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Land Armaments Directorate



IM Upgrade of Italian Army DM111 155 mm Artillery Projectile

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NDIA Insensitive Munitions & Energetic Materials Technology Symposium, April 2021

IM Upgrade of Italian Army DM111 155 mm Artillery Projectile

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Introduction

- The Land Armaments Directorate (*Direzione Armamenti Terrestri, DAT*) are the department within the *Ministero della Difesa* in Italy responsible for technical development and procurement of artillery
- DAT asked RWM Italia to demonstrate the feasibility of reloading its stock of DM111 projectiles, which are currently loaded in Composition B
 - 64 × DM111 rounds were demilitarised and provided to RWM Italia
- In October 2015, RWM Italia signed a **Cooperative Research and Development Agreement** (CRADA) with the US Army Combat Capabilities Development Command (CCDC DEVCOM) at Picatinny Arsenal (formerly known as ARDEC)
- CCDC DEVCOM and BAE Systems OSI at Holston have developed a range of less sensitive melt-cast explosives:
 - Large-calibre artillery (105 and 155 mm): **IMX-101** to replace TNT fills
 - Mortar ammunition (60 and 81 mm): **IMX-104** to replace Composition B fills
 - Large improvement in IM characteristics, while maintaining lethality for the user

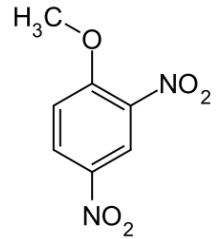
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Modernisation of the DM111 Design: Explosive Materials

- Existing projectile utilises Composition B with an RDX/wax booster
- Energetic materials upgraded to less sensitive explosives
- Main charge explosive in IMX-104**
 - Melt-cast: same infrastructure as TNT/Comp B filling

NTO	DNAN	RDX
53 %	32 %	15 %

- Removable booster (Supplementary Charge) in PBXN-9**
 - 92 wt% HMX-based, pressed explosive composition
 - Successful history in munitions that perform well in IM tests
 - Including in the US Army's 155 mm artillery rounds
 - Booster can be removed to allow use of a deep intrusion fuze



2,4-dinitroanisole (DNAN)



IMX-104 flakes



PBXN-9 booster

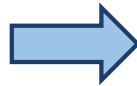
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Modernisation of the DM111 Design: Lifting Plug

- Use of meltable ionomeric plastic fuze plug
 - Melting point $\sim 125^{\circ}\text{C}$
 - Provides a venting path in cook-off scenarios (as we shall see later)



Old style steel plug



Meltable plastic plug



Ejected plastic plug after FCO test

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Development of the IMX-104 Melt-Cast Loading Process

- Upgrade of RWM Italia's melt-cast filling plant at Domusnovas in Sardinia
 - Higher m.p. of DNAN-based explosive (95 °C) vs TNT-based explosive (80 °C)
- Filling tooling:
 - Water-filled carts and cooling chambers to cool in a controlled manner
 - Ensures high-quality casts (free of piping, shrinkage porosity, etc.)
- Development of process for radiographic examination process
 - To ensure that we are getting high quality X-ray images so that we're sure we're actually seeing any defects present in the cast



Result: rounds meet the applicable requirements for cast quality in 155 mm projectiles

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Testing Phase 1: Reliability of Initiation Train

- Essential to show that:
 - The fuzes already in service with Italian Army reliability initiate new PBXN-9 booster
 - And also that the PBXN-9 booster initiates the IMX-104 main charge
- Series of tests carried out at the DAT artillery test centre at Nettuno near Rome, across the range of anticipated operational temperatures:
 - Cold (-46 °C); ambient temperature; hot (+63 °C)
- Instrumentation (blast overpressure and high speed video) provided by DAT
- **All tests showed full detonation of the explosive train**



0.0 ms



0.1 ms



0.2 ms

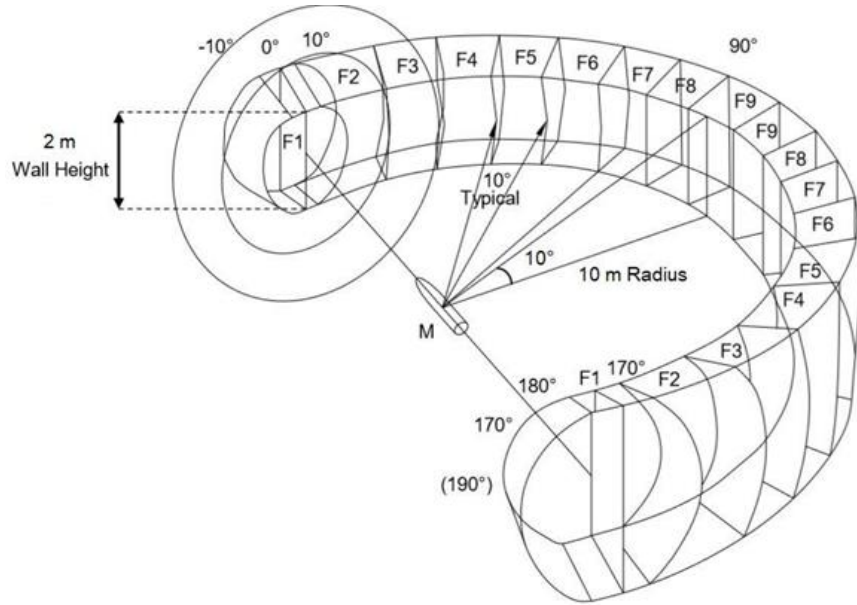


0.3 ms

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Testing Phase 2: Fragmentation/Performance Tests

- Full fragmentation arena trials, as per ITOP 4-2-813, were carried out at COTEC



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Testing Phase 2: Fragmentation/Performance Tests

- Full fragmentation test results are **CLASSIFIED**
- But we can say:
 - Fragment velocities slightly lower than L15/Comp B, but this was expected
 - Spatial and mass distribution of fragments also slightly different
- But **overall**, lethality of the DM111/IMX-104 is equivalent to that of the old projectile

	Composition B	IMX-104
Velocity of Detonation	7900 m/s	7400 m/s
Pressure of Detonation	260 kbar	240 kbar

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Testing Phase 3: IM Tests: Fast Cook Off

- Liquid fuel fire test in accordance with AOP-4240 at COTEC (UK)
- Plastic lifting plug and booster ejected and recovered a few metres from the hearth
 - No reaction of the PBXN-9 explosive in the booster
- IMX-104 main charge burned out in around 10 minutes



Type V - Burning

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Testing Phase 3: IM Tests: Slow Cook Off

- Test carried out at 15 °C per hour as required by AOP-4382 at COTEC (UK)
- First signs smoke seen at approximately 190 °C (oven temperature)
- Explosive burned from the top down in around 35 minutes
 - (Temperature plot appended to this presentation)
- Plastic lifting plug not ejected – merely softened and hot gases vented around it

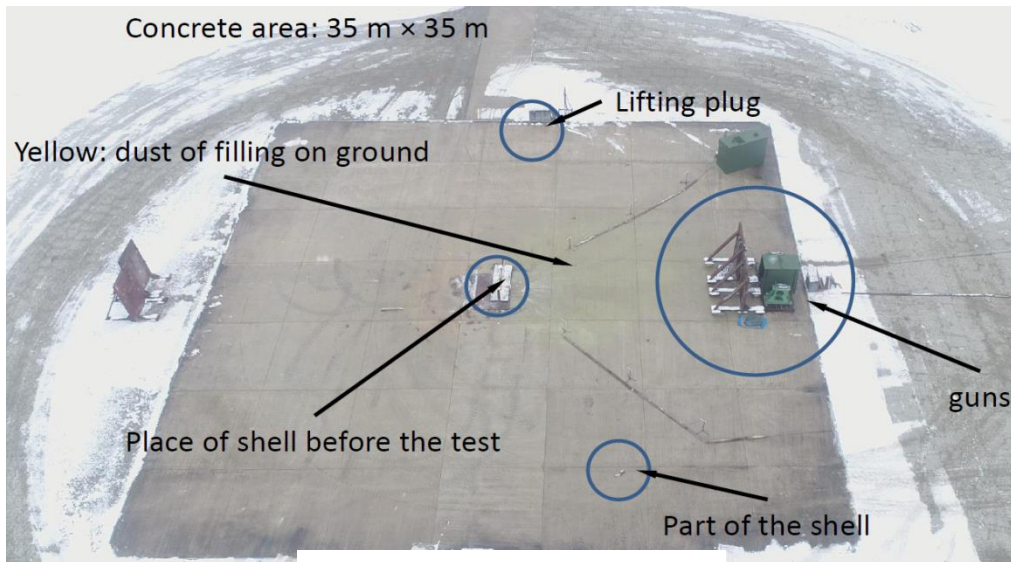


Type V - Burning

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Testing Phase 3: IM Tests: Bullet Impact

- Test performed at RWM Unterlüß (Germany)
- Three-round burst of .50" (12.7 mm) AP ammunition
- No evidence of reaction of the explosive
- But steel lifting plug (750 g) was ejected ~19 m
- Possibly Type V reaction with plastic lifting plug



Type IV - Deflagration

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Testing: Summary

1. Initiation tests show that the new explosive train functions with the Italian Army's in-service fuzes across the range of operating temperatures
2. Lethality is equivalent to the existing in-service L15/DM111 rounds loaded in Composition B
3. But the DM111 projectile loaded in IMX-104 performs significantly better in the Insensitive Munitions tests

	Fast Heating	Slow Heating	Bullet Impact
<i>Requirement from STANAG 4439</i>	<i>Type V</i>	<i>Type V</i>	<i>Type V</i>
DM111/IMX-104	Type V	Type V	Type IV
L15/Comp B (from MSIACAIMS database)	Type III	Type II	Type III*

* BI Test result for an M107 projectile loaded in Composition B, rather than an L15

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Acknowledgements

- Italian Ministry of Defence:
 - Donation of the old DM111/Comp B rounds
 - Use of the DAT firing range, instrumentation, and facilities at Nettuno
- The US Army CCDC DEVCOM technical team:
 - Scott Faluotico and Erik Boykin for development of the IMX-104 loading process
 - Scott McClain for development of the X-ray process
 - Phil Samuels and Keyur Patel for advice on the selection of explosive materials, and on the test procedures and methods
 - Lethality Analysis Group for advice with the analysis of the fragmentation tests
- RWM Italia:
 - Fabio Mantega and his Production Line B team at Domusnovas, who actually did all the hard dirty work of loading the rounds, machining the fuze cavities, etc.



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IM Tests: Slow Cook Off temperature plot

