Small Arms Ammunition and Personal Armour – Standards versus the Real World

PL Gotts

Phil Gotts Consulting Ltd, 23 Thorney Rd, Capel St Mary, Ipswich, Suffolk, IP9 2HL, UK
phil@philgotts.com

Abstract. Much personal armour is designed to protect the wearer from specified types of small arms ammunition. The definition of these small arms ammunition threats may be included within a user requirement, or may be referenced in a ballistic test standard or method. Either way there will be a definition of an ammunition type, combined with an impact velocity, a shot pattern and perhaps some other associated pieces of information, all of which theoretically allow the armour testing to be conducted. The easiest option for the specifier of personal armour is to use a test standard which includes specified levels of ammunition. However, the available ammunition found in the test standards may not reflect the required protection levels from an operational perspective. There is also the possibility that ammunition required for armour testing from an operational perspective may not be suitable as test ammunition for some reason. This paper explores the relationship between ammunition specified in armour standards and the ammunition most relevant for real life scenarios. Both military and law enforcement environments are considered. As a common ammunition calibre used for soft body armour testing, 9 mm ammunition of different configurations is discussed. As perhaps the most common real world threat to hard armour upgrade plates, 7.62 x 39 mm ammunition of different configurations is discussed. As one example, the latest version of the UK Home Office Body Armour test standard is discussed, with respect to the choice of test ammunition, both what has been included and what has been omitted or made optional. These ammunition types are compared to their terminal effects related to armour and the reality of use.

1. INTRODUCTION

One of the major threats for which personal armour is designed, is that of small arms ammunition. The armour may include soft armour components for the defeat of low velocity handgun and sub-machine gun ammunition and/or upgrade plates for the defeat of high velocity rifle and machine gun ammunition. When the user of personal armour, or their representative, needs to specify the small arms ammunition threat regime for their armour, they need to make decisions as to which ammunition types to include. The immediately obvious choice would be for ammunition which the user of the personal armour is likely to encounter during the conduct of their duties. However, this may not always be the best option.

One ammunition type which is included within many Western body armour standards is the 9 mm FMJ (full metal jacket) Luger and the history and use of this ammunition has issues associated with it.

An interesting ammunition type with respect to the trade-off between realism and repeatability is the 7.62 x 39 mm Russian.

At the end of July 2017 the UK HO CAST (Home Office Centre for Applied Science and Technology) published its first new body armour standard for 10 years [1], and this includes a different approach to the ammunition specified, which in part addresses some of the aspects of realism versus repeatability, as well as the blue-on-blue possibility.

2. TEST STANDARD AMMUNITION VERSUS REAL LIFE

In an ideal world, the ammunition chosen to be used for the testing of personal armour should be both realistic and repeatable. In order to be realistic, it should represent a ballistic threat which the particular user community would be expected to encounter during the conduct of their duties. In order to be repeatable the chosen ammunition should be manufactured within close tolerances, such that one shot interacts with the personal armour in the exact same manner as all other shots for the same impact scenario. Unfortunately in many cases the requirements for repeatability and realism may not be achievable with the same ammunition type.

In those situations where the requirements for repeatability and realism cannot both be met, a decision needs to be made as to which of the two requirements takes priority. In most cases the need for repeatability takes priority, and this determines the ammunition types usually included in the test standards. This is one reason that many test standards are criticised as being unrealistic with regards to test ammunition.

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One source of ammunition which is renowned for causing repeatability issues is anything manufactured within the former Eastern Bloc countries. It is for this reason that former-Soviet ammunition is quite rare in Western body armour test standards (it is however more common in vehicle armour standards). Some former-Soviet ammunition types do appear in VPAM (Vereinigung der Prüfstellen für angriffs-hemmende Materialien und Konstruktionen) APR 2006 [2] levels 6, 8 and 10 and have also been included within levels B4, C4 and C6 of AEP-2920 [3]. In both of these cases, there are also Western and/or NATO ammunition types included within the standard. The Russian GOST 50744-95 Armour Clothing standard [4] uses only ex-Soviet ammunition types.

3. 9 mm TEST AMMUNITION

The 9 x 19 mm FMJ ammunition is often used as a test round for soft body armour. Over the years certain specific designations of this 9 mm ammunition have been used. The choice of the ammunition has partly been dictated by its availability, and partly by its consistency and/or variability.

3.1 Background of 9 mm Parabellum / Luger Ammunition

The 9 mm FMJ ammunition used in body armour testing mainly complies with the generic description of 9 x 19 mm Parabellum or Luger.

The cartridge was developed in 1902 by Georg Luger in Germany, in order to improve the stopping power of his 9 mm pistol, and was adopted by the German Armed Forces before World War One. Initially the bullet was cylindro-conoidal with a flat tip. However, this was found not to always feed smoothly and thus led to weapon jams. Therefore the modification to an ogival shaped bullet was made and this entered service in 1917. It is this later ogival design which is normally used for the testing of soft body armour today.

Figure 1: Typical 9 mm FMJ Bullets

3.2 Body Armour Test Standards and Bespoke Requirements

This section will focus predominantly upon the 9 mm requirements of the UK, US and European Police body armour test standards, although there will also be reference to the historic UK MOD (Ministry of Defence) approach.

3.2.1 PSDB, HOSDB, HO CAST Test Standards

For the UK Police the relevant body armour test standards are those produced by the Home Office, Centre for Applied Science and Technology (HO CAST) and its predecessors; PSDB (Police Scientific Development Branch) and HOSDB (Home Office Scientific Development Branch). Since the first documented standard of 1993, there have been a number of versions of this standard. The 9 mm ammunition appears in more than one test level in every version of the standard.

3.2.2 PSDB Publication No: 12/93 (1993) [5]

Two levels in this standard use 9 mm FMJ Dynamit Nobel ammunition:

- HG1 - 9 mm DM11A1B2 at 330 ± 10 m/s
- HG2 - 9 mm DM11A1B2 at 425 ± 10 m/s

3.2.3 PSDB Publication No: 2/96 (1995) [6]

Two levels in this standard use 9 mm FMJ Dynamit Nobel ammunition:

- HG1 - 9 mm DM11A1B2 at 360 ± 10 m/s
- HG2 - 9 mm DM11A1B2 at 425 ± 10 m/s

Therefore the only change has been an increase in velocity of the HG1 level.

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3.2.4 PSDB Publication No: 7/03/B (2003) [7]

Two levels in this standard use 9 mm FMJ Dynamit Nobel ammunition:

- HG1 - 9 mm DM11A1B2 at 360 ± 10 m/s
- HG2 - 9 mm DM11A1B2 at 425 ± 10 m/s

The use of 9 mm ammunition in this version of the standard is exactly the same as the previous version.

3.2.5 HOSDB Publication No: 39/07B (2007) [8]

Three levels in this standard use 9 mm FMJ Dynamit Nobel ammunition:

- HG1 - 9 mm DM11A1B2 at 365 ± 10 m/s
- HG1A - 9 mm DM11A1B2 at 365 ± 10 m/s
- HG2 - 9 mm DM11A1B2 at 430 ± 10 m/s

The 2007 version includes the addition of the HG1A level which is identical for the 9 mm ammunition and velocity, but allows for 44 mm back-face signature instead of 25 mm.

3.2.6 Summary of UK Home Office Body Armour Test Standards to 2017

In summary, 9 mm ammunition has been included in all versions of the standard and has always been to the DM11A1B2 specification. DM11A1B2 is a generic German specification for the ammunition and does not specify a manufacturer. Initially the ammunition was manufactured by the German company Dynamit Nobel Ammotec GmbH, but this company was acquired in 2002 by the Swiss company RUAG and became RUAG Ammotec AG. RUAG Ammotec AG continued to manufacture the DM11A1B2 for a few years. The Dynamit Nobel ammunition is in theory the same as that manufactured by RUAG. As can be seen from the different versions of the standard, the choice of the Dynamit Nobel / RUAG Ammotec DM11A1B2 has remained constant, but with slightly varying impact velocities. There have also been slightly different levels with the notable addition of Level HG1A for the 2007 version.

3.2.7 HO CAST 2017 [1]

This latest version of the HO standard incorporates the following levels and ammunition:

- HO1 - 9 mm DM11A1B2 (MEN) at 365 ± 10 m/s
  - 9 mm Federal Premium JHP P9HST1 at 365 ± 10 m/s
- HO2 - 9 mm DM11A1B2 (MEN) at 430 ± 10 m/s
  - 9 mm Federal Premium JHP P9HST1 at 430 ± 10 m/s

The addition of the 9 mm JHP will be discussed later.

3.3 MEN DM11A1B2

The DM11A1B2 specification ammunition is also manufactured by MEN (Metallwerk Elisenhütte GmbH), and this is now specified in the 2017 HO CAST Body Armour standard. It cannot however, be guaranteed that the MEN version performs against soft body armour in exactly the same way as the RUAG version. The MEN DM11A1B2 has previously been shown to be more penetrative versus some armour designs than the RUAG ammunition. Jones and Barnes-Warden [9] presented results of a recent study at PASS 2018, which emphasises and explains the differences between the RUAG and MEN versions of the DM11A1B2.

The author has been involved with a series of ballistic testing for a European military organisation, in which the ammunition was suspected of producing a rogue result. The ammunition in this case was identified as an NSN (NATO Stock Number)-marked version of the DM11A1B2 manufactured by MEN, thus further indicating variability in the MEN version of the DM11A1B2.

3.4. NIJ (National Institute of Justice) Test Standards

The US Law Enforcement community are supported by the NIJ (National Institute of Justice) and its predecessor, NILECJ (National Institute of Law Enforcement and Criminal Justice). As with the HO

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CAST standards, the 9 mm FMJ ammunition is used in different levels of the standards. The main difference with the HO CAST standard is that for much of its life the NIJ series of standards, did not provide a specification for the ammunition used, except for it being a 124 grain 9 mm FMJ. This changed only with the NIJ-0101.06 version, for which a specific supplier was suggested.

3.4.1 NILECJ-0101.00 (Mar 1972) [10]

The first version of the NIJ-0101.0n series of body armour test standards did not include any 9 mm ammunition within its test levels.

3.4.2 NILECJ-0101.01 (Dec 1978) [11]

This test standard includes the following levels which incorporate 9 mm 124 grain (8.0 g) FMJ ammunition:

- Level IIA – 9 mm FMJ 124 grain (8.0 g) at 1,090 fps (332 m/s)
- Level II – 9 mm FMJ 124 grain (8.0 g) at 1,175 fps (358 m/s)

3.4.3 NIJ-0101.02 (Mar 1985) [12]

This test standard includes the following levels which incorporate 9 mm 124 grain (8.0 g) FMJ ammunition:

- Level IIA – 9 mm FMJ 124 grain (8.0 g) at 1,090 fps (332 m/s)
- Level II – 9 mm FMJ 124 grain (8.0 g) at 1,175 fps (358 m/s)
- Level IIIA – 9 mm FMJ 124 grain (8.0 g) at 1,400 fps (427 m/s)

3.4.4 NIJ-0101.03 (Apr 1987) [13]

This test standard includes the following levels which incorporate 9 mm 124 grain (8.0 g) FMJ ammunition:

- Level IIA – 9 mm FMJ 124 grain (8.0 g) at 1,090 fps (332 m/s)
- Level II – 9 mm FMJ 124 grain (8.0 g) at 1,175 fps (358 m/s)
- Level IIIA – 9 mm FMJ 124 grain (8.0 g) at 1,400 fps (427 m/s)

3.4.5 NIJ-0101.04 (Sep 2000) [14]

This test standard includes the following levels which incorporate 9 mm 124 grain (8.0 g) FMJ ammunition:

- Level IIA – 9 mm FMJ RN 124 grain (8.0 g) at 1,120 fps (341 m/s)
- Level II – 9 mm FMJ RN 124 grain (8.0 g) at 1,205 fps (367 m/s)
- Level IIIA – 9 mm FMJ RN 124 grain (8.0 g) at 1,430 fps (436 m/s)

Shortly after this revision was accepted NIJ instructed test laboratories only to use the Remington bullet, although this was never formally adopted in the 04 version of the standard.

3.4.6 NIJ 2005 Interim Requirements for Bullet-Resistant Body Armour

The test level requirements for the 2005 Interim are the same as those of NIJ-0101.04.

3.4.7 NIJ-0101.06 (Jul 2008) [15]

This test standard includes the following levels which incorporate 9 mm 124 grain (8.0 g) FMJ ammunition:

- Level IIA – 9 mm FMJ RN 124 grain (8.0 g) at 355 m/s for conditioned armour and 373 m/s for new armour
- Level II – 9 mm FMJ RN 124 grain (8.0 g) at 379 m/s for conditioned armour and 398 m/s for new armour
- Level IIIA – there is no longer any 9 mm ammunition in this level.

Appendix A of NIJ-0101.06 states that the 9 mm ammunition to be used is 9 mm Luger FMJ RN (round nose) Remington 23558.

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3.4.8 NIJ-0101.07 – Draft January 2018[16]

This draft test standard includes the following levels which incorporate 9 mm 124 grain (8.0 g) FMJ ammunition:

- Level HG1 – 9 mm FMJ RN 124 grain (8.0 g) Remington 23558 at 398 m/s
- Level HG2 – 9 mm FMJ RN 124 grain (8.0 g) Remington 23558 at 448 m/s

3.5 UK MOD / Military Test Standards

The UK MOD / Military do not have a usual requirement for protection against low velocity bullets. However, there have been exceptions.

3.5.1 Mk 2z Luger

During the 1990s, there were some limited requirements for specialised body armour with this level of protection. Initially the UK MOD specified a test programme using the 9 mm Mk 2z Luger bullet. The test results obtained using the Mk 2z showed to be very inconsistent and a detailed investigation into the possible causes was conducted. The eventual conclusions were that the cause of the inconsistencies related to a variable jacket thickness between different bullets, particularly around the nose. This variation was apparent even between bullets from the same box. It was therefore determined that the Mk 2z was not a suitable ammunition type to be used for testing body armour. Therefore the UK MOD also moved over to using the DM11A1B2 as its standard 9 mm FMJ body armour test ammunition.

3.6 DAG 9 mm Luger

DAG 9 mm Luger has been previously specified as an alternative to the Dynamit Nobel / RUAG DM11A1B2. The DAG 9 mm Luger is also a 124 grain (8.0 g) FMJ bullet, with a copper jacket. In theory this may also be a 9 mm GECO as it is now manufactured under RUAG in Switzerland. The head-stamp may be DAG 9 mm Luger or GECO.

3.7 9 mm FMJ DM41

There have been a number of occasions when the future manufacture of the DM11A1B2 has been uncertain, and an alternative has been suggested. This alternative has usually been the DM41. The DM41 specification is predominantly used by the German police. Like the DM11A1B2, it is a 124 grain (8.0 g) FMJ. The jacket is described as being made of steel and copper and tin plated. The DM41 is also manufactured by RUAG Ammotec AG. The DM41 can be found in some European body armour test standards, such as the Technische Richtlinie Ballistische Schutzwesten (TR 03/2008; Rev 10/2008) [17] and the VPAM APR 2006 [2] levels 2 and 3. Ballistic testing with this ammunition has shown some inconsistency, particularly with angled shots. For this reason it has not been adopted as a test round in the UK or the USA.

3.8 Swedish Norma / Bofors M39B

This 9 mm ammunition has been specified in specific body armour tenders. It is of a slightly different construction to the DM11A1B2, as the rough sectioning of a bullet shows (figure 2). It consists of a lead core and a copper full metal jacket, but with a steel under-jacket of significant thickness. This means that it has a higher penetration performance than a DM11A1B2.

This ammunition has been included within Scandinavian Police Body Armour tenders, for example.

Figure 2. Sectioned M39B

3.9 Summary of 9 mm Ammunition in Body Armour Standards

The same type of 8.0 g FMJ 9 mm ammunition has been used in body armour standards for 40 years. Specified velocities have changed over the years. A few variations on the theme have occurred in some standards, such as the DM41 and the M39B.

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4. 7.62 x 39 mm AMMUNITION

The 7.62 x 39 mm is probably the most prolific high velocity rifle ammunition currently in existence. As such it is produced in a number of configurations and by many different factories, in many countries. It would perhaps be naïve to expect all of the ammunition from all of the factories, to be identical and to perform in exactly the same way, and indeed they do not.

4.1 Ammunition Development [18]

Soviet development of an intermediate rifle cartridge began in the 1930s, but it was not until 1943 that a design was approved. On July 15, 1943, the Technical Council of the People's Commissariat for Armaments met to discuss the introduction of a Soviet intermediate cartridge. The job of designing the Soviet intermediate cartridge was assigned to a committee led by chief designer NM Elizarov. Elizarov collaborated closely with some leading weapons designers, including Fedorov, Tokarev, Simonov, and Shpagin.

A first variant of the new cartridge was officially adopted for service after completing range trials in December 1943; it was given the GRAU index 57-N-231. This cartridge actually had a case length of 41 mm, so it is sometimes referred to as the 7.62 x 41 mm. The bullet it contained was 22.8 mm long and had a core made entirely of lead. This bullet has a somewhat stubbier appearance than later 7.62 x 39 mm bullets and it was lacking a boat tail.

After more detailed testing results became available, starting in 1944 the cartridge was modified in order to improve its accuracy and penetration. Initially, the boat tail had been omitted because the Soviet designers had assumed (incorrectly) that it would only make a difference at long ranges when the bullet became subsonic, and the accuracy of the intermediate cartridge at these ranges was considered inconsequential. However, further testing showed that the boat tail improved accuracy even at shorter ranges, where the bullet was still supersonic. In order to maintain the overall mass of the bullet, after adding the boat tail, the ogival head section of the bullet was lengthened as well, making the bullet more streamlined overall. Additionally, the new bullet had a core made of low-carbon steel wrapped in lead and a jacket of Gilding Metal Clad Steel (GMCS). This bullet was given the acronym ‘7.62 PS’ (7.62 ПС). The ‘S’ initially stood for ‘surrogate’, but later the letter was taken to refer to the steel component of the core, which accounted for about 50% of the core volume. The 7.62 x 39 mm cartridge equipped with the PS bullet finally overcame all objections of the GRAU in mid-1947, when it was ordered into series production, and given the index 57-N-231S. In an effort to simplify terminology, sometime thereafter the 57-N-231 designation was recycled to denote all steel-core 7.62 x 39 mm Soviet ammunition, irrespective of case material.

4.2 Increased Core Hardness [18]

After 1989, the regular (PS) Russian bullets started to be manufactured with a steel core with a higher carbon concentration and subjected to heat treatment. This change improved their penetration by 1.5 to 2 times. It is not possible to externally distinguish these bullets from the earlier, softer PS ones except by year of fabrication. At about the same time, tool steel was adopted for a normal velocity 7.62 x 39 mm bullet. Called BP, this bullet was developed in the 1980s and 1990s. It was officially adopted for Russian service in 2002 under the service name ‘7.62 BP’, and with the GRAU designation 7-N-23. The BP bullet is claimed to achieve over three times the penetration of the PS bullet. The BP cartridge has the tip of its bullet painted black. The BP bullet itself is slightly longer (27.4 mm) compared to the PS bullet, but has the same mass of 7.9 g.

When armour manufacturers state that their armour defeats the 7.62 x 39 mm mild-steel core PS ball, it is critical that they have completed their testing on ammunition later than 1989, and preferably later than 2002. This information is critical for armour testing and design.

4.3 Improvements [18]

The original Soviet M43 bullets are 123 grain (7.97 g) boat-tail bullets with a copper-plated steel jacket, a large steel core, and some lead between the core and the jacket. The cartridge itself consisted of a Berdan-primed, highly tapered (usually steel) case which seats the bullet and contains the propellant charge.

The complete solidity of the M43 projectile causes its only drawback - it is very stable, even while traversing tissue. It begins to yaw only after traversing nearly 26 cm of tissue. This greatly reduces the potential wounding effectiveness of the projectile against humans.

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In the 1960s, Yugoslavia experimented with new bullet designs to produce a round with a superior wounding profile, velocity, and accuracy to that of the M43. The M67 projectile is shorter and flatter-based than the M43. This is mainly due to the deletion of the mild steel insert. This has the side effect of shifting the centre of gravity rearward in comparison to the M43. This allows the projectile to destabilize nearly 17 cm earlier in tissue. This causes a pair of large temporary cavities at a depth likely to cause effective wound trauma. When the temporary cavity intersects with the skin at the exit area, a larger exit wound will result. Additionally, when the temporary cavity intersects a dense organ such as the liver, it will cause damage to that organ.

Many people believe that the lead cored ammunition was the initial design, which was then phased out and hence less likely to be encountered. However, in reality the lead-cored ammunition was a later development to increase wounding potential. Therefore it may well still be available in significant numbers.

4.4 Types of 7.62 x 39 mm Ammunition [18]

The 7.62 x 39 mm round is also referred to as 7.62 mm M43, 7.62 mm M1943, 7.62 x 39 mm Soviet, 7.62 mm short, 7.62 mm Kalashnikov and 7.62 mm Obr 43 g.

The 7.62 x 39 mm round can deliver bullets of different configurations for different purposes. These include: FMJ PS ball, AP (armour-piercing), AP – hard core, API (armour-piercing incendiary), subsonic, soft point and frangible types

4.5 Implications of Ammunition Type and Differences for Armour

The design and the variability of 7.62 x 39 mm ammunition have implications for body armour upgrade plates.

The first modern body armour upgrade plates consisted of a ceramic strike-face with some level of composite backing. This composite backing may be just a couple of layers, or may be a substantial thickness. The backing textile-based composite material may be glass-fibre reinforced plastic (GFRP), para-aramid (Kevlar®, Twaron® etc), or now more commonly ultra-high molecular weight polyethylene (UHMWPE, such as Dyneema®, Spectra® etc).

The ceramic strike-face breaks up or erodes the steel core of the bullet, as its hardness greatly exceeds that of the core. The kinetic energy of a typical 7.62 x 39 mm bullet as it leaves the muzzle of a typical weapon is approximately 2 kJ, whereas the muzzle kinetic energy of a typical 7.62 x 51 mm bullet is approximately 3.3 kJ. This means that armour that is capable of defeating the higher energy 7.62 x 51 mm ball round, should be capable of defeating the lower energy 7.62 x 39 mm ball round, thus negating the testing against the 7.62 x 39 mm round. For ceramic-faced armour this is, in fact, the case.

More recently however armour has been produced of monolithic ultra-high molecular weight polyethylene (UHMWPE) composite, for which the above rule no longer holds. If armour is designed to defeat the 3.3 kJ of the 7.62 x 51 mm NATO ball, it will not defeat the lower energy 7.62 x 39 mm PS ball, as it contains a mild steel, rather than lead, core.

For armour considerations the main two 7.62 x 39 mm ammunition types of interest are the PS ball and the API-BZ.

4.5.1 PS Ball

The 7.62 x 39 mm PS ball (figure 3) has been extensively described earlier, during which three main types have been identified:

1. Original Steel-Cored – This will be easily defeated by ceramic-faced armour designed to defeat 7.62 x 51 mm NATO ball (e.g. to HOSDB 2007 Level RF1 [2]), but will defeat monolithic UHMWPE armour of an areal density designed for the 7.62 mm NATO ball.
2. Later Steel-Cored (post-1989) – This should be easily defeated by a ceramic-faced plate designed to defeat 7.62 x 51 mm NATO ball (e.g. to HOSDB 2007 Level RF1), but will defeat monolithic UHMWPE armour of an areal density designed for the 7.62 mm NATO ball.
3. Lead-Cored – This should be easily defeated by either ceramic-faced or monolithic UHMWPE armour designed to defeat 7.62 x 51 mm NATO ball (e.g. to HOSDB 2007 Level RF1).

Monolithic UHMWPE armour can defeat the mild steel-cored ammunition if the thickness, and hence the areal density, of the armour is increased above that required for the 7.62 x 51 mm NATO ball.

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However, if specifying UHMWPE it is critical to know exactly which factory and year of manufacture of PS ball the armour is being tested with.

Figure 3. 7.62 x 39 mm PS Ball

The UK HO CAST has acknowledged both that the 7.62 x 39 mm PS ball is a realistic threat and that it also experiences significant variability as a test projectile. Therefore in their 2017 Body Armour standard they have included a surrogate PS ball projectile. This surrogate is discussed further during the discussion of this standard.

4.5.2 API BZ [18]

The 7.62 x 39 mm API BZ contains a hardened steel core and also an incendiary component in the tip, and possibly in the tail, of the bullet. This incendiary ignites upon impact with a hard target. The incendiary ammunition is designed for the engagement of lightly armoured / soft-skinned vehicles, and particularly with the aim of igniting fuel tanks and systems. The API BZ is to the same dimensions as the PS ball and is ballistically matched. The API BZ is significantly more penetrative than a 7.62 x 39 mm PS ball, and also a 7.62 x 51 mm NATO ball. However it is not as penetrative as a 7.62 x 51 mm AP or the 30.06 AP M2 as found in the NIJ-0101.06 Level IV.

Figure 4. 7.62 x 39 mm API BZ

It should be noted that even 16 years ago, this API BZ ammunition was shown to be defeated by a simple ceramic-faced armour with an areal density of 34 kg/m^2. The armour tested was of a 1980s design and consisted of an alumina strike-face bonded to a para-aramid composite backing. This particular armour was designed to defeat the 7.62 x 51 mm NATO ball and the 5.56 x 45 mm SS109, but was known to have a significant safety margin.

For identification purposes the bullet tip of the API BZ has markings which comply with the standard Russian system. The tip is painted black with a red band just below the tip, as shown in figure 4. This paint is known to wear off with handling over time.

A recent test programme used 7.62 x 39 mm BZ API of a specific Russian factory and year. They were procured in factory-sealed tins. During the test process it became obvious that the projectiles within the sealed tin were of two different constructions. The bullets were sectioned to reveal two different constructions of steel AP core (figure 5), each of the same length (22.7 mm) and diameter (6.1 mm). The mass of the boat-tailed core was an average of 4.04 g and the one without the boat tail was 4.18 g. The two different core types were hardness tested (Vickers diamond indenter with 30 kg load), the results of which showed that the hardness of the two designs was consistent within experimental error at 788 to 811 VHN for the flat base and 811 to 812 VHN for the boat-tail.

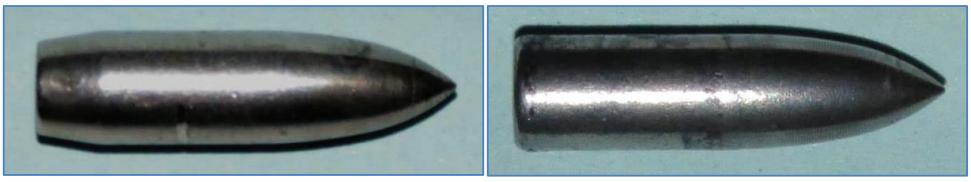

Figure 5. Two Different AP Cores

Testing has also been conducted using a surrogate for the BZ API, and this has been shown to significantly over-perform compared to typical worst case real threats, such as the Factory 539. The construction of the surrogate included an exposed core nose and it is suspected that this significantly modified the terminal ballistic effects versus certain armour constructions. More work would be required to confirm this. Any surrogate should only enter service as a test projectile, once it has undergone extensive validation trials versus a wide range of armour materials and constructions and in all typical test scenarios.

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5. HO CAST 2017 BODY ARMOUR STANDARD [1]

July 2017 saw the arrival of the long-awaited replacement for the 2007 UK Home Office Body Armour Standard. This 2017 standard [1] is not a minor update, but a significant change in many aspects. One of the major changes is the ammunition types now included in the new series of test levels.

5.1 Standard Ammunition Categories

The standard ammunition categories are listed as HO1 through to HO4 and SG1.

Levels HO1 and HO2 are low velocity 9 mm ammunition levels. Level HO1 includes 9 mm FMJ and 9 mm JHP at 'handgun' velocities (365 ± 10 m/s) and level HO2 includes the same ammunition types at 'sub-machine gun' velocities (430 ± 10 m/s). Levels HO1 and HO2 allow for 44 mm BFS in the clay-based backing material. Levels HO1 and HO2 are met by the use of soft body armour.

Level HO3 includes the 7.62 x 51 mm NATO ball (L2A2 or L44A1) at 830 ± 15 m/s, along with the 7.62 x 39 mm surrogate projectile at 705 ± 15 m/s. Level HO3 allows 25 mm BFS. Level HO3 may be met by either ceramic-faced or monolithic UHMWPE upgrade plates. The 7.62 x 39 mm surrogate based upon a typical and higher performing Russian PS ball is referenced as PT11009 (manufactured by EPA Manufacturing Ltd). The surrogate use is an attempt to address the issues of both repeatability and realism.

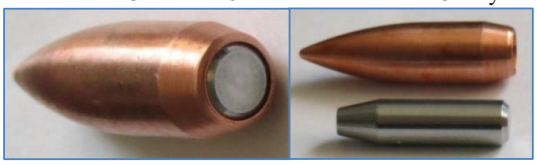

Figure 6. Surrogate – Complete and Components

Level HO4 includes two options of .308 ammunition, which are the SAKO .308 Win 480A Powerhead or the Barnes .308 TSX BT both at a velocity of 820 ± 15 m/s. Level HO4 allows 25 mm BFS. Level HO4 is expected to require a ceramic-faced upgrade plate.

Level SG1 includes the Winchester 1 oz rifled 12 RSE.

5.2 Optional Ammunition Categories

There are three optional ammunition types listed as follows:

- .357" Magnum Soft Point Flat Nose Remington R357M3 at either 390 or 455 ± 10 m/s
- 5.56 x 45 mm SS109 (L17A1 or L15A1) at 920 ±15 m/s
- 5.56 x 45 mm Federal Tactical Bonded (LE223T3) at 750 ± 15 m/s

5.3 Implication of Ammunition Choices

5.3.1 Levels HO1 and HO2

These levels include 9 mm ammunition of both FMJ and JHP designs. Both projectile types are of the same mass, and projected at the same two velocities. It may be expected that the most aggressive of these two ammunition types would be the FMJ, as the JHP is designed to expand on impact with the target. However, with some types of armour material, and particularly with the higher test velocity the JHP could be the most aggressive, as it punches a hole before it expands.

5.3.2 Level HO3

The HO3 level includes two ammunition types which are very different. The first is the 7.62 x 51 mm NATO ball, which equates to the RF1 level of the 2007 HOSDB standard. The second ammunition type is a surrogate of a 7.62 x 39 mm PS ball. This is the first use of a small arms bullet surrogate in a test standard. The surrogate was developed by Dstl and the Defence Academy of the UK.

It should be noted that a 7.62 x 39 mm surrogate projectile is also intended for inclusion in NIJ-0101.07 [17] which is due to be published during 2020. The indicated surrogate is included in both levels RF1 and RF2 and is a 7.81 g (120.5 grain) projectile with a specified impact velocity of 725 m/s.

5.3.4 Level HO4

Level HO4 includes two types of ammunition which are new to the body armour standard. These are the SAKO .308 480A Powerhead and Barnes TSX BT, both .308 calibre with 10.7 g (165 grain) solid copper expanding bullets, predominantly used for large deer hunting.

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7. SUMMARY

There is often a trade-off between realism and repeatability with the types of small arms ammunition used for the testing of personal armour. 9 mm FMJ ammunition has been used for many years for testing of soft body armour within the UK and USA including in many law enforcement test standards. 7.62 x 39 mm ammunition is often a very realistic ammunition type, but also one which has introduced issues regarding repeatability. The use of a repeatable surrogate bullet in the 2017 HO CAST body armour standard is the first step towards addressing this trade-off. The 2017 HO CAST body armour standard has introduced a different focus on the ammunition being specified for testing body armour for UK police, specifically including UK Police ammunition to allow for blue-on-blue incidents.

References

[1] Payne, T; O'Rourke, S; Malbon, C; 'Body Armour Standard (2017)'; CAST Publication No. 012/17, July 2017

[2] VPAM APR 2006 (English); 'General basis for ballistic material, construction and product testing'; May 2009

[3] AEP-2920; 'Procedures for the Evaluation and Classification of Personal Armour; Bullet and Fragmentation Threats' Edition A Version 2; Sep 2016

[4] GOST R 50744-95; 'Armour Clothing'; July 1995

[5] Pettit, MJ; 'PSDB Ballistic Body Armour Standard (1993)'; PSDB Publication 12/93

[6] Pettit, MJ; 'PSDB Ballistic Body Armour Standard (1995)'; PSDB Publication 2/96

[7] Croft, J; 'PSDB Body Armour Standards for UK Police (2003), Pt 2 Ballistic Resistance'; PSDB Publication No 7/03/B

[8] Croft, J; Longhurst, D; 'HOSDB Body Armour Standards for UK Police (2007), Part 2: Ballistic Resistance' Publication No 39/07/B; July 2007

[9] Jones, AH; Barnes-Warden, J; 'Determination of the Cause of the Differing Ballistic Performance of 9 mm DM11 Bullets from Two Manufacturers' Proc PASS 2018; Sep 2018

[10] NILECJ-STD-0101.00; 'The Ballistic Resistance of Police Body Armor NIJ 0101.00; NILECJ; Mar 1972

[11] NILECJ–STD–0101.01; 'Ballistic Resistance of Police Body Armor, NILECJ–STD–0101.01'; Washington, D.C.: U.S. Department of Justice; December 1978

[12] NIJ Standard-0101.02; 'Ballistic Resistance of Police Body Armor'; US Dept of Justice; March 1985

[13] NIJ Standard-0101.03; 'Ballistic Resistance of Police Body Armor'; US Dept of Justice; February 1987

[14] NIJ Standard-0101.04; 'Ballistic Resistance of Body Armor NIJ Standard-0101.04'; US Dept of Justice; June 2001

[15] NIJ Standard-0101.06; 'Ballistic Resistance of Body Armor NIJ Standard-0101.06'; US Dept of Justice; Jul 2008

[16] Greene, ME et al; 'The Next Revision of the NIJ Performance Standard for Ballistic Resistance of Body Armor, NIJ Standard 0101.07: Changes to Test Methods and Test Threats'; PASS 2018; Sep 2018

[17] TR 03/2008; 'Technische Richtlinie Ballistische Schutzwesten'; Rev 10/2008

[18] Edited by Cutshaw, CQ and Ness, L; 'Jane's Ammunition Handbook 2003 -2004'

https://doi.org/10.52202/078352-0034