Designation: C356 – 22

Standard Test Method for Linear Shrinkage of Preformed High-Temperature Thermal Insulation Subjected to Soaking Heat[1]

This standard is issued under the fixed designation C356; 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 U.S. Department of Defense.

1. Scope

1.1 This test method covers the determination of the amount of linear shrinkage and other changes that occur when a preformed thermal insulating material is exposed to soaking heat. This test method is limited to preformed high-temperature insulation that is applicable to hot-side temperatures in excess of 150°F (66°C), with the exception of insulating fire brick which is covered by Test Method C210.

1.2 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.

1.3 *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.*

1.4 *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]

C168 Terminology Relating to Thermal Insulation

C210 Test Method for Reheat Change of Insulating Firebrick

C411 Test Method for Hot-Surface Performance of High-Temperature Thermal Insulation

3. Terminology

3.1 *Definitions*—Terminology C168 shall apply to the terms used in this test method.

4. Significance and Use

4.1 Linear shrinkage, as used in this test method, refers to the change in linear dimensions that has occurred in test specimens after they have been subjected to soaking heat for a period of 24 h and then cooled to room temperature.

4.2 Most insulating materials will begin to shrink at some definite temperature. Usually the amount of shrinkage increases as the temperature of exposure becomes higher. Eventually a temperature will be reached at which the shrinkage becomes excessive. With excessive shrinkage, the insulating material has definitely exceeded its useful temperature limit. When an insulating material is applied to a hot surface, the shrinkage will be greatest on the hot face. The differential shrinkage which results between the hotter and the cooler surfaces often introduces strains and may cause the insulation to warp. High shrinkage may cause excessive warpage and thereby may induce cracking, both of which are undesirable. High shrinkage may also open gaps at the insulation joints to an excessive extent rendering the application less efficient and more hazardous. In order to predict the limit of permissible shrinkage in service, the degree of linear shrinkage to be tolerated by specimens of an insulating material when subjected to soaking heat must be determined from experience.

4.3 It is recognized that a fixed relation between linear shrinkage under soaking heat and actual shrinkage in service cannot be established for different types of insulating materials. Generally the amount of shrinkage increases with time of exposure. The amount and rate of increase varies from one material to another. In addition, the various types of materials may have different amounts of maximum permissible shrinkage. Therefore, each product must define its own specific limits of linear shrinkage under soaking heat.

5. Apparatus

5.1 *Furnace*—A gas-fired or electrically heated muffle furnace, having a size sufficient to accommodate at least four

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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.

test specimens and two guard specimens, 6 by 2½ by 1½ in. (152.4 by 63.5 by 38.1 mm) (Note 1), spaced so as to allow a clearance of at least ½ in. (12.7 mm) on all surfaces of every test specimen. The guard specimens shall be placed in such a manner to protect the test specimen from open flames or exposed heating elements of the furnace. The temperature of the furnace shall be controlled throughout the volume occupied by the specimens to within ± 1 % of the desired temperature. A furnace-temperature indicator or recorder is required.

NOTE 1—If the structure is not homogeneous throughout its thickness, or if thinner materials are under test, then test the specimen at the original thickness. For smaller ovens, unable to accommodate the required number of specimens, it will be necessary to make several test batches in order to secure the minimum number of specimens required.

5.2 *Oven*—A controlled-temperature conditioning oven with range up to at least 250°F (121°C).

5.3 *Specimen-Measuring Apparatus*—An instrument suitable for measuring a gauge length up to 6 in. (152.4 mm), and having an accuracy of measurement of 0.002 in. (0.05 mm) or better. Care must be taken, by the use of proper measuring techniques, to ensure reproduction of any measurement to within 0.01 in. (0.2 mm). It is particularly important to avoid crushing the ends of the specimens during measurement, especially in the case of soft materials.

NOTE 2—Reference points, such as pins, inserted near the ends of the specimen, serve to improve reproducibility without specimen damage; or it is acceptable to insert metal strips may be inserted between the specimen ends and the jaws of the caliper. Suggested instruments are dilatometers, vernier caliper, or comparators. One suitable type of comparator is equipped with a fine adjustment. It has a long-range, continuous dial indicator. The dial is attached to a wide-face (½-in. (12.7-mm) diameter flat) button point which is held against the specimen by internal spring pressure. When the point is lifted ½ in. (12.7 mm), the pressure is about 50 g, corresponding to a bearing force of 0.6 psi (4.8 kPa), and suitable for very soft materials. For harder materials, an additional weight of 0.25 lb (0.114 kg) may be applied, making the load of the specimen, at ½ in. (12.7 mm) compression of the spring, about 1.9 psi (13.1 kPa). Directly beneath the button point is another wide-face button point tapped to the base of the comparator. The comparator is adjustable and requires a set of steel shaftings, ½ in. (12.7 mm) in diameter, having lengths at 1-in. (25.4-mm) intervals from 1 to 6 in. (25.4 to 152.4 mm), to zero the comparator accurately.

5.4 *Balance*—A balance, having an accuracy of 0.01 g, for weighing the specimen before and after heating.

6. Sampling and Preparation of Test Specimens

6.1 All samples that will be required to complete the tests shall be selected at one time and in such a manner as to be representative of the average of the material.

6.2 Specimens for any one test condition shall be selected from the original sample lot so as to be as representative as possible. The specimens shall be cut or sawed from full-size pieces in such a manner that they will be fully representative of the entire, full-size piece as well as of the material generally. These specimens shall be cut to size 6 by 2½ by 1½ in. (152.4 by 63.5 by 38.1 mm), in such a manner that the length and width are cut parallel to the length and width, respectively, of the original, full-size piece. If it is impossible to faithfully represent the material by cutting to a 1½-in. (38.1-mm) thick specimen, or for thinner pieces, then the original thickness of the material shall be tested. Rectangular specimens cut from pipe covering shall be used if the material is homogeneous and if the sections are large enough. If the material is not homogeneous or the sections are not sufficiently large, then curved or partly curved segments of a cylinder shall be used. In this case, the specimens shall preferably be cut to an over-all width of 2½ in. (63.5 mm), with the sides cut parallel rather than on a radius.

7. Procedure

7.1 Select and prepare a minimum of four test specimens as prescribed in Section 6. Weigh the specimens in the as-received condition and dry them to constant weight following applicable specifications for the material unless it has been shown that the dimensional stability is not significantly affected by moisture content. In the absence of such specifications, dry the specimen in an oven or desiccator at a temperature of 215 to 250°F (102 to 121°C) or at a suitable lower temperature if these temperatures would be destructive. If specimens are dried, allow specimens to cool to room temperature and if necessary held in a desiccator before testing. Other conditioning procedures are acceptable only where agreed upon between manufacturer and purchaser. After conditioning and before any changes in dimensions occur, determine the linear dimensions. Make at least one measurement of length and two each of width and thickness at points marked so that remeasurements can be made at the same points after soaking heat.

7.2 Place the measured and weighed specimens in the furnace, the temperature of which shall not exceed 250°F (121°C). The specimens shall rest on their 6 by 1½-in. (152.4 by 38.1-mm) edges, supported by at least three supports (such as small ceramic triangular bars, or cylindrical rods), which in turn shall be supported on a protective plate. The supporting bars or rods shall be large enough so that the specimens have a clearance of at least ½ in. (12.7 mm) above the protecting plate. Arrange the specimens face to face in a group, but separated at least ½ in. (12.7 mm) from each other. Place dummy blocks or other protective means along the sides of the two specimens at each end of the group, so as to protect the faces of these two specimens from radiation losses or gains from the inner surfaces of the furnace. This arrangement of the specimens will allow free access of the heat to all of their surfaces.

7.3 Apply the source of heat after the specimens have been arranged in the furnace. The rate of heat supply shall be controlled so that the average rise to the temperature of test shall not exceed 300°F (167°C)/h (Notes 3 and 4). During the heating-up period, especially in the initial stages, make frequent observations to note any signs of combustibility, by opening the furnace door momentarily or, if possible, through observation ports. After the furnace has reached the desired test temperature, maintain soaking-heat conditions for a period of 24 h, and then cut off the supply of heat. When the furnace has cooled to 200 to 250°F (93 to 121°C), or a suitable lower temperature if these temperatures would be destructive, remove the specimens and place them directly into a desiccator.

NOTE 3—It is realized that the actual rate of increase in temperature will not be uniform. The temperature will rise rapidly at first, and then will