# **Bangalore Torpedo Replacement**



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## Background

- First devised in 1912 by Captain McClintock, of the British Indian Army.
- Used for exploding booby traps and barricades left over from the Boer and Russo-Japanese Wars.
- Exploded over a mine without having to approach the device.
- Placed through a barbed wire fence or other obstacle in order to clear an exploitable path.



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#### **Objectives**

To develop the 'Next Generation' Bangalore Torpedo with improved Insensitive Munition (IM) signature.

Achieved by packaging design and use of Insensitive explosive materials.

To improve the performance over the existing in-service product.

 Performance Trials conducted against replicated targets / obstacles.

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## Objective

To reduce the load on the user by minimising the mass of the product.

Achieved by making the tube from aluminium and ancillary parts from plastic.

To create a flexible modular product to be used for multiple applications.

 Single revolution thread allows for quick removal of ancillary parts and ability to link multiple tubes together.
 Tactical Packaging allows quick deployment.

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## Product Design Concept

- Pre-fragmented aluminium tube, designed to produce long 'cutting' strips.
- High level of blast energy due to high Theoretical Maximum Density (T.M.D.) of the pellets.
- > The main fill is a Chemring explosive, DPX1 Type II.
- The booster material is a Chemring explosive known as DPX10 (Plastic Explosive).
- Both compositions are RDX based with different types and quantities of plasticisers and binders.

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## Sensitivity Testing of DPX1 Type II and DPX10

Figure of Insensitivity (F of I)
 RDX = 80
 DPX1 Type II = 85
 DPX10 = 144

Figure of Friction (F of F)
 RDX = 3.0
 DPX1 Type II = 4.7
 DPX10 = >6

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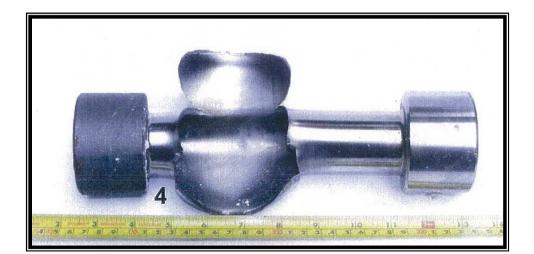




## Sensitivity Testing of DPX1 Type II and DPX10

EMTAP 35 (Tube Test)
 Maximum no. of Fragments = 4
 Minimum no. of Fragments = 1
 Average no. of Fragments = 1.8





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## Sympathetic Reaction Type

- Is Sympathetic Initiation caused by blast or fragment ?
- Mitigation barriers need to be selected depending on the type of energy they have to contain / reduce.
- Sympathetic Reaction Fragmentation
  - An acceptor Bangalore Tube placed 50mm away from a donor tube without any mitigation barriers in place will sympathetically detonate.



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## Sympathetic Reaction – Blast

- > A cardboard tube was used in lieu of aluminium.
- > Cardboard provided lower fragment energy.
- The acceptor tube along with a high percentage of the explosive fill was recovered.
- > Protection from fragmentation is required.



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## Sympathetic Trials

Several Blast Mitigation specialist companies were contacted.

> Sample packaging solutions were supplied.

- MSIAC were contacted and a search conducted on our behalf.
- > Mitigation Trials Conducted.

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## Sympathetic Reaction Trial Results

- > Waterproof coated aggregate bonded material, 70mm thick.
- Successfully prevented propagation.





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## Sympathetic Reaction Trial Results

- > Resin bonded aggregate contained within GRP moulding.
- > 30mm and 40mm separation.
- Both thicknesses of material successfully prevented propagation.





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## **Bangalore I.M. Trials**

## Sympathetic Reaction Trial Results

HDPE (High Density Polyethylene) Tubes.
 Polyethylene Foam (high density).
 Successfully prevented propagation.







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## Sympathetic Reaction Trial Results

- Polyethylene Foam Low Density.
- > Polyethylene Foam High Density.
- > Only the higher density foam prevented propagation.





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## Sympathetic Reaction Trial Results

- HDPE Tubes
- $\geq$  Nominal air gap separation.
- Successfully prevented propagation.





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#### **Bangalore I.M. Trials**

## Sympathetic Reaction Trial Results

- > GRP Tubes, nominal air gap separation.
- Successfully prevented propagation but acceptor tube extremely damaged and perforated through to explosive fill.



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## Packaging Design

- Chosen Mitigation material was HDPE tube separated by a nominal air gap.
- This solution was the most cost effective, robust, lightest and offered the most versatility in packaging design.





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#### UN Series 6a - Single Package Test

- A Single Package Test was conducted in accordance with the Orange Book Series 6a tests.
- One Donor tube (detonated by det cord) and three Acceptor Tubes



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## UN Series 6a - Result

Witness plate dented but not perforated.
Three acceptor tubes recovered.









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#### Bullet Impact

A Bullet Impact trial was conducted on an all up logistic box containing 4 Bangalore Tube Assemblies.





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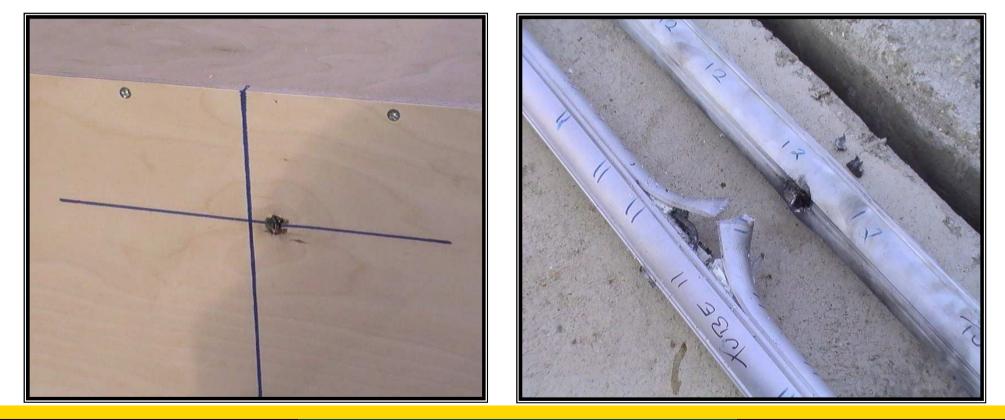
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## Bullet Impact – Trial Results

The projectile passed through two tubes without causing any reaction.



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#### UN Series 6c – Bonfire

Three logistic boxes were strapped to a pallet and subjected to a bonfire test.



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### UN Series 6c – Results

> External temperatures of 800 – 1000 degC were recorded.

- Internal temperatures of 220 degC were recorded before any reaction was observed.
- > Circa 15 mins, burning pellets were ejected from the bonfire.
- Circa 18 mins, a further reaction occurred which dispersed packaging from the bonfire.
- > On completion, the majority of tubes were recovered.



## **Conclusions**

> The selection of explosive fill has improved the IM signature.

- No reaction to bullet impact.
- Small number of fragments in EMTAP35 Tube test.
- The density of the HE pellets is critical to the IM performance.
   Lower density pellets burned in a previous bullet impact trial.
- The packaging design prevents sympathetic propagation within the logistic box and from box to box.
- The packaging protects the product for circa 15 mins in a bonfire before any reaction is observed.

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# **Any Questions ?**

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