PANZERFILM is a product of Bomb Blast / Anti Shatter Film Test Report
Disaster Hits When Least Expected

Bomb Blast and Anti Shatter Protection Glass Containment PANZERFILM

Protect your business, property, employees and members of the public.

The greatest danger in a bomb blast attack is from flying shards of glass, causing 90% of all bomb-related injuries.

Even if not considered to be a target, powerful shockwaves from this type of high-velocity attack emanate in all directions and cause devastation for miles around.

ORPRO PANZERFILM is the simple and cost-effective installation of bomb blast glass-containment window film which will significantly reduce the hazards of flying glass, holding broken glass safely within the film. It dramatically reduces injury and damage while minimizing clear-up time.
PANZERFILM - Technical Data

BENEFITS
Glass Fragmentation Containment – Anti-Shatter/Bomb Blast Protection  
Protects Against Deliberate Attack – Increased Glazing Security  
Upgrades Sub-standard Glazing – Meets HSE Legislation for Safety Glazing  
Reduces Ultraviolet Radiation – Protects Against Fading

GLAZING TREATMENTS
Safety and Security (Anti-Shatter) Films are suitable for application to windows, structural glazing, curtain wailing, glazed partitions, glass exteriors, rooflights and atrium roofs to efficiently and economically increase glazing safety in the event of breakage or failure.

PRODUCT RANGE
Our range of Premium Grade Safety and Security Window Film also includes Combination Solar/Safety & Security Grades in attractive and pleasing shades of Silver, Charcoal and Neutral (Natural) with a choice of light transmission levels.

SCRATCH RESISTANT
All internal grade Window Films have the patented ‘SRC’ Scratch Resistant Coating to protect the product and avoid the appearance of scratches during normal handling and cleaning practices.

FILM/GLASS COMPATABILITY

<table>
<thead>
<tr>
<th>Glass Type</th>
<th>Clear S/G</th>
<th>Clear D/G</th>
<th>Tinted S/G</th>
<th>Tinted D/G</th>
</tr>
</thead>
<tbody>
<tr>
<td>F/Annealed</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Toughened</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Laminated</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Georgian wired</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>

All values are as applied to 6mm clear glass and as determined by the manufacturers and independent testing laboratories.

TESTS DONE (SELECTION):
- Fire resistance test DIN 75200*
- Pendulum glass impact test EN 12600 (= DIN 52290 Part 4 – A1)**
- Drop Impact test DIN 52310*
- Visible light transmittance test DIN 5036 Part 3*
- Determination of luminous and solar characteristics of glazing EN 410*

* Tested on Crystal 100, Crystal 200
** Tested on Crystal 200

Above tests done by Material-Prüfungsamt (MPA), Germany or Technical University, Berlin
Panzerfilm® ASF Crystal 200

TECHNICAL DETAILS

SOLAR ENERGY
reflected: 5 %
absorbed: 19 %
transmitted: 76 %
total energy rejected: 16 %

VISUAL LIGHT
transmitted: 82 %
reflected: 9 %
asorbed: 9 %

UV VALUES
UV Transmission: < 1 %

THERMAL ISOLATION
Shading coefficient: 0.96
U Factor: 1.07

PHYSICS
Thickness: 200 μ
Ply: 2-ply
Tensile strength at break: > 1900 Kg/cm²
Elongation at break: > 150 %
Peel strength (post curing): above 1.5 Kg/inch
Impact Test BS EN 12600 for class “2B”: pass

TEST DETAILS:
Tested on: Double Insulating Glass
Date of test: 15th December 2003
Tested by: University of Berlin

BENEFITS

When glass breaks as a result of explosion, accident, vandalism or natural disaster this type of Panzerfilm provides a high performance anti shatter resistant protection from airborne splintered glass. They also offer a special anti lacerate protection for people sitting next to the windows. A two-ply configuration, with an excellent high strength adhesive ensures adequate absorption of extreme levels of stress during and post-impact. They are especially designed for application on shop windows, shopping malls, displays, offices, doors and partitions. They can furthermore be outfitted with a colorproof filter that provides people and products with almost perfect protection against harmful ultraviolet rays.
Test Report (Excerpt)

Explosion Range Testing on PANZERFILM CRYSTAL 200 (FT 800)

ComBlast 2002

Test authorized by: Filmtek Limited, Chesham (England)
Test Report Ref: GDA/71-1400s

May 13th - May 16th 2002
Test Specimen

The test report records the results of a range test conducted on glass protection systems supplied by Pentagon Filmtek Limited of Amersham Road, Chesham, Bucks as part of the Home Office sponsored Comblast 2002 Explosion Range Trials.

The Comblast 2002 trials were established to allow commercial companies to undertake explosion testing of their products alongside the formal Home Office annual range trails. The commercial trials element of the Comblast tests was managed by a partnership comprising of Advantica Limited (test site provider and shot firing), D. J. Goode & Associates and Grendon Design Agency (GDA) (Commercial Trials Manager).

The Pentagon Filmtek explosion range test was undertaken on the 17th May 2002 at the Advantica Technology test site at Spadeadam, Cumbria, England, under the supervision of Simon Trundle, Managing Director of Grendon Design Agency. A total of three separate test specimens were provided for explosion testing as follows:

Test specimen L1

<table>
<thead>
<tr>
<th>Test specimen window frame:</th>
<th>1590mm x 1190mm wide.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Style:</td>
<td>Fixed lite non-opening</td>
</tr>
<tr>
<td>Clear glass area:</td>
<td>1480mm x 1080mm.</td>
</tr>
<tr>
<td>Glass:</td>
<td>10mm Heat soaked toughened safety glass supported on 4 No Pilkington Planar mountings with Pentagon Filmtek Bolted Glass Anchor.</td>
</tr>
<tr>
<td>Window film:</td>
<td>PANZERFILM Crystal 200 (FT800)</td>
</tr>
<tr>
<td>Protection system:</td>
<td>Pentagon Filmtek washer system</td>
</tr>
<tr>
<td>Mounting of test specimen:</td>
<td>Total 4 x M10 mild steel bolts into test cubicle</td>
</tr>
</tbody>
</table>
Test specimen C2

Test specimen window frame: 1590mm x 1190mm wide.
Style: Fixed lite non-opening
Clear glass area: 1480mm x 1080mm.
Glass: 4mm toughened/16mmair/4mm toughened
Window film: PANZERFILM Crystal 200 (FT800)
Protection system: Gullwing® profile L fixed to UPVC frame using Dow 895 silicone sealant and to glass using FrameGard® security grade adhesive tape.

Test specimen R3

Test specimen window frame: 1590mm x 1190mm wide.
Style: Fixed lite non-opening
Clear glass area: 1480mm x 1080mm.
Glass: 10mm Heat soaked toughened safety glass supported on 4 No Pilkington Planar glass mountings.
Window film: none
Protection system: none
Mounting of test specimen: Total 4 x M10 mild steel bolts

The individual test specimens were prepared by Pentagon Filmtek Limited. Details of the manufacturing process relating to the individual window specimens have been fully declared to GDA however, within this report, details of construction are limited to maintain commercial confidentiality. Full construction details are held on record at Grendon Design Agency and may be viewed with permission from Pentagon Filmtek Limited.
The PANZERFILM Crystal 200 micron window safety film (FT 800) used in this test program is manufactured exclusively for Pentagon Filmtek Limited by Orpro Industries and is marketed under the trade name of Pentagon Filmtek FT800 (England). These test results relate only to the materials and the configurations tested and no alterations to the material manufacturer, composition or assembly method can be accepted unless further testing is undertaken.

Test specimen #2 incorporated the Gullwing™ patented film anchoring system provided to Pentagon Filmtek Limited by FrameGard Anchoring Systems Limited, Moulton Park, Northampton. All design details relating to the Gullwing film anchoring systems used in this test are the copyright of FrameGard® Anchoring Systems and are protected under United Kingdom and international patents.

High Explosiv Testing

The following text describes in general terms the forces applied to a test specimen in an explosion.

Detonation of a high order explosive produces a shock in air, which takes the form of a rapidly expanding pressure wave in the surrounding atmosphere. The blast wave expands outwards until it meets an object in its path i.e. the test cubicle.

The expanding blast pressure wave is arrested in its travel and in this instance ‘reflects’ against the front surface of the test cubicle. This expanding pressure wave is referred to as the positive phase or reflected pressure load.

A negative phase effect is experienced immediately following the rapid overpressure load generated by the expanding pressure wave. The negative phase [suction] is created when the detonation of the high explosive and rapid outward movement of the blast wave creates a vacuum at the seat of the explosion, which is rapidly filled by the surrounding atmosphere being drawn back into the evacuated space. This rapid return of air to fill the void created at the centre of the blast causes a reverse flow in the surrounding atmosphere, which causes drag or suction on the face of the test specimen. The negative phase can sometimes coincide with the elastic response of the test specimen and thereby further increase the rebound effect.
Details Of The Explosive Charges

Tests were conducted using a nitro-methane based explosive liquid contained within a cylindrical container set at a height of 800mm above the surface of the concrete test pad. Pre-testing of the nitro-methane based explosive was undertaken by Advantica to determine the net equivalency to TNT. The nitro-methane charge size used in these tests was selected as a direct equivalent to 100kg TNT High Explosives. The explosive charge was supported on polystyrene packing to ensure that no fragments would be ejected from the charge support.

Blast Pressure And Impulse Loading

Table 1 summarises the average values using the Conwep [Conventional Weapons Effects Program] analytical program developed by the US Government and in use with the UK PSDB and Home Office.

<table>
<thead>
<tr>
<th>100kg TNT charge</th>
<th>Measured Side-On Pressure</th>
<th>Reflected Impulse</th>
<th>Equivalent Reflected Pressure On face of Test Specimen</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shot number and range</td>
<td>P so kPa</td>
<td>P so psi</td>
<td>KPa-msec</td>
</tr>
<tr>
<td>Shot No 9 @ 32metres</td>
<td>25.40</td>
<td>3.75</td>
<td>410</td>
</tr>
</tbody>
</table>
Details Of The Test Specimens

The individual test specimens are numbered as follows:

L = left hand window opening
C = centre window opening
R = right hand window opening

View of test structure prior to detonation

Photo shows test specimen L: 10mm toughened glass with PANZERFILM Crystal 200 window film (FT800) and Pentagon Filmtek Bolted Glass Anchor System.

Photo shows Anglian UPVC window frame with PANZERFILM Crystal 200 window film (FT800) installed with Gullwing® film anchoring system.

Photo shows 10mm toughened glass with 4 planar point mountings.
Gullwing® Film Anchoring System

The Gullwing® film anchoring system utilised in test specimen C comprises of an extruded plastic element forming an angled profile with one face adhered to the window film and the second face adhered to the window frame.

The Gullwing profile was tested with a 20mm leg [referred to as Gullwing L] in test specimen C – Anglian Window Frame.

Security Window Film

The trials were undertaken using multi-laminate PANZERFILM window film manufactured exclusively for Pentagon Filmtek Limited by Orpro Limited. The window film was applied to the internal face of the glass on specimens L and C. Specimen R contained plain toughened glass.
Hazard Criteria And Classification Of Results

The UK EDICTS test criteria relates to the classification of hazard for glazing systems in post break condition and is based on the following performance criteria:

**B/S**

‘Break Safely’ is where the glass cracks but remains within the window frame. If it is toughened or plain glass (annealed) it may crack and fall outside or into the test cubicle but with no projection of the fragments beyond a 1000mm distance internally. If it is laminated or filmed glass it should remain securely in place. (1)B/S has recently being redesignated as ‘Minimal Hazard’ to overcome the confusion which can arise from a material being designated ‘break safe’ that evidently has disintegrated under blast load with clear evidence of glass fragments within the test structure.

**L**

‘Low Hazard’ is where fragments or the entire pane of glass falls into the test cubicle to land on the floor without striking the rear wall which is set 3m away from the window opening. This implies that the fragments or pane of glass would be travelling at low velocity and thus proves less injurious to persons within a property affected by blast.

**H**

‘High Hazard’ is when the glass fragments/pane or any part of the test specimen strikes the rear wall of a 3metre deep test cubicle at 0.5m above the floor.

The UK EDICTS hazard classification has been adopted by the United States General Services Administration [GSA] as is evident from the following text extracted from a previous GSA test program.

Note: In the USA, Category C facilities require protection from window fragments up to a blast load with a peak pressure of 4psi and an impulse of 28 psi-ms. A performance condition (Damage Level) 4 is permitted for Category C. A graphical depiction of the performance conditions contained in the criteria is shown in Figure 1.
Results And Photographic Record Of Tests

Test Results: 100kg TNT Equivalent Charge Weight @ 32 Metres

View of test cubicle post detonation of 100kg TNT at 32metres range.

Left (L): 10mm Planar with PANZERFILM Crystal 200 (FT800) window film and Pentagon Filmtek washer system. Glass and film package ejected out of cubicle and on ground within 1.50m of cubicle.

Centre (C): Anglian Windows UPVC window frame fitted with PANZERFILM Crystal 200 (FT800) window film and four-sided application of Gullwing system. Outer pane of 4mm toughened glass shattered and landed outside cubicle. External glazing beads became detached and landed outside structure. Gullwing® profile and PANZERFILM Crystal 200 (FT800) security window film resisted the blast pressure and the glass was remained within the window frame. The top rail of UPVC window became detached from the frame and dropped inside the test cubicle.

Right (R): 10mm toughened glass on 4 Planar mountings. The majority of the 10mm toughened glass [36 kilograms] landed inside the test cubicle.
Result on C: Anglian Window with PANZERFILM Crystal 200 window film and Gullwing® Profile

The PANZERFILM Crystal 200 (FT800) window film fitted with the Gullwing® anchoring system resisted both the positive and negative phases of the blast wave.

The outer lite of 4mm toughened glass shattered and landed on the ground outside of the test cubicle. More than 95% of the internal lite of 4mm toughened glass was retained on the PANZERFILM Crystal 200 (FT800) window film and the Gullwing® anchoring system retained the filmed lite within the window frame.

The top rail of the UPVC window frame broke at each end and dropped inside the test cubicle landing within 600mm of the window opening in GSA zone 3A.

Test specimen C achieved a UK Low Hazard and US GSA 3A performance classification.

Photos show damage to UPVC head rail and rail on floor of test cubicle within 600mm of window opening.
Flexing of the bottom rail of the UPVC window caused the Gullwing® profile to tear across a 20mm width, however, the Gullwing® profile remained attached to the window frame and glass and prevented dislodgement of the glass from the frame.

Photo also shows angled mounting bracket 50mm x 50mm x 6mm mild steel with M10 mounting bolt. Angle bracket was distorted approximately 3mm in the blast.