Firearms Identification

(Forensic Ballistics)

Introduction

Firearms Identification. Sometimes incorrectly referred to as ***ballistics***, firearms identification can be defined as,

> ***The identification of fired bullets, cartridge cases or other ammunition components as having been fired from a specific firearm.***

Firearms identification is actually a form of ***Toolmark Identification*** where the firearm, because it is made of a material harder than the ammunition components, acts as a tool to leave impressed or striated marks on the various ammunition components that come into contact with the firearm.

Firearms evidence submitted to a lab's Firearms Section will typically include a firearm, fired bullets, spent cartridge cases, spent shot shells, shot, shot shell wadding, live ammunition, clothing, and you wouldn't believe me if I told you.



In addition to comparing ammunition components to firearms, firearm examiners conduct other examinations that usually include the following:

- Testing firearms to determine if they function properly.
- Examine clothing and other items for gunshot residues and/or shot patterns in an attempt to determine a muzzle-to-garment distance.
- Determine caliber and manufacturer of ammunition components. Including the examination of various shotshell components.
- Determine the manufacturer or manufacturers of firearms that may have fired a particular bullet or cartridge case.

Firearm examiners will perform specific scientific examinations upon the evidence submitted. Once the examinations are completed reports detailing their findings are forwarded to the investigating officer and eventually to all parties involved in any subsequent criminal proceedings.

Firearm examiners finish their involvement of a case by presenting their findings in a court of law.

Fundamentals of Firearms Identification

Studies have shown that no two firearms, even those of the same make and model, will produce the same unique marks on fired bullets and cartridge cases. Manufacturing processes, use, and abuse leave surface characteristics within the firearm that cannot be exactly reproduced in other firearms.

Firearms do not normally change much over time. This allows for firearms recovered months or even years after a shooting to be identified as having fired a specific bullet or cartridge case. Tests have been conducted that found that even after firing several hundred rounds through a firearm the last bullet fired could still be identified to the first.

It should be noted that not all firearms leave consistent reproducible marks. But overall it has been my experience that around eighty percent of the firearms that I examine produce what is sometimes called a "mechanical fingerprint" on the bullets and cartridge cases that pass through them.

All cases that involve firearms identification start with preliminary examinations of the evidence for similar ***class characteristics***. Class characteristics can be defined as:

> ***Intentional or design characteristics that would be common to a particular group or family of items.***

A very basic example would be that several no. 2 pencils in a box are yellow and have pink erasers. The color and eraser type is a common class characteristic to all of the pencils.

When it comes to firearms and ammunition it is not quite so simple.

The class characteristics of firearms that relate to the bullets fired from them includes the ***caliber*** of the firearm and the ***rifling*** pattern contained in the barrel of the firearm.

Cartridges and Cartridge cases on the other hand are examined for class similarities in what are called ***breech marks***, ***firing pin impressions***, ***extractor marks***, ***ejector marks*** and others.

If dissimilarities in class characteristics are found or if a general lack of good class characteristics are present no further comparisons may be necessary.

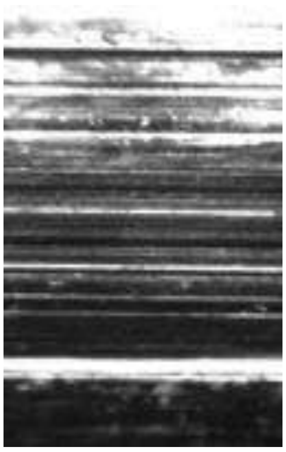
When similar class characteristics are identified the examinations progress to a final stage where an attempt is made to find a "match" in what are called ***individual characteristics***. ***The AFTE Glossary defines Individual characteristics as:***

> ***marks produced by the random imperfections or irregularities of tool surfaces. These random imperfections or irregularities are produced incidental to manufacture and/or caused by use, corrosion, or damage. They are unique to that tool and distinguish it from all other tools.***

The transfer of individual characteristics from a firearm to the ammunition components passing through it is what makes firearms identification possible.

Bullet Identification

Bullets collected for comparison to a specific firearm are examined first to see if they are of a ***caliber*** that could have been fired from the submitted firearm. They are then examined to determine if the pattern of ***rifling impressions*** found on the bullet match the pattern of ***rifling*** contained in the barrel of the questioned firearm. If these class characteristics agree the next step is to try to make a positive match between the individual characteristics that may have transferred to the bullet from the barrel.



Located within the rifling impressions on a bullet can be microscopic striations or scratches like those seen on the bullet below. They sort of look like a bar code don't they?

Imperfections in the surface of the interior of the barrel leave striations on the projectiles. Striations have the potential to be consistently reproduced in a unique pattern on every bullet that passes down the barrel of a firearm. The key word in the previous sentence is *unique*.

Examinations conducted

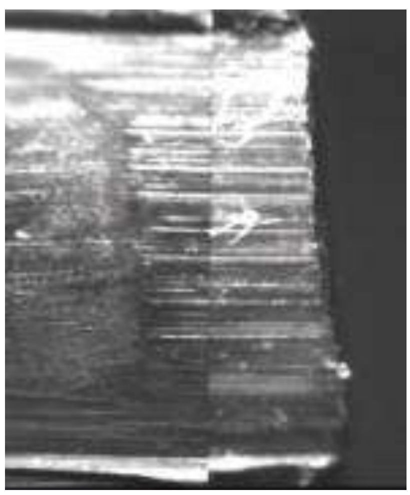
A submitted firearm will be fired several times using a water tank like the one on the left to obtain *standards* from the firearm. Lids on the tank are closed and locked and the muzzle of the firearm is placed in the open tube at the end of the tank and fired. Friction from passing through the water slows the bullets down and they end up on the bottom of the tank about halfway down its length. The tank is approximately 3 feet wide, 10 feet long and 3 feet high.

Fired standards, like those to the right, are examined first to determine if in fact the barrel is producing striated marks in a unique and consistent pattern. Once a consistently reoccurring pattern to the marks is identified on standards, the standards are compared to the evidence bullets to see if the same pattern of marks exists on the evidence. To make these comparisons the firearm examiner will use a ***comparison macroscope*** *(below right)*.

Notice that this is called a ***macro***scope and not a ***micro***scope. Microscopes typically use objectives that are 100x and above. Magnifications typically used in firearms identification are 5X, 10X, 20X, 30X, and 40X. It is not unusual however to see these lower powered scopes referred to a microscopes. In fact if you see it referred to as a microscope on this website just ignore it!

All firearm sections will have a comparison macroscope. The comparison macroscope consists of two macroscopes mounted side by side and connected by an optical bridge. There are two stages on the lower part of the macroscope that the bullets to be compared are mounted on. The bullets are attached to the stages using some type of sticky substance. Images of the bullets travel up through the objectives, bounce off several mirrors in the optical bridge, and are combined in a round field of view seen by looking into the stereoscopic eyepieces. The resulting image will show the bullets mounted to the stages, side-by-side, with a thin dividing line down the middle. The images below show rifling impressions on a 32 caliber bullet at progressively increasing magnifications.

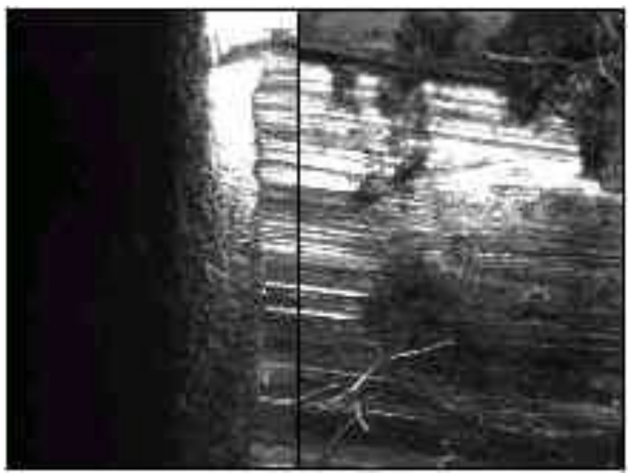
The stages that the bullets are attached to allow the bullets being examined to be rotated on their axis and moved up, down, to the left, and to the right. The bullets are rotated around to see if any microscopic similarities are present. Most positive identifications are made on striations that occur in land impressions and the best marks are usually near the base of the bullets like those seen below.



Not all bullet identifications are like those seen in the above image. Firearm examiners will examine the entire bullet for striations that agree with the standards. Bullets can have as many as six, eight or even twenty-two different land and groove impressions and each one may have areas of agreement between the striations. Taking an image of striations, like the one seen above will usually not be representative of the actual overall positive identification. It really comes down to the experience of the firearm examiner and what they perceive to be the overall uniqueness of the striations that are present.

One of the biggest problems in making an identification is that few evidence bullets are submitted intact. Most are badly distorted, wiped and/or fragmented. The fragment seen below may not look like much but even small fragments and badly damaged bullets can still retain sufficient marks for an identification to be made.

Until the questioned bullet is examined microscopically by a trained firearm examiner you just don't know if it has marks of comparative value. The comparison image below shows the above bullet fragment (right) compared to a standard (left) fired from the submitted firearm.



Results

When comparisons are made between firearms and fired ammunition the results can read as follows:

Exhibit 1 (bullet) was identified as having been fired from Exhibit 2 (revolver).

This conclusion is reached after all class characteristics agree and a sufficient correlation between individual characteristics is found.

Exhibit 1 (bullet) could neither be identified nor eliminated as having been fired from Exhibit 2 (revolver). All comparisons were inconclusive.

This conclusion is reached if class characteristics agree but there is an insufficient correlation between individual characteristics.

Exhibit 1 (bullet) was not fired from Exhibit 2 (revolver).

This conclusion is reached if class characteristics disagree.

In some cases, a firearm may not be recovered for comparison. When this happens firearm examiners can examine bullets for ***general rifling characteristics (GRC)*** in an attempt to determine what brands of firearms from which the bullet may have been fired.

We have now discussed how bullets can be identified as having been fired from a firearm but what about the cartridge cases.

Bullet Basics 1- Caliber

When a bullet is submitted for comparison to a firearm, one of the first examinations conducted will be to determine the bullet's ***caliber***.

Caliber is a term used to indicate the diameter of a bullet in hundredths of an inch. A bullet that is 30 hundredths of an inch (.30) in diameter is called a 30 *caliber* bullet. The term caliber is of English origin and is used by ammunition and firearm manufacturers in the United States. Firearms and ammunition of European origin use the metric system and would refer to a 30 caliber bullet as an 7.62mm bullet.

The caliber of the bullet is just the first class characteristic that must agree with the questioned firearm. The bullet must also be of the type found in ***cartridges*** that the firearm will fire. A cartridge is a single unit of ammunition consisting of the cartridge case, primer, and propellant with or without one or more projectiles. The image below shows these various components.

Cartridges are usually given a name or ***cartridge designation*** by their developer, who is more often than not the manufacturer of a firearm (It doesn't make much sense to develop a cartridge if you don't have a firearm to fire it in). The cartridge designation typically includes a numerical value to indicate the approximate diameter of the bullet and will often include the manufacturer's name.

It never fails that when a cartridge is developed the manufacturer or others will immediately try to improve on the design. Variations to the original cartridge are usually inevitable and may be in the form of a longer or shorter case, differences in gunpowder, or differences with the weight and type of bullet contained in the cartridge.

When a variation in the cartridge case length occurs the cartridge's name may include the term Short, Long, or Magnum to denote the difference. Examples of which are the 32 S&W and the 32 S&W LONG cartridges seen below. SMITH & WESSON developed both of these cartridges for use in their 32 caliber revolvers. As you can see, the 32 S&W Long cartridge on the right has the longest cartridge case.

Long or magnum cartridges may also have a heavier bullet when compared to the standard or short versions. The 32 S&W cartridge above contains an 88 grain bullet and the LONG version contains a 98 grain bullet.

Other variations can occur in the bullet weight and bullet construction within the same cartridge designation. All of the cartridges seen on the right are in the 22 caliber "family" yet each has a different cartridge designation. From the left they are: 22 Blank, 22 Short, 22 Long, 22 Long Rifle Shot, 22 Viper, 22 Long Rifle, 22 Stinger, 22 Magnum, and 22 Maximum.

Cartridges designed for use in auto loading pistols will usually have the word ***AUTO*** in their cartridge designation (i.e. 32 AUTO, 45 AUTO). Cartridges can also carry a ***+P*** designation that stands for *plus power*. Cartridges with the +P designation usually have no external differences from the lower powered varieties but contain different types of gunpowder to achieve higher velocities.

Measuring the bullet's diameter, weighing the bullet, and examining the physical characteristics of the bullet help firearm examiners to arrive at a basic caliber for the submitted bullet. Firearm examiners also can compare the questioned bullet to known reference standards. Most firearms sections maintain an ammunition reference collection and manufacturers catalogs that can be used as reference material in determining a bullet's caliber.

Sounds simple doesn't it? Well.... not so fast!

It's one thing to look at the bullet above (looking down on the bullet with a mirror in the back showing the bullet's profile) and to say "that's a Federal 9mm *Hyda-Shok* bullet," when more than likely you've got a bullet from the victim like the one on the right. Is the bullet from a 9mm LUGER, a 38 SPECIAL, a 380 AUTO, or a 357 MAGNUM cartridge? You get the idea. Sometimes firearm examiners can be very specific but there are times when we just can't narrow things down to one particular caliber or cartridge.

To further confuse the issue, firearms are normally designed to fire a specific type of cartridge. However, some firearms chambered to fire one cartridge can also fire another. One of the most common examples is that a revolver chambered for 357 MAGNUM cartridges can also fire a 38 SPECIAL cartridge. However, a firearm chambered for 38 SPECIAL cartridges cannot fire 357 MAGNUM cartridges. This must be considered in examining the submitted bullet. You don't want to automatically eliminate a bullet based on its caliber until you determine the varieties that may be fired in the questioned firearm.

If the caliber of the bullet submitted for examination matches the caliber of the submitted firearm or if we just aren't sure of the bullet's caliber, the firearm examiner will look for additional class characteristics in the form of *rifling* to further narrow their search.

Bullet Basics 1- Materials

Identifying the manufacturer and caliber of a submitted bullet is an important examination conducted in a forensic laboratory by Firearm and Toolmark Examiners.

There are a number of good reasons to determine who made the bullet but one that stands out to be of particular importance occurs when the bullet cannot be identified to a specific firearm through normal firearm identification techniques. Let's say that several shots are fired at a crime scene and all of the shooters are firing GLOCK brand 9mm Luger caliber pistols. In this situation all of the bullets collected will have the same diameter and will have the same general rifling characteristics.

The only way in this situation to determine who may have fired one bullet vs. another is to look at the brand of ammunition that each shooter was using (hopefully they used different brands!) and then try to match the physical characteristics and materials to those used by one brand cartridge or the other.

The fired cartridge cases collected at the scene have headstamps that will identify who made the cartridge case, so once they are identified to the gun they were fired from, we can look at the bullets to see if they are similar to bullets made by those manufacturers.

By identifying the bullet manufacturer we can now determine which gun most likely fired those bullets given the limited universe of this one crime scene. Firearm examiners will examine the unknown bullets and compare the physical properties of the bullets to known standards. Through this process of direct comparison often times the manufacturer can be determined and in doing so provide the investigation just one more clue to help bring the case to a desirable outcome.

There are several things that firearm examiners look for when they examine the bullets. The diameter and weight are helpful in determining caliber, but the *materials used* and the general *shape* of the bullet can assist in determining the manufacturer of the unknown bullet.

Let's start with the *materials* used in the manufacture of bullets.

Bullet Materials

Projectiles in general have come along way over the last several centuries. What started out as crude rocks and pebbles have steadily evolved into bullets born from very advanced engineering.

It wasn't until the late 15th century that bullets were starting to be produced by casting metal into balls using molds. The modern bullet can be manufactured through casting, swaging, milling, plating, stamping or compression processes. Bullets are usually made of a single metal alloy or a layered combination of various materials to include lead, copper, brass, bronze, steel, and aluminum. These layered bullets are referred to as ***jacketed*** bullets. The materials used in the manufacture of a bullet effect its performance both in flight and when they reach their target.

There are two very important things that manufacturers constantly try to strike a balance between. They are penetration and expansion. The type of target you are shooting at dictates the type of bullet you will use. If a bullet fails to penetrate deep enough it may not reach the internal organs of the target and therefore not immobilize or kill the target. Too much penetration and the bullet can pass through the target and continue down range wasting energy.

So manufacturers are constantly trying to design a bullet that does the best job for it's intended purpose. The materials used in the manufacture of the bullet are very critical to achieving the goal of the bullets impact.

Non-jacketed Bullets- The most common material used in the manufacture of non-jacketed bullets is lead. Lead bullets are usually an alloy of lead and antimony which is added to give the bullet some additional hardness. Variations are the norm when it comes to the materials used in bullets and it's not uncommon to find lead bullets with a thin coating of copper or brass plating. Bullets having this thin coating is sometimes referred to as a copper-washed or "Lubaloy" bullet. This thin coating can be easily scratched away from the surface of the lead causing problems for firearm examiners when these bullets are damaged. Another example of a coated bullet is the Federal "Nyclad" bullet that is designed to reduce lead emissions.

Plain Lead Round-nosed bullet

Copper-washed or "Lubaloy" lead round-nosed bullet

Federal "Nyclad" nylon coated bullet

Other solid bullets can be machined out of a piece of copper, brass, or similar material. Newer manufacturing techniques use pressure to compress a material like tungsten into a bullet referred to as a "frangible" bullet. Examples of these can be seen below.

THV Solid brass machined bullet

KTW Teflon coated solid brass machined bullet

Frangible tungsten compressed bullets

Jacketed bullets- Jacketed bullets are a laminate of material, with the harder "jacket" covering a core typically made of lead. This jacket material differs from the thin copper plating seen on the copper-washed bullets above. The jacket material cannot be easily removed.

The most common bullet jacket material is copper. These can sometimes be plated with nickel to give the bullet a silver finish but the jacket can also be made of a number of other materials such as aluminum or steel. Steel jackets are widely used in bullets that originate in the European and Chinese markets. Steel jacketed bullets are usually coated or plated to help prevent rusting.

Copper jacketed full-metal-case bullet and cross-section

Winchester "Silver-tip" nickel-plated copper jacket bullet

Copper plated steel jacketed bullet

Jacketed bullets usually have an opening at the base or the nose but some are have no opening in the jacket material. These bullets are called totally-metal-jacketed bullets (TMJ) or encapsulated bullets.

CCI totally-metal-jacketed bullet

The most common jacketed bullet core material is lead but exceptions again exist and a common example is the 7.62x39mm armor piercing bullet (show above right). This bullet has a steel jacket over a thin layer of lead which surrounds a steel core. It is not uncommon for firearm examiners to receive just the steel core as an exhibit. When this bullet strikes a target the steel core can punch right through the nose of the jacket material. I had a case several years ago where several of these bullets were fired through the windshield of a car, killing the lone occupant. All that was recovered from the victim were several steel bullet cores like those seen below.

Steel cores from 7.62x39mm
steel jacketed bullets

Jacketed bullets may also contain something other than a lead or steel core. Some may contain small lead pellets, plastic, or maybe even a silicone rubber material as seen below.

Glaser Safety Slug containing
small lead pellets and a plastic plug

Federal Expanding Full-Metal-Jacketed (EFMJ)
bullet with silicone nose material

Another somewhat unusual jacketed bullet is the Remington Accelerator. This centerfire rifle bullet consists of a copper jacketed bullet that is of a smaller caliber than the rifle it is fired in. This smaller bullet is surrounded by what is called a **Sabot**. The sabot actually rides down the rifling of the barrel and once leaving the barrel of the rifle the sabot and the bullet separate. The sabot falls to the ground fairly close to the rifle but the light weighted bullet travels down range at a high velocity minus any identifiable rifling characteristics. They are on the sabot!

Remington Accelerator "sabot" enclosed bullet

So as you can see the materials used in bullets can vary widely. Just remember that the above examples are a mere drop in the bucket. I have just briefly mentioned centerfire rifle bullets primarily because I don't receive many in casework. Handgun centerfire and rimfire bullets are by far the most common projectiles seen in most forensic laboratories.

Bullet Basics 2- Shapes

The shape of a bullet dictates the aerodynamic and impact characteristics of the bullet. Manufacturers always seem to be tinkering with the shape of bullets. They are trying to find the right combination of materials and shape to make the perfect bullet.

So what is the perfect bullet? Well good question. The answer is that it hasn't been made yet!

Most bullet manufacturers will produce a variety of bullet shapes within one caliber. Let's briefly discuss a few of them.

Bullet Shapes

All bullets will generally fall into several distinct shapes. These shapes usually involve variances in nose and base of the bullet.

The two most common bullets for the longest time have been the ***round nosed lead*** bullet and the ***full-metal-jacketed*** bullet. Common examples of these can be seen below.

Round Nose Lead and Full-metal-jacketed bullets

These bullets have a solid nose and as a result they remain fairly intact when they strike soft targets. In a lot of cases they will pass right through a target when they don't encounter something significant like bone.

Other common solid nosed bullets can be seen below.

Lead "Wadcutter" bullet **Lead "Semi-wadcutter" bullet**

Solid nose bullets are commonly used in target practice and shooting competitions because they are relatively inexpensive and have decent ballistic characteristics. But that's where the use of the solid nosed, non-expanding bullet ends.

Because these bullets have a tendency to pass easily through a target the energy they have left is wasted energy. Let's not misunderstand the purpose of a bullet when used against a living target. The sole purpose of the bullet is to kill or incapacitate that living target. So, wasted energy is not a desirable characteristic of bullets used by law enforcement or by private citizens for hunting/self-defense.

The big focus today in bullet design is creating a bullet that has an expanding point. This expansion is needed to slow down the bullet when it strikes a target. A bullet that expends all of its energy in a target is more efficient and in turn produces more damage. Think of the nose of a bullet as being a parachute. When it strikes a target it is designed to open up expanding its surface area as much as twice the original diameter of the bullet. This expansion is typically called "mushrooming" as the bullet takes on a shape similar to a mushroom. See the example below.

Winchester "Black Talon" bullet

Bullets designed to expand usually have a hollow cavity formed into the nose of the bullet. These are referred to as ***hollow-point*** bullets. Below are some common hollow-point bullets.

Federal Hyda-Shok bullet with center post.

Remington semi-jacketed hollow-point bullet

But wait just a minute! Bullets can expand too much if they aren't put together just right or can fail to expand sufficiently. A bullet that expands too much can break up into smaller pieces and this fragmentation can limit penetration. This is not necessarily a bad thing and a bullet designed to fragment is called the Glaser Safety Slug seen on the previous page. This bullet is designed to break apart scattering numerous small lead pellets throughout the target. Each of the small pellets will create it's own wound track and cause an enormous amount of bleeding. Unfortunately this type of bullet must hit the torso of a body to be effective.

Sometimes more penetration is desirable. Take for example shooting at an elephant. If the bullet is designed to expand rapidly it will not penetrate deeply enough to get the job done. Bullets that have controlled expansion may have a soft area of lead exposed at the nose and usually lack the hollow-point cavity. Some examples are below.

Semi-jacketed Soft Point bullet

Jacketed Soft Point bullet

Police officers also need a bullet that has decent penetration characteristics. They need a bullet that can possibly pass through the windshield of a car or through heavy clothing and still retain the integrity to strike the target with enough energy to disable the threat. This is accomplished a lot of times by increasing the velocity, weight, and hardness of the bullet. A good example of a bullet designed for Law Enforcement use is the Speer Gold-Dot bullet seen below. This expanding point bullet uses a copper jacket that is bonded to the lead core to slow down the expansion of the bullet. When it mushrooms you will see a unique small copper dot at the center of the hollow-point cavity.

Speer Gold-Dot Jacketed Hollow-point bullet.

The base shape of a bullet can also be an area firearm examiners will use to help determine the manufacturer of a bullet. Some bullets have bases that taper in, these are referred to as "Boat-tail" bullets. Others may have expanded bases or banded bases.

Gas-check copper base lead bullet

Remington Golden Sabre expanded base bullet

7.62x39mm boat-tail bullet

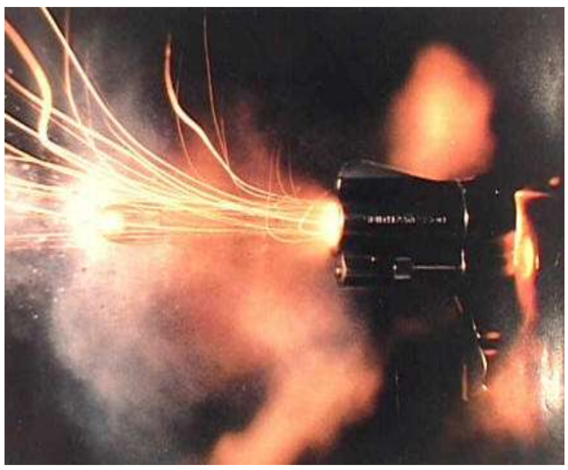
It will always be impossible for firearm examiners to remember all bullet types. Some are not widely distributed and new bullet designs come out it seems everyday! But we still try.

It may not seem like a big deal but in a trial the bullet manufacturer or caliber may end up being a very critical piece of evidence that will help with a conviction or prove the innocence of a defendant.

Gunshot Residue

When the firing pin of a firearm strikes the primer of a cartridge the ***primer compound*** ignites sending a flame into the cartridge case. ***Gunpowder*** in the cartridge case starts to burn, causing it to change from a solid material to a gas. This change creates pressure within the cartridge, which in turn forces the bullet down the barrel and down range. Pressure building behind the bullet is released when the bullet exits the muzzle of the firearm.

The bullet acts like the cork in a shook up Champagne bottle. When the bullet exits the muzzle, pressure behind it blows the gunshot residues out of the firearm's barrel under high velocity. The residues are expelled from the barrel in a smoky cone shaped pattern.



Time-lapsed image showing a bullet exiting from the barrel. Streaks of burning gunpowder, smoke, and unburned particulate can be seen exiting the barrel as well.

The further gunshot residues travel from the muzzle, the broader and less concentrated the pattern becomes. Because the various elements included in gunshot residues are very small and lack mass they lose their energy rapidly.

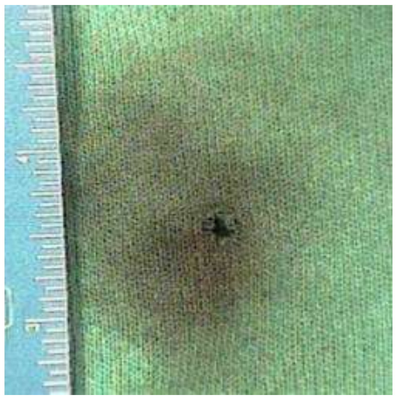
Gunshot residues can also be emitted from other areas of a firearm. As you can see in the above image, gunshot residue is escaping from the barrel/cylinder gap of the revolver.

The muzzle-to-garment distance can vary considerably depending on the firearm and type of ammunition being used. Short-barreled firearms and lower velocity cartridges will not normally expel residues as far as a high velocity rifle. At shorter distances however, they may deposit greater concentrations of gunshot residues. Also, gunpowder can come in several forms such as ball, flake, disc, and others. Ball powder being spherical in shape is more aerodynamic than say a particle of flake gunpowder and as a result will travel farther. A number of other variables can influence the amount of gunshot residues that may reach a target; therefore, it is essential that the firearm and ammunition used in the shooting incident be recovered.

Gunshot residues emitted from the muzzle will travel out to distances of approximately 3 and 5 feet in most firearms but in some cases can travel even greater distances. At the 3-5 foot range the gunshot residues may only consist of a few trace particles and make determining the firing distance difficult if not impossible.

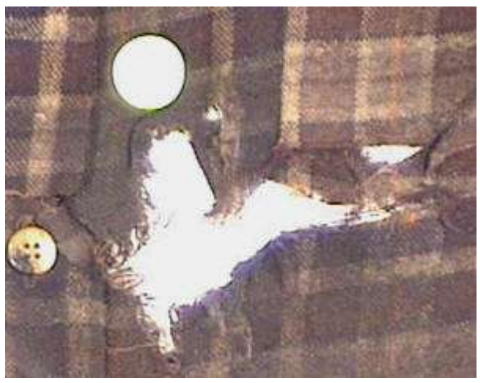
As the firearm gets closer to its target the residue concentrations increase and the actual size or diameter to the pattern gets smaller. At around 18-24 inches most firearms will start to deposit considerable concentrations of gunshot residues that may or may not be visible to the eye.

At distances of less than around 12 inches heavy concentrations of visible gunshot residues will normally be deposited.



Visible gunshot residues around bullet entrance hole.

When the muzzle of the firearm gets next to or is in contact with the target, hot gases escaping from the muzzle at high velocity will typically rip, tear, shred, and/or melt the material of the target. A very intense deposit of gunshot residues will be found around the margins of a contact or near contact entrance hole.

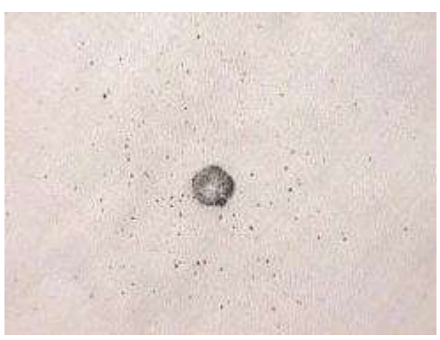


Contact gunshot entrance hole.

There have actually been cases where a hard contact gunshot (muzzle pressed hard against the victim) caused the residues to blow through the wound tract in the victim and be deposited around the inside of the exit hole of the victim's clothing.

Gunshot residue is normally a combination of ***gunpowder residues*** and ***lead residues***. I say normally because some newer ammunition is virtually lead-free. More and more ammunition manufacturers are using lead free or low lead propellants because of the toxicity of lead.

Gunpowder residue can contain unburned gunpowder particles, partially burned gunpowder particles or the carbonaceous soot from completely burned gunpowder. The image below show a bullet hole surrounded by gunpowder particulate residue.



Gunpowder particulate residue around bullet entrance hole.

Modern smokeless gunpowder, and black powder, contains ***nitrate*** compounds. Black powder normally contains a combination of potassium nitrate (75%), charcoal (15%), and sulfur (10%). Smokeless powders can either be ***single based*** or ***double based***. Single based gunpowder will contain ***nitrocellulose*** (cellulose hexanitrate) as its main ingredient.

Double based gunpowder contains nitrocellulose and ***nitroglycerin*** (glyceral trinitrate) as its base. Some triple-based powders are also now available.

When either of these types of gunpowder burns the residue left behind will be in the form of a ***nitrite***-based compound. Nitrite particles when emitted from the muzzle of a firearm will strike a nearby target and either be imbedded in the target's surface or leave a deposit of nitrite residue.

Lead residues will be in a vaporous or particulate form and can come from a couple sources within a discharged cartridge. The most common source is the ***primer.*** Primers are used to start the ignition process in cartridges and commonly contain ***lead styphnate, barium nitrate, and antimony sulfide*** compounds.   However, some newer primer compounds are being used that are lead and/or barium free.

Cartridges containing lead based primers, when ignited, produce a vaporous cloud of residue that is expelled from the muzzle of the firearm. Additional vaporous lead residues can be produced when the hot gases pushing a lead bullet down a barrel melt lead from the base of the bullet.

A third form of lead residue will be in a particulate form. Particulate lead residue comes from minute lead particles that are shaved from the sides of a lead bullet as it travels down the barrel. Lead particulate has more mass than vaporous lead and travels greater distances. Also, gunpowder particles can be coated by the vaporous lead residues and leave what appears to be a lead particulate deposit upon striking the target.

The amount of lead residue emitted from a gun can vary slightly from shot to shot. Fouling in the barrel from previous shots can slightly increase the amount of lead residue emitted from one shot to the next.

As described above, gunshot residue can be deposited on articles of clothing when in close proximity to a discharged firearm. *But will it stay there?* In most cases the answer is yes.

The various elements contained in gunshot residue are not readily water soluble and clothing left exposed to the elements will not usually diminish the residue deposits. Other factors such as heavy bleeding and rough handling of the garment can cover up or dislodge some residues. This has to be taken into consideration when conducting all such examinations. The garments must be promptly collected, allowed to air dry, and packaged in a way that will minimize contamination.

The clothing submitted to the laboratory will be examined to determine if a pattern of gunshot residue is present and there are a number of examinations conducted to aid in this determination.

Shotgun Pattern Testing

Another test conducted by firearm examiners is known as ***Shotgun Pattern Testing***. This test involves shotguns and allows for a muzzle-to-target distance to be determined.

Shotgun pattern testing involves examining evidence for a pattern of holes created by the pellets fired from a shotgun. The "unknown" pattern is then compared to "test" patterns created with the suspect shotgun fired at known distances. This will allow for an approximate muzzle-to-target distance to be determined.

Two overlapping shot patterns. A large dispersed pattern overlaps a small close-range shot pattern.

When a shotgun is fired using a multiple pellet shotshell, the pellets exit the barrel of the shotgun and begin to spread out into a pattern that increases in diameter as the distance increases between the pellets and the shotgun.

To better understand the principles involved in shotgun pattern testing it's important to first learn a little about shotguns and the shotshells they fire.

Shotguns are firearms typically fired from the shoulder that are designed to fire shotshells containing anywhere from one large projectile to as many as several hundred small pellets. Shotguns aren't classified by caliber but come in different ***gauges***. *The gauge of a shotgun is determined by the number of round lead balls of bore diameter that it takes to equal one pound.* Shotguns can come in 10, 12, 16, 20, 28, and .410 gauge. The .410 is actually an exception with .410 referring to the caliber of the shotgun's bore. It would actually be about a 67 gauge in "lead ball" terms.

Although some newer shotgun barrels are produced with rifling, shotguns have traditionally had smooth bored barrels. Except in some rare cases the projectiles fired from them cannot be matched back to the shotgun.

Auto loading shotgun with conventional barrel (top) and an auto loading shotgun with a rifled "slug" barrel (bottom).

Shotguns come in a number of different styles and actions. From auto loading shotguns like those seen above to very *"customized"* versions like the one below.

"Sawed-off" pump-action shotgun.

Shotguns are typically manufactured with what is called a ***choke*** in their barrels. A choke is a constriction in the last couple of inches in the barrel and can vary in the degree of constriction. Common choke designations are "full", "modified", and "improved cylinder." A barrel that has no choke is referred to as a cylinder-bore barrel.

Barrel modified for use in a "Turkey-Shoot" competition.
Extreme constriction or choke can be seen at the muzzle.

Shotguns can be manufactured with a permanent fixed choke or can have the muzzle of the barrel machined in a way to accept interchangeable or adjustable choke tubes. Shotguns that have had their barrels sawed off have had their choke removed. This creates a shotgun with a cylinder-bore barrel.

The whole point to this "choke thing" is that the choke plays an important role in the rate at which the shot pellets spread as they travel away from the shotgun. A full-choke barrel will tend to shoot smaller shot patterns at a given distance than a barrel with a modified-choke.

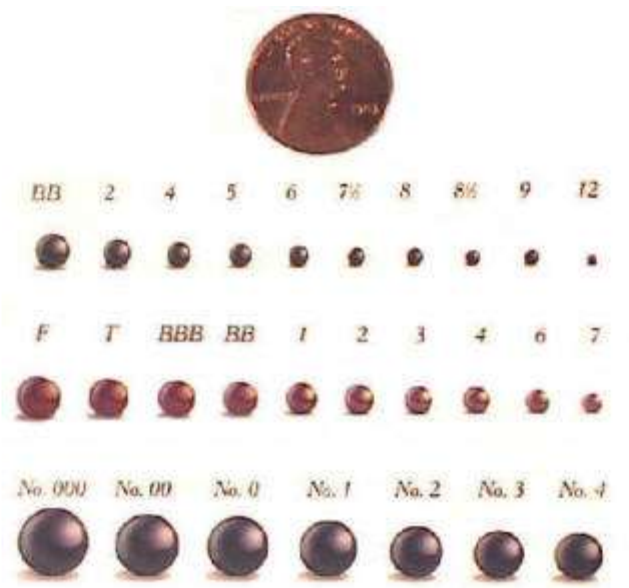
Shotshells are cartridges designed to be fired in shotguns and can contain a single large projectile - a slug - or as many as several hundred small spherical pellets called ***shot***. Shot used in shotshells has traditionally been made of lead but because of it's toxicity, other materials are being used as a substitute, with the most common alternative being steel.

The size of the shot can vary as can the total weight of the shot loaded into a shotshell. Shot comes in two basic varieties, small pellets commonly referred to as ***birdshot*** and larger pellets called ***buckshot***.

Components from a typical shotshell containing
birdshot and a one-piece plastic wad.

Components from a typical shotshell containing
buckshot and a fiber/plastic wad combination.

Lead birdshot comes in 12, 11, 9, 8 1/2, 8, 7 1/2, 6, 5, 4, 2, and BB sizes. As the numbers get smaller the diameter of the shot gets larger. Buckshot on the other had comes in 4, 3, 2, 1, 0, 00, and 000. Again, as the number decreases the diameter increases. See the chart below.



Shot size table: lead shot (top), steel shot (middle) and buckshot (bottom).

As you can see from the above chart, steel shot comes in slightly larger sizes than lead shot. Steel doesn't have the density of lead and larger shot is needed to achieve a range comparable to that of lead shot.

Shotshells contain a variety of different ***wads*** - plastic, paper, or fiber material designed to separate the shot from the gunpowder and/or protect the shot as it is pushed down the barrel - that are expelled from the shotshell, along with the shot, when fired.

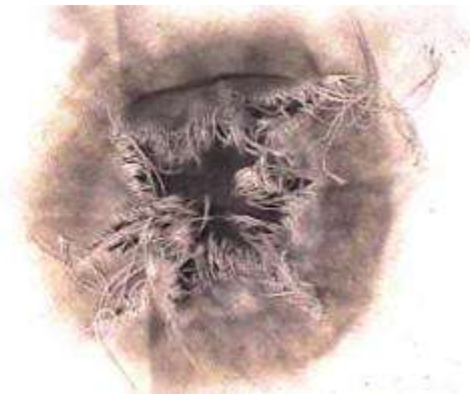
Various plastic and fiber shotshell wads.

Shotshells come in a variety of loads. The amount of gunpowder in a shotshell can vary and the measurement is referred to by as the ***dram equivalent.*** The dram equivalent is the amount of smokeless powder that produces a velocity comparable to that of black powder.

All of these variables are important in determining a given shot pattern distance.

When a shotgun is fired the shot and wadding travel down the barrel and exit the muzzle in a concentrated mass.

As a result a contact entrance hole will produce a large hole with significant damage to the margins of the hole, but can vary greatly depending on the material being fired into. The same thing also applies to gunshot residue deposits. Most contact entrance holes will have a significant deposit of gunshot residues like the one seen below, but this is not always the case. Some may display very little visible gunshot residue.



Contact shotgun entrance hole.

A hole like the one above will be processed chemically like that previously described on the Distance Determination/Gunshot Residue pages.

At ranges of around 5-10 feet* the shot and wadding mass will produce a single large hole in a target. If the target happens to be a person, the wadding material will be blown into the wound tract with the pellets.

Close-range shotshell pellet entrance hole.

The close-range entrance (less than 5 feet*)hole seen above is almost square, and is a common shape for this range. You might notice a pinkish color (lead residue) to the material around the hole.

At distances greater than 5-10 feet* the shot mass starts to break up. Fliers (individual pellet holes) will start to appear around the edge of an entrance hole and the wadding may or may not enter the victim.

Individual pellets starting to break apart from the main mass of pellets.

As the wadding slows down it will start to take a separate trajectory from that of the shot and can actually leave abrasions or bruises to the area around an entrance wound. Wadding will lose its energy and fall harmlessly to the ground at distances of around 20 feet*.

As the pellets get further and further away from the shotgun the pattern will eventually become dispersed to the point that only individual pellet holes are present in a target.

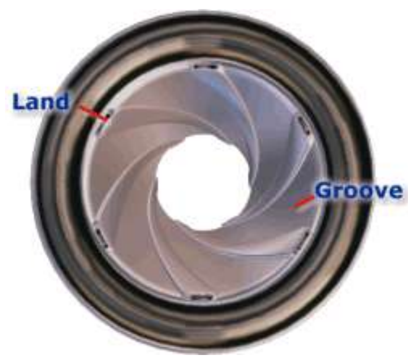
Witness panel fired into at a distance of 28 feet.

Firearm examiners will try to reproduce the pattern by firing into witness panels at known distances. Shot patterns can be affected by the load, pellet size, wad type, and choke of the shotgun. That is why it is essential that the shotgun is recovered and the type of shotshells used is known. Hopefully some shotshells will be recovered at the scene that can later be used in firing the distance standards. Also, patterns produced by a shotgun at any given distance can vary slightly. Multiple tests patterns will be fired at known distances and compared directly to the pattern in question. Based on this comparison a minimum and maximum firing distance can be determined.

Unlike the tests conducted on clothing for gunshot residues, shotgun pattern testing is not limited to distances of a few feet or less.

Rifling

Most modern pistols, revolvers, rifles, and some shotgun barrels have what are called ***rifling*** in their barrels.



Rifling consists of grooves cut or formed in a spiral nature, lengthwise down the barrel of a firearm.

Rifling is placed in the barrels of firearms to impart a spin on the bullets that pass through it. Because bullets are oblong objects, they must spin in their flight, like a thrown football, to be accurate. Looking down the barrel of a firearm you might see rifling like that depicted on the right. This image shows a pattern of rifling containing six grooves with a right twist.

In firearm examiner lingo we refer to the rifling as ***lands*** & ***grooves***. The lands are the raised areas between two grooves. A rifling pattern of eight grooves with also have eight lands. **Registered users only! See new 3-D bullet.**

Firearms can be manufactured with any number of lands and grooves in their barrels. They can also spiral either left or right. A few of the more common rifling patterns are 4/right, 5/right, 6/right, 6/left, 8/right, and 16/right.

To see several rifling pattern illustrations go to **Registered users only! Rifling Illustrations Page**.

The procedures described below are abbreviated somewhat but I hope that they will provide you a better understanding of basic rifling techniques.

When barrels are manufactured, they start out as a solid rod of steel. A hole is drilled down the center of the rod and the rifling is then placed in the barrel.

There are three basic machining processes that modern firearms manufacturers use to form the rifling in barrels. Rifling can be cut into the inner surface of a barrel using a ***broach***, the rifling can be formed using a hardened steel ***button***, or the rifling will be formed through a process called ***hammer forging***. A newer method of rifling barrels, called ***Electrochemical Rifling,*** does not involve the normal machining processes of the other techniques.

Broach Rifling

The modern broach method of rifling uses a hardened steel rod with several cutting rings spaced down the rod. Like the one shown below. Broaches can be over 16 inches long and because they have several cutting rings, they are referred to as ***gang broaches***.

Each successive cutting ring is slightly larger in diameter and when the last ring on the broach passes down the barrel the desired depth to the grooves is obtained. The cutting rings have gaps evenly spaced around them to allow for the lands. The rod is twisted as it is pulled through the barrel and this forms the spiral to the rifling pattern. A cut-away of the inside of a barrel below shows the cut grooves and the lands with original drilling marks.

Button Rifling

Probably the most common method used today to rifle barrels is ***button rifling***. Button rifling uses a different approach to forming the grooves in the barrel. A button as seen below is a very hard steel plug that is forced down an unrifled barrel.

The grooves are then formed in the barrel under very high pressure. The pressure created to form the rifling in the barrel hardens and polishes the inside of the barrel.

Hammer Forged Rifling

The newest mechanical method of rifling barrels is accomplished through a process called ***hammer forging***. Hammer forging produces a type of rifling called polygonal rifling. A hardened steel mandrel is produced with the shape of the rifling formed on its outer surface. The mandrel is inserted into a barrel blank and the outer surface of the barrel is machine hammered. The hammering forces the barrel material down against the mandrel and the inner surface of the barrel takes on the shape of the mandrel. The mandrel is then removed from the barrel and the outer surface of the barrel is cleaned up. Just as in the other types of rifling, polygonal rifling can have different patterns. The most common polygonal patterns are 6/right and 8/right. This form of rifling is used by Glock, Steyr, IMI, and a few other manufacturers.

Electrochemical Rifling

In a process that eliminates the conventional machining of metal, rifling is formed by wet-etching the interior of a barrel under an electric current. The metal inside the barrel is actually eaten away or dissolved to create grooves in the barrel. An electrode (cathode) that has metal strips in the shape of the rifling is placed in the barrel (anode) and the the assembly is submerged in a salt solution. An electric current is applied and the electrode is moved down the length of the barrel and twisted to create the spiral shaped grooves. As the current travels from the barrel to the electrode metal is removed by electrolysis thus forming the grooves in the barrel. This process creates the rifling in the barrel very quickly and does not require consumable tooling.

Both broach and button rifling are considered conventional rifling techniques. The transition from a land to a groove is very distinct and the lands and grooves are flat to slightly curved. The two illustrations below show the rifling in two conventionally rifled barrels.

Click for larger views
Registered users only!

A bullet fired from a conventional 6/right rifled barrel will have impressions on it like those seen in the image below.

Because there is a distinct edge at the transition from a land to a groove impression, the widths of the lands and grooves can be measured.

Polygonal rifling on the other hand is very different from conventional rifling. There are no distinct transitions between the lands and the grooves. The illustration below shows the polygonal rifling in a Glock 9mm LUGER pistol.

Click for larger view
Registered users only!

Polygonal rifling takes on a shape that is sometimes referred to as "hills and valleys." This gradual transition prevents firearm examiners from measuring the individual rifling elements in a polygonal rifled barrel. Provided a bullet is in good condition, polygonal rifling impressions like those seen on the 40 caliber bullet below, are fairly easy to spot.

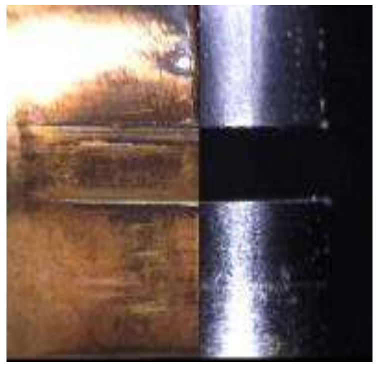
Electrochemical rifling is more similar in shape to the button and broach rifled barrels but has slightly less distinct transitions between the lands and grooves.

Rifling Impressions

A bullet is slightly larger in diameter than the ***bore diameter*** of the barrel in which it is designed to be fired. The bore diameter is the distance from one land to the opposite land in a barrel. As a result, a rifled barrel will impress a negative impression of itself on the sides of the bullet like those seen below.

The rifling pattern in the barrel that fired a particular bullet can be determined by counting the number of groove or land impressions around the circumference of the bullet. Then, by holding the nose of the bullet pointing away from you, the direction the impressions run away from you (either to your left or right) determines the direction of twist. If the rifling impression pattern on the bullet matches the rifling pattern in the barrel of the questioned firearm, the next step is to measure the rifling impressions on the bullet.

The lands and grooves on a bullet are measured in thousandths of an inch or in millimeters. One way to measure individual rifling impressions is to use a micrometer like the one below. The right image below shows the micrometer positioned next to a land impression on a bullet.



This is important because even though the rifling pattern may match between the bullet and questioned barrel one 6/right rifled barrel can have lands and grooves of a differing width than another. The image below shows the land impressions on two bullets. Both were fired from 6/right rifled barrels. The land impressions are lined up at the bottom edge but as you can see, the upper edges do not line up because the land impression on the right bullet is wider.

The widths of the lands and grooves on a bullet provide a further class characteristic that can be used as a preliminary means to determine if the submitted bullet could have been fired from the submitted firearm.

Another class characteristic of rifling that is seldom comes into play is the ***rate of twist*** or ***pitch*** of the rifling in the barrel. The rate of twist is the distance the rifling needs to spiral down the barrel for it to complete a single revolution. An example would 1 turn in 12 inches. The term pitch refers to the angle at which the rifling is cut in the barrel. The two images below show the rifling in a 5 inch barrel on the left opposed to a 1 3/4 inch barrel on the right. Note the difference in pitch of the rifling.

The barrel on the right actually has very little pitch to the rifling. Depending on which way you look at it the direction of twist could be to the right or left. It is a 10/right rifled barrel.

When bullets are compared to standards from a given barrel the pitch to the rifling impressions can be a means to eliminate the bullet as having been fired from the firearm. If the angle disagrees with the angle found on standards then the comparison will be a negative one based on those class characteristics. The problem with this is that it is hard to accurately measure the pitch. Unless there is a noticeable difference in the pitch, it can be hard to use this class characteristic as a means of elimination. As a result, firearm examiners rarely measure the rifling impression pitch. The two bullets below were fired from different 6/right rifled barrels but the pitch is different. Not by much though and any damage to a bullet like this could make the difference difficult if not impossible to see.

Firearm examiners can run into problems determining any of the previously described class rifling characteristics on the bullet if the bullet is damaged like the one seen below.

You may get a bullet fragment that only has one or two land and groove impressions and the direction of twist may not be obvious.

Therefore, here is where a little math comes in. Let us say you have a fragment with only one land and one groove impression visible (the minimum number for this to work). You measure the land impression width to be .055 inches and the groove impression width to be .130 inches. Divide the diameter of the bullets suspected or measured caliber, in this case .357, by the sum of the width of the one land and groove impression (.185), and then multiply that number by pi (3.14).

$$.357 / .185 * 3.14 = 6.05$$

This will give you the approximate number of lands or grooves that would have been in the barrel that fired the bullet. In this example, the approximate number of lands and grooves would be six.

If a bullet is badly damaged and exhibits poor class characteristics not all is lost. There is still a possibility that some unique microscopic marks from the barrel still exist on the surface of the bullet.

General Rifling Characteristics

Shootings frequently occur where no firearm is recovered. The only evidence of the shooting may be a bullet recovered from the scene or the victim. To aid the investigators in searching for the questioned firearm, rifling parameters taken from the recovered bullets can be used to determine the possible manufacturers of the firearm from which the bullets were fired.

General rifling characteristics or ***GRC*** are the identified rifling pattern (i.e. 8/right) and the diameters of the individual lands and grooves. Using these parameters, firearm examiners can search through a database of known rifling data. The resulting search will help the investigator narrow down the search for the unknown firearm.

A typical GRC search might involve a 9mm LUGER bullet, fired from a 6/right rifled barrel, with a land width of .055 and a groove width of .125. Firearm examiners will usually search with a plus or minus .003-.005 tolerance and the results of the search would look something like the data contained in the following table.

CARTRIDGE	MANUFACTURER	TWIST	L&G	LAND	GROOVE
9MM LUGER	**AA ARMS INC**	**R**	**6**	**.055**	**.120**
9MM LUGER	**ASTRA**	**R**	**6**	**.053**	**.128**
9MM LUGER	**BERETTA**	**R**	**6**	**.055**	**.130**
9MM LUGER	**HI-POINT FIREARMS**	**R**	**6**	**.055**	**.120**
9MM LUGER	**INTERDYNAMIC**	**R**	**6**	**.055**	**.124**
9MM LUGER	**LLAMA**	**R**	**6**	**.054**	**.120**
9MM LUGER	**MAUSER**	**R**	**6**	**.054**	**.128**
9MM LUGER	**SMITH & WESSON**	**R**	**6**	**.056**	**.122**
9MM LUGER	**STAR**	**R**	**6**	**.054**	**.126**
9MM LUGER	**SWD INC**	**R**	**6**	**.055**	**.120**

Many years ago, a double murder occurred in our community. An elderly couple was found shot to death in their home by their son. It appeared from the scene that there had been a break-in but the son was immediately a suspect. Investigators had a feeling that the son may have committed the crime but could not determine if he had owned or had access to a firearm. Bullets from the scene were examined and it was determined that they were of 38 caliber and were fired from an 8/right rifled barrel. A list of manufacturers was compiled and given to the investigators. Using this list, the investigators searched a weekly "Bargain Mart" classified ad publication. By calling the ads for firearms included on the list of possibilities, the investigators found one individual who said he had sold his revolver to an individual who matched the description of the son. The son was then picked out of a police line-up by the individual who had sold him the gun. When confronted with the evidence the son confessed to the killings.

Cartridge Case Identification

Like bullets, cartridge cases can be identified as having been fired by a specific firearm. As soon as cartridges are loaded into a firearm the potential for the transfer of unique tool marks exists. However, the cartridge does not have to be fired for these marks to be transferred. Simply *loading* a cartridge into a firearm can cause unique identifiable marks that can be later identified.

Cartridge cases like those on the right are mostly made of brass but can also be made of other materials such as steel and plastic. Cartridge cases come in a variety of finishes but all are made of a material that is softer than the materials found in a firearm. Any surface of the cartridge case that meets the inner workings of the firearm may be marked.

Tool marks produced on the cartridge cases will be in two basic forms. As the microscopic striations found on bullets, cartridge cases can pick up ***striated action marks***. These "scratches" are produced when the cartridge case moves laterally against the tool (inner surface of the firearm) producing a scrape or *striated* mark. The other form of marks that can be left on a cartridge case are ***impressed action marks***. Impressed marks are created on cartridge cases when it impacts the tool (again, the firearm) with adequate velocity or pressure to leave an impressed or indented mark.

Cartridge cases are compared to fired standards from a firearm using a comparison microscope as described on the ***bullet identification*** page. Standards are first examined to determine what marks, if any, the firearm is consistently reproducing. Evidence cartridge cases are then directly compared to the standards to see if they too are also similarly marked.

Cartridge case comparison results may be reported as follows:

Exhibit 1 (cartridge case) was identified as having been fired by Exhibit 2 (firearm).

The above conclusion is reached if the action marks present on the questioned cartridge case are determined to be because of the actual firing process. An example of which can be breech marks as seen in the comparison image below.

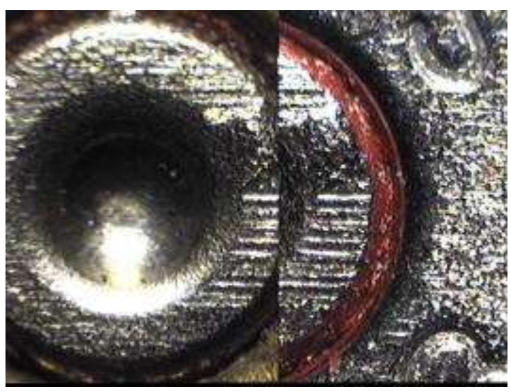


Exhibit 1 (cartridge case) could neither be identified nor eliminated as having been fired by Exhibit 2 (firearm).

The above conclusion is reached if the cartridge case lacks sufficient action marks to be identified as having been fired by the questioned firearm or the firearm in question fails to produce reproducible individual characteristics on standards. All general class characteristics such as caliber and firing pin shape would have to agree. The image below shows a comparison between two cartridge cases that lack any individual characteristics but have a similar general appearance.

Exhibit 1 (cartridge case) was not fired by Exhibit 2 (firearm).

This conclusion can sometimes be reached when the submitted cartridge case exhibits very good individual characteristics that are very dissimilar to those produced on standards. However, consideration must be given to the possibility that the firearm in question could have changed significantly. If all dissimilarities can be accounted for, a negative conclusion will be reached. The comparison image below shows two cartridge cases that exhibit noticeably different breech marks and firing pin impressions.

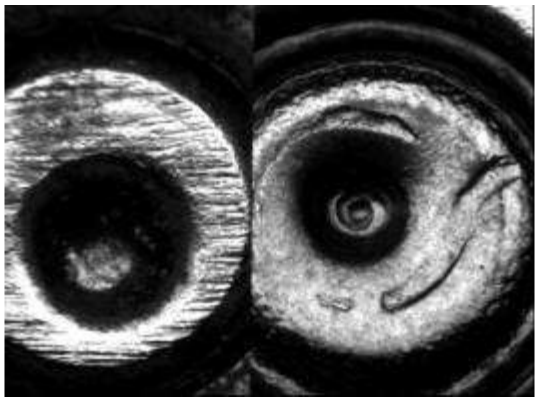


Exhibit 1 (cartridge case) was identified as having passed through the action of Exhibit 2 (firearm).

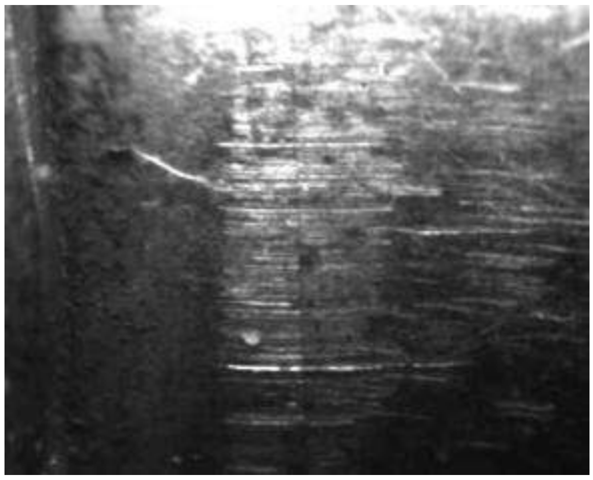
This conclusion can be reached if the cartridge case is found to have action marks that result from simply loading and/or unloading a cartridge case in a firearm. The comparison image below shows striated action marks on the shoulder of cartridges that have been loaded and unloaded in a Chinese AK Type assault rifle.

Striated Action Marks

Striated action marks are common to cartridge cases that have passed through the action of an auto loading or repeating firearm. Striated action marks can be produced on cartridge cases by contact with a number of different areas within the firearm. Some of the more common striated action marks include chamber marks; shear marks, firing pin drag marks, extractor marks, and ejector marks.

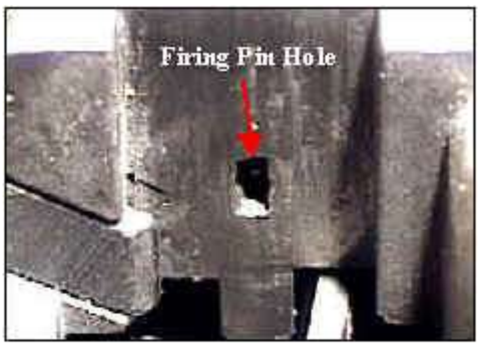
Chamber Marks

One of the most common striated action marks are called ***chamber marks***. Roughness in the chamber of a firearm can scratch the outer walls of a cartridge case when loaded and removed from the chamber. Most chamber marks occur after the cartridge is fired. Cartridge cases expand when fired pressing out against the walls of the chamber. When they are pulled out of the chamber, the sides of the cartridge case can be scratched. The comparison image below shows chamber marks on 22 caliber, rimfire cartridge cases.

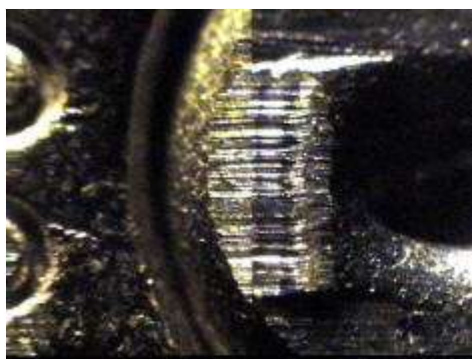


Shear Marks

Another common striated action mark are ***shear marks*** produced by GLOCK pistols on cartridge case primers. GLOCK pistols have a rectangular firing pin hole (below) in their breech face.

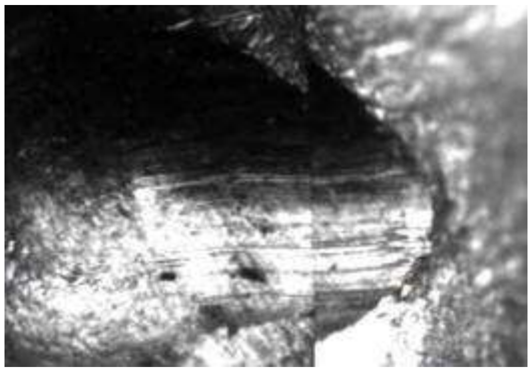


When a cartridge case is forced backwards from recoil the primer imbeds itself in the firing pin hole. As the slide of the pistol starts to recoil, the barrel will drop slightly as the action opens. The dropping barrel forces the cartridge case to move down slightly and when this happens the lower edge of the imbedded primer is sheared downward and out of the firing pin hole. The resulting striated marks can be seen in the comparison image below.



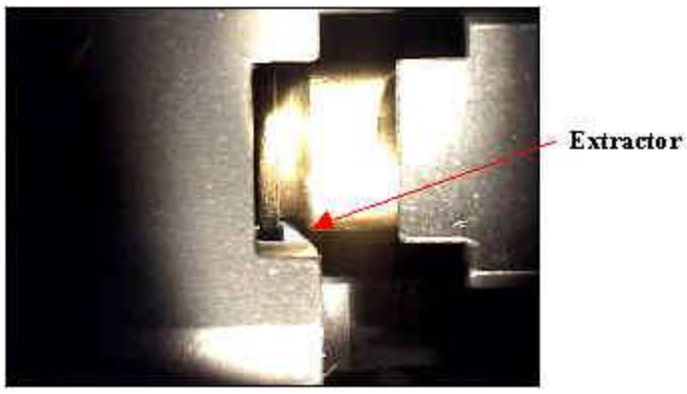
Firing Pin Drag Marks

In a similar process, striated marks called ***firing pin drag marks*** can be produced. When the firing pin springs forward to strike the primer of a cartridge, it may remain slightly forward and imbedded in the primer. Certain barrels (like in the GLOCK) drop down slightly as recoil is forcing the action open. The cartridge case drops with the barrel causing the nose of the protruding firing pin to drag across the primer as it leaves the firing pin impression. The below comparison image shows firing pin drag marks produced by a Colt 45 AUTO pistol.

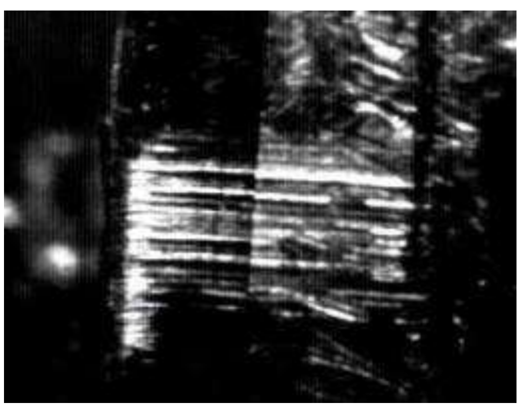


Extractor Marks

Another action mark, usually found in a striated form, are those created by the ***extractor*** of most auto-loading or repeating firearms. The extractor is a small part sometimes resembling a hook that is used to remove a cartridge or cartridge case from the chamber of a firearm. The image below shows the extractor of a 9mm GLOCK pistol hooked into the extractor groove of a cartridge. As the slide of the pistol moves to the rear, the extractor pulls the cartridge case along with it until it is ejected from the pistol.

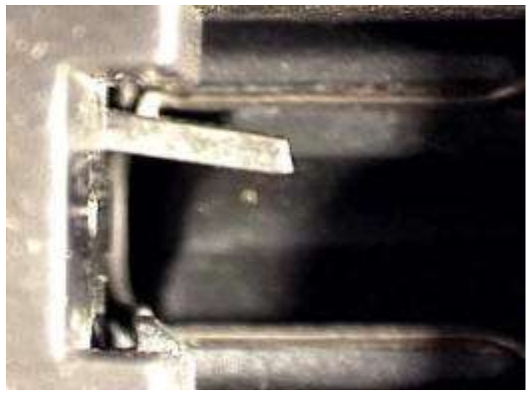


The extractor may or may not leave an identifiable mark on the cartridge case. This is true if the cartridge is fired or simply hand chambered and extracted without firing. Extractor marks may look like those seen in the comparison image below.

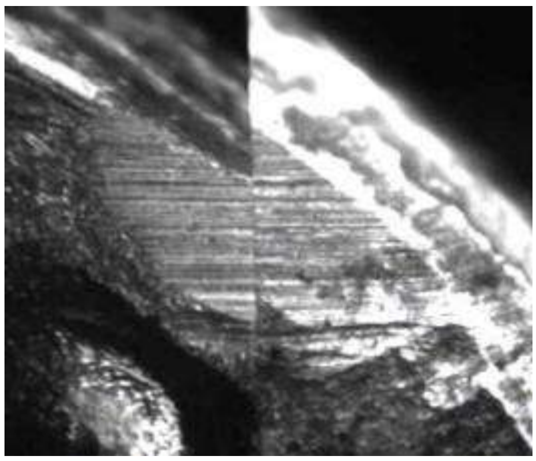


Ejector Marks

As described above, the extractor pulls the cartridge case out of the firearm's chamber. As the cartridge case is pulled to the rear it will be struck somewhere on an opposing edge by a part as seen below called the ***ejector***.



The ejector is designed to expel the cartridge case from the action of the firearm. The resulting impact of the cartridge case with the ejector will cause another action mark that can be used as a means of identification.



Ejector marks can be striated in nature but a lot of the time they are ***impressed action marks***. Click the next button below to learn more about impressed action marks.

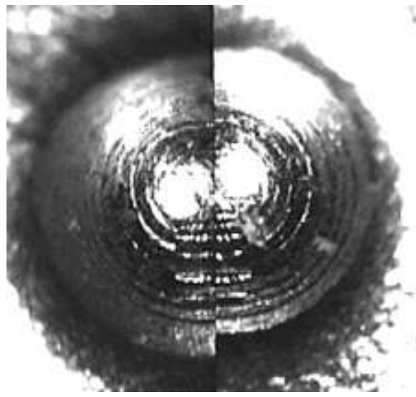
Impressed Action Marks

Impressed action marks, with a few exceptions, are produced when a cartridge case is fired in a firearm. The two most common impressed action marks are ***firing pin impressions*** and ***breech marks***. As mentioned at the end of the Striated Action Marks page, ***ejector marks*** can also be in the form of an impressed action mark.

Firing Pin Impressions

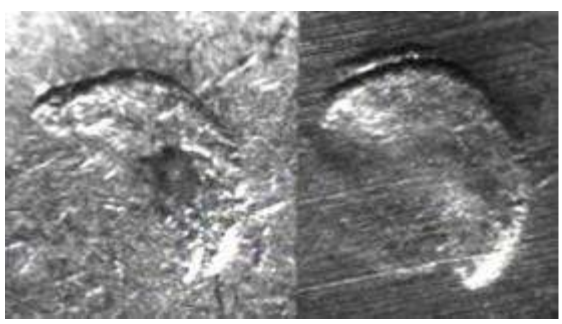
Firing pin impressions are indentations created when the firing pin of a firearm strikes the primer of centerfire cartridge case or the rim of a rimfire cartridge case. If the nose of the firing pin has manufacturing imperfections or damage, these potentially unique characteristics can be impressed into the metal of the primer or rim of the cartridge case.

The comparison image below shows the firing pin impressions on two centerfire cartridge cases. As you can see, the firing pin impressions have both circular manufacturing marks and parallel marks from a defect in the nose of the firing pin.



The comparison image below shows firing pin impressions on two rimfire cartridge cases. Imperfections in the surface of the nose of the firing pin consistently produced these impressed marks.

Firing pin impressions also can be found on live cartridges. One of those few exceptions I mentioned earlier. In some cases, the firing pin may miss the primer of a cartridge or fail to strike the primer of a cartridge with sufficient force for it to discharge. The cartridge may also misfire due to a contaminated or deteriorated primer compound. For whatever reason, the result will be the presence of a firing pin impression on the cartridge case of a live cartridge. This could be significant if the cartridge is say, left at the scene or found at a suspect's house. The comparison image below shows light firing pin impressions on an evidence cartridge case (left) and a test standard from a suspected firearm (right).



Breech Marks

By far the most common impressed action marks on cartridge cases are ***breech marks***. Most fired cartridge cases are identified as having been fired by a specific firearm through the identification of breech marks.

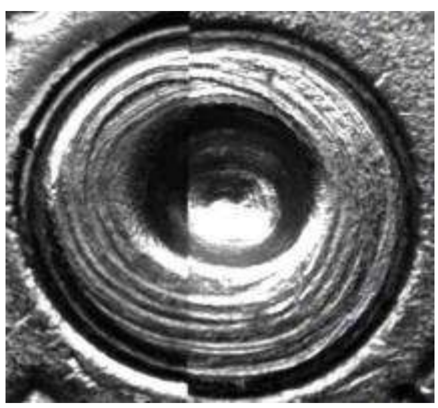
Very high pressures are generated within a firearm when a cartridge is discharged. These pressures force the bullet from the cartridge case and down the barrel at very high velocities. When a firearm is discharged, the shooter will feel the firearm jump rearward. This rearward movement of the firearm is called ***recoil***. Recoil is for the most part caused by the cartridge case moving rearward as an opposite reaction to the pressures generated to force the bullet down the barrel.

When the head or base of the cartridge case moves rearward, it strikes what is called the ***breech face*** of the firearm. The image below shows the breech face of a 12 GAUGE, single-shot shotgun.

The breech face rests against the head of the cartridge case and holds the cartridge case in the chamber of the firearm. When the head of a cartridge case slams against the breech face, the negative impression of any imperfections in the breech face are stamped into either the primer of the cartridge case or the cartridge case itself. The image below shows the primer of a shotshell fired in the above shotgun.

Breech marks come in various forms. Those seen above are called parallel breech marks. Obviously, because the marks are a series of parallel lines.

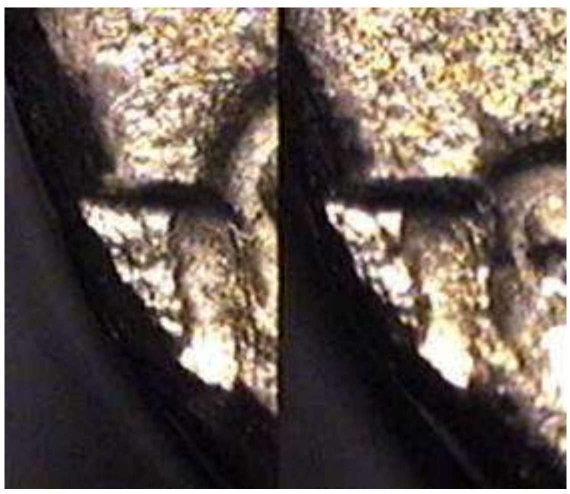
Another form of breech marks are circular breech marks like those seen in the comparison image below.



Breech marks can also show no obvious pattern. They may have a stippled or mottled appearance as seen below.

Ejector Marks

Now back to ***ejector marks***. Ejector marks are sometimes created when cartridges or cartridge cases are ejected from the action of a firearm. Ejector marks can be either striated or impressed but the impressed ejector marks not only can be used to identify a cartridge case as having passed through a firearm's action they can also be an indication that the cartridge case was fired in the firearm. Ejector marks like those seen below could only be reproduced when the cartridge cases were fired in the firearm and not by simply hand chambering and ejecting a live cartridge.



Expert Witness Testimony

Yeah right, you're a what?

When all of the examinations in a particular case are complete the firearms examiner will issue a report of their findings to the submitting party. Although the examinations are complete the case is still only partially finished. The next big step is to present the findings of his or her examinations in a court of law.

Expert testimony is commonplace in almost every criminal trial. Expert testimony is defined in **Microsoft's Encarta 97** as...

Expert testimony is that given by a specialist who has been recognized by the court as having expert knowledge about evidence in the case."

Encarta goes on to say..

"Such testimony is governed by different rules than the testimony of ordinary witnesses in a trial. Ordinary testimony is restricted to statements concerning what the witness actually saw or heard. An ordinary witness is prohibited from stating opinions about the case and from quoting statements made by other people. In contrast, an expert witness is allowed to express an opinion about the validity of the evidence in a case and may quote the statements of other experts in support of an opinion."

Do you swear to tell the truth and nothing but the truth, so help you God?

The first step in testifying usually involves stating your name, job description, and where you are employed. I normally explain to the jury what firearms identification is and will tell them a little about our lab system. Next, I will attempt to be recognized or qualified as an expert by the court. I will describe to the jury my education, training and experience.

I will first tell the jury where and when I graduated from college and what degrees I received. Next I will describe in detail the training I received and what schools and other classes I may have completed since starting my career in Firearms Identification. Lastly, I am usually asked how long I have been employed in my present capacity, how many times I have been qualified as an expert in firearms identification and where I have been so qualified.

The judge is then asked, either by the prosecutor or defense attorney, to rule on whether he thinks my qualifications are sufficient for me to be recognized as an expert. The judge will make a ruling and advise the jury that I am to be recognized as an expert in Firearms Identification and can give my opinion as to the findings of my examinations.

Just tell me the facts, ma'am...

At this point I am asked to describe the exhibits that I received, what was requested of me by the submitting officer, what examinations I conducted, what were my findings; and how did I arrive at those conclusions.

It usually goes something like this:

Q. What items did you receive in this case?

A. (Somewhat abbreviated)

I received four exhibits from Det. Smith. Exhibit 1 is a Smith & Wesson 38 Special, double-action revolver, serial number 123456; Exhibit 2 is a fired, plain lead bullet; Exhibit 3 is a spent centerfire cartridge case; and Exhibit 4 is a blue T-shirt.

Q. What were you asked to do with these items?

A. (Somewhat abbreviated)

I was asked to examine Exhibit 1 and determine if it functioned properly. I was asked to determine if Exhibits 2 and 3 were fired from/by Exhibit 1. Lastly, I was asked to examine Exhibit 4 for bullet holes and try to determine how far Exhibit 1 was from Exhibit 4 when it was fired.

Q. What were your conclusions and how did you arrive at those findings?

A. (Very abbreviated)

I determined that Exhibit 1 was a functional firearm (I will also at this point describe to the jury how the firearm operates); that Exhibits 2 and 3 were identified as having been fired from/by Exhibit 1; and Exhibit 4 had a large bullet entrance hole in the front chest area and gunshot residues were found around this hole that indicate Exhibit 1 was in close proximity to Exhibit 4 when fired.

I would then explain to the jury how I arrived at these conclusions by describing the principles of Firearms Identification detailed on the various pages of this web site (Firearms Identification, Firearm Function Testing, and Distance Determinations).

You work for who?

Firearms Identification is a branch of Forensic Science and as such those who qualify are ***scientists***. It is often assumed that since I work for a law enforcement agency that I have a vested interest to help the law enforcement community prove the facts of a case and help gain a conviction through my testimony. Actually, the job that the firearm examiner performs is not to prove innocence *or* guilt. As a scientist our job is to merely convey to the jury what we did, how we did it, and what our results were. It is up to the *jury* to decide innocence or guilt through the process of hearing all of the facts of the case. The jury will hear my testimony and decide if it is or is not relevant to the case.

As scientists and expert witnesses (and to remain as such) it is of the utmost importance that we maintain complete impartiality in our job. I would take great offense to someone implying I am testifying for or against anyone. I am simply conveying facts based on a degree of scientific certainty, nothing more.

When testifying in court it is the responsibility of any expert to treat the prosecutor and defense attorney with an equal degree of candor. The jury will see how a witness reacts to questions and will use those reactions to judge, for themselves, whether you are telling the truth or are stretching the truth to one side's benefit.

All of the examinations one may conduct will be for nothing if the expert cannot convey the examinations conducted in a way that the jury can understand *and* believe.

I. The Fundamentals of Firearm Safety

The three basic general rules of safe gun handling.

1. Always point the muzzle in a safe direction; never point a firearm at anyone or anything you don't want to shoot.
2. Keep your finger off the trigger and outside the trigger guard until you are ready to shoot.
3. Keep the action open and the gun unloaded until you are ready to use it.

II. Additional specific rules of safe gun handling

Safety Rules Related to the Shooter and His Behavior.

1. Treat every firearm as if it were loaded.
2. Never pass a firearm to another person, or accept a firearm from another person, until the cylinder or action is open and you've personally checked that the weapon is completely unloaded.
3. Before handling any firearm, understand its operation.
4. Never rely on any mechanical device for safety.
5. Think before shooting: once you pull the trigger you can't take back the shot you've just fired!
6. Never joke around or engage in horseplay while handling or using firearms.
7. Be alert at all times; never shoot if you're tired, cold or impaired in any way. Don't mix alcohol or drugs with shooting.

8. Don't sleep with a loaded firearm in your bedroom if you sleepwalk, have nightmares, sleep restlessly or have other sleep problems.
9. Safeguard your sight, hearing and health. Always wear eye and ear protection. Endeavor to limit your exposure to heavy metal particulates and gases, and minimize your contact with aromatic organic solvents (such as those commonly used in gun cleaning products).
10. If you see unsafe behavior any time when firearms are being handled or used, speak up and take action to correct the unsafe behavior at once.
11. Receive competent instruction from a qualified person before beginning to shoot. If questions arise later, after you've been shooting for a period of time, get answers to those questions from a competent authority.

Safety Rules Related to Your Target.

1. Positively identify your target and the threat it poses before firing at it.
2. What's behind your target? Always make sure that a stray shot, or a bullet which penetrates its intended target through and through, will be safely stopped.
3. Never shoot at a hard surface, or at water -- your shot may glance off, ricochet and injure someone.
4. Never shoot at glass bottles, living trees, or inappropriate targets which would create a hazard for other persons or damage the environment.
5. Never shoot a rifle or handgun directly upwards, or at a high angle of elevation. Even a rimfire .22 bullet fired at an angle into the air can have enough energy a mile and a half away to accidentally kill someone!
6. Never shoot across a highway or other roadway.
7. Never vandalize a road sign (or other public or private property) by using it as a target.
8. Never poach a game animal out of season, or shoot any game animal you don't intend to eat.

Safety Rules Related to Your Firearm.

1. Make sure your firearm is in good mechanical condition before firing it. Periodically have your firearm checked for signs of erosion, cracking, or wear by the factory, by a qualified armorer, or by a factory certified gunsmith.
2. Never try to fire a gun which may have a plugged or partially obstructed barrel.
3. Insure that any modifications made to a firearm are made by a qualified individual, and that those modifications don't interfere with your firearm's safety features.
4. Be sure all accessories, such as holsters and grips, are compatible with the firearm and won't interfere with its safe operation.
5. Remember: a backup firearm carried about your person may be highly valuable to you in the event your primary firearm is ever rendered inoperable or is taken from you by an assailant.
6. It is your responsibility to insure that your firearm is always either about your person and under your personal control, or positively secured from access by children or other unauthorized parties. Prevent tragedy: lock down your firearms when they aren't in use.
7. When storing a firearm for a long period of time, consider storing the slide, bolt, or other critical components of the firearm separately under separate lock and key.
8. Never carry a single action revolver with a round under the hammer unless that revolver is a modern transfer-bar type, equipped with an inertial firing pin.
9. Never carry a pistol with a round in the chamber unless the pistol has an automatic firing-pin block and/or an inertial firing pin.
10. Generally avoid carrying or storing an external hammer-type firearm with its hammer cocked. Exercise extreme care in decocking any external hammer firearm: it is very easy to experience an accidental discharge while doing so if your thumb slips off the hammer.
11. Generally avoid unloading a firearm by working the cartridges through the action one-at-a-time; drop the magazine and then eject the round which may be left in the chamber, instead, if possible.
12. Never use a scope mounted on a firearm as a general purpose spotting scope: while observing an area you may end up accidentally aiming your firearm at fellow hunters, or other non-targets.

13. Avoid trying to catch a live round (while unloading a semiautomatic pistol) by cupping your hand around the ejection port while retracting the slide; doing so may result in an accidental discharge.

Safety Rules Related to Ammunition.

1. Be sure your gun and ammunition are compatible. Shooting incorrect ammunition in a firearm may cause it to be damaged or even make it blow up.
2. Relying on ammunition which doesn't feed reliably in your particular firearm may make your firearm malfunction at a critical juncture: get experience with a particular lot of ammunition in your firearm before relying on it for defensive purposes.
3. Use only ammunition recommended for your firearm by its manufacturer. Never fire ammunition which exceeds industry standard pressure specifications. Over-pressure ammunition will reduce the service life of your handgun, and puts you and those around you at risk of a catastrophic firearm failure.
4. Use reloaded ammunition judiciously. Be aware that many firearms manufacturers specifically forbid the use of reloaded ammunition in their products, and will void their product's warranty if you elect to use reloaded ammunition in contravention of their instructions.

   Also remember that a cartridge which has: the wrong powder, no powder charge, or too large a powder charge; an inverted primer, mis-seated primer, the wrong type of primer or an inert primer; a mis-seated, inverted, or mis-sized bullet; a collapsed, weakened, improperly sized or mis-crimped case; incorrect overall length or any of a host of other defects may seriously jeopardize your safety, the safety of those around you, and/or the reliability of your firearm in a defensive situation.

   Many shooters prepare and safely use reloaded ammunition each day, and it can be an economical way to stretch your ammunition budget, but the safety of that reloaded ammunition directly depends on the care, components, equipment, and practices used in preparing it.

5. Carry only one caliber of ammunition when shooting. Accidentally grabbing the wrong ammunition while shooting can result in a shooter or third party being injured, or damage or destruction of a firearm.
6. Insure you carry sufficient spare ammunition for your defensive firearm, and make sure you carry it in a readily employable fashion (such as in spare magazines or in speedloaders).
7. Store ammunition that isn't being used under lock and key, inaccessible to unauthorized parties and children.
8. Dispose of unwanted ammunition safely.

Safety Rules Related to Your Firearm's Holster and Ammo Carrier.

1. Always use a holster which is designed for, and which fits, your handgun.
2. Make sure your holster covers the trigger guard of your handgun.
3. Purchase a holster which allows you to obtain a secure grip on your handgun while it is still holstered.
4. Be sure the thumb break, safety strap, or other firearm retention device on your holster is functional and consistently employed. A good holster should retain your firearm during normal carry and routine physical activity, but no holster can insure that a firearm will be secure against determined attempts at disarmament, or keep a firearm secure during all possible physical activities.
5. Avoid clip-on holsters and magazine pouches. These carriers may fail to stay clipped to the belt and end up being drawn along with the firearm or the magazine they still hold, thereby interfering with use of the firearm or with timely reloading.
6. Avoid paddle-style holsters, cross draw holsters, and similar holsters which provide poor weapon retention.
7. Avoid ankle holsters, shoulder holsters and other types of holsters which can introduce unnecessary delays in accessing a defensive firearm.

8. Avoid carrying a defensive firearm in a purse, pocketbook, daypack or briefcase. A firearm carried in that fashion is:
   - Typically hard to rapidly access due to the presence of slow-to-open zippers, multiple latches, etc.,
   - Often hard to find and draw amidst all the other items routinely carried, since few purses or briefcases include a dedicated handgun-carrying compartment,
   - Prone to being unavailable when needed, since briefcases, purses and other carriers are routinely set down or put away in a desk drawer where they may or may not be readily accessible and under your physical control,
   - Unusually vulnerable to being stolen, since purses, pocketbooks, daypacks and briefcases are prime targets for purse snatchers, pick pockets, muggers and thieves,
   - Prone to misfunction in an emergency since materials carried along with your handgun in a purse or brief case may gum up the firearm's mechanism and potentially interfere with its proper operation, and
   - Likely to allow your handgun to accidentally become visible to shop clerks, bank tellers or other parties while you are searching for your checkbook or locating a credit card, and that inadvertent exposure may potentially result in a tense situation or even a tragic over-reaction on the part of an individual noticing the firearm and/or summoning law enforcement officers to the scene.
9. Never carry a handgun tucked into your belt or waistband without a holster (i.e., so-called ``mexican carry"). A handgun carried in this fashion may be unintentionally dislodged, fall onto a hard surface and accidentally discharge or be damaged. Inside the waistband-type holsters will allow you to obtain the concealment of this type of carry while simultaneously providing vastly improved firearm retention.
10. Always employ a proper magazine holder or speed loader carrier to carry your spare ammunition. Select a design that secures and protects your speedloaders or magazines while still making them readily available for use. Avoid ammunition loops and ammo dump boxes.
11. Never put a partially empty magazine or speedloader back into a magazine carrier or speedloader pouch: only full magazines or full speedloaders belong in a carrier. Partially empty magazines or speed loaders should go into your pocket; empty magazines or speedloaders should be allowed to fall where they're used during an emergency.

Miscellaneous Safety Rules.

1. At a range, obey the commands of the range officers, or any individual calling `cease fire,' at once. Read, know and follow any rules peculiar to a particular range which you may be using.
2. Be careful of hot gases and metal shavings ejected at the forcing cone of a revolver.
3. Keep your fingers and other parts of your body away from the muzzle, the rear of the slide, and the ejection area of a semiautomatic pistol.
4. In the event of a misfire, keep the firearm pointed in a safe direction, remove your finger from the trigger, wait ten seconds, then eject the cartridge and dispose of it properly.
5. If you hear an unusual sound upon squeezing the trigger or feel an unusual recoil, stop shooting and investigate. You may have experienced a ``squib" load (or under-powered cartridge), and it may have caused a bore obstruction. Keep the firearm pointed in a safe direction, remove your finger from the trigger, wait ten seconds, then unload the firearm and safely examine the barrel, checking carefully for any possible obstructions before reloading and resuming shooting.
6. Never ---
   - Climb a tree with a loaded firearm,
   - Cross a fence with a loaded firearm,
   - Jump a ditch or ford a stream with a loaded firearm,
   - Scale or descend a steep incline or hill with a loaded firearm,
   - Climb a tree, or climb into a hunting stand with a loaded firearm,
   - Prop or lean a loaded firearm against a tree or other surface which may allow it to slide, or
   - Transport a cased loaded firearm.

7. Always carry your firearms in a way which will allow you to control where the muzzle is pointing, should you stumble or fall.
8. A ballistic vest may substantially improve your chances of surviving an armed encounter on the street.
9. Always wear a thousand square inches or more of blaze orange while in the field during hunting season.
10. Blackpowder (and replica blackpowder) firearms require additional safety precautions not discussed here. Obtain qualified instruction in the safe operation of blackpowder firearms before attempting to load or fire any such firearm.
11. Circumstances may require additional safety rules unique to a particular situation.

III. Safe Gun Storage.

When you are not using your firearm, you should insure that it is store safely. Affirmative measures designed to prevent unauthorized access to a defensive firearm by minors, or firearm theft, include:

12. Use of a simplex-type locking box for securing firearms which need to be kept loaded yet available for ready-access defensive use, and
13. Use of trigger locks or padlocks to secure firearms which don't need to be kept immediately available for defensive use.

Also note that:

14. Gun security devices which rely solely on physical strength to secure firearms from unauthorized use are generally undesirable since ingenious children can potentially employ leverage or tools to overcome those devices.
15. "Hiding" a firearm won't secure it from discovery and possible misuse by curious children or intruders.
16. Metal gun cabinets or gun safes can be used to safeguard firearms from unauthorized access or theft in many circumstances and metal gun cabinets or gun safes are generally preferable to open racks or glass-front cabinets.
17. Firearms should be stored unloaded and separate from ammunition when the firearm isn't needed for ready-access defensive use.
18. You may want to store critical components of a firearm (such as the gun's bolt or slide) separately from the rest of the firearm when the gun won't be used in the immediate future.
19. Consider engraving your firearms with your social security number, driver's license number, or concealed firearms license number to deter theft and facilitate return of stolen firearms which may happen to be recovered.
20. Explore "gun-proofing" your child by proper training, and by controlled and closely supervised access to firearms to reduce your child's natural unsatisfied curiosity about firearms.