Designation: G201 – 09

StandardPractice for Conducting Exposures in Outdoor Glass-Covered Exposure Apparatus with Air Circulation[1]

This standard is issued under the fixed designation G201; 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 practice covers the basic principles and operating procedures for using outdoor glass-covered exposure apparatus with air circulation. This practice is limited to the procedures for obtaining, measuring and controlling conditions of exposure. A number of exposure procedures are listed in Appendix X1; however, this practice does not specify the exposure conditions best suited for the material to be tested.

1.2 For direct weathering exposures, refer to Practice G7. For exposures behind glass without air circulation, refer to Practice G24.

1.3 Test specimens are exposed to solar radiation filtered through glass under partially controlled environmental test conditions. Different glass types and operating parameters are described.

1.4 Specimen preparation and evaluation of the results are covered in ASTM methods or specifications for specific materials. More specific information for determining the change in properties after exposure and reporting these results is described in Practices D5870, D2244 and Test Method D523.

1.5 The values stated in SI units are to be regarded as standard.

1.6 *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]

D523 Test Method for Specular Gloss

D2244 Practice for Calculation of Color Tolerances and Color Differences from Instrumentally Measured Color Coordinates

D5870 Practice for Calculating Property Retention Index of Plastics

E903 Test Method for Solar Absorptance, Reflectance, and Transmittance of Materials Using Integrating Spheres

E1084 Test Method for Solar Transmittance (Terrestrial) of Sheet Materials Using Sunlight

G7 Practice for Atmospheric Environmental Exposure Testing of Nonmetallic Materials

G24 Practice for Conducting Exposures to Daylight Filtered Through Glass

G113 Terminology Relating to Natural and Artificial Weathering Tests of Nonmetallic Materials

G141 Guide for Addressing Variability in Exposure Testing of Nonmetallic Materials

G173 Tables for Reference Solar Spectral Irradiances: Direct Normal and Hemispherical on 37° Tilted Surface

G177 Tables for Reference Solar Ultraviolet Spectral Distributions: Hemispherical on 37° Tilted Surface

G179 Specification for Metal Black Panel and White Panel Temperature Devices for Natural Weathering Tests

G183 Practice for Field Use of Pyranometers, Pyrheliometers and UV Radiometers

2.2 *Other Document:*[3]

WMO No. 8 Guide to Meteorological Instruments and Methods of Observation, Fifth Edition

2.3 *ISO Standard:*[4]

ISO 9060 Solar energy — Specification and classification of instruments for measuring hemispherical solar and direct solar radiation

3. Terminology

3.1 The definitions given in Terminology G113 are applicable to this practice.

3.2 *Other Definitions*:

[1] This practice is under the jurisdiction of ASTM Committee G03 on Weathering and Durability and is the direct responsibility of Subcommittee G03.02 on Natural and Environmental Exposure Tests.

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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.

[3] Available from World Meteorological Organization (WMO), 7bis, avenue de la Paix, Case postale 2300, CH-1211 Geneva 2, Switzerland, http://www.wmo.int.

[4] Available from International Organization for Standardization (ISO), 1, ch. de la Voie-Creuse, Case postale 56, CH-1211, Geneva 20, Switzerland, http://www.iso.ch.

3.2.1 *limit temperature, n*—For enclosures operated in temperature control mode, the specified black panel temperature at which the circulating fan switches on in order to prevent or minimize black panel temperature readings above the set temperature.

4. Summary of Practices

4.1 Specimens are exposed to light, moisture (in the form of humidity) and heat in an outdoor glass-covered enclosure with air circulation.

4.2 The exposure conditions may be varied by selection of:

4.2.1 Glass Type:

4.2.2 Operation of the circulating fan (whether constantly on during daylight hours or only on when a specific limit temperature is reached).

4.2.3 Temperature level at which the fan operates.

4.2.4 Orientation of the test fixture.

5. Significance and Use

5.1 As with any accelerated test, the increase in rate of weathering compared to in-service exposure is material dependent. Results from exposures conducted to this practice may provide good rank correlation to results from actual use conditions for one type of material or product. It should not be assumed that this will be true for other materials or products. It is always best to verify the ability of an accelerated exposure test to properly rank the durability of materials with actual use conditions. Guide G141 provides information about using rank correlation.

5.2 Variation in results may be expected when operating conditions are varied within the accepted limits of this practice. Therefore, no reference shall be made to results from the use of this practice unless accompanied by a report detailing the specific operating conditions in conformance with Report Section 8.

5.3 The durability of materials in outdoor use can be very different depending on the location of the exposure because of differences in solar radiation, moisture, heat, pollutants, and other factors. Therefore, it cannot be assumed that results from exposure in a single location will be useful for determining durability ranking of materials in a different location.

5.4 It is strongly recommended that at least one control material be exposed with each test. The control material should be of similar composition and construction and be chosen so that its failure modes are the same as that of the material being tested. It is preferable to use two control materials, one with relatively good durability, and one with relatively poor durability. If control materials are included as part of the test, they shall be used for the purpose of comparing the performance of the test materials relative to the controls.

6. Apparatus

6.1 *Enclosure:*

6.1.1 Exposures shall be conducted in a glass-covered enclosure of any convenient size (see Fig. 1). The enclosure shall be constructed of a corrosion-resistant metal, such as anodized aluminum or stainless steel, and be designed to prevent outside air from circulating over specimens. Optionally, vents covered with air filter material may be installed in the bottom of the test fixture if required to limit the black panel temperature to a specified maximum.

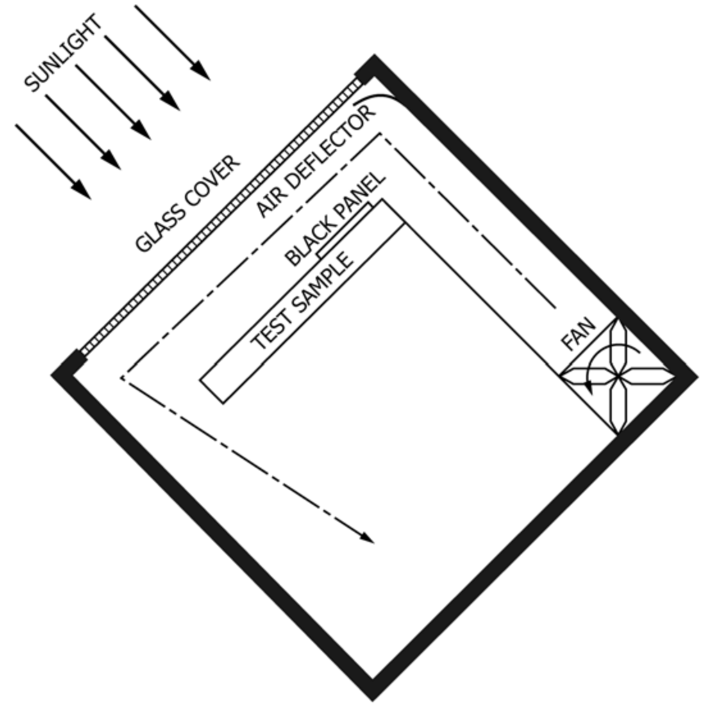
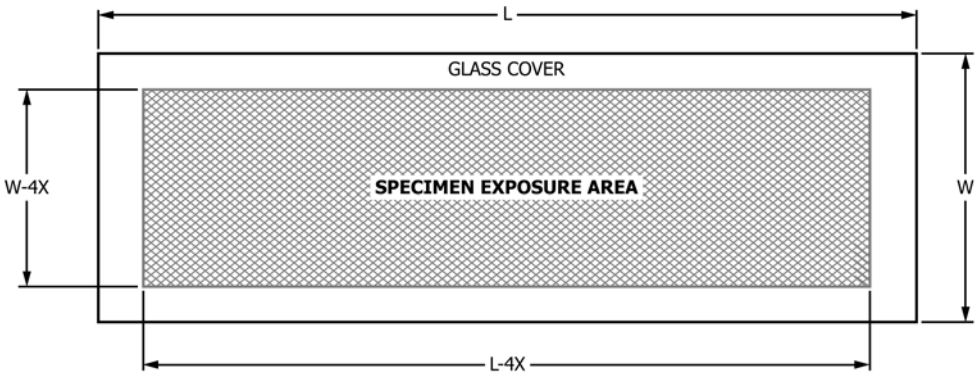


FIG. 1 Diagram of Typical Enclosure with Air Circulation

6.1.2 The enclosure shall be located where it will receive solar radiation throughout the day with no shadow on any specimen when the sun's angle of elevation is greater than 20 degrees. When the enclosure is installed over grass, the distance between the bottom of the enclosure and the ground shall be sufficient to prevent contact with plant growth, or to minimize damage that might occur during maintenance.

6.1.3 The enclosure shall be equipped with a rack which supports the specimens in a plane parallel to the glass. Alternately, the specimens can be mounted in an in-service position. Unless otherwise specified, the distance between the exposed surface of flat specimens shall be 75 ± 25 mm from the back surface of the glass cover.

6.1.4 Formed specimens with irregular dimensions may require custom mounting with varying distances from the glass cover. In such cases, mount the test specimen surface of major interest parallel to the glass cover at a distance of 75 ± 25 mm from the glass cover. The mounting frame or plate shall be constructed of a material that is compatible with the test specimens. In order to minimize shadowing from the top and sides of the enclosure, the usable exposure area under the glass shall be limited to that of the glass cover reduced by twice the distance from the cover to the specimens as shown in Fig. 2. The effective width of the specimen mounting area is L-4X and the effective height of the mounting area is W-4X, where L is the width of the glass cover, W is the height of the glass cover, and X is the distance between the glass cover and the specimens.



Legend: L = length of glass cover; W = width of glass cover; X = distance between glass cover and specimens

FIG. 2 Sample Exposure Area Diagram

6.1.5 The enclosure shall be capable of being oriented in a manner mutually agreed upon between interested parties. The test report shall contain the orientation used. Possible exposure orientations are:

6.1.5.1 Fixed tilt angle, typically in the range of 5 to 45 degrees, with cabinet facing equator.

6.1.5.2 Fixed tilt angle, typically 51 degrees, with tracking in rotation (azimuth).

6.1.5.3 Tracking azimuth and elevation in order to maintain the exposure plane normal to the sun's direct beam.

6.1.5.4 Any other angle that is mutually agreed on by all interested parties may be used. In some instances, exposures facing directly away from the equator or some other specific direction may be desired.

6.2 *Glass Cover:*

6.2.1 The glass cover shall be flat glass of one of the following types:

6.2.1.1 *Clear Tempered Glass*—The glass cover shall be non-laminated, tempered, clear flat glass having a nominal thickness of 3 to 4 mm. The glass thickness used shall be included in the test report.

6.2.1.2 *Clear Laminated Glass*—The glass cover shall be laminated, clear flat glass having a nominal thickness of 5.8 mm and containing a PVB (polyvinyl butyral) inner layer with an approximate thickness of 0.76 mm (.030 in.). This type of glass is typically used in automotive applications.

6.2.1.3 Any other glass type as agreed upon between interested parties.

6.2.2 Wash the exterior and interior surfaces of the glass cover every month (or more frequently, if required) to remove dust particles and other undesirable material.

6.2.3 It is recommended that the spectral transmittance of representative glass samples be measured. If transmittance is measured, report the average for at least three representative pieces of the lot of glass being used. Follow the instructions of the UV-visible spectrophotometer used for measurement of the glass. If a spectrophotometer with an integrating sphere is used, the measurements shall be performed in accordance with Test Method E903.

6.3 *Black Panel Thermometer:*

6.3.1 For enclosures with a temperature-controlled circulating fan, one of the following black panel thermometer types shall be installed in the enclosure:

6.3.1.1 *Automotive Black Panel*—The black panel thermometer shall be constructed of 0.60 ± 0.06 mm (24 gauge) sheet steel with dimensions of approximately 100 by 125 mm (4 by 5 in.). The exposed surface of the black panel shall be primed and painted with black high heat spray paint.

6.3.1.2 *Specification G179 Black Panel*—The black panel thermometer shall be constructed in accordance with the requirements of Specification G179 with dimensions of approximately 100 by 125 mm (4 by 5 in.).

6.3.1.3 The type of black panel thermometer used shall be described in the test report. Regardless of which type of black panel is used, the black panel is exposed parallel to the glass at the same respective depth from the surface of the glass as the exposed surface of the test specimen. The panel must be mounted on 13 mm (½ in.) thick plywood, painted black, whose dimensions are at least 110 by 135 mm (4⅜ by 5⅜ in.) with a machined recess to allow space for the temperature sensor, thermocouple and their respective lead wires attached to the back of the black panel. The black panel must be fastened to the plywood with small screws near the corners of the panel. The black panel assembly shall be mounted in the plane of the test samples near the top edge of the sample mounting area no closer than 200 mm from the left or right edge of the glass cover as shown in Fig. 3.

6.4 *Circulating Fan:*

6.4.1 The test enclosure shall be equipped with a circulating fan which directs air between the top surface of specimens and the glass cover. This fan can be set to operate continuously during daylight hours, or based on the temperature reading from a black panel thermometer. Unless otherwise specified, when the circulating fan is switched off and on based on the temperature of a black panel thermometer, set the controller to turn on at the desired limit temperature and off at a temperature that is 3°C less than the limit temperature.

6.5 *Over Temperature Protection:*

6.5.1 Unless otherwise specified, test enclosures shall be equipped with over temperature protection to prevent specimen