



Standard Test Method for Testing Resistance to Fogging in Insulating Glass Units¹

This standard is issued under the fixed designation E2189; 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 procedures for testing the resistance to fogging of preassembled permanently sealed insulating glass units or insulating glass units with capillary tubes intentionally left open.

1.2 This test method is applicable only to sealed insulating glass units that are constructed with glass.

1.3 This test method is applicable to both double-glazed and triple-glazed insulating glass units; for triple-glazed insulating glass units where both of the outer lites are glass and the inner lite is either glass or a suspended film.

1.4 The unit construction used in this test method contains construction details that are essential components of the test. Different types of glass, different glass thicknesses and different airspace sizes may affect the test results.

1.5 This test method is not applicable to sealed insulating glass units containing a spandrel glass coating due to testing limitations.

1.6 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

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.*

2. Referenced Documents

2.1 *ASTM Standards:*²

C162 Terminology of Glass and Glass Products

C717 Terminology of Building Seals and Sealants

E631 Terminology of Building Constructions

E2188 Test Method for Insulating Glass Unit Performance

E2190 Specification for Insulating Glass Unit Performance and Evaluation

3. Terminology

3.1 *Definition of Terms:*

3.1.1 For definitions of terms found in the standard, refer to Terminology **C717**, Terminology **C162** and Terminology **E631**.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *fog, n*—visible deposits present after testing in accordance with Section 8 that were not present prior to testing. Fog does not include defects in a glass coating or the glass substrate when examined prior to testing.

4. Significance and Use

4.1 This test method is intended to provide a means for testing the resistance to fogging in sealed insulating glass units.

4.2 This test method is also intended to provide a means for testing the resistance to fogging caused by components in the interior of the unit. These interior components include, but are not limited to, suspended or applied films, decorative components, muntins, and coatings.

5. Test Specimens

5.1 Each test specimen shall be manufactured in accordance with Test Method **E2188**, Section 5.

5.2 For test specimens containing muntin bars, the specimens shall be fabricated with the muntin bars dividing the specimens into nine equal areas (3 by 3). See **Fig. 1**.

5.3 Viewing of the fog shall not be compromised by any internal component.

5.4 For double-glazed units, at least three specimens of identical component materials and construction shall be submitted.

5.5 For triple-glazed units, at least five specimens of identical component materials and construction shall be submitted. For these units, the manufacturer shall specify the exterior surface.

NOTE 1—Certain reflective coatings may interfere with the ability to view fog.

5.6 During all stages of storage and handling, the units shall be held in a vertical position with equal support to all panes and no compression loading.

5.7 Damaged units shall not be tested.

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

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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.

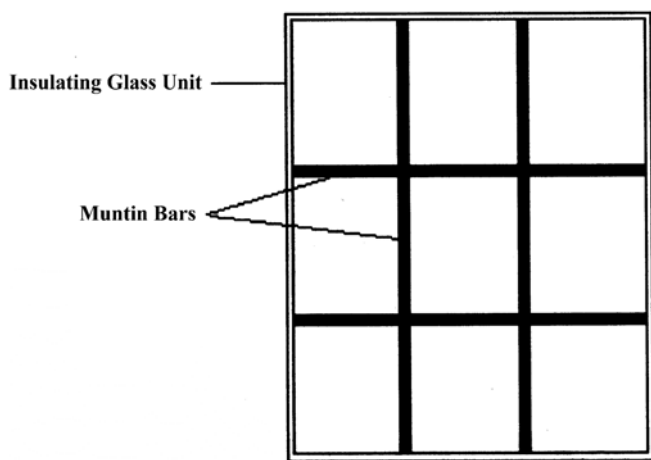


FIG. 1 Schematic Drawing of Insulating Glass Unit with Muntin Bars

6. Apparatus

6.1 Volatile Fog Test Apparatus:

6.1.1 The dimensions and components are found in Fig. 2. The construction of the apparatus shall be capable of maintaining $50 \pm 3^\circ\text{C}$. In order to maintain this temperature, a fan shall be mounted in the box. The fan shall run as needed in order to maintain the air temperature in the apparatus.

6.1.2 The apparatus shall be constructed from sturdy, solid materials that minimize the escape of ultraviolet light into the surrounding area. $\frac{1}{2}$ or $\frac{3}{4}$ in. plywood has been found suitable for this purpose. Stainless steel construction is also acceptable.

6.1.3 The interior of the apparatus shall have a reflective surface. If plywood is used to construct the apparatus, then line the entire interior of the apparatus with aluminum foil or other reflective material.

6.1.4 The test specimen supports shall be located as shown in Fig. 2.

6.1.5 The chamber shall have radiation-shielded thermocouples to continuously monitor the chamber air temperature at the locations shown in Fig. 2, identified by the labels TC1 through TC4.

6.1.6 The cooling plates shall be constructed of a conductive material such as copper or brass. The cooling plates shall be 150 ± 5 mm diameter and shall be placed directly in complete contact with the glass surface for the duration of the test. Alternatively, a rectangular cooling plate shall be 177 ± 6 m² in area with an aspect ratio (long side/short side) less than or equal to 1.4.

6.1.7 The cooling water temperature shall be determined as the water immediately exits the apparatus from each cooling plate as shown in Figure 1. The cooling water temperature at these locations shall be $21 \pm 2^\circ\text{C}$.

6.1.8 Alternatively, an electric chilling apparatus shall be used to control the cooling plate.

6.2 Ultraviolet Light Source:

6.2.1 **Warning**—Ultraviolet light sources used in this test method are harmful to the human body, especially to the eyes. Appropriate protective measures must be observed. The source

shall consist of one 300 W ultraviolet lamp³ and shall be placed as shown in Fig. 1. The output of the UV source shall be measured from a distance of 355 ± 5 mm with a long-wave ultraviolet meter⁴ and shall not be less than $400 \mu\text{W}/\text{cm}^2$.

6.3 Fog Examination Light Source:

6.3.1 The source shall consist of two fluorescent light bulbs in a standard two bulb fixture. These bulbs shall be 20 W, cool white bulbs and shall be nominally 610 mm in length.

7. Test Specimen Preparation

7.1 The sealed insulating glass units shall be sealed a minimum of 4 weeks from date of manufacture to allow for stabilization before testing begins. The manufacturer has the option to waive this requirement.

7.2 The glass surfaces shall be clean prior to testing.

8. Procedure

8.1 Chamber Preparation:

8.1.1 The cooling plate shall be clean and the contact surface shall be flat.

8.1.2 For double-glazed units with low-e coatings, the cold plate shall be located on the low-e coated lite.

8.1.3 For triple-glazed units, both cavities shall be tested. Two units shall be tested with the exterior lite (as identified by the manufacturer) towards the cooling plate and two units shall be tested with the interior lite (as identified by the manufacturer) towards the cooling plate.

8.2 Test Procedure:

8.2.1 Randomly select two double-glazed specimens or four triple-glazed specimens for testing.

8.2.2 Examine the surfaces of each test specimen prior to testing for flaws and deposits as indicated in 8.3. Record the position or location of any surface flaws that are seen. If any deposits are seen, the specimen shall not be tested.

8.2.3 Mount the two selected specimens within a volatile fog test apparatus similar to that shown in Fig. 2 and close the lid before turning on the UV lamp.

8.2.4 Turn on the UV lamp source.

8.2.5 Maintain all thermocouples (shown in Fig. 2 as TC1, TC2, TC3 and TC4) at $50 \pm 3^\circ\text{C}$. The fan and vents shall be used to regulate this air temperature. The temperature differential from thermocouple #1 to thermocouple #2 shall not exceed 3°C . The temperature differential from thermocouple #3 to thermocouple #4 shall not exceed 3°C .

8.2.6 Maintain the temperature of the cooling water at $21 \pm 2^\circ\text{C}$. Determine the temperature of the cooling water immediately after it leaves the test apparatus for each cooling plate.

³ The only suitable lamp is the Osram Ultra Vitalux lamp. The sole source of supply of the apparatus known to the committee at this time is from Westburne Electric, 635 Westburn Drive, Vaughn, Ontario L4K 4R8 Canada. If you are aware of alternative suppliers, please provide this information to ASTM International Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee,¹ which you may attend.

⁴ The only suitable meter is the Blak-Ray UV Meter with J221 sensor cell. The sole source of supply of the apparatus known to the committee at this time is UVP, LLC, 2066 West 11th St., Upland, CA 91786. If you are aware of alternative suppliers, please provide this information to ASTM International Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee,¹ which you may attend.

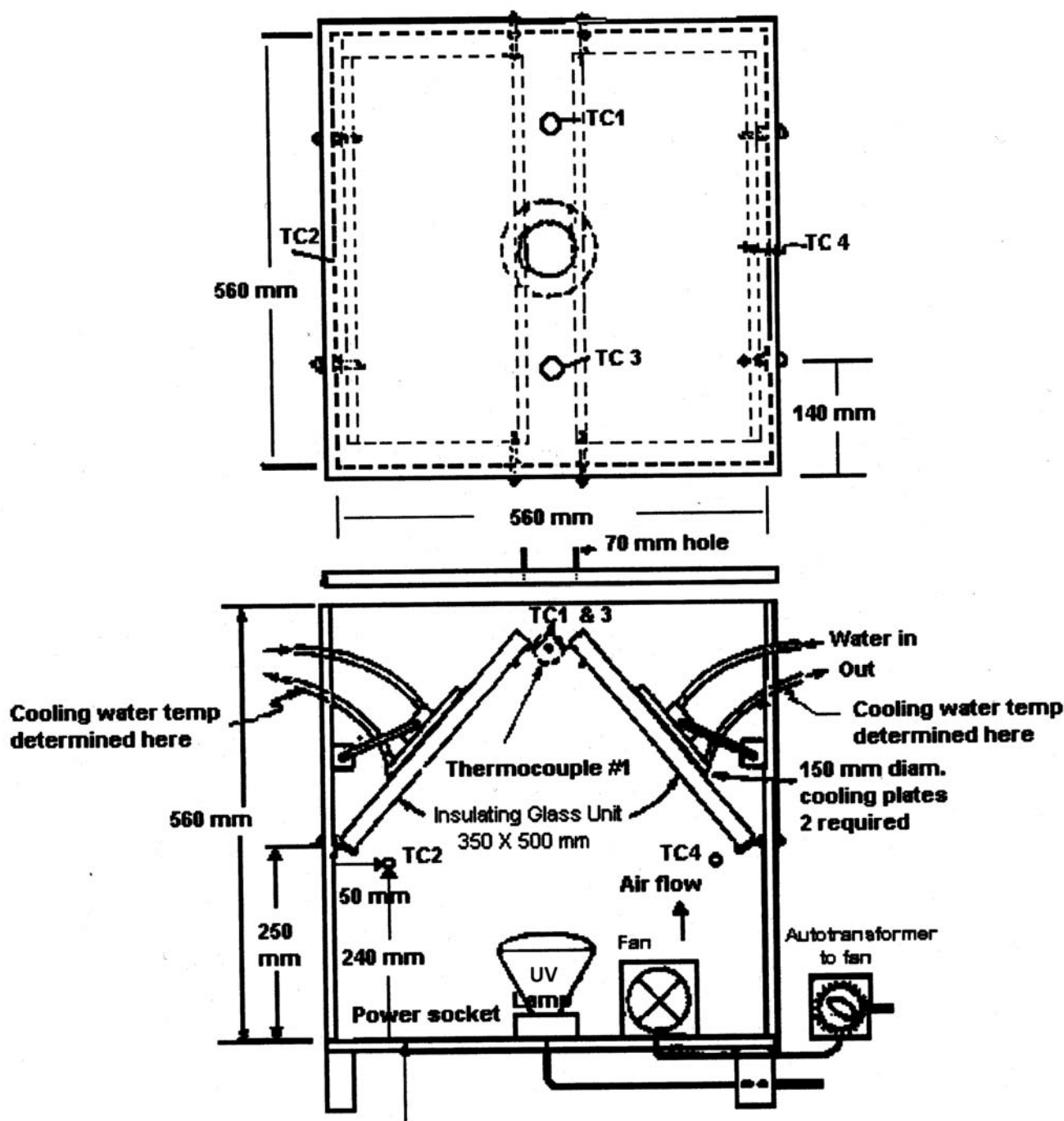


FIG. 2 Volatile Fogging Exposure Box

8.2.7 If an electric chilling apparatus is used to control the cooling plate temperature, maintain the required temperature as noted in 8.2.6. Measure the temperature of the surface of the cold plate portion of this device.

8.2.8 The specimens shall be exposed to these conditions for a period of seven days or as determined by the specifier.

8.2.9 For triple pane units, both cavities shall be tested. Two units shall be tested with the exterior lite (as identified by the manufacturer) towards the cooling plate and two units shall be

tested with the interior lite (as identified by the manufacturer) towards the cooling plate.

8.3 After exposure, remove the test specimens from the test apparatus. Examine them carefully for fog by holding at arm's length (approximately 500 to 750 mm) from the eyes. Move the specimen to any angle necessary using both reflected and transmitted light to thoroughly check the surface of the glass for fogging.

8.3.1 The examination for the presence of fog shall be done in a dark room or darkened area where the only light source for viewing the test specimens in the fog examination light source described in 6.3.

8.3.2 The lights used to examine the test specimens shall be a minimum of 1.5 m from the examiner.

8.3.3 To view the specimens in transmitted light, hold the test specimens in front of the fluorescent bulbs and examine the area of glass where the cooling plate had been located.

8.3.4 To view the specimens in reflected light, the examiner shall stand between the light source and the test specimens. Hold the test specimens to reflect the fluorescent light and again examine the glass surface as in 8.3.3.

8.3.5 The glass surface shall be viewed directly through the area where the cooling plate was located during testing and through the opposite lite of glass.

8.3.6 In addition to examining the area under the cooling plate, the entire glass surface shall be examined and compared to the glass surface before testing. Flaws or deposits seen after testing shall be recorded and reported.

8.4 If fog is not observed, record this information. The testing is complete.

8.5 If fog is observed, record this information and hold the test specimen(s) for 24 h at room temperature. After this 24-h period, re-examine the specimen(s), as in 8.3.

8.6 Record the temperature readings for each of the four thermocouples at least once during the testing period.

8.7 If fog is not observed, record this information. The testing is complete.

8.8 If fog is observed at the 24-h observation, record this information and hold the test specimen an additional 6 days. After the 7 day period, reexamine the specimens, as in 8.3.

8.9 The units shall show no evidence of fogging when tested and viewed in accordance with 8.3-8.8.

9. Report

9.1 Report the following data:

9.1.1 *Complete Description of Specimen Tested:*

9.1.1.1 Dimensions of the test specimen (width, height and overall thickness).

9.1.1.2 Type and thickness of glass.

9.1.1.3 Glass coatings and surface locations if applicable.

9.1.1.4 Airspace thicknesses.

9.1.1.5 Spacer composition(s) and configuration(s).

9.1.1.6 Corner construction including the type and number of corner keys.

9.1.1.7 Desiccant type and quantity, if provided.

9.1.1.8 Presence and type of tube, if applicable.

9.1.1.9 Presence and composition (if known) of muntin bars.

9.1.1.10 Sealant type and dimensions, if provided.

9.1.1.11 Manufacturer and manufactured date (month or quarter, if known, and year).

9.1.2 Duration of fog test (number of days).

9.1.3 The four thermocouple temperatures (TC1 through TC4) range.

9.1.4 Presence or absence of fog after removal from the chamber, after 24 h and after 7 days, if applicable.

9.1.5 Glass breakage, if observed.

10. Precision and Bias

10.1 *Precision and Bias*—No information is presented about either the precision or bias of Test Method E2189 for measuring fog since the test result is nonquantitative. Initial interlaboratory test results show that specimens randomly chosen from the same group of test specimens produce the same test results within each test facility. When test specimens of identical construction were tested at five different laboratories, four of the five laboratories were able to correctly identify all test specimens as either passing or failing the test. One test laboratory incorrectly reported one set of test specimen results. In total, of the 40 specimens tested, 38 test specimens were correctly identified as either passing or failing the test. Additional interlaboratory studies are being planned.

11. Keywords

11.1 fogging of IGU; insulating glass units IGU; sealed insulating glass units

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