

Are Polycarbonate Demining Visors Embrittled By A Flame Polishing Renovation Process?

Informal Blast Testing



Background

Following successful informal ballistics testing on 5th June 2007 where PDV were tested against a 'standard fragment' ¹ it was decided to continue research in this area with informal blast testing. Whilst the tests carried out are referred to as informal great care was taken to ensure good scientific method throughout, including the use of control visors during each testing serial.

Description of components used in testing.

The tests used consisted of 3 separate components – steel test rigs to securely hold PDV at proper range and angle, PDV, and explosives. These 3 separate components are described in detail below.

Test Rigs

4 steel testing rigs were prepared for use in the tests by PM WRA staff.

¹ 115 grain 9mm NATO bullet fired from Beretta 92 SF service pistol fired at range of 5000 mm.

Test Rig Overview



PDV Attachment Point Detail



There are several design aspects of the rig that are worthy of note – particularly the following:

1, PDV mounting.

The mounting was designed to replicate the conventional MED ENG Sport Helmet mounting – without the need to create a set of anthropomorphic surrogate heads that could be fitted within the Sports Helmet for testing. Use of anthropomorphic heads would have necessitated identical chin strap tension – identical size and weight – and would have been outside the scope (and budget) of a trial carried out at reasonable cost in Afghanistan.

Visors were mounted within rubber bushings in order to partially replicate the shock absorption that would occur upon blast loading² if the visor is mounted on a helmet worn by a deminer.

2, Standard Buffer.

A full 2 litre water bottle was attached to the rig using duct tape to ensure that upon blast loading the PDV would impact the bottle causing the visor to decelerate in a realistic fashion without sudden shock loading as would be caused if the visor were to strike the steel frame of the test rig.

A water bottle was chosen as it allowed an identical buffer to be added to the test rig for each successive serial. A new water bottle was fixed to each test rig for each successive test.

3, Anthropomorphic/un-fixed test rig

During blast loading, a deminer in the kneeling position will tend to be pushed away from the blast as a result of the rapid movement of the blast pressure wave. An attempt was made to measure the force required to pull a kneeling volunteer out of the kneeling position so that the rig could be designed to move away from the blast when a similar force was applied.

A spring scale³ was sourced locally in order to make these measurements, and it was found that a force of IRO 200N was required to pull a kneeling volunteer out of a kneeling position.

Accordingly – sand bags were added to the test rig until it was found that the rig could be rocked/pulled backwards with a force of IRO 200N.

Visors

MED Eng 6mm demining visors as used widely throughout Afghanistan were used throughout testing. **No 5 mm visors⁴ were tested, and as such results of this trial apply only to 6mm MED ENG visors.** Four different kinds of visor were tested, that can be described as follows.

1, Brand new MED ENG 6mm visors

2, Brand new MED ENG 6mm visors – artificially scratched and then renovated as follows

- A, Rubbed with scouring pad⁵ on both faces (front and back) until obscured⁶
- B, Cleaned with warm water, scouring pad and liquid soap
- C, Dried with white kitchen paper
- D, Dried in a domestic fan oven at IRO 120° C for at least 9 hours
- E, Cleared of scratches and haze until 10pt text could be read easily at range of 600mm
- F, Oven annealed at IRO 140° C – and allowed to cool to room temperature inside oven.

A total of 4 visors were prepared in this fashion.

3, Old MED ENG 6mm visors

2 Due to compression of the foam head band and elastic deformation of the sport helmet

3 0 – 100 KG in 1KG increments

4 Security Devices PVT/ROFI/ENVOTECH etc.

5 No other technique tried by the author has been found to successfully deep clean – and de-grease visors

6 New visors were scratched on both faces until 10pt text was difficult to read with the visor in service position and the text positioned 600mm away.

For the purposes of this test – an old visor is any visor of indeterminate age that has been retired from service due to a reduction in its optical quality.

4, Old renovated visors

- A, Thoroughly cleaned with warm water, scouring pad and liquid soap
- B, Dried with white kitchen paper
- C, Dried in a domestic fan oven at IRO 120° C for at least 9 hours
- D, Cleared of scratches and haze until 10pt text could be read easily at range of 600mm
- E, Oven annealed at IRO 140° C – and allowed to cool to room temperature inside oven.

Testing Method



The testing method was designed to meet guidelines laid down in IMAS 10.3b. 'Provide eye protection capable of retaining integrity against the blast effects of 250gm TNT at 60cm, providing full frontal coverage of face and throat as part of the specified frontal protection ensemble'. Testing consisted of 5 serials – testing 16 visors in all.

The primary aim of the testing methodology was to recreate a 'field situation' as closely as possible. Real PMN landmines were used as opposed to a measured mass of high explosive and visors were mounted in a close approximation of the head position of a prodding deminer. Visors were positioned so that they would be well within the blast cone during detonation, and careful note was taken of the position of each visor used relative to the fuse bosses of the PMN mine – since it is clear that an unsymmetrical object such as a PMN mine produces different threat profiles at different angles – broadly – increased fragments/decreased blast in line with the fuse bosses and increased blast/decreased fragmentation at 90 degrees to the fuse bosses.

Serial 1

Explosive Mass	240g TNT
Explosive Type	PMN AP Landmine
Overburden	20mm Sieved sand – 5mm down
Initiation	Electrical
Safety Distance	100M
Distance to Target (Centre of Explosive Mass to front face of visor)	600mm
No of Targets	1
Description of targets	
A	Brand New MED ENG Visor (Ref S1a)
B	
C	
D	
Orientation of targets/s	90degrees to blast
Orientation to blast	45 degrees - within blast cone
Orientation of PMN to Targets	



A

Serial 2

Explosive Mass	240g TNT
Explosive Type	PMN AP Landmine
Overburden	20mm Sieved sand – 5mm down
Initiation	Electrical
Safety Distance	100M
Distance to Target (Centre of Explosive Mass to front face of visor)	600mm
No of Targets	4
Description of targets	
A	Brand New Visor (Ref S2a)
B	Old Visor (S2b)
C	Brand new Visor – Scratched, Renovated (S2c)
D	Old Visor Renovated. (S2 d)
Orientation of target/s	90degrees to blast
Orientation to blast	45 degrees - within blast cone
Orientation of PMN to Targets	

A (S2a)



B (S2b)

D (S2d)

C (S2c)

Serial 3

Explosive Mass	240g TNT
Explosive Type	PMN AP Landmine
Overburden	20mm Sieved sand – 5mm down
Initiation	Electrical
Safety Distance	100M
Distance to Target (Centre of Explosive Mass to front face of visor)	600mm
No of Targets	4
Description of targets	
A	Brand New Visor (Ref S3a)
B	Old Visor (S3b)
C	Brand new Visor – Scratched, Renovated (S3c)
D	Old Visor Renovated. (S3 d)
Orientation of target/s	90degrees to blast
Orientation to blast	45 degrees - within blast cone
Orientation of PMN to Targets	

B (S3 b)



A (S3 a)

C (S3 c)

D (S3 d)

Serial 4



Explosive Mass
 Explosive Type
 Overburden
 Initiation
 Safety Distance
 Distance to Target
 (Centre of Explosive Mass
 to front face of visor)
 No of Targets
 Description of targets
 A
 B
 C
 D
 Orientation of target/s
 Orientation to blast
 Orientation of PMN to Targets

240g TNT
 PMN AP Landmine
 NONE
 Electrical
 100M

 600mm
 1
 Brand New Visor (Ref S4a)

 90 degrees to blast
 0 degrees - within blast cone



See Photo

Serial 4b

Explosive Mass
 Explosive Type
 Overburden
 Initiation
 Safety Distance
 Distance to Target
 (Centre of Explosive Mass
 to front face of visor)
 No of Targets
 Description of targets
 A
 B
 C
 D
 Orientation of target/s
 Orientation to blast
 Orientation of PMN to Targets

240g TNT
 PMN AP Landmine
 20mm Sieved sand – 5mm down
 Electrical
 100M

 600mm
 2
 Old Visor (S4b)

 Old Visor Renovated. (S4 d)
 90degrees to blast
 45 degrees - within blast cone

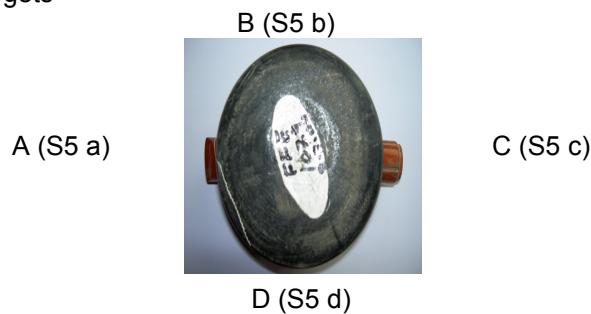
B (S4 b)



D (S4 d)

Serial 5

Explosive Mass	240g TNT
Explosive Type	PMN AP Landmine
Overburden	20mm Sieved sand – 5mm down
Initiation	Electrical
Safety Distance	100M
Distance to Target (Centre of Explosive Mass to front face of visor)	600mm
No of Targets	4
Description of targets	
A	Brand New Visor (Ref S5a)
B	Old Visor (S5b)
C	Brand new Visor – Scratched, Renovated (S5c)
D	Old Visor Renovated. (S5 d)
Orientation of target/s	90degrees to blast
Orientation to blast	45 degrees - within blast cone
Orientation of PMN to Targets	



Results

Serial 1

Results from serial one showed that the test rig behaved as expected, and that a new visor was capable of withstanding the blast from 240g TNT at 600mm. Results at this stage provided sufficient confidence in the rig design and testing methodology to continue to serial 2.

Serial 2

All visors remained in 1 piece – with no visible cracking/holes. All visors sustained a significant number of high velocity impacts (indicated by denting of the polycarbonate surface) All visors would have prevented injury to the face/eyes in a real world incident.

Serial 3

All visors sustained a significant number of high velocity impacts (indicated by denting of the polycarbonate surface) One visor – S3b (old renovated visor) broke away from the test rig at the 'ears' the regions near the mounting holes. The visor absorbed the full force of the blast, and would have prevented injury to the face eyes in a real world accident.⁷ All other visors remained in 1 piece with no visible cracking/holes - and would have prevented injury to the face/eyes.

Serial 4a

⁷ 'It is fairly common for visors to be torn away by the blast front, but at 60cm from the seat of the explosion the fragments have overtaken the blast front - so they strike the visor just before it is torn away'
<http://www.nolandmines.com/mineblastwebpage.htm>

The test visor (S4a – Brand new visor from packaging) was destroyed completely – with multiple holes, and a large brittle fracture extending upwards from the bottom visor edge. The visor would not have prevented injury to the eyes/face in a real world accident.

Serial 4b

Both visors sustained a significant number of high velocity impacts (indicated by denting of the polycarbonate surface) Visor S4b (old visor) broke away at one of the ears through the attachment hole. The visor remained attached to the test rig. Visor S4d (old renovated visor) remained in one piece with a crack (propagated by the mounting hole) running half way through the visor ear. Both visors would have prevented injury to the eyes/face in a real world accident.

Serial 5

All visors sustained a significant number of high velocity impacts (indicated by denting of the polycarbonate surface) One ear on visor S5d (Old renovated visor) broke off, though there was no damage to the other ear – and the visor remained attached to the test rig. All other visors remained in one piece. All visors would have prevented injuries to the eyes/face in a real world accident.

Results of Serial 4a



Conclusion

- The renovation technique proposed by Elegant Design and Solution (EDaS) does not cause detrimental changes in PDV. No new renovated visors broke during the trial. Old visors (both renovated and none renovated) showed a tenancy to break at the ears/attachment points.

- Old visors may be more brittle in the region surrounding the ears than new visors. This was not in any doubt pre trial as old visors often sustain fracture of one of the ears in normal service – and without being exposed to blast.
- In certain instances, the test rigs used caused almost identical fractures of the visor ears. Whilst the test rigs provided good results – the design of the visor mounting would need to be modified in any subsequent blast testing of PDV.
- **All visors tested** would have provided protection to the eyes/face in the event of a real world demining accident with a PMN mine – except the new visor tested in serial 4a. With the exception of the GYATA 64 – the PMN is the largest AP blast mine in existence, is the largest AP blast mine found in Afghanistan and the mine used for the creation of IMAS standard 10.3b.

Discussion

Results of this trial indicate that without mention of orientation of the explosive mass to the visor, and position of visor within the blast cone – the relevance of IMAS 10.3b is brought into question. Serial 4a caused a brand new MED ENG 6mm visor to comprehensively fail IMAS standards testing in a situation that is reported regularly by demining experts working in the field⁸

For future tests the author would propose the following test rig.

- Visor mounted to MED ENG Sports Helmet
- Helmet attached to 5kg mass via existing central 25mm hole in the superior surface of the helmet.
- Weighted visor suspended via chains attached to existing holes in LHS and RHS of the helmet.
- Visor tilted to 45 degrees to blast via single chain attached to 2 existing posterior holes in helmet
- 2 visors tested during each serial- hung at 90 degrees to the 3 PMN mine faces without fuse bosses present – as testing indicates that the highest blast pressure is produced at these sites.

This blast test rig would provide a more realistic blast loading of the visor ears, and would not necessitate the use of expensive anthropomorphic mannequins such as the Hybrid 2 – costing in excess of \$50,000 each.

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⁸ PMN mines found in a tilted position