CHAPTER 4

Weapons Identification: Small-calibre Ammunition

Introduction

Ammunition for small arms is frequently encountered in conflict zones, but is often overlooked despite its importance to the arms and ammunition identification process. While firearms are durable goods, and can last for decades, ammunition is a consumable, and supplies must be periodically replenished. As such, ammunition plays a decisive role in escalating, prolonging, and intensifying armed conflict (Greene, 2006).

Small-calibre ammunition (less than 20 mm) is used primarily with small arms, although it is also in use with some light weapons (most notably heavy machine guns). This chapter provides an overview of small-calibre ammunition and how to identify it by looking at its physical characteristics, markings, and packaging.

Small-calibre ammunition: an overview

The vast majority of modern small arms use cartridges as ammunition. In the field of small-calibre ammunition, the terms 'cartridge' and 'round' are synonymous: both refer to a single complete unit of ammunition. Modern small-calibre cartridges are generally comprised of:

1. A **projectile**, or bullet, which is fired from the gun. It typically consists of a 'core' and 'jacket'.
2. **Propellant**, which, when ignited, generates the gas pressure that propels the projectile out of the barrel.
3. A **primer**, which contains chemical compounds designed to be ignited by a firing pin. The primer then, in turn, ignites the propellant.
4. A **cartridge case**, which contains the components of a complete round of ammunition and, when the weapon is fired, blocks the escape of gases in a way that causes pressure to build up behind the projectile (Goad and Halsey, 1982; Jenzen-Jones, 2016a, p. 13).[83]

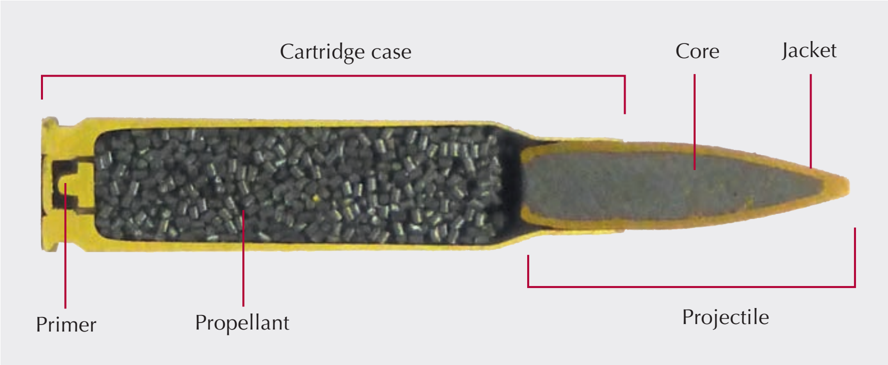
Figure 4.1 shows the component parts of a typical small-calibre cartridge.

During the first half of the 20th century, most global militaries had a single cartridge, typically a so-called 'full-power' round in the 7.5 to 8 mm range.[84] These

83 An exception is caseless ammunition.

84 Some nations, however, adopted cartridges in the 6.5 mm range. These nations later adopted supplementary cartridges in the range of 7.7 to 8 mm (Williams, 2015).

Figure 4.1 Cross-section of a 7.62 × 51 mm cartridge



Source: Anthony G. Williams/ARES

rounds were used both in the standard bolt-action rifles of the time and in machine guns. During the Second World War, the German military introduced the first of a series of so-called 'intermediate-calibre' cartridges; that is, cartridges that are intermediate in size, weight, and power, between those fired by handguns and SMGs, and those fired by 'full-power' rifles. The most influential intermediate-calibre round is the 7.62 × 39 mm cartridge, which was adopted in 1943 and widely used in the ubiquitous SKS and AK series of self-loading rifles (Jenzen-Jones, 2016a; Ponomarev, 2004).

In the early 1960s, the United States adopted the 5.56 × 45 mm cartridge, which was the first small-calibre, high-velocity (SCHV) round to be widely issued for military service. SCHV rounds have a longer effective range and weigh less than previous small-calibre rounds. The cartridge was adopted in conjunction with the AR-15 (designated as the M16 in US military service), and was a commercial and military success; at least 16 million AR-15-type rifles had been produced by late 2015 (Jenzen-Jones, 2017d; Williams, 2015).

In 1980, NATO accepted the 5.56 × 45 mm cartridge as a standard cartridge, alongside the 7.62 × 51 mm round. Today, the 5.56 × 45 mm cartridge is in service with numerous NATO and non-NATO states (Johnston and Nelson, 2010; Rottman, 2011). In the mid-1970s, the Soviet military also adopted a SCHV round, the 5.45 × 39 mm cartridge, which became standard issue. Nonetheless, the 5.56 × 45 mm and 7.62 × 39 mm cartridges remain the predominant military rifle cartridges in service globally (ARES, 2015a).

Despite the widespread adoption of intermediate and SCHV cartridges, full-power rifle cartridges remain in military service (ARES, 2016a). Most of the world's armies now employ a two-calibre system for primary infantry arms (generally rifles and machine guns). A full-power rifle cartridge is generally employed with general-purpose machine guns and specialized precision rifles, while an intermediate or SCHV cartridge is employed with standard service rifles and light machine guns (Jenzen-Jones, 2017d).

In NATO and allied nations, these two calibres are the 5.56 × 45 mm and 7.62 × 51 mm cartridges. Former Warsaw Pact states have a history of employing the 7.62 × 39 mm and 7.62 × 54R mm cartridges, although some countries have since replaced or supplemented the former with the 5.45 × 39 mm cartridge. China relied on the standard Warsaw Pact cartridges before supplementing these with their own 5.8 × 42 mm cartridge in 1995 (Andrew, 2015; Williams, 2015). These calibres are described in Table 4.1 and illustrated in Image 4.1.

Recent trends in design and development reveal increasing interest in a so-called 'general-purpose' calibre, which is intended as a single calibre to replace the current two-calibre system. To date, however, no major military has transitioned to a general-purpose calibre (Jenzen-Jones, 2017d).

Handgun-calibre cartridges are significantly less powerful than rifle-calibre ammunition and require a shorter barrel to achieve their optimum performance.

Table 4.1 Dominant rifle and machine gun cartridges in global military service

Cartridge designation	Country of origin	Total weight (g)*	Bullet weight (g)*	Muzzle velocity (m/s)*	Muzzle energy (J)*
7.62 × 54R mm	Russian Empire	24.0	9.5	845	3,400
7.62 × 51 mm	United States	24.0	9.5	838	3,340
7.62 × 39 mm	Soviet Union	16.5	7.9	715	2,020
5.8 × 42 mm	China (PRC)	12.8	4.6	790–970	1,920
5.56 × 45 mm	United States	12.0	4.0	875–950	1,530–1,800
5.45 × 39 mm	Soviet Union	10.5	3.4	900	1,417

Note: All figures are approximations and vary according to barrel length, cartridge type and loading, and other factors.
* 'g': grams; 'm/s': metres per second; 'J': joule.
Source: Ness and Williams (2015)

Image 4.1 Common rifle and machine gun cartridges

Note: (a) 5.56 × 45 mm; (b) 7.62 × 51 mm; (c) 7.62 × 39 mm; (d) 5.45 × 39 mm; (e) 7.62 × 54R mm; and (f)5.8 × 42 mm. The cartridges in this image are represented in their actual real-life dimensions.
Source: Anthony G. Williams/ARES

Consequently, handgun ammunition generally has a shorter effective range than rifle ammunition (typically of up to 100 m).[85] Due to the design imperative to fit ammunition inside a pistol's handgrip, these cartridges are limited in size. It is worth noting, however, that some ammunition used in rifles (notably .22 LR) also has a short case length (ARES, 2017).

Compared to rifle-calibre cartridges, which were largely standardized by most countries in the 20th century, different nations adopted a wide variety of handgun-calibre cartridges. Later in the 20th century, NATO and other Western coun-

85 Some of the newer SCHV cartridges used by personal defence weapon (PDW)-type weapons can be effective up to 150 m or further in longer-barrel SMGs (ARES, 2017). When used in a SMG or carbine, the ammunition is sometimes loaded to higher pressures which, in conjunction with the longer barrel, may deliver increased performance (Popenker and Williams, 2012).

tries widely adopted the 9 × 19 mm and .45 ACP, while former Warsaw Pact nations largely standardized on the 9 × 18 mm cartridge. Some handguns and SMGs are chambered for other ammunition, such as the 5.7 × 28 mm FN round (ARES, 2016a). Table 4.2 and Image 4.2 show some common pistol-calibre cartridges.

Table 4.2 Selected common pistol cartridges worldwide

Cartridge designation	Country of origin	Bullet weight (g)*	Muzzle velocity (m/s)*	Muzzle energy (J)*
.45 ACP	United States	14.9	280	584
9 × 19 mm	Germany	8.0	440	774
9 × 18 mm	Soviet Union	6.1	310	348
.38 Special	United States	9.7	270	366
7.62 × 25 mm	Soviet Union	5.5	540	802
5.7 × 28 mm	Belgium	2.0	715	511
4.6 × 30 mm	Germany	2.0	720	520

Note: All figures are approximations and vary according to barrel length, cartridge type and loading, and other factors.
* 'g': grams; 'm/s': metres per second; 'J': joule.
Sources: Barnes and Woodard, 2016; Ness and Williams (2015)

Image 4.2 Common pistol cartridges

Note: (a) 9 × 19 mm; (b) 9 × 18 mm; (c) 7.62 × 25 mm; (d) .38 Special; (e) .45 ACP; (f) 5.7 × 28 mm; and (g) 4.6 × 30 mm. The cartridges in this image are represented in their actual real-life dimensions.
Source: Anthony G. Williams/ARES

Common cartridges for civilian applications vary significantly by country. In many countries, the cartridges in widespread civilian use reflect those in service with militaries and law enforcement agencies. In other countries, military cartridges are restricted or proscribed by law. In France, for example, any weapons chambered for common military calibres are subject to more stringent ownership requirements (France, n.d.). As a result, weapons originally chambered for cartridges in 'military' calibres are sometimes modified to fire ammunition not restricted under state law (McCollum, 2014a; Yasin, 2013).

Describing and identifying small-calibre ammunition

All small-calibre ammunition is of the same class (munitions (land)), group (projectiles), and subgroup (small-calibre ammunition) (ARES, forthcoming).[86] In order to determine the type, model, make, manufacturer, and other information, three steps should be taken:

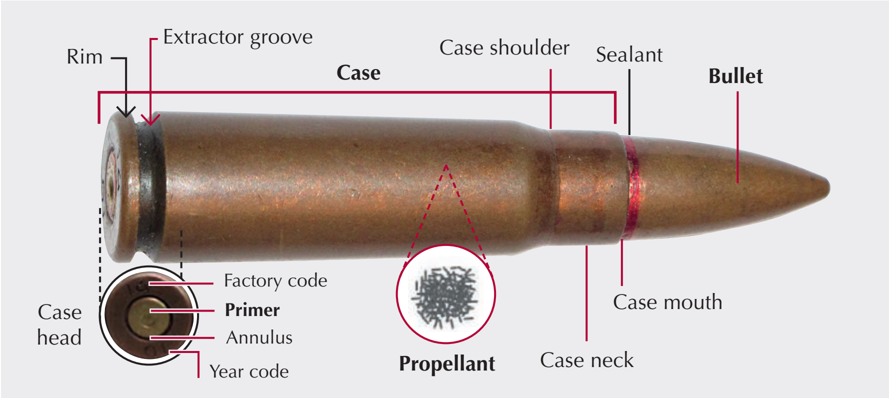
1. Determine the cartridge designation.
2. Determine the country of origin, make and/or manufacturer, and/or year of production.
3. Determine the functional type.

While these steps are presented here in a logical order, it is often the case that information regarding, for example, a cartridge's functional type may be established before, or in the absence of, a positive identification of the make or manufacturer.

Figure 4.2 shows one example of the thousands of cartridge configurations, which vary widely in terms of case composition, projectile and powder type, and case design. All of these characteristics are important for the identification process. Markings, including headstamps, also vary substantially, and the top and bottom codes do not necessarily correspond to 'factory' and 'year', as is the case in Figure 4.2. Many different types of cartridges are found in conflict zones. In general terms, the current norm in military small arms ammunition is centrefire ammunition (see below) with metal cases and jacketed projectiles.

86 There are a very limited number of examples of small arms ammunition—mostly of novel designs such as miniature rockets—that do not fit into this group and subgroup (ARES, forthcoming). These types are almost never encountered in the field.

Figure 4.2 Basic composition of a 7.62 × 39 mm cartridge



Source: N.R. Jenzen-Jones/ARES

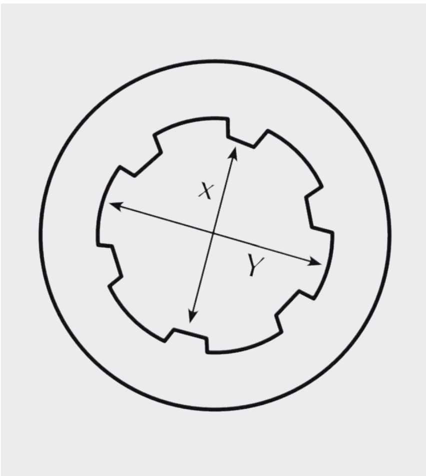
Cartridge designation

The term 'cartridge designation' often refers to the cartridge's calibre and case length (for example, 5.56 × 45 mm). In some cases, a descriptive term may also be included (for example, 5.56 NATO, or 5.56 × 45 mm NATO). The term 'calibre' is sometimes used as a stand-in for cartridge designation, but has its own definition (see below). The cartridge designation can generally be determined by taking physical measurements of the cartridge or cartridge case. This Handbook uses standard metric designations to describe cartridges, measured in millimetres. The calibre of the projectile is provided first (for example, 7.62), followed by the cartridge case length (for example, 39 mm). In this example, the cartridge designation would be 7.62 × 39 mm. For cartridges that are usually described using imperial measurements, the imperial measurement should be listed first, followed, if necessary, by the metric measurement in parentheses. An example would be: .303 British (7.7 × 56R mm). The calibre designation of a cartridge reflects the nominal projectile diameter (see next section). However, this is not necessarily a precise reflection of the projectile's actual diameter. The case type may also be reflected in a cartridge's designation (see 'Cartridge case type and shape' section).

Calibre

The first step in determining a cartridge designation is to identify the calibre of the cartridge. The calibre designation of a cartridge originates from the nominal projectile diameter. The nominal projectile diameter is typically based on the bore of a weapon, as measured across the features of the weapon's rifling.[87] The calibre can be determined by measuring the diameter of the lands (X), the diameter of the grooves (Y), or the average diameter of both (X+Y divided by two) (see Figure 4.3).[88] In some cases, the nominal calibre—the calibre typically associated with the weapon—is an arbitrary figure, which is provided by the cartridge or weapon designer, or another party. For example, when the M40 recoilless rifle, a 105 mm calibre weapon, was adopted into US military service, it was described as 106 mm in order to avoid potential confusion with ammunition from the earlier 105 mm M27 (Jenzen-Jones, 2015c). Recovered projectiles can also be measured for calibre, and may bear rifling impressions that can help to determine the type of weapon from which they were fired (see Image 4.3).

Figure 4.3 Distance measured between the lands (X) or grooves (Y) of a rifled barrel



Source: ARES

Image 4.3 A fired projectile, showing characteristic impressions left by a weapon's rifling (lands)

Source: Diehl and Jenzen-Jones (2012)

87 See Chapter 3 for a description of rifling.

88 Some calibres (typically those using imperial measurements) are commonly measured between the grooves, instead of being based on the diameter of the lands of the barrel's rifling, although this is not always the case. The .303 British cartridge, for example, actually uses a .311 inch bullet when measured across the lands (7.70 mm vs. 7.90 mm) (Diehl and Jenzen-Jones, 2012).

Country of origin, make, manufacturer, and year of production

The country of origin, make and/or manufacturer, and year of production are typically identified by examining both the physical characteristics and markings. The cartridge's headstamp is generally the most important source of information on the manufacturer and production year. In Image 4.4, for example, '60' is the factory (and, in this case, manufacturer) code, while '75' indicates the year of production. It is worth noting that headstamp configurations are highly variable (see 'Headstamps and primers' section), and this represents a very simple-to-interpret example.

Image 4.4 Headstamp markings on a 7.62 × 39 mm cartridge case

Note: The markings show a factory code (60) and year of production (75).
Source: N.R. Jenzen-Jones/ARES

Once a country of origin and rough period of production have been ascertained, determining the cartridge's functional type is typically a straightforward task. It is most often indicated by projectile colouration, especially markings on the tip of a bullet, and/or by the physical features of a projectile or additional markings on the cartridge case.

Functional type

Different types of cartridges are produced to fulfil different roles. A wide range of functional types are produced, but which types are available varies by calibre. Common calibres favoured by both military and civilian users—such as 5.56 × 45 mm (and similar .223 Remington) or 7.62 × 51 mm (and similar .308 Winchester)—often have the widest variety of available types (see Image 4.5, for example). In modern military usage, ball projectiles, which feature an inert metal core, often made of lead or a combination of mild steel and lead, are the most common.[89] These cartridges are designed to engage personnel under most circumstances, and are typically cheaper to produce than other types.

Other common types of ammunition in military use include tracer, incendiary, armour-piercing (AP), and combination types. Many types of ammunition have combined effects, essentially combining two or more functional types (for example, armour-piercing incendiary (API); see Table 4.3). In civilian and law enforcement use, soft-point and hollow-point (HP) ammunition is common. These types of rounds are most often used for hunting and against human targets that are not wearing body armour, respectively.

A cartridge without a projectile is referred to as a 'blank', while inert cartridges are generally 'drill' or 'dummy' rounds.[90] Drill rounds are visually identifiable as inert cartridges by their lack of a primer, colour, and/or the shape of the case. Dummy rounds, on the other hand, are intended to look like live rounds, but have had their propellant removed and their primer fired (or otherwise rendered inert).

89 Ball ammunition is the most common type in military service due, in part, to a legal prohibition against the use of expanding bullets, which is outlined in the Declaration of Saint Petersburg of 1869, and the Hague Declaration of 1899 (IMC, 1868; IPC, 1899; Jenzen-Jones and Williams, 2016).

90 Grenade propelling cartridges, a type of blank, are used in conjunction with rifle grenades or grenade adapters to propel munitions from the rifle muzzle. They are sometimes known as 'grenade blanks'.

Table 4.3 outlines some common functional types of ammunition, their primary purpose, and typical users. It is worth noting that there are numerous exceptions to the examples provided here, and that there are other specialized types of ammunition that are not included in the table.

The important information to record and analyse when attempting to identify small-calibre cartridges by their physical characteristics and markings is addressed in the following sections.

Table 4.3 Purposes and users of ammunition by functional type

Functional type	Primary purpose	Typical users
Ball (full metal jacket; FMJ)	Anti-personnel	Military; law enforcement; civilians
Soft-point	Anti-personnel; hunting	Civilians
Hollow-point	Anti-personnel	Law enforcement; civilians
Tracer	Anti-personnel; aiming correction	Military
Incendiary	Anti-materiel; anti-armour (light vehicles)	Military
High-explosive (HE) and high-explosive incendiary (HEI)	Anti-armour (light vehicles); anti-materiel	Military
Armour-piercing (AP)	Anti-personnel; anti-armour (light vehicles)	Military
Subsonic	Anti-personnel; suppressed fire	Military; law enforcement
Blank	Training; movies/TV	Law enforcement; civilians
Grenade propelling	Firing rifle grenades	Military; law enforcement
Training	Training	Military; law enforcement
Inert (e.g. dummy and drill)	Training; collecting	Military; law enforcement; civilians

Image 4.5 Various types of 7.62 × 51 mm cartridges

Note: These include ball, blank, tracer, dim tracer, API, short-range training, and other types of cartridges.
Source: Drake Watkins/ARES

Physical characteristics

Cartridge case type and shape

In addition to the case length, cartridge cases are described by two additional primary physical characteristics: the type of case rim and the shape of the case walls. These characteristics are very useful when trying to determine cartridge designation. The case rim, where present, generally serves to aid in the extraction of fired cartridge cases from the weapon.[91]

Cartridges are produced with a number of distinct case rim designs. While most rims are simple enough to visually identify, it is somewhat more difficult to tell the difference between the various semi-rimmed and rimless ammunition in circulation. The most common cartridge case rims, examples of which are shown in Image 4.6, are as follows:

91 The presence, or absence, of a case rim and the design of a case's rim and walls also influence a weapon's headspace. Headspace, sometimes termed 'cartridge headspace' (CHS), is the distance from the face of the closed breech of a firearm to the surface in the chamber on which the cartridge case seats. Due to the high pressures involved, precise measurement and setting of CHS is crucial to the safe and reliable operation of a firearm. For a further discussion on CHS, see Ferguson (2015).

Image 4.6 Typical cartridge case rim configurations

Note: (a) Rimmed; (b) semi-rimmed; (c) rimless; (d) rebated rim; (e) rimless/grooveless; and (f) belted.
Source: Diehl and Jenzen-Jones (2012)

- **Rimmed** cartridge cases feature a case rim with a diameter that is greater than the diameter of the case body. The calibre designation of rimmed cartridges often includes the suffix 'R', for example, 7.62 × 54R. Some rimmed cartridges may use a rimfire priming system (see 'Headstamps and primers' section).
- **Semi-rimmed** cartridge cases have a case rim diameter which is slightly larger than the case body diameter. The calibre designation of these cartridges often ends in 'SR', for example, 7.65 × 15SR (.32 ACP).
- **Rimless** cartridge cases feature a case rim diameter which is approximately the same as the case body diameter. Many modern military cartridges are rimless (including 9 × 19, 5.56 × 45, etc.).
- **Rebated rim** cartridge cases, sometimes known as 'reduced rim' cases, have a case rim diameter which is less than the diameter of the case body. The calibre designation of rebated cartridges sometimes includes the suffix 'RB', for example, 20 × 110RB. Rebated rim cartridges are most often encountered in relatively large bore rifle cartridges and cannon cartridges.
- **Belted** cartridge cases feature a raised portion on the case body (the 'belt'), typically located just above the extractor groove.[92] The calibre designation of belted cartridges often includes the suffix 'B', for example 23 × 152B. Small-calibre examples are uncommon, but include several long-range rifle rounds. Several medium-calibre cartridges use belted cases (Goad and Halsey, 1982; Diehl and Jenzen-Jones, 2012).

92 Not strictly a rim characteristic, but a similar identifier.

Caseless ammunition also exists, but is very rare.[93]

Cartridge case shape is often described as either straight-walled (straight) or tapered, either of which may also be bottle-necked (necked) (Barnes and Woodard, 2016; Diehl and Jenzen-Jones, 2012) (see Image 4.7).

Image 4.7 Common cartridge case configurations

Note: (a) Tapered (8 × 58R mm Sauer); (b) straight-walled (.40-72 WCF); (c) tapered bottle-necked (.280 Ross); and (d) straight-walled bottle-necked (.378 Weatherby).
Sources: Drake Watkins/ARES

93 For more information on caseless ammunition, see Jenzen-Jones (2016a). Similarly, rimless/grooveless cartridge cases are very unusual, and rarely encountered in the field. These cartridges have no rim at all; they exist with and without a bevel.

- **Straight-walled** cartridge cases are the simplest of case designs. Their case walls appear to be parallel or near-to-parallel when examined in profile. It should be noted that many cartridge cases typically considered to be 'straight' do, in fact, have a slight taper. Straight-walled cases are most commonly used in pistol-calibre cartridges.
- **Tapered** cartridge cases feature a noticeable taper in diameter along the length of the cartridge case, designed to aid in the extraction of the case after the cartridge is fired. The taper generally runs from the base of the cartridge to either the mouth or the shoulder.
- **Bottle-necked** (or simply 'necked') cartridge cases feature a relatively abrupt reduction in diameter toward the mouth (top) of the case. The vast majority of modern rifle and machine gun cartridges use necked cartridge case designs. Necked cartridge cases may be straight-walled or tapered in design.

The type and shape of a cartridge case are very useful distinguishing features for small-calibre cartridges, and are generally straightforward to assess. Physical features such as case rim type can often be assessed from images, assuming photographs taken in profile are available.

Case composition

Cartridge cases are made of a variety of materials, but the most common are brass, copper-clad steel, and coated (often 'lacquered') steel. The material type is often a good indicator of the factory or country of production. Some key materials are as follows (Diehl and Jenzen-Jones, 2012; Jenzen-Jones, 2016a):

- **Brass** is the most common cartridge case material. It is used primarily for its optimal elasticity, which allows for a consistently good case-bore seal when a weapon is fired. Most 'cartridge brass' is so-called 'yellow brass' (for example, Copper Alloy 260, C260), with a composition of roughly 70 per cent copper and 30 per cent zinc. Minor variations in brass composition are sometimes referred to as 'brass alloy' to distinguish them; however, this term is technically redundant.
- **Copper-clad steel**,[94] sometimes abbreviated CCS, is frequently and incorrectly referred to as 'copper washed steel'. This case material is commonly used in cartridges from former Eastern Bloc countries.

94 The cladding is typically composed of 90–95 per cent copper + zinc.

- **Coated steel** is a common cartridge case composition, with various coatings having been applied over time. Two cartridges in Image 4.8—one in greenish translucent lacquer typical of Eastern Bloc military production (c), and one in light grey polymer (d) as seen in more recent Eastern Bloc commercial production and elsewhere—are typical examples.[95]
- **Aluminium** is primarily used because it weighs less than other materials. It is most commonly encountered in certain practice ammunition, but is also available in various pistol calibres for regular use.[96] Aluminium cases may also be coated.

Image 4.8 Cartridges with cases made of various materials

Note: (a) Brass; (b) CCS; (c) and (d) two different lacquered steel examples; (e) aluminium; (f) polymer; (g) nickel-plated brass; (h) blackened.
Source: Diehl and Jenzen-Jones (2012)

95 Other lacquers in various shades of green, brown, grey, and other colours also exist. Various 'washes' and light coatings may also be used in the cartridge production process, regardless of cartridge case composition. These typically include acids, detergents, and anti-tarnish compounds.

96 Aluminium is easier to extrude than brass, but aluminium cartridge cases are not suitable for reloading.

- **Polymer** (plastic) cartridge cases are most often used in dummy or training rounds, as well as shotgun cartridges. Polymer cartridge cases are not yet widely used because of ongoing performance issues. Nonetheless, a number of countries are exploring polymer cases, which weigh significantly less than conventional (metal) cases. Limited examples are now in service with some armed forces. The vast majority of polymer cased cartridges currently being produced use metal case heads to ensure reliable function (see Image 4.9).[97]
- **Nickel-plated brass** cartridge cases are used mainly as an identification feature for special types of ammunition, such as high-pressure test rounds. Sometimes this finish is also encountered on blank and dummy/drill ammunition.

Image 4.9 Two cartridges of the same calibre (.264 USA)

Note: (a) Conventional (all brass) construction; (b) polymer construction with a brass case head. Due to material differences, the internal dimensions of the cartridge case may be different.
Source: Rebekah Ehrich

97 For more information on ammunition using polymer cartridge cases and other emergent ammunition technologies, see Jenzen-Jones (2016a).

Unusually-coloured cartridge cases, including blackened cases, generally serve as a marking feature for special purpose ammunition, such as high-pressure test rounds, dummy/drill cartridges, or other types (Diehl and Jenzen-Jones, 2012).

Some cartridge cases, most commonly those made of brass, may be suitable for 'reloading'—reuse after being fired. While reloading, or handloading, is most common in the civilian shooting world, some armed forces, law enforcement agencies, and armed groups also reload their ammunition. The latter, in particular, may resort to reloading ammunition when there is an insufficient quantity of industrially-produced cartridges or when their quality is poor. Cartridges may be reloaded to different specifications or purposes than the original round, and reloaded cartridges are often difficult for non-specialists to identify.

Projectile shape, weight, and jacket

The shape, weight, and jacket characteristics of a projectile can all help to identify ammunition. Projectile shape can vary significantly between calibres, and even among different types of ammunition in the same calibre. Several different 'loadings' of the same calibre and type may be produced, featuring different bullet dimensions and weights, differing amounts or types of propellant, and other changes. Image 4.10 shows four different projectiles for the 5.56 × 45 mm cartridge, of different functional types and projectile shapes. Three of these are the same weight (62 grains), despite clear differences in dimensions (i.e. shape).

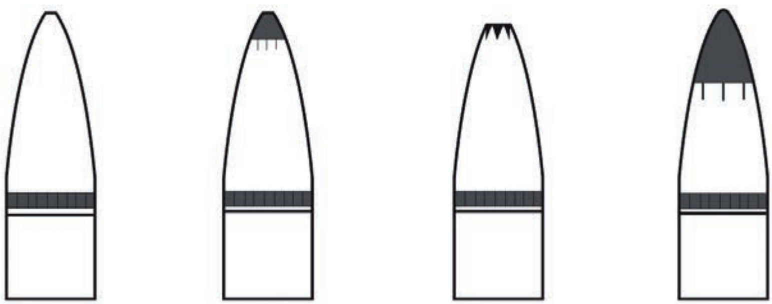
The weight of a projectile is generally measured in grains (United States, United Kingdom) or grams (Europe). While it would be difficult for a layperson to determine a projectile's weight as part of an assembled cartridge, bullet weight is often marked on packaging—and even sometimes indicated directly or indirectly in a headstamp. Recovered projectiles may also be weighed. Bullet weight can sometimes, depending on the cartridge, help to determine the loading or functional type of a cartridge.

Most modern cartridges feature projectiles covered by a thin envelope of metal known as a jacket. Projectile jackets vary with the purpose of the cartridge (see Figure 4.4). Jackets are most commonly made from gilding metal (an alloy of copper and zinc), steel, or gilding metal-clad steel (GMCS). The latter is particularly common in Eastern Bloc ammunition (Diehl and Jenzen-Jones, 2012). Cartridges with so-called 'full metal jacket' (FMJ) projectiles are by far the most common, and ball ammunition, the most common type in military usage, features an FMJ.

Image 4.10 Different projectiles for the 5.56 × 45 mm cartridge

Note: (a) 55 grain jacketed soft point; (b) 62 grain M855 ball; (c) 62 grain M856 tracer; (d) early 62 grain M855A1 ball.[98]
Source: Drake Watkins/ARES

Figure 4.4 Examples of common projectile jacket configurations



Source: ARES

98 Some consider the M855A1 to be 'semi-armour-piercing', a term with no precise, established meaning.

For law enforcement and civilian applications, including hunting, expanding projectiles are often employed. These bullets generally fall into two broad categories: jacketed bullets in which the jacket does not cover the tip, leaving the lead core exposed (known as jacketed soft-point, or JSP); and bullets that have a deep cavity in the tip to encourage them to deform (known as jacketed-hollow point, or JHP).[99] These are distinct from precision target bullets that also have a reverse-drawn jacket that wraps around the base of the bullet, but leave only small hole in the tip (most often known as open-tipped match, or OTM). Some hollow point projectiles may be capped, or 'tipped', to increase aerodynamic stability (Jenzen-Jones and Williams, 2016).

Crimping, cannelures, and fluting

Primer crimping is intended to hold the primer in place during transport, handling, and firing of the weapon (especially in automatic weapons). Primers are often secured to cartridge cases using a variety of crimping and 'staking' methods, which appear as a 'stab', 'ring', 'box', or other types of indented markings on the case head (see Image 4.11c, d). Primer crimping may prove useful in distinguishing cartridges from different manufacturers, batches, lots, or periods of production.

Cannelures are used as crimping rings for the case neck, ensuring the projectile is securely seated at the correct depth in the cartridge case (see Image 4.11a). Cannelures may also help mate the core and jacket of a bullet together, and prevent the latter from 'shedding' once fired. When applied above the case mouth, cannelures and knurling of the projectile jacket are sometimes used for identification purposes (particularly on military cartridges) (see Image 4.11e). Cartridges may feature multiple cannelures.

Fluting is a term used to refer to a groove or series of grooves decorating the surface of a cartridge case. Fluting is most often seen on drill rounds, generally oriented longitudinally along the case (see Image 4.11b). This serves as a visual and tactile indicator to distinguish dummy from live cartridges.

99 There are non-jacketed versions of both types, as well.

Image 4.11 Examples of various crimping, fluting, and cannelures

Source: Diehl and Jenzen-Jones (2012)

Markings

Headstamps and primers

Cartridges typically feature alphanumeric characters and/or symbols applied to the base of cartridge cases, known as headstamps. Headstamps often provide valuable information about the country of origin, producer, year of production, calibre, or type of cartridge in question. Some headstamps also include the lot or batch number of the cartridge. The headstamp is most commonly applied to the cartridge case during the manufacturing process.

When documenting headstamps, it is customary to refer to the location of the markings as they would appear on a clock face. Image 4.12d is a typical Eastern Bloc headstamp, with the factory (manufacturer) code in the 12 o'clock (top) position, and the last two digits of the year of production in the 6 o'clock (bottom) position. It is important to note that headstamp configurations vary widely, as illustrated by the other examples in Images 4.12 and 4.13.

Two common priming methods are used with modern cartridges. Most small-calibre cartridges make use of a separate primer, a small metallic cup containing an impact-sensitive chemical compound that is struck by the firing pin of a weapon, releases energy quickly, and ignites the propellant in a cartridge. The primer is located centrally in the head of the cartridge case, and cartridges using this method of priming are known as centrefire cartridges.[100] Primers can be a useful identification feature based on their colour, and method of securing (including stakes and crimping; see Images 4.12 and 4.13). Some rimmed cartridges, referred to as rimfire cartridges, contain primer compound within the rim of the cartridge instead of a separate primer (see Image 4.12c). Rimfire cartridges are now uncommon in military and law enforcement services.

100 The two most common small-calibre centrefire priming systems are known as the Berdan and Boxer types, after their inventors. Historically, cartridges using Berdan primers are more common in Europe (including widely-proliferated Eastern Bloc production from the Soviet Union, Russian Federation, and China), while those using Boxer primers are more common in the United States and Canada (Wallace, 2008). When primers have been ruptured or are absent from a fired cartridge case, images of the space left and the interior geometry of the case as viewed from the base of the cartridge can prove a useful identification feature.

Image 4.12 Sample headstamps

a. German 5.56 × 45 mm cartridge produced by Dynamit AG with 3-stab primer crimp. The lot number is required by law on German military ammunition.
b. Russian 9 × 18 mm Makarov cartridge with unusual bi-script headstamp in Latin and Cyrillic. Manufactured by Novo-sibirsk Low Voltage Equipment Plant in 2007.
c. British .22 LR rimfire cartridge produced by Imperial Chemical Industries.
d. Russian/Soviet 5.45 × 39 mm cartridge made by what is now Tula Cartridge Works with standard Eastern Bloc headstamp configuration, giving the factory at the 12 o'clock position and the year of manufacture at the six o'clock position.
e. Russian (commercial) headstamp of Tula Cartridge Works, with primer missing and Berdan priming system exposed, seen on a 7.62 × 39 mm cartridge.
f. Unmarked 7.62 × 39 mm cartridge with ring-crimped primer.

Source: Diehl and Jenzen-Jones (2012)

Image 4.13 Further sample headstamps

a. Danish 5.56 × 45 mm cartridge with three-stab primer crimp produced in 2009. The NATO Symbol of Interchangeability (‘cross in circle’) is at the 12 o’clock position.
b. German .300 Winchester Magnum (7.62 × 67B mm) cartridge manufactured by Metallwerk Elisenhütte for export to the Slovakian Police.
c. Saudi Arabian 7.62 × 51 mm cartridge with three-stab primer crimp, manufactured in Islamic Year 1425 (21 February 2004–9 February 2005). Note the palm tree and crossed swords, Saudi national symbols.
d. British .303 cartridge made by Royal Laboratories in 1937 with a ring-crimped primer.
e. Ukrainian .45 Rubber less-lethal cartridge made by Tekhkrim.
f. Yugoslavian (now Macedonian) 7.62 × 39 mm cartridge with convex primer and distinct primer annulus sealant, produced by Suvenir AD.

Source: Diehl and Jenzen-Jones (2012)

Box 4.1 Unmarked, mismarked, and counterfeit headstamps

As with other arms and ammunition, cartridges can be copied or counterfeited. False markings may be intended to increase the commercial value of a cartridge, or simply to obscure its origins. An example of a counterfeit headstamp is shown in Image 4.14. The markings on this cartridge case indicate it was produced at the Royal Ordnance Factory Radway Green, in the United Kingdom, in 1960. However, an examination of the physical features of the cartridge (including the calibre and case composition), as well as a detailed assessment of the quality and nature of the markings, reveal that the cartridge in question was almost certainly produced in China (Diehl and Jenzen-Jones, 2012).

Image 4.14 A counterfeit 7.62 × 51 mm cartridge produced in China, marked so as to appear to have been produced in the United Kingdom

Source: Diehl and Jenzen-Jones (2012)

Cartridges are also found with unmarked or blank headstamps, or with errors and omissions in headstamps.[101] For example, the cartridges shown in Image 4.15 are of Sudanese origin, produced by the Military Industry Corporation (Jenzen-Jones, 2014c). Recently-produced Sudanese cartridges typically feature a three-position headstamp (see Image 4.15b) that includes a calibre identifier (in this case, 39, indicating a 7.62 × 39 mm cartridge), a two- or three-digit code representing the year of manufacture (in this case 12, indicating production in 2012), and a single digit believed to represent the batch number or production line. The headstamp in Image 4.15a lacks this third marking. It is unclear whether this omission was deliberate, or a production error.

101 Errors and omissions may be introduced during the production process, or subsequently.

Image 4.15 Sudanese 7.62 × 39 mm cartridges

Note: (a) Cartridge produced in 2009 by Sudan's Military Industry Corporation, with just two markings, rather than the usual three. (b) A typically-configured cartridge of this period (produced in 2012) and calibre, which includes all three markings.
Source: C.J. Chivers/*The New York Times*

Finally, reloaded cartridge cases may bear headstamps that do not accurately reflect the type and nature of the cartridge in question.

It is also important to note that shotgun cartridges are particularly difficult to identify from headstamps alone.[102] A range of third-party producers supply cases (and, less commonly, their components (hulls and brass heads)) to the manufacturers of complete cartridges. It is these third-party producers who often apply the markings to shotshell components, and sell the marked parts to a number of cartridge producers for assembly. Many shotgun cartridges supplied on military contracts also follow commercial marking practices, making them difficult to distinguish from cartridges manufactured and/or used for civilian purposes (Jenzen-Jones, 2014b).

Case markings (other)

Cartridge cases are sometimes marked in locations other than the case head (that is, feature markings other than headstamps). Markings on cartridge case walls often indicate special-purpose functional types, such as grenade blanks and training rounds, but are also present on shotshells.

102 Shotgun cartridges are sometimes called 'shotshells', a term which has been applied to various cartridges containing shot, not just those fired from shotguns.

Projectile colouration and markings

Projectiles are variously marked and coloured, generally to indicate their type or purpose. Markings on certain commercial cartridges are for branding or marketing purposes. A wide range of different projectiles with different marking schemes are available in common calibres. Image 4.16 shows several projectiles from 7.62 × 39 mm cartridges. It is worth noting the tip colours, as well as the variations in cannelures, sealants, jacket materials, and projectile shapes.

Various coloured paints and sealants may be applied, sometimes in more than one colour. It is not uncommon, for example, for a projectile tip to have two colours (often indicating functional type). The tip marking is often in addition to a sealant, which may be a different colour. Ammunition commonly documented in conflict zones will often follow either Warsaw Pact or NATO markings schemes, which are generally as shown in Tables 4.4 and 4.5 and Figures 4.5 and 4.6.

Image 4.16 Various 7.62 × 39 mm cartridge projectiles from a range of countries and manufacturers

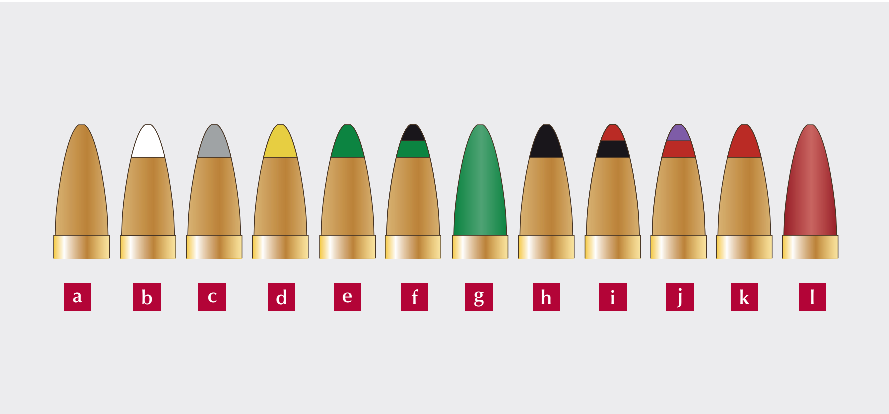
Note: (a) Tracer (Soviet Union); (b) tracer (Soviet Union); (c) tracer (Yugoslavia); (d) tracer (Finland); (e) armour-piercing (Czechoslovakia); (f) armour-piercing (Yugoslavia); (g) ball with mild steel core (Czechoslovakia); (h) ball with mild steel core (Albania); (i) ball with lead core (Finland); and (j) high-pressure test projectile (German Democratic Republic).
Source: Diehl and Jenzen-Jones (2012)

Table 4.4 Selected Warsaw Pact projectile colour codes

Projectile colour	Cartridge type
No colour	Ball
White (tip)	Ballistic reference ball
Silver (tip)	Light ball with steel core
Yellow (tip)	Heavy ball
Green (tip)	Tracer
Green (entire projectile) or black (tip) with green band	Subsonic
Black (tip)	Armour-piercing (AP)
Black (tip) with red band or red (entire projectile) with black tip	Armour-piercing incendiary (API)
Violet (tip) with red band	Armour-piercing incendiary tracer (API-T)
Red (tip)	Incendiary
Red (entire projectile)	High-explosive incendiary (HEI)

Note: This is a non-exhaustive list; several exceptions and contradictions exist.
Sources: Koll (2009); USSR (1946)

Figure 4.5 Selected Warsaw Pact projectile colour codes



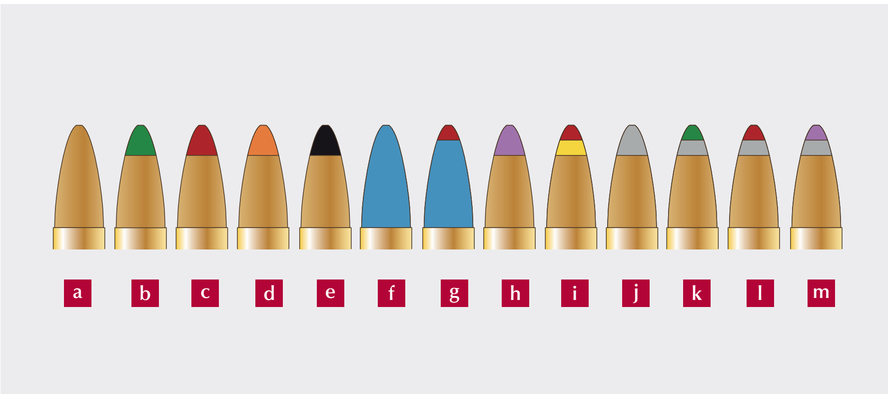
Note: (a) Ball (FMJ); (b) ballistic reference; (c) light ball; (d) heavy ball; (e) tracer; (f) subsonic; (g) subsonic; (h) AP; (i) API; (j) API-T; (k) incendiary; (l) HEI.
Source: ARES

Table 4.5 Selected NATO and associated military projectile colour codes

Projectile colour	Cartridge type
No colour	Ball
Green (tip)	Ball
Red (tip) or orange (tip)	Tracer
Black (tip)	Armour-piercing (AP)
Blue (entire projectile) or blue (tip)	Short-range training
Blue (entire projectile) with red tip or red (tip) with blue band	Short-range tracer training
Violet (tip)	Dim tracer
Red (tip) with yellow band	Observation
Silver (tip) or green (tip) with silver band	Armour-piercing incendiary (API)
Red (tip) with silver band	Armour-piercing incendiary tracer (API-T)
Violet (tip) with silver band	Armour-piercing incendiary dim tracer (API-DT)

Note: This is a non-exhaustive list; several exceptions and contradictions exist.
Sources: US DoD (2009); Williams (n.d.)

Figure 4.6 Selected NATO and associated military projectile colour codes



Note: (a) Ball (FMJ); (b) ball (FMJ); (c) tracer; (d) tracer; (e) AP; (f) short-range training; (g) short-range tracer training; (h) dim tracer; (i) observation; (j) API; (k) API; (l) API-T; (m) API-DT.
Source: ARES

Figure 4.7 Examples of the different colours, types, and application locations of sealants

Sources: Diehl and Jenzen-Jones (2012); Damien Spleeters; N.R. Jenzen-Jones/ARES

Sealants

Sealants, which are commonly used to protect the round from moisture, are occasionally useful for identifying the type or production batch of a particular cartridge. Some cartridges feature primers or projectiles that are entirely coated in a sealant. The cartridge in Figure 4.7e, a Romanian made 14.5 × 114 mm MDZ high-explosive incendiary cartridge, features a sealant-coated projectile and case mouth sealant. Figure 4.7f, a Vietnamese 7.62 × 39 mm cartridge, shows case mouth sealant. In some instances, sealants are made from a rubberized polymer or have an opaque finish (see Figure 4.7d).

Packaging

Packaging for small-calibre ammunition is another valuable source of information. Such packaging often consists of several layers. Individual rounds for rifles and handguns are typically packaged in paper and/or card wrappers and cardboard

Box 4.2 Myths and misconceptions: 'poisoned bullets'

Reports of 'poisoned bullets' are sometimes encountered in conflict areas, including Afghanistan, Iraq, Libya, Syria, and Yemen. In Libya in 2011, rebel fighters reported to ARES researchers that they had recovered 'poison-tipped ammunition' from regime forces. These cartridges, photos of which were shared with ARES, feature a green tip colouration. One fighter said: 'The green is to indicate the bullet is poisoned. When shot at someone venom is injected and he dies instantly.'[103]

In fact, the 7.62 × 39 mm cartridges in question were tracer cartridges. While some limited examples of small-calibre projectiles containing biological or chemical agents have been produced by governments, they are nearly unheard of in conflict zones. Some non-state actors have experimented with cartridges containing noxious substances, including the Islamic State group in Syria.[104] These rounds are extremely rare, however, even in regions where governments or armed groups have reportedly developed—or attempted to develop—ammunition containing biological or chemical agents.

boxes (see Image 4.20), usually in multiples of five or ten. A 'card wrapper' is a single piece of card wrapped around some or all of the cartridges in a container. Some ammunition, particularly pistol-calibre ammunition, may be packaged in plastic trays, which are sleeved inside a cardboard box (see Image 4.19). Even seemingly mundane pieces of packaging such as card wrappers may contain markings or physical features which can be interpreted by specialists. The next layer of packaging for military-issued ammunition typically consists of a metal storage container, or 'tin'. Belted ammunition is typically placed directly into the containers (that is, without additional inner packaging). The metal containers are then packed into shipping crates (see Image 4.17). The markings on all layers of packaging contain important information about the age, country of origin, make, model, and/or purpose of their contents. Examples of this packaging, and the information conveyed by their markings, are provided below. The paperwork found inside of, or accompanying, boxes and crates often contains additional information.

All markings on packaging for small arms ammunition should be recorded, as should the contents of documents found inside of ammunition crates and boxes. Image 4.17 shows an example of the markings on the outer packaging of some small-calibre cartridges. The box marking indicates the calibre (7.62); cartridge

103 ARES interviews with confidential sources.

104 ARES interviews with confidential sources. A Norwegian right-wing extremist also reportedly planned to incorporate chemical agents into small-calibre ammunition (Diethelm and McKee, 2011).

type (Б-32; B-32, an API designation; this also makes it possible to determine the complete cartridge designation, in this case 7.62 × 54R); case type (ГЖ; GZh, 'bi-metallic' also known as copper-clad steel); number of cartridges (880 ШТ; 880 sht, or pieces); cartridge lot number (04); year of manufacture (1977); and factory code (17; factory code for Barnaul Machine Tool Plant JSC, in what was then the Soviet Union).[105] The crate also contains information relating to the propellant type, lot, year of manufacture, and source. Image 4.18 shows a representative 7.62 × 54R mm B-32 cartridge such as would be contained within this packaging. The copper-clad steel cartridge case and tip colour code (black over red, indicating an API projectile) matches the information on the box in Image 4.17.

Image 4.17 Common markings on Eastern Bloc outer packaging (wooden crate)

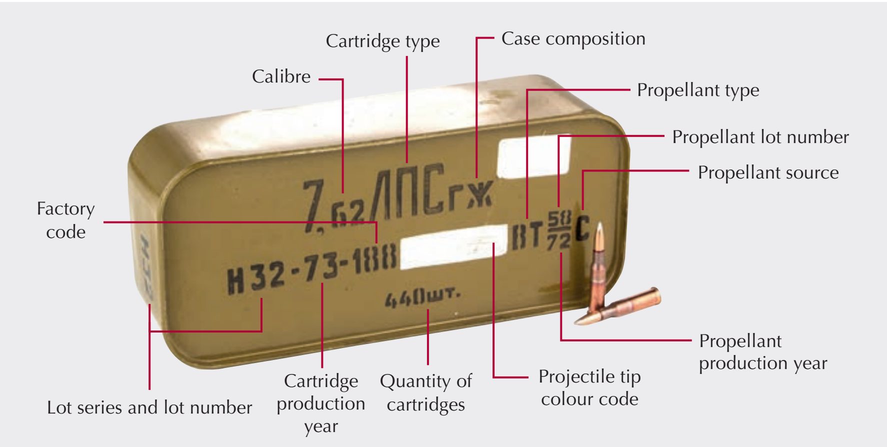
Note: This crate contains Soviet 7.62 × 54R mm API cartridges.
Source: Small Arms Survey

105 Now Barnaul Cartridge Plant CJSC.

Image 4.18 A representative Soviet 7.62 × 54R mm B-32 cartridge

Source: 7.62x54r.net

Figure 4.8 Typical marking format on Eastern Bloc inner packaging (metal tin) containing Soviet 7.62 × 54R mm light ball cartridges



Source: Bulkammo.com

Image 4.19 American Armscor USA .22 TCM cartridges in cardboard packaging with an inner plastic tray, common to modern commercial ammunition

Source: N.R. Jenzen-Jones/ARES

Image 4.20 Examples of cardboard inner packaging associated with cartridge-based ammunition (especially small arms ammunition)

Note: These are examples of Eastern Bloc packaging. In the centre column (and one example in the left-hand row), the coloured stripes indicate the tip colour code—and hence cartridge type—of the ammunition.
Source: Diehl and Jenzen-Jones (2012)

— Author: N.R. Jenzen-Jones