiation, convection, and conduction. The reflective liners (also referred to as radiation shields) are made of metals having low surface emittance and high surface reflectance. The emittance should be tested according to Test Method C 835. The number and spacing of the liners are determined by the required limitation of heat flow.

6.2 The temperature limits of various materials should be based on the potential increase in radiant heat transfer across spaces due to a reduction in reflectance and a corresponding increase in emittance resulting from surface oxidation. Individual components of the insulation system which will be elevated to a temperature of 750°F (400°C) or higher should not be made of aluminum or aluminum alloys. If components will be elevated to 1200°F (649°C) or higher, Type 300 series austenitic stainless steel should be used. Other materials and alloys are available for use over 1200°F (649°C).

6.3 A representative unit or assembly shall be tested in

accordance with Test Method C 411.

7. Thermal Performance

7.1 The purchase specification should clearly indicate the permissible average rate of heat loss per unit area for each type of surface. The tests should be in accordance with Test Method C 335 for horizontal pipes, Test Method C 1033 for vertical pipes, or Test Method C 1061 for flat surfaces, or a test method as agreed upon between the purchaser and manufacturer.

7.2 Due to the limitation of present configurations of reflective insulation, those being flat, cone and cylindrical, there can be a significant difference between the hot equipment surface area and the outer case area. Therefore, the thermal performance for equipment should be referenced to the area of the outer case, unless otherwise specified. To be consistent, the outer case area shall also be used for pipe, unless otherwise specified.

7.3 Thermal performance of pipe insulation per unit of cold surface area may be obtained by multiplying transference (T) or conductance (C) as reported by Test Methods C 335 or C 1033, by ratio of the radii of the insulation outer surface (r_2) and the test pipe (r_o). Example:

$$Cc = C \times r_o/r_2 \quad (1)$$

where:

Cc = conductance based on the area of the insulation (cold surface).

7.4 Heat loss shall include consideration of insulation orientation (horizontal or vertical) and the insulation joint design.

7.5 The specification should not limit both heat loss through insulation and outer case temperature at the same time. If personnel exposure to high surface temperatures is considered to be a danger in limited areas, those areas should be explicitly identified with the maximum allowable surface temperature and the ambient design conditions, and one or more of the following alternatives may be required.

7.5.1 External guarding,

7.5.2 Additional insulation,

7.5.3 High emittance outer case, or

7.5.4 Other acceptable techniques agreed upon between the purchaser and the supplier.

7.6 During the field installation, there may be areas where the insulation thickness must be reduced, or insulation sections eliminated altogether, due to obstructions or other interferences. The increased heat loss associated with these modifications must be identified.

8. Design and Construction

8.1 The insulation shall be metal construction and shall form a system of prefabricated insulation units in integrated assemblies designed to fit the surfaces to be insulated with allowance for thermal expansion and contraction.

8.2 Insulation shall be designed to fit the specified surface, being insulated as necessary to limit heat losses due to convection and conduction. Insulation shall be manufactured so that edges or projections do not cause damage to the surface of the insulated pipe or equipment.

8.3 Insulation units shall have end (or edge) supports and convection stops at intervals as required to limit convective heat loss. Insulation units shall have banded and sealed ends, lapped or stepped ends, or a purchaser approved design that minimizes heat leakage at joints. Gaps required for thermal expansion or for internal unit construction are permitted when approved by the purchaser.

8.4 Insulation units and assemblies shall have the strength and rigidity to withstand specified seismic forces, and the operational loading and vibration requirements. Each unit shall have strength and rigidity to hold its internal parts in its spacial relationship without bunching or matting.

8.5 Insulation units and assemblies shall have provisions to retard entrance of liquids and to drain condensate, moisture, or other liquids from spill or other exposures specified in the ordering information.

8.6 Units shall have provisions to prevent internal pressure build-up.

8.7 Attachments, fasteners, and interlocking construction shall hold the insulation units firmly in place in the assemblies under all specified operating and test conditions. Locations of such items on interchangeable insulation units shall be matched.

8.8 Provisions shall be included for mating insulation to branch piping insulation at valves, pumps, and noncylindrical sections for penetrations through the insulation for instrumentation or other purposes.

9. Installation and Removal

9.1 Individual or groups of removable insulation units shall be provided for examination of component surfaces at locations shown on purchaser's drawings, or as otherwise specified or agreed upon between the purchaser and supplier. Insulation assembly design shall permit removal of such units with a minimum of disturbance to adjacent insulation units.

9.2 Insulation units shall be installed either individually or in groups so that replacement, maintenance, examination, and repairs of the insulated components may be performed with minimum disturbance of large portions of the insulation system. Limits on size of groups or number of units shall be as specified by the purchaser.

9.3 The insulation shall permit removal and reinstallation manually without the use of special tools unless otherwise specified by the purchaser.

9.4 The maximum weight of each individual insulation unit or combination units attached together during removal and reinstallation shall be as specified by the purchaser.

10. Cleaning

10.1 Materials shall be kept visibly free of oil, grease, and other dirt during all fabricating operations.

10.2 All materials' components shall be cleaned to an acceptable level as agreed upon between the purchaser and manufacturer.

10.3 Once cleaned, the surface shall be handled so as to limit, to the most practical extent possible, contamination from outside sources.

11. Installation and Inspection

11.1 Since prefabricated reflective insulations are custom-made to fit the vessel or piping to which they are to be

installed, with casing lapping required for slip joints, water-shedding, and weather protection, they must be installed in proper sequence. The insulation manufacturer is expected to provide installation diagrams or procedures, or both, to show the proper sequence of installation.

11.2 Normally, insulation modifications should be referred to the manufacturer. Field cutting or fitting should be done in a workmanlike manner with cuts that are clean and neat and flashed to restrict air flow in or out of the insulation.

11.3 Units of insulation shall be installed in proper sequence with ends closely butted and with lap straps arranged to shed water.

11.4 Fitting, flange, and valve covers shall be installed to mate with straight pipe insulations.

11.5 Where insulation units are secured by bands and seals, the bands should draw the assembly snug, but not so tight as to cause deformation of the assembly.

11.6 Insulation units, equipped with buckles or hinges and snap-locks, are placed in position and secured by fastening the snap-lock or buckle. For field variations of piping or fittings, adjustments should be made for proper fit.

11.7 Where screws are used for securing piping and vessel insulation units, they should be installed in properly drilled holes. Units shall be erected with screws securely tightened, or with locking devices to prevent loosening under vibration or movement. Screws should not be used to secure telescoping assemblies where movement between adjacent units is needed to allow for expansion and contraction.

11.8 Insulation units shall be handled in such a manner so as to maintain the manufacturer's cleanliness level.

11.9 Before installation, other trades working in the area should be made aware that the purpose of the reflective insulation system is for thermal insulation. Other crafts should be warned not to install conduit, piping, or supports in such a way that they will interfere with the application or removal of the insulation. They also should be warned not to strike or damage the insulation in the performance of their duties.

11.10 Insulation and support steel should be handled in such a manner as to prevent damage to the insulation, the insulation support steel, and the items being insulated.

11.11 After erection is completed, there should be a final inspection to ensure that the insulation has been installed in accordance with the manufacturer's instructions. Of extreme importance is the sealing of the insulation system to prevent excessive convective heat loss.

12. Product Marking

12.1 A permanent system of identification and markings of units and assemblies, and correlation with drawings, shall be established by the supplier for approval by the purchaser prior to fabrication. Suppliers shall furnish for review or approval, or both, by owner or his representative the following:

12.1.1 An outline drawing showing the external dimensions for each insulation unit or typical unit. In addition, a drawing showing the internal construction of a typical insulation unit shall be provided that may be used by the purchaser to verify that production units conform to the design of tested units. These drawings shall include:

12.1.2 Material designation,

12.1.3 Spacing between reflective liners,

12.1.4 Information to determine the spacing between inner casing and insulated surface,

12.1.5 Spacing between ventilation stops on vertical piping or equipment,

12.1.6 Method of joining, and

12.1.7 Liner support method.

12.2 *Assembly Drawings*—Assembly drawings shall show the arrangement of the insulation units in each assembly, insulation terminating points, and individually removable insulation units showing the identification mark number of each unit. Instructions for installation shall be shown on these drawings where feasible and, if not feasible, instruction manuals shall be furnished.

13. Packaging, Shipping, Storage, and Handling

13.1 All insulation materials should be shipped, stored, and handled in a manner that will limit contamination from external sources and maintain the cleanliness level as fabricated.

13.2 Shipping containers should be weather-resistant and sturdy to limit entrance of contaminant, and damage to the insulation during shipment and storage.

13.3 Shipping containers should be identified as specified by the purchaser.

13.4 Shipping containers should be arranged in such a manner that identification markings on the outside are clearly visible.

13.5 Insulation should be stored in its *as shipped* condition in the shipping containers to preserve its shop cleanliness level until it is ready to be installed.

13.6 Containers in storage should be elevated high enough above the ground level to provide for drainage of surface water.

13.7 Periodic storage inspection should be conducted until the insulation is removed for installation. The frequency of the inspections should be governed by the results of previous inspections and on-site storage conditions.

14. Keywords

14.1 metallic reflective insulation; nuclear power plants; prefabricated insulation; prefabricated insulation systems; reflective insulation; reflective liners; removable/reusable; thermal performance