Chapter 16: Firearms and Toolmarks

Categories of Firearms with their Size Designation (Gauge or Caliber):

1. **Shotguns** - gauge
2. **Rifles** - caliber
3. **Handguns** - caliber
4. **Rifles and handguns are rifled** (inner surface of barrel is spiraled).

**Shotguns:**
5. Unlike rifled firearms (such as rifles and handguns), a shotgun has a smooth barrel on the inside.
6. Shotguns generally fire shotgun shells packed with small lead balls or pellets that are not impressed with any characteristic markings that can be related back to the weapon.
7. The diameter of the shotgun barrel is expressed by the term **gauge**.
8. The higher the gauge number, the smaller the barrel’s diameter.
9. For example – a 16 gauge shotgun barrel has a smaller barrel diameter than a 12 gauge shotgun.

**How the Gauge of a Shotgun is Determined:**
10. Gauge - the system used to determine the interior diameter of the barrel of a shotgun.
11. It is determined by taking one pound of lead and divide that pound into 16 balls of equal size, the diameter of each of the balls will fit a 16 gauge shotgun.
12. In other words, the ball diameter is the same inner diameter as a 16 gauge shotgun.

**Shotgun Shells:**
13. Come in different gauge shells to fit the correct barrel diameter
14. Different shot sizes: number 9 (smaller) through 0, 00, 000 and slug (one single piece of “lead”)

**Handguns & Rifles - Rifling:**
15. **Caliber** - the system used to determine the bore diameter of a handgun or rifle.
16. **Bore diameter** - the distance from land to land in the inside of a rifled barrel.
17. **Rifling** - a “cut” made down the center of the barrel of a rifle in a twisted pattern.
18. **Lands** – the higher areas on the inside surface of the barrel.
19. **Grooves** – the lower areas on the inside surface of the barrel.
20. The bullet **spirals** as it moves through the air. Making the bullet travel a longer distance more accurately.
21. **Spiral** can be to the right or left.
22. It can take 8 inches for one spiral to be completed. This is called twist and can vary from 8 to 20 inches.
23. **How much** twist a gun has depends on the type of ammunition to be used (mass of bullet and amount and type of powder)
24. The number of grooves inside the barrel can also vary. From 3 to 8 grooves.
25. For example, rifle can have a 4 groove 14 twist.

**Three Methods of Rifling:**
26. A button forces grooves into the metal under high pressure as the barrel surrounds the button.
27. A **broach** is a set of **steel rings** on a rod that cuts the grooves into the barrel as the rod is rotated down the length of the barrel.

28. A **mandrel** is a rod, the **same length** as the barrel, that has the **reverse rifling** pattern on its outside. It is placed inside an oversized barrel and the rifling is rolled or hammered into the inside of the barrel.

**What Happens When the Trigger is Pulled:**

29. Pulling the trigger causes the **firing pin** to strike the back of the **primer cup**, leaving the **impression** of the firing pin on the back of the primer cup. The primer cup contains a **primary explosive**. (A primary explosive is one that is sensitive to **friction**, **heat** and or **mechanical** shock.)

30. When the primary explosive receives this mechanical shock, it **explodes**.

31. This explosion causes the **gun powder** in the cartridge to **ignite**. The burning of gun powder (KNO3 + sulfur + carbon) produces the gases CO2, nitrogen oxides, and SO2.

32. The gases, produced in this reaction, take up greater space causing the bullet that is in front of them to be forced **forward** through the **rifled** barrel of the gun. Rifling marks and striations from inside surface of the **barrel** are impressed upon the sides of the bullet.

**Action and Reaction:**

33. For every **action** there is an equal and opposite **reaction**.

34. When the bullet is pushed **forward**, it pushes **back** on the cartridge case and the **gun** itself (recoil).

35. The cartridge case is pushed **back** against the **breechface** (rear wall of the firing chamber) of the gun. The **striations** found on the breechface are impressed upon the back (or bottom) of the **cartridge** case.

**Removing the Cartridge Case:**

36. The cartridge case is then removed from the firing chamber by an **extractor**. The extractor, a metal device, leaves a **mark** on the **rim** of the cartridge case.

37. The firing pin, breechblock, and ejector and extractor mechanisms also offer a highly distinctive signature for **individualization** of cartridge cases.

38. The **cartridge case**, in its rearward thrust, is impressed with the surface **markings** of the breechblock.

39. The **ejector** then pushes the cartridge case **out** of the firearm, leaving its **mark** on the **side** of the cartridge case. These marks, made by the extractor and ejector, will **match** the marks made on **other** cartridge cases fired by that same firearm.

**Gunpowder Residue:**

40. When a firearm is discharged, unburned and partially burned particles of **gunpowder** in addition to smoke are **propelled** out of the barrel along with the bullet **toward** the **target**.

41. If the muzzle of the weapon is sufficiently **close**, these products will be **deposited** onto the **target**.

42. The distribution of gunpowder particles and other discharge **residues** around a bullet hole permits an assessment of the **distance** from which a handgun or rifle was **fired**.

43. **Comparisons** are made between the powder-residue **pattern** located on the **victim’s** clothing or skin against test patterns made when the suspect weapon is test fired at **varying** distances from a target.

44. Enough similarity in shape and **density** of pattern upon which to base an opinion as to the **distance** shot was fired.
Gunpowder Residue – Con’t:
45. When the weapon is held in contact with or less than 1 inch from the target, a star-shaped (stellate) tear pattern around the bullet hole entrance is noted, as well as a narrow rim of smokeless deposit of vaporous lead.
46. A wider circle of vaporous lead (smoke) deposited around a bullet hole is normally noted in a discharge of 12 to 18 inches from the target.
47. Scattered specks of unburned and partially burned powder grains without any accompanying soot around the bullet hole is often observed at distances up to 25 – 36 inches.
48. More than 3 feet away will usually not deposit any powder residues, and the only visual indication is a dark ring around the hole, known as a bullet wipe.

49. In the crime laboratory, the surface of a garment and/or body are first examined microscopically for the presence of gunpowder residue.
50. Chemical tests, such as the Greiss test, may be needed to detect gunpowder residues that are not visible. In addition, Infrared (IR) photography can easily show the presence of GSR.

Powder Residue on Hands:
51. The firing of a weapon not only propels residues toward the target, but gunpowder and primer residues are also blown back toward the shooter.
52. Traces of these residues are often deposited on the firing hand of the shooter, and their detection can provide valuable information as to whether or not an individual has recently fired a weapon.
53. Examiners measure the amount of Lead (Pb), Barium (Ba), and Antimony (Sb) elements on the relevant portion of the suspect’s hands, such as the thumb web, the back of the hand, and the palm.
54. SEM (Scanning Electron Microscope) may also characterize the morphology or shape of GSR particles containing these elements to determine whether or not a person has fired, handled a weapon, or was near a discharged firearm.

Serial Number Restoration:
55. Items of value may have ID or serial numbers stamped into them (i.e. Rolex watch, firearm, safe).
56. A criminalist can be asked to restore a serial number when it has been removed or obliterated by grinding, rifling, or punching.
57. Restoration is possible through acid chemical etching because the metal crystals in the stamped zone are placed under a permanent strain that extends a short distance beneath the original numbers.
Firearms Evidence – Individual or Class?

58. Individual:
- Striae
- Firing pin marks
- Breech marks
- Extractor marks
- Ejector marks
- Chamber marks

59. Class:
- Bullet type
- Bullet caliber
- Bullet weight
- No. of Lands and grooves
- Left or Right Rifling
- Cartridge case head stamp

60. The metal tools used to make the metal parts of a firearm change as they are being used in the manufacturing of the gun. That is, microscopic particles are being worn away as the tools come into contact with the firearm. This makes the metal parts of the firearm that come in contact with the bullet and cartridge case different for each firearm.

61. Rifling marks on the bullet only show the number of grooves and information that can give the twist. This is class information only. It can sometimes tell the manufacturer of a firearm (i.e. 6 lands/grooves with a left twist is common to Smith & Wesson gun manufacturer).

Databases

62. Computerized systems used to compare tool marks founds on bullets and cartridge cases.
63. Drugfire – two programs. One compares bullets and the other compares cartridge cases.
64. IBIS – Integrated Ballistics Identification System uses to programs:
   - *Brasscatcher – compares cartridge cases
   - *Bulletfire – compares bullets
66. Comparisons in all systems are made using a comparison microscope.

Bullet Components

Collection of Firearms Evidence

67. Spent bullets & cartridge (have been fired) - Wrapped in soft material and individually placed in rigid containers.
68. Firearms – Must be unloaded; Placed in secured box.
69. Live Ammunition (has not been fired)- Carefully wrapped to prevent premature firing if dropped
70. Bullets should be initialed only on the base or nose.
71. Shotgun shells should be initialed on the brass, close to the plastic.
Bullet Trajectory & Projectile Motion
72. The flight path of a projectile.
73. Two reference points along the flight path of the projectile are needed.
74. Reference points can be a bullet hole in an object, such as a wall or a window, or a bullet wound on a victim. Investigators look for clues at scene to help calculate the bullet’s trajectory to determine where the shooter fired the weapon.
75. Every moving object has horizontal & vertical velocity.
76. Vertical velocity is changed by force of gravity.
77. Horizontal velocity stays the same

The ball is in free fall vertically and moves at constant speed horizontally!!!

\[
y = y_0 + v_0 \sin(\theta) t - \frac{1}{2}gt^2
\]

78.  
- \(y\) = height of victim / wound (m)
- \(y_0\) = height of shooter’s location (m)
- \(v_0\) = initial speed of the bullet (m/s)
- \(\theta\) = angle of firing in (degrees)
- \(t\) = time for bullet to travel (s)
- \(g\) = acceleration due to gravity (always 9.8 m/s²)

1. A sharpshooter is located in a tree. The sharpshooter fires down at a 30 degree angle. It takes the bullet 0.5s to hit the victim’s shoulder at 1.2m high. The speed of the bullet was 62m/s. How high up is the sharpshooter?

\[
1.2 = y_0 - 62 \sin(30) \times (0.5) - (0.5)(9.8)(0.5)^2
\]
\[
1.2 = y_0 - 15.5 - 1.225
\]
\[
1.2 = y_0 - 16.725
\]
\[
18.925m = y_0
\]
2. A sharpshooter is located in a tree 15m tall. The sharpshooter fires down at a 25 degree angle. It takes the bullet 0.5s to hit the victim’s shoulder (located at 1.5m high). What is the speed of the bullet as it leaves the gun?

$$1.5 = 15 - v_0 \sin(25) \times (0.5) - (0.5)(9.8)(0.5)^2$$
$$1.5 = 15 - 0.211v_0 - 1.225$$
-12.275 = -0.211v_0

$$58.2\text{m/s} = v_0$$

3. A sharpshooter fires a gun from the ground at a height of 2.0m and angle of 45 degrees up. It takes the bullet 1.2s to hit the victim located in a building 120m high. What is the speed of the bullet as it leaves the gun?

$$120 = 2.0 + v_0 \sin(45) \times (1.2) - (0.5)(9.8)(1.2)^2$$
$$120 = 2.0 + 0.849v_0 - 7.056$$
$$125.056 = 0.849v_0$$

$$147.3\text{m/s} = v_0$$
5. A sharpshooter is located in a tree 35m tall. The tree is located 10m away from the victim. It takes the bullet 0.25s to hit the victim’s shoulder (located at 1.8m high). What is the speed of the bullet as it leaves the gun?

\[
\begin{align*}
\tan \theta &= \frac{35}{10} \\
\theta &= \tan^{-1}(3.5) \\
\approx 74 \text{ degrees}
\end{align*}
\]

\[
y = y_0 + v_0 \sin(\theta)t - \frac{1}{2}gt^2
\]

\[
y = y_0 - v_0 \sin(\theta)t + \frac{1}{2}gt^2
\]

\[
1.8 = 35. - v_0 \sin(74) \times (0.25) - (0.5)(9.8)(0.25)^2
\]
\[
1.8 = 35. - v_0(0.96126) \times (0.25) - 0.30625
\]
\[
1.8 = 35. - v_0(0.240315) - 0.30625
\]
\[
1.8 + 0.30625 = 35. - v_0(0.240315)
\]
\[
2.10625 = 35. - v_0(0.240315)
\]
\[
2.10625 - 35. = -v_0(0.240315)
\]
\[
-32.89375 = -v_0(0.240315)
\]
\[
-32.89375 ÷ 0.240315 = v_0
\]
\[
136.877 \text{ m/s} = v_0 \approx 140 \text{ m/s}
\]

**Toolmarks**

79. **Tools** often used in crimes may leave **marks** at points of entry into homes, **autos**, and businesses. Marks may also be **found** on the **evidence** such as a safe.

80. **Class** characteristics: **type**, **size**, and **shape** (i.e. screwdriver, ¼”, flat-head)

81. **Individual** characteristics: features from **wear** and **damage** to tool. (i.e. screwdriver edge is pitted or scratched leaving those same marks on the evidence)

82. The **comparison microscope** is used to compare **crime-scene** tool marks with **test impressions** made with the **suspect tool**.

83. When practical, the **entire object** or the part of the object bearing the **tool mark** should be submitted to the crime laboratory for examination.

84. Under **no** circumstances must the crime scene investigator attempt to **fit** the suspect tool **into** the tool mark. Any **contact** between the tool and the marked surface may **alter** the mark and will, at the least, raise **serious** questions about the **integrity** of the evidence.

**Other Impressions – Shoe, Tire, Fabric**

85. Impressions of other kinds, such as **shoe**, **tire** or **fabric** impressions, may be important evidence.
86. Before any impression is moved or otherwise handled, it must be photographed (including a scale) to show all the observable details of the impression. If the impression is on a readily recoverable item, such as glass, paper, or floor tile, the evidence is transported intact to the laboratory.

87. When shoe and tire marks are impressed into soft earth at a crime scene, their preservation is best accomplished by photography and casting.

88. In areas where a bloody footwear impression is very faint or where the subject has tracked through blood leaving a trail of bloody impressions, chemical treatment can visualize latent or nearly invisible blood impressions.

Points of Comparisons in Impressions
89. A sufficient number of points of comparison or the uniqueness of such points will support a finding that both the questioned and test impressions originated from one and only one source.

90. New computer software such as SICAR and web sites may be able to assist in making shoe print and tire impression comparisons.

Shoe Impressions – Class & Individual Characteristics
91. Class characteristics— manufacturer, type, model, size. (i.e. Nike, running shoe, Flex Experience 2, size 7)

92. Individual characteristics— wear patterns, nicks, marks, occlusions (like pebbles or sticks stuck in tread).

Tire Impressions – Class & Individual Characteristics
93. Class characteristics - involve design, size, type, and model. (i.e. 15”, automobile tire, Michelin Defender)

94. Individual characteristics - Wear and damage cause defects

Bite Mark Impressions
95. Result from assault or sexual attack, common in domestic violence.

96. Can be individual evidence, if enough impression is left behind in skin or food (i.e. Bite mark in flesh; partially eaten apple found at crime scene)

Famous Bite Mark Evidence Case
97. Ted Bundy, a serial killer who confessed to killing over 30 women from 1975-1978, was convicted in the deaths of 6 of these women in 1979.

98. He received the death penalty and died by lethal injection in 1989. Upper and lower dental impressions were taken from Bundy.

99. Forensic odontologists compared a bite mark left on one of his victims by outlining the structure of the unique alignment, the chips, the size of the teeth, and the sharpness factors of the bicuspids, lateral, and incisor teeth.

100. These unique indentation marks on the victim were shown to match the dental impressions of Bundy's teeth.