

The following notes and diagrams are extracts from a Technical report issued by Grendon Design Agency Report. The original report recorded the performance of Pilkington Planar under Blast load conditions, as witnessed at the Comblast trials in May 2002. For security purposes, Pilkington have withheld specific information relating to the size of the explosive charge, the dynamic forces which that charge induced and the exact specification of the glass panels under test.

Introduction

This test report records the results of explosion range testing conducted on Pilkington Architectural products 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 element of the Comblast 2002 trials were 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 Comblast 2002 explosion range tests were undertaken on the 16th and 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 four separate test specimens [2 sets of 2 identical specimens] were provided for explosion testing as follows:

1.1 Test specimen 1L-1 [27mm laminate]

- Test specimen: Pilkington Planar bolted glazing system.
- Style: Fixed lite non-opening supported on 4 bolt support points Planar Type 902 pivoting supports.
- Clear glass area: 2000mm x 2000m.
- Glass: **Exact specification withheld by Pilkington**
- Mounting of test specimen: Total 4 x M12 mild steel bolts into test support frame and said frame welded to face of test cubicle.

1.2 Test specimen 1R-1 [49mm IGU]

- Test specimen: Pilkington Planar bolted glazing system.
- Style: Fixed lite non-opening supported on 4 bolt support points Planar Type 902 pivoting supports.
- Clear glass area: 2,000mm x 2,000m.
- Glass: **Exact specification withheld by Pilkington**

- Mounting of test specimen: Total 4 x M12 mild steel bolts into test support frame and said frame welded to face of test cubicle.

1.3 Test specimen 2L-1 [27mm laminate]

- Test specimen: Pilkington Planar bolted glazing system
- Style: Fixed lite non-opening supported on 4 bolt support points Planar Type 902 pivoting supports.
- Clear glass area: 2000mm x 2000m.
- Glass: **Exact specification withheld by Pilkington**
- Mounting of test specimen: Total 4 x M12 mild steel bolts into test support frame and said frame welded to face of test cubicle.

1.4 Test specimen 2R-1 [49mm IGU]

- Test specimen: Pilkington Planar bolted glazing system.
- Style: Fixed lite non-opening supported on 4 bolt support points Planar Type 902 pivoting supports.
- Clear glass area: 2000mm x 2000m.
- Glass: **Exact specification withheld by Pilkington**
- Mounting of test specimen: Total 4 x M12 mild steel bolts into test support frame and said frame welded to face of test cubicle

The individual test specimens were prepared by Pilkington Architectural 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.

1.5 Sequence Of Testing

The original test schedule required testing of specimens 1L-1 and 1R-1 at a range of 25 metres and a second test series on specimens 2L-1 and 2R-1 at a range to be determined.

In the event, neither specimen at 25 metres range appeared to suffer any visible damage and a repeat test was conducted on the same two test specimens with the only difference being that the silicone edge sealant bonding the glass to the steel carrier frame was cut through in case the edge restraint offered by the sealant affected the performance of the Planar system.

The test specimens survived unbroken once again without the benefit of the silicone sealant around the perimeter of the glass.

The third and final test involved specimens 2L-1 and 2R-1 tested at 16.75 metres range.

1.6 Details Of The Test Specimens

Window test specimens were mounted into a steel test structure details of which are included within Annex A.



P1: View of test structure prior to first detonation.

The individual test specimens are numbered as follows:

1L-1 = left hand specimen

1R-1 = right hand specimen

The timber beams and side sheeting were added to prevent pressure leakage behind the test specimens into the interior of the test chamber. The timber elements needed to remain in place long enough for the shock wave to decay [approx 12 milliseconds] and dislodgement of the timber was not deemed to invalidate any of the results.



P2: Planar Bolt Support.

All four of the test specimens were mounted into a steel carrier frame and secured in place by a total of 4 Planar bolted connections. The above photograph shows the exterior of test specimen 1L-1. Note the structural sealant gasket connecting the glass to the steel carrier. The initial test was conducted with the structural silicone intact and subsequent tests were performed without the benefit of the sealant to ensure that tests replicated unsealed bolted glazing solutions.



P3: Internal support detail.

Details of assembly of bolted glass support point are included in the annex of this report.

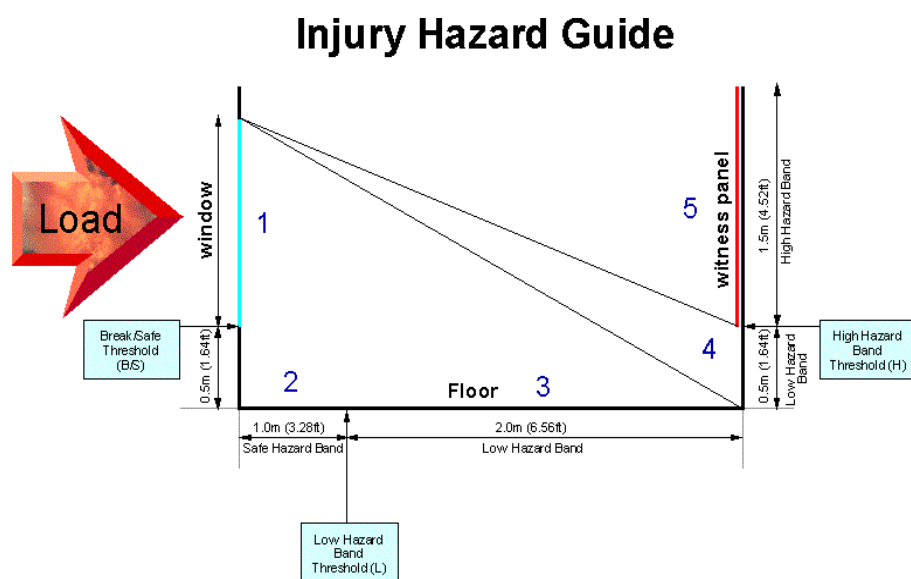
4. Hazard Criteria And Classification Of Results

The United Kingdom Home Office has undertaken explosion testing of glazing materials on an annual basis since 1980 under the EDICTS test program. The EDICTS test program was undertaken to develop a better understanding of the performance of different glass types, under blast load. The data extracted from the EDICTS research program has led to it being possible to judge the hazard threshold for unprotected common forms of glass such as annealed float and to identify the benefits that can be gained by retrofitting the annealed glass with window safety film or by replacing the annealed glass with laminated or toughened safety glass.

For the purpose of these current trials, we have adopted the EDICTS hazard classification system in the absence of any formal UK or CEN test standards for blast resistance.

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⁽¹⁾** ‘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 3 metres 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 3 metre deep test cubicle at 0.5m above the floor.

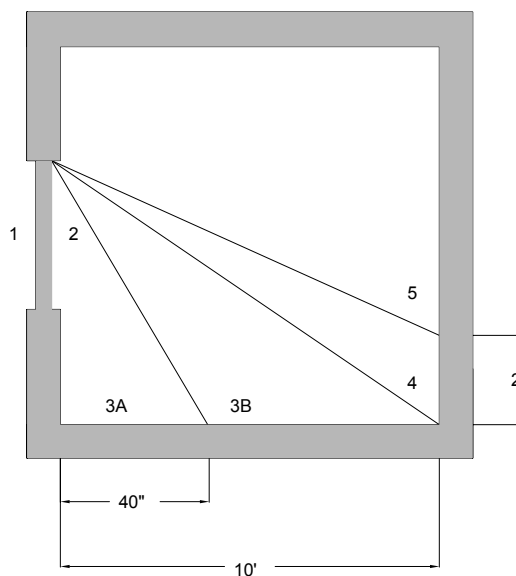


The UK EDICTS hazard classification has been adopted by the United States General Services Administration [GSA] as is evident from the following text extracted from a previous GSA test program.

Table 3. GSA Criteria for Test Specimen Performance Conditions

Performance Condition	Description	Glass Fragments		Hazard Level	Protection Level
		Exterior to Structure	Interior to Structure		
1	Glass not cracked, fully survived and/or fully retained by frame and no glass fragments either inside or outside structure.	None	None	NA	Very High
2	Glass may be cracked but is retained by the frame.	Yes	No significant fragments. Dusting or very small fragments near sill or on floor acceptable.	Very Low	Very High
3a	Glass failed and not fully retained in frame.	Yes	Yes - land on floor no more than 40 inches from window	Low	High
3b	Glass failed and not fully retained in frame.	Yes	Yes - land on floor no more than 10 ft from window.	Low	High
4	Glass failed and not fully retained in frame.	Yes	Yes - Land on floor more than 10 ft from window and impact a vertical surface located not more than 10 ft behind the window no higher than 2 ft above floor level.	Medium	Medium
5	Glass fails catastrophically.	Yes	Yes - land on floor more than 10 ft from window and impact a vertical surface not more than 10 ft behind window above a height of 2 ft.	High	Low

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. A description of the performance conditions and hazard levels are outlined in Table 3.

**Figure 1. GSA Performance Conditions**

2. Results And Photographic Record Of Tests

2.1 Test 1: ***kg @ 25 Metres – Test Specimens 1L-1 & 1R-1

The test specimens were subjected to a high order detonation of ***Kg TNT set back at a distance of 25 metres from the explosive charge.



P4: View of test specimens post detonation.

Timber cladding torn off by blast wave. Both Planar test specimens appeared to be undamaged and the same samples were re-tested in test No 2 with the edge gasket cut through to simulate unsupported Planar glazing.

2.1.1 Result Test 1: Pilkington Specimen 1L-1 [27mm laminate]

RESULT: The Pilkington test specimen 1L-1 achieved a UK Break Safe and US GSA Class 1 [undamaged] rating against ***kg TNT detonation at 25 metres.

2.1.2 Result Test 1: Pilkington Specimen 1R-1 [49mm IGU]

RESULT: The Pilkington test specimen 1R-1 achieved a UK Break Safe and US GSA Class 1 [undamaged] rating against ***kg TNT detonation at 25 metres.

*** Information withheld by Pilkington

2.2 Test 2: ***kg TNT @ 25 Metres – Re-Test 1L-1 & 1R-1

Test specimens 1L-1 [27mm laminate] and 1R-1 [49mm IGU] were retested under similar blast load conditions as test No 1. The silicone sealant around the perimeter of the glass was cut through on both specimens to represent a test on four point supported glass units without perimeter restraint.

The test specimens were subjected to a high order detonation of ***kg TNT set back at a distance of 25 metres from the explosive charge.



P5: Results Of Re-Test On Specimens 1L-1.

2.2.1 Result Test 2: Pilkington specimen 1L-1 [27mm laminate] retest

RESULT: Pilkington test specimen 1L-1 achieved a UK Break Safe and US GSA Class 1 [undamaged] rating against ***kg TNT detonation at 25 metres.

2.2.2 Result Test 2: Pilkington Specimen 1R-1 [49mm IGU] retest

RESULT: Pilkington test specimen 2R-1 achieved a UK Break Safe and US GSA Class 1 [undamaged] rating against ***kg TNT detonation at 25 metres.

These test results were particularly impressive as the test specimen had already undergone severe loading in Test No 1.

2.3 Test 3: ***kg TNT @ 16.75 Metres

Following the success at 25 metres, it was decided to test the remaining specimens at 16.75 metres standoff distance from the explosive charge of ***kg TNT equivalent.

The Pilkington test specimens 2L-1 and 2R-1 were subjected to a high order detonation of ***kg TNT set back at a distance of 16.75 metres from the explosive charge.



P7: Test specimen 2L-1.

2.3.1 Result Test 3: Pilkington Planar Specimen 2L-1 [27mm laminate]

RESULT: Pilkington Planar test specimens 2L-1 achieved a UK Break Safe and US GSA Class 1 [undamaged] rating against ***kg TNT detonation at 16.75 metres.

Test specimen 2R-1 containing insulated glass unit [49mm IGU] was mounted in a steel carrier frame and the silicone seal around the boundary of the glass was cut through to allow free movement of the glass independent of the test structure.



P11: Test specimen 2R-1 post detonation of *kg TNT @ 16.75m.**

The outer toughened glass shattered and fell to the ground below the test frame with approximately 10% of the glass found more than 1 metre to the front of the cubicle.

2.3.2 Result Test 3: Pilkington Planar Specimen 2R-1 [49mm IGU]

RESULT: Pilkington Planar test specimens 2L-1 achieved a UK Low Hazard and US GSA Class 3A rating against *kg TNT detonation at 16.75 metres.**