Designation: C 1376 – 03

Standard Specification for Pyrolytic and Vacuum Deposition Coatings on Flat Glass[1]

This standard is issued under the fixed designation C 1376; 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, and organic films.

1.4 Dimensional values are stated in inch pound units and are to be regarded as the standard units for this specification. The metric units given in parentheses are for information only.

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:*

C 162 Terminology of Glass and Glass Products[2]

C 1036 Specification for Flat Glass[2]

C 1048 Specification for Heat-Treated Flat Glass—Kind HS, Kind FT Coated and Uncoated Glass[2]

D 2244 Test Method for Calculation of Color Differences from Instrumentally Measured Color Coordinates[3]

3. Terminology

3.1 *Definitions*—Refer to Terminology C 162, Specification C 1036 or Specification C 1048 as appropriate:

3.1.1 *blemishes in flat glass*—refer to Specifications C 1036 or C 1048, as appropriate.

NOTE 1—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.

NOTE 2—The following terms are designed to guide the user to the appropriate inspection charts and requirements.

3.2.2 *coated spandrel 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.

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.)

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

3.2.10 *nonuniformity*—obvious variation in reflected color of the coating within a lite of glass or between two lites of coated glass in the same building or both.

3.2.10.1 *banding*—wide or narrow areas of nonuniformity with demarcation that appears as a linear line and may occur anywhere on a lite.

3.2.10.2 *edge to edge*—gradient nonuniformity within a lite of glass.

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[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.

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[2] *Annual Book of ASTM Standards*, Vol 15.02.

[3] *Annual Book of ASTM Standards*, Vol 06.01.

3.2.10.3 *lite to lite*—nonuniformity between individual lites.

3.2.10.4 *mottling*—splotchy or patchy nonuniformity (not to be confused with strain pattern inherent to heat-treated glass or in-service staining, or both, or damage of glass).

3.2.10.5 *picture framing*—perimeter nonuniformity.

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

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

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

3.2.14 *stock size*—flat glass sheets cut to standard dimensions that will be cut to smaller sizes in future use.

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

3.2.16 *vacuum sputtering*—see *vacuum deposition.*

4. Significance and Use

4.1 This specification groups coated glass according to application. These groups are: vision, spandrel/nonvision, 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 Specification C 1036 and Specification C 1048.

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 C 1036 or Specification C 1048 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.

5.1.2 *Kind CO*—Flat transparent glass conforming to the applicable requirements of Specification of C 1036 or Specification C 1048 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 Specifications of C 1036 or Specification C 1048 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 glass.

NOTE 3—Coated spandrel glass may have additional material designed to opacify the glass that is not included in the scope of this specification.

6. Requirements

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

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	1/16(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
Mark/contaminant	2 (50) max length	3 (75) max length
Coating rub	none allowed	length plus width not to exceed 3/4 (19)
Crazing	none allowed	none allowed
Corrosion	none allowed	none allowed

[A]These specifications apply to cut size glass only. For specifications of stock size glass 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.

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

6.3 *Blemishes for Coated Spandrel Glass*—The type and number of blemishes shall be no greater than those specified in Table 3.

6.4 *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

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]
Pinhole	3/32(2.4) max	1/8(3.2) max
Spot	3/32(2.4) max	1/8(3.2) max
Coating scratch	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 3/4 (19)	Length plus width not to exceed 3/4 (19)
Crazing	none allowed	none allowed
Corrosion	none allowed	none allowed

[A]These specifications apply to cut size glass only. For specifications of stock size glass 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.

TABLE 3 Quality Specifications for Cut Size Coated Spandrel Glass (Kind CS)[A]

Blemish[B,C]	Range Number 1, in. (mm)[D]	Range Number 2, in. (mm)[D]
Pinhole	⅛(3.2) max	5⁄32(4.0) max
Spot	⅛(3.2) max	5⁄32(4.0) max
Coating scratch	3 (75) max length	6 (150) max length
Mark/contaminant	3 (75) max length	6 (150) max length
Coating rub	none allowed	length plus width not to exceed ¾(19)
Crazing	none allowed	none allowed
Corrosion	none allowed	none allowed

[A]These specifications apply to cut size glass only. For specifications of stock size glass contact the manufacturer.

[B]The glass shall be inspected, in reflection, at a distance equal to or greater than 15 ft (4.6 m) at a viewing angle of 90° to the specimen under uniform lighting conditions. 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 specifications separates glass by the distance that it will be viewed when installed. Range No. 1 is for all glass within a viewing distance of 15 ft (4.6 m) or less, and Range No. 2 is all glass viewed from a distance greater than 15 ft (4.6 m).

size mock-ups under typical site conditions and surrounding landscape is highly recommended before construction.

6.4.1 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 differences in reflected color or intensity of light transmittance or reflectance or both. Perceivable differences are not immediate cause for rejection.

6.4.2 Glass should be viewed as installed and from the exterior of the building for uniformity comparison. Coating nonuniformity may occur from lite to lite in a building. It may also occur within a lite in the form of edge-to-edge gradation, banding, mottling, or picture framing.

6.4.3 Nonuniformity is defined using a ΔE*ab as defined in Test Method D 2244 for CIE 1976 L*A*B*, Illuminant D65, and 10° Observer. Using a reference target established by the manufacturer, or the average color readings as defined below, no color readings should exceed a ΔE*ab of 4.5. To calculate ΔE*ab, the following procedure should be used: Using a mobile/handheld spectrophotometer, color readings will be taken and documented from a predetermined number of units that have been installed on a building. A minimum of ten readings should be taken and should include any glass that is in question. The readings taken should then be averaged and that average will be used as a target for calculating the ΔE*ab. Using the average color reading as a target, no color readings should exceed a ΔE*ab of 4.5.

NOTE 4—Design professionals and building owners should be aware that certain coated glass products will yield color differences when used in adjacent vision and spandrel area conditions and when used in laminated glass constructions or on different glass thickness.

NOTE 5—Refer to manufacturer for blemishes not listed in this specification.

7. Keywords

7.1 coated glass; flat glass; glazing; nonuniformity; overhead glass; pyrolytic coating; spandrel glass; sputtered coatings; vacuum deposition coating; vision glass