A Novel Tuneable Effects Explosive Charge

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2012 NDIA IM&EM Symposium
Las Vegas, USA

15th May 2012
QinetiQ/12/00779

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01 Introduction

There has been an objective for many years to design warheads to achieve tuneable terminal effects in delivering precision and reducing collateral damage.

The tuneable effects charge concept proposed and tested under this programme has the potential to provide flexibility in warhead effects from a single weapon.

In principle the proposed concept should be applicable to a wide range of HE warheads.

02 Technical Objective

Feasibility study designed to make a preliminary assessment of the 'Tuneable Effects Warhead' concept.

Ideally by molecular design but very complicated chemistry.

The concept proposed is for a charge with a dual functioning mode.

Prior to deployment it will be possible to select between two terminal effect options:

- Minimise peak pressure and fragmentation but provide a high Quasi Static Pressure (QSP).
    - minimise collateral damage

Provide higher peak pressure and increased fragmentation for open battlefield attack.

All the reactive material is employed in both functioning modes, but to produce different effects.

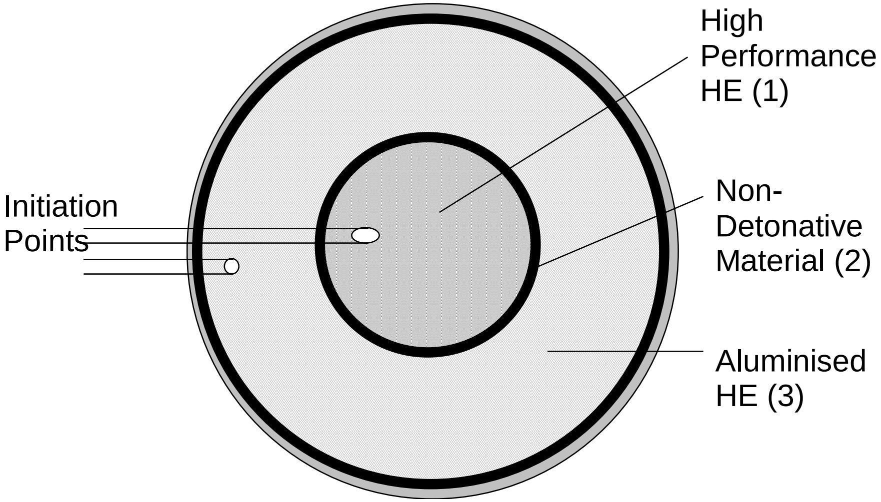
Other variable output warhead designs have been suggested but these work on the principle of simply 'wasting' the output from various sections of the explosive to reduce the yield, or involve controlled fragmentation

03 Technical Approach (1)

3 principal components:

- (1) A high performance HE (e.g. a highly loaded HMX PBX).
- (2) A reactive, but non-detonable composition (e.g. a rubber loaded with aluminium powder).
- (3) A highly aluminised explosive composition (e.g. an RDX/Al/PBX)

High performance explosive (1) will be surrounded by a concentric jacket of the reactive but non-detonable composition (2). This jacket would in turn be surrounded by a further concentric layer of the aluminised explosive (3).



03 Technical Approach (2)

First design mode

- the high performance explosive (1) will be initiated by the fuze train.
- The reactive rubber jacket (2) will be chosen to provide sufficient shock attenuation to prevent detonation of the aluminised PBX (3).
- Components (2) and (3) will be ignited and dispersed leading to a large after-burn and high QSP in a closed environment.

Second design mode

- both explosive compositions (1 and 3) will be initiated by the fuze train.
- will lead to higher peak pressure and fragment velocities than in the first design mode.

In a real warhead the casing would be designed to produce significant fragmentation when used in the second design mode (i.e. when there is detonating HE in contact) but burst easily when functioned in the first design mode with minimal fragmentation.

However, in this preliminary study the test charges were bare and hence fragmentation was not assessed.

04 Results – Charge Design

Compositions chosen were:

(1) PBXN-110 (88% HMX, 12% HTPB), for the central high performance charge.

(2) QRX 263, non-detonable attenuator material

- 79.8% by weight spherical aluminium powder (10.5mm) in a cured HTPB binder system.

(3) QRX 104 [53% RDX, 35% Al (10.5mm spherical), 12% HTPB/DOS/IPDI binder], for the outer aluminised explosive.

Results – Attenuation layer

Confident that compositions would deliver performance but initial obstacle was the attenuating layer.

QRX 263 attenuating layer needs to prevent detonation of the outer QRX 104 when the inner PBXN-110 is detonated.

Cylindrical pellets of QRX 104 (mean weight 22.5g) and PBXN-110 (mean weight 20.5g) were manufactured.

Used in a ‘Gap Test’ arrangement with a varying thickness attenuator layer and a 5mm thick aluminium witness plate to establish if initiation take-over had occurred.

Last test used two pellets of PBXN-110 for the donor charge to provide added confidence that 15mm of attenuator would be sufficient to prevent take-over.

Results – Attenuation layer

Test No.	Attenuator thickness (mm)	Donor (PBXN-110) mass (g)	Results
0580	0	20.5	Go - clean hole through witness plate.
0581	10	20.5	Go - clean hole through witness plate.
0582	20	20.5	No-Go – bent witness plate
0583	15	20.5	No-Go – bent witness plate
0585	15	41	No-Go – severely bent witness plate

Tests clearly showed that take-over did not occur provided the attenuating layer was 15mm or greater in thickness.

Based on these results it was decided to base the generic warhead design on a 15mm QRX 263 attenuation layer.

04 Results – Charge Manufacture

Four prototype charges were manufactured to the following design:

PBXN-110 was used for the central core charge at a diameter of 35mm.

This was surrounded by QRX 263 in a 15mm thick layer.

QRX 104 was used for the outer layer, again at a thickness of 15mm.

Charges were 200mm long and each had a total mass of ca. 2.6kg.

04 Results – Testing

Charges were tested in the Bofors cell at Fort Halstead

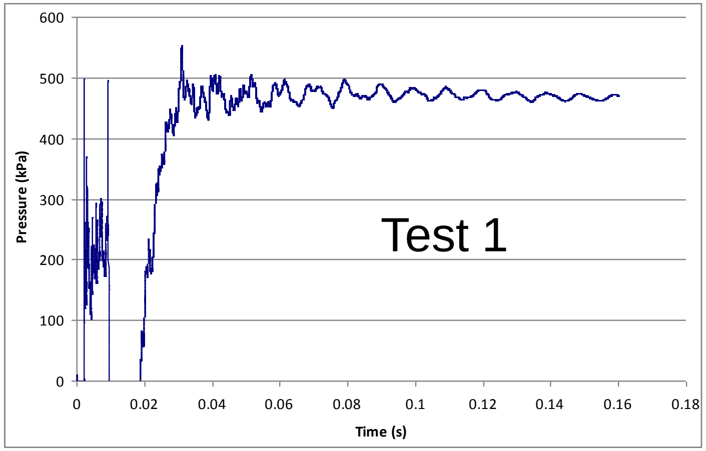
- QSP and incident pressure gauges (two gauges at 1m and one gauge at 1.5m).
- Charges were all suspended in the centre of the chamber in line with the pressure gauges.
- Initiation set-up changed according to desired output

04 Results – Test 1

First firing was designed to test the charge in high pressure mode, when both explosive components are detonated.

Initiation was by 2x3mm thick disks of SX2 sheet explosive placed over the complete top of the charge.

SX2 (76g) was initiated by a 2g Tetryl pellet and an EBW detonator.



Incident pressure (1m) kPa	**Incident pressure (1m) kPa**	**Incident pressure (1.5m) kPa**	**QSP kPa**
2638	**2644**	**1234**	**480**

04 Results – Test 2

Second firing was designed to test the charge in the low collateral damage mode

Only the central charge of PBX N110 is initiated directly.

Initiation was by 76g of SX2 (same mass as for test 1) in the form of a stack of 15 x 3mm thick disks placed over the central core charge only.

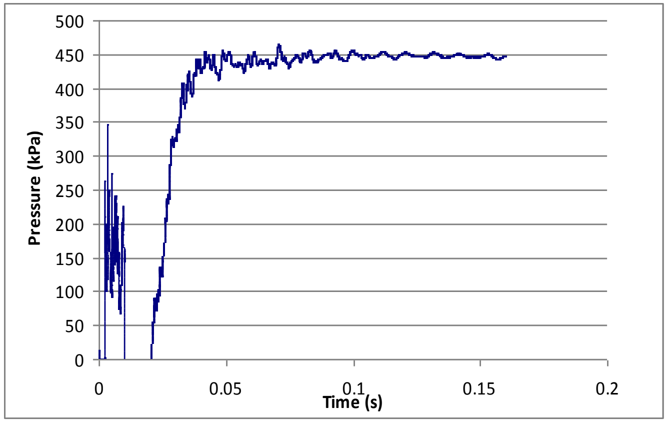
The SX2 was again initiated by a 2g Tetryl pellet and an EBW detonator.

Incident pressure (1m) kPA	Incident pressure (1m) kPa	Incident pressure (1.5m) kPa	QSP kPa
1736	1812	927	447

04 Results – Test 3

Essentially a repeat of test 2 except the central PBX N110 core was initiated by a 2g Tetryl pellet and EBW detonator only.

To ensure direct comparison with the previous tests, 76g of SX2 was attached to the base of the charge (opposite end from initiation), covering the central charge only.



Incident pressure (1m)	Incident pressure (1m)	Incident pressure (1.5m)	QSP
1630	**1094**	**928**	**450**

04 Results – Test 4

Remote possibility that the QRX 104 had failed to detonate fully

- thickness of the QRX 104 layer (15mm) slightly < the critical diameter for this explosive (between 15.5 and 18.9mm for a bare cylindrical stick).

Decided for the final test to wrap the outside of the charge with a layer of SX2 to ensure full detonation of the QRX 104.

Initiation was as for test 1 with 2x3mm thick disks of SX2 covering the top of the charge.

The external wrapping of SX2 added an additional 491g of explosive - increases QSP

Incident pressure (1m) kPa	Incident pressure (1m) kPa	Incident pressure (1.5m) kPa	QSP
2638	**2545**	**1185**	**520**

04 Results – Controls

A number of PE4 gauge test firings were also carried out

Compare the data from the largest of these (2 tests of 2kg)

Test No.	Incident pressure (1m)	Incident pressure (1m)	Incident pressure (1.5m)	QSP
1	**1859**	**2645**	**1321**	**277**
2	**2638**	**2649**	**1194**	**281**

Incident pressures from 2kg of PE4 are similar to those from the tuneable charges (one abnormally low reading at 1m) when initiated in the high pressure design mode

QSP from the PE4 charges is very much lower than that measured in all the tuneable charge tests (HE mass ca. 1.7kg)

Indicates a substantial contribution to the QSP from the aluminium.

04 Results – Summary

Test No.	Incident pressure (1m)	Incident pressure (1m)	Incident pressure (1.5m)	QSP
1	**2638**	**2644**	**1234**	**480**
2	**1736**	**1812**	**927**	**447**
3	**1630**	**1094**	**928**	**450**
4	**2638**	**2545**	**1185**	**520**
PE4	**1859**	**2645**	**1321**	**277**
PE4	**2638**	**2649**	**1194**	**281**

Incident pressures are considerably lower in tests 2&3 (ca. 65% of that from tests 1&4 at 1m)

Confirms that the attenuating layer prevented detonation transfer to the outer charge.

The QSP obtained was only slightly lower in rounds 2 & 3, indicating that the majority of the QRX 104 burnt and contributed to the quasi static over-pressure.

Comparison of the QSP data from PE4 controls and the four tuneable charge tests shows that there has been a substantial contribution to the QSP from the aluminium (in both the QRX 104 and QRX 263).

05 Conclusions

Tests carried out under this programme have clearly demonstrated a prototype charge with dual output capability.

In the tests in which both explosive components of the charge were initiated, a high incident pressure and QSP were produced.

However, when the central explosive charge only was initiated the incident pressure was significantly lower, whilst the QSP was only marginally less.

This latter mode of operation should therefore lend itself to enclosed scenarios where minimum collateral damage is required.

06 Recommendations

Preliminary study has demonstrated the feasibility of the tuneable effects charge concept.

Needs to be taken forward with a study of cased charges in a fragmentation arena to demonstrate ‘Tuneable Effects Warhead’ concept.

07 Acknowledgements

The author would like to thank the following people for carrying out the experiments and building the test charges:

- Peter Haskins
- Derek Honour
- Bernard Garaty
- Kevin Cox
- Phil Ottley
- Andrew Wood
- Barry Jenner
- Kevin Wales
- This work was carried out as an Innovation study part of the UK-Energetics research programme from the Dstl Programmes Office of the Ministry of Defence

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