Designation: E2141 – 21

Standard Test Method for Accelerated Aging of Electrochromic Devices in Sealed Insulating Glass Units[1]

This standard is issued under the fixed designation E2141; 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 the accelerated aging of electrochromic devices (ECD) integrated in insulating glass units.

1.2 The test method is applicable for any electrochromic device incorporated into sealed insulating glass units (IGUs) fabricated for vision glass (superstrate and substrate) areas for use in buildings, such as sliding doors, windows, skylights, and exterior wall systems. The layers used for constructing the EC device and electrochromically changing the optical properties may be inorganic or organic materials.

1.3 The electrochromic (EC) glazings used in this test method are exposed to environmental conditions, including solar radiation. They are employed to control the amount of transmitted radiation by absorption and reflection and, thus, limit the solar heat gain and amount of solar radiation that is transmitted into the building.

1.4 The test method is not applicable to other chromogenic devices, such as, photochromic and thermochromic devices which do not respond to electrical stimulus.

1.5 The test method is not applicable to electrochromic (EC) glazings that are constructed from superstrate or substrate materials other than glass.

1.6 The test method referenced herein is a laboratory test conducted under specified conditions. The test is intended to simulate and, in some cases, to also accelerate actual in-service use of the electrochromic glazing. Results from these tests cannot be used to predict the performance with time of in-service units unless actual corresponding in-service tests have been conducted and appropriate analyses have been conducted to show how performance can be predicted from the accelerated aging tests.

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

1.8 *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.*

1.9 *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]

C168 Terminology Relating to Thermal Insulation

E177 Practice for Use of the Terms Precision and Bias in ASTM Test Methods

E631 Terminology of Building Constructions

E691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method

E2953 Specification for Evaluating Accelerated Aging Performance of Electrochromic Devices in Sealed Insulating Glass Units

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

G155 Practice for Operating Xenon Arc Lamp Apparatus for Exposure of Materials

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

2.2 *ISO Standard:*[3]

ISO 9050 Glass in building - Determination of light transmittance, solar direct transmittance, total solar energy transmittance, ultraviolet transmittance and related glazing factors

[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.

[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.

3. Terminology

3.1 *Definitions*—For definitions of general terms used in this test method related to building construction, thermal insulating materials and natural and artificial weathering tests for nonmetallic materials, refer to Terminologies E631, C168 and G113, respectively.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *accelerated aging test, n*—a test in which the rate of degradation of building components or materials is intentionally increased from that expected in actual service.

3.2.2 *electrochromic device (ECD), n*—a combination of materials that include materials in which the transmittance, reflectance, and absorptance properties can be altered in response to an applied electrical voltage or current.

3.2.3 *electrochromic (EC) glazing, n*—glazing installed in a building that consists of an ECD with layer(s) of materials in which the optical properties can change in response to an applied electrical field.

3.2.4 *electrochromic layer(s), n*—in an ECD, the layer(s) of material(s) in which the optical properties can change in response to application of an electrical voltage or current, or both.

3.2.5 *electro-optic cycling, n*—the process of applying repetitive voltages or currents, or both, to an ECD for the purpose of reversibly changing the optical properties of the EC glazing from the highest to the lowest transmittance state.

3.2.6 *highest transmittance state, n*—also referred to as the clear state or bleached state, a descriptor for an EC glazing when it is in the transmittance state with the highest photopic specular light transmittance.

3.2.7 *lateral uniformity, n*—the degree of variation in the amount of irradiance in the x and y directions in the test plane used for exposing an EC glazing.

3.2.8 *lowest transmittance state, n*—also referred to as the tinted state, dark state or colored state, a descriptor for an EC glazing when it is in the transmittance state with the lowest photopic specular light transmittance.

3.2.9 *photopic transmittance ratio (PTR), n*—photopic transmittance ratio or PTR = τ_H/τ_L. The photopic transmittances (τ_H, τ_L) are obtained by integrating the spectra in the wavelength range of 380 to 780 nm using the spectral photopic efficiency Ip (CIE, 1924) as the weighting factor.

3.2.10 *room temperature, n*—ca 22 °C.

3.2.11 *serviceability, n*—the capability of a building product, component, assembly, or construction to perform the function(s) for which it was designed and constructed.

3.2.12 *solar irradiance, n*—as related to natural weathering of materials, the irradiance of the sun incident on the earth's surface, having wavelengths between 295 nm and 4050 nm.

3.2.13 *specular (regular) transmittance, n*—the optical transmittance that does not include light with a diffuse component.

3.2.14 *switching cycle, n*—a transition in visible light transmittance through the whole or part of the EC-IGU's visible light transmittance range starting at one end of the range (at τ_H or τ_L) and ending back at the same point. For example, one switching cycle can be a transition from the highest transmittance state to the lowest transmittance state and back to the highest transmittance state, or a transition from the lowest transmittance state to the highest transmittance state and back to the lowest transmittance state.

3.2.15 *switching times T_H and T_L, n*—switching time, T_H, is the time it takes for the EC glazing to transition from its highest transmittance state over 80 % of its initial dynamic range (where dynamic range is τ_H-τ_L). Switching time (T_L) is the time it takes for the EC glazing to transition from its lowest transmittance state across 80 % of its dynamic range (where dynamic range is τ_H-τ_L).

3.3 *Abbreviations:*

3.3.1 *AM*—air mass

3.3.2 *AWU*—accelerated weathering unit

3.3.3 *DBT*—dry-bulb temperature

3.3.4 *DPM*—digital panel meters

3.3.5 *ECD*—electrochromic device

3.3.6 *IG*—insulating glass

3.3.7 *IGU(s)*—insulating glass unit(s)

3.3.8 *NIR*—near-infrared (radiation)

3.3.9 *PTR*—photopic transmittance ratio

3.3.10 τ_H—specular (regular) transmittance in the *highest transmittance state*

3.3.11 τ_L—specular (regular) transmittance in the *lowest transmittance state*

3.3.12 T_H—time to switch from the highest transmittance state to a transmittance of $\tau_H - 0.8\ (\tau_H\text{-}\tau_L)$

3.3.13 T_L—time to switch from the lowest transmittance state to a transmittance of $\tau_L + 0.8\ (\tau_H\text{-}\tau_L)$

3.3.14 *UV*—ultraviolet (radiation)

4. Significance and Use

4.1 EC glazings perform a number of important functions in a building envelope including: minimizing the solar energy heat gain; providing for passive solar energy gain; controlling a variable visual connection with the outside world; enhancing human comfort (heat gain), illumination, and glare control; and providing for architectural expression. It is therefore important to understand the relative serviceability of these glazings.

4.2 This test method is intended to provide a means for evaluating the relative serviceability of EC Glazings as described in Section 1.

4.3 The procedures in this test method include (*a*) rapid but realistic current-voltage cycling tests emphasizing the electrical properties, and (*b*) environmental test parameters that are typically used in weatherability tests by standards organizations and are realistic for the intended use of large-area EC IGUs.