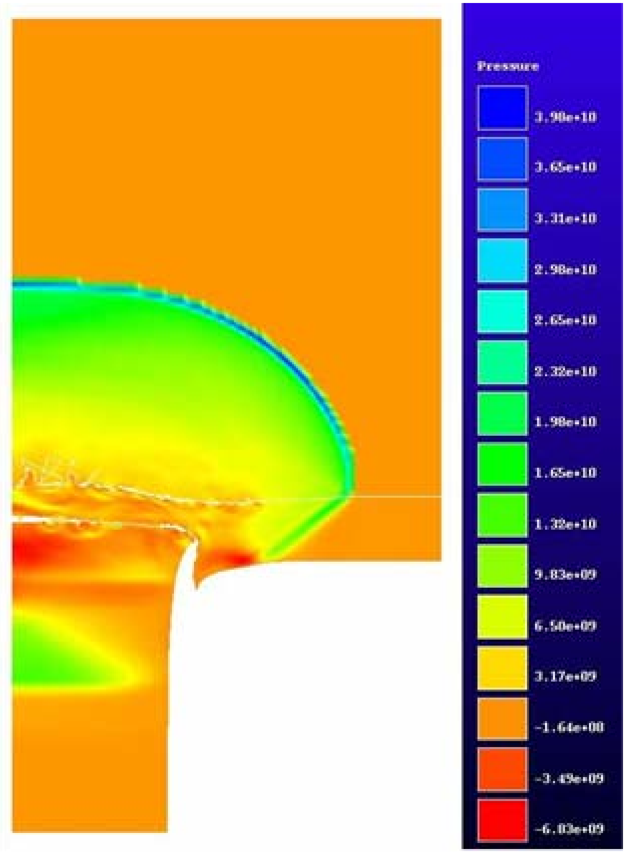

High-Velocity Fragment Impact Testing

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Contents

Introduction

- High velocity fragments can pose a significant threat to weapon safety.
- As a consequence STANAG 4496 stipulates a testing regime which requires a standard Fragment Simulating Projectile (FSP) to be fired at the weapon under test.
- The defined FSP is a 14.3mm diameter steel rod with a 160^{o} conical nose and, depending upon the perceived threat, a velocity of either 1830m/s or 2530m/s is stipulated.
- For many years we have carried out fragment impact testing at velocities up to ca. 2000m/s using a 30mm powder gun to launch the fragments. However, this gun system was incapable of reaching the 2530m/s requirement so over the last few years we have developed a new 40mm gun to address this need.
- In this presentation we describe the new gun system, our overall approach to fragment impact testing, and some recent results against both small-scale energetic targets and weapon systems.

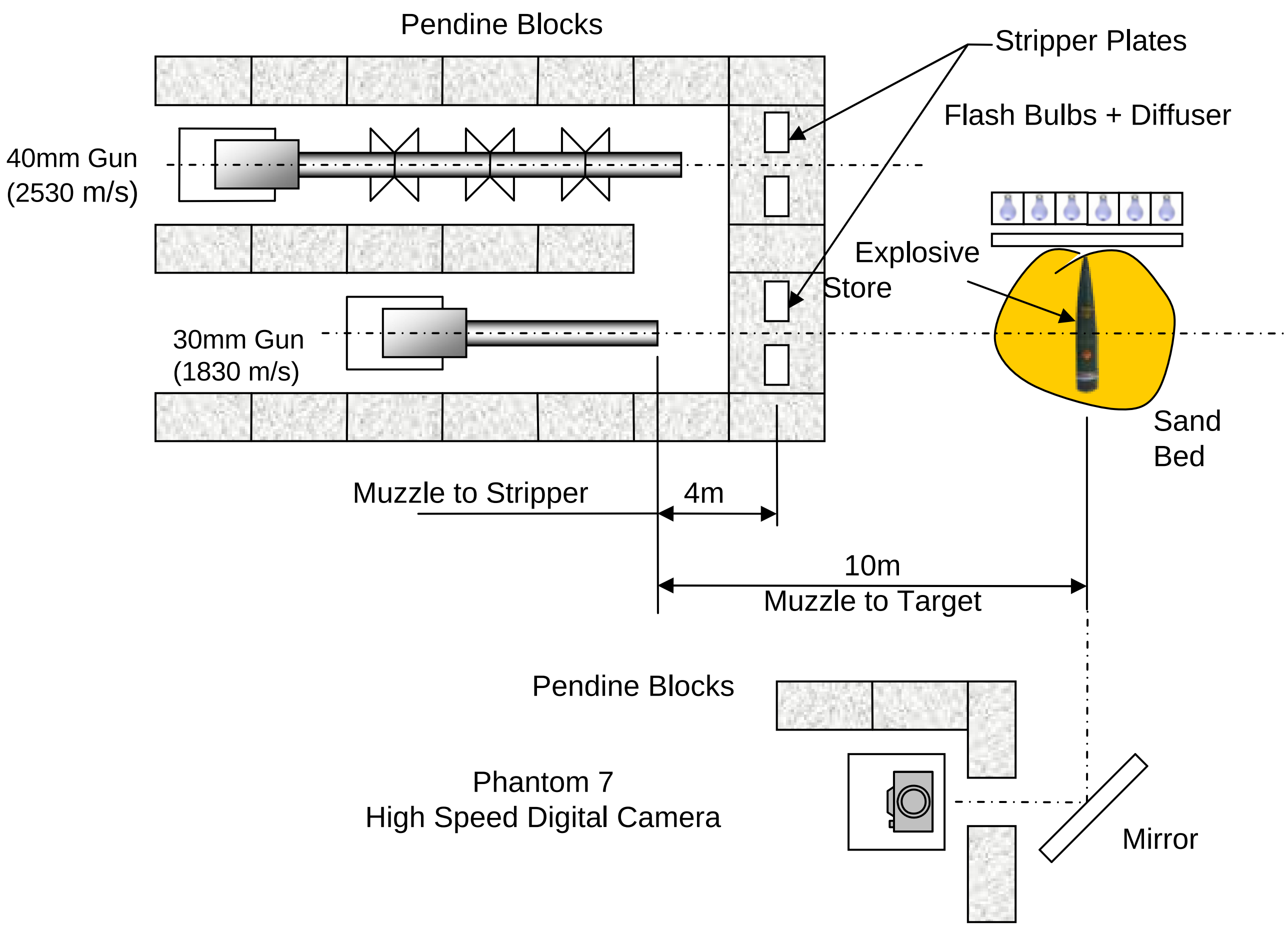
Experimental Set-Up(1)

- Our approach to fragment impact testing is to use our 30mm gun for the lower velocity requirement (1830m/s) and our new 40mm gun for the higher velocity (2530m/s).
- Whilst the 40mm gun could be used for all velocities this approach has benefits due to reduced operating costs and faster turn around times for the 30mm gun.
- For both gun systems the projectiles are housed in discarding plastic sabots and fired through a stripper plate to ensure that the target is not struck by sabot fragments.
- The 30mm ammunition is of two-piece construction, whereas the 40mm ammunition is one-piece, with the sabot and fragment pressed into the cartridge case before loading.
- Both gun systems are rifled, with the 40mm gun having two barrel stages which require careful alignment.
- The 40mm gun barrel is evacuated prior to firing when high velocities are required. It should be noted in this context that to achieve 2530m/s at impact with the target it is necessary to have a muzzle exit velocity of ca. 2700m/s when working at a typical muzzle to target separation of 10m.

Experimental Set-Up (2)

- All tests are filmed using high speed video (Phantom 7 camera), typically at ca. 100,000 frames per second. In some experiments we use two cameras, the additional camera providing a close-up view of the target.
- These records are used to determine:
  - Projectile velocity
  - Projectile stability
  - Target reaction details
- The events are back-lit with flash bulbs behind a diffusing screen.
- The overall trial arrangement is shown on the following slide.

Experimental Arrangement



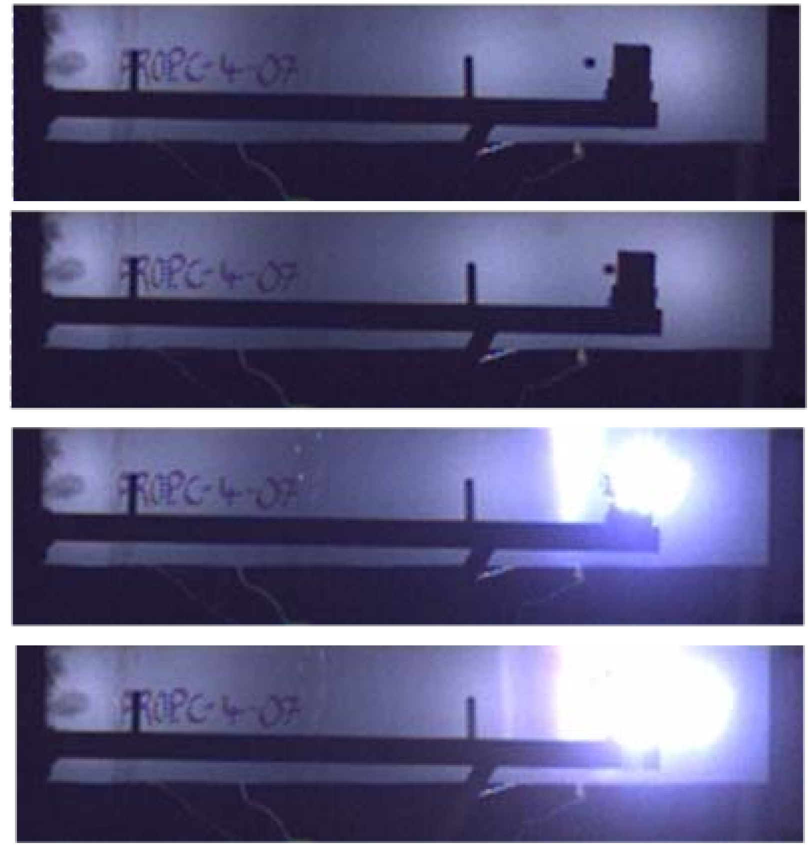
30mm Gun System

40mm Gun System

30mm Ammunition (left) and 40mm Ammunition (right)

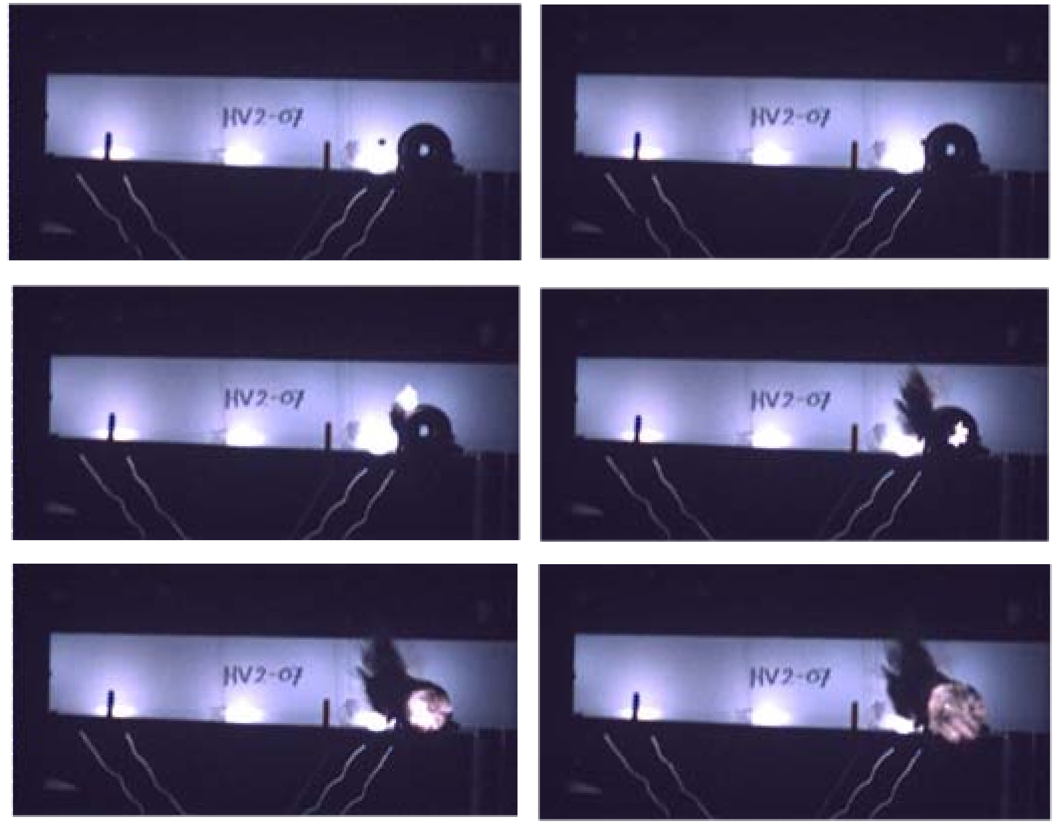
Experiments on Sectioned Propellants

- Small 51mm cubes of CDB propellant were used.
- 2 types – same formulation except one set had refractories added.
- Phantom high-speed video record shows STANAG projectile impacting a bare CDB propellant charge (with refractory's) at 1808m/s. This resulted in prompt detonation.



Experiments on Sectioned Rocket Motors

- CDB rocket motors were sectioned & impacted with the STANAG projectiles.
- The Phantom high-speed video record shows a STANAG projectile impacting a rocket motor section, in its casing, at 1717m/s.
- Note that there is little reaction on impact, but there is substantial reaction when the projectile crosses the bore of the motor and impacts the bare internal propellant face.



Experiments on Complete Rocket Motors

- We have carried out a few tests on complete proprietary rocket motors with the STANAG projectile at the higher (2530m/s) velocity.
- In the following slide a motor can be seen configured ready for testing with the aim mark clearly visible. The subsequent slide shows the aftermath of the test, which in this instance resulted in a detonation.

Rocket Motor Ready for Testing

Aftermath Following Detonation of Motor

Experiments on HE Filled Shells

- Five tests have been carried out against experimental PBX filled shells (un-fused and without booster pellet) with the STANAG projectile at the higher velocity requirement.
- Four of these tests have been carried out with the shell inside a section of the spiral wound steel tube that holds it in the universal load container. The final test was against a bare shell.
- The tests all resulted in either a mild burn through the impact hole or a pressure burst.
- The following slides show rounds 2 and 3. Round 2 burnt out completely through the impact hole (over a period of ca. 30 minutes) and also ejected the nose plug, whereas round 3 underwent a pressure burst (into 3 large pieces) and scattered a considerable amount of un-reacted explosive.
- The final test (at 2536m/s) on a bare shell also resulted in a pressure burst (this time into 2 halves) with a large amount of un-reacted explosive being recovered.

Experiments on HE Filled Shells – Round 2, Shell in Spiral Wound Tube Section, Velocity = 2450 m/s.

Before firing

After firing

Experiments on HE Filled Shells – Round 2, Shell in Spiral Wound Tube Section, Velocity = 2450 m/s.

Impact hole – close up

Nose – close up

Experiments on HE Filled Shells – Round 2, Phantom Camera Records.

Experiments on HE Filled Shells – Round 3, Shell in Spiral Wound Tube Section, Velocity = 2521 m/s. Shell Fragments and Recovered Explosive

Experiments on HE Filled Shells – Round 3, Phantom Camera Records.

Conclusions

- We have developed a cost-efficient capability to carry out the STANAG 4496 fragment impact tests at either of the prescribed velocities.
- The capability has been exercised on both small-scale tests and against complete rocket motors and HE filled shells.
- The tests on experimental PBX filled shells have shown that it is possible to achieve IM compliance even at the higher, 2530m/s velocity.