11 February 2022

EVALUATION OF THE USE OF NON LEAD AMMUNITION AT THE NATIONAL SHOOTING CENTRE
19 September 2021

Evaluation Participants

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INTRODUCTION

1. The Government is considering a ban of lead ammunition as part of new plans under Registration, Evaluation, Authorisation and Restriction of Chemicals (UK REACH). The Environment Agency, together with the Health and Safety Executive, have started a two-year process to review the evidence. It is likely there will be new legislation to phase out the use of lead ammunition across all environments in England, Scotland and Wales.

2. Currently the use of non-lead ammunition (NLA) is not permitted on ranges at the National Shooting Centre. The MOD has not tested NLA to determine its suitability, thus ballistic data is not available from the usual source used in design of ranges in the UK. The NRA has carried out a comparative firing trial to compare and contrast the characteristics of lead and non-lead ammunition with a view to providing evidence that the use of NLA on constructed ranges offers no more risk than the use of traditional full metal jacket lead ammunition.

3. Sand bullet catchers are not completely effective in retaining high velocity bullets. The design requirements for ranges making use of such bullet catchers allows for this by requiring a canopy over the catcher or a 100 metre danger area behind. Empirical evidence over many years use of ranges indicates that such measures are effective. Given that the danger area applied on a Gallery Range to contain other types of ricochet from high velocity ammunition typically extends 1830 metres beyond the target, it follows that regardless of the precise nature of a ricochet out of the bullet catcher, the residual energy of such a ricochet is relatively small.

AIM

4. The aim of the Evaluation was to provide assurance that Non Lead Based Ammunition (NLA) presents no greater risk than Lead Based Ammunition (LBA) when fired on constructed ranges into sand bullet catchers.

OUTLINE

5. The following properties and characteristics were compared during the evaluation:

    a. Ricochet when fired into a sand bullet catcher
    b. Muzzle velocities
    c. Terminal velocities
    d. Accuracy and consistency

Ricochet characteristics off the range floor and off range structures other than the bullet catcher were not explored. It follows that if NLA is accepted for use on NRA ranges, measures must be put in place to mitigate the risk of such ricochet until the characteristics are confirmed as not creating additional hazard.

6. A direct examination of the penetration, expansion and fragmentation characteristics of NLA was carried out.

7. Ammunition types used in these evaluations were:

    a. .308 LBA (FMJ GGG 155gr Match ammunition)
    b. .243 LBA (PPU 100gr SP ammunition)
    c. .243 NLA (Fox Classic Hunter 80gr expanding ammunition)
    d. .308 NLA (Fox Classic Hunter 130gr expanding ammunition)

The use of Fox ammunition in this evaluation is not an endorsement or promotion of the manufacturer or the ammunition itself.

SUMMARY OF RESULTS

8.

a. **Ricochet**. When fired into a reasonably maintained sand bullet catcher neither NLA nor LBA exhibited ricochet in the trial sample. Ricochet is known to occur with LBA. Thus it can be concluded that ricochet of LBA is, at worst, reasonably infrequent. (See Annex A).

b. **Muzzle Velocity**. The spread of muzzle velocities in a variety of combinations of calibre, bullet type and barrel length was not such as to have a significant effect on bullet capture. NLA is often deliberately loaded to give higher MV to compensate for lighter projectiles. Such performance was demonstrated in the tests, to the extent that, from a 24" barrel (long for a hunting rifle), the range velocity limit of 1000 m/s was routinely exceeded. (See Annex B).

c. **Terminal Velocity**. NLA can be expected to lose velocity more rapidly than LBA of the same dimensions; the tests demonstrated that. (See Annex B).

d. **Accuracy and Consistency**. All NLA calibres consistently shot tighter groups than LBA. All the groups of both ammunition types were small enough that dispersion was irrelevant to bullet capture given the size of a typical bullet catcher.

e. **Penetration, Expansion and Fragmentation**. The NLA bullets exhibited reliable expansion and / or fragmentation on impact. That expansion / fragmentation absorbs energy and increases drag in any medium, both of which effects improve the ability of range structures to capture the bullets. (See Annex C).

CONCLUSION

9. None of the characteristics of NLA examined would, of themselves, make capture of the projectile on a range less likely than capture of an equivalent LBA bullet. NLA bullets exhibit more rapid velocity decay than equivalent LBA bullets, and expand or fragment reliably on impact. Both these factors tend to improve bullet capture in range structures compared with LBA. A functional test of bullet capture in sand showed no escape of bullets or bullet fragments in 300 rounds. NLA ammunition in some combinations of firearm and calibre marginally exceeded the range velocity limit.

RECOMMENDATION

10. The National Shooting Centre should permit the use of NLA on Gallery Ranges subject to:

a. Inclusion of use of NLA as a specific item in the Bisley Ranges Regulations

b. A procedure and controls that:

i. Forbid the use of NLA that is not designed to expand
ii. Implement regular inspection and maintenance of the bullet catcher where NLA is to be fired

c. A check of zero and grouping of the shooter rifle and ammunition combination at a maximum distance of 100 metres under the supervision of a NRA RCO, RSO or NSC Range Office Supervisor; for further details refer to [website link]

d. Limitation to use at a maximum distance of 300 metres, which again keeps the cone of fire off the range floor subject to the demonstration of zero and grouping at 100 metres even if sights are not correctly adjusted for the greater distance.

Andrew Mercer
Chief Executive
National Shooting Centre

ANNEXES:

Annex A: Comparative Assessment of Ricochet Properties
Annex B: Comparative NLA and LBA Muzzle and Terminal Velocities
Annex C: Consistency
Annex D: Penetration and Expansion of NLA on Impact
Annex E: Equipment Employed

COMPARATIVE ASSESSMENT OF RICOCHET PROPERTIES

Methodology

1. Correx (target backing material) "Shoot In" boxes were constructed and installed on the Century Range stop butt. A total of 3 x boxes were situated on Lanes 85, 86 and 87. The boxes were located to cover the MPI generated when an NRA Round Bull target is mounted on an 1830 x 1830mm target screen and exposed in the standard Hythe frame. There was no special preparation of the stop butt, which had been heavily shot upon during the preceding weekend and can therefore be assumed to be heavily contaminated with lead based projectiles.

2. In excess of 150 rounds were fired accurately into each box:

   a. There was no significant "backsplash" indicated on the front of the correx boxes
   b. The side walls were not penetrated
   c. All box tops were penetrated and marked by materials being ejected from the sand. **There was no evidence that projectiles were ricocheting off the surface of the sand or "bouncing back" out of the sand**

3. Each box was designated to receive shots from a particular type of ammunition.

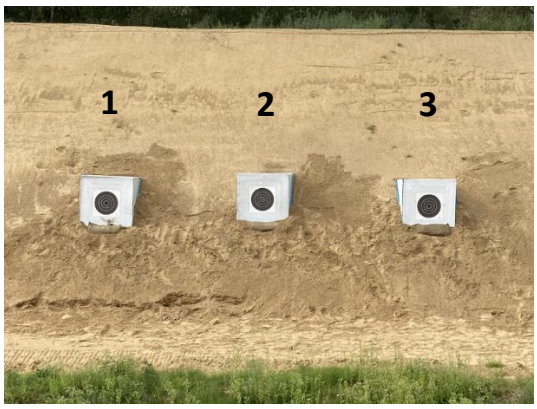

Fig 1 Correx Shoot-in Boxes

Box 1:
.308 LBA (FMJ GGG 155gr Match ammunition) &
.243 LBA (PPU 100gr SP ammunition)

Box 2
.243 NLA (Fox Classic Hunter 80gr expanding ammunition)

Box 3
.308 NLA (Fox Classic Hunter 130gr expanding ammunition)

CONCLUSION

4. When fired into a sand stop butt that has been maintained to a reasonable standard, ricochet of NLA is, at worst, an infrequent occurrence.

COMPARATIVE LBA AND NLA MUZZLE AND TERMINAL VELOCITIES

Concept

1. Basic ballistic theory states that given two projectiles of the same dimensions, the lighter one will lose velocity more quickly because the drag force causing the loss is dependent on the dimensions but the resistance to loss comes from inertia (in ordinary language the weight of the projectile). There is thus a design decision as to the extent to which muzzle velocity should be increased when using a non-lead projectile so as to achieve similar terminal effects to LBA. Also, non-lead projectiles can be manufactured, either deliberately or as an unintended consequence of the shape and process, to have improved aerodynamics. This comparison provides an indication as to whether the effect of increased muzzle velocity and aerodynamic improvement is significant in relation to the effect of reduced density.

Methodology

2. Shots were fired using LBA and NLA from various barrel lengths. Velocities were measured at the muzzle using a Labradar chronograph which is a Doppler type radar. Terminal velocity was measured at the target using a Shotmarker electronic target which uses acoustic sensors to determine the strike position and calculate velocity. Combinations compared were limited by the firearms available.

Comment

3. Drag due to air resistance is related to a power greater than 1 of the instantaneous velocity. The power itself varies indirectly with velocity because of associated changes in the behaviour of air, particularly as the Mach number (the speed of the projectile relative to the speed of sound) increases above M1. A consequence is that, in general, the velocity change over distance of a bullet should be greater nearer to the muzzle. Thus the figures tabulated below for 100 yds, which show velocity change figures inconsistent with manufacturers' data and significantly less than half of those for 200 yds and significantly less than one-third of those for 300 yds, should be treated with great caution.

Analysis

4. In every case, for the same calibre and barrel length, NLA gave a higher muzzle velocity than LBA.

5. In every case beyond 100 yds, for the same calibre and barrel length, NLA suffered greater loss of velocity than LBA.

6. Terminal velocities, for the same calibre and barrel length, were very similar for both ammunition types at 300 yds.

7. Fired from a 24" barrel, NLA in .243" calibre exceeded the range limit on muzzle velocity in six shots from ten. Two of the four shots at 100 yds were still above the range limit at the target. The range limit is 1000 m/s (3281 ft/s) which is rather obviously a limit with an element of rounding in the choice of value.

8. The spread of muzzle velocities if data from 100yds is included is atypical of expected performance of commercial ammunition. If the data from 100 yds is excluded, the results are typical, and not such as to produce a significant variation in accuracy over distances up to 300 yds.

9. Tables of velocities

At 100yds:										Mean Vel Loss
Barrel		MV1	TV1	MV2	TV2	MV3	TV3	MV4	TV4	
20	.243 LBA	2489	2435	2515	2453	2758	2606			89.33
20	.243 NLA	3053	3002	3024	2992	3035	2963	3107	2951	77.75
24	.243 LBA	2962	2922	2935	2880	2951	2923			41
24	.243 NLA	3412	3347	3005	2879	3295	3177	3408	3365	88
24	.308 LBA	2682	2597	2805	2677	2737	2610			113.3
24	.308 NLA	3043	2977	3041	2961	3048	2959			78.33
30	.308 LBA	2964	2920	2898	2866	2913	2875	2920	2895	34.75
30	.308 NLA	3211	3149	3209	3139	3205	3165			57.33
At 200yds:										
Barrel		MV1	TV1	MV2	TV2	MV3	TV3	MV4	TV4	
20	.243 LBA	2701	2200	2704	2210	2716	2190			507
20	.243 NLA	3092	2368	3050	2345	3128	2407			716.7
24	.243 LBA	2884	2360	2923	2385	2903	2363			534
24	.243 NLA	3237	2510	3264	2529	3285	2504			747.7
24	.308 LBA	2821	2430	2848	2445	2842	2443			397.7
24	.308 NLA	3060	2436	3039	2426	3049	2413			624.3
30	.308 LBA	2977	2597	2998	2605	3004	2603			391.3
30	.308 NLA	3219	2556	3231	2579	3194	2552			652.3
At 300yds:										
Barrel		MV1	TV1	MV2	TV2	MV3	TV3	MV4	TV4	
20	.243 LBA	2759	1979	2736	2134	2715	1919			726
20	.243 NLA	3118	2045	3066	2005	3067	2064			1046
24	.243 LBA	2969	2158	2946	2134	2971	2114			826.7
24	.243 NLA	3315	2223	3281	2251	3220	2147			1065
24	.308 LBA	2869	2243	2813	2182	2825	2063			673
24	.308 NLA	3064	2064	3053	2052	3054	2063			997.3
30	.308 LBA	2996	2364	2998	2412	2996	2398			605.3
30	.308 NLA	3235	2201	3154	2137	3211	2175			1029

Muzzle Velocities		100 yds				200 yds			300 yds				All distances			200+		
Barrel		MV1	MV2	MV3	MV4	MV1	MV2	MV3	MV1	MV2	MV3	Mean	Max	Min	dV	Max	Min	dV
20	.243 LBA	2489	2515	2758		2701	2704	2716	2759	2736	2715	2677	2759	2489	270	2759	2701	58
20	.243 NLA	3053	3024	3035	3107	3092	3050	3128	3118	3066	3067	3074	3128	3024	104	3128	3050	78
24	.243 LBA	2962	2935	2951		2884	2923	2903	2969	2946	2971	2938	2971	2884	87	2971	2884	87
24	.243 NLA	3412	3005	3295	3408	3237	3264	3285	3315	3281	3220	3272	3412	3005	407	3315	3220	95
24	.308 LBA	2682	2805	2737		2821	2848	2842	2869	2813	2825	2805	2869	2737	132	2869	2813	56
24	.308 NLA	3043	3041	3048		3060	3039	3049	3064	3053	3054	3050	3064	3039	25	3064	3039	25
30	.308 LBA	2964	2898	2913	2920	2977	2998	3004	2996	2998	2996	2966	3004	2898	106	3004	2977	27
30	.308 NLA	3211	3209	3205		3219	3231	3194	3235	3154	3211	3208	3235	3154	81	3235	3154	81

CONCLUSION

10. At distances up to 300 yds, neither consistency of velocity nor velocity decay with distance of NLA differ enough from those of LBA to raise a concern over the safety of NLA of the type tested on a range designed for LBA of similar calibre.

11. One combination of firearm and ammunition resulted in the range velocity limit being routinely exceeded. Design decisions leading to higher muzzle velocity as a means of retaining trajectory and terminal effect with a lighter bullet make such exceedance more probable with NLA than with LBA. Whether exceeding range limits is of significance should be considered in the light of other aspects of NLA performance.

CONSISTENCY

Methodology

1. A series of 5 round groups were fired from 100 and 300yds in order to compare consistency of LBA and NLA

Calibre	Barrel	Distance	LBA (moa)	NLA (moa)
.243	24	100	0.76	0.54
.308	24	100	0.57	0.5
.243	20	300	1.73	1.4
.308	24	300	1.01	1.23
.308	30	300	1.48	1.36

Conclusion

2. The NLA were generally more consistent and grouped better than the LBA projectiles. All the groups were small enough that dispersion was irrelevant to bullet capture given the size of a typical stop butt.

PENETRATION AND EXPANSION

1. Shots were fired from 100, 200 and 300 yards into a line of 3 x 25litre water filled plastic drums.

2. The .308 projectile was not contained within the 3 x drum line, and therefore not retrieved, until the number of drums was increased.

Comment

3. The containment of a bullet on a range depends on capturing its energy and reducing its aerodynamic efficiency so as to bring it to a stop in a reduced distance compared with free flight. A bullet designed to expand on impact will absorb energy in the process of expanding and as a result of the expansion will have a form that is less aerodynamic and thus more prone to stop whether in air or a heavier medium. Reliable expansion is thus a positive feature in improving safety of operation on a range.

.243 at 100yds Petals were held in Barrel 2 Remaining slug held in Barrel 3		
.308 at 100yds 3 x barrels penetrated petals remained intact Projectile held in Barrel 4		

.243 at 200yds 1 x barrel penetrated petals remained partially attached Projectile held in Barrel 2		
.308 at 200yds 3 x barrels penetrated round not captured		
.243 at 300yds 1 x barrel penetrated petals remained partially attached Projectile held in Barrel 2		
.308 at 300yds 3 x barrels penetrated round not captured		

Conclusion

4. NLA hunting bullets expand reliably across the range of distances that they might reasonably expect to be employed over. That reliable expansion is likely to improve the ability of range structures to capture such bullets when compared with bullets not designed to expand (such as jacketed target shooting bullets).

EQUIPMENT EMPLOYED

The following equipment was used during the evaluation:

a. Firearms

Howa 1500 in .243
Howa 1500 in .308
Sako A7 in .243
Dolphin in .308

b. **Ammunition**

.243 Fox Classic Hunter 80gr
.308 Fox Classic hunter 130gr
.243 PPU SP 100gr
.308 GGG Match 155gr

c. **Chronograph**

Labradar – Doppler radar

d. **Targetry**

Paper target face mounted on correx backing
Plastic 25 litre adhesive drums filled with water
Terminal Velocity -Shotmarker electronic target – utilising acoustic sensors