Designation: G 24 – 97

AMERICAN SOCIETY FOR TESTING AND MATERIALS
100 Barr Harbor Dr., West Conshohocken, PA 19428
Reprinted from the Annual Book of ASTM Standards. Copyright ASTM

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

This standard is issued under the fixed designation G 24; 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 evaluates the resistance of nonmetallic materials to solar radiation filtered through glass.

1.2 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.

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

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

1.3.2 *Type B*—Enclosed cabinet with exterior painted black that allows no ventilation of specimens exposed behind glass. Exposures conducted using a Type B cabinet are typically referred to as "black box under glass exposures".

1.4 This practice is technically similar to Method B of ISO 877.

1.5 *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:*

E 782 Practice for Exposure of Cover Materials for Solar Collectors to Natural Weathering under Conditions Simulating Operational Mode[2]

E 824 Method for Transfer of Calibration from Reference to Field Pyranometers[2]

E 903 Test Method for Solar Absorptance, Reflectance, and Transmittance of Materials Using Integrating Spheres[2]

G 84 Practice for Measurement of Time-of-Wetness on Surfaces Exposed to Wetting Conditions as in Atmospheric Corrosion Testing[3]

G 113 Terminology Relating to Natural and Artificial Weathering Tests of Nonmetallic Materials[4]

2.2 *Other Documents:*

WMO Guide to Meteorological Instruments and Methods of Observation WMO No. 8, Fifth Edition.[5]

ISO 105 B01 Textiles—Tests for Colour Fastness, International Standards Organization, Geneva, Switzerland.[6]

ISO 877 Plastics—Methods of Exposure to Direct Weathering, to Weathering Using Glass-Filtered Daylight, and to Intensified Weathering by Daylight Using Fresnel Mirrors, International Standards Organization, Geneva, Switzerland[6]

AATCC 16C Colorfastness to Light, Daylight[7]

3. Terminology

3.1 *Definitions:*

3.1.1 The definitions contained in Terminology G 113 are applicable to this practice.

4. Significance and Use

4.1 Since solar irradiance, air temperature, relative humidity, and the amount and kind of atmospheric contaminants vary continuously, results from exposures based on time may differ. The variations in the results may be minimized by timing the exposures in terms of one or more environmental parameters such as solar radiant exposure, or in terms of a predetermined property change of a reference specimen with known performance.

4.2 Moisture combined with atmospheric contaminants may produce degradation effects as great as those produced by solar irradiance. This may explain differences in rankings of specimens exposed to equivalent solar radiant exposure when other environmental conditions vary.

4.3 Since the method of mounting may influence the temperature and other parameters of the specimen during exposure, there should be a mutual understanding as to the method of mounting the specimen for the particular exposure test under consideration.

4.4 There can be large differences in 300 to 350 nm UV transmission of single strength window glass. For example, at 320 nm, the percent transmission for seven different lots of single strength window glass ranged from 8.4 to 26.8 %. For

[1] This practice is under the jurisdiction of ASTM Committee G-3 on Durability of Nonmetallic Materials and is the direct responsibility of Subcommittee G 03.02 on Natural Environmental Testing.

Current edition approved July 10, 1997. Published October 1997. Originally published as G 24 – 73. Last previous edition G 24 – 73 (1980).

[2] *Annual Book of ASTM Standards*, Vol 12.02.

[3] *Annual Book of ASTM Standards*, Vol 03.02.

[4] *Annual Book of ASTM Standards*, Vol 14.02.

[5] Available from World Meteorological Organization, Geneva, Switzerland.

[6] Available from American National Standards Institute, 11 W. 42nd St., 13th Floor, New York, NY 10036.

[7] American Association of Textile Chemists and Colorists, Research Triangle Park, PO Box 12215, NC 27709-2215.

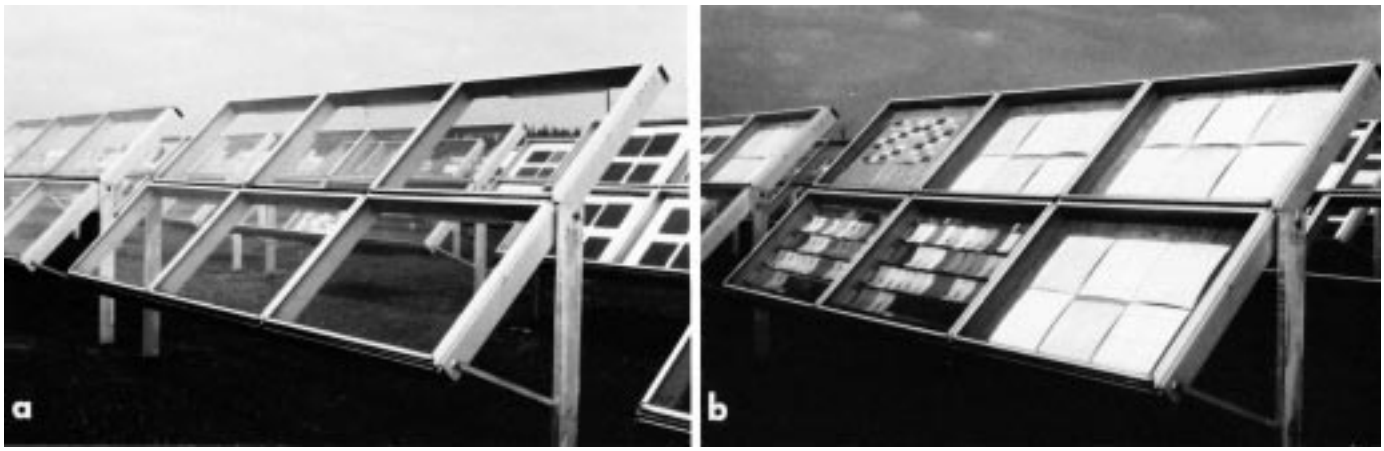

FIG. 1 a and 1b Typical Well-Ventilated Under Glass Exposure Cabinet, Type A

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

this range of transmission, the rate of degradation for materials sensitive to short wavelength UV from 300 to 320 nm could vary by as much as 300 %.[8] In addition, exposures conducted at different times of the year can cause large differences in rate of degradation.[9]

4.5 In order to minimize differences in 300 to 340 nm UV transmission caused by rapid solarization of new glass, this practice requires that glass be pre-aged for three months prior to use in exposure cabinets.

4.6 Differences in UV transmission between different lots of glass persist after solarization.[8] The largest differences in UV transmission of glass are between 300 and 320 nm. Use of radiant exposure based on total solar radiation or total solar UV radiation to determine exposure periods is not sensitive to these differences. For materials very sensitive to differences in short wavelength UV radiation, monitoring UVB radiation behind glass may be the best approach for use when radiant energy is used to determine the length of exposures. However, for materials sensitive to long wavelength UV or visible radiation, monitoring UVB radiation or using reference materials that are very sensitive to short wavelength solar ultraviolet radiation to determine exposure periods may produce inconsistent results.

4.7 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. This practice should not be used to establish "pass/fail" approval of materials after a specific period of exposure unless performance comparisons are made relative to a control material exposed simultaneously, or the variability in the test is quantified so that statistically significant pass/fail judgments can be made.

4.8 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 degradation mechanisms or 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.

4.9 There are other standards which describe exposures to glass filtered daylight. Three cited standards are ISO 105-B01, ISO 877, and AATCC 16C.

4.10 Because of the possibility that certain materials may outgas during exposure, it is recommended that only similar materials be exposed in the same under glass cabinet.

5. Apparatus

5.1 *Exposure Cabinet*:

5.1.1 *Type A*—Exposures shall be conducted in a glass-covered enclosure or cabinet of any convenient size. It shall be constructed of wood, metal, or other satisfactory material, in

[8] Ketola, W. D., and Robbins, J. S. "UV Transmission of Single Strength Window Glass", *Accelerated and Outdoor Durability Testing of Organic Materials, ASTM STP 1202*, Warren D. Ketola and Douglass Grossman, Eds, American Society for Testing and Materials, Philadelphia, 1993.

[9] Crewdson, L. F., and Bahadur-Singh, C., "A Review of the Variability Encountered When Exposure Materials to Glass Filtered Sunlight", *Accelerated and Outdoor Durability Testing of Organic Materials, ASTM STP 1202*, Warren D. Ketola and Douglass Grossman, Eds, American Society for Testing and Materials, Philadelphia, 1993.

order to protect the specimens from rain and weather, and shall be open on the back or sides to allow ambient air to circulate over the specimens (Fig. 1a and b).

5.1.2 *Type B (Black Box Under Glass)*—Exposures shall be conducted in 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.[10] Exterior nonglass surfaces shall be painted flat black. The interior shall remain unpainted (Fig. 2).

NOTE 1—The black box under glass test method is often used to simulate under glass exposures under conditions of high temperature, such as the interior of an automobile. However, because black box under glass cabinets are enclosed, air temperatures may exceed 80°C under conditions of high outside ambient air temperature and solar irradiance. In addition, significant differences in air and specimen temperatures can be experienced between upper and lower portions of the cabinet. Frequent temperature measurement and specimen rotation may be required to properly use this test method.

5.1.3 Unless otherwise specified the glass cover shall be a piece of good grade, clear, flat-drawn sheet glass, free of bubbles or other imperfections. Typically, "single strength" glass, that is 2 to 2.5 mm thick, is used.

5.1.3.1 In order to reduce variability due to changes in UV transmission of glass, all new glass shall be exposed facing the equator, at the site latitude angle, according to Practice G 7, or on an empty under glass exposure cabinet, for at least three months prior to installation in test cabinets.

NOTE 2—Other standards describing exposures behind glass have different requirements for glass transmittance and do not require pre-aging.

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. If 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. If a spectrophotometer with an integrating sphere is used, the measurements shall be performed in accordance with Test Method E 903.

NOTE 3—After the initial pre-aging period, the UV transmission of window glass is suitable for at least 60 months of use. UV transmission differences between lots of glass persist during this time, however.

5.1.3.3 Wash the exterior surface and the interior surface of the glass cover monthly (or more frequently, if required) to remove dust particles and other undesirable material.

NOTE 4—Different pieces of single-strength window glass can have different optical properties even if purchased from the same manufacturer.

5.1.4 The enclosure or cabinet shall be equipped with a rack which supports the specimens in a plane parallel to the glass cover at a distance of not less than 75 mm (3 in.). 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. Three types of mounting frames or backings may be used.

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.[11]

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 The cabinet shall be located where it will receive direct sunlight throughout the day and where shadows of objects in the vicinity will not fall upon it. When the cabinet is installed over soil, the distance between the bottom of the cabinet and the plane of the cleared area shall be a sufficient distance above ground to prevent possible undesirable effects of contact with plant growth, or to prevent damage during maintenance.

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

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

5.1.6.2 Tilt angle of 45° facing the equator,

5.1.6.3 Seasonally adjusted tilt angle with cabinet facing the equator (the tilt angles suggested by Practice E 782 may be used), and

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

5.2 *Climatological Instruments*:

5.2.1 Instruments suitable for determining 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 determining the maximum, minimum, and average daily ambient air humidity, and cabinet humidity (optional).

5.2.3 Instruments for recording solar radiant exposure under glass.

5.2.3.1 Instrumental means of measuring solar radiant exposure under glass shall consist of a pyranometer connected to an integrating device to indicate the total energy received over a given period. It shall be mounted under glass having the spectral transmittance characteristics specified in 5.1.3. The pyranometer shall be sensitive to solar irradiance received at a

[10] Suitable Cabinets meeting these requirements can be obtained from the William Harrison Company, Hialeah, FL.

[11] Exterior plywood having either a smooth paper finish on one side or covered with white cardboard such as Franklin, Grain long-felt side up, 110/500 white index, stock number 06506 or equivalent may be substituted.

geometry similar to that over which solar irradiance is received by the test specimens. The pyranometer shall be a World Meteorological Organization (WMO) Second Class instrument or better as defined by the WMO Guide to Meteorological Instruments.[12] The pyranometer shall be calibrated in accordance with Method E 824 no less often than annually against a WMO Secondary Standard pyranometer or a reference pyranometer whose calibration is traceable to the World Radiation Reference (WRR).[13]

5.2.3.2 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). The spectral response of the narrow-band radiometer shall be known and shall be as flat as possible throughout the spectral region utilized. It shall be mounted under glass having the spectral transmittance characteristics specified in 5.1.3.

NOTE 6—Solar radiant exposure should be measured and expressed in SI units of joules per square metre. One langley is equivalent to 4.184×10^4 J/m^2.

5.2.4 Instruments suitable for measuring time-of-wetness in accordance with Practice G 84 (optional). Time-of-wetness shall be measured in the same type of cabinet used for exposing the specimens.

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, control specimens, and/or specimens of an applicable weathering reference material, (for example, blue wool) in the glass-covered exposure cabinet continuously 24 hours a day and remove from the cabinet only for inspection, return, or to protect specimens from possible damage during severe weather events.

6.3 Measure and record daily the maximum, minimum, and average air temperature and relative humidity in the vicinity of the test cabinet. It is also recommended that cabinet air temperature and humidities as well as specimen temperature be recorded.

NOTE 7—While these conditions cannot be controlled, a record of them is desirable to indicate the general conditions that prevailed during the exposure.

6.4 Remove the test specimens, control specimens, and/or specimens of applicable weathering reference material from the cabinet using one of the following procedures:

6.4.1 *Based on Amount of Solar Radiant Exposure*— Expose the test specimens for a specified solar radiant exposure dose, either total (all wavelengths) or a selected wavelength band. Report the results in terms of any specified method of measuring changes in test specimens.

6.4.2 *Based on Predetermined Property Change*—Expose the test specimens (and any specified reference specimen if desired) until a specified amount of property change has occurred in either the candidate materials or standard samples.

6.4.3 *Based on Duration of Exposure*—Expose the test specimens for a specified time period. Report the results in terms of any specified method of measuring changes in test specimens.

6.4.4 *Based on Any Other Specified Environmental Parameter*.

7. Report

7.1 The report shall include the following:

7.1.1 Type of exposure cabinet used, including the angle of the exposure rack. Report the transmittance characteristics of the glass, if measured. The wavelengths at which transmission is reported should be agreed upon by all interested parties.

7.1.2 Dates and location of exposure, including the latitude of the exposure site,

7.1.3 Applicable physical property or appearance data for each specimen obtained prior to exposure and after each exposure increment. If replicate specimens are used, report the mean and standard deviation of each property measured.

7.1.4 Methods used for measuring physical or appearance properties of test and control specimens.

7.1.5 Solar radiant exposure data expressed in SI units,

7.1.6 Maximum, minimum, and average daily temperatures, as well as cabinet air and specimen temperatures, if recorded,

7.1.7 Maximum, minimum, and average daily relative humidity, as well as cabinet humidity, if recorded,

7.1.8 Any other specified environmental parameter,

7.1.9 Any variations from the specified conditions, and

7.1.10 Type of specimen rack and mounting employed.

8. Keywords

8.1 aging; exposure; glass; ultraviolet; weathering

[12] Certain WMO Second Class pyranometers, notably those with segmented, black-and-white receivers (the so-called star pyranometers) have been found to exhibit significant deviations from the cosine law and significant tilt and temperature errors that are magnified by employment in glass-covered enclosures. They should only be employed when careful calibration tests have shown specific instruments to be free of such errors.

[13] Calibration certificates issued by the calibrating laboratory should state the chain of traceability to the WRR. If a pyranometer manufacturer is unable to meet this requirement for traceability, the calibration shall be performed by a nationally recognized calibration laboratory. Certified calibrations traceable to the WRR may be obtained from: The Eppley Laboratories, 12 Sheffield Ave., Newport, RI 02840; Heraeus DSET Laboratories, Inc., 45601 N. 47th Ave., Phoenix, AZ 85027-7042; and Environmental Research Laboratories, NOAA, 325 Broadway, Boulder, CO 80303.