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MULTIROLE APFSDS-T EXPANDING THE TRADITIONAL TERMINAL BALLISTICS FOR MEDIUM CALIBRE APPLICATIONS

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This paper describes analysis and recent findings on the performance with a new design philosophy implemented in a medium calibre APFSDS-T ammunition.
It is clear that the traditional armor defeating role represents only a portion of the capacity of a sub-calibre penetrator system designated for use with modern combat vehicles, and a new arena of targets like bunkers, buildings, high speed boats and submerged mines are analysed in a network of international expertise and programmes.
In this work extensive use of simulation tools are beeing presented together with recent terminal ballistic performance recorded from tests.
The new methodology has been implemented in the development process and represents a new way of optimization in the interior, exterior and specifically the terminal ballistics phase aimed at safe, reproducable and optimized performance.

INTRODUCTION

This presentation covers ballistic analysis and performance of a sub-calibre ammunition designated for use with medium calibre gun systems. The ammunition concept integrates innovative technology enhancements with well known principles of functioning. As a result, an ammunition with multi-role capability for the modern infantry combat vehicle is now qualified with state-of-the art performance.

The optimization process of a modern sub-calibre sabot design, utilizes simulation tools that allows for in-bore analysis of the penetrator-sabot dynamics. In the separation and exterior ballistics phase, a new approach utilizing Computer Fluid Dynamics, CFD, simulation tools enabled reduction of drag and increased downrange stability.

In the terminal ballistics phase, finally, 3-D Finite Element, FEM, simulation clearified and calculated state-of-the-art penetration capability.

This ammunition type is qualified for the Norwegian Army IFV, the CV9030N, the Swiss Army IFV, CV9030CH and the USMC-AAAV advanced amphibious assault vehi-

cle equipped with a 30 mm Bushmaster II MK 44 automatic gun. As a result of extensive testing of the penetrator, it is clear that the likelihood of defeating other targets then armoured vehicles is significantly increased compared to more traditional designs of medium calibre penetrators as discussed in the paper.

BACKGROUND

A traditional engagement scenario for medium calibre ammunition is highlighted in Figure 1.

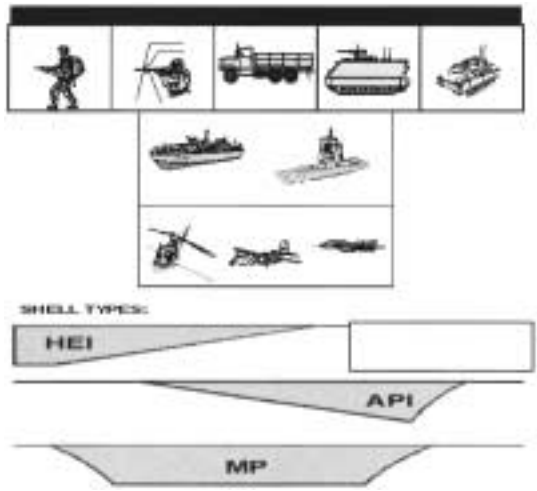

Figure 1.

It is obvious that the need to overlap the gap between a normal full-calibre ammunition like the HEI and a sub-calibre APFSDS-T exists, but the solution on the problem is unexplored with earlier penetrator designs since they were aiming at more armour penetrating capacity.

ANALYSIS APPROACH

The need for armour penetrating performance was still a dominant factor in the analysis of the new penetrator design. The use of PC-based finite element codes [1], enabled parametric studies of the penetrator design to ensure the fulfilment of the armour requirement. In this work, several different impact conditions were studied, and the influence of projectile yaw and yaw rate at impact was analysed. Based on this work, several improvements on the projectile exterior flight behaviour was made to minimize the performance reduction. Figure 2. This was the base for penetrator nose modifications.

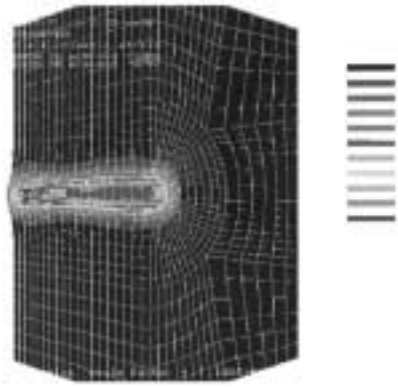

Figure 2.

The traditional penetrator shape comprises a ballistic wind-screen to ensure a minimum of nose shape induced drag. This screen is typically made of aluminum to minimize efforts within production. In our efforts, we discovered that a stretch of the penetrator material, WNiCo, was the best combination of low drag and high penetration capacity. The penetration capacity of a point sharp nose is demonstrated in Figure 3. The penetration performance was increased with 30% over a baseline design with blunt nose and an aluminum wind screen. Penetrator data in Table 1.

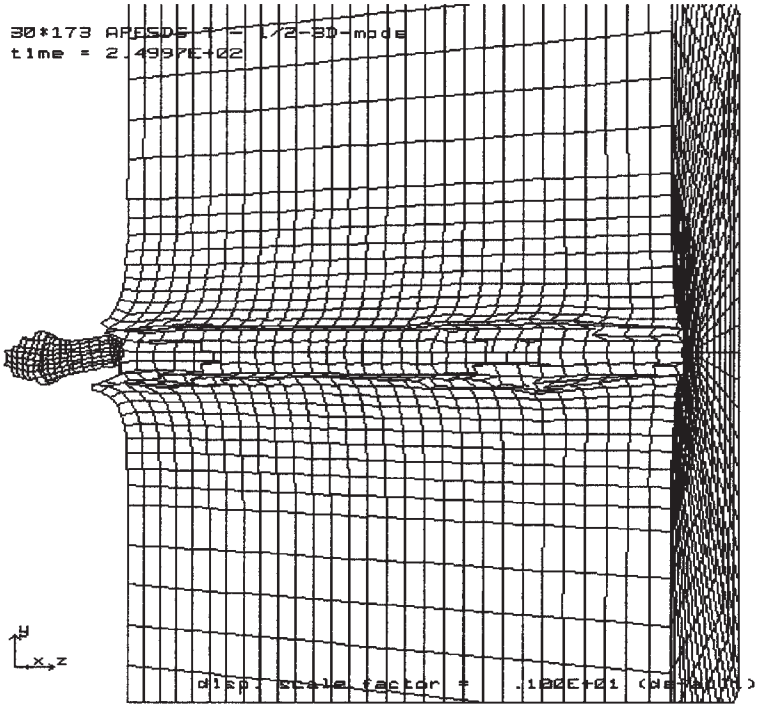

Figure 3.

Table 1.

Configuration	Penetrator mass,g	Velocity,m/s	Residual vel,m/s	Penetration,mm
Baseline	153	1400	0	88
Modified sharp	153	1420	780	115

In order to calculate the penetrator performance in an oblique, multiplate target array, the simulation tool DYNA3D was used. [2]. The results from a 3D analysis of a 10 mm +25 mm RHA target at 70 deg. NATO is described in figure 4.

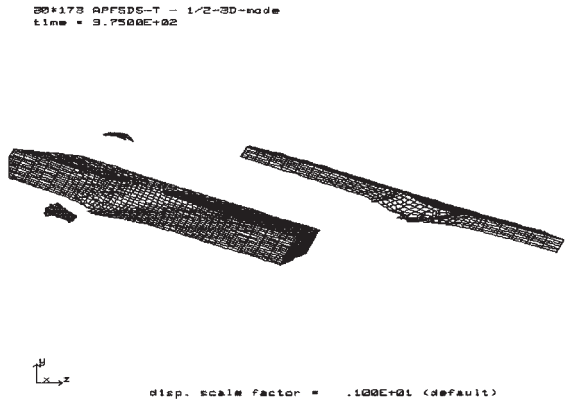

Figure 4.

Based on the analysis of the penetration behaviour in an oblique target, the need for a modified nose that could adapt to modifications of any such target array was discovered. The introduction of a notch in the forward section of the penetrator was introduced, the NSN concept. This weak zone of the tip is determining the onset of penetrator perturbation, i.e penetrator break-up. To explore this phenomena, a target of nearly isotropic concrete was designed and tested with the dimensions 600 x 600 x l200 mm and strength 24 MPa. Figure 5 and 6.

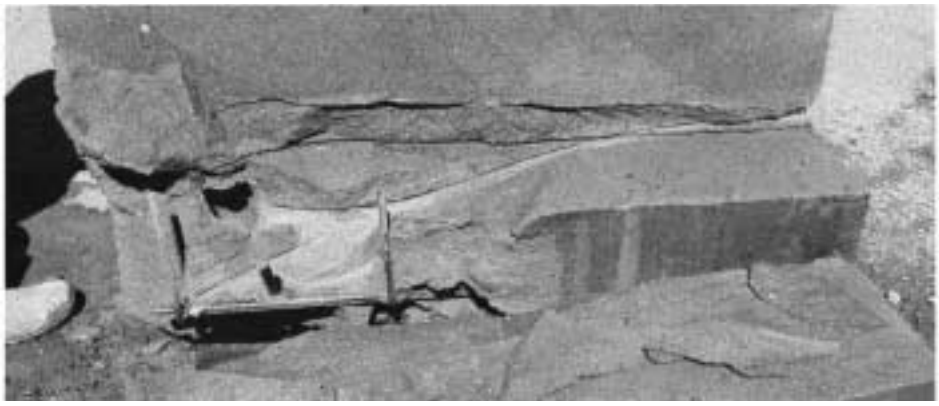

Figure 5.

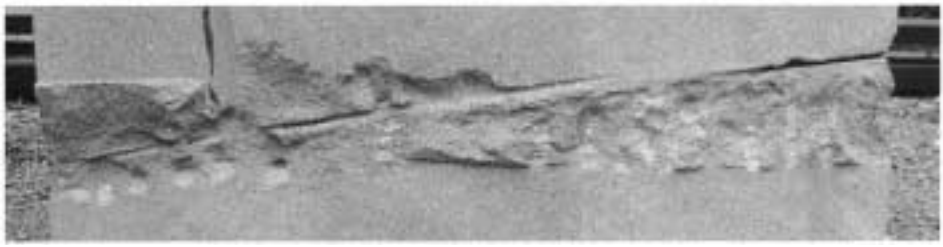

Figure 6.

The tests indicated that the onset of perturbation and penetrator break-up could be influenced by the introduction of a notch in the penetrator tip region. With the perturbation of the penetrator a significant improvement in the number of fragments and damage to the target was recorded. This also introduced a significant improvement potential on the lethality of the penetrator, not only giving one hole in-one hole out performance.

RESULTS

As a result of the analysis, a modified set of targets have been possible to evaluate. In the process of gathering target information, it is clear that a mix of concrete and armour targets does represent a modern threat, also recognized from military operations in urban terrain. In order to evaluate the perturbation process of the penetrator, a target set-up was described as in Figure 7.

– 5 rds burst from the Bushmaster II MK44 mod 1 (chromed 0–7,5 deg)
– Reinforced Concrete block 1500 x 1500 x 300 (5ft x 5ft x 1ft)
– Strength C55; Double matrix 12,7 mm re-bar; Grain < 8 mm
– 10,6 mm ARMOX MIL-A-12560 with hardness HB 367
– 3 mm Steel witness plate of size 2000 x 2000 approx.

Figure 7. The results from a realistic engagement when firing a five round burst is presented in Figure 8.

Figure 8. Concrete front and rear side.

The penetration of concrete was studied according to [3], and found to be in close description for an ideal, symmetric penetration. In this test, each penetrator was subjected to high transversal loads as the vicinity of the penetrator was damaged from the creation of a nearby penetration channel in the five round burst scenario. This added to the onset of perturbation and the rotation of the residual penetrator departing on the rear side of the concrete block and the striking the 10,6 mm ARMOX plate after 1,5 m of air-space. Figure 9.

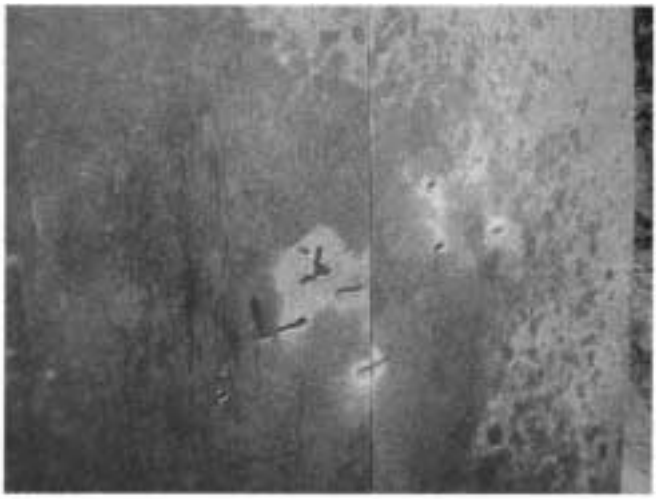

Figure 9.

The residual penetrator broke up into 3 parts, giving a total amount of fragments equal to fifteen striking the ARMOX plate. The amount of fragments was then multiplied to 150 in the 3 mm steel witness plate. Figure 10.

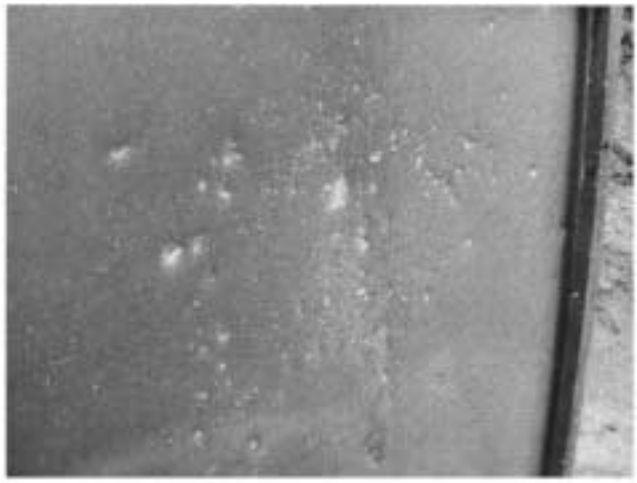

Figure 10.

This test was conducted four times, giving the same number of fragments in the ARMOX plate and an average of 150 +/-20 fragments in the 3 mm witness plate. The results are encouraging, since the level of repetitiveness is very high between tests. The importance of this phenomena is not to be under-estimated. It could change the importance of a medium calibre APFSDS-T and enable safe, precise operations on urban terrain with little damage to other structures besides the target. The possibility of using the described concept for underwater applications, such as mines, have been evaluated by [4], with important milestones within reach in close future.

CONCLUSIONS

This work is related to the qualification of a new family of medium calibre ammunition. This ammunition is likely to be fielded and used for many years to come. The importance of further understanding of the phenomena described is critical. This could be done within national research, but the ammunition is addressing an international need, and therefore continued research in an international network is required. To summarize the findings at this point we understand that:

– Penetration capability increased 30% compared to early baseline design of penetrator tip
– Aluminum wind screen is not preferred
– A sharp penetrator tip with a weak zone, NSN, has adaptivness to a set of modified targets
– Onset of penetrator perturbation gives a rapid increase in lethal fragments
– Modified penetrator gives a multirole capability with concrete and armour
– A modified tungsten nose enables underwater applications
– Perturbation control parameters needs to be further analyzed

ACKNOWLEDGEMENTS

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