



Designation: ~~C1376—15~~ C1376 – 21

Standard Specification for Pyrolytic and Vacuum Deposition Coatings on Flat Glass¹

This standard is issued under the fixed designation C1376; 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 specification covers the optical and aesthetic quality requirements for coatings applied to glass for use in building glazing.

1.2 The coatings covered are applied to the glass using either pyrolytic or vacuum (sputtering) deposition methods and are typically applied to control solar heat gain, energy performance, comfort level, and condensation and enhance the aesthetic of the building.

1.3 This specification addresses blemishes related to the coating only. It does not address glass blemishes, applied ceramic frits, frits to spandrel glass, and organic films/film opacifiers.

1.4 The Nonuniformity for Coated Glass requirements, given in 6.10, pertain to as installed in the building exterior glazing units of vertical and sloped orientations.

1.5 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

1.6 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 Reference to these documents shall be the latest issue unless otherwise specified by the authority applying this specification.

2.2 *ASTM Standards:*²

[C162 Terminology of Glass and Glass Products](#)

[C1036 Specification for Flat Glass](#)

[C1048 Specification for Heat-Strengthened and Fully Tempered Flat Glass](#)

[D2244 Practice for Calculation of Color Tolerances and Color Differences from Instrumentally Measured Color Coordinates](#)

3. Terminology

3.1 *Definitions*—Refer to Terminology ~~C162~~, Specification ~~C1036~~ or Specification ~~C1048~~ as appropriate:

¹ This specification is under the jurisdiction of ASTM Committee C14 on Glass and Glass Products and is the direct responsibility of Subcommittee C14.08 on Flat Glass. Current edition approved Nov. 1, 2015; Feb. 1, 2021. Published November 2015; March 2021. Originally approved in 1997. Last previous edition approved in 2010 as C1376 – 10; C1376 – 15. DOI: 40.1520/C1376-15.10.1520/C1376-21.

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.

3.1.1 ~~blemishes in flat glass~~—refer to Specifications ~~C1036~~ or ~~C1048~~, as appropriate.

3.1.2 These definitions do not apply to in-service damage.

3.1 Definitions:

3.1.1 Refer to Terminology ~~C162~~ or Specification ~~C1036~~ or ~~C1048~~, as appropriate.

3.1.2 ~~blemishes in flat glass~~—refer to Specification ~~C1036~~ or ~~C1048~~, as appropriate.

3.1.3 These definitions do not apply to in-service damage.

3.2 Definitions of Terms Specific to This Standard:

3.2.1 ~~coated overhead glass~~—glass used in an installation in which the lower edge of the glass is more than 6 ft (1.8 m) above (the viewer’s) floor level or cannot be approached within 10 ft (3.0 m); the glass can usually but not always be viewed in both transmission and reflection; the glass is usually sloping in from the vertical plane, however, may also be vertical or sloping out from the vertical plane.

3.2.2 ~~coated spandrel/spandrel/non-vision glass~~—glass used in an installation in which the glass is only viewed in reflection from the building’s exterior. The glass is usually installed vertically, however, may be at a slope to the vertical ~~plane~~.plane

3.2.3 ~~coated vision glass~~—glass used in an installation in which the lower edge of the glass is a maximum of 6 ft (1.8 m) above (the viewer’s) floor level; the glass can be viewed in transmission or reflection; the glass is usually vertical, however, may also be sloping in or out from the vertical plane; and the glass can be approached within 10 ft (3.0 m) or less. (~~If~~ the distance is greater than 10 ft (3.0 m), see coated overhead ~~glass~~).glass.

3.2.4 ~~coating rub~~—a surface abrasion of appreciable width that has partial, or complete, removal of the coating producing a hazy appearance.

3.2.5 ~~coating scratch~~—partial, or complete, removal of the coating along a thin straight or curved line.

3.2.6 ~~corrosion~~—change in the color or level of reflected or transmitted light over all or part of the glass surface as a result of degradation of the coating from external sources.

3.2.7 ~~crazing~~—a random conglomeration of fine lines or cracks in the coating.

3.2.8 ~~cut size~~—flat glass sheets cut to specific dimensions.

3.2.9 ~~edge deletion~~—the process of removing a portion of the vacuum deposition coating from the glass surface typically within 1 in (25 mm) or less of all edges before insulating or laminating the glass.

3.2.10 ~~mark/contaminant~~—a deposit of foreign material on the glass surface.

3.2.11 ~~nonuniformity~~—obvious variation in reflected color of the coating within a lite of glass, or between two lites of coated glass of like construction that have been installed in the same plane and elevation in the same building, or both.

3.2.11.1 ~~banding~~—wide or narrow ~~areas~~area(s) of nonuniformity with demarcation that appears as a linear ~~line~~feature and may occur anywhere on a lite.

3.2.11.2 ~~edge to edge~~—gradient nonuniformity within a lite of glass.

3.2.11.3 ~~lite to lite~~—nonuniformity between individual lites.

3.2.11.4 ~~mottling~~—splotchy or patchy nonuniformity (not to be confused with strain ~~pattern~~ ~~inherent~~pattern; see ~~X1.1.5 to heat-treated glass or in-service staining, or both, or damage of glass~~).

3.2.11.5 ~~picture framing~~—perimeter ~~nonuniformity~~.nonuniformity within a lite of glass.

3.2.12 *pinhole*—small area in which the coating is entirely or partially absent.

3.2.13 *pyrolytic*—term used to describe a method of manufacture of a coating. ~~Process~~coating; process applies the coating to hot glass, usually at the time of flat glass manufacturing.

3.2.14 *spot*—a small, opaque blemish in the coating.

3.2.15 *stock size*—flat glass sheets cut to standard dimensions that will be cut to smaller sizes in ~~future use~~a subsequent process.

3.2.16 *vacuum deposition*—term used to describe a method of manufacture of a coating. ~~The~~coating; the process applies the coating in a vacuum chamber to flat glass.

3.2.17 *vacuum sputtering*—see *vacuum deposition*.

4. Significance and Use

4.1 This specification groups coated glass according to application. These groups are: vision, ~~spandrel/non-vision~~spandrel/non-vision, and overhead. Similar but unique quality tolerances and inspection guidelines have been outlined for each application. The glass to be coated shall comply with the applicable provisions of Specifications **C1036** and **C1048**.

4.2 Coating blemishes are an inherent part of the glass-coating process. In addition, coatings can be damaged as a result of improper transportation, storage, handling, fabrication, or installation.

4.3 Individual manufacturers should be contacted for recommended handling, fabrication, installation, and application guidelines.

5. Classification

5.1 *Kinds*—Coated flat glass furnished under this specification shall be of the following kinds, as specified:

5.1.1 *Kind CV*—Flat transparent glass conforming to the applicable requirements of Specification **C1036** or **C1048**, or both, and having a coating applied to one or more of the glass surfaces which further conforms with the requirements hereinafter specified for coated vision glass. [iteh.ai/catalog/standards/sist/6ade8e20-74cb-468c-a6aa-40d1baef9623/astm-c1376-21](https://standards.iteh.ai/catalog/standards/sist/6ade8e20-74cb-468c-a6aa-40d1baef9623/astm-c1376-21)

5.1.2 *Kind CO*—Flat transparent glass conforming to the applicable requirements of Specification **C1036** or **C1048**, or both, and having a coating applied to one or more of the glass surfaces which further conforms with requirements hereinafter specified for coated overhead glass.

5.1.3 *Kind CS*—Flat glass conforming to the applicable requirements of Specification **C1036** or **C1048**, or both, and having a coating applied to one or more of the glass surfaces that further conforms with the requirements hereinafter specified for coated ~~spandrel~~spandrel/non-vision glass.

6. Requirements

6.1 These specifications apply to cut size glass only. For specifications of stock size glass and blemishes not listed, contact the manufacturer.

6.2 All glass is to be inspected in transmission at a viewing angle of 90° to the specimen, using a bright uniform background with diffused daylight conditions, without direct sunlight. For factory inspection, the specimen shall be placed a minimum of 12 in. from the light source using uniform diffused background lighting with a minimum luminance of 1700 lux (160 foot-candles) and maximum of 2500 lux (230 foot-candles) measured at the center of the glass surface closest to the light source. If a blemish is readily apparent under these viewing conditions and detection distance as stated in 6.3, the criteria in Table 1, Table 2, or Table 3 applies for each kind of coated glass.

6.3 Defect detection distance for coated vision glass (*Kind CV*) is 10 ft. (3.0 m) and for coated overhead glass (*Kind CO*) and coated spandrel/non-vision glass (*Kind CS*) is 15 ft (4.6 m).

6.4 No more than two readily apparent blemishes are allowed in a 3-in. (75 mm) diameter circle, and no more than five readily apparent blemishes are allowed in a 12-in. (300 mm) diameter circle.

6.5 The central area is considered to form a square or rectangle defined by the center 80 % of the length and 80 % of the width dimensions centered on a lite of glass. The remaining area is considered the outer area.

6.6 For coating edge deletion, the demarcation between where the coating was removed and where it still remains may be visible in the finished glazing unit and is not considered a defect. Any discoloration in the edge deleted area is also not considered a defect.

6.7 *Blemishes for Coated Vision Glass*—The type and number of blemishes shall be no greater than those specified in **Table 1**.

6.8 *Blemishes for Coated Overhead Glass*—The type and number of blemishes shall be no greater than those specified in **Table 2**.

6.9 *Blemishes for Coated Spandrel/Spandrel/Non-vision Glass*—The type and number of blemishes shall be no greater than those specified in **Table 3**; and only apply to the pyrolytic or vacuum deposition coating used in a spandrel/non-vision glass. See Specification **C1048** for inspection criteria and lighting conditions used in evaluating spandrel glass.

6.10 *Nonuniformity for Coated Glass*—The phenomenon of nonuniformity in coated glass may be visible within an individual lite, or between lites of glass, in a particular building or curtain wall. Consultation with suppliers and viewing full size mock-ups under typical site conditions and surrounding landscape is highly recommended before construction begins. See **Appendix X1** for additional information.

TABLE 1 Quality Specifications for Cut Size Coated Vision Glass (Kind CV)^A

Blemish ^{B,C}	Central Area, in. (mm) ^D	Outer Area, in. (mm) ^D
Pinhole	1/4 (1.6) max	3/32 (2.4) max
Pinhole	1/16 (1.6) max	3/32 (2.4) max
Spot	1/4 (1.6) max	3/32 (2.4) max
Spot	1/16 (1.6) max	3/32 (2.4) max
Coating scratch	2 (50) max length	3 (75) max length
Coating Scratch	2 (50) max length	3 (75) max length
Mark/contaminant	2 (50) max length	3 (75) max length
Mark/Contaminant	2 (50) max length	3 (75) max length
Coating rub	none allowed	length plus width not to exceed 3/4 (19)
Coating Rub	none allowed	length plus width not to exceed 3/4 (19)
Crazing	none allowed	none allowed
Crazing	length plus width not to exceed 2 in. (50) max	length plus width not to exceed 3 in. (75) max
Corrosion	none allowed	none allowed
Corrosion	none allowed	none allowed

^A These specifications apply to cut size glass only. For specifications of stock size glass, and blemishes not listed, contact the manufacturer.

^B The glass shall be inspected, in transmission, at a distance of 10 ft (3.0 m) at a viewing angle of 90° to the specimen against a bright uniform background. If a blemish is readily apparent under these viewing conditions, the above criteria applies.

^C No more than two readily apparent blemishes are allowed in a 3-in. (75-mm) diameter circle, and no more than five readily apparent blemishes are allowed in a 12-in. (300-mm) diameter circle.

^D The central area is considered to form a square or rectangle defined by the center 80 % of the length and 80 % of the width dimensions centered on a lite of glass. The remaining area is considered the outer area.

TABLE 2 Quality Specifications for Cut Size Coated Overhead Glass (Kind CO)^A

Blemish ^{B,C}	Central Area, in. (mm) ^D	Outer Area, in. (mm) ^D
Blemish	Central Area, in. (mm)	Outer Area, in. (mm)
Pinhole	$\frac{3}{32}$ (2.4) max	$\frac{1}{8}$ (3.2) max
Pinhole	$\frac{3}{32}$ (2.4) max	$\frac{1}{8}$ (3.2) max
Spot	$\frac{3}{32}$ (2.4) max	$\frac{1}{8}$ (3.2) max
Spot	$\frac{3}{32}$ (2.4) max	$\frac{1}{8}$ (3.2) max
Coating scratch	3 (75) max length	4 (100) max length
Coating Scratch	3 (75) max length	4 (100) max length
Mark/contaminant	3 (75) max length	4 (100) max length
Mark/Contaminant	3 (75) max length	4 (100) max length
Coating rub	length plus width not to exceed $\frac{3}{4}$ (19)	Length plus width not to exceed $\frac{3}{4}$ (19)
Coating Rub	length plus width not to exceed $\frac{3}{4}$ (19)	length plus width not to exceed 1 (25)
Crazing	none allowed	none allowed
Crazing	length plus width not to exceed 2 in. (50) max	length plus width not to exceed 3 in. (75) max
Corrosion	none allowed	none allowed
Corrosion	none allowed	none allowed

^A These specifications apply to cut size glass only. For specifications of stock size glass, and blemishes not listed, contact the manufacturer.

^B The glass shall be inspected, in transmission, at a distance of 15 ft (4.6 m) at a viewing angle of 90° to the specimen against a bright uniform background. If a blemish is readily apparent under these viewing conditions, the above criteria applies.

^C No more than two readily apparent blemishes are allowed in a 3-in. (75-mm) diameter circle, and no more than five readily apparent blemishes are allowed in a 12-in. (300-mm) diameter circle.

^D The central area is considered to form a square or rectangle defined by the center 80 % of the length and 80 % of the width dimensions centered on a lite of glass. The remaining area is considered the outer area.

ASTM C1376-21

6.10.1 The scientific nature of controlling gas flow, electrical charges, and coating layer densities require production tolerances for light transmittance, reflectance, and color of coated glass products. Glass within allowable production tolerances may yield visual differences in reflected color or intensity of light transmittance or reflectance, or both. Perceivable differences are not immediate cause for rejection.

6.10.2 Glass of the same kind and type should be viewed as installed on the same elevation and from the exterior of the building at a consistent angle in daylight for color uniformity comparison. Coating Appearance nonuniformity may occur from lite to lite in a building (see building Appendix XI). It may also occur within a lite in the form of edge-to-edge gradation, banding, mottling, haze, or picture framing. In order to quantify color variation, measurements can be taken in the field with a handheld spectrophotometer.

6.10.3 Color Survey—Color non-uniformity is defined using ΔE^*_{ab} as defined in Test Method Actual color of glazing can be measured with a hand held D2244 for CIE 1976 L*a*b*, Illuminant D65, and 10° Observer looking straight at the glass (normal incidence, or 90°, to the glass plane). Using a reference target established by the manufacturer, or the average color measurements as defined below, no color readings spectrophotometer and compared in order to remove the subjectivity of human eye evaluation. The color of glazing in question can be compared to the manufacturer’s reference target (consult with the glass manufacturer) or to the onsite developed reference target (preferred method). The color difference equation ΔE^*_{ab} is defined in Test Method D2244 for CIE 1976 L*a*b* Uniform Color Space. No glazing color measurement shall exceed a ΔE^*_{ab} of 4.5. If a manufacturer’s color target is not used, the following procedure for establishing a reference shall be 4.0 when compared to the reference target color, incorporated:

6.10.3.1 Onsite Developed Reference Target—Using a mobile/handheld spectrophotometer, color readings will be taken and documented from the exterior of the building from Clean the exterior of the glazing in the area to be measured and take two color measurements about 12 in. apart in the central area or as close as reach will allow using a hand-held spectrophotometer (see Note 1). Avoid taking measurements within 2 in. of the daylight opening or sight line as this can affect the color measurement. Do this