Designation: E2354 – 10

Standard Guide for Assessing the Durability of Absorptive Electrochromic Coatings within Sealed Insulating Glass Units[1]

This standard is issued under the fixed designation E2354; 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 guide provides the recommended sequence for using the referenced ASTM test methods for assessing the durability of absorptive electrochromic coatings (ECCs) within sealed insulating glass units. Cross sections of typical electrochromic glazings have three to five-layers of coatings that include one to three active layers sandwiched between two transparent conducting electrodes (TCOs, see Section 3). Examples of the cross-sectional arrangements can be found[2] in "Evaluation Criteria and Test Methods for Electrochromic Windows." (For a list of acronyms used in this standard, see Appendix X1, Section X1.1).

1.2 This guide is applicable only for layered (one or more active coatings between the TCOs) absorptive ECCs on vision glass (superstrate and substrate) areas planned for use in IGUs for buildings, such as glass doors, windows, skylights, and exterior wall systems. The layers used for electrochromically changing the optical properties may be inorganic or organic materials between the superstrate and substrate.

1.3 The ECCs used in this guide will ultimately be exposed (Test Method E2141) to solar radiation and deployed to control the amount of 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 This guide is not applicable to other types of coatings on vision glass with other chromogenic coatings, for example, photochromic and thermochromic coatings.

1.5 This guide is not applicable to IGUs that will be constructed from superstrate or substrate materials other than glass.

1.6 The test methods referenced in this guide are laboratory test methods conducted under specified conditions.

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 There is no comparable International Standards Organization Standard.

1.9 *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 requirements prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*[3]

C168 Terminology Relating to Thermal Insulation

E2141 Test Methods for Assessing the Durability of Absorptive Electrochromic Coatings on Sealed Insulating Glass Units

E2188 Test Method for Insulating Glass Unit Performance

E2189 Test Method for Testing Resistance to Fogging in Insulating Glass Units

E2190 Specification for Insulating Glass Unit Performance and Evaluation

E2240 Test Method for Assessing the Current-Voltage Cycling Stability at 90°C (194°F) of Absorptive Electrochromic Coatings on Sealed Insulating Glass Units

E2241 Test Method for Assessing the Current-Voltage Cycling Stability at Room Temperature of Absorptive Electrochromic Coatings on Sealed Insulating Glass Units

E2355 Test Method for Measuring the Visible Light Transmission Uniformity of an Absorptive Electrochromic Coating on a Glazing Surface

3. Terminology

3.1 *Definitions*—Refer to Terminology C168 for definitions of general terms.

3.2 *Definitions of Terms Specific to This Standard:*

[1] This guide 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.

Current edition approved Oct. 1, 2010. Published November 2010. Originally approved in 2004. Last previous edition approved in 2004 as E2354 – 04. DOI: 10.1520/E2354-10.

[2] Czanderna, A. W., and Lampert, C. M., "Evaluation Criteria and Test Methods for Electrochromic Windows," *SERI/PR-255-3537*, Solar Energy Research Institute, Golden, CO, July 1990.

[3] 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.

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

3.2.2 *bleached state*—a descriptor for an EC coating when no ions reside in the electrochromic layer or after ions have been removed (or inserted, depending on the type of material) from the electrochromic layer(s) and if applicable, the maximum number of ions have been returned to the counterelectrode layer to restore the photopic optical specular transmittance in the bleached state (τ_b) from that of the photopic optical specular transmittance in the colored state (τ_c).

3.2.3 *colored state*—a descriptor for an EC coating after ions have been inserted (or removed, depending on the type of material) into the electrochromic layer and, if applicable, removed from the counterelectrode layer to reduce the photopic optical specular transmittance (of wavelengths from 400 nm to 730 nm) from that in the bleached state (τ_b).

3.2.4 *durability*—the capability of maintaining the serviceability of a product, component, assembly, or construction over a specified time.

3.2.5 *electrochromic coating (ECC)*—the multilayered materials that include the electrochromic layers, other layers, and transparent conducting oxide layers required for altering the optical properties of the coating.

3.2.6 *electrochromic layer(s)*—the material(s) in an EC coating that alter its optical properties in response to the insertion or removal of ions, for example, Li^+ or H^+.

3.2.7 *electrochromic (EC) glazing*—a device with an ECC consisting of several layers of electrochromic, attendant materials, and one or more lites of glass, which are able to alter their optical properties in response to a change in an applied electric field. The changeable optical properties include transmittance, reflectance, and absorptance result in changes in the solar heat gain, visible transmittance, and U-factor of the glass.

3.2.8 *fenestration*—Any opening in a building's envelope including windows, doors, and skylights.

3.2.9 *performance parameters*—the photopic transmittance ratio (PTR = τ_b/τ_c) between the bleached and colored states; coloring and bleaching times and open-circuit memory.

3.2.10 *sealed insulating glass unit*—is defined in Test Method E2190 but see also Appendix X1, Section X1.3.

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

3.3 For additional useful definitions for terminology used in this standard, see Appendix X1, Section X1.3.

4. Significance and Use

4.1 This guide provides a recommended systematic sequence for using the referenced test methods for evaluating the durability of EC insulating glass units (IGUs) as described in section 1.2.[2,4] (See Appendix X1, Section X1.4.)

4.2 This guide provides a summary of the durability issues addressed by each of the series of standards that are necessary for assesing the durability of electrochromic coatings (ECCs) in insulating glass units (IGUs). When fully implemented in buildings in the U.S., ECCs in IGUs have the potential of significantly reducing our current energy consumption for all uses-not just buildings. IGUs with ECCs will, of necessity, have to be able to pass the applicable standards listed in Appendix X1, Section X1.4, as well as an ASTM standard on wind loading for IGUs. Passing these will not be sufficient because the operating temperatures of ECCs in IGUs can potentially be as high as 90°C at the center-of glass, whereas the highest temperature used in Test Method E2188 is 60°C . Listings of existing and proposed standards are given in Table 1 and in Appendix X1, Section X1.4.

5. Background

5.1 Durability is a critical requirement for an EC glazing product for use on the building envelope. In selecting the materials, device design, and glazing for any application, the ability of the glazing to perform over time is an indication of that glazing's durability. The purpose of this guide is to provide a recommended sequence for assessing the durability of absorptive ECCs within sealed IGUs.

5.2 EC glazing perform a number of important functions in a building envelope including: minimizing the solar energy

[4] Czanderna, A. W., Benson, D. K., Jorgensen, G. J., Zhang, J-G., Tracy, C. E., and Deb, S. K., "Durability Issues and Service Lifetime Prediction of Electrochromic Windows for Buildings Applications," *NREL/TP-510-22702*, National Renewable Energy Laboratory, Golden, CO, May 1997; *Solar Energy Materials and Solar Cells*, 56, 1999 , pp. 419–436.

TABLE 1 Recommended Sequence for Using the Referenced or Planned Test Methods or Practice to Address Questions about the Durability or Serviceability of ECCs within an IGU

Standard	Qualification or Durability Question Addressed
	Stability of the ECC within an IGU
E2355	Will the ECC in the IGU pass initial uniformity inspection and transmittance measurements in the colored and bleached states? This test method shall also be used to demonstrate if an acceptable uniformity is maintained after the specimens have been subjected to one or more of the accelerated life tests.
E2241	Can the ECC survive at least 50 000 current-voltage (coloring/bleaching) cycles over 5000 h at room temperature without a loss in performance below an acceptable level"?
E2240	Can the ECC survive at least 50 000 current-voltage (coloring/bleaching) cycles over 5000 h at the anticipated highest operating temperature of 90°C without a loss in performance below an acceptable level"?
E2141	Can the ECC survive 50 000 current-voltage (coloring/bleaching) cycles at 90°C in the presence of UV without a loss in performance below an acceptable level"?
	Assessing the Durability of the ECC within an IGU and of the Stability and Durability of the IGU
E2190	Will the IGU with the ECC pass the industry standard for the performance of IGUs?