Designation: C 1303 – 07

Standard Test Method for Predicting Long-Term Thermal Resistance of Closed-Cell Foam Insulation[1]

This standard is issued under the fixed designation C 1303; 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 test method covers a procedure for predicting the long-term thermal resistance (LTTR) of unfaced or permeably faced rigid gas-filled closed-cell foam insulations by reducing the specimen thickness to accelerate aging under controlled laboratory conditions (**1-5**) .[2]

1.2 Rigid gas-filled closed-cell foam insulation includes all cellular plastic insulations manufactured with the intent to retain a blowing agent other than air.

1.3 This test method is limited to unfaced or permeably faced, homogeneous materials. This method is applied to a wide range of rigid closed-cell foam insulation types, including but not limited to: extruded polystyrene, polyurethane, polyisocyanurate, and phenolic. This test method does not apply to impermeably faced rigid closed-cell foams or to rigid closed-cell bun stock foams.

NOTE 1—See Note 5 for more details regarding the applicability of this test method to rigid closed-cell bun stock foams.

1.4 This test method utilizes referenced standard test procedures for measuring thermal resistance. Periodic measurements are performed on specimens to observe the effects of aging. Specimens of reduced thickness (that is, thin slices) are used to shorten the time required for these observations. The results of these measurements are used to predict the long-term thermal resistance of the material.

1.5 The test method is given in two parts. The Prescriptive Method in Part A provides long-term thermal resistance values on a consistent basis that can be used for a variety of purposes, including product evaluation, specifications, or product comparisons. The Research Method in part B provides a general relationship between thermal conductivity, age, and product thickness.

1.5.1 To use the Prescriptive Method, the date of manufacture must be known, which usually involves the cooperation of the manufacturer.

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

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 limitations prior to use.*

1.8 *Table of Contents*:

[1] This test method is under the jurisdiction of ASTM Committee C16 on Thermal Insulation and is the direct responsibility of Subcommittee C16.30 on Thermal Measurement.

Current edition approved Feb. 15, 2007. Published February 2007. Originally approved in 1995. Last previous edition approved in 2000 as C 1303 – 00.

[2] The boldface numbers in parentheses refer to the list of references at the end of this standard.

2. Referenced Documents

2.1 *ASTM Standards:* [3]

C 168 Terminology Relating to Thermal Insulation

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

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

C 578 Specification for Rigid, Cellular Polystyrene Thermal Insulation

C 591 Specification for Unfaced Preformed Rigid Cellular Polyisocyanurate Thermal Insulation

C 1029 Specification for Spray-Applied Rigid Cellular Polyurethane Thermal Insulation

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

C 1126 Specification for Faced or Unfaced Rigid Cellular Phenolic Thermal Insulation

C 1289 Specification for Faced Rigid Cellular Polyisocyanurate Thermal Insulation Board

D 1622 Test Method for Apparent Density of Rigid Cellular Plastics

D 2856 Test Method for Open-Cell Content of Rigid Cellular Plastics by the Air Pycnometer[4]

D 6226 Test Method for Open Cell Content of Rigid Cellular Plastics

E 122 Practice for Calculating Sample Size to Estimate, With a Specified Tolerable Error, the Average for a Characteristic of a Lot or Process

2.2 *Other Standards:*

CAN/ULC S770 Standard Test Method for Determination of Long-Term Thermal Resistance of Closed-Cell Thermal Insulation Foams[5]

ISO 2440 Flexible and Rigid Cellular Polymeric Materials—Accelerated Aging Tests, Third Edition[6]

2.3 *ASTM Adjuncts:*

Test Method for Predicting Long-Term Thermal Resistance of Closed-Cell Foam Insulation[7]

3. Terminology

3.1 *Definitions*—For definitions of terms and symbols used in this test method, refer to Terminology C 168.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *aging*, *v*—the change in thermophysical properties of rigid closed–cell plastic foam with time, primarily due to changes in the composition of the gas contained within the closed cells.

3.2.2 *core slice*, *n*—a thin-slice foam specimen that was taken at least 5 mm (0.2 in.) or 25 % of the product thickness, whichever is greater, away from the surface of the full-thickness product.

3.2.3 *effective diffusion thickness*, *n*—one-half of the geometric thickness minus the total thickness of damaged surface layer(s) (TDSL).

3.2.4 *facing*, *n*—a material adhered to the surface of foam insulation, including any foam product that has been suffused into the facing material, but not inclusive of any skin formed by the foam insulation itself.

3.2.5 *homogeneous material*, *n*—sufficiently uniform in structure and composition to meet the requirements of this test method (see A1.2).

3.2.6 *long-term*, *adj*—for the purposes of the Prescriptive Method, long term refers to five years.

3.2.7 *normalized service life*, *n*—product service life divided by the square of the full product thickness, units of time/length^2.

3.2.8 *scaled time*, *n*—time divided by the square of the specimen thickness.

3.2.9 *scaled service life*, *n*—time necessary for a thin specimen to reach the same thermal conductivity that a full thickness specimen would reach at the end of its service life, equals the product service life multiplied by the square of the ratio of the full product thickness to the slice thickness, value has units of time.

3.2.10 *service life*, *n*—the anticipated period of time that the material is expected to maintain claimed thermophysical properties, may be dependent on the specific end-use application.

3.2.11 *surface slice*, *n*—a thin-slice foam specimen that was originally adjacent to the surface of the full-thickness product and that includes any facing that was adhered to the surface of the original full-thickness product.

3.2.12 *thickness of damaged surface layer (TDSL)*, *n*—the average thickness of surface cells, on one surface, that are either destroyed (ruptured or opened) during the preparation of test specimens or were originally open due to the manufacturing process.

3.3 *Symbols*:

i = counter used in a summation

k = thermal conductivity, W/(m·K)

n = counter used in a summation

N = number of cut planar surfaces

n_{SL} = counter in a time series that corresponds to the service life.

R = thermal resistance, (m^2·K)/W

$TDSL$ = average thickness of damaged surface layer, m

ΔX_{eff} = effective diffusion thickness of thermal resistance specimen, m

[3] 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.

[4] Withdrawn.

[5] Underwriters Laboratory of Canada, 333 Pfingsten Road, Northbrook, IL 60062-2096 USA,www.ulc.ca

[6] International Standards Organizations, International Organization for Standardization (ISO) 1, rue de Varembé, Case postale 56, CH-1211 Geneva 20, Switzerland, www.iso.org

[7] Available from ASTM International Headquarters. Order Adjunct No. ADJC1303.

4. Summary of Test Method

4.1 Rigid gas-filled closed-cell foam insulation is thin-sliced to reduce the gas diffusion path length which accelerates the aging process. The resulting temporal acceleration is proportional to the square of the ratio of the product use thickness to the slice thickness.

4.2 Careful and precise slice preparation is necessary and the process is described in detail in 6.4.

4.3 In Part A, the Prescriptive Method, specific test dates are calculated and the thermal resistance of the thin slices is measured on those dates.

4.3.1 Qualification tests are included to determine whether this method is applicable to a given material.

4.4 In Part B, the Research Method, thermal conductivity is measured for a series of time periods and extensive data analysis is possible.

5. Significance and Use

5.1 Rigid gas-filled closed-cell foam insulations include all cellular plastic insulations which rely on a blowing agent (or gas), other than air, for thermal resistance values. At the time of manufacture, the cells of the foam usually contain their highest percentage of blowing agent and the lowest percentage of atmospheric gases. As time passes, the relative concentrations of these gases change due primarily to diffusion. This results in a general reduction of the thermal resistance of the foam due to an increase in the thermal conductivity of the resultant cell gas mixture. These phenomena are typically referred to as foam aging.

5.1.1 For some rigid gas-filled closed-cell foam insulation products produced using blowing agent gases that diffuse very rapidly out of the full-thickness foam product, such as expanded polystyrene, there is no need to accelerate the aging process.

5.2 The change in thermal resistance due to the phenomena described in 5.1 usually occurs over an extended period of time. Information regarding changes in the thermal resistance of these materials as a function of time is required in a shorter period of time so that decisions regarding formulations, production, and comparisons with other materials can be made.

5.3 Specifications C 578, C 591, C 1029, C 1126 and C 1289 on rigid closed-cell foams measure thermal resistance after conditioning at 23 ± 1°C (73 ± 2°F) for 180 ± 5 days from the time of manufacture or at 60 ± 1°C (140 ± 2°F) for 90 days. This conditioning can be used for comparative purposes, but is not sufficient to describe long-term thermal resistance. This requirement demonstrates the importance of the aging phenomena within this class of products.

5.4 The Prescriptive Method in Part A provides long-term thermal resistance values on a consistent basis for a variety of purposes, including product evaluation, specifications, or product comparisons. The consistent basis for these purposes is provided by a series of specific procedural constraints, which are not required in the Research Method described in Part B. The values produced by the Prescriptive Method correspond to the thermal resistance at an age of five years, which corresponds closely to the average thermal resistance over a 15-year service life (**6**, **7**).

5.4.1 It is recommended that any material standard that refers to C 1303 to provide a product rating for long-term thermal resistance specify the Part A Test Method of C 1303.

5.5 The Research Method in Part B provides a relationship between thermal conductivity, age, and product thickness. The calculation methods given in Part B can be used to predict the resistance at any specific point in time as well as the average resistance over a specific time period.

NOTE 2—The 5-year aged values produced in Part A can be derived from the Part B data only if all other Part A requirements are met.

5.6 This test method addresses three separate elements relating to the aging of rigid closed-cell plastic foams.

5.6.1 *Specimen Preparation*—Techniques for the preparation of thin flat specimens, including their extraction from the "as manufactured" product, and the measurement of specimen thickness are discussed.

5.6.2 *Measurement of the Thermal Resistance*—Thermal resistance measurements, taken at scheduled times, are an integral part of the test method.

5.6.3 *Interpretation of Data*—Procedures are included to properly apply the theory and techniques to achieve the desired goals.

6. Part A: The Prescriptive Method

6.1 *Applicability*:

6.1.1 *Qualification Requirements*—Before reporting the results from a C 1303 Part A aging test, the material must be qualified using the procedures given in Annex A1.

6.1.1.1 The qualification requirement tests must be performed whenever a significant change that would affect the thermal resistance properties is made to the product.

6.1.1.2 The qualification is valid for a period not to exceed two years.

NOTE 3—This test method is founded upon gas diffusion physical laws that apply to homogeneous materials with free surface exposure to the atmosphere as discussed more fully in Appendix X3 (**2-4** and **8-10**). Although rigid closed-cell foam insulation may not rigorously meet these homogeneity and exposure criteria, this test method has been shown to provide useful information for a wide range of products. Recognizing that none of the foam insulation products available today is perfectly homogeneous, the qualification requirements determine whether the product is sufficiently homogeneous for this test method to produce meaningful results. The user should also be aware that the material characteristics of the thin specimens must approximate those of the material under investigation. The material characteristics that are of most importance are gas diffusion coefficients and initial cell gas content. One-dimensional diffusion must dominate in the full use thickness material; by design, one-dimensional diffusion dominates in the thin slice.

NOTE 4—If two thicknesses of a particular foam product are manufactured from identical components and have identical foam morphology, then thin slices from one specimen will accurately predict the long-term aging behavior of the other. However, due to possible differences in the foam morphology, the applicability of data derived from specimens taken from one product thickness to a different thickness of the same product is currently a subject of research. The "alternate product equivalence test" qualification in Annex A1 is provided in Part A to allow this type of data generalization.

NOTE 5—The age acceleration test method applies when one-dimensional diffusion dominates in the full-use thickness material. In bun-stock products, this condition does not exist during the time period between the initial foam production and the manufacturing process that cuts the buns into flat sheets. Because this time is variable, it is not possible to define a consistent initial time for the Prescriptive Method. Also, because the sheets may be cut from the bun stock in different orientations, the foam morphology may vary from one sheet to another.

6.1.2 *Facing Permeability*:

6.1.2.1 Unfaced foam insulation meets the criteria of a free exposure to the atmosphere so the test method is applicable.

6.1.2.2 Faced products, with the exception of those foil-faced products that are Type 1 in Specification C 1289, that pass the homogeneity qualification test in Annex A1 meet the criteria of this test method.

6.2 *Apparatus*:

6.2.1 Thermal resistance test apparatus used for this test method shall conform to all of the requirements of Test Method C 518.

6.2.2 Specimen preparation equipment must produce slices that are consistent in dimension and surface morphology.

6.2.2.1 *Surface Damage*—Equipment for preparing thin specimens shall be selected based on the ability of the equipment to consistently limit the amount of surface damage (open cells) that occurs during the preparation process.

6.2.2.2 *Thickness Uniformity*—The equipment used to prepare specimens shall be capable of producing uniform thickness slices able to meet the requirements of 6.4.4.

6.2.2.3 The following two types of equipment have successfully been used to prepare thin slice specimens. Reference **(11)** summarizes these techniques and compares their effectiveness.

(1) High Speed Band-saw, with a fine-tooth 1 tooth/mm (14 teeth/in.) blade, 0.6 mm (0.025 in.) blade thickness, and blade speed of about 6 m/s (1185 ft/min).

(2) Combination Lathe/Motor-driven Meat Slicer.

6.2.2.4 Use of a hot-wire cutter is prohibited because it can produce a surface skin. For further discussion, please see 9.3 and Note 26.

6.3 *Sampling*:

6.3.1 *Schedule*—Specimens shall be collected between 7 and 20 days after production. The specimen collection schedule must be coordinated with the specimen preparation time requirement of 6.4.2.

6.3.2 *Replicate Product Samples*—The minimum number of product samples used to prepare test specimens shall be selected so that there is confidence that the average results from these product sheets are representative of the typical production quality. For additional guidance, refer to Practice E 122.

6.3.3 *Replicate Test Specimen Sets*—The minimum number of replicate specimens to be tested shall be selected so that there is confidence that the average results from these sliced specimens are representative of the material undergoing testing. At least three sets of thermal resistance specimens per material are recommended. For additional guidance, refer to Practice E 122.

6.4 *Specimen Preparation*:

6.4.1 *Goal*—The goal of this section is to produce thin slices, that when aged, are representative of the aged performance of the full-thickness product.

6.4.2 *Schedule*—The specimens shall be prepared between 14 and 21 days after the production date.

6.4.3 *Specimen Extraction*—Test specimens shall be extracted either from full size product sheets or from specially prepared spray-product constructions.

6.4.3.1 Extraction of test specimens from full size product sheets:

(1) Cut 300 by 300 mm ± 6 mm (12 by 12 in. ± 0.25 in.) full-thickness sections from two full-size product sheets. These sections shall be taken as close to the center line of the full-size product sheets as possible. In no case shall these sections be taken within 15 cm (6 in.) of the product edge. The number of full-thickness sections needed will depend upon the equipment used to prepare the thin slices and the number of replicate sets tested, as discussed in 6.3.3.

(2) Slice the 300 by 300 mm ± 6 mm (12 by 12 in. ± 0.25 in.) full-thickness specimens prepared in 6.4.3.1*(1)* to produce stacks of thin slices. Surface slices shall include the product skin or facing.

6.4.3.2 The preparation and extraction of test specimens from spray-foam product is described in Annex A2.

6.4.4 *Slice Flatness*:

6.4.4.1 During the slicing process, the thickness of each individual slice shall be measured in eight locations distributed evenly over the surface of the slice as shown in Fig. 1.

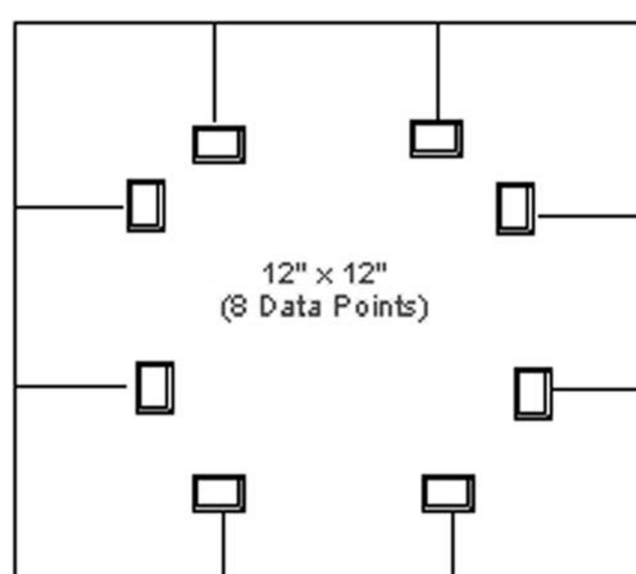
(1) These measurements shall be made using a digital caliper or a digital length meter. Care shall be taken so that the contact between the caliper jaws or the length meter's pressure foot does not indent the foam surface.

6.4.4.2 Each of these eight measurements must be within ±5 % of the average of the eight measurements.

6.4.4.3 The average of these eight measurements shall be used to represent the thickness of the slice for the purposes of 6.4.5.3.

6.4.4.4 Apparatus and cutting technique adjustments may be necessary to meet the requirements of this section and those of 6.4.5.3. Practice is recommended.

6.4.5 *Slice Thickness*:



NOTE—Lines show position of caliper jaws.

FIG. 1 Location of Measuring Points for Slice Thickness

6.4.5.1 Each core slice shall be a minimum of 9 mm thick.

6.4.5.2 The foam portion of each surface slice shall be a minimum of 9 mm (0.35 in.) thick. The total thickness of each surface slice shall be a minimum of 9 mm (0.35 in.) plus the thickness of any facing material. If the facing thickness is not known, the facing shall be removed from an edge portion of the product sheet and the thickness measured with a caliper or digital length meter to the nearest 0.1 mm (0.004 in.). If the facing thickness is less than 2 % of the total slice thickness, it shall be considered negligible in all succeeding calculations and the total slice thickness shall be used to represent the thickness of the foam portion of the surface slice.

6.4.5.3 Slice uniformity within each stack: The thickness of the foam portion of every slice (from 6.4.4.3) must be within ±5 % of the average of the foam portion of all the slices used within that stack.

6.4.5.4 The average of the foam portion of the slice thickness within the stack will be used later in 6.7.1 to determine appropriate testing periods.

NOTE 6—The presence of a damaged layer of cells on every cut surface introduces errors into both the calculated testing period (causing it to be overestimated) and the thermal resistance (causing the measured value to be less than the true value). The 9 mm minimum thickness was selected based upon the magnitude of these errors (discussed in Appendix X1) and a desire to limit the controllable error sources associated with this test method to no more than the uncertainty of the Test Method C 518 thermal resistance test method. There have been numerous experiments that show results from accelerated aging with 10 mm slices are in good agreement with full-thickness aged values, as discussed more fully in Section 9.

NOTE 7—If foam product morphology is changed by the introduction of new materials or manufacturing processes, the manufacturer may wish to pursue the TDSL investigation described in the Part B test method to determine whether the slice thickness should be increased to keep the TDSL errors within the uncertainty of the Test Method C 518 thermal resistance test method.

NOTE 8—As discussed in Appendix X1, the errors in both the calculated testing period and the measured thermal resistance have the greatest effect for thermal resistance measurements made in the earlier portion of the aging curve. Therefore, when predicting aged values for thicker products, for example, 75 or 100 mm (3 or 4 in.) products, users may wish to elect slice thicknesses greater than the 9 mm minimum to reduce the relative fraction of TDSL.

6.4.6 *Stack Composition*:

6.4.6.1 All thermal resistance measurements are made using stacks of slices in order to avoid errors (often referred to as the "thickness effect") introduced by radiation heat transfer phenomena at small specimen thicknesses **(12)**.

6.4.6.2 Three stacks shall be prepared: four core slices, four surface slices, and a mixed stack of core and surface slices.

NOTE 9—For background and rationale regarding the use of these three stacks, please see Appendix X2.

6.4.6.3 Slice uniformity among the three stacks: The average slice thickness of each of the three stacks (that value calculated in 6.4.5.3 and used in 6.7.1 for each stack) must agree within ±1 mm (±0.04 in.).

6.4.6.4 For the stack of surface slices, the slices shall be organized so that every skin or facing faces upward, as shown in Fig. 2.

6.4.6.5 For the mixed stack, the core and surface slices shall be prepared at a uniform slice thickness that represents the reassembled full cross-section of the product except for small amounts destroyed in the slice-cutting process and excluding any remainder less than 9 mm (0.35 in.) in thickness. The slicing shall be organized so that any such remainder comes from a non-surface section of the foam and both surfaces shall be included as the outward facing layers of the stack. The number of core sections in the mixed stack will vary according to the product thickness, as shown in Fig. 2.

6.4.6.6 Each stack shall be marked to assure that the specimens are placed in the same top to bottom order for every thermal measurement. Each stack shall be marked to assure that the stacks are oriented in the thermal measurement apparatus in the same direction for every measurement. Fig. 3 is one example of an effective marking scheme.

6.5 *Storage Conditioning*:

6.5.1 Specimens shall be stored during the extended time periods between thermal conductivity measurements in a conditioned space, at a temperature of 22°C (72°F) [±5°C (10°F)] and relative humidity between 40 and 70 %.

NOTE 10—The long-term storage conditioning requirements defined here are separate from the specimen conditioning requirements of Test Methods C 518 and C 177.

6.5.2 Specimens shall be stored so that each surface of each slice is exposed to free air circulation.

NOTE 11—One method used to assure such exposure is to stand the slices like books on a shelf with small spaces between each adjacent slice.

6.6 *Test Procedure*:

6.6.1 *Thermal Resistance Measurement Schedule*:

6.6.1.1 Calculate the testing period(s) corresponding to the desired product thickness(es), as described in 6.7. Add the testing period to the slicing date to determine the test date for each product thickness.

6.6.1.2 Measure the thermal resistance of the stack on the test dates determined in 6.6.1.1 within ±24 h. Meeting the

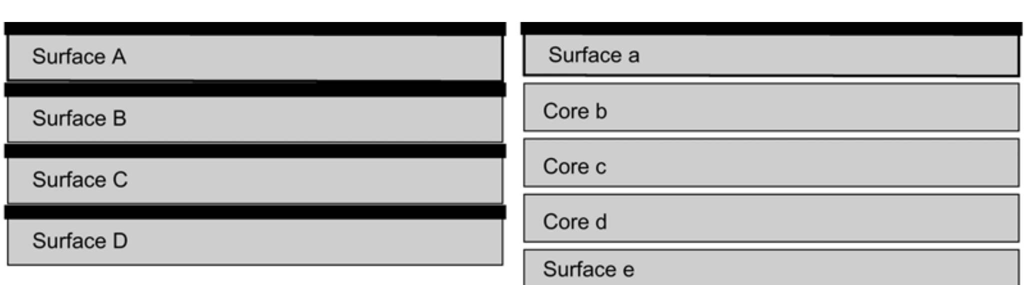


FIG. 2 Surface Stack Arrangement (left) and Mixed Stack Arrangement (right)

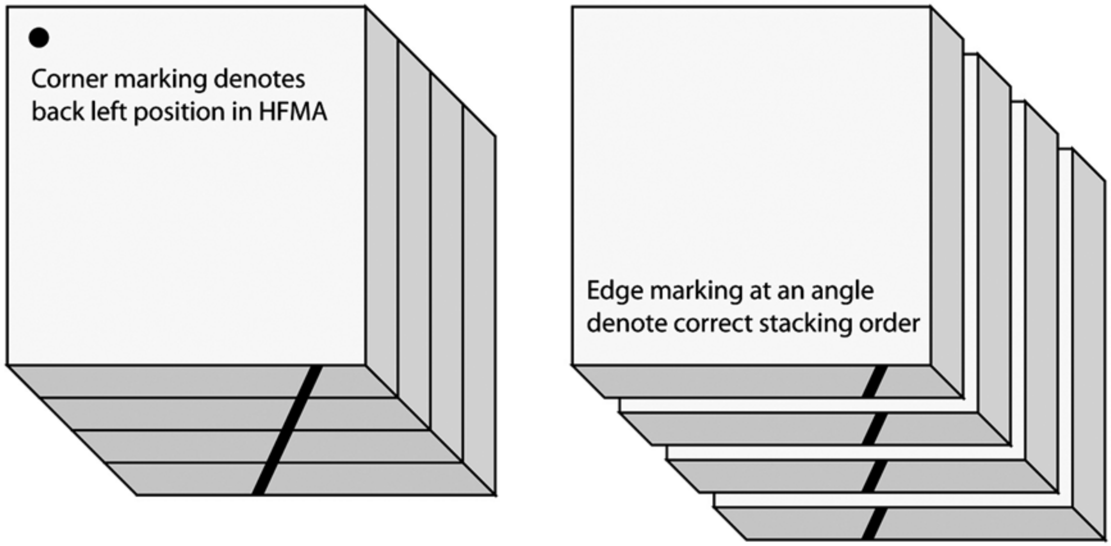


FIG. 3 Examples of Useful Specimen Stack Marking Techniques

calculated time period precisely is especially critical for any time period less than 40 days.

6.6.2 *Thermal Resistance Measurements*—All thermal conductivity and resistance measurements shall be made according to Test Method C 518 or C 177, used in conjunction with Practice C 1045. Of these test methods, the heat flow meter apparatus, Test Method C 518, is recommended.

6.6.2.1 The mean test temperature shall be 24 ± 2°C (75 ± 4°F) with a temperature difference of 22 ± 2°C (40 ± 4°F).

6.6.2.2 It is important to eliminate any air gaps between slices within the stack and between the stack and the controlled temperature plates. Therefore, if the apparatus offers the option of automatically positioning the plates and determining the specimen thickness, that option shall be used.

6.6.2.3 If the apparatus does not include an automatic positioning feature, the user must ensure that there are no air gaps within the specimen stack or between the stack and the controlled temperature plates.

NOTE 12—The thermal conductivity reported by Test Method C 518 or C 177 apparatus is directly proportional to the distance between the controlled-temperature plates. If the apparatus reports the temperature difference and heat flux rather than the thermal conductivity, then the stack thickness used to calculate the thermal conductivity must equal the distance between the plates. This is not likely to be the sum of the individual slice thicknesses because of the pressure applied by the plate positioning apparatus within the device.

6.6.3 *Product Density*—For product identification and reporting purposes, the product apparent density shall be measured in accordance with Test Method D 1622.

6.6.3.1 The density of interest is that of the foam. Therefore, for faced products, the facing shall be removed before the product density is measured.

6.7 *Calculations*:

6.7.1 The equation used to determine each testing period (in days) is shown in Eq 1:

$$\text{Test Time} = \left[\frac{\text{Average Slice Thickness}}{\text{Product Thickness}}\right]^2 \times 1826 \qquad (1)$$

6.7.1.1 The Average Slice Thickness is that value calculated in 6.4.5.4. The constant 1826 represents the number of days in a 5-year period. Be sure to state the Average Slice Thickness and the Product Thickness in the same set of units.

6.7.2 Use the equation in 6.7.1 to determine the test time for each product thickness of interest, subject to the limitations of Annex A1.

6.7.3 For the purpose of this calculation, the average slice thickness for surface slices shall not include the thickness of any facing material.

7. Part B: The Research Method

7.1 *Background*—In general, the prescriptive procedure described in Section 6 shall be followed. Modifications made to meet research needs must be carefully documented when reporting the results and must be based on a clear understanding of the gas diffusion physics that form the foundation of the accelerated aging theory. (See Appendix X3.)

7.1.1 Data taken using the Research Method shall not be used for product rating purposes unless all the requirements of the Prescriptive Method in Section 6 are satisfied.

7.1.2 The qualification tests of Annex A1 are not required, but are recommended.

NOTE 13—For research purposes, such as to benchmark numerical analysis methods, it may be desirable to perform thin slicing age acceleration of specimens known to be highly non-homogeneous.

NOTE 14—This method applies when one-dimensional diffusion dominates in the full-use thickness material. In bun-stock products, this condition does not exist during the time period between the initial foam production and the manufacturing process that cuts the buns into flat sheets. Also, because the sheets may be cut from the bun stock in different orientations, the foam morphology may vary from one sheet to another. Therefore, if this type of product is tested using the Research Method, extensive information regarding the specimen source and extraction must be provided.

7.2 *TDSL Apparatus*—Apparatus used to measure the effective diffusion thickness of the specimen shall be as specified in Test Method D 2856 or D 6226 or shall have demonstrated