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PILKINGTON

NSG GROUP

Pilkington **Planar**™ enhanced performance range.

Explosion-resistant glazing.

Excellence born of innovation

Since the launch of the float process in 1959, the Pilkington brand has been synonymous with cutting edge developments in the design and manufacture of all things glass for both architectural and automotive applications. In 2006, Pilkington PLC was acquired by the NSG Group of Japan; and is now one of the world's largest manufacturers of glass and glazing products with manufacturing operations in 29 countries and sales in around 130.

A revolutionary product for over 30 years

The Pilkington **Planar**™ system is part of the Group's comprehensive suite of glass products, manufactured in the UK in the world's only facilities dedicated to the development, design and manufacture of custom and point-fixed structural glazing systems. A vital part of the Pilkington **Planar**™ offering is a dedicated team of design engineers who have overseen the safe application of the system on landmark projects around the globe. With more than 100 year's experience between the team, allied to a 30 year heritage in the manufacture and supply of structural glass systems, our team of design engineers continues to keep Pilkington **Planar**™ at the forefront of its technology class. And the area of explosion-resistant performance is no exception!

Summary of Test Results:

Type:	Free field range tests
Quantity of tests:	40+
Product Types Tested:	Pilkington **Planar**™ bolt fixed Single toughened PVB laminates SentryGlas® laminates Insulated laminates
Support Structures Tested:	Glass mullions Tension structures Conventional test frames
Glass Sizes:	Ranging from 1.23 x 1.52 m to 2.0 x 3.0 m
Glass thickness:	10 mm, 12 mm, 15 mm, 19 mm
Test types:	VBIED (Vehicle Borne Improvised Explosive Device) PBIED (Person Borne Improvised Explosive Device) GSA and ISO 16933 style evaluations
Results:	Ranging from low hazard to no break

The best performance is assured by the toughest testing

Our blast test history

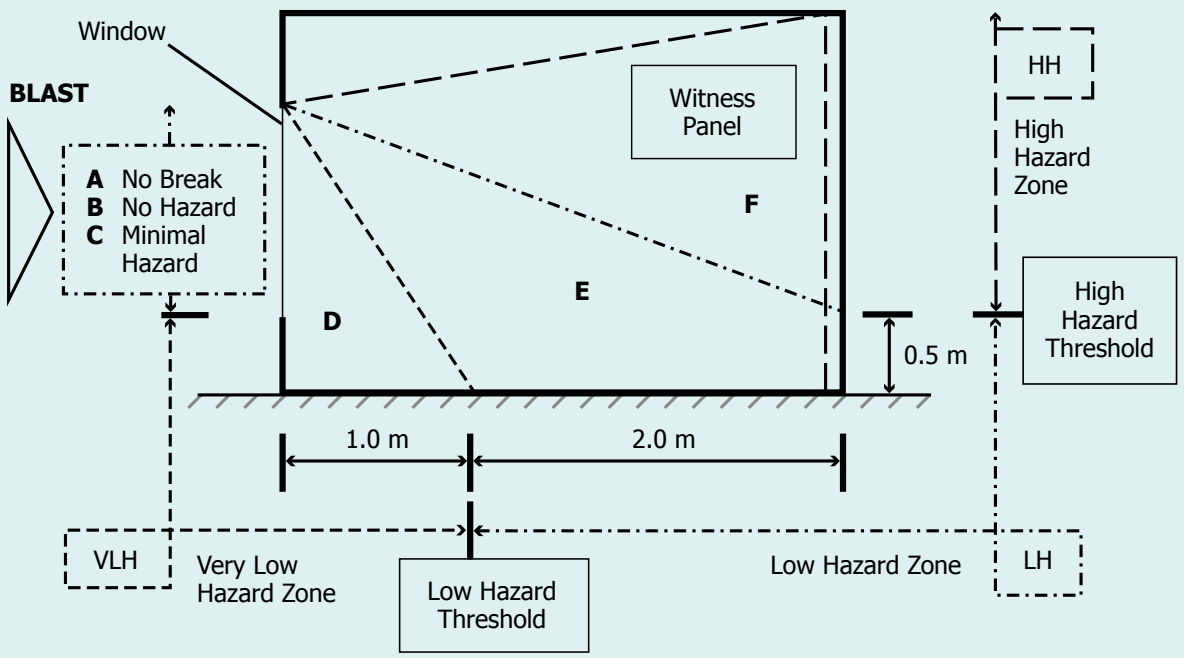
The first Pilkington **Planar**™ blast test programme was undertaken in 1993 and was intended to test the performance of a point-fixed, 10 mm, single, toughened product and also IGU laminated point-fixed glazing (approx size 1.3 x 1.6 m). Over the years, we have continued to invest in a comprehensive programme of testing. This has explored the use of larger panels (2 x 2 m), covered the full suite of glass thicknesses (10, 12, 15 and 19 mm), used different interlayer materials (PVB and SentryGlas®) and different forms of point fixation (insulated, laminated, countersunk, integrated and capped). Tests have also been undertaken to understand performance under threat from vehicle borne devices (VBIEDs) and smaller, person borne devices (PBIEDs). Most recently, we took part in the performance testing of a series of complete façades, rather than the more conventional single or double cell test chambers.

Whilst some testing has been undertaken by shock tube, the majority of results have been collected from free, field arena blast tests. We believe these to be more applicable to a point-fixed product in which directionality can have a significant impact on performance. With more than 40 tests now completed on individual point-fixed panels, the Pilkington **Planar**™ design team has access to an unparalleled wealth of experience and test data to assist on projects where blast mitigation is an essential requirement.

Current standards of performance

Since 2007 Pilkington **Planar**™ has been blast tested in accordance with ISO 16933: Glass in building – *Explosion-resistant security glazing – Test and classification for arena air-blast loading.* This standard defines two blast classifications, associated either with a vehicle bomb or a hand carried satchel. In both cases, the result of an explosion is defined using a combination of mean peak air-blast pressure and mean positive phase impulse at the glazing location. These variables change in relation to the size of the device and its stand-off from the glazing at the point of detonation.

ISO 16933 also defines the hazard rating of a product when subject to a particular classification of blast. Since flying glass is known to present an extreme hazard to life during a blast event, it is absolutely vital that the behaviour of the glazing in a particular blast scenario is well understood. The hazard rating description in ISO 16933 ranges from A (no break), through to F (high hazard), whereby particles of glass are projected into the witness panel 3 m away and 0.5 m above floor level, with sufficient force to create a defined number of rateable perforations. The following diagram and table provide details of the hazard rating descriptions :



Hazard rating	Hazard rating description	Definition
A	No Break	The glazing is observed not to fracture and there is no visible damage to the glazing system.
B	No Hazard	The glazing is observed to fracture but the inner, rear face leaf is fully retained in the facility test frame or glazing system frame with no breach and no material is lost from the interior surface. Outer leaves from the attack face may be sacrificed and may fall or be projected out.
C	Minimal Hazard	The glazing is observed to fracture. Outer leaves from the attack face may be sacrificed and may fall or be projected out. The inner, rear face leaf shall be substantially retained having the total length of tear plus the total length of pullout from the edge of the frame less than 50 percent of the glazing sight perimeter. Also, there are no more than 3 rateable perforations or indents anywhere in the witness panel and fragments on the floor between 1 m and 3 m from the interior face of the specimen have a sum total united dimension of 250 mm or less. Glazing dust and slivers are not accounted for in the hazard rating. If by design intent there is more than 50% pullout but the glazing remains firmly anchored by purpose designed fittings a rating of C (minimal Hazard) may be awarded provided the other fragment limitations are complied with. The survival condition and anchoring provisions shall be described in the test report.
D	Very Low Hazard	The glazing is observed to fracture and significant parts are located no further than 1 m behind the original location of the rear face. Parts may be projected any distance from the attack face towards the blast source. Also, there are no more than 3 rateable perforations or indents anywhere in the witness panel and fragments on the floor between 1 m and 3 m from the interior face of the specimen have a sum total united dimension of 250 mm or less. Glazing dust and slivers are not accounted for in the rating.
E	Low Hazard	The glazing is observed to fracture but glazing fragments or the whole of the glazing fall beyond 1 m and up to 3 m behind the interior face of the specimen and not more than 0.5 m above the floor at the vertical witness panel. Also, there are 10 or fewer rateable perforations in the area of the vertical witness panel higher than 0.5 m above the floor and none of the perforations penetrate more than 12 mm.
F	High Hazard	Glazing is observed to fracture and there are more than 10 rateable perforations in the vertical witness panel higher than 0.5 m above the floor or there are one or more perforations in the same witness panel area with fragment penetration more than 12 mm.

2011 Test Chamber Programme

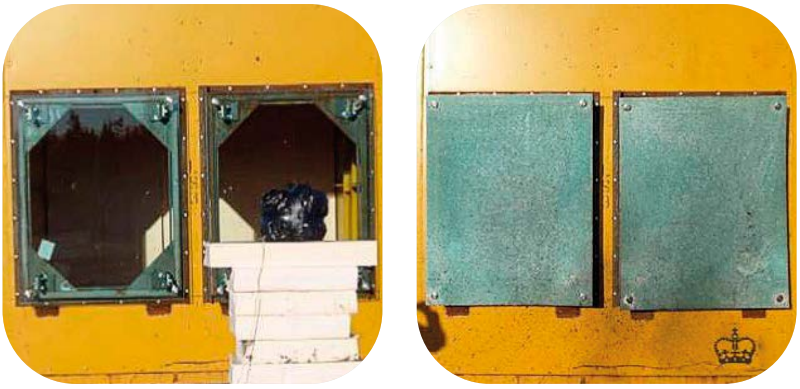
Our latest chamber test series took place in 2011, in conjunction with the UK Government Centre for the Protection of National Infrastructure (CPNI). The tests were performed using a blast-enhanced Pilkington **Planar**™ fitting technology developed by the Pilkington Architectural design team in partnership with Crossley Consult Limited and Aibara Associates.

A combination of IGU laminates and single laminates incorporating various thicknesses of PVB and SentryGlas® interlayer were subjected to VBIED testing at 3 different stand-offs, the closest corresponding to a distance of 29 m. A range of minimal hazard and very low hazard results were recorded, with some panels exiting the opening in the direction of the threat but most remaining securely fixed in place.

Tests were also conducted on two laminates incorporating different thicknesses of interlayer, using a PBIED at two stand-off distances of less than 10 m. Remarkably, one of these close quarter detonations failed to break either test sample, demonstrating the considerable potential of these systems for blast mitigation. The PBIED event from the closer stand-off did break the glass, however both remained securely fastened into the test rig.

Before VBIED Blast test After

Fig 1 – IGU (left): Minimal Hazard result & Single Laminate (right): Very Low Hazard result



Before PBIED Blast test After

Fig 2 – Both interlayer types returning a No Hazard result for PBIED after a previous No Break result.

Facade Test Programme

During 2010 and 2011, in parallel with the standard double cell test chamber programme described above, we participated in a test programme designed to understand the real practicality of using point-fixed structural glazing in a facade designed for blast mitigation. In total, four complete 6 m high facades were built and tested to VBIED conditions in what is believed to be the largest point-supported facade testing programme of its kind. The facade tests included the use of monolithic toughened panels and custom reinforced laminates (PVB and SentryGlas®), combined with specially designed Pilkington point fixings.

Fig 3 – VBIED test on a toughened glass facade – supported by tension structure.

Before Blast test.

During the facade test programme, we also took the opportunity to explore the performance of three different support systems: conventional steel, monolithic toughened fins and a high-tension rigging support system. As might be expected, the test results proved conclusively that the performance of explosion resistant glazing is directly related to the suitability of the host structure to which it is attached.

A further focus of the 2011 test programme was the reduction of facade panel glass thicknesses. Earlier versions of the Pilkington **Planar**™ explosion resistant system had used 15 mm and 19 mm products, incorporated into thick and therefore expensive laminates. This latest test programme demonstrated conclusively that more traditional point-fixed glass specifications could be used, if combined with reasonable panel sizes, informed detailing at the point fixings and a rigorous approach to manufacturing quality. In fact, the thickness of the Pilkington **Planar**™ point-fixed glass which successfully passed the facade test was not significantly more than that required to deal with the wind load. The additional blast-enhanced performance was achieved by careful analysis of the interconnectivity between the glass panel and the custom designed Pilkington **Planar**™ fixing bolt. This allowed the natural weight and flexibility of the system to be used to maximum effect in the event of blast loading.

After Blast test.

For expertise, specify Pilkington Planar™

Pilkington Architectural has been designing, manufacturing and supplying explosion-resistant Pilkington **Planar**™ glazing systems for 20 years. In that time, we have worked with a wide range of clients and applications in a sensitive and confidential manner. This experience, combined with an exhaustive range of test results collected over many years, means the Pilkington **Planar**™ design team is uniquely placed to offer support and assistance to any client or blast consultant, developing a project with security in mind. Not because they are experts in explosives or security, but because they have a deep understanding of the application of high performance glass products in a construction project environment.

The rigorous blast-testing programme, has demonstrated without question that a suitably designed point-fixed structural glass system can deliver a practical and useful level of blast mitigation. Of course, it may never match the performance of a product of equivalent thickness in a fully framed and bonded system. However, it combines good blast mitigation and high performance energy management with the additional advantage of aesthetic appeal. This is not always achieved in a fully-framed bonded system. Pilkington **Planar**™ explosion resistant glazing offers an aesthetically pleasing solution including peace of mind to clients, architects and building occupants alike.

Please note that imagery throughout is for illustration purposes only.

Front cover image courtesy of Ron Parke.

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