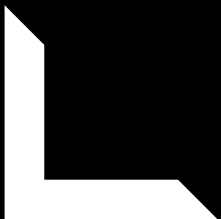
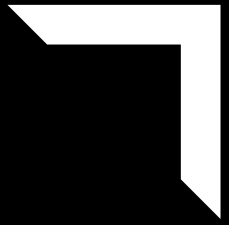




GLASS GRADING GUIDELINES





Reference Materials; ASTM C 1376, ASTM C 1048

This guide is written for informational purposes only and was created using ASTM C 1376 as the basis. The guide will cover the optical and aesthetic quality requirements for coated glass (Low E Coated) and spandrel glass used in buildings. The standard measurements used are imperial inch pound measurements.

In addition to coating quality requirement, this guide will also discuss quality requirements pertaining to heat staining, roller and / or other tempering concerns and iridescence.

1. Inspection Process

All optical and aesthetic inspections are to be completed at a distance of 10 ft (Low E Coated) and 15 ft (Spandrel Glass), and a viewing angle of 90 degrees to the specimen against a uniform bright background.

When comparing different units of glass with others, on a single site, viewing must be done from the same area (interior or exterior) for all units.

When viewing clerestory glass or other glass at a significant height above finish floor or exterior ground level, it must still be done at a 90 degree angle to the specimen.

Product is not to be viewed and / or graded by viewing through multiple specimens.

2. Allowable Defects for Low E Coated Vision Glass

See Table 1.

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.

No more than 2 readily apparent blemishes, as defined in table 1, are allowed in a 3" diameter circle, and no more than five readily apparent blemishes are allowed in a 12" diameter circle.

3. Allowable Defects for Spandrel Glass

See Table 2.



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.

No more than 2 readily apparent blemishes, as defined in table 1, are allowed in a 3" diameter circle, and no more than five readily apparent blemishes are allowed in a 12" diameter circle.

4. Tempered Glass and Insulated Glass Units (IG)

Unless specifically stated, all AeroFRAME windows and doors are supplied with tempered glass in all locations. Tempering is process by which annealed glass is heated in a tempering system to a temperature at which the glass becomes slightly plastic. Immediately after heating, the glass surfaces are rapidly cooled by quenching with air. The original flatness of the glass is slightly modified by the process, causing reflected images to be distorted. When viewing images through the glass, the distortion, in most glazing applications, is less than that of reflected images.

This process, when completed via a horizontal tempering system, may contain surface distortion as well. Surface distortions may include picture framing, heat distortion or roller wave distortion. In general, these distortions will be most visible in reflected images.

Pressures exerted around the periphery of glass by the glazing system and / or IG fabrication can also impact flatness, thereby distorting reflective images.

Insulated glass units also contribute to distortion. IG's are fabricated as a sealed system with either inert gas or air in the gap. This gas will expand and / or contract with changes in temperature and barometric pressure, creating a pressure differential between the sealed gap and atmosphere.

Regardless of glass flatness, the degree of reflected distortion perceived is largely due to the characteristics or symmetry of the object being reflected. Linear objects (such as building curtain walls and telephone poles) and moving objects (such as cars) may appear distorted. Irregular and free-form objects such as trees and clouds may appear to have less perceived distortion.



In general, the factors noted above may have a larger influence on the perception of distortion on reflected images and images viewed through the glass. These are not considered defects, but biproducts of the manufacturing and tempering process.

Strain patterns, or iridescence, is inherent in all tempered glass. The strain pattern may become visible under certain lighting and other conditions. It is a characteristic of heat treated glass and can not be mistaken as discoloration, non-uniform tint or color, or a defect in the glass. The strain pattern does not affect any physical properties or performance values of the glass.

In summary, tempered glass and IG's are imperfect by design and due to the inherent limits of the manufacturing process. Generally, these imperfections are not considered defects or warrantable claims. AeroFRAME uses the above guides and statements to evaluate the aesthetic properties of glass supplied on AeroFRAME projects as a base standard for inspection.



Standard Specification for Pyrolytic and Vacuum Deposition Coatings on Flat Glass¹

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 Products²

C 1036 Specification for Flat Glass²

C 1048 Specification for Heat-Treated Flat Glass—Kind HS, Kind FT Coated and Uncoated Glass²

D 2244 Test Method for Calculation of Color Differences from Instrumentally Measured Color Coordinates³

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.

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 April 10, 2003. Published May 2003. Originally approved in 1997. Last previous edition approved in 1997 as C1376-97.

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

^AThese specifications apply to cut size glass only. For specifications of stock size glass contact the manufacturer.

^BThe 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.

^CNo 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.

^DThe 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

^AThese specifications apply to cut size glass only. For specifications of stock size glass contact the manufacturer.

^BThe 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.

^CNo 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.

^DThe 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	1/8(3.2) max	5/32(4.0) max
Spot	1/8(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 3/4(19)
Crazing	none allowed	none allowed
Corrosion	none allowed	none allowed

^AThese specifications apply to cut size glass only. For specifications of stock size glass contact the manufacturer.

^BThe 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.

^CNo 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.

^DThe 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; over-head glass; pyrolytic coating; spandrel glass; sputtered coatings; vacuum deposition coating; vision glass

ASTM International takes no position respecting the validity of any patent rights asserted in connection with any item mentioned in this standard. Users of this standard are expressly advised that determination of the validity of any such patent rights, and the risk of infringement of such rights, are entirely their own responsibility.

This standard is subject to revision at any time by the responsible technical committee and must be reviewed every five years and if not revised, either reapproved or withdrawn. Your comments are invited either for revision of this standard or for additional standards and should be addressed to ASTM International Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee, which you may attend. If you feel that your comments have not received a fair hearing you should make your views known to the ASTM Committee on Standards, at the address shown below.

This standard is copyrighted by ASTM International, 100 Barr Harbor Drive, PO Box C700, West Conshohocken, PA 19428-2959, United States. Individual reprints (single or multiple copies) of this standard may be obtained by contacting ASTM at the above address or at 610-832-9585 (phone), 610-832-9555 (fax), or service@astm.org (e-mail); or through the ASTM website (www.astm.org).

CONTACT

aeroframe.com
1-877-323-7263

US Office
Suite 110 – 22745 29th Drive SE,
Bothell, WA 98021
USA

Canada Office
Jameson House, 838 W Hastings St #700,
Vancouver, BC V6C 0A6
Canada