



Standard Test Method for Frost Point of Sealed Insulating Glass Units¹

This standard is issued under the fixed designation E 546; 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.

^{e1} NOTE—Keywords were added in October 1999.

1. Scope

1.1 This test method describes a laboratory procedure for determining the frost point within the air space(s) of sealed insulating glass units, and establishes the criteria for determining whether that point is below or above a given or specified temperature.

1.2 This test method also describes the apparatus to be used for these determinations.

1.3 The values stated in SI units are to be regarded as the standard. The values given in parentheses are 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.* For specific hazard statements, see Notes 2 and X1.1.

2. Referenced Documents

2.1 *ASTM Standards:*

C 1036 Specification for Flat Glass²

E 77 Test Method for Inspection and Verification of Thermometers³

E 576 Test Method for Frost Point of Sealed Insulating Glass Units in Vertical Position⁴

3. Terminology

3.1 *frost point*—the temperature at which visible frost begins to deposit on the lower air space glass surface of a sealed insulating glass unit in contact with the measuring surface of the frost point apparatus.

3.2 *frost state*—the case where the frost point of a sealed insulating glass unit is above the test temperature specified by the purchaser or user.

3.3 *no-frost state*—the case where the frost point of a sealed insulating glass unit is below the temperature specified by the purchaser or user.

4. Summary of Test Method

4.1 This test method is conducted by the use of a special apparatus, consisting basically of two chilled cylindrical metal blocks positioned one over the other and separated by a gap of controllable distance. The upper block has an exposed flat circular surface, 25 mm (1 in.) in diameter, and can be chilled to far below the ice point by regulating the air-gap distance between it and the lower metal block which is maintained at approximately -78°C (-109°F) by dry ice. The test specimen is placed in contact with this chilled flat circular surface of the upper block for specified short periods of time, with the metal surface at successively lower temperatures, to determine at what temperature frost appears on the corresponding lower air space glass surface.

5. Significance and Use

5.1 This test method and the apparatus described are intended primarily for sealed insulating glass units positioned horizontally. If the procedure is applied to such units in other than a horizontal position, the results may not be comparable to those obtained by this procedure.

NOTE 1—A similar method is Test Method E 576.

6. Apparatus

6.1 *Test Apparatus*⁵ (see Fig. 1), consisting of upper and lower cylindrical metal blocks, with a thermocouple, bimetallic thermometer, or other suitable temperature sensors being inserted in the upper block; a control ring; and an insulated containment cylinder fitted with a retainer spring assembly.

⁵ Available from Dennis Industries, 20032 Waynegarden Court, Germantown, MD 20874.

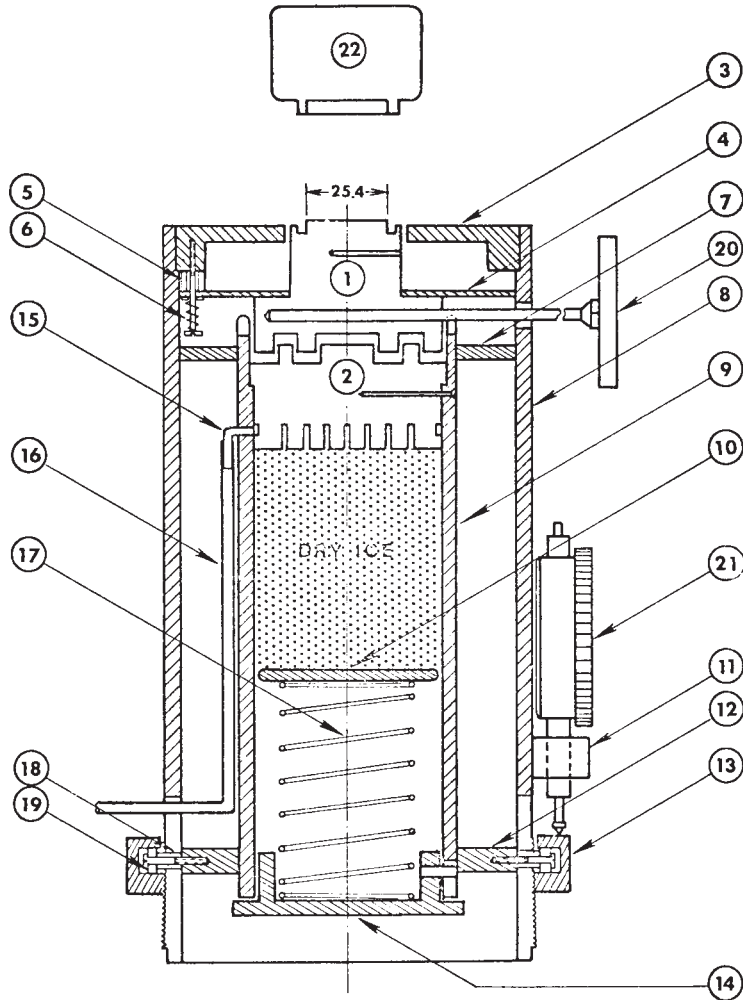
¹ This test method is under the jurisdiction of ASTM Committee E-6 on Performance of Buildings and is the direct responsibility of Subcommittee E06.22 on Durability Performance of Building Constructions.

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² *Annual Book of ASTM Standards*, Vol 15.02.

³ *Annual Book of ASTM Standards*, Vol 14.03.

⁴ *Annual Book of ASTM Standards*, Vol 04.07.



Parts List

| Part No. | Nomenclature | Part No. | Nomenclature |
|----------|-------------------------------------|----------|---------------------------------------|
| 1 | upper metal block | 12 | supporting ring, bottom of inner tube |
| 2 | lower metal block | 13 | control ring |
| 3 | top cover | 14 | cover lid, inner tube |
| 4 | supporting plate, upper metal block | 15 | elbow |
| 5 | spacer | 16 | tube, nylon |
| 6 | spring, upper metal block | 17 | main spring |
| 7 | supporting plate, top of inner tube | 18 | spacer |
| 8 | outer tube | 19 | bearing |
| 9 | inner tube | 20 | bimetallic dial thermometer |
| 10 | disk, dry ice pushing | 21 | dial indicator |
| 11 | clamp, dial gage | 22 | heat source block |

FIG. 1 Schematic Diagram of Frost Point Apparatus

The two metal blocks are separated by a small air gap, the distance of which can be regulated by the control ring. The exposed flat circular surface of the upper block is 25 mm (1 in.) in diameter, has a ground or lapped finish, and when placed in contact with the glass test specimen, forms the frost point measuring surface. The lower block is chilled by a dry ice pack kept in contact with it by the retainer spring assembly, maintaining it at a temperature near to that of sublimating dry ice (-78°C (-109°F)). Because the solid metal blocks are highly conductive, the temperature of each is virtually uniform. Use of the control ring adjusts the air gap distance between the two blocks to give the desired thermal resistance across the

gap. The circular measuring surface of the upper block is thus readily adjusted to the desired temperature while in contact with the test specimen. The circular measuring surface diameter specified is suitable for frost point measurement of glass up to 6.0 mm (¼ in.) thick.

6.1.1 *Upper and Lower Metal Blocks*, aluminum alloy that may be anodized, conforming to the dimensions shown in Fig. 1. Other parts of the apparatus may be fabricated from any appropriate materials.

6.1.2 *Calibrated Temperature-Measuring Device*, such as a thermocouple, thermistor, or bimetallic thermometer, having a suitable range graduated in 1°C (2°F) or smaller units, and an

accuracy of $\pm 0.5^{\circ}\text{C}$ ($\pm 1^{\circ}\text{F}$) over the full scale. A suggested calibration of the bimetallic thermometer is described in Appendix X1.

7. Test Specimen

7.1 The specimen to be tested shall be representative of the units to be evaluated and capable of being positioned horizontally.

8. Conditioning

8.1 Prior to testing, condition the test specimen at a temperature of $24 \pm 3^{\circ}\text{C}$ ($75 \pm 5^{\circ}\text{F}$) for not less than 24 h.

9. Procedure

9.1 *Preparation of Apparatus:*

9.1.1 Disassemble the apparatus by taking out the dry ice container and retainer spring assembly. Carefully clean the measuring surface with a soft cloth or paper. Do not scratch the measuring surface. Wipe and clean the apparatus thoroughly if any moisture is condensed on the surfaces and walls.

9.1.2 Assemble the dry ice container and turn the control ring so that the air gap distance between upper and lower metal blocks is about 13 mm (0.5 in.). Invert the apparatus onto a soft cloth.

9.1.3 Spray alcohol or acetone (**Warning**—See Note 2) on the fin of the dry ice container to ensure good contact with the dry ice. Compactly charge the container with the crushed or pulverized dry ice up to the “full” mark. Compress the dry ice with the spring assembly and lock the cover lid.

NOTE 2—**Warning:** Both alcohol and acetone are flammable.

9.1.4 Return the apparatus to an upright position and secure it onto a horizontal surface. Allow sufficient time for the temperature of the lower metal block to approach that of the dry ice temperature.

9.2 *Recharging of Apparatus:*

9.2.1 During the test procedure, replenish the supply of dry ice whenever it becomes depleted by turning the apparatus upside down on a soft cloth, opening the cover lid, taking out the retainer spring assembly, and repeating steps 9.1.3 and 9.1.4.

9.3 *Determination of Frost State and No-Frost State:*

9.3.1 Charge the frost point apparatus with dry ice as described in 9.1 or 9.2.

9.3.2 Clean both exterior surfaces of the specimen.

9.3.3 Place a piece of silver-colored aluminized polyester film⁵ (highly reflective mirror surface, not thicker than 0.08 mm (0.003 in.) and 25 mm (1 in.) in diameter or 25 by 25 mm (1 by 1 in.) on the measuring surface by wetting both surfaces of the film with acetone or alcohol (**Warning**—See Note 2). Center the specimen on the apparatus. Examine the lower air space glass surface in the region where frost is to be deposited, to be aware of any dirt or other foreign particles that might be mistaken for frost. Note, however, that a small foreign particle on the lower air space glass surface may be helpful in focusing on the surface where the frost is to be deposited (see Fig. 2).

9.3.4 Slowly reduce the air gap distance between upper and lower metal blocks by turning the control ring while watching the temperature of the upper metal block.

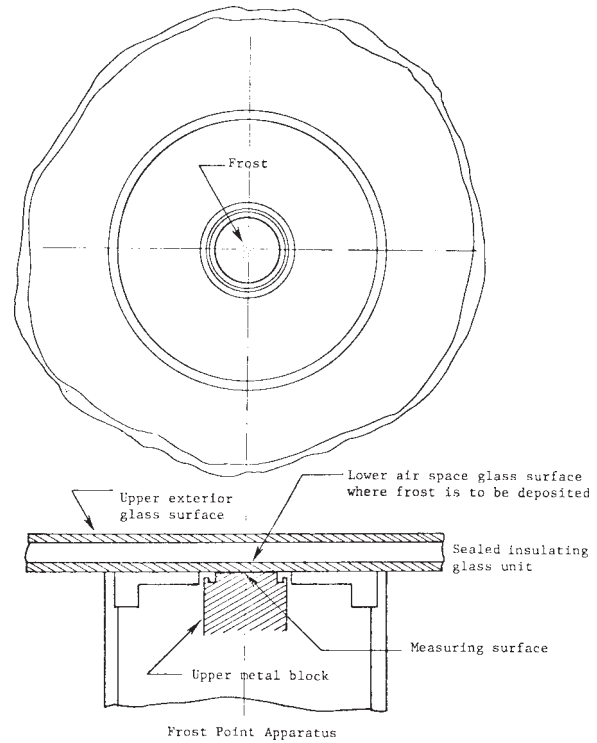


FIG. 2 Cross Section of Sealed Insulating Glass Unit for Frost Point Measurement

9.3.5 Bring the temperature of the upper metal block to the temperature to be checked for frost and stabilize it by fine adjustment of the control ring. Temperature fluctuation should not exceed $\pm 1^{\circ}\text{C}$ (2°F).

9.3.6 Maintain the stabilized temperature for a duration as follows:

| Glass Thickness Designation, mm (in.) | Stabilized Temperature—Duration, min |
|--|---|
| 2.5 (3/32) | 3 |
| 3.0 (1/8) | 3 |
| 5.0 (3/16) | 4 |
| 6.0 (1/4) | 5 |

NOTE 3—See Specification C 1036 for glass thickness tolerances.

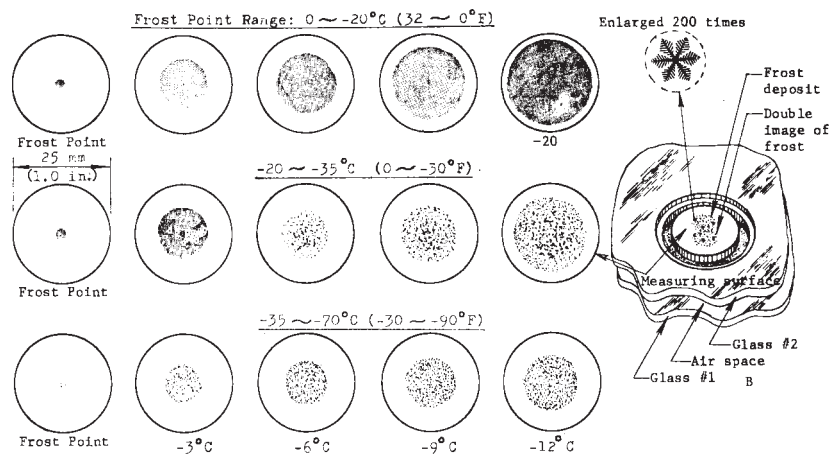
9.3.7 Wipe off the condensation that may have occurred on the upper exterior surface of glass, or spray the upper surface with clear water.

9.3.8 Examine the lower air space glass surface in contact with the measuring surface for frost. Illuminate this surface with a fluorescent desk lamp (two 15-W daylight bulbs), or equivalent for better detection of frost (see Fig. 3).

9.3.9 If a clearly visible frost deposit appears on the lower air space glass surface during or after the temperature stabilization period, the frost point of the specimen is above this stabilized temperature (frost state) (see Fig. 4 for frost formation). Check for double image of the frost to assure that the frost lies on the lower air space glass surface (see Fig. 4B). If the frost deposit is so small and faint that it cannot be distinguished from dirt or other foreign particles, lower the temperature of the measuring surface by 1°C (2°F) and hold this value for the duration given in 9.3.6. Reexamine the suspected particles. If the deposit is frost, its size or population will grow or get heavier.



FIG. 3 Frost Point Test Apparatus in Use



NOTE 1—Number - X means X°C below frost point.
 NOTE 2—Size of frost deposit varies with the thickness of glass.

FIG. 4 References of Frost Deposit at a Glass Thickness of 5.0 mm (3/16 in.)

9.3.9.1 Frost point determination as described in 9.3.9 is difficult to observe on reflective glass. It is acceptable to lift the specimen off the tester and observe for frost by viewing the unit when held up to light. The observation shall be made within 5 s of removal from the tester.

9.3.10 If frost does not appear after the temperature stabilization period, the frost point of the specimen is below this stabilized temperature (no-frost state).

9.3.11 To check at other temperatures, repeat the test procedure described in 9.3.3-9.3.10 for the temperatures desired.

9.4 Determination of Approximate Frost Point Range:

9.4.1 Perform a series of measurements as described in 9.3 at successively lower temperatures until frost state is proven. Temperature intervals of 10°C (20°F) are preferable: for example, - 10°C (20°F), - 20°C (0°F), - 30°C (-20°F), - 40°C (-40°F), - 50°C (-60°F), and - 60°C (-80°F) as de-

scribed in 9.3. Other temperature levels can be checked as desired. The frost point will be between the temperature at which frost appeared and the next higher temperature.

9.4.2 When the frost point range can be predicted by experience (newly fabricated specimen, etc.), only the temperatures bracketing the predicted frost point need be checked.

9.4.3 Estimate the frost point of the specimen within the temperature range between frost and no-frost found in 9.4.1 by comparing the frost at the lower temperature limit (frost state) with the reference photograph (see Fig. 4) of similar temperature range.

9.5 Final Measurement of Frost Point:

9.5.1 Perform a series of no-frost, frost state measurements described in 9.4 by starting at a few degrees Celsius above the estimated frost point. Lower the temperature by intervals of less than 2°C (3°F) (preferably 1°C (2°F)). If frost appears at

the first starting temperature, reestimate the frost point using Fig. 4 and repeat the test.

9.5.2 The frost point is the temperature at which visible frost first appears, or between this temperature and the next higher temperature that was checked.

9.5.3 Record the frost point as the temperature of the upper metal block when the visible frost first appears.

9.5.4 For repeated measurements of frost point on the same specimen, allow the frost to evaporate completely, or choose another spot at least 50 mm (2 in.) away from the previous measuring spot. Use a counterweight to balance the specimen. The heat source block (see Fig. 1, Part No. 22) may be warmed and placed in momentary contact with the upper metal block to raise its temperature before proceeding with a repeated measurement.

10. Report

10.1 Report the following information:

10.1.1 Complete description of the test specimen, including size, glass thickness, air space(s) thickness, desiccant type and quantity, and sealant type.

10.1.2 Specimen conditioning temperature, if other than that specified in 8.1.

10.1.3 Frost point temperature.

11. Precision and Bias

11.1 The precision and bias of the test method were determined after assembling various laboratory personnel in one common laboratory with their respective test equipment. All tests were performed on the same set of specially prepared test specimens.

11.2 When the temperature measuring device is calibrated in accordance with 6.3 and Appendix X1, the frost point differential measured was within 2°C (4°F).

12. Keywords

12.1 building; frost point; insulating glass; sealed insulating glass units

APPENDIX

(Nonmandatory Information)

X1. CALIBRATION OF BIMETALLIC THERMOMETER

X1.1 Required Equipment

X1.1.1 Secondary Standard Thermometer

ASTM Thermometer 99F or equivalent (−50 to + 10°C (−55 to + 40°F), maximum scale error 0.2°C (0.4°F)). Another calibrated secondary standard (thermocouple, resistance thermometer, etc.) can be used.

X1.1.2 Dewar flask or well-insulated liquid container.

X1.1.3 Acetone or alcohol.

X1.1.4 Dry ice.

X1.2 Procedure

X1.2.1 Pour a sufficient amount of acetone or alcohol into the Dewar flask.

NOTE X1.1—**Warning:** Both acetone and alcohol are flammable.

X1.2.2 Insert both the secondary standard thermometer and the bimetallic thermometer in the liquid bath to specified depths of the thermometer.

X1.2.3 Slowly drop the small pieces of dry ice into the liquid bath to cool it while continuously stirring it.

X1.2.4 Bring the temperature of the liquid bath to $0 \pm 3^\circ\text{C}$ ($30 \pm 5^\circ\text{F}$) and stabilize it for at least 3 min after the dry ice is completely sublimated.

X1.2.5 Tap the thermometer stem gently, and record the readings of both thermometers. Recheck the readings after 1 min. The readings should remain the same.

X1.2.6 Repeat the test described in X1.2.1-X1.2.5 for the temperatures of −20, −35, and $-50 \pm 3^\circ\text{C}$ ($0, -30$ and $-60 \pm 5^\circ\text{F}$). Other temperatures may be checked as desired but should cover the intended temperature range of use. The indications of the bimetallic thermometer should be within $\pm 0.5^\circ\text{C}$ ($\pm 1^\circ\text{F}$) of the secondary standard thermometer indications over the temperature range to be measured.

X1.2.7 To recalibrate the bimetallic thermometer, choose the temperature of calibration within the intended range of use, and control the liquid bath at that temperature. Adjust the bimetallic thermometer by firmly holding the thermometer head and immersing the stem at least 50 mm (2 in.) in the liquid bath and turn the hexagon nut at the base of the thermometer head until the pointer indicates the correct temperature indicated by the secondary standard thermometer.

X1.2.8 Repeat the test described in X1.2.1-X1.2.6 to check the calibration.

X1.2.9 For routine check, the bimetallic thermometer may be checked against ice point in accordance with the procedure described in Test Method E 77.



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