



Designation: C1908 – 21

# Standard Test Method for Pummel Adhesion Testing of Two-ply Laminated Architectural Glass<sup>1</sup>

This standard is issued under the fixed designation C1908; 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 ( $\epsilon$ ) indicates an editorial change since the last revision or reapproval.

## 1. Scope

1.1 This test method determines the relative strength of the adhesive bond between interlayer and glass, inks, coatings, frit or other materials adhered to the glass surface to which interlayers may bond (hereinafter, glass substrate).

1.2 This test method outlines a test method to be used on laminated architectural glass with two layers of glass substrate bonded by an interlayer. Glass substrate can be undecorated, decorated, uncoated, coated, annealed or strengthened, flat or patterned. One or more of the surfaces of glass may have a surface with ink, coatings, frit, patterns, a low-e type coating etc.

1.3 This test method is a qualitative test which covers manual and semi-automatic mechanical pummel testing and visual rating of tested specimens.

1.4 *Units*—The values stated in SI units are to be regarded as standard. The values given in parentheses after SI units are provided for information only and are not considered standard.

1.5 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.6 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

## 2. Referenced Documents

2.1 *ASTM Standards:*<sup>2</sup>

C162 Terminology of Glass and Glass Products

<sup>1</sup> This test method is under the jurisdiction of ASTM Committee C14 on Glass and Glass Products and is the direct responsibility of Subcommittee C14.08 on Flat Glass.

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<sup>2</sup> For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

C1172 Specification for Laminated Architectural Flat Glass

## 3. Terminology

3.1 *Definitions:*

3.1.1 Refer to terminology in Specifications C162 and C1172.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *ball peen hammer, n*—(also known as a machinist's hammer), a type of hammer having two heads, one hemispherical (peen) and the other flat.

3.2.2 *cardboard backer panel, n*—used in rating the pummel, a very thick (3 mm (0.125 in.) or greater) cellulose fiber paper material, usually pale brown in color (typically used for making boxes), sized to fit completely under the specimen to be rated.

3.2.3 *glass substrate, n*—laminated comprised of glass and interlayer which may include inks, coatings, frit, or other materials adhered to the glass surface to which interlayers may bond.

3.2.4 *laminates, n*—two pieces of glass bonded together by an interlayer

3.2.5 *pummel, v*—the act of systematically striking the laminated glass sample with a defined hard object such as a ball peen hammer.

3.2.6 *pummel box, n*—an enclosed area in which glass specimens are pummeled, having a primary function of containing glass particles and dust coming from pummeling laminates; a secondary function of providing a frame on which to mount lighting to aid in the visual evaluation; this may be an enclosed room; acoustic damping material may be used on the walls of the box or room.

3.2.7 *pummel rating, n*—visually assessed amount of glass versus interlayer characterized as high, medium, low or zero and abbreviated PU.

3.2.8 *short wave UV lamp, n*—lamp capable of emitting short wave UV light in the range of 254 nm.

3.2.9 *split shot, n*—small spherical piece of lead or tin, size number 5, which is cut part way through; typically used to weight a fishing line.

3.2.10 *strike plate, n*—a hard metal flat surface with a 45° angle which allows the pulverized glass to slide away from the specimen.

3.2.11 *two-ply, n*—two glass layers, which are the outer layers of the laminated glass (for example, glass | interlayer(s) | glass).

#### 4. Summary of Test Method

4.1 This test method involves rapid systematic and progressive striking of a laminate in an effort to pummel the glass substrate to expose the interlayer. Energy is necessary to separate the two different materials at their interface. The percentage of remaining particulates of the glass substrate which are adhered to the interlayer is then visually assessed to determine a ratio of exposed interlayer. The less interlayer visible after pummeling, the higher the adhesion of the interlayer to the surface it was in contact with.

#### 5. Significance and Use

5.1 Pummel adhesion of laminated glass is a method used to measure the relative adhesive bond strength between the interlayer and glass substrate interface. The interlayer to substrate adhesion has a great effect on the impact resistance of laminates as well as long term stability. This test method is intended to provide three levels of grading. This test method is not intended to provide more precision. The laminate bond strength, in most applications, must be controlled to avoid potential problems of delamination at low adhesion and impact failures or undesirable post breakage characteristics at high adhesion.

#### 6. Apparatus

6.1 *Safety Equipment (Minimum):*

6.1.1 *Face Shield.*

6.1.2 *Dust Mask.*

6.1.3 *Cut Resistant Clothing,* clothing such as jacket or similar.

6.1.4 *Heavy Cut Resistant Glove.*

6.1.5 *Hearing Protection,* in accordance with occupational exposure limits.

6.2 *Tools:*

6.2.1 *Freezer or Cold Cabinet,* capable of maintaining  $-18 \pm 2$  °C ( $0 \pm 4$  °F).

6.3 *Ball Peen Hammer,* nominally  $0.45 \pm 0.05$  kg ( $16 \pm 1.8$  oz), with wood or fiberglass handle. Overall length of hammer is  $330 \pm 13$  mm ( $13 \pm 0.5$  in.) with the head length of  $105 \pm 6$  mm ( $4 \pm 0.25$  in.). The flat head strike face  $26 \pm 2$  mm ( $1 \pm 0.8$  in.).

6.3.1 *Split Shot,* size number 5.

6.3.2 *Strike Plate.*

6.3.3 *Cardboard Backer Panels.*

6.3.4 *Short Wave UV Light,* capable of emitting in the range of 254 nm.

6.4 As an alternative, an automated hammering device with a flat metal head with the same strike face dimensions to that of a ballpeen hammer as stated in 6.3 may be used.

#### 7. Hazards

7.1 Glass dust, glass particulate, and hammer strikes.

#### 8. Sampling, Test Specimens, and Test Units

8.1 Specimens cut to a minimum 76 mm (3 in.) wide and between 150 and 300 mm (6 and 12 in.) long to make it easier to hold during the test.

8.2 A minimum of two laminate specimens per sample set.

#### 9. Calibration and Standardization

9.1 Hammer shall be weighed, and properly dimensioned with no damage to the head.

9.2 *Impact Consistency of Semi-automatic Pummeler*—Split shot thickness shall be measured then attached to the face of the hammer head with tape. A single impact of the strike plate with the hammer, having a single split shot attached shall be executed with the face of the hammer head parallel to the surface of the strike plate. The split shot is removed from the hammer head and the thickness re-measured after impact (Fig. 1(a)). A minimum of three impacts are needed with a new split shot for each impact. The change in the thickness of the split shot from original to post strike is measured. An average of the three hits is taken. A minimum change of 3 mm (0.125 in.) for each impact is required to ensure sufficient force is being applied with a standard deviation between the three split shots of 0.10 mm (0.004 in.) being acceptable.

NOTE 1—Split shot attached to the flat face of the ball peen hammer is also used to provide the person carrying out the test a sense of how hard to strike the laminated glass (Fig. 1(b)).

#### 10. Conditioning

10.1 Specimens shall be conditioned at the prescribed temperature for the interlayer being tested for a time long enough to reach temperature equilibrium throughout the thickness of the laminate.

10.1.1 To determine the conditioning temperature for the type of interlayer in the laminated glass, consult the interlayer manufacturer.

10.1.1.1 Laminated glass of the same configuration of the specimens being tested may be prepared with an embedded thermocouple in the interlayer and measured to determine exact time and temperature.

10.1.1.2 Thermal conductivity calculations may be used to determine time to equilibrium.

10.2 Air movement in the conditioning cabinet shall be present and assist in temperature uniformity within the chamber. No cold spots should occur due to fans or coolant vents.

10.2.1 Allow sufficient space between specimens for air to circulate freely.

10.3 *Frozen Pummel:*

10.3.1 Specimens shall be placed in a cold air cabinet at  $-18 \pm 2$  °C ( $0 \pm 4$  °F) for the minimum time required to reach a temperature equilibrium throughout the thickness of the laminate.

NOTE 2—Depending on the type of cold cabinet and space between the laminates for air circulation, this typically takes between 4 and 6 h for

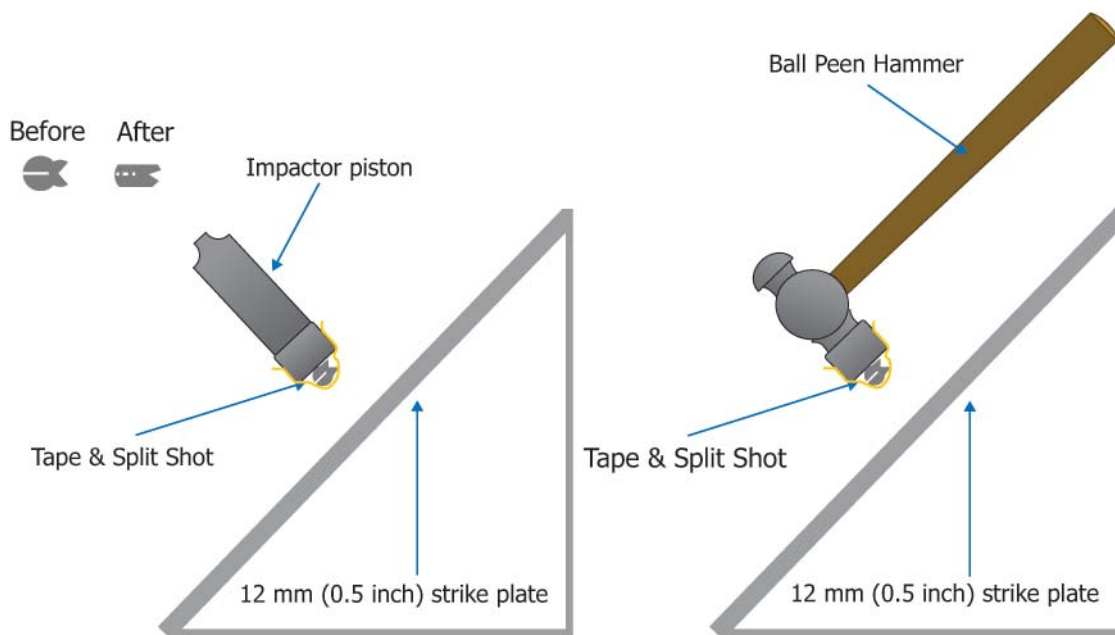


Fig. 1a Split Shot Calibration Semi-automatic

Fig. 1b Strike Awareness for Manual Pummel

FIG. 1 (a) and (b)

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samples starting at an ambient temperature of approximately 22 °C (72 °F).

10.4 Room Temperature Pummel:

10.4.1 Specimens shall be kept at a consistent room temperature 22 ± 2 °C (72 ± 4 °F) for a minimum of 1 h or the time required to reach a temperature equilibrium throughout the thickness of the laminate if the laminate had been exposed to a warmer or colder temperature immediately prior to conditioning for this test.

10.5 Alternate Temperature Pummel:

10.5.1 Specimens shall be kept at an alternate temperature ±2 °C (±4 °F) for the time required to reach a temperature equilibrium throughout the thickness of the laminate.

11. Procedure

11.1 Pummeling:

11.1.1 After laminates have been conditioned and have reached the temperature equilibrium, position the specimen on the strike plate so as only the bottom edge of the laminate furthest from the operator holding point is touching the strike plate. The specimen is held, by hand, at approximately a 5° angle to the plane of the strike plate (typically, the space necessary for fingers to wrap beneath the specimen to hold it on the strike plate) (see Fig. 2). This allows the pulverized glass to fall away from the side of the sample opposite the impact and not artificially elevate the results.

11.1.2 For laminates conditioned to temperatures different than ambient, the time between removal from the conditioning chamber to completion of pummeling must be kept as short as possible (<1 min) to obtain accurate results, begin pummeling within seconds of removing the specimen from the condition-

ing chamber. Changes in the specimen temperature will cause deviation within the individual specimen and among the sample set.

11.1.3 Using the flat face of the ball peen hammer, start pummeling. The laminate is struck progressively in about 12 mm (0.5 in.) overlapping increments along the bottom 18 mm (0.75 in.) of the laminate moving in a line from left to right (or right to left), across the narrow dimension of the laminate. The strike face of the hammer is intended to impact the laminate as flat as possible, using the full surface of the strike face for each impact. Striking should not be intentionally angled. Adjust the number of strikes based on the ease of glass removal via pummeling and width of the specimen.

NOTE 3—Low adhesion specimens will require seven to ten strikes per row while high adhesion specimens may require additional strikes per row.

11.1.4 When the bottom edge has been completely pulverized, the next row 18 mm (0.75 in.) is pulverized in the same manner (see Fig. 3).

11.1.5 Repeat pummeling on the same specimen moving up the face of the laminate until at least 70 to 100 mm (2.5 to 3 in.) of the laminate has been pummeled.

11.1.6 Ensure all smooth glass is pulverized. If necessary, the specimen may be turned over and the back side pummeled in the areas that contain smooth glass.

11.1.7 If the specimen length allows, flip the specimen over and repeat the pummel procedure on the opposite face and opposite end. Care should be taken when holding a laminate that is pummeled in this manner as the glass will need to be held on the intact portion of the pummeled end in order to pummel the opposite end.

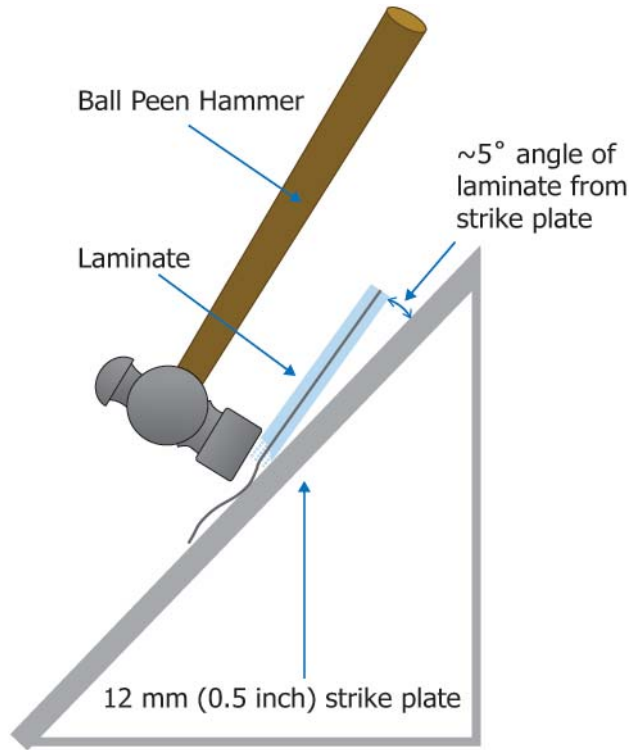


FIG. 2 Pummel Equipment and Materials Set-up

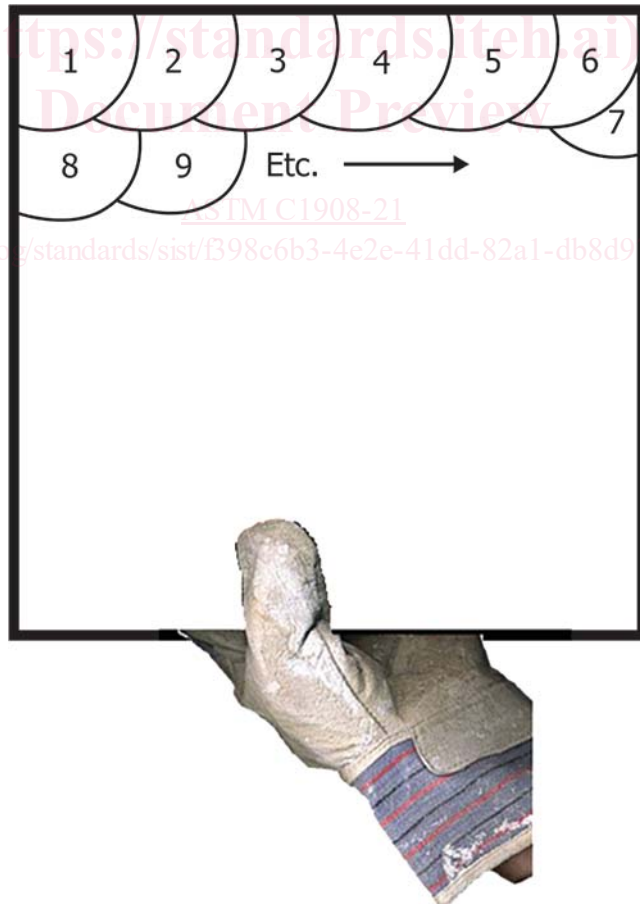


FIG. 3 Sequence of Hammer Strikes

11.1.8 Heat-treated and glass thicker than 6 mm (0.25 in.) will require increased force to pulverize the glass from the laminates.

NOTE 4—Do not over-pummel the specimen by impacting areas where the glass has already been removed as this can yield to erroneous data (see Fig. 8).

11.1.9 The pummeled sample can then be gently set aside pending visual rating.

11.1.10 Conditioned samples must be allowed to equilibrate at room temperature.

11.1.11 For frozen laminates, condensed moisture must be allowed to evaporate before rating them. Assuring no condensation is present on the surface of the pulverized specimen is important for accurate rating.

NOTE 5—Typically, a minimum of 2 to 4 h is necessary for condensation to completely evaporate, however this is affected by the humidity and temperature. In most cases it is appropriate to leave the specimens for 16 to 24 h before rating.

## 12. Rating Pummeled Specimens

12.1 Pick up the dry pummeled laminate and remove any loose glass dust by lightly brushing or tapping loose particles from the surface. Place the laminate on a piece of cardboard which is slightly larger than the laminate.

12.2 Carefully compare the specimen to the pummel adhesion ranges (see Figs. 4-8) or to physical standards (if available) to find the level which the specimen most closely matches. Tilt the laminate in different ways to see the reflection of the exposed interlayer. If the match is deemed to be between two ratings, the lower rating is assigned.

12.3 Turn or flip the laminate over and repeat rating the other side in the same manner. Record rating of each side. (for example, medium = the inboard side; low = the outboard side). Record location of any coating, ink, frit or other material which may be between the glass and interlayer if applicable.

12.4 Any areas that have non-uniform adhesion, not associated with a pre-existing crack, must be noted in the report with the approximate size and location on the specimen.

### 12.5 Pummel Rating Ranges:

12.5.1 *Pummel Zero (0-PU)*—Virtually no glass remains on the interlayer (except dusting or remnants from striking). Nearly 100 % of glass-free interlayer is visible on the pummeled surface.

12.5.2 *Pummel Low (L-PU)*—Sparse amounts of glass remain on the interlayer. Greater than 80 % of glass-free interlayer is visible on the pummeled surface.

12.5.3 *Pummel Medium (M-PU)*—Evenly dispersed amounts of glass and interlayer throughout the specimen, between 20 and 80 % of glass-free interlayer is visible on the pummeled surface.

12.5.4 *Pummel High (H-PU)*—Only very small areas of interlayer can be seen. Less than 20 % of glass-free interlayer is visible on the pummeled surface.

## 13. Interpretation of Results

13.1 A minimum of two (2) specimens shall be included in the sample set. This constitutes four (4) pummel readings (front and back for two specimens). The ratings are reviewed and if greater than 50 % of the ratings are classified as the same PU levels, the sample set is assigned that level. If there is an even split of 50 %, of the ratings the lower PU level is assigned to the sample set.

13.2 Sample sets noted with more than three (3) abnormal areas of adhesion (high or low) not associated with a crack, shall have the abnormality noted in the report. Consideration of the frequency of spots and size of any deviation from the rest of the specimen as well as consistency of the deviation shall be taken into account for intended product use (that is, low adhesion spot in security glazing may result in spall from that location upon testing).

13.3 Over-pummeled samples shall be dismissed and not rated.

## 14. Report

14.1 Report shall include the following:

- 14.1.1 Specimen designation.
- 14.1.2 Number of specimens per sample set.
- 14.1.3 Calibration details and date.
- 14.1.4 Conditioning temperature.
- 14.1.5 Conditioning duration.
- 14.1.6 Glass ply thickness.
- 14.1.7 Glass type and color.
- 14.1.8 Glass and low-e coating orientation.

NOTE 6—Glass orientation is determined using the UV lamp, tin side fluoresces.

- 14.1.9 Interlayer formulation and type.
- 14.1.10 Interlayer thickness (mm).
- 14.1.11 Any non-uniform adhesion areas.
- 14.1.12 Any non-glass residuals (ink, coatings, frit, etc.) remaining on the pummeled surface.
- 14.1.13 Each individual PU rating Inboard/Outboard per specimen.
- 14.1.14 Overall sample set PU rating.

## 15. Precision and Bias

15.1 Pummel ratings are not a continuous variable and technically, normal distribution statistics do not apply.

## 16. Keywords

- 16.1 adhesion; laminated glasspummel



FIG. 4 Zero Pummel Adhesion

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**FIG. 5 Low Pummet Adhesion**

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