STANDARDSWATCH™

ISO Safety Glass Test Standards Developments

ISO technical committee TC 160, 'Glass in Building', was established in 1974 for the purpose of developing worldwide standards for glass and glass products. The title of the committee was changed in 1996 to 'Glass and glazing in building'. ISO/TC 160 is made up of two subcommittees entitled 'Product considerations' (SC1) and 'Use considerations' (SC2).

The ISO/TC 160 subcommittees make use of working groups (WG) to prepare competent drafts on given subjects ready for committee discussion and possibly voting. Working groups are composed of experts from the various countries. By ISO directive, the experts involved "act in a personal capacity and not as the official representative of the member organisation by which they have been appointed". ISO/TC 160/SC2/WG6 'Safety glazing tests' was established in 1995 and in 1996 SC2 decided that the objective of WG6 was: "To develop an ISO test method for determining the safe breakage characteristics of glasses which are to be used in critical safety locations in buildings" (ISO/TC 160/SC2 Meeting Tokyo 6 December 1996).

In the UK, prior to 1995, British Standard BS 6206:1981 required only the lead shot bag impact test for classification of safety glass. Safe breakage, or no glass breakage, at an impact height of 450 mm was considered satisfactory for doors in the then existing UK Code of Practice. In 1995 the standard was amended to require a fragmentation test using a metal centre punch in addition to the lead shot bag impact test. This was the direct result of "painstaking deliberations within BSI (British Standards Institute)" following the death of a 6-year old boy who ran into a toughed glass door producing "lethal spikes as long as 10 inches (250 mm)". In contrast to the fragmentation test in Regulation ECE R 43 for automotive toughened safety glass, the fragmentation test adopted in BS 6206 required only fragmentation at a point near the mid-point of the longest edge. It was known, however, that the critical impact point in the ECE R 43 fragmentation test relating to long particles was the centre point of the glass.

Both the UK (BSI) and Germany (DIN) had adopted the lead shot bag impactor for safety glass testing based on the USA ANSI Z97.1 standard (Karlson, GPD1995 & GPD1997). In the UK, however, the lead shot bag was wrapped with filament tape in accordance with ANSI Z97.1:1972, whereas in Germany the bag was not taped as was the case in the original ANSI Z97.1:1966 standard. Agreement could not be reached within Europe (CEN) on which lead shot bag to adopt for a homonized European standard. Eventually, a new 'twin tyre' impactor consisting of a weighted double pneumatic tyre was adopted in place of the lead shot bag impactor in prEN 12600 'Glass in Building – Pendulum test – Impact test method for flat glass and performance requirements'.

In 1997 draft ISO standard ISO/FDIS 12543-2 on laminated safety glass proposed the twin tyre impactor in place of the Z97.1 shot bag. However, at the February 1999 meeting of ISO/TC 160/SC1/ WG3 ‘Laminated glass’ USA, Japan and Australia voted in favour of the retention of the lead shot bag impactor.

prEN 12150-1 'Thermally toughened soda lime silicate safety glass – Part 1: Definition and description' was tabled at the February meeting of ISO/TC 160/SC1/WG2 ‘Toughened glass’. This specified fragmentation with a pointed metal tool at a point near the mid-point of the longest edge and a requirement that the longest particle not exceed 100 mm. In addition, prEN 12150-1 stated: “When it should be used to offer protection under accidental human impact, toughened soda lime silicate safety glass should also be classified according to prEN 12600.” Attention was drawn at the meeting to the lack of a limitation on the length of particles in the prEN 12600 test criterion which specified only, as in ANSI Z97.1, that the ten largest particles be weighed.

As the reason for Australia’s negative vote on ISO/FDIS 12543-2 was lack of test data on the equivalence of the twin tyre impactor to the ANSI Z97.1/AS1288 lead shot bag impactor a test program was carried out in Australia in 1999 to compare breakage performance of the lead shot bag impactor with the twin tyre impactor. The program involved 6.38 mm laminated glass and 4 mm, 5 mm and 6 mm toughened glass. It was found that the two impactors gave similar results with laminated glass, but breakage results with toughened glass were found to be vastly different with the twin tyre impactor compared to the lead shot bag. The differences observed were:

- Every toughened glass panel impacted with the lead shot bag Fractured. The average height to break 6 mm toughened glass was 630 mm, with a range of break heights from 450 mm to 750 mm.
- In contrast, numerous toughened glass samples did not fracture with the twin tyre impactor even at 1300 mm drop height. In these cases, following impact the impactor rebounded to around 80% to its original height due to the high coefficient of restitution of the rubber tyres.
- When toughened glass was fractured by the twin tyre impactor it broke with explosive force dispersing the glass over a distance of up to 10 metres from the test rig. In contrast, toughened glass broken by the lead shot bag fell mainly around the base of the test rig and no further than 2 metres from the test rig.
- Some long shards of glass were found on breakage of some of the toughened glass panels.

A report (WG6/N31) and video from the Australian test program were reviewed at a SC2/WG6 meeting in Tokyo in May 2000. Based on the test program results it was unanimously agreed that the following cautionary text (WG6/N32) on toughened glass breakage characteristics be incorporated into the future ISO standard:

> “The breaking behaviour of toughened glass is generally characterised by the formation of small relatively harmless particles. However, under certain conditions, depending on the method of framing and means of breakage, there can be clumping together of small particles or the formation of shards. If these breakage patterns occur, they may increase the risk of injury.”

It was also decided that SC2/WG6 review all types of impact devices for the development of an ISO Standard “to determine safety related performance of glass-based glazing panels for impact events representative of accidental human body contact”.

At the ISO/TC 160/SC1 and SC2 meetings in London in October 2000 Australia proposed a new work item (SC2 N89) to develop an ISO impact test method that includes criteria on safe breakage required for classifying toughened safety glass. Discussion on this proposal resulted in the adoption of the following three resolutions proposed by the USA:

> SC 1 Resolution 37 [London: 10/2000]
> ISO/TC 160/SC 1 resolves to direct SC 1/WG 2 (Toughened Glass) to develop an AWI (Approved Work Item) which will establish the product definitions for ‘toughened glass’ and ‘toughened safety glass’ and establish performance characteristics which identify it as ‘toughened safety glass’.
>
> SC 2 Resolution 69 [London 7: 2000]
> It was resolved that ISO/TC/SC 2/WG 6 consider the technical input provided by Australia in document N89. Working Group 6 must also consider Resolution 37 adopted by SC 1.
>
> SC 2 Resolution 71 (London 9: 2000)
> ISO/TC 160/SC 2 resolves to instruct Working Group 6 to develop one or two ISO Technical Report(s) Type 2 that covers Pendulum Impacting Testing, which includes both impact and performance requirements for the Dual-tire Impact Test and the Shot Bag Impact Test.

In support of these resolutions the China Building Materials Academy (CBMA) offered the use of their laboratory in Beijing to carry out the necessary testing. Consequently, over the period December 2000 to July 2004, seven test programs were conducted at the CBMA.

In addition to two ANSI Z97.1 lead shot bag impactors, using the Everlast® 4212 and 4207 leather punching bags, a JIS lead shot bag impactor was fabricated.

Assistance was provided throughout the CBMA test programs by the GGF (UK). The US ISO/TC 160 delegation leader who had moved the three resolutions adopted at the London 2000 meeting also participated in two of the test programs. One of these involved testing of 4 mm toughened glass by both the twin tyre impactor and by breakage with a metal punch at two points – the mid-point of the longest panel edge, as prescribed in EN 12150-1, and the panel centre point. The 4 mm toughened glass panels were obtained in two sizes - 360 mm x 1100 mm (EN 12150-1 fragmentation test size) and 876 mm x 1938 mm (EN 12600 pendulum impact test size). The panels were produced with two levels of surface compression (SC) – 80-90 MPa and 110-120 MPa.

- No long particles were found in any of the panels fragmented at the mid-point of the long edge in accordance with EN 12150.
- Long particles ('splines') were found however with all the panels that were fragmented by the metal punch at the panel centre.
- The length of splines was greater with the EN 12600 panels than the EN 12150 panels - average maximum spline length of 300 mm with EN 12600 size panels versus 156 mm with EN 12150-1 size panels with SC of 87 MPa; average maximum spline length of 208 mm with EN 12600 size panels versus 95 mm with EN 12150-1 size panels with SC of 97 MPa.
- Five of the six panels impact tested with the twin tyre impactor did not break at the maximum impact height of 1200 mm. In each case the panel was broken at a drop height of 300 mm after a tiny flaw, representative of contact damage (Lawn), was imparted to the panel centre using a Vickers indenter.
- A maximum spline length of 270 mm was obtained in the pendulum impact tests of panels with surface compression of 87 MPa – very similar to the spline length (270 mm - 330 mm) obtained with panels of the same size and surface compression in the fragmentation test with fracture at the panel centre.
- The weights of the ten largest particles for all panels broken in the EN 12600 pendulum impact test were well within the specified weight for classification as safety glass.

In addition to the CBMA test programs, in June 2003 a test program was conducted at the GGF test laboratory. While confirming the equivalency of the twin tyre impactor with lead shot bags for testing of laminated safety glass the test programs conducted at the CBMA and GGF laboratories confirmed the findings of the test program carried out in Australia in 1999. The results of the programs were documented in Glass Processing Days (GPD) Conference papers in **2001**, **2003**, and **2005**.

In summary, the conclusions and recommendations from the test programs were:

- As the EN 12600 impactor generally did not break 4 mm, 5 mm and 6 mm toughened glass with normal levels of surface compression, whereas the JIS lead shot impactor always broke toughened glass of these thicknesses, there is no equivalency between the two impactors with toughened glass. The JIS bag is a more appropriate impactor because it allows the breakage characteristics of toughened glass to be assessed.
- In view of long particles observed in testing of some toughened glass panels a long particle requirement, similar to that which exists in EN 12150-1 should be incorporated into the ISO impact test.
- An ISO fragmentation test procedure should be established for production size specimens of toughened safety glass involving fracture by a metal punch at the panel centre.

At the 6th meeting of SC2/WG in Singapore in 2002, following lengthy deliberations on the results of the CBMA test programs held up to that time, the test requirement that "the length of the longest particle shall not exceed 100 mm" was added to the

draft for the ‘Technical Report on Pendulum Impact Testing and Classification of “safety” Glass for use in Buildings’.

However, this long particle test requirement was subsequently excised from the draft at a SC2/WG6 meeting in Europe in 2005. Key members of WG6 who had been involved in the CBMA test programs and had attended all prior WG6 meetings were prevented from attending this meeting due its timing and location, whereas people who had not been previously involved in WG6 prominently influenced the outcome of the meeting.

At the final meeting of SC2/WG6 in November 2007 the Chairman of ISO/TC 160 paid tribute to the Working Group for the work done but ruled out the re-inclusion of a long particle requirement in the pendulum impact test. He commented:

“When performing impact testing, on toughened glass, historically the weight of the 10 largest particles had greater significance than their length.”

The absurdity of this statement is self-evident. History is irrelevant to technical correctness. This page shows a small number of the hundreds of long slender “particles” (splines) that were generated in an impact test of glass which the ISO Standard would find acceptable for classification as Safety Glass.

Regarding the significance of particle length, research was carried out to determine the depth of a piercing injury that could be lethal for adults (for the purpose of stab resistance Standards in the UK and the USA). This was found to be 7 mm (approximately 1⁄4”). For children, this length would be less. This research has been published, and can be viewed **HERE**. **It is clear from the research that any long, narrow spline longer than about 6mm (1/4”) is lethal, and that certifying and installing glass that generates longer “particles” in the event of human impact, amounts to reckless endangerment.**

The case for inclusion of the centre of panel break point for fragmentation testing and for a long particle requirement in the pendulum impact test was again raised at the meetings of TC 160/SC 1 and SC2 in Sydney in 2008. The Chairman of SC1/WG2 however insisted that the toughened safety glass test should only specify fragmentation at the mid-point of the longest edge.

ISO 29584 ‘Glass in building – Pendulum impact testing and classification of safety glass’ was published in 2015. For toughened safety glass the only test requirement relates to the weight of the ten largest particles.

ISO 12540:2017 ‘Glass in building - Tempered safety glass’ was published in 2017. The fragmentation test specifies fracture at only the mid-point of the longest edge of the panel.

This is the same fracture point specified in the current Australian Standard AS/NZS 2208, the inadequacy of which is discussed in detail in other sections of this website. The consequences are therefore just as lethal.