

Toughened (Tempered) Safety Glass Standards Development in the USA

In 1966, as a result of the growing public awareness in the USA of the dangers of ordinary glass in many glazing applications, the Accredited Safety Glazing Z97 Committee of the American National Standards Institute (ANSI), issued Specification ANSI Z97.1 as a national voluntary standard for safety glazing requirements.

The Z97.1 standard specified the following breakage requirement for 'Tempered' glass (also known as 'Toughened' glass):

"When broken at any point, the entire piece immediately breaks into innumerable small granular pieces."

Safe breakage for toughened glass in the Z97.1 standard is determined by weighing the ten largest 'crack-free' particles following fracture from impact of a leather punching bag filled with lead shot weighing 100 lb (45 kg) simulating the impact of a running person. Toughened glass is classified as passing the lead-shot bag impact test if after fracture of the glass broken particles weigh no more than a defined amount, as stated in the following clause:

Disintegration occurs, but the 10 largest crack-free particles 3 minutes after impact shall weigh no more than the mass equivalent to 6500 mm² of the original test material.

The obvious implied assumption in the standard is that the particles will be granular (or cubical) in shape with no elongated shards that could cause piercing injuries. One provision in the 1972 edition of the Z97.1 standard was that no pieces of broken glazing material "shall be of such a nature or shape that it could be described as sharp edged, pointed, or dagger-like"; however, this provision was apparently only intended to be applied to safety plastics glazing and was omitted from the 1975 and subsequent editions of the Z97.1 standard. The Australian Glass and Glazing Association website explains that when toughened glass breaks the counteracting stresses in the glass "cause it to produce regular, small, typically square fragments rather than long, dangerous shards that are far more likely to lead to injuries".

In 1977 the U.S.A. Consumer Product Safety Commission (CPSC) enacted Federal Regulation 16 CFR Part 1201 for safety glass in doors. At the time it was estimated that about 190,000 injuries associated with architectural glazing

materials were being treated annually in U.S.A. hospital emergency rooms, with glass doors involved in about 40 percent of the accidents and with the greatest risk of such injuries being to children under 15 years old. The Commission decided that the minimum impact level in ANSI Z97.1 was too low and found fault with the Z97.1 impact test protocol. It however dismissed a suggestion from a prominent test laboratory that a particle shape factor be included in the standard.

In 2002 the Z97.1 Committee held a ballot on deletion of a draft 'center-punch fragmentation test' proposed for panels that remained unbroken after the lead-shot bag impact test. The proposed test was similar to the fragmentation test that was added to British Standard BS 6206 (and subsequently incorporated in European standard BS EN 12150-1:2000) following a heavily publicised fatal accident in Croydon, England in 1988 involving a 6-year old boy who fell through glass which "met the toughened standards". A Croydon Council spokesman told the press that the glass produced "lethal spikes as long as 10 inches (250 mm)" and expressed criticism that at the time the British safety glass specification "only took account of the weight and not the length of shattered pieces".

The Tempering Division of the Glass Association of North America (GANA) argued that the weight per particle of 1.2 grams for ¼-inch glass specified in the center-punch test proposed in the 2002 Z97.1 draft represented a dramatic unjustified decrease in the weight per particle of 9.1 grams for ¼-inch glass permitted in the lead-shot bag test. Based on this argument the Z97.1 Committee decided to remove the center-punch fragmentation test from the 2002 draft standard. In 2004 the GANA Tempering Division announced the publication of Specification No. TD 05-28-04, 'Standard Test Method for Center-Punch Fragmentation of Fully Tempered Glass' with the identical weight criterion for the 10 largest particles as lead-shot bag tests in the ANSI Z97.1 and CPSC 16 CFR 1201 standards.

Test programs carried out in support of USA motions on safety glass testing adopted at the London 2000 meeting of ISO/TC160/SC2 (see page on ISO Toughened Safety Glass Standard Developments) demonstrated however that breakage of 4 mm, 5 mm and some 6 mm toughened glass meeting the lead-shot bag impact test weight requirement can produce lethal spikes of glass as illustrated in Figure 1.

In 2013 the Consumer Protection Safety Commission amended 12 CFR 1201 by replacing the testing procedures for safety glazing materials in section 1201.4 with those contained in ANSI Z97.1 2009. Section 5.2 of the current 2015

edition of ANSI Z79.1 incorporates the GANA center punch fragmentation test. This test allows glass which generates lethal dagger like pieces when broken, to continue to be certified as safety glass and installed throughout the USA in homes, schools and workplaces in locations that are identified by regulation as being subject to human impact.

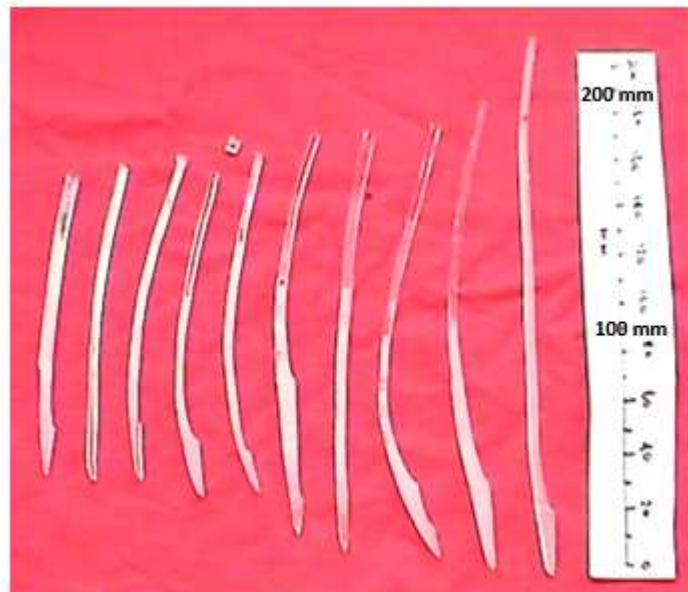


Figure 1: 4 mm Toughened Glass with surface compression 84 MPa
Result from lead-shot bag impact test - Weight 45 grams
versus permitted weight of 65 grams