Designation: G24 – 21

Standard Practice for Conducting Exposures to Daylight Filtered Through Glass[1]

This standard is issued under the fixed designation G24; 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 describes procedures for conducting exposures of various materials to daylight filtered through glass in passively ventilated and non-vented enclosures. For exposures in under glass enclosures with forced air circulation, refer to Practice G201.

1.1.1 This practice is not intended for corrosion testing of bare metals.

1.2 For direct exposures, refer to Practice G7.

1.3 This practice is limited to the method of conducting the exposures. The preparation of test specimens and evaluation of results are covered in various standards for the specific materials.

1.4 Exposure conducted according to this practice can use two types of exposure cabinets.

1.4.1 *Type A*—A cabinet that allows passive ventilation of specimens being exposed behind glass.

1.4.2 *Type B*—Enclosed cabinet with exterior painted black that does not provide for ventilation of specimens exposed behind glass. Exposures conducted using a Type B cabinet are typically referred to as "black box under glass exposures."

1.5 Type A exposures of this practice are technically similar to Method B of ISO 877-2.

1.6 *Units*—The values stated in SI units are to be regarded as standard. The values given in parentheses after SI units are provided for information only and are not considered 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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.8 *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]

C1036 Specification for Flat Glass

D4303 Test Methods for Lightfastness of Colorants Used in Artists' Materials

D6901 Specification for Artists' Colored Pencils

E824 Test Method for Transfer of Calibration From Reference to Field Radiometers

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

G7 Practice for Natural Weathering of Materials

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

G147 Practice for Conditioning and Handling of Nonmetallic Materials for Natural and Artificial Weathering Tests

G201 Practice for Conducting Exposures in Outdoor Glass-Covered Exposure Apparatus with Air Circulation

2.2 *ISO Standards:*[3]

ISO 877-2 Plastics – Methods of Exposure to Solar Radiation – Part 2: Direct Weathering and Exposure Behind Window Glass

ISO 9060:2018 Solar Energy – Specification and Classification of Instruments for Measuring Hemispherical Solar and Direct Solar Radiation

2.3 *Other Document:*[4]

WMO Guide to Meteorological Instruments and Methods of Observation WMO No. 8, 2014 Edition (2017).

3. Terminology

3.1 *Definitions:*

3.1.1 The definitions contained in Terminology G113 are applicable to this practice.

[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 International Organization for Standardization (ISO), ISO Central Secretariat, Chemin de Blandonnet 8, CP 401, 1214 Vernier, Geneva, Switzerland, https://www.iso.org.

[4] Available from World Meteorological Organization (WMO), 7bis, avenue de la Paix, Case Postale No. 2300, CH-1211 Geneva 2, Switzerland, http://www.wmo.int.

***A Summary of Changes section appears at the end of this standard**

4. Significance and Use

4.1 Since solar radiation, air temperature, relative humidity, and the amount and kind of atmospheric contaminants vary continuously, results from exposures based on elapsed time will sometimes differ. The variations in the results will usually be reduced by timing the exposures in terms of:

4.1.1 One or more environmental parameters such as solar radiant exposure, or

4.1.2 A predefined property change of a weathering reference specimen with known performance.

4.2 Variations in temperature, moisture, and atmospheric contaminants can have a significant effect on the degradation caused by solar radiation. In addition, exposures conducted at different times of the year can cause large differences in the rate of degradation. Different materials generally have different sensitivities to heat, moisture, and atmospheric contaminants, and this could explain differences in rankings of specimens exposed to equivalent solar radiant exposure when other environmental conditions vary.

4.3 Since the method of mounting has an influence on the temperature and other parameters during exposure of the specimen, there shall be agreement between contractual parties as to the method of mounting the specimen for the particular exposure test under consideration.

4.4 There are differences among various single strength window glasses in their transmittance in the 300 to 350 nm region. For example, at 320 nm, the percent transmittance for seven different lots of single strength window glass ranged from 8.4 to 26.8 %. At 380 nm, the percent transmittance ranged from 84.9 % to 88.1 %.[5]

4.5 Differences in UV transmittance between different lots of glass generally continue even after solarization. The largest differences among window glasses in UV transmittance are in the spectral range of 300 to 320 nm.

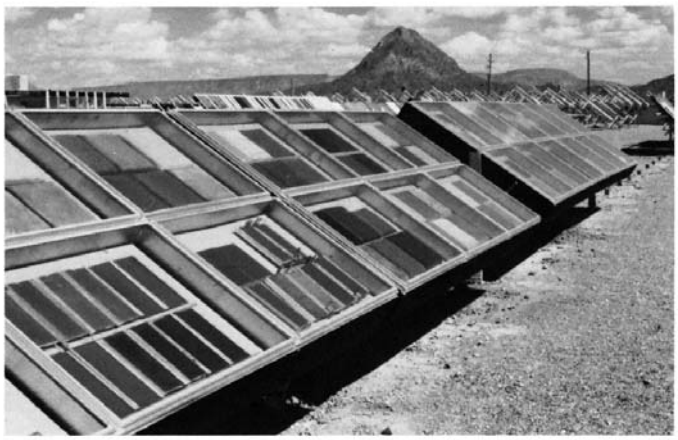

FIG. 2 Typical Non-Ventilated Enclosed Under Glass Exposure Cabinet, Type B (Black Box Under Glass)

4.6 This practice is best used to compare the relative performance of materials tested at the same time behind the same lot of glass. Because of variability between lots of glass and between exposures conducted at different times of the year, comparing the amount of degradation in materials exposed for the same duration or radiant exposure at separate times, or in separate fixtures using different lots of glass, is not recommended.

4.7 It is recommended that at least one control material with known performance be exposed with each test. The control material should be of similar composition and construction as the test specimen, 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. When 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.

4.8 Because of the possibility that certain materials will outgas during exposure and potentially contaminate other specimens, it is recommended that only similar materials be exposed in the same under glass cabinet at the same time.

[5] Ketola, W. D., and Robbins, J.S., III, "UV Transmission of Single Strength Window Glass," *Accelerated and Outdoor Durability Testing of Organic Materials, ASTM STP 1202*, Warren D. Ketola and Douglas Grossman, Eds., American Society for Testing and Materials, Philadelphia, 1994.

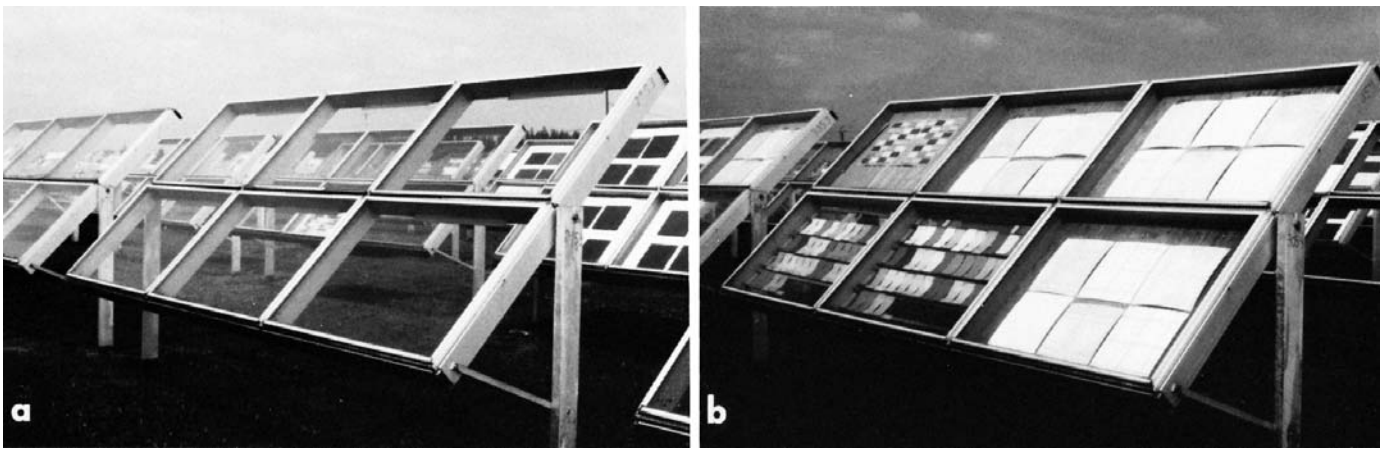

FIG. 1 a and 1b Typical Passively-Ventilated Under Glass Exposure Cabinet, Type A

5. Apparatus

5.1 *Exposure Cabinet:*

5.1.1 *Type A*—A glass-covered enclosure or cabinet of any convenient size, constructed to protect the specimens from rain. It typically is constructed of metal or wood, and shall be open on the back or sides to allow ambient air to passively circulate over the specimens (Fig. 1a and b show a typical glass cabinet empty, and with specimens, respectively).

5.1.2 *Type B (Black Box Under Glass)*—A glass-covered enclosure or cabinet of any convenient size. It shall be constructed of corrosion resistant metal and be enclosed to prevent ambient air from circulating over specimens. Exterior non-glass surfaces that will be irradiated shall be painted flat black. The interior shall remain unpainted (Fig. 2).

NOTE 1—For some exposures (for example, Method B of Test Methods D4303 or Method A of Specification D6901), a small fan is inserted into the Type B enclosure to minimize condensation. For enclosures with forced air circulation, refer to Practice G201.

NOTE 2—The black box under glass enclosure is often used to simulate under glass exposures under conditions of high temperature, such as the interior of an automobile. Black box under glass cabinets are enclosed, and air temperatures inside the cabinet may exceed 80 °C under conditions of high outside ambient temperature and solar irradiance. Significant differences in air and specimen temperatures can be experienced between upper and lower portions of the cabinet. Frequent temperature measurement and specimen repositioning may be required to properly use this enclosure.

5.1.3 Unless otherwise specified, the glass cover shall be a piece of clear, non-laminated, transparent flat glass, greenhouse quality Q4 or better as specified in subsection 4.1 of Specification C1036. Thickness shall be 2.0 to 3.2 mm.

5.1.3.1 In order to reduce variability of results due to changes in UV transmittance of glass, all new glass shall be exposed for at least three months prior to using to expose specimens per this practice. Expose the new glass facing the equator at any convenient exposure tilt angle within the range of 5 to 45°, according to Practice G7 or on an empty under glass exposure cabinet.

5.1.3.2 After the three-month pre-exposure period, it is recommended that the spectral transmittance of representative samples from each lot of glass be measured. Typically, "single strength" glass will have a transmittance of 10 to 20 % at 320 nm and at least 85 % at wavelengths of 380 nm or higher after the three month pre-aging procedure. When transmittance of the glass is measured, report the average for at least three pieces of the lot of glass being tested. Follow the instructions for measurement of transmittance of solid samples recommended by the manufacturer of the UV-visible spectrophotometer used. When a spectrophotometer with an integrating sphere is used, the measurements shall be performed in accordance with Test Method E903.

NOTE 3—Other standards describing exposures behind glass have different requirements for glass transmittance and do not require pre-aging.

NOTE 4—After the initial pre-aging period, the UV transmittance of window glass is suitable for at least 60 months of use. UV transmittance differences between lots of glass persist during this time, however. Different lots of single-strength window glass can have different optical properties even when purchased from the same manufacturer.

5.1.3.3 The exact history of each individual piece of glass is typically not tracked.

5.1.3.4 Wash the exterior surface of the glass cover every month with soap and water, and the interior surface of the glass cover every 3 months (or more frequently, as required) to remove dust particles and other undesirable deposits. Cleaning the interior surface with solvents will be needed when outgassing products are seen, followed by washing with soap and water to remove the cleaning agents. Remove the glass from the exposure frame when cleaning the interior surface.

5.1.4 The enclosure or cabinet shall be equipped with a rack which supports the specimens in a plane which is as close to parallel to the glass as practically possible. Whenever possible, the specimens are positioned such that the primary surface is supported at a distance of 75 ± 25 mm (3 ± 1 in.) behind the glass cover. Formed specimens with irregular dimensions will require custom mounting with varying distances from the glass cover. In such cases, mount the test specimen so that the surface of major interest is parallel to the glass cover at a distance of 75 ± 25 mm (3 ± 1 in.) behind 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 cabinet, 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. 3. 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. For example, when the primary surfaces of the specimens are 75 mm below the

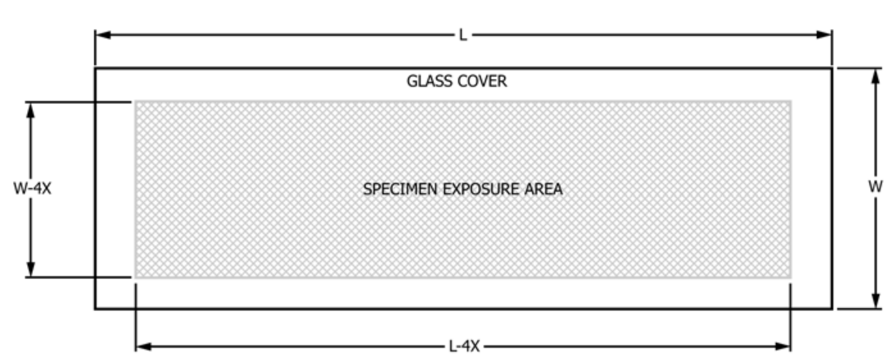

FIG. 3 Mounting Frame Dimensions

glass, then all specimens shall be at least 150 mm from the top, or bottom, or sides. Use one of these three types of mounting frames or backings.

5.1.4.1 *Unbacked or Open Mounting*—Specimens are attached only at edges.

5.1.4.2 *Expanded Aluminum Mounting*—Specimens are attached to an expanded aluminum backing.

5.1.4.3 *Solid Mounting*—Specimens are attached to a solid backing such as plywood.

NOTE 5—The method used to mount specimens shall be related to their end-use. In evaluating the specimens, the edges of these specimens that are used to secure the specimen to the framework should be disregarded.

5.1.5 Unless otherwise specified, test fixtures or racks shall be located in areas free of vegetation which can shade specimens. Unless otherwise specified, the area beneath and in the vicinity of the test fixtures shall have ground cover typical of the climatological area where the exposures are being conducted. In desert areas, the typical ground cover is often gravel to control dust and in most temperate or subtropical areas, the typical ground cover is low-cut grass. The type of ground cover at the exposure site shall be indicated in the test report. If test fixtures are placed over ground covers not typical of the climatological area (for example, rooftops, concrete, or asphalt), specimens may be subjected to different environmental conditions than if using typical ground cover or exposing at ground level. These differences may affect test results.

5.1.5.1 The glass cover should be fixed to the frame so that it cannot be blown off by the wind.

5.1.6 The lowest row of specimens on a test fixture or rack shall be positioned at least 0.45 m (18 in.) above the ground and shall not contact vegetation. This will also minimize damage that might occur during area maintenance.

5.1.7 Test fixtures shall be placed in a location so that there is no shadow on any specimen when the sun's angle of elevation is greater than 20°.

5.1.8 The glass cover and the test specimens shall be oriented in a manner mutually agreed upon between interested parties. The tilt angle shall be reported in the results of the test. Possible exposure orientations are listed as follows:

5.1.8.1 Fixed tilt angle equal to the latitude of the exposure site with cabinet facing equator,

5.1.8.2 Tilt angle of 45° facing the equator,

5.1.8.3 Tilt angle of 5° facing the equator,

5.1.8.4 Tracking azimuth and tilt angle in order to maintain the exposure plane normal to the sun's direct beam.

5.1.8.5 Any other angle that is mutually agreed on by all interested parties. In some instances, exposures facing directly away from the equator or some other specific direction will be desired. The test report shall contain the exact angle and specimen orientation.

NOTE 6—When exposures are performed in the Type A fixture at angles greater than 45°, extra care must be taken to keep the specimens dry, since it is more possible for rain to affect the specimens at the greater tilt. Enclosed fixtures such as "Test Houses" are often used to mount specimens behind glass in a vertical configuration.

5.2 *Climatological Instruments:*

5.2.1 Instruments suitable for measuring and recording maximum, minimum, and average daily ambient air temperature, cabinet air temperature (optional), and specimen temperature (optional). Ambient air temperature will be measured in a shielded, elevated location in the general vicinity of the under glass exposure cabinet.

5.2.2 Instruments suitable for measuring and recording the maximum, minimum, and average daily ambient air humidity, and cabinet humidity (optional).

5.2.3 Instruments for measuring and recording solar radiant exposure.

5.2.3.1 Instrumental means of measuring full-spectrum solar radiant exposure shall consist of a pyranometer connected to an integrating device to indicate the total energy received over a given period. The pyranometer shall be sensitive to solar irradiance received at a geometry similar to that over which solar irradiance is received by the test specimens. The pyranometer shall be a World Meteorological Organization (WMO) Class A or B as defined by the WMO Guide to Meteorological Instruments. The pyranometer shall be calibrated in accordance with Test Method E824 no less often than annually against a WMO Class A or B pyranometer whose calibration is traceable to the World Radiometic Reference (WRR).

5.2.3.2 A device for measuring full-spectrum solar radiant exposure shall consist of a pyranometer with data integrated over a given period. The pyranometer shall be sensitive to solar irradiance received at a geometry similar to that over which solar irradiance is received by the test specimens. The pyranometer shall meet either ISO 9060:2018 Class A or B requirements or WMO High Quality or Good Quality specifications. The pyranometer shall be calibrated in accordance with Test Method E824 no less often than annually against an ISO 9060:2018 Class A or WMO High Quality pyranometer whose calibration is traceable to the World Radiometric Reference (WRR).

5.2.3.3 Instrumental means of measuring solar radiant exposure in specific wavelength regions (such as all or a portion of the ultraviolet spectrum) shall consist of a wavelength-band specific global irradiance radiometer connected to an integrating device to indicate the energy received in a specified wavelength band over a given period (optional).

NOTE 7—Solar radiant exposure shall be measured and expressed in SI units of joules per square meter.

5.2.4 All instruments for measuring and recording environmental parameters shall have a current NMI traceable calibration.

6. Procedure

6.1 Unless otherwise specified, or agreed to by all interested parties, it is recommended that a minimum of three replicates of each material being tested be exposed. The simultaneous exposure of a similar number of specimens of a control is also strongly recommended.

6.2 Expose the test specimens, and any control or reference specimens, in the glass-covered exposure cabinet. Exposure will be continuously 24 hours a day and the specimens will only be removed from the cabinet for inspection, return to customer, or to protect specimens from possible damage during severe weather events.