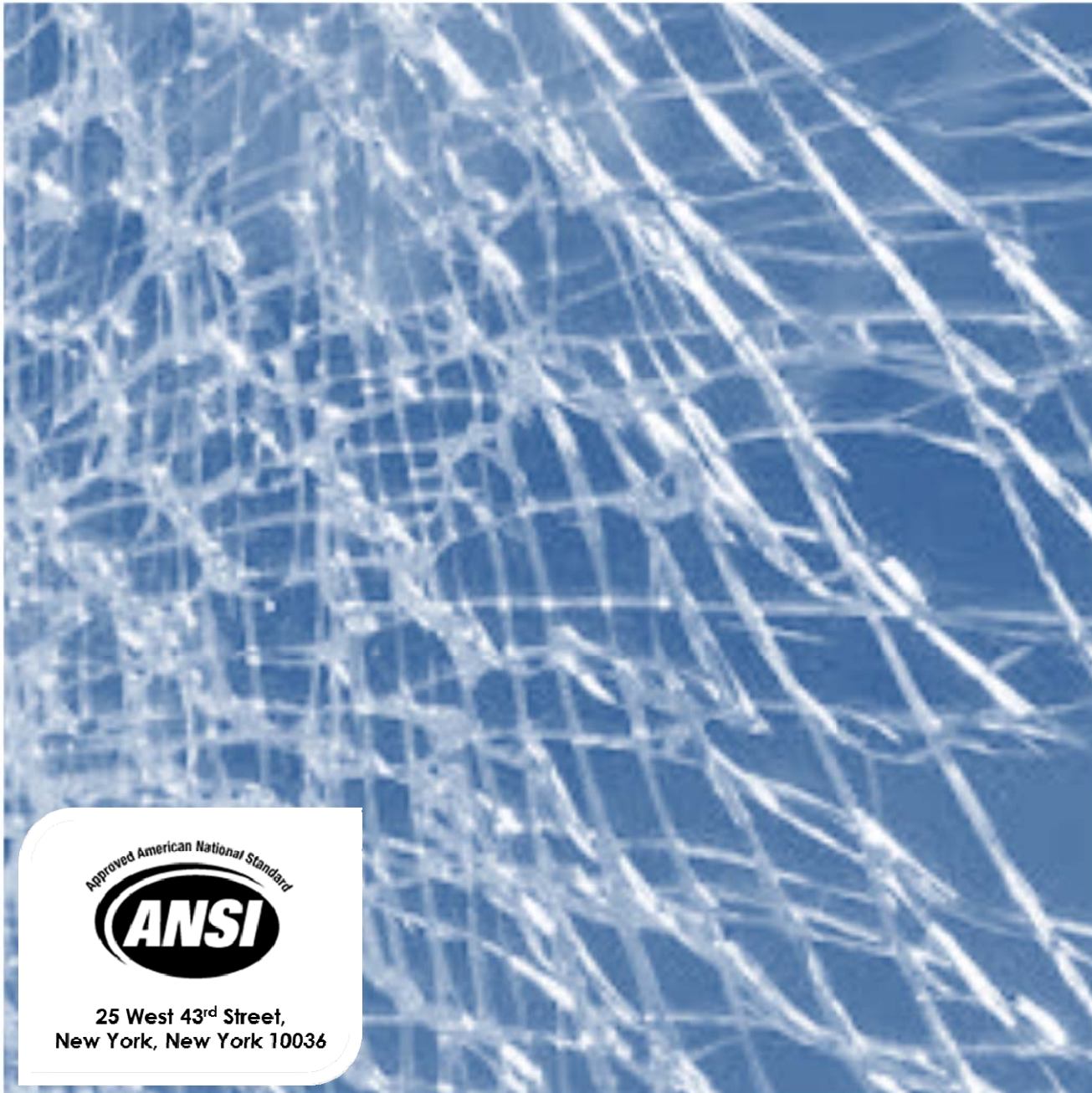


# ANSI Z97.1-2015

For safety glazing materials used in buildings –  
safety performance specifications and methods of test

American  
National  
Standard



Approved American National Standard



25 West 43<sup>rd</sup> Street,  
New York, New York 10036

ANSI Z97.1 – 2015  
Revision of ANSI Z97.1-2009e2

**American National Standard**  
for Safety Glazing Materials Used in Buildings -  
Safety Performance Specifications and Methods of Test

Secretariat

Glazing Industry Secretariat Committee

Approved by Accredited Standards Committee (ASC) Z97  
March 2015

American National Standards Institute, Inc.

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## FORWARD

(This forward is not part of ANSI Z97.1-2015)

This Standard was developed under procedures accredited as meeting the criteria for American National Standards. The consensus committee that approved the Standard was balanced to ensure that individuals from competent and concerned interests have had an opportunity to participate. It was developed within the approved scope as stated in section [1.1](#) of the standard.

This Standard is available for public review on a continuing basis. This provides an opportunity for additional public input from industry, academia, regulatory agencies, and the public-at-large. The use of an addenda system will allow revisions made in response to public review or committee actions to be published as required.

This Standard, which is the result of extended and careful consideration of available knowledge and experience on the subject, is intended to provide minimum requirements that are recommended for use, adoption, enforcement by federal, state and local authorities and by model codes. This standard is to be referenced but not incorporated in any statute or any other standard without the prior written permission of the publisher.

This Standard does not recommend where safety glazing should be used or, when it is used, what type of glazing material should be used. For this information one should consult other codes, standards and manufacturer's information.

Neither the standards committee nor the secretariat feel that this standard is perfect or in its ultimate form. It is recognized that, although safety-glazing materials are widely used and accepted, new developments are to be expected and revisions of the standards are necessary as the art progresses and further experience is gained.

This standard is a successor standard to the 2009e2 edition. The 2009e2 standard succeeded those of the 2009e, 2009, 2004, 1984 (reaffirmed in 1994), 1975, 1972 and 1966 editions.

The 2015 edition of ANSI Z97.1 has removed reference to Class C, 12 inch drop height and fire-rated wired glass. No test methods, references or exceptions appear in this document for Class C, 12 inch drop height and fire-rated wired glass. Compliance of all safety glazing products must be rated to either Class A or Class B in accordance with the procedures of this edition.

In order for material to be considered for reference or to continue to be referenced in the ANSI Z97.1 standard, it shall meet the following criteria:

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2. The standard or portions of a standard intended to be enforced shall be written in mandatory language.
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5. The standard shall not prescribe a proprietary agency for quality control or testing.

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## Table of Contents

<b>ANSI Z97.1-2015</b> .....	<b>I</b>
FOR SAFETY GLAZING MATERIALS USED IN BUILDINGS – .....	I
SAFETY PERFORMANCE SPECIFICATIONS AND METHODS OF TEST .....	I
AMERICAN NATIONAL.....	I
TABLE OF FIGURES.....	2
<b>1 SCOPE, PURPOSE, AND LIMITATIONS</b> .....	<b>3</b>
1.1 SCOPE.....	3
1.2 PURPOSE.....	3
1.3 LIMITATIONS .....	3
<b>2 REFERENCED STANDARDS</b> .....	<b>4</b>
<b>3 DEFINITIONS</b> .....	<b>5</b>
<b>4 SPECIMENS TO BE TESTED</b> .....	<b>7</b>
4.1 CONDITION OF SPECIMENS.....	7
4.2 THICKNESS OF SPECIMENS.....	7
4.3 SIZE CLASSIFICATION OF SPECIMENS.....	8
4.4 SPECIMENS FOR IMPACT TESTS.....	8
4.5 SPECIMENS FOR THERMAL TEST .....	8
4.6 SPECIMENS FOR WEATHERING TESTS.....	8
4.7 SPECIMENS FOR MODULUS AND HARDNESS TESTS .....	9
<b>5 TEST SPECIFICATIONS</b> .....	<b>10</b>
5.1 IMPACT TEST .....	10
5.2 CENTER PUNCH FRAGMENTATION TEST .....	24
5.3 THERMAL TEST FOR LAMINATED AND ORGANIC COATED GLAZINGS.....	25
5.4 WEATHERING TESTS FOR LAMINATED, ORGANIC COATED AND PLASTIC GLAZINGS.....	26
<b>6 MARKING OF SAFETY GLAZING MATERIAL</b> .....	<b>34</b>
6.1 MARK INFORMATION .....	34
6.2 APPLICATION OF MARK .....	34
6.3 SPECIAL APPLICATION MARKING .....	35
<b>7 ANNEX</b> .....	<b>36</b>
<b>8 APPENDIX A</b> .....	<b>37</b>
A1. GENERAL .....	37
A2. SAFE PERFORMANCE CRITERIA (SEE SECTION 5.1.2).....	37
A3. DEVELOPMENT OF HUMAN ENGINEERING DATA CHART.....	37
A4. INTERPRETATION OF RESULTS (SEE SECTION 5.1.4).....	39
<b>9 APPENDIX B</b> .....	<b>40</b>

## Table of Figures

FIGURE 1: IMPACT TEST STRUCTURE .....	11
FIGURE 2: IMPACT TEST FRAME - FRONT VIEW .....	12
FIGURE 2.1: DETAIL OF SECTION A-A PROPERLY CLAMPED TEST SPECIMEN .....	13
FIGURE 2.2: DETAIL OF SECTION A-A IMPROPERLY CLAMPED TEST SPECIMEN .....	13
FIGURE 3: IMPACT TEST FRAME – SIDE VIEW .....	14
FIGURE 4: IMPACT TEST FRAME – BENT GLAZING – FRONT VIEW .....	15
FIGURE 4.1: DETAIL OF SECTION B-B .....	16
FIGURE 4.2: DETAIL OF SECTION C-C .....	16
FIGURE 4.3: DETAIL OF SECTION D-D .....	17
FIGURE 5: BENT GLASS IMPACT TEST FRAME (EXPLODED VIEW) .....	17
FIGURE 6: IMPACT TEST FRAME - BENT GLAZING - SIDE VIEW .....	18
FIGURE 7: IMPACTOR .....	20
FIGURE 8: CENTER PUNCH FRAGMENTATION .....	25
FIGURE A1: HUMAN ENGINEERING DATA .....	38

## Table of Tables

TABLE 1: GROUPING OF TESTS FOR SAFETY GLAZING MATERIALS .....	7
TABLE 2: APPLICABLE INTERPRETATION OF RESULTS FOR SHOT BAG IMPACT .....	23
TABLE 3: ACCELERATED WEATHERING CONDITIONS .....	27
TABLE 4: ACCELERATED WEATHERING CONDITIONS – INDOOR PRODUCT USE .....	32
TABLE X1: ASC Z97.1-2015 - REFERENCE STANDARDS .....	36
TABLE B1: SUMMARY TABLE FOR WEATHERING AND SUBSEQUENT TESTING .....	40

# American National Standard for Safety Glazing Materials Used in Buildings - Safety Performance Specifications and Methods of Test

## 1 Scope, Purpose, and Limitations

### 1.1 Scope

This standard establishes the specifications and methods of test for the safety properties of safety glazing materials (glazing materials designed to promote safety and reduce the likelihood of cutting and piercing injuries when the glazing materials are broken by human contact) as used for all building and architectural purposes.

### 1.2 Purpose

The purpose of this standard is to prescribe the minimum safety performance characteristics of safety glazing materials. This standard affords a basis for; (1) safety standards for adoption in regulations by federal, state, and local regulatory bodies; and (2) for use by building code officials, architects, designers, specifiers and others as a reference standard. Approval of a material under this standard constitutes acceptance of its safety characteristics and the retention of those characteristics. It is not to be construed as appraisal of its durability or appearance as a glazing material.

### 1.3 Limitations

- 1.3.1 Conformance of a material to this standard demonstrates minimum acceptable safety characteristics of the material in use
- 1.3.2 Conformance of a material to this standard is not to be construed as an appraisal of its strength, durability or appearance as a glazing material, nor does this standard specify situations in which safety-glazing materials should be used.
- 1.3.3 This standard does not address the methods used for the installation of safety glazing materials.
- 1.3.4 A condition of conformance of a material to this standard is its uniform production so that it will consistently exhibit these safety characteristics.
- 1.3.5 Monolithic annealed glass, monolithic heat strengthened glass, monolithic chemically strengthened glass, monolithic wired glass (not fire rated) and monolithic fire rated wired glass are not considered safety glazing materials under this standard.

## 2 Referenced Standards

This standard is intended for use in conjunction with the cited editions of the following standards (see [ANNEX X](#) for edition year):

ASTM<sup>1</sup> C1036 Standard Specification for Flat Glass

ASTM C1048 Standard Specification for Heat-Strengthened and Fully Tempered Flat Glass

ASTM C1172 Standard Specification for Laminated Architectural Flat Glass

ASTM C1349 Standard Specification for Architectural Flat Glass Clad Polycarbonate

ASTM C1464 Standard Specification for Bent Glass

ASTM D785 Standard Test Method for Rockwell Hardness of Plastics and Electrical Insulating Materials

ASTM D790 Standard Test Methods for Flexural Properties of Un-reinforced and Reinforced Plastics and Electrical Insulating Material

ASTM D1003 Standard Test Method for Haze and Luminous Transmittance of Transparent Plastics

ASTM D1435 Standard Practice for Outdoor Weathering of Plastics

ASTM D2240 Standard Test Method for Rubber Property-Durometer Hardness

ASTM D2244 Standard Practice for Calculation of Color Tolerances and Color Differences from Instrumentally Measured Color Coordinates

ASTM D2565 Standard Practice for Xenon Arc Exposure of Plastics Intended for Outdoor Applications

ASTM D4459 Standard Practice for Xenon-Arc Exposure of Plastics Intended for Indoor Applications

ASTM D6110 Standard Test Methods for Determining the Charpy Impact Resistance of Notched Specimens of Plastics

ASTM E308 Practice for Computing the Colors of Objects by Using the CIE System

ASTM E313 Standard Practice for Calculating Yellowness and Whiteness Indices from Instrumentally Measured Color Coordinates

ASTM G155 Standard Practice for Operating Xenon Arc Light Apparatus for Exposure of Non-Metallic Materials

ISO<sup>2</sup> 4892-2 Plastics - Methods of Exposure to Laboratory Light Sources - Part 2 Xenon Arc Sources

<sup>1</sup> ASTM, International. 100 Barr Harbor Drive, West Conshohocken, PA

<sup>2</sup> International Organization for Standardization (ISO) Geneva Switzerland

### 3 Definitions

**asymmetric material:** Glazing in which component layers of its construction makeup are different in thickness, kind, type or pattern texture about its interlayer and/or central plane surface.

**bent glass:** Flat glass that has been shaped while hot into a form that has curved surfaces.

**bubble:** A visible gas pocket in the interlayer material or in the plastic glazing sheet material, or between the interlayer and another layer of glass or plastic glazing sheet material.

**cracking:** The visible breaking, splitting or fissuring, either partially or completely through the thickness of an individual layer of material.

**crack-free particle:** A portion of a broken test specimen that is determined by identifying the smallest possible perimeter around all points in the portion of the broken test specimen, always passing along un-separated cracks or exposed surfaces.

**crazing:** The visible breaking, splitting or fissuring of a material, typically patterned with a network of fine lines that do not penetrate through the thickness of an individual layer of material.

**delamination:** A condition in which one of the glass or plastic glazing sheet material layers loses its bond to an interlayer and separates physically.

**discoloration:** A visibly noticeable chemical or process induced color deviation in the appearance of a material.

**laminated glazing:** A manufactured assembly consisting of at least one sheet of glass bonded to at least one other sheet of glass or plastic glazing material with an organic interlayer. Note: when broken, numerous cracks appear, but glass fragments tend to adhere to the interlayer. See ASTM C1172 for additional information.

**2-ply glass laminates:** Laminated glazing consisting of two sheets of glass bonded together with an interlayer.

**multi-ply glass laminates:** Laminated glazing consisting of more than two layers of glass and/or plastic glazing sheet material bonded together by interlayers, where both of the outer surfaces are glass.

**glass/plastic laminates:** Laminated glazing consisting of one or more layers of glass and one or more layers of plastic glazing sheet material bonded together with one or more interlayer(s) in which the plastic surface faces inward when the glazing is installed in a structure.

**mirror glazing:** Architectural glazing materials whose intended use is based on their reflective quality. These materials are composed of a reflective surface and may have a substrate of glass, or plastic.

**organic coated glazing:** An assembly consisting of a sheet of glass covered on one or both surfaces with either: (1) an adhesive-applied organic film or sheeting, or (2) an

applied coating. When broken numerous cracks appear, but the glass fragments tend to adhere to the applied organic material.

***plastic glazing material:*** A single sheet of synthetic plastic material, a combination of two or more such sheets laminated together, or a combination of plastic material and reinforcement material in the form of fibers or flakes. This material contains as an essential ingredient an organic substance of large molecular weight; is solid in its finished state; and, at some stage in its manufacture or in its processing into finished articles, can be shaped by flow. See ASTM C1349 for additional information.

***safety glazing materials:*** Glazing materials so constructed, treated, or combined with other materials that, if broken by human contact, the likelihood of cutting or piercing injuries that might result from such contact is reduced.

***tempered glass:*** (also known as toughened glass). Glass of any shape that has been subjected to a thermal treatment process characterized by uniform heating followed by rapid uniform cooling to produce compressively stressed surface layers. See ASTM C1048 for additional information.

## 4 Specimens to Be Tested

Table 1: Grouping of Tests for Safety Glazing Materials

Test	Glazing Type <sup>1</sup>			
	Laminated Glazing	Tempered Glass	Organic Coated Glazing	Plastic Glazing
Impact <a href="#">Test 5.1</a>	X	X	X	X
Center Punch Fragmentation <a href="#">Test 5.2</a>		X <sup>2</sup>		
Thermal <a href="#">Test 5.3</a>	X		X <sup>3</sup>	
Weathering <sup>4</sup> <a href="#">Test 5.4</a>	X		X <sup>5</sup>	X
Indoor aging <a href="#">Test 5.4.3</a>	X		X	X
Hardness <a href="#">Test 4.7, 5.1.4 Type 3</a>				X <sup>6</sup>
Modulus <a href="#">Test 4.7, 5.1.4 Type 3</a>				X <sup>6</sup>

Notes:

- 1 Bent glass and mirror glazings shall be tested in accordance with requirements of the base-glazing product; see section [4.4](#).
- 2 Center Punch Fragmentation test is used to evaluate the fracture pattern of tempered glass specimens that do not break during impact test of section [5.1](#).
- 3 Thermal test only applies to organic coated glazing when organic coated glazings are used for exterior glazing.
- 4 Weathering tests on laminated and organic coated glazing shall be performed on the thinnest construction of all components with clear glass, clear plastics and clear interlayers.
- 5 Mirror glazing shall be tested in accordance with [5.4.3](#).
- 6 Only required if breakage occurs under impact

### 4.1 Condition of Specimens

Tests shall be applied to specimens as shipped by the manufacturer and shall be representative of commercial production, except that any protective masking material shall be removed prior to test.

### 4.2 Thickness of Specimens

The thickness of the specimens to be tested shall be measured and recorded along with the nominal thickness in accordance with accepted industry practice (for glass as set forth in ASTM C1036 or other national or international standards). No manufacturer shall mark or advertise as passing the tests, described in this standard, any product of different nominal thickness than that of the specimens passing the tests.

### 4.3 Size Classification of Specimens

A description of impact specimens to be tested as required for size classification as set forth below:

<b>Unlimited Size (U)</b>	34 inches by 76 inches, $\pm 0.125$ (1/8) inch (864 mm by 1930 mm, $\pm 3$ mm)
<b>Limited Size (L)</b>	Appropriate to Manufacturer, Largest size commercially produced by the manufacturer less than 34 inches by 76 inches, $\pm 1/8$ inch (864 mm by 1930 mm, $\pm 3$ mm). Minimum specimen size: 16 inches by 30 inches, $\pm 1/8$ inch (406 mm by 762 mm, $\pm 3$ mm).

No manufacturer submitting specimens that are in the Limited Size Classification shall mark or advertise as passing the tests, described in this standard, any product with either dimension greater than those of the specimens passing the tests.

### 4.4 Specimens for Impact Tests

For impact test (see section [5.1](#)) of any safety glazing material, four specimens, each of the thickness and size described in sections [4.2](#) and [4.3](#) respectively, shall be required. If the test specimens are of an asymmetric material, two shall be impacted from each side.

For impact test of safety glazing materials after aging (see section [5.4.3](#)) as used in indoor applications only, four specimens, each of the thickness and size described in sections [4.2](#) and [4.3](#) respectively, shall be required. If the test specimens are of an asymmetric material two shall be impacted from each side.

For mirror glazing using either reinforced or non-reinforced organic adhesive backing material, four specimens each with the backing material applied, of the thickness and size described in sections [4.2](#) and [4.3](#) respectively, shall be required. The specimens shall be impacted only on the non-reinforced side and with no other material applied.

Bent glass test methods shall be the same as for flat sample testing except as referenced in the text and figures of this standard (See Figure [4](#), [4.1](#), [4.2](#), [4.3](#), [5](#) and [6](#)). For unlimited size (U) classification of bent glass, 34 in x 76 in (864 mm x 1930 mm) specimens with a simple arc-shaped bend of 40 inches (1016 mm) shall be tested. Interpretation of results shall be the same. See ASTM C1464 for additional information.

*Note: Where project specific requirements or limitations in production exist, other shapes and sizes may be tested.*

### 4.5 Specimens for Thermal Test

For thermal test (see section [5.3](#)), three specimens, each 12 inches by 12 inches (310 mm x 310 mm), representative of commercial production and of identical manufacture and nominal thickness as submitted for impact testing (see section [4.4](#)), shall be required.

### 4.6 Specimens for Weathering Tests

For weathering tests (see section [5.4](#)), specimens as described in sections [4.6.1](#) and [4.6.2](#), representative of commercial production and of the thinnest construction for which



qualification is desired (see section 4.4), shall be required. Specimens constructed of laminated, organic coated or plastic glazings that have decorative or other functional materials inserted or embedded within the glazing material shall not need to undergo weathering and subsequent testing if all of the following criteria are met:

- 1.) the interlayer, organic coating or plastic material encapsulates the decorative or otherwise functional material,
- 2.) the interlayer, organic coating or plastic is deemed to comply with section 5.4.
- 3.) the thickness of the interlayer, organic coating or plastic on each side of the insert or embedded material is at least the minimum thickness as qualified in section 5.4.

The use of an insert or embedded material does not preclude the requirements for impact testing.

#### 4.6.1 Plastic Glazing Material

One un-backed panel, a minimum 6 inches by 6 inches (152 mm by 152 mm), shall be exposed. One additional un-backed panel, a minimum 6 inches by 6 inches (152 mm by 152 mm), shall be kept in darkness and used as a control.

*NOTE: A minimum of five specimens, each 0.5 inch by 5 inches (12.7 mm by 127 mm), is necessary for the Charpy Impact Test (ASTM D6110). Alternate panel sizes may be used provided that enough material exists to cut a total of five specimens after exposure. Edges shall be trimmed from exposed panels prior to cutting specimens to minimize edge effects. For materials suspected of being anisotropic, the direction of one axis shall be marked on each panel, and all specimens shall be cut in the same direction.*

#### 4.6.2 Laminated and Organic Coated Glazing

Six specimens, each, a minimum of 2 inches by 5.5 inches (minimum 50 mm by 140 mm) shall be prepared. Three specimens shall be exposed and three shall be kept in darkness and used as controls. Optical measurements for visible light transmittance, yellowness, haze and color may be taken on an unexposed sample designated for exposure to serve as the unexposed control values.

### 4.7 Specimens for Modulus and Hardness Tests

#### 4.7.1 Specimens for Flexural Modulus

The specimen dimensions are dependent on the thickness of the material and the span distance capabilities of the testing machine. The dimensions shall meet the requirements of ASTM D790 for flatwise tests. For common plastic glazing thicknesses and common testing machine capabilities, specimens 0.5 inch (12.7 mm) wide and 5 inches (127 mm) long can meet the requirements. Decreased width and/or increased length may be needed in some cases to meet the span to depth ratio, span to width ratio and span to length requirements of the standard.

#### 4.7.2 Specimens for Rockwell Hardness

The specimens shall be at least 1 inch (25 mm) square and at least 1/4 inch (6 mm) thick. Materials less than 0.25 inches (6 mm) thick may be stacked provided that the precautions noted in ASTM D785 are met.

## 5 Test Specifications

### 5.1 Impact Test

Required specimens shall be tested as submitted except that any protective masking or protective material shall be removed prior to the test. Any applied coating integral to the specimens shall not be removed. The specimens shall be conditioned to a uniform test temperature between 65°F and 85°F (18°C and 29°C) for at least 4 hours with separation to permit free air circulation.

#### 5.1.1 Apparatus

The test apparatus shall consist of a test frame and an impactor system. The test frame consists of a main frame mounted on two base beams with stiffening members and a sub-frame, in which the specimen is held. The impactor system consists of the impactor, traction, release, and suspension devices.

**(1) Main Frame** The main frame shall be constructed to minimize movement, deflection, twisting or racking of its members during testing. For this purpose, the structural framing members shall be steel angles 3 inches by 5 inches by 0.25 inch (76 mm by 127 mm by 6 mm) or other sections and materials of equal or greater rigidity. The main frame shall be welded or securely bolted at the corners and braced as shown in [Figure 1](#), [Figure 2](#) and [Figure 3](#).

The main frame is mounted to a rigid floor and/or wall. Horizontal members made of steel sections connect the main frame to a rigid wall. The base beams are connected to the main frame by diagonal members of steel sections (see [Figure 1](#), [Figure 2](#) and [Figure 3](#)). Attach the two base beams of the main frame to a concrete base or floor using bolts M16 or equivalent.

Internal dimensions of main frame<sup>3</sup> ([Figure 2](#)) shall be:  
Internal width: 33.25 inches  $\pm$  0.2 inch (835 mm  $\pm$  5 mm)  
Internal height: 75.25 inches  $\pm$  0.2 inch (1902 mm  $\pm$  5 mm)

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<sup>3</sup> The internal dimensions of the main frame shall be 1.1 inch (28 mm) less than unlimited-size (34 inches by 76 inches [864 mm by 1930 mm]) specimen dimensions.

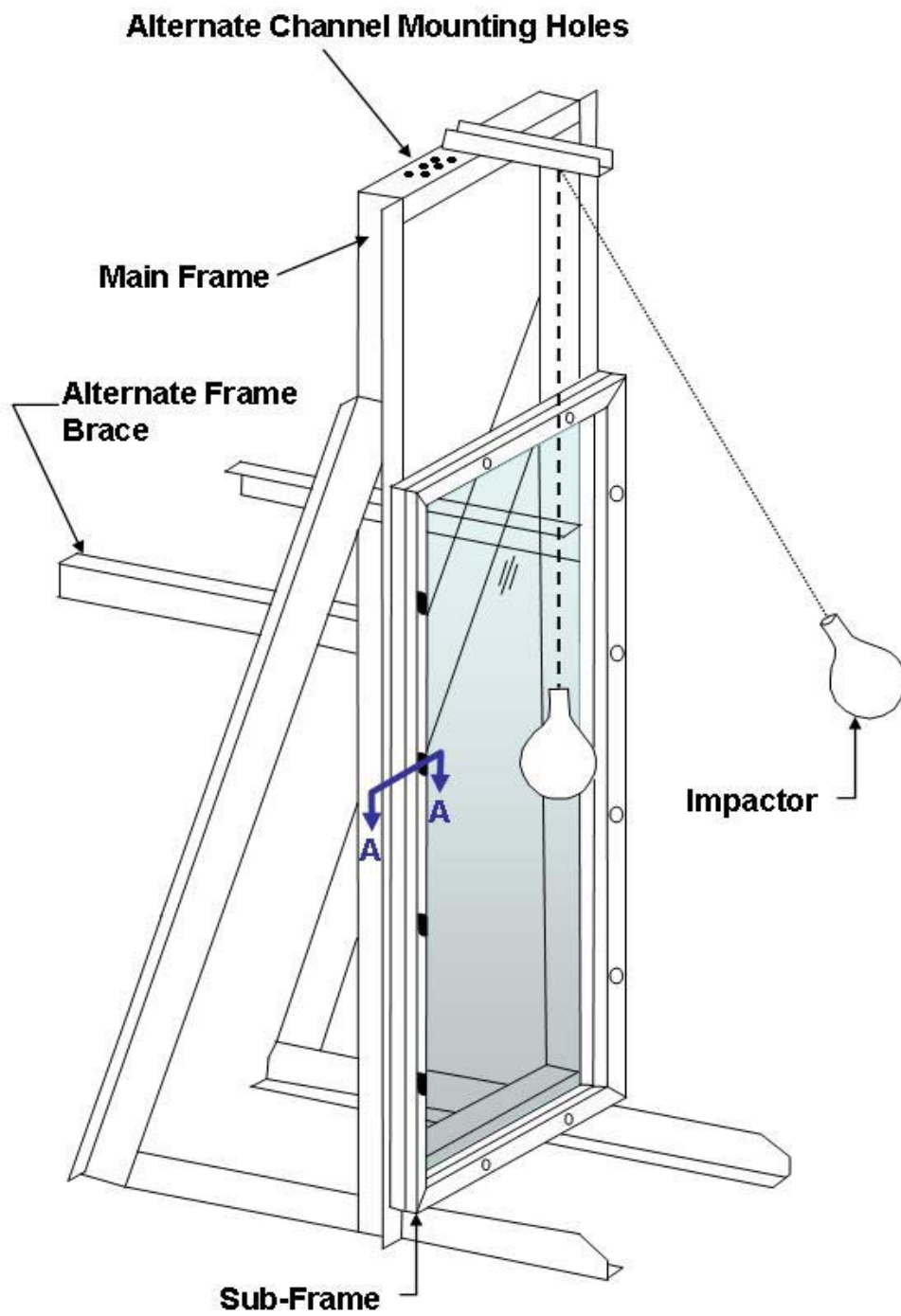


Figure 1: Impact Test Structure

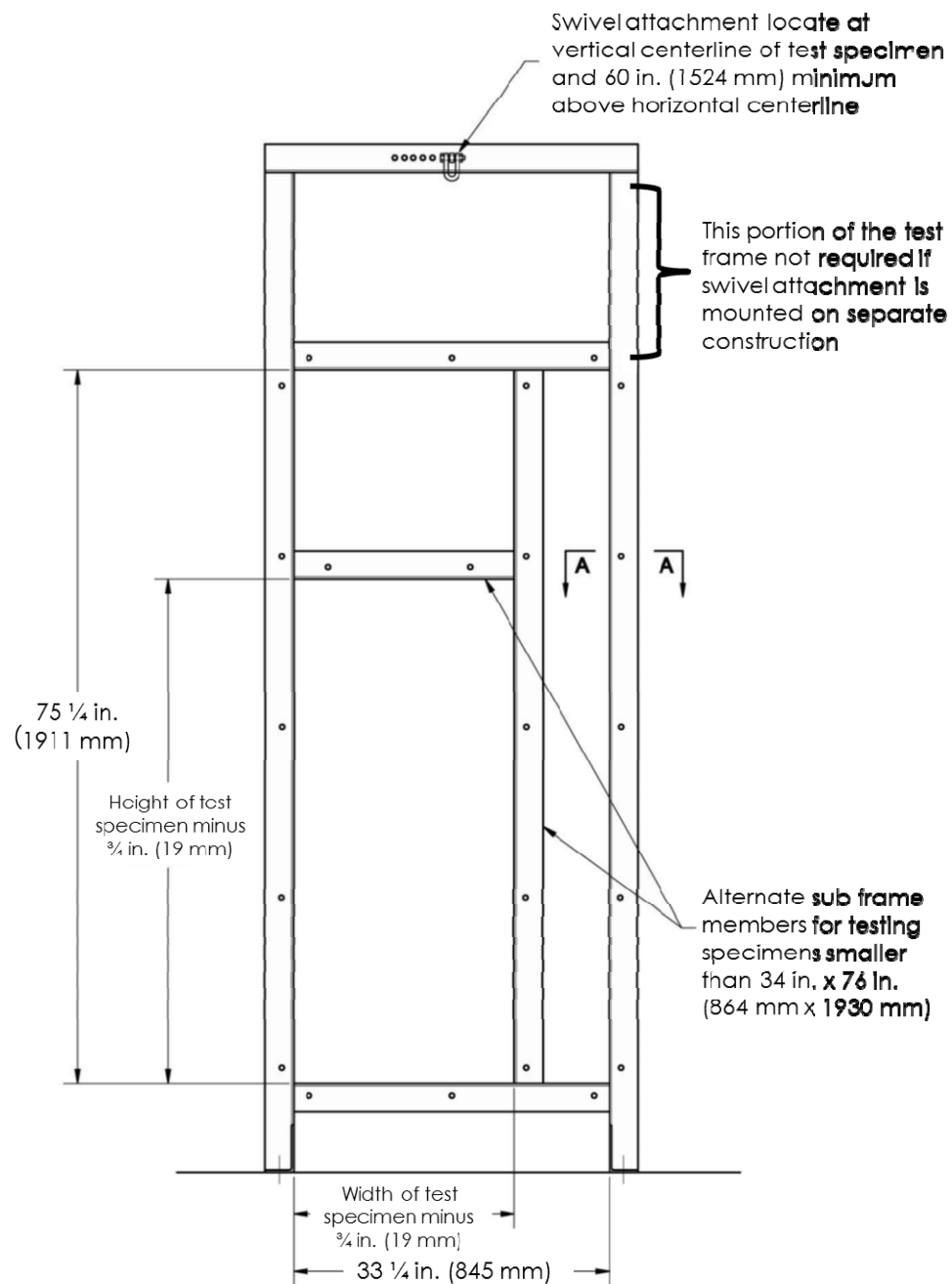


Figure 2: Impact Test Frame - Front View

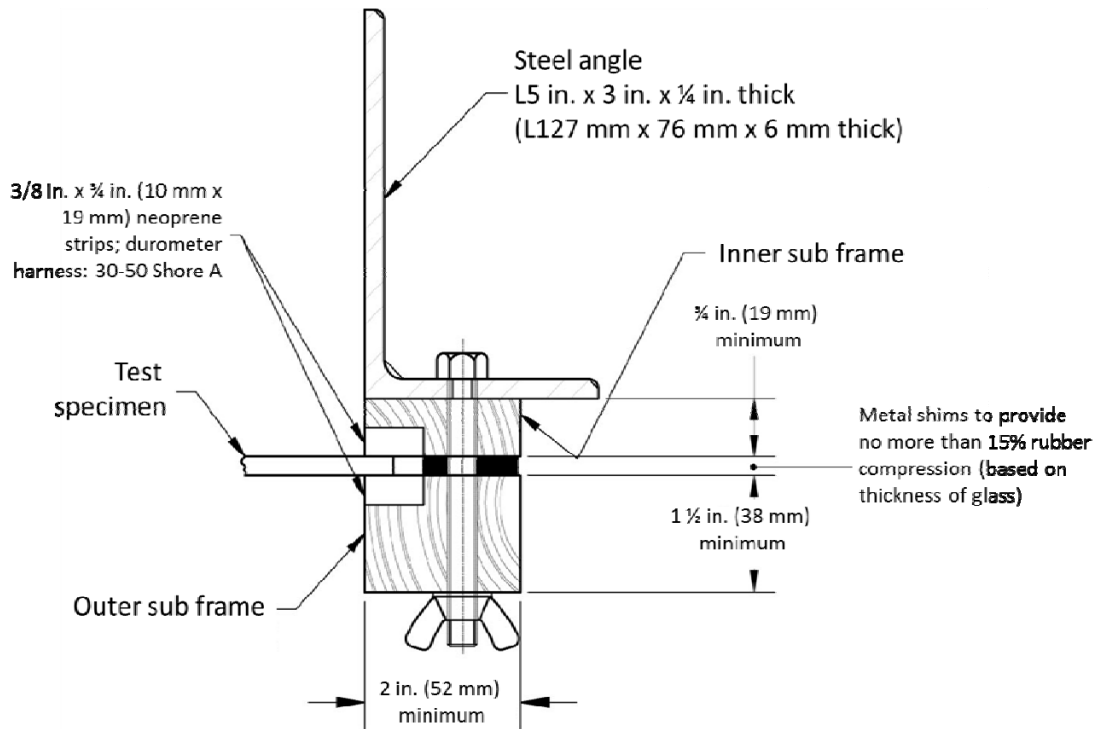


Figure 2.1: Detail of Section A-A PROPERLY Clamped Test Specimen (>1/8 inch (3 mm))

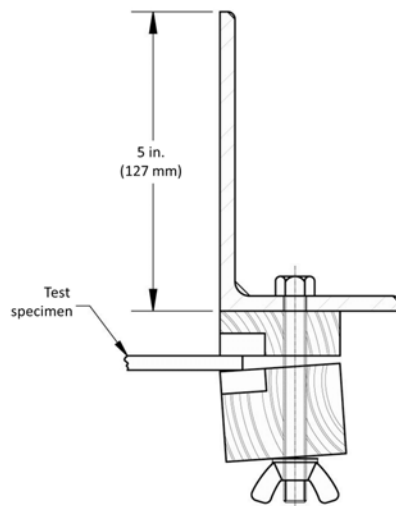


Figure 2.2: Detail of Section A-A IMPROPERLY Clamped Test Specimen (>1/8 inch (3 mm))

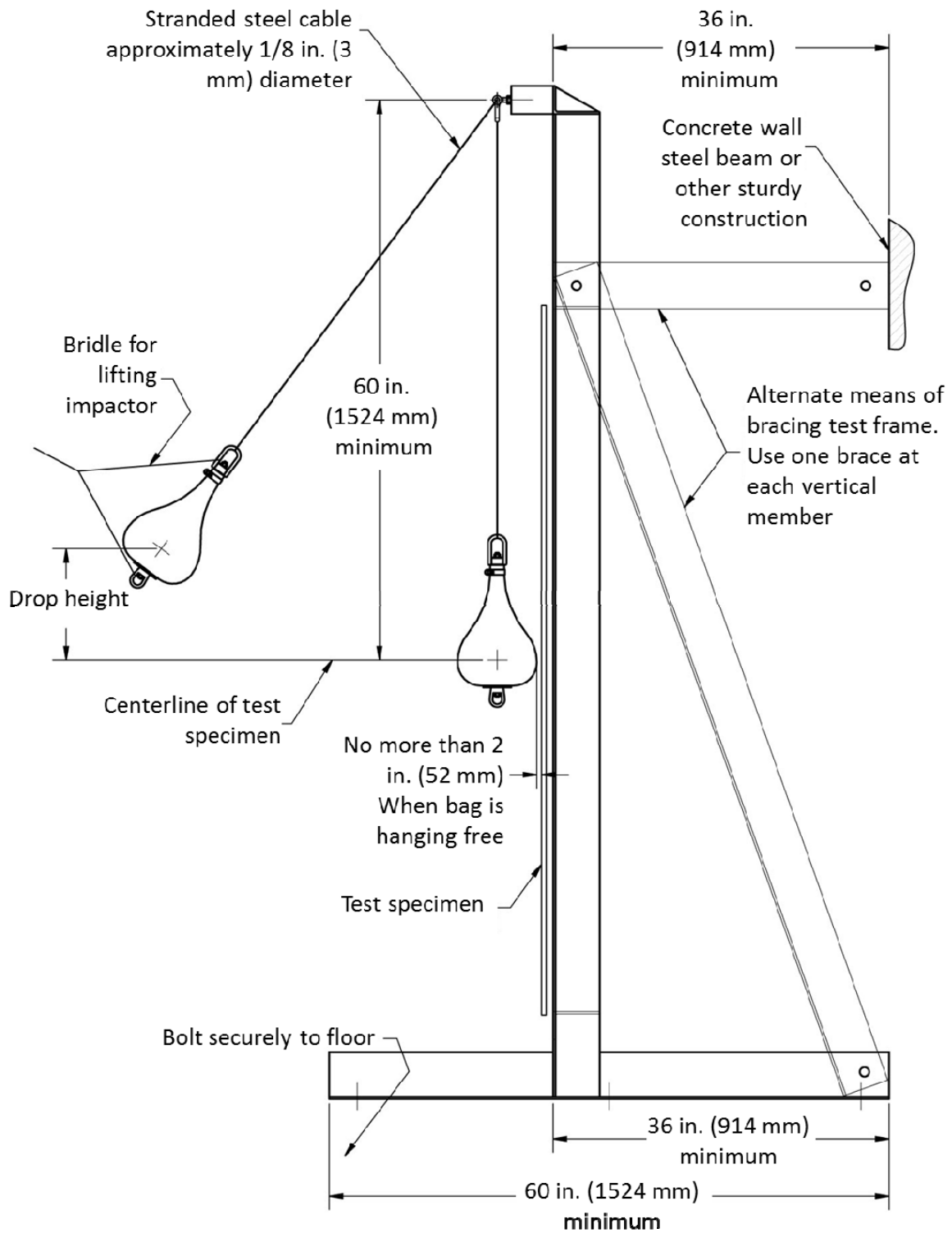


Figure 3: Impact Test Frame – Side View

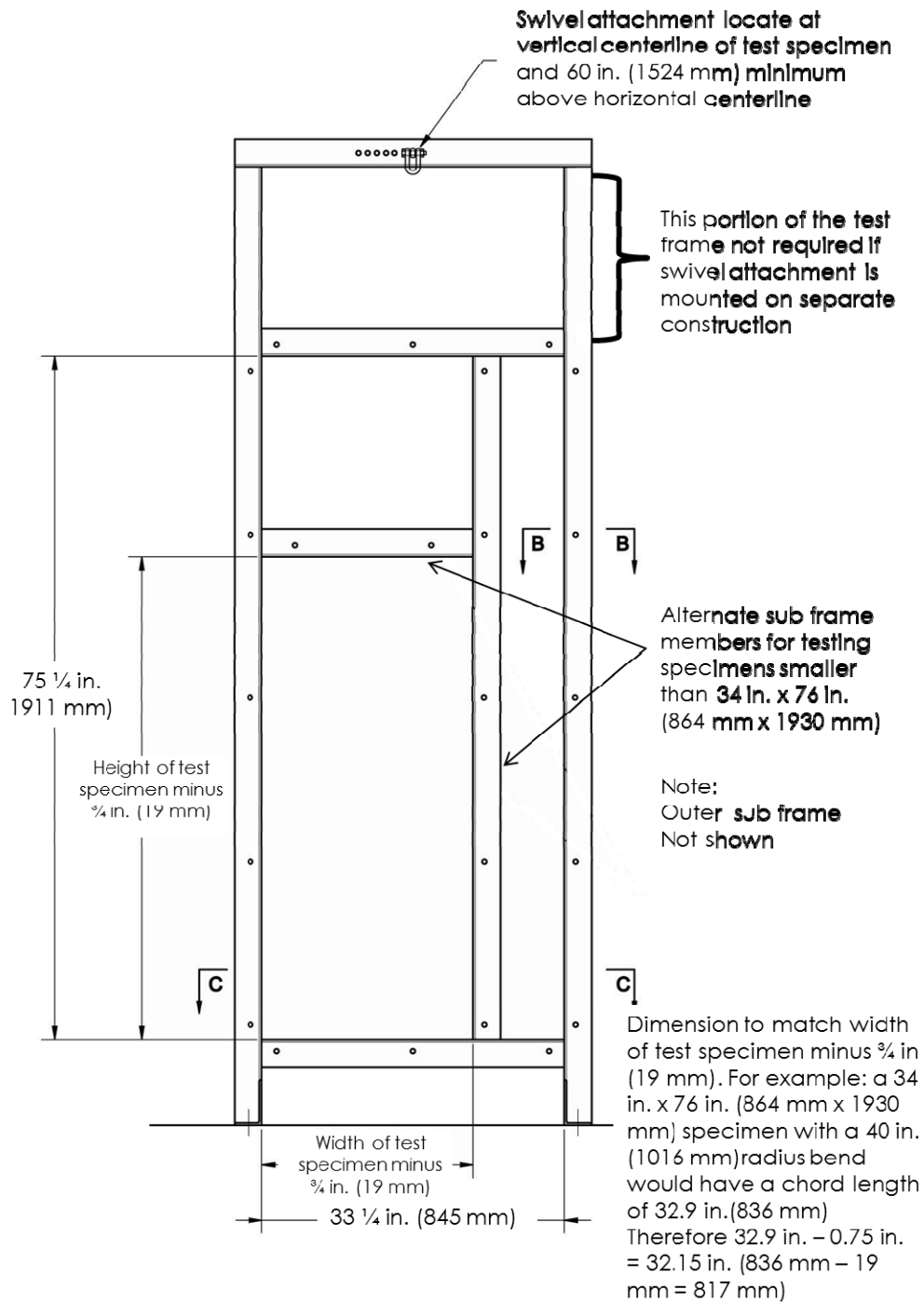


Figure 4: Impact Test Frame – Bent Glazing – Front View

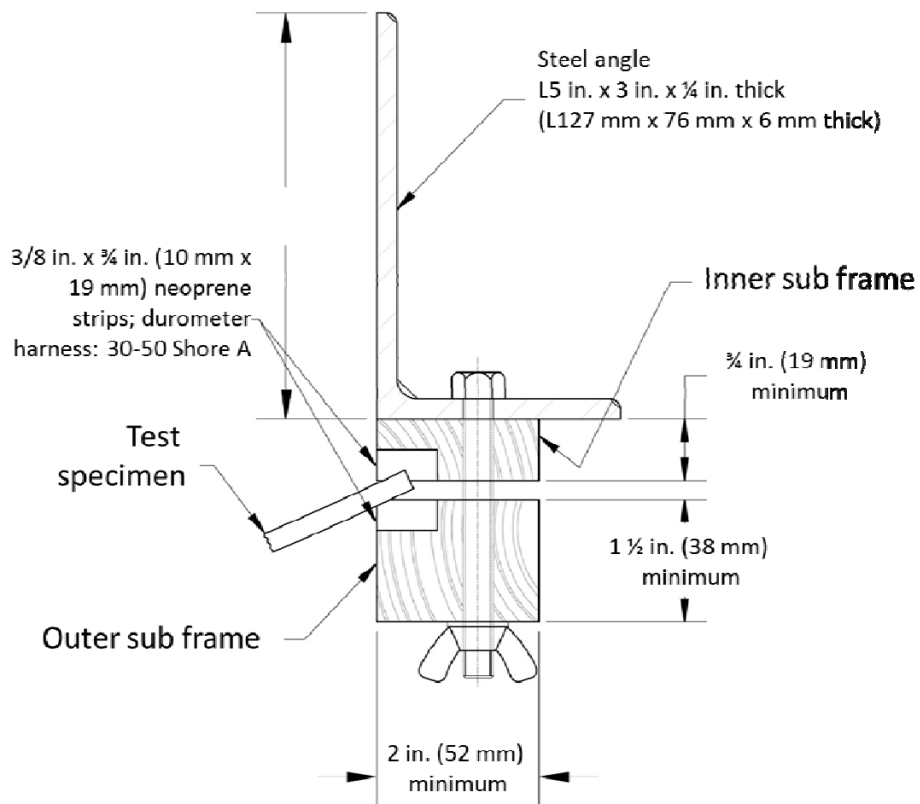


Figure 4.1: Detail of Section B-B

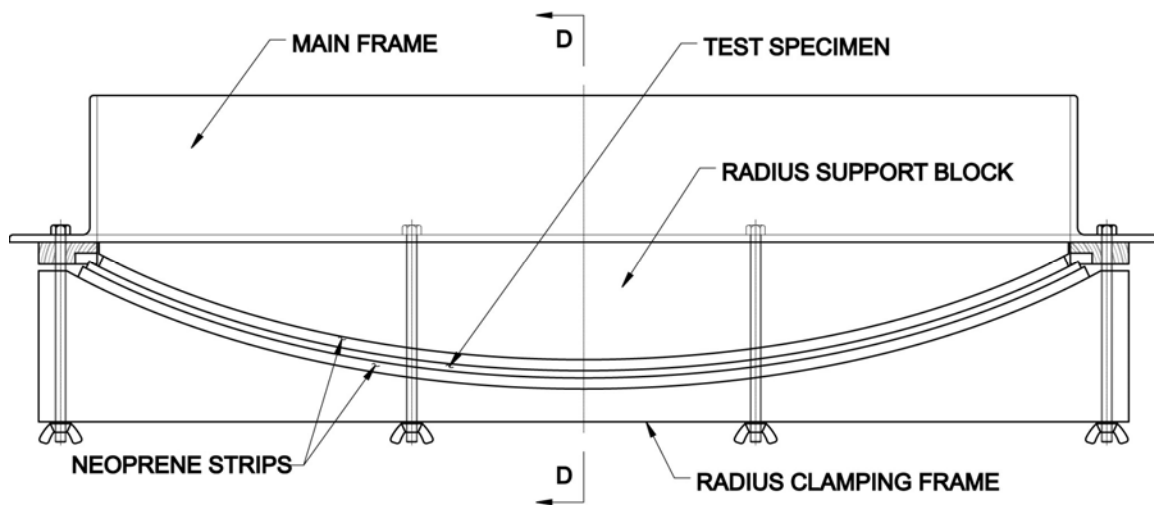


Figure 4.2: Detail of Section C-C



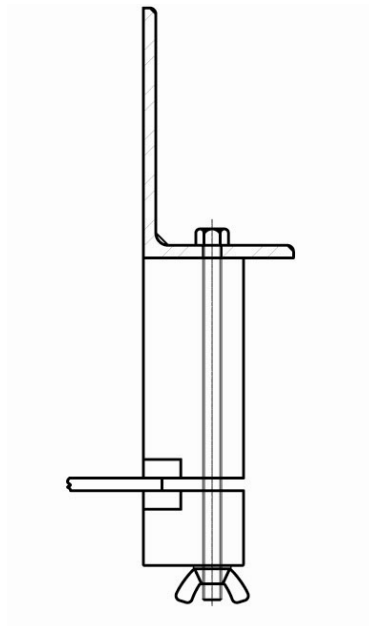


Figure 4.3: Detail of Section D-D

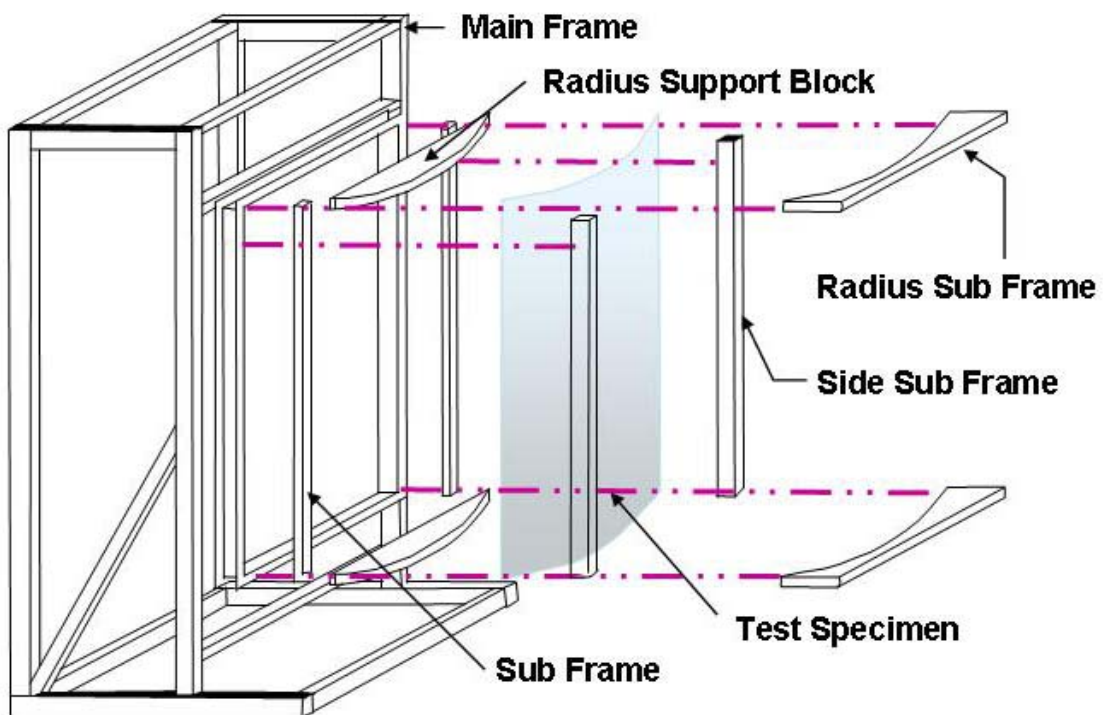


Figure 5: Bent Glass Impact Test Frame (Exploded View)

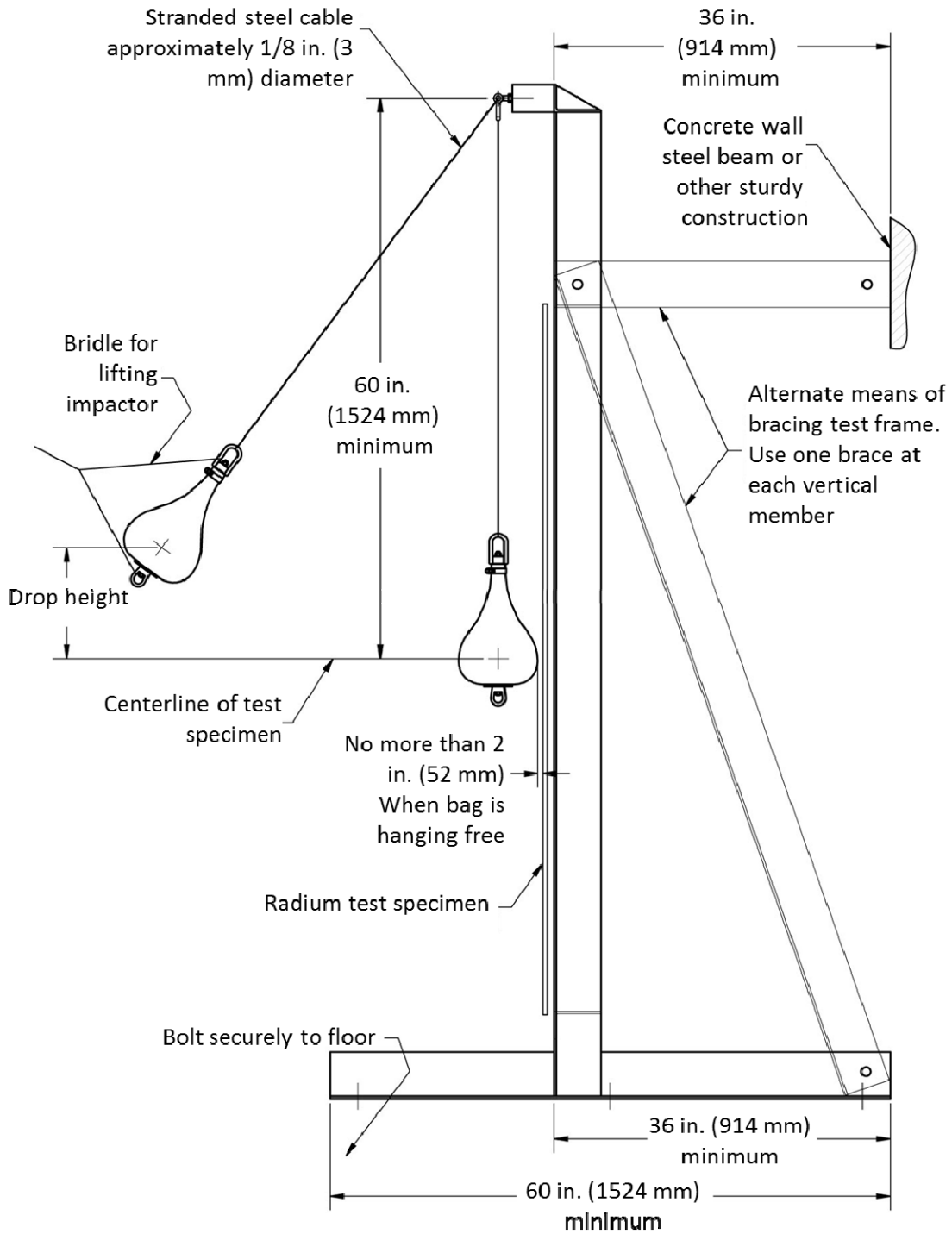


Figure 6: Impact Test Frame - Bent Glazing - Side View

**(2) Sub-frame** (Test Specimen Mounting Frame). (See [Figure 1](#) and [Figure 2](#)) The sub-frame for securing the specimens on all four edges consists of two parts made from wood or other material which is hard enough to withstand the pressure exerted by the clamping forces. Each part shall be provided with a groove or rebate in which a strip of elastomeric rubber is laid; the specimen shall only contact the elastomeric rubber strips.

The inner sub-frame ([Figure 2.1](#) and [Figure 2.2](#)), which is in contact with the specimen, is 2- inches by 0.75 inch (50 mm by 19 mm) minimum. The outer part of the sub-frame holds the specimen and is 2 inches by 1.5 inches (50 mm by 38 mm) minimum.

The sub-frame is fixed to the main frame by at least twelve bolts (M10 bolts, scissors clamps or equivalent). These shall be fixed at the points marked on [Figure 1](#) and [Figure 2](#), with no fewer than two on any edge and spaced no more than 18 inches (450 mm) apart.

To provide and limit elastomeric rubber compression and avoid sub-frame distortion, non-compressible shims appropriate to glazing thickness shall be used to separate the inner and outer parts of the sub-frame (See [Figure 2.1](#)).

The elastomeric rubber strip, the only element of the sub frame that the test specimen shall come into contact with, shall be 0.8 inch (20 mm) wide by 0.4 inch (10 mm) thick and have a Shore-A hardness of  $40 \pm 10$  (ASTM D2240, Standard Test Method for Rubber Property - Durometer Hardness).

*NOTE: Modifications that clearly do not alter the function or performance of the main frame or sub-frame are acceptable. Any reasonable means may be used to secure the sub-frame to the main frame provided the mounting is secure and the pressure on the glazing specimen in the sub-frame is controlled.*

**(3) Impactor** The impactor shall consist of the leather bag described in [Figure 7](#), a commercial punching bag<sup>4</sup> with its bladder left in place, or any other leather bag of nominally identical shape and size. The bag shall be filled with lead shot of 2.4 mm + 0.1 mm diameter (nominal USA No. 7 1/2 or European No. 7 lead shot) and taped. After filling with lead shot, the top shall be either pulled over the metal sleeve and tied with a cord; or twisted around the threaded eyebolt shaft and tied below the metal sleeve, or both. To reduce bag damage during testing, the exterior of the leather bag surface shall be completely covered with glass filament reinforced pressure sensitive polyester adhesive tape<sup>5</sup>, 0.5 inch to 0.6 inch (12 mm to 15 mm) in width and 0.006 inch (0.15 mm) thick. Tape the entire bag, using three (3) rolls or 180 yards (165 m) total length, and taping in a diagonal-overlapping manner. Tape the neck of the bag separately, with additional glass filament reinforced tape of the same kind. The total mass of the impactor assembly shall be 100 lb.  $\pm 4$  oz. (45.4 kg  $\pm 0.2$  kg) as described in Figure 7, excluding traction system attachments.

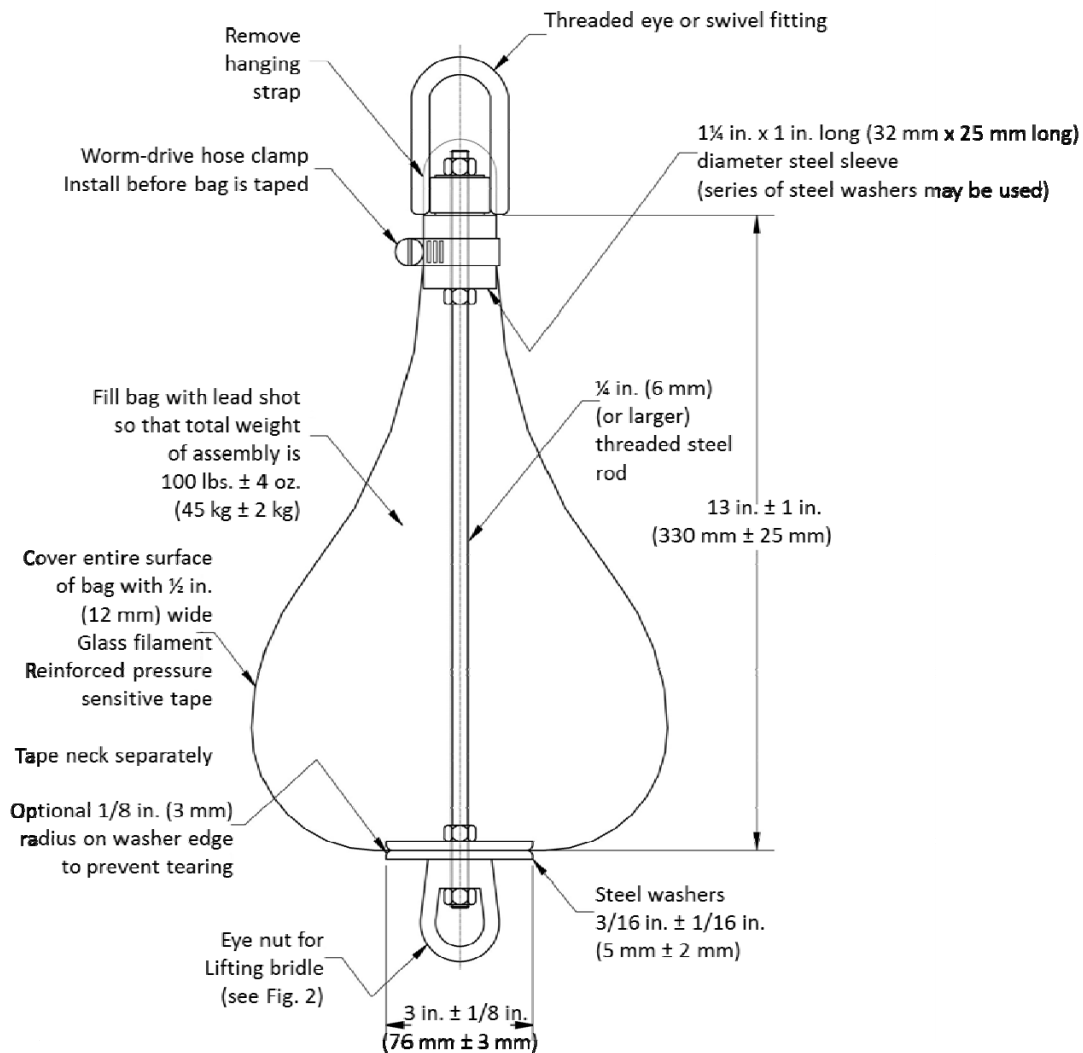
To reduce bag deformation during testing, the bag shall be rotated about the axis of its suspension device before each specimen or sample set, by no less than 30 degrees, and by no more than 90 degrees.

<sup>4</sup> Such as 9 inch (229 mm) diameter by 14 inch (356 mm) high Everlast 4207 (raw, full grain 3 ounce (85 grams) cowhide) or Everlast 4212 (split 3 ounce (85 grams) cowhide) available from Everlast Sports, Bronx, New York, USA. These are trade names. This information is given for the convenience of users and does not constitute an endorsement of any product named. Equivalent products may be used if they can be shown to lead to the same results. As of the date of publication of this version, Everlast no longer supplies these bags. A source of supply is SGCC at [www.sgcc.org](http://www.sgcc.org)

<sup>5</sup> Such as 3M No. 898 (a trade name), or equal. (See footnote<sup>4</sup> regarding trade name).

*NOTE: To reduce bag damage during testing, a thin homogeneous or non-woven plastic film no more than 0.005 inch (0.13 mm) thick or a loosely draped woven cloth towel weighing no more than 0.05 g/cm<sup>2</sup> (0.0113 oz./in<sup>2</sup>) shall not be attached to the impactor, but rather may be suspended vertically in front of the surface of the specimen at a distance no more than 0.4 inch (10 mm).*

The impactor shape shall be maintained constant during testing. To reduce visible deformation of the impactor, it shall be removed from the suspension device and pummeled with a rubber mallet into its approximate original shape.



**Figure 7: Impactor**

**(4) Suspension Device:** The impactor is suspended by means of a single, stranded steel cable, approximately 0.125 inch (3 mm) diameter, from an upper swivel-fixture above the head of the main frame at an elevation of which the minimum distance between the swivel-fixture and impactor centerline is 60 inches (1524 mm). The upper swivel-fixture

must be rigid to ensure the point of suspension remains stationary. The lower swivel(s) or equivalent shall be provided on the bag for rotation of the impactor about its suspension device axes between impact events.

When at rest, the surface of the impactor, at its maximum diameter, shall be located no more than 2 inches (51 mm) from the surface of the specimen and no more than 2 inches (51 mm) from the center of the specimen.

**(5) Traction and Release System** A traction system shall be used which enables the impactor to be brought into its launch position. The launch position depends on the drop height selected. The traction cable is connected to the impactor traction system by a release mechanism, with provisions for rotating the impactor.

To position the impactor at the selected drop height, a traction force shall be applied to raise the impactor such that the axis of the impactor shall be aligned with the suspension cable, with the cable remaining taut. To ensure this, the top and bottom ends of the impactor shall be connected to the release device by a suitable link.

### 5.1.2 Impact Classification

Glazing materials shall be submitted for impact testing to a selected drop height class.

#### (1) Drop Height Class

Glazing materials conforming to this standard are classified by their performance under the impact test at the selected drop height.

**Class A** - glazing material that complies with the requirements of section [5.1.4](#) when tested by the procedure of section [5.1.3](#) at a drop height between 48 inches and 48.5 inches (1219 mm and 1232 mm) using an impact specimen appropriate to the size classification.

**Class B** - glazing material that complies with the requirements of section [5.1.4](#) when tested by the procedure of section [5.1.3](#) at a drop height of between 18 inches and 18.5 inches (457 mm and 470 mm) using an impact specimen appropriate to the size classification.

#### (2) Drop Height Qualification

Glazing material qualified for classification at the higher impact drop height level "Class A", shall be deemed to comply with the lower impact drop height level "Class B".

### 5.1.3 Impact Procedure

(1) Place and center each specimen in the sub-frame so each edge is encased in the elastomeric rubber strip to a depth of at least 0.4 inch (10 mm). With the specimen mounted, the elastomeric rubber strip shall not be compressed by more than 15% of its thickness. For bolts, torque shall be 15 ft-lb. + 4 ft-lb (20Nm+ 5Nm).

- (2) Select a drop height classification from section [5.1.2\(1\)](#). Rotate the impactor as required. Raise the impactor to the selected drop height intended for classification and stabilize it. At the selected drop height, the suspension device shall be taut and the axes of the impactor and cable shall be in line.
- (3) The impactor, stabilized in the launch position in a vertical plane normal to the test specimen, is released and falls without initial velocity or axial rotation. At least one impact shall occur on each test specimen. Unbroken specimens may be reused for higher classification impact testing.
- (4) Classify the test specimen according to the Glazing Types in [Table 2](#). Inspect each test specimen after impact and record and report whether it complied or did not comply with the Applicable Interpretation of Results contained in [Table 2](#). If classified as Tempered Glass, open the sub frame to allow any particles to be released and fall free.
- (5) If any of the required specimens fail to comply with the requirements of section [5.1.4](#), the material shall not be classified for impact.
- (6) For asymmetric materials, the test shall be carried out on both sides using equal numbers of separate specimens.
- (7) When the required number of specimens are impacted and inspected, report the impact classification as described in section [5.1.2](#). If all specimens tested by impact either do not break, or break according to the requirements of section [5.1.4](#), the glazing material shall be classified as described in section [5.1.2](#), at the impact level tested. Classification shall comprise the word "Class", followed by a letter designation ("A" or "B") for drop height class.
- (8) If it is required to test the material to a higher impact classification level, repeat the test on the required number of undamaged specimens of the same material at the higher impact level. At the fabricator's discretion, previously tested but unbroken specimens may be used for higher impact classification testing.
- (9) Each specimen of bent glass will be impacted on the convex surface at the center of the specimen perpendicular to the frame from the selected drop height (see [Figure 6](#)).

*Note: The convex surface is tested due to the realistic constraints of the test set-up in impacting the concave surface. Additionally, as of the date of this publication no data was available that showed one surface is more or less likely to break during impact.*

#### 5.1.4 Interpretation of Results

Evaluation after impact shall occur whether the specimen remains fully engaged in the frame or partially engaged in the frame, or is entirely disengaged from the frame. A glazing material shall be judged to pass the impact test if any one of the applicable evaluation criteria below is met by each of the required number of impact specimens tested.

**Table 2: Applicable Interpretation of Results for Shot Bag Impact**

Interpretation of Results	Laminated Glazing	Tempered Glass	Organic coated glazing	Plastic Glazing
5.1.4 Type 1	X		X	
5.1.4 Type 2		X		
5.1.4 Type 3				X
5.1.4 Type 4	X	X	X	X

**Type 1:**

Upon impact, one or more cracks may appear. Fragments tend to be contained by the interlayer or adhesive like laminated or organic coated glazing.

Specimen Evaluation Criteria: No tear or shear or opening develops within the vertical specimen through which a 3.0 inch (76 mm) diameter sphere can pass using a horizontally applied force of 4.0 lb. (18 N) or less. Additionally, if particles are detached from the test specimen up to 3 min after impact, they shall, in total weigh no more than a mass equivalent to 15.5 in<sup>2</sup> (10,000mm<sup>2</sup>) of the original test specimen. The single largest particle shall weigh less than a mass equivalent to 6.82 in<sup>2</sup> (4,400 mm<sup>2</sup>) of the original test specimen. Detached individual particles less than the mass equivalent of 1 in<sup>2</sup> (650 mm<sup>2</sup>) shall be excluded from the fragment analysis.

**Type 2:**

Upon impact, the specimen shatters like tempered glass.

Specimen Evaluation Criteria: The 10 largest crack-free particles shall be selected within 5 minutes subsequent to the impact and shall weigh no more than the equivalent weight of 10 square inches (6452 square millimeters) of the original specimen. For purposes of impact test evaluation when breakage occurs, the average thickness of a tempered glass specimen containing grooves, bevels, or other thickness altering fabrication shall be considered the average of the thinnest measurement of each of the ten (10) geometrically largest crack-free particles. This average thickness will then be used to determine the maximum allowable weight of the ten (10) largest crack-free particles.

*NOTE: The weight in ounces of 10 square inches of soda lime glass is equal to 14.5 times the glass thickness in inches. The weight in grams of 10 square inches of glass is equal to 412 times the glass thickness in inches (16.18 grams/mm).*

**Type 3:**

Upon impact, the specimen breaks like plastic glazing.

Specimen Evaluation Criteria: The stiffness and hardness of the specimen shall be determined. A modulus of elasticity (see ASTM D790) less than 550,000 psi (3.9 GPa) and a Rockwell hardness (see ASTM D785) less than M or R 140 shall indicate satisfactory compliance.

**Type 4:**

Upon impact, the specimen does not break.

Specimen Evaluation Criteria: No breakage occurs. All specimens of tempered glass that do not fracture must pass section [5.2](#).

## 5.2 Center Punch Fragmentation Test

This test is to be performed on tempered glass specimens in addition to the test described in section [5.1](#). Specimens for testing shall previously have been tested per section [5.1](#) and, when impacted, no breakage has occurred. Specimens temperature shall be between 65°F and 85°F (18.3°C and 29.4°C) prior to testing.

### 5.2.1 Equipment

The following equipment is required:

- (1) A sharp impactor such as a pointed hammer of about 2.65 ounces (75 g) mass, or a spring loaded center punch<sup>6</sup> or similar appliance can be used.
- (2) A means of specimen support consisting of a flat base with adjustable horizontal curbs to prevent scattering of fragments.
- (3) A calibrated scale suitable for accurately weighing selected particles to the nearest 0.004 ounce (0.1 gram).
- (4) A calibrated micrometer<sup>7</sup> capable of measuring the thickness of the selected specimen / particle.

### 5.2.2 Procedure

- (1) Flat Glass: Place the specimen on the flat base and place the curb lightly along the specimen edges so the sample can elongate slightly yet the fragments remain interlocked.
- (2) Bent Glass: Place the specimen on the bent glass impactor frame on a flat base with the convex side facing up. The specimen shall have edges continuously supported.
- (3) Strike the test specimen 1 inch (25 mm) inboard of the longest edge at its midpoint until fracture occurs.

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<sup>6</sup> Starrett No. 18C automatic center punch. This information is given for the convenience of users and does not constitute an endorsement of any product named. Equivalent products may be used if they can be shown to lead to the same results.

<sup>7</sup> Starrett No. 230, 0 inch – 1 inch (0 mm to 25 mm) . This information is given for the convenience of users and does not constitute an endorsement of any product named. Equivalent products may be used if they can be shown to lead to the same results.



### 5.2.3 Particle Weight Determination

- (1) Within five minutes after fracture collect and weigh the ten (10) largest crack-free particles. In the event any of the ten (10) largest particles cracks after original selection, all pieces shall be weighed.
- (2) For transparent flat glass, measure the thickness of the largest particle. For patterned glass thickness measurement, see ASTM C1036 for thickness measurement technique. Record the thickness.

### 5.2.4 Center Punch Fragmentation Interpretation of Results

- (1) The total weight of the ten (10) largest crack-free pieces shall weigh no more than the equivalent weight of 10 square inches (6452 mm<sup>2</sup>) of the original test sample. (The weight in ounces of 10 square inches of glass is equal to 14.5 times the glass thickness in inches. The weight in grams of 10 square inches of glass is equal to 412 times the glass thickness in inches (16.18 grams/mm)).
- (2) No one particle shall be longer than 4 inches (102 mm) excluding an area of radius 4 inch (102 mm) centered on the impact point, and a border of 1 inch (25 mm) around the entire perimeter/edge of the test specimen ([Figure 8](#)).

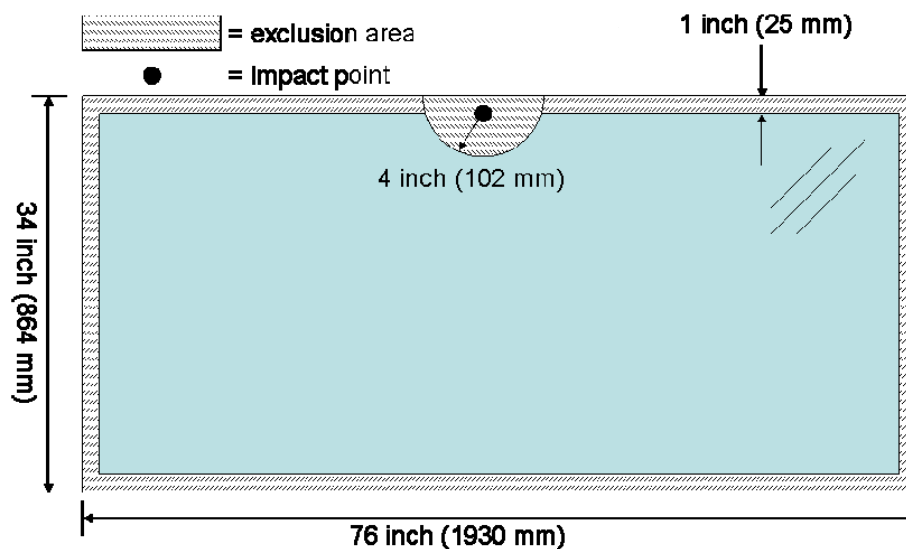


Figure 8: Center Punch Fragmentation

- 5.2.5 If any of the required specimens fail to comply with the requirements of section [5.2.4](#), the material shall not be classified for impact.

## 5.3 Thermal Test for Laminated and Organic Coated Glazings

This test shall be made to determine the probable effect of exposure to high temperature and humidity conditions for a long period of time.

### 5.3.2 Procedure

Three 12 inch by 12 inch (305 mm x 305 mm) flat specimens, as submitted, shall be subjected to an extended heat history through bake testing in an oven or boil testing. The thermal test may be conducted either in a heating chamber or boiling water. The test temperature is 212°F ± 4°F (100 °C ± 2°C). The specimens shall be conditioned to a uniform test temperature between 65°F and 85°F (18°C and 29°C) for at least 4 hours with separation to permit free air circulation prior to rating.

#### (1) Boil Testing

Samples are immersed, vertically, in water at 150°F ± 10°F (65.6°C ± 6°C) for 3 minutes and then quickly transferred to and similarly immersed in boiling water. The specimens shall be kept in the boiling water for 2 hours and then removed.

#### (2) Bake Testing

Samples are placed in a preheated chamber with samples not contacting the walls of the chamber and allowing for free flow of air around each specimen with the exception of the racking mechanism. The chamber is allowed to regain set temperature and test is maintained at temperature for 16 hours.

### 5.3.3 Interpretation of Results

The glass itself may crack in this test, but no bubbles or delaminations shall develop more than 0.5 inch (12 mm) from the outer edge of the specimen or from any crack that may develop. Any specimen in which the glass cracks to an extent confusing the results shall be discarded without prejudice, and another specimen shall be tested instead.

## 5.4 Weathering Tests for Laminated, Organic Coated and Plastic Glazings

The purpose of these tests is to determine whether these safety glazing materials will successfully retain their safety characteristics after exposure to weathering conditions for an extended period of time. The weathering methods described in section [5.4.1](#) shall be used for all materials subjected to exterior exposure. After weathering, organic coated glazing shall be tested as described in sections [5.4.2\(1\)](#) and [5.4.2\(2\)](#); laminated glazing shall be tested as described in sections [5.4.2\(1\)](#) and [5.4.2\(3\)](#), and plastic glazing shall be tested as described in section [5.4.2\(4\)](#) in order to evaluate whether or not the safety glazing meets the weathering requirements. Plastic, organic coated or laminated materials intended for interior use only shall be subjected only to the ageing requirements of section [5.4.3](#).

*Note: See [Appendix B](#) for a summary table of weathering requirements and post weathering testing.*

### 5.4.1 Weathering Methods

The specimens shall be subjected to one of the following two weathering exposure alternatives. For laminated, organic coated, and plastic glazing, three (3) specimens with the side marked for exterior exposure shall be exposed to the energy source. Three (3) additional specimens shall be controls and shall be held in darkness at 73.4°F ± 3.6°F (23°C ± 2°C) until needed (see sections [5.4.2\(2\)](#) and [5.4.2\(3\)](#)). For the plastics, see section [4.6.1](#).

**(1) Natural Exposure****a. Procedure**

The specimens shall be exposed in accordance with ASTM D1435 using a 26° North latitude, 45° angle of exposure, direct, facing South, open-backed mounting.

**b. Location**

The specimens shall be exposed in South Florida, United States of America.

**c. Duration**

The specimens shall be exposed for one year. On average, a one year exposure approximates a Total Ultraviolet (TUV) exposure of  $300 \pm 25$  MJ/m<sup>2</sup> at 295-385 nm.

**(2) Accelerated Exposure****a. Apparatus**

The specimens shall be subjected to exposure in a Xenon-Arc Type Operating Light Apparatus as specified in ASTM G155 with filters as specified in accordance with section 6.1.3 of ASTM G155 Spectral Irradiance of Xenon Arc with Daylight Filters.

**b. Procedure**

The specimens shall be exposed in accordance to ASTM D2565 (or ISO 4892-2) and the following conditions as stated in Table 3:

**Table 3: Accelerated Weathering Conditions**

Parameter	Description
ASTM D2565 Cycle	Cycle 1
Black Panel Temperature	145° ± 4°F (64° ± 2°C)
Relative Humidity	50% ± 5%
Spray Water	De-ionized
Irradiance*	0.35 ± 0.02 watts/m <sup>2</sup> @ 340 nm, or 41.5 ± 2.5 watts/m <sup>2</sup> from 300 – 400nm
Exposure Duration*	3000 hours

\*Minimum acceptable levels of irradiance and duration are indicated and shall be recorded in the report section.

**(3) Weathering for Laminated and Organic Coated Glazings**

The purpose of weathering laminated or organic coated glazings is to determine if degradation of the interlayer occurs over the duration of the exposure. Surface

etching of the glazing may occur in the accelerated chamber or on natural exposure and erroneously indicate interlayer or adhesive changes. An identical piece of glazing material from which the laminates have been manufactured, a blank (i.e.: glass, plastic etc...), may be weathered concurrently to determine the weathering of glazing and eliminate those changes from the interlayer or adhesive evaluation.

## 5.4.2 Tests after Weathering

Specimens exposed in accordance with section [5.4.1](#) shall be tested after weathering according to the procedures outlined in sections [5.4.2\(1\)](#) and [5.4.2\(2\)](#). For organic coated glazing, section [5.4.2\(1\)](#) and [5.4.2\(2\)](#); for laminated glazing, section [5.4.2\(1\)](#) and [5.4.2\(3\)](#); and for plastic glazing, section [5.4.2\(4\)](#).

### (1) Tests after Weathering for Laminated and Organic Coated Glazings

Assessment of optical changes after weathering are included for laminated and organic coated glazings as significant changes can be indicative of product degradation which may have an effect on impact and safety performance. Changes in the blank glazing ([5.4.1\(3\)](#)) based on the comparison of non-weathered retain data, shall be deducted from the weathered laminated or organic coated specimens for evaluation of the properties listed in [5.4.2\(1\)b](#).

**a. Measurement Location:** Specimens shall be measured at a point more than 10 mm inward from any edge.

**b. Performance Requirements:** When compared to control (unexposed) samples, no weathered specimen shall exhibit more than the allowable change, as specified, for the following properties:

- [1] **Visible Light Transmittance** change not greater than 5 percentage units (e.g.: 91% control  $\pm$  5% = 96% or 86%) as measured according to ASTM D1003.
- [2] **Yellowness Index** (for clear products only) increase not greater than 0.5 YI units (e.g.: 0.70 YI control + 0.5 = 1.20) as measured according to ASTM E313.
- [3] **Haze** increase not greater than 0.5 percentage units (e.g.: 0.70 control  $\pm$  1.20) as measured according to ASTM D1003.
- [4] **Delta E** less than or equal to 5 units as measured according to ASTM E308 and calculated according to ASTM D2244, section 6.2.1.

**c. Interpretation of Results:** When the thinnest construction of all components of laminated or organic coated glazings have passed the applicable weathering requirements and subsequent evaluation as stated in section [5.4](#), thicker components and colored components of the same material are deemed as qualified for weathering compliance.

## (2) Tests after Weathering for Organic Coated Glazing Only

Organic coated glazing specimens shall be judged satisfactory if they pass the requirements of section [5.4.2\(1\)](#), adhesion test (see section [5.4.2\(2\)a](#)) and the tensile strength test (see section [5.4.2\(2\)b](#)).

### a. Adhesion Test

- [1] **Specimens:** Six specimens, [nominally 2 inch by 6 inch (52 mm by 152 mm)] prepared as described in section 4.6.2 shall be tested. The specimens shall be conditioned just prior to the performance of the adhesion test at  $73.5^{\circ}\text{F} \pm 3.5^{\circ}\text{F}$  ( $23^{\circ}\text{C} \pm 2^{\circ}\text{C}$ ) and  $50\% \pm 2\%$  relative humidity for 24 hours.
- [2] **Apparatus:** The test apparatus shall be (a) a tensile tester of the constant-rate-of-extension (CRE) type with the moving crosshead set to move at 12 inches (305 mm) per minute and the load range set so that the average peel force will fall at 30%-50% of full scale and (b) a cutting device containing new razor blades for cutting 1 inch (25 mm) wide specimens (use each blade one time only).
- [3] **Procedure:** Using the 1 inch (25 mm) razor cutting device, cut a straight strip of the organic coating in the lengthwise direction of the specimen. Peel back about 2 inches (52 mm) of one end of the 1 inch (12 mm) wide organic strip. Attach a strip of pressure-sensitive tape to the side of the organic strip opposite the adhesive to extend this free end to about 8 inches (203 mm) in length. Place the end of the glass panel from which the organic strip was removed in the lower clamp of the tensile tester and the free end of the tape in the upper clamp. Peel the remainder of the organic strip from the glazing mechanically and obtain a record of the peel value. Determine the average pull for each specimen from the chart record.
- [4] **Interpretation of Results:** The organic coated glazing adhesions shall be judged satisfactory if the average adhesion value of the three exposed specimens is no less than 75% of the average adhesion value of the three control (unexposed) specimens.

### b. Tensile Strength Test

- [1] **Specimens:** The samples for this test are the same specimens used in the adhesion test as in section [5.4.2\(2\)a](#), and conditioned as in section [5.4.2\(2\)a\[1\]](#).
- [2] **Apparatus:** The test apparatus shall be:
  - (a) a CRE tensile tester set as follows:
    - gauge length: 2 inches (52 mm);
    - crosshead speed: 2 inches (52 mm) per minute;

load range: set full-scale load so that specimens will break at 30%-60% of full scale, and

(b) a cutter containing new razor blades for cutting 1/2 inch (12 mm) wide specimens (use each blade one time only).

[3] **Procedure:** Using the 1/2 inch (12 mm) razor cutting device, cut a straight strip of the organic coating in the lengthwise direction of the glass sample for the full 6 inch (152 mm) length. Carefully peel this strip from the glass panel and test it for breaking strength in the tensile strength tester.

[4] **Interpretation of Results:** The organic coating tensile shall be judged satisfactory if the average tensile value of the three exposed specimens is no less than 75% of the average tensile value of the three control specimens.

### (3) Tests after weathering for Laminated Glazing only

**a. Specimens:** After exposure, the test specimens may be cleaned, if necessary, using a procedure recommended by their manufacturer to remove any residues present.

**b. Conditioning:** Both the unexposed and exposed specimens shall be conditioned prior to examination or further testing for a minimum of 48 hours at 71°F to 75°F (22°C to 24°C) and 50% ± 2% relative humidity.

**c. Viewing:** When irradiated and conditioned, the exposed specimens shall be examined and compared visually with the unexposed controls. Specimens shall be placed in a vertical position. The viewer shall look through the specimen using daylight without direct sunlight, or using a background light suitable for observing blemishes. View at 36 inches (910 mm).

**d. Interpretation of Results:** Any improvement in clarity or discoloration is acceptable. When examined after ultraviolet exposure, each exposed test specimen shall meet the criteria of [5.4.2\(1\)](#) and be substantially free of noticeable decomposition as defined by absence of the following specific kinds of developed defects or blemishes, when observed by this inspection method in comparison to unexposed control specimen(s):

- (1) No bubbles or delamination shall be visible more than 0.4 inch (10 mm) from any outer edge of the specimen, and
- (2) No crazing or cracking is allowed.
- (3) If no noticeable decomposition and no other defects develop upon exposure, the glazing material shall be reported as visually acceptable. Otherwise, unacceptable glazing material shall be reported as visually blemished.

#### (4) Tests after Weathering for Plastics Only

**a. Specimens:** Shall be evaluated before and after exposure in accordance with ASTM D6110, Charpy Impact Test, method B, with the following exceptions:

- (1) The specimens shall not be notched.
- (2) The specimens shall be tested with the exposed surface in tension.
- (3) The specimens shall be exposed and tested flatwise.
- (4) The span shall be reduced to 2 inches (52 mm) for thin material that may slip through the supports without breaking.
- (5) The average of five (5) samples taken from the weathered specimens shall be reported.

**b. Interpretation of Results:** Plastic materials shall be acceptable for use as safety glazing if the impact strength as measured by the Charpy Impact Test is not reduced by more than 25% as a result of the natural or accelerated exposure. No bubbles or other physical degradation shall develop in the exposed portion.

#### 5.4.3 Indoor Applications Only - Aging Tests for Laminated, Plastic, Organic Coated and Mirror Glazings

The purpose of these tests is to determine whether laminated, plastic, organic coated or mirror glazings for indoor use only will successfully retain their safety characteristics after exposure to simulated aging conditions for an extended period of time. The specimens described in 4.4 for impact test after aging shall be used. Specimen size shall be in accordance with 4.6. Specimens passing the requirements of natural or accelerated exposure (section 5.4.1) and subsequent testing (section 5.4.2) are deemed qualified for indoor applications without further evaluation.

##### (1) Accelerated Exposure

###### a. Apparatus

The specimens shall be subjected to exposure in a Xenon-Arc Type Operating Light Apparatus as specified in ASTM G155 with filters as specified in accordance with ASTM D 4459.

###### b. Procedures

The specimens shall be exposed in accordance to ASTM D4459 and the following conditions as indicated in Table 4:

**Table 4: Accelerated Weathering Conditions – Indoor Product Use**

Parameter	Description
Light Mode	Continuous
Black Panel Temperature	131° ± 4°F (55° ± 2°C)
Relative Humidity	55% ± 5%
Spray Water	None
Irradiance*	0.3 ± 0.02 w/(m <sup>2</sup> * nm)@ 340 nm, or 0.8 ± 0.05 w/(m <sup>2</sup> * nm) @ 420 nm, or 36.5 ± 2.5 w/m <sup>2</sup> between 300 and 400 nm
Exposure Duration	3000 hours

\* Minimum acceptable levels of irradiance indicated. Higher irradiance levels and longer duration are permitted. Levels and duration shall be recorded in the report section.

### c. Interpretation of Results

#### [1] Aging Tests for Plastics used in Indoor Applications Only

After exposure in accordance with [5.4.3\(1\)](#) specimens must pass the requirements of section [5.4.2\(4\)](#), to be qualified for indoor applications.

#### [2] Aging Tests for Laminates and Organic Coated Glazing used in Interior Applications Only

After exposure in accordance with [5.4.3\(1\)](#), specimens must pass the requirements of section [5.4.2](#) to be qualified for indoor applications.

### (2) Aging Tests for Mirror Glazing used in Interior Applications Only

#### a. Apparatus

A conditioning chamber of sufficient size to hold up to 34 inch by 76 inch (864 mm x 1930 mm) panels vertically and capable of maintaining conditions of 140°F ± 5°F (60°C ± 3°C), 100°F ± 5°F (38°C ± 3°C) and 95% ± 5% relative humidity, and 0°F ± 5°F (18°C ± 3°C).

#### b. Procedure

Place four of the organic coated glazing specimens positioned vertically and spaced at least 1 inch (25 mm) apart in the chamber. Raise the temperature to 140°F ± 5°F (60°C ± 5°C) within 3 hours and maintain for 21 hours. Change the chamber conditions to 100°F ± 5°F (38°C ± 3°C) and 95% ± 5% relative humidity in 3 hours and maintain for 21 hours. This represents one complete cycle. Expose the specimens to 10 complete cycles. At the completion of the tenth cycle, change the chamber conditions to 0°F ± 5°F (18°C ± 3°C) in 3 hours and maintain for 21 hours. The fifth specimen shall be retained unexposed as a control for the effects of the exposure cycling. Upon completion of the required number of exposure cycles, all specimens shall be tested as described in section [5.4.3 \(3\)](#).



### **(3) Impact Test after Aging for Mirror Glazing**

#### **a. Apparatus**

The apparatus described in section [5.1.1](#) shall be used.

#### **b. Procedure**

All the specimens exposed as described in section [5.4.3](#)(2) shall be conditioned as described in section [5.1](#) and evaluated by the procedure in section [5.1.2](#).

#### **c. Interpretation of Results**

The exposed specimens shall again satisfactorily complete the impact test in accordance with section [5.1.3](#). Milkyness may develop but defects other than these shall be cause for rejection.

## 6 Marking of Safety Glazing Material

After having successfully passed the appropriate tests in this standard, like products and materials produced in the same manner as specimens submitted per test shall be legibly and permanently marked.

### 6.1 Mark Information

#### 6.1.1 Content of Mark

The mark shall contain the following information:

- (1) Supplier's name, distinctive mark or designation.
- (2) The words "American National Standard Z97.1-2015" or the characters "ANSI Z97.1-2015."
- (3) Classification of test size (L or U) and drop height class (A or B). Plastic glazing does not require drop height.
- (4) Place of fabrication (if fabricator has more than one location fabricating the product).

*NOTE: Additional details and information, such as glass type, thickness and date of manufacture, are permitted.*

#### 6.1.2 Example of Mark

Individual lay-out of the mark may vary based on manufacturer and product, and are deemed acceptable upon meeting the requirements of 6.1.1.

##### Basic

Glazing Company A  
ANSI Z97.1-2015 UA  
Plant ID (if more than one location)

##### Basic with some optional information

Glazing Company B  
Laminated (optional)  
ANSI Z97.1-2015 UA  
Plant ID (if more than one location)  
101014 (Date Code optional)

### 6.2 Application of Mark

The appropriate party using the following guidelines shall apply the permanent mark:

- (1) Laminated glazing stock sheets (i.e., size produced by the manufacturer) shall be marked by the manufacturer of the stock sheet.
- (2) All glazing products including cut size laminates and tempered glass shall be marked by the company producing the finished cut to size glass product.
- (3) The fabricator or manufacturer shall mark plastic glazing materials.

- (4) The installer of the safety film shall mark field-applied organic coatings (films).

### **6.3 Special Application Marking**

Certain types of glazing material shall also be marked with additional information as appropriate.

#### **6.3.1 Safety Glazing Materials Used in Indoor Applications Only**

After having successfully passed the appropriate tests (see section [5.4.3](#)), like products and materials produced in the same manner as specimens submitted for testing shall be legibly and permanently marked with the words - "Indoor Use Only".

#### **6.3.2 Organic Coated Glazing Only**

Organic coated glazing materials shall be legibly and permanently marked with the words "Glaze This Side In," to indicate to the installer, inspector, or user which side of the organic coated glazing should be exposed to the elements if there is a specific side that should be exposed.

## 7 ANNEX

(This Annex is a mandatory part of American National Standard Z97.1-2015 and indicates the publication year of the applicable standard referenced in ANSI Z97.1-2015.)

### ANNEX X

**Table X1**  
**ASC Z97.1-2015 - Reference Standards**

As listed in ANSI Z97.1-2015	Location Referenced Section(s)	Current Edition
ASTM C1036	4.2	2011e1
	5.2.3	
ASTM C1048	3	2012e1
ASTM C1172	3	2014
ASTM C1349	3	2010
ASTM C1464	4.4	2006(2011)
ASTM D785	4.7.2	2008
	5.1.4(3)	
ASTM D790	4.7.1	2010
	5.1.4(3)	
ASTM D1003	5.4.2(1)	2013
	5.4.2(3)	
ASTM D1435	5.4.1(1)	2013
ASTM D2240	5.1.1(2)	2005(2010)
ASTM D2244	5.4.2(1)	2015a
ASTM D2565	5.4.1(2)	1999(2008)
ASTM D4459	5.4.3(1)	2012
ASTM D6110	4.6.1 Note	2010
	5.4.2(4)	
ASTM E308	5.4.2(1)	2015
ASTM E313	5.4.2(1)	2015e1
ASTM G155	5.4.1(2)	2013
	5.4.3(1)	
ISO 4892-2	5.4.1(2)	2013

## 8 APPENDIX A

(This Appendix is not part of American National Standard Z97.1-2015, but is included for information only.)

### Basis of Safety Performance Specifications and Methods of Test

#### A1. General

One purpose in the development of this standard is to provide a single functional test that will simulate such human contact as normally results in cutting and piercing injuries. The performance of each safety glazing material is evaluated by impacting in the normally installed position. The test should be conducted from the direction that human impact would occur. Only such auxiliary tests as are considered necessary to evaluate the continued performance level, are used in the case of glazing containing organic material.

#### A2. Safe Performance Criteria (See section [5.1.2](#))

The performance criteria are directly related to the reduction of cutting and piercing injuries to persons who impact the glazing used in buildings.

The 150-ft. lbf (667 N) energy level has been established as practically related to those situations in which the limited acceleration path precluded, in most cases, the possibility of an individual developing their full kinetic energy (ke) potential (see section [1.3](#)).

The 400-ft. lbf (1779 N) impact level was established for relatively unlimited acceleration paths in which it might be reasonable to expect that an energetic teenager might develop something approaching his or her full impact velocity.

As section A3 of this Appendix indicates, the independent safety experts who considered the matter judged that these values were practical. (See section [A3](#) and [Figure A1](#))

#### A3. Development of Human Engineering Data Chart

Safety experts indicate that a 100-lb (45 kg) person is representative of glass breakage accident victims. From Figure A1 it is apparent that a 100-lb (45 kg) person running at the rate of a 4-minute mile has about 755 ft. lbf (3358 N) of kinetic energy. The amount of this energy a person might deliver to a glazed opening would depend upon the way the glazed surface was impacted. A "straight-arm" would transmit more energy to the glazing material than an arm that flexes with the impact.

For test purposes, Accredited Standards Committee Z97 decided, after extensive evaluation, to use a readily available leather punching (speed) bag filled with 100 pounds of lead shot to simulate the running (person). The test impact values were selected as representative of energy levels likely to be delivered by humans in practical situations involving interior doors and patio doors. These test levels were set considerably below the 755-ft. lbf (3358 N) kinetic energy level of the typical victim, since the impact

energy delivered to the glazing material - perhaps first by the hands, then by the head, and then by the knees - is much less than the kinetic energy of the running (person). Also, the impact will be at less than normal (90-degree) incident angle in most cases.

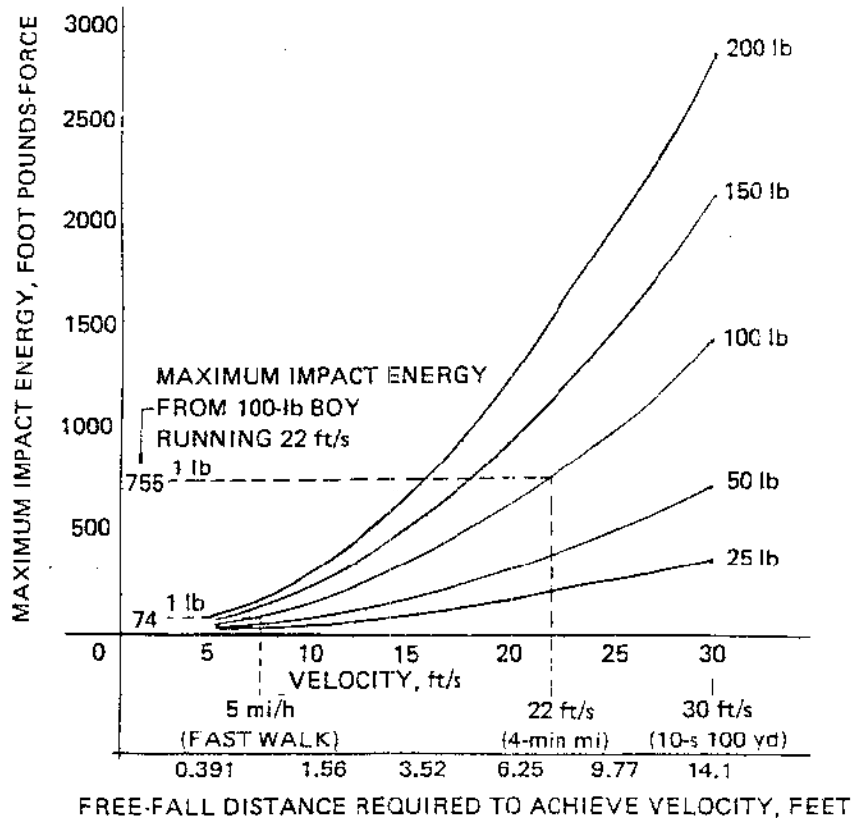


Figure A1: Human Engineering Data

Figure A1 was developed to assist ASC Z97 committee in establishing performance criteria for safety glazing materials subject to human impact. It is based on the following kinetic energy formula:

$$ke = 1/2mv^2$$

where

ke = kinetic energy in foot pounds-force

m = mass of missile

= weight of missile in pounds/ (32.2 ft./s<sup>2</sup>)

v = velocity of missile in feet per second

Maximum impact energy equals the kinetic energy of the person in motion at the moment of impact. Actual impact energy (that which the person delivers) is considerably less, except perhaps in the case of a person falling on a non-vertical surface.

#### **A4. Interpretation of Results (See section [5.1.4](#))**

Within the scope of this standard, which has as its objective reducing the frequency and severity of cutting and piercing injuries, it is evident that a material that does not break under impact is safe from these types of injuries. Section [1.3.5](#) specifically identifies glass types that are known to break in a manner not consistent with safety glazing as related to this standard.

"Break safe" criteria were developed largely as a matter of judgment based on observation of available glazing materials breaking under the test conditions. It is intended that any material that meets any one of the criteria in section [5.1.4](#) be considered safe within the scope of this standard.

To allow for practical interpretation of results, which admittedly may appear loosely defined to the uninitiated, rather severe impact levels were selected. The safety experts and the members of the original drafting committee who observed the many tests conducted in developing the standard were confident that laboratory personnel will quickly develop an ability to apply objective judgments using these criteria.

## 9 APPENDIX B

(This Appendix is not part of American National Standard Z97.1-2015, but is included for information only.)

**Table B1:** Summary Table for Weathering and Subsequent Testing

Test	Section	Glazing Type				
		Laminated Glazing	Tempered Glass	Organic Coated Glazing	Plastic Glazing	Mirror Glazing
<b>EXTERIOR GLAZING APPLICATIONS</b>						
Natural Exposure <sup>18</sup>	5.4.1(1)	X		X	X	n/a
Accelerated Exposure <sup>1</sup>	5.4.1(2)	X		X	X	n/a
<b>Tests after weathering (exterior)<sup>9</sup></b>						
Visible Light Transmittance (VT)	5.4.2.(1)b[1]	X		X		
Yellowness Index (YI)	5.4.2.(1)b[2]	X		X		
Haze	5.4.2.(1)b[3]	X		X		
Delta E	5.4.2.(1)b[4]	X		X		
Adhesion	5.4.2.(2)a			X		
Tensile	5.4.2.(2)b			X		
Visual Assessment	5.4.2.(3)	X				
Charpy Impact	5.4.2.(4)				X	
<b>INTERIOR GLAZING APPLICATIONS ONLY</b>						
Accelerated Weathering	5.4.3(1)	X		X		
<b>Tests after weathering (interior)</b>						
Visible Light Transmittance (VT)	5.4.2.(1)b[1]	X		X		
Yellowness Index (YI)	5.4.2.(1)b[2]	X		X		
Haze	5.4.2.(1)b[3]	X		X		
Delta E	5.4.2.(1)b[4]	X		X		
Adhesion	5.4.2.(2)a			X		
Tensile	5.4.2.(2)b			X		
Visual Assessment	5.4.2.(3)	X				
Charpy Impact	5.4.2(4)				X	
Full Size Weathering	5.4.3(2)					X
Impact after Weathering	5.4.3 (3)					X

<sup>18</sup> Natural or accelerated exposure is required. Although specimens may be evaluated by both types of exposure, only one type is required for the determination of compliance to this standard.

<sup>9</sup> In accordance with section 5.4.3, specimens passing the requirements of natural or accelerated exposure of section 5.4.1, and subsequent testing, section 5.4.2, are deemed qualified for indoor applications without further evaluation.



## About ANSI Overview

[http://www.ansi.org/about\\_ansi/overview/overview.aspx?menuid=1](http://www.ansi.org/about_ansi/overview/overview.aspx?menuid=1)

As the voice of the U.S. standards and conformity assessment system, the American National Standards Institute (ANSI) empowers its members and constituents to strengthen the U.S. marketplace position in the global economy while helping to assure the safety and health of consumers and the protection of the environment.

The Institute oversees the creation, promulgation and use of thousands of norms and guidelines that directly impact businesses in nearly every sector: from acoustical devices to construction equipment, from dairy and livestock production to energy distribution, and many more. ANSI is also actively engaged in accrediting programs that assess conformance to standards – including globally-recognized cross-sector programs such as the ISO 9000 (quality) and ISO 14000 (environmental) management systems.

### Mission

To enhance both the global competitiveness of U.S. business and the U.S. quality of life by promoting and facilitating voluntary consensus standards and conformity assessment systems, and safeguarding their integrity.

**Founded**      October 19, 1918

**Legal Status**    A 501(c)3 private, not-for-profit organization

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## Introduction to ANSI

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## Overview of the U.S. Standardization System

The American National Standards Institute (ANSI) has served in its capacity as administrator and coordinator of the United States private sector voluntary standardization system for more than 90 years. Founded in 1918 by five engineering societies and three government agencies, the Institute remains a private, nonprofit membership organization supported by a diverse constituency of private and public sector organizations.

Throughout its history, ANSI has maintained as its primary goal the enhancement of global competitiveness of U.S. business and the American quality of life by promoting and facilitating voluntary consensus standards and conformity assessment systems and promoting their integrity. The Institute represents the interests of its nearly 1,000 company, organization, government agency, institutional and international members through its office in New York City, and its headquarters in Washington, D.C.

## National Standardization

ANSI facilitates the development of American National Standards (ANS) by accrediting the procedures of standards developing organizations (SDOs). These groups work cooperatively to develop voluntary national consensus standards. Accreditation by ANSI signifies that the procedures used by the standards body in connection with the development of American National Standards meet the Institute's essential requirements for openness, balance, consensus and due process.

ANSI is often asked about the total number of standards (and standards setting bodies) in the United States. It is estimated that in the U.S. today there are hundreds of "traditional" standards developing organizations - with the 20 largest SDOs producing 90% of the standards - and hundreds more "non-traditional" standards development bodies, such as consortia. This means that the level of U.S. participation is quite expansive as the groups themselves are comprised of individual committees made up of experts addressing the technical requirements of standards within their specific area of expertise.

At year-end 2006, about 200 of these standards developers were accredited by ANSI; there were more than 10,000 American National Standards (ANS).

In order to maintain ANSI accreditation, standards developers are required to consistently adhere to a set of requirements or procedures known as the "ANSI Essential Requirements," that govern the consensus development process. Due process is the key to ensuring that ANSs are developed in an environment that is equitable, accessible and responsive to the requirements of various stakeholders. The open and fair ANS process ensures that all interested and affected parties have an opportunity to participate in a standard's development. It also serves and protects the public interest since standards developers accredited by ANSI must meet the Institute's requirements for openness, balance, consensus and other due process safeguards.

That is why American National Standards are usually referred to as "open" standards. In this sense, "open" refers to a process used by a recognized body for developing and

approving a standard. The Institute's definition of openness has many elements, but basically refers to a collaborative, balanced and consensus-based approval process. The content of these standards may relate to products, processes, services, systems or personnel.

In its role as the only accreditor of U.S. voluntary consensus standards developing organizations, ANSI helps to ensure the integrity of the standards developers that use our ANSI Essential Requirements: Due process requirements for American National Standards. A separate process, based on the same principles, determines whether standards meet the necessary criteria to be approved as American National Standards. Our process for approval of these standards (currently numbering approximately 10,000) is intended to verify that the principles of openness and due process have been followed and that a consensus of all interested stakeholder groups has been reached.

The hallmarks of this process include:

- Consensus must be reached by representatives from materially affected and interested parties
- Standards are required to undergo public reviews when any member of the public may submit comments
- Comments from the consensus body and public review commenters must be responded to in good faith
- An appeals process is required

ANSI's use of the terms "open" and "openness" to describe standards is meant to characterize documents that have undergone this kind of consensus-based, transparent process. All ANSI-accredited standards developers follow the Essential Requirements which embrace globally-accepted principles of standardization implemented by well-recognized, international standards bodies such as the International Telecommunication Union (ITU), International Organization for Standardization (ISO), and International Electrotechnical Commission (IEC).

The terms and conditions used in the development of "open standards" should balance the interests of those who will implement the standard with the interests and voluntary cooperation of those who own intellectual property rights that are essential to the standard. Such terms and conditions should readily promote, and not unreasonably burden, accessibility to the standard for the communities of interested implementers. To achieve such balance, the payment of reasonable license fees and/or other reasonable and nondiscriminatory license terms may be required by the intellectual property rights holders.

This balance of licensing rights (rather than waiver thereof) is consistent with an open standard. The word "open" does not imply "free" from monetary compensation or other reasonable and nondiscriminatory license terms. Further, an open standard may involve the payment of a fee to obtain a copy of the standard. Such fees are sometimes used to offset the costs associated with managing open standards development process.

The ANSI process serves all standardization efforts in the United States by providing and promoting a process that withstands scrutiny, while protecting the rights and interests of every participant. In essence, ANSI standards quicken the market acceptance of products while making clear how to improve the safety of those products for the protection of consumers.

## International Standardization

ANSI promotes the use of U.S. standards internationally, advocates U.S. policy and technical positions in international and regional standards organizations, and encourages the adoption of international standards as national standards where they meet the needs of the user community.

The Institute is the sole U.S. representative and dues-paying member of the two major non-treaty international standards organizations, the International Organization for Standardization (ISO), and, via the U.S. National Committee (USNC), the International Electrotechnical Commission (IEC). As a founding member of the ISO, ANSI plays a strong leadership role in its governing body while U.S. participation, via the USNC, is equally strong in the IEC.

Through ANSI, the U.S. has immediate access to the ISO and IEC standards development processes. ANSI participates in almost the entire technical program of both the ISO and the IEC, and administers many key committees and subgroups. Part of its responsibilities as the U.S. member body to the ISO include accrediting U.S. Technical Advisory Groups (U.S. TAGs), whose primary purpose is to develop and transmit, via ANSI, U.S. positions on activities and ballots of the international Technical Committee. U.S. positions for the IEC are endorsed and closely monitored by the USNC Technical Management Committee (TMC).

In many instances, U.S. standards are taken forward to ISO and IEC, through ANSI or the USNC, where they are adopted in whole or in part as international standards. For this reason, ANSI plays an important part in creating international standards that support the worldwide sale of products, which prevent regions from using local standards to favor local industries. Since volunteers from industry and government, not ANSI staff, carry out the work of the international technical committees, the success of these efforts often is dependent upon the willingness of U.S. industry and government to commit the resources required to ensure strong U.S. technical participation in the international standards process.

## Conformity Assessment

Conformity Assessment, the term used to describe steps taken by both manufacturers and independent third parties to determine fulfillment of standards requirements, also remains a high priority for the Institute. ANSI's program for accrediting third-party product certification have experienced significant growth in recent years, and the Institute continues its efforts to obtain worldwide acceptance of accredited certifications performed in the U.S.

One of the best indicators of the strength of the U.S. system is the government's extensive reliance on, and use of, private sector voluntary standards. Pursuant to OMB Circular A119, federal government agencies are required to use voluntary standards for regulatory and procurement purposes when appropriate. State and local governments and agencies have formally adopted thousands of voluntary standards produced by ANSI, and the process appears to be accelerating.

In summary, ANSI continues to be fully involved in its support of the goals of U.S. and global standardization and remains committed to enhancing of the quality of life for all global citizens.

ANSI Z97.1 -2015

Approved by Accredited Standards Committee March 2015