Designation: C 592 – 04

Standard Specification for Mineral Fiber Blanket Insulation and Blanket-Type Pipe Insulation (Metal-Mesh Covered) (Industrial Type)[1]

This standard is issued under the fixed designation C 592; 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.

This standard has been approved for use by agencies of the Department of Defense. This specification replaces HH-I-558B in part.

1. Scope

1.1 This specification covers the composition, dimensions, and physical properties of metal-mesh covered mineral fiber (rock, slag, or glass) blanket and blanket-type pipe insulation (typically on 24 in. (610 mm) diameters or larger) for use on cooled surfaces at temperatures operating below ambient to 0°F (−18°C) and on heated surfaces operating at temperatures up to 1200°F (649°C). Specific applications outside the actual use temperatures shall be agreed upon between the manufacturer and purchaser.

1.2 For satisfactory performance, properly installed protective vapor retarders or barriers shall be used on below ambient temperature applications to reduce movement of moisture through or around the insulation to the colder surface. Failure to use a vapor barrier when insulating below ambient systems creates conditions that, unless otherwise treated will lead to insulation and system damage. Refer to Practice C 921 to aid material selection. Although vapor retarder properties are not part of this specification, properties required in Specification C 1136 are pertinent to applications or performance.

1.3 The orientation of the fibers within the blanket is primarily parallel to the heated surface. This specification does not cover fabricated pipe and tank wrap insulation where the insulation has been cut and fabricated to provide fiber orientation that is perpendicular to the heated surface.

1.4 This standard does not purport to provide the performance requirements of hourly-rated fire systems. Consult the manufacturer for the appropriate system.

1.5 See Supplementary Requirements for modifications to paragraphs in this standard when using Specification C 592 in lieu of the United States Department of Defense, Department of Navy, Naval Sea Systems Command, in Washington, DC, Military Specifications No.(s) MIL-I-2818B and MIL-I-2818C.

1.6 The values stated in inch-pound units shall be regarded as the standard. The System International (SI) equivalents of inch-pound units are given in parentheses for information only and are approximate.

1.7 *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 requirements prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:* [2]

C 167 Test Methods for Thickness and Density of Blanket or Batt Thermal Insulations

C 168 Terminology Relating to Thermal Insulating Materials

C 177 Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded-Hot-Plate Apparatus

C 356 Test Method for Linear Shrinkage of Preformed High-Temperature Thermal Insulation Subjected to Soaking Heat

C 390 Criteria for Sampling and Acceptance of Preformed Thermal Insulation Lots

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

C 447 Practice for Estimating the Maximum Use Temperature of Thermal Insulations

C 518 Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus

C 665 Specification for Mineral-Fiber Blanket Thermal Insulation for Light Frame Construction and Manufactured Housing

C 680 Practice for Determination of Heat Gain or Loss and the Surface Temperatures of Insulated Pipe and Equipment

[1] This specification is under the jurisdiction of ASTM Committee C16 on Thermal Insulation and is the direct responsibility of Subcommittee C16.23 on Blanket and Loose Fill Insulation.

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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.

TABLE 1 Physical Requirements

Properties	Type I	Type II	Type III
Maximum use temperature °F (°C) (see 6.2.1) (Excluding metal-mesh facings and metal tie wires/stitching)	850 (454)	1200 (649)	1200 (649)
Apparent Thermal Conductivity[A] (Excluding metal-mesh facings and metal tie wires/stitching) max Btu, in./h ft²°F (W/m K)			
Mean Temperature, °F (°C)			
25 (−4)	0.21 (0.030)	0.21 (0.030)	0.23 (0.033)
75 (24)	0.25 (0.036)	0.25 (0.036)	0.24 (0.035)
100 (38)	0.27 (0.039)	0.27 (0.039)	0.26 (0.038)
200 (93)	0.34 (0.049)	0.34 (0.049)	0.31 (0.045)
300 (149)	0.43 (0.062)	0.42 (0.060)	0.37 (0.053)
400 (204)	0.55 (0.079)	0.53 (0.076)	0.44 (0.063)
500 (260)	0.70 (0.101)	0.64 (0.092)	0.52 (0.075)
600 (316)		0.75 (0.108)	0.60 (0.087)
700 (371)		0.86 (0.124)	0.70 (0.101)
Linear Shrinkage, max % at maximum use temperature	4.0	4.0	4.0
Water Vapor Sorption,[B] max % by weight	5.0	5.0	1.25
Surface Burning Characteristics			
Maximum-flame spread index	25	25	25
Maximum smoke developed index	50	50	50
Density maximum,[C] lb/ft³ (kg/m³)	10 (160)	12 (192)	8 (128)

[A] Values for apparent thermal conductivity are for insulation and do not include mesh and wire through insulation thickness. Therefore, Practice C 680 or other heat loss analysis using these data are not possible without accounting for heat losses through attaching media.

[B] Some water sorption characteristics will change after the product is subjected to elevated temperatures within normal service conditions.

[C] The maximum density specified is for the weight design purpose only and includes weight for the facings. Additional density requirements including the density for the blanket without facing(s) are permitted to be specified by agreement between the purchaser and the manufacturer or seller.

by the Use of a Computer Program

C 921 Practice for Determining the Properties of Jacketing Materials for Thermal Insulation

C 1045 Practice for Calculating Thermal Transmission Properties Under Steady-State Conditions

C 1058 Practice for Selecting Temperatures for Evaluating and Reporting Thermal Properties of Thermal Insulation

C 1104/C 1104M Test Method for Determining the Water Vapor Sorption of Unfaced Mineral Fiber Insulation

C 1114 Test Method for Steady-State Thermal Transmission Properties by means of the Thin-Heater Apparatus

C 1136 Specification for Flexible, Low Permeance Vapor Retarders for Thermal Insulation

C 1304 Test Method for Assessing the Odor Emission of Thermal Insulation Materials

C 1335 Test Method for Measuring the Non-Fibrous Content of Man-Made Rock and Slag Mineral Fiber Insulation

E 84 Test Method for Surface Burning Characteristics of Building Materials

E 136 Test Method for Behavior of materials in a Vertical Tube Furnace at 750°C

2.2 *Other Document:*

CAN/ULC-S102–M88 Standard Method of Test for Surface Burning Characteristics of Building Materials and Assemblies[3]

3. Terminology

3.1 Terminology C 168 shall be the terms used in this specification.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *mean temperature*—the sum of the cold surface temperature and the hot surface temperature divided by two.

3.2.2 *metal-mesh covered blanket*—mineral fiber thermal insulation held together by metal-mesh facings on one or both sides with heat-resistant metal ties attached through the blanket from one face to the other.

3.2.3 *metal-mesh covered blanket-type pipe*—mineral fiber thermal insulation sized to fit around a large Nominal Pipe Size (NPS) and held together by metal-mesh facings on one or both sides with heat-resistant metal ties attached through the blanket from one face to the other.

4. Classification

4.1 Mineral fiber metal-mesh covered blanket insulation covered by this specification shall be classified into the three types shown in Table 1. The classification is based upon the maximum use temperature and apparent thermal conductivity.

5. Ordering Information

5.1 The type, dimensions, maximum use temperature, and facings for one or both sides shall be specified by the purchaser. A product certification shall be specified in the purchase order.

[3] Available from Underwriters Laboratories of Canada, 7 Crouse Road, Scarborough, Ontario, Canada M14 3A9.

6. Materials and Manufacture

6.1 *Composition*—Mineral fiber metal-mesh covered blanket shall be composed of rock, slag, or glass processed from the molten state into fibrous form, bonded with or without an organic binder, and secured with metallic supporting facing(s). Asbestos shall not be used as an ingredient or component part of the product.

6.2 *Facings*:

6.2.1 Types of facings for one or both sides of blanket units shall be specified. When both sides are to be faced, units are permitted to have the same or different types on the two sides. (**Warning**—The user of this specification is advised that the maximum use temperature of some facings and adhesives will be lower than the maximum use temperature of the insulation. For example, usually galvanized hexagonal wire-woven netting and tie wires or stitching perform well under continuous exposure to temperatures up to 392°F (200°C). Exposure to temperatures above this limit will cause the outer free zinc layer to peel. Though there are potential or occasional concerns for corrosion conditions at various temperatures, galvanized wire, stitching, or facings are not recommended for temperatures above 500°F (260°C). In addition, the user of this specification shall ensure that sufficient insulation thickness is installed so that none of the accessory items (facings, adhesive, coatings, and lagging) are exposed to temperatures above their maximum use temperature. Practice C 680 shall be used to determine surface temperatures.)

6.2.2 *Standard Types of Metal Mesh Used as Facings*:

6.2.2.1 Woven netting, No. 20 to 22 gage (0.88 to 0.73 mm) diameter, galvanized wire mesh, 1 in. (25 mm) hexagonal shaped.

6.2.2.2 Woven netting, nonferrous No. 20 to 22 gage (0.82 to 0.64 mm) diameter, 300 series stainless steel wire mesh, 1 in. (25 mm) hexagonal shaped.

6.2.2.3 Stucco expanded metal lath, (painted finish, not flattened, not galvanized) having 1.5 in. (38 mm) diamond-shaped openings, No. 18 gage (1.2 mm) thickness, weighing 1.8 lb/yd^2 (1010 g/m^2).

6.2.2.4 Expanded metal lath, (painted finish, not flattened, not galvanized) having diamond-shaped openings, weighing 2.5 lb/yd^2 (1400 g/m^2).

6.2.3 Other kinds or compositions of facings are permitted to be specified.

6.3 *Manufacture/Fabrication*:

6.3.1 Metallic facing(s) or wire mesh(s) shall be secured to the insulation face on one or both side(s) with minimum (diameter) No. 28 gage (0.32 mm), 300 Series alloy, nonferrous stainless steel tie wires or stitching no greater than 12 in. (305 mm) apart passing vertically through the blanket. Spacing (attachment pattern) for vertical steel tie wires and stitching must include rows within 2 in. (51 mm) from all edges of the blanket.

6.3.2 Minimum (diameter) No. 28 gage (0.41 mm) galvanized steel tie wires or stitching are permitted to be used for securement with galvanized steel facings.

7. Physical Requirements

7.1 *Handling and Transporting*—Each piece of metal-mesh covered insulation shall be coherent to permit handling / transportation and installation as a unit.

7.2 The blanket insulation type shall conform to the following requirements in Table 1: maximum use temperature, density (for weight design purposes only), apparent thermal conductivity, water vapor sorption, and surface burning characteristics.

7.3 *Odor Emission*—A detectable odor of objectionable nature recorded by more than two of the five panel members shall constitute rejection of the material when tested in accordance with 11.6.

7.4 *Corrosiveness to Steel, Copper, Aluminum*—When tested and evaluated in accordance with 11.7, the corrosion resulting from the unfaced insulation blanket in contact with metal plates shall be judged to be no greater than comparative plates in contact with sterile cotton.

7.5 *Non-Fibrous (Shot) Content*—The averaged maximum shot content of mineral fiber rock or slag type products shall not exceed 30 % by weight as defined in 11.3.

7.6 *Maximum Use Temperature*—When tested in accordance with 11.1, the blanket insulation shall not warp, flame, or glow during hot surface exposure. No evidence of melting or fiber degradation shall be evident upon post test inspection.

7.7 *Maximum Exothermic Temperature*—When tested in accordance with 11.1, the blanket mid-point temperature shall not at any time exceed the hot surface temperature by more than 100°F (55.5°C). The 100°F (55.5°C) criterion applies during heat-up as well as steady state conditions. Exceeding this limit constitutes noncompliance to specification.

7.8 *Non-Combustibility*—When tested in accordance with 11.10, shall not exceed the recorded temperature rise more than 54°F (30°C) with no flaming and weight loss exceeding 5 %.

8. Dimensions and Permissible Variations

8.1 *Dimensions*—Standard sizes of metal-mesh blanket insulation shall be as follows:

Length	=	48 in. (1219 mm) and 96 in. (2438 mm) (except for Nominal Pipe Sizes (NPS) system
Width	=	24 in. (610 mm) and 36 in. (914 mm)
Thickness	=	1 to 6 in. (25 mm to 152 mm)[A] in ½ in. (13 mm) increments

[A] Thickness over 2 in. (51 mm) may be composed of two or more blankets plied together to establish total thickness before facings applied.

8.2 *Dimensional Tolerances*—The average measured length, width, and thickness shall differ from the manufacturer's standard dimensions by not more than the following:

		Blanket	Blanket-Type Pipe
Length	=	± ½ in. (13 mm)	± ¼ in. (6 mm)
Width	=	± ¼ in. (6 mm)	Not applicable
Thickness	=	± ¼ in. (6 mm), –⅛ in. (3 mm)	+¼ in. (6 mm), –⅛ in. (3 mm)

8.2.1 *Pipe Diameters (Fit and Closure)*—When fitted around the appropriate size pipe, by banding on 9-in. (229-mm) centers, the longitudinal seams on both sides of the pipe insulation shall close along the entire length of the section or piece.

9. Workmanship

9.1 The insulation blanket shall have good workmanship and shall not have defects that adversely affect its installation and performance qualities.

10. Sampling

10.1 Inspection and qualification of the insulation shall be in accordance with Criteria C 390 or as otherwise specified in the purchase order or contract as agreed upon between the purchaser, supplier, or the manufacturer, or a combination thereof.

11. Test Methods

11.1 *Maximum Use and Exothermic Temperature Rise*—The insulation shall be tested in accordance with Test Method C 411 and the hot surface performance section of Practice C 447 at the insulation's maximum use temperature and at the manufacturer's maximum recommended thickness for that temperature. The test surface shall be at the intended surface temperature when test begins. No special requirements for heat up shall be specified by the manufacturer.

11.2 *Density*:

11.2.1 The thickness and density of insulation shall be tested in accordance with Test Methods C 167.

11.2.2 The maximum density of a rock, slag or glass type of insulation shall not exceed that shown in Table 1. When density is part of the purchase contract, the delivered product density shall be calculated on the basis of single package units excluding the container and metal mesh facing weights and with a tolerance of not more than –10 % on the individual package.

11.3 *Non-Fibrous (Shot) Content*:

11.3.1 The maximum non-fibrous (shot) content that would be retained on all screens (sieves) up to and including 100-mesh (150 µm) screen (sieve) as determined by the test method and calculation procedure in Test Method C 1335.

11.3.2 A minimum of three specimens per lot (shipment) shall determine the averaged non-fibrous (shot) content. The manufacturer shall furnish certification of the shot content of the delivered product if so specified at time of purchase.

11.4 *Apparent Thermal Conductivity*:

11.4.1 The thermal conductivity as a function of temperature for the representative specimens shall be determined with data obtained from a series of thermal tests utilizing Test Methods C 177, C 518, or C 1114 as appropriate for the material under study. Specimen shall be tested unfaced and at a maximum thickness of 2 in. (51 mm).

11.4.1.1 Test Method C 518 shall not be used at temperatures or resistances other than those in the range of the calibration.

11.4.1.2 Test Method C 1114 shall not be used at temperatures or resistance ranges other than those with comparable results to Test Method C 177.

11.4.1.3 Mineral fiber blanket-type insulations for pipes are typically used at 24-in. (610-mm) or larger diameter surfaces. Thermal calculations shall be based on a flat surface.

11.4.2 The test method selected shall have proven correlation with Test Method C 177 over the temperature range of conditions used. In cases of dispute, Test Method C 177 shall be the final authority for material having flat geometry.

11.4.3 Practice C 1058 shall be used to obtain recommended test temperature combinations for testing purposes.

11.4.4 As specified in Practice C 1045, the range of test conditions must include at least one test where the hot surface temperature is greater than, or equal to, the hot limit of the temperature range of desired data and at least one test where the cold surface temperature is less than, or equal to, the cold limit of the temperature range desired. Additional tests, at least two, shall be distributed somewhat evenly over the rest of the temperature range.

11.4.5 Conduct final analysis of the thermal data in accordance with Practice C 1045 to generate a thermal conductivity versus temperature relationship for the specimen.

11.4.6 The final step of Practice C 1045 analysis would be to calculate the thermal conductivity using the equations generated at a set of mean temperatures for comparison to the specification. (**Warning**—While it is recommended that the specification data be presented as conductivity versus temperature, several existing specifications shall contain mean temperature data from tests conducted at specific hot and cold surface temperatures. In these cases, the conductivity as a function of temperature from the Practice C 1045 analysis will provide different results. To insure that the data are compatible, a Practice C 680 analysis, using the conductivity versus temperature relationship from Practice C 1045 and the specific hot and cold surface temperatures, is required to determine the effective thermal conductivity for comparison to the specification requirements.)

11.5 *Surface Burning Characteristics*—Test the surface burning characteristics in accordance with Test Method E 84. For Canada, test in accordance with Test Method CAN/ULC-S102–M88. The test shall be performed with any facing in place, if facing is intended to be the end product. Tests for unfaced mineral fiber blankets are allowed provided the facings are constructed with inorganic materials and contain no organic adhesives.

11.6 *Odor Emission*—The insulation shall be tested in accordance with Test Method C 1304.

11.7 *Corrosiveness to Steel, Copper, and Aluminum*—The insulation shall be tested in accordance with the corrosiveness method of Specification C 665.

11.8 *Water Vapor Sorption*—The insulation shall be tested in accordance with Test Method C 1104/C 1104M for determining vapor sorption of unfaced mineral fiber insulation.

11.9 *Linear Shrinkage*—The insulation shall be tested in accordance with method described in Test Method C 356.

11.10 *Non-combustibility*—Shall be determined with passing Test Method E 136 when all four specimens comply with the reported conditions.

12. Qualification Requirements

12.1 The following requirements shall be employed for the purpose of initial material or product qualification:

12.1.1 Maximum use and exothermic temperatures,

12.1.2 Apparent thermal conductivity,

12.1.3 Non-combustibility,

12.1.4 Water vapor sorption,

12.1.5 Odor emission,

12.1.6 Surface burning characteristics,

12.1.7 Corrosiveness,
12.1.8 Shot content, and
12.1.9 Flexibility.

13. Inspection

13.1 The following requirements are employed for the purpose of acceptance sampling of lots or shipments of qualified insulation:

13.1.1 This test does not address the effects of thermal bridging due to the effect of the tie wire system,

13.1.2 Density (when specified) (shall be calculated in accordance with 11.2.2),

13.1.3 Dimensional tolerances,

13.1.4 Compliance with facing type specification, facing attachment, and

13.1.5 Workmanship.

14. Rejection

14.1 Failure to conform to the requirements in this specification shall constitute cause for rejection. Rejection shall be reported to the manufacturer or the supplier promptly and in writing. The manufacturer and supplier have the right to verify the results causing the rejection and inspect the rejected products.

15. Certification

15.1 When specified in the purchase order or contract, the manufacturer's or seller's certification shall be furnished to the purchaser stating that samples representing each lot have been manufactured, and inspected in accordance with this specification and the requirements have been met. A report of the test results shall be furnished when specified in the purchase order or contract.

16. Packaging and Marking

16.1 *Packaging*—Unless otherwise specified, the insulation shall be packed in the manufacturer's standard commercial containers.

16.2 *Marking*—Unless otherwise specified, each container shall be plainly marked as follows:

16.2.1 *Blanket Insulation*—Manufacturer name, address and phone number of manufacturer, product name, type, description of facing(s), quantity in square feet (meters) and number of pieces, nominal dimensions, manufacturers lot or date code, and identification of the material in the container.

16.2.2 *Pipe Insulation*—Manufacturer name, address and phone number of manufacturer, product name, type, description of facing(s), quantity in linear feet (meters) and number of pieces, nominal dimensions including pipe size if applicable, manufacturers lot or date code, and identification of the material in the container.

16.3 When specified in the purchase order or contract, each container shall be marked with the appropriate Specification C 592 type.

17. Keywords

17.1 blanket insulation; blanket-type pipe insulation; facing; metal-mesh covered; mineral fiber insulation; stitching; tie wires; vibration resistance

SUPPLEMENTARY REQUIREMENTS

The following supplementary requirements shall apply only when specified by purchaser in the contract or order when Specification C 592 replaces Military Specification No.(s) MIL-I-2818B, MIL-I-2818C, and MIL-PRF-2818D for use by the U.S. Department of Defense, Department of Navy and Naval Sea Systems Command.

S1. *Add 1.8 to Section 1, Scope:*

S1.1 1.8 The Supplementary Requirements and exceptions are for thermal insulation materials on piping, machinery, and equipment for non-nuclear shipboard applications nor applicable on nuclear submarines.

S2. *Replace 4.1 and Add to Section 4, Classification:*

S2.1 4.1 Mineral fiber metal-mesh covered blanket insulation covered by this Supplementary Requirements shall be classified as only Types III shown in Table 1 and Type IV defined in 4.2. The classification is based upon the maximum use temperature and apparent thermal conductivity.

S2.2 4.2 Type IV Mineral fiber blanket insulation is relevant to all the specifications and physical requirements required for Type III blanket insulation including the Supplementary Requirements except that all metal mesh coverings are excluded from the blanket.

S3. *Amend and Add subsections to 6.1 Composition:*

S3.1 *Amend last sentence* 6.1—Asbestos and ceramic (refractory) fibers shall not be used as an ingredient or component part of the product.

S3.2 6.1.1 *Binder*—The organic binder shall not exceed 1.5 % by mass of the total mineral wool blanket mass less any facings and securement wires.

S4. *Amend 6.2.2 Standard Types of Metal Mesh Used as Facings:*

S4.1 *Delete* 6.2.2.1.

S5. *Amend 6.3 Manufacture/Fabrication:*

S5.1 6.3.1 The blanket shall be secured between the metallic facings, wire mesh, or members by 300 series stainless steel tie wire or stitching no greater than 7 in. (178 mm) apart

passing vertically through the blanket. Spacing for vertical wires must include rows within 1 in. (25 mm) from all face edges of the blanket.

S5.2 *Replace* 6.3.2.

S5.2.1 6.3.2 Type IV blanket shall not be secured between any metallic facings, wire mesh, tie wires or stitching. All other physical properties shall be identical to Type III as shown in Table 1.

S6. *Replace 7.5 Non-Fibrous (Shot) Content:*

S6.1 7.5 *Non-Fibrous (Shot) Content*—The averaged maximum shot content of mineral fiber rock or slag type products shall not exceed 20 % by weight as defined in 11.3.

S7. *Add 7.8 Resistance to Vibration to Section 7, Physical Requirements:*

S7.1 7.8 *Resistance to Vibration*—The insulation blanket without supporting members or tie wires, or both, shall not sag, settle, or shake down beyond criteria when tested in accordance within Supplementary Requirements 11.11 *Resistance to Vibration*

S7.8.1 *Rejection Criteria:*

S7.8.1.1 Sag difference of 3 in. (76 mm) between control specimen and either heat treated or heat/vibrated specimens.

S7.8.1.2 Mass loss difference of 15 % between control specimen and either heat treated or heat vibrated specimens.

S7.8.1.3 Detrimental heat or vibration affect the overall physical characteristics of the blanket when comparing to a control specimen. Obvious observations, for example, are the bolts cutting through the insulation material which cause large quantities of fiber or insulation blanket pieces to drop off the test stand holder during or after the test.

S8. *Replace 11.8 Water Vapor Sorption:*

S8.1 11.8 *Water Vapor Sorption*—The insulation shall be tested in accordance with Test Method C 1104/C 1104M for determining vapor sorption of unfaced mineral fiber insulation. The moisture absorption percent will be determined after 6 hours at 120°F (49°C) and 90 % relative humidity.

S9. *Add 11.11 to Section 11, Test Methods:*

S9.1 11.11 *Resistance to Vibration:*

11.11.1 *Scope*—This is a method of determining the sag, settlement, or shake down of the mineral fiber blanket without the attachment of any tie wires or metal mesh coverings (facings). The comparison is between materials before and after heating or vibrating.

11.11.2 *Significance and Use*—It is possible that vibration after heating will create excessive sagging or loss of structural integrity of the insulation, adversely affecting overall thermal performance.

11.11.3 *Apparatus:*

11.11.3.1 Furnace capable to heat uniformly one side of a 24 in. (610 mm) by 36 in. (914 mm) panel at controlled and maintain temperatures of 750 ± 10°F (400 ± 12°C).

11.11.3.2 *Vibration Machine,* capable of timed vibrations at 12 Hz and 0.131 in. (3 mm) amplitude (total displacement 0.131 in. (3 mm)).

11.11.3.3 *Balance Scale,* capable of weighing 4 in. (102 mm) by 24 in. (610 mm) by 36 in. (914 mm) sample up to 24 lb ± 0.7 oz (10.9 kg ± 1 g).

11.11.3.4 Ruler capable of measuring up to 36 in. (914 mm) with ±1⁄32 in. (±1 mm) tolerance.

11.11.4 *Specimens*—Cut with a knife two identical pieces (representative thickness by 24 in. (610 mm) by 36 in. (914 mm) of mineral fiber blanket without tie wires, facings, etc. The mass of each specimen shall be determined to within ± 1 gram and the density shall be calculated. A density difference greater than 20 % will result in rejection of the specimen pair and new specimens shall be prepared. The dimensions of each specimen shall be determined by averaging 10 measurements to with in 1⁄32 in. (1 mm) in each dimension. The final pair of test specimens shall be compared by heat treated and vibration versus static control conditions.

11.11.5 *Procedure for Control Specimen:*

11.11.5.1 One specimen shall be placed on a rigid horizontal surface with 6 in. (152 mm) of the long dimension of the insulation extending beyond the edge of the surface. The vertical distance from the horizontal surface to the bottom on the insulation furthest from the edge shall be measured to ±1⁄32 in. (±1 mm) at ten equally spaced locations. The specimen shall be turned over and the sag measurements repeated. The sag measurements shall be repeated on the opposite end of the specimen to provide four each "sag" average lengths.

11.11.5.2 The measurements shall be completed within 5 to 30 min after the specimen is positioned. The average of the 40 measurements shall be identified as the control specimen sag length.

11.11.5.3 Record the following measurements for comparison:

Mass of controlled specimen
Sag, end up; Sag, end down
Sag, other end up
Sag, other end down
Control specimen "sag"
Mass of specimen
Any pertinent unusual observation

11.11.5.4 The control specimen shall be moved horizontally to one side of the mounting holder for vibration testing. Impale insulation over six evenly spaced 3⁄8 in. (10 mm) diameter bolts and fasten in place with 1 in. (25 mm) washers on the outside face/surface of the insulation blanket. Temporarily set aside the holder until it becomes possible to fasten the heat treated specimen to the other side.

11.11.6 *Procedure for Heat and Vibration:*

11.11.6.1 Weigh the other prepared specimen to within ±0.35 oz (±1 g) immediately before heating and then place on the electrically heated furnace surface. Subject one face (bottom side) of the specimen to the following time temperature schedule heat-up. Expose the top face to ambient room temperature.

Ramp Time	Temperature
0–10 min	Ramp from room temperature to 250°F (121°C)
10–20 min	Ramp from 250°F (121°C) to 500°F (260°C)
20–30 min	Ramp from 500°F (260°C) to 750°F (399°C)
30–300 min	Hold at 750°F (399°C)
After 300 (±5) min	Turn off heat and allow to cool to room temperature for 17 to 24 h

11.11.6.2 Remove specimen from furnace taking particular care not to drop or lose any blanket insulation and weigh to an accuracy of ±0.35 oz (±1 g) to determine after heat treated mass.

11.11.6.3 The sag measurements identified in 11.11.5.1 through 11.11.5.4 shall be completed on the heat treated specimen.

11.11.6.4 After the heat treated specimen has been weighed and tested for sag, and horizontally move the blanket insulation to the mounting holder for vibration testing. Impale the heat treated blanket to the other side of the holder containing the control specimen on six equally spaced 3/8 in. (10 mm) diameter bolts and fasten with 1 in. (25 mm) washers on the outside face/surface of the blanket material.

11.11.6.5 Rotate the holder assembly containing both specimens to a vertical position and bolt to the vibration machine.

11.11.6.6 Operate vibration machine for 6 h at 12 Hz and amplitude total displacement 0.131 in. (3 mm).

11.11.6.7 After vibration time has expired, removed the holder from the vibration machine and remove the "control/vibrated" specimen for weighing.

11.11.6.8 Move control/vibrated specimen back to the original horizontal surface referenced in paragraph 11.11.5.1 and perform the total sag testing procedures per 11.11.5.1 through 11.11.5.4.

11.11.6.10 Move heat/vibrated specimen back to the horizontal surfaced referenced in 11.11.5.1 and perform the total sag testing procedure per 11.11.5.1 through 11.11.5.4.

11.11.7 *Calculations:*

11.11.7.1 Calculate the sag difference(s) as follows:

$$S_c - S_h = S_{dh} \text{ or } S_c - S_{hv} = S_{dhv}$$

where:

S_c = average 40 measurements of sag on the control specimen,
S_h = average 40 measurements of sag on the heat treated specimen,
S_{hv} = average 40 measurements of sag on the heat/vibrated specimen,
S_{dh} = total sag difference, heat treated, and
S_{dhv} = sag difference, heated/vibrated.

11.11.7.2 Calculate mass loss differences in percent as follows:

$$\frac{Wc - Wh}{Wc} = (P_{dh})\ \% \text{ or } \frac{Wc - Whv}{Wc} = (P_{dhv})\ \%$$

where:

Wc = mass of control specimen,
Wh = mass of heat treated specimen,
Whv = mass of heat/vibrated specimen,
P_{dh} = percent difference, heat treated, and
P_{dhv} = percent difference, heated/vibrated.

11.11.8 *Precision and Bias:*

11.11.8.1 *Precision*—It is not possible to specify the precision of the procedure in 11.11 *Resistance to Vibration* because the only test data and details for 28 mineral fiber high temperature insulation specimens were provided by Tennessee Technological University for the Naval Ship Systems Engineering Station. This test research report by Dr. David W. Yarbrough has been filed at ASTM International Headquarters.

11.11.8.2 *Bias*—No information can be presented on the bias of the procedure in 11.11 *Resistance to Vibration* because no material having an acceptable reference value is available.