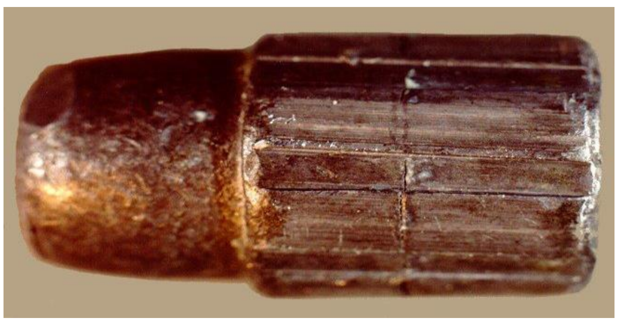
Chapter #24952

Barrels:

Inside the barrels of handguns and rifles are spiral impressions called rifling. The raised portions of the rifling are known as lands and the recessed portions are known as grooves. When a weapon is fired, these lands and grooves cut into the bullet, putting spin on it as it travels through the barrel of a firearm. Because bullets have an oblong shape, spin is necessary for accurate flight.



The impressions of lands and grooves remain on the bullet after it has been fired.

Since rifling characteristics can differ from one firearm manufacturer to another, forensic firearm examiners can determine the type of weapon that fired a particular bullet by examining the impressions of the lands and grooves on the bullet. They examine the width, the number, and the direction of the twist of the lands and grooves. For example, a 9mm pistol made by one company might have a barrel with 6 lands and grooves that twist to the right and another company's 9mm might have 6 that twist to the left. In addition, the width of the lands and grooves may differ.

- **Bore:** The inside of the barrel. "Smoothbore" weapons (typically shotguns) have no rifling. Most handguns and rifles have "rifling".
- **Breech:** The end of the barrel attached to the action.
- **Chamber:** The portion of the "action" that holds the cartridge ready for firing

- **Muzzle:** The end of the barrel out of which the bullet comes.

The caliber is normally obtained by measuring between the faces of opposite lands (*i.e.*, the ridges between the grooves in the barrel). In the traditional Anglo-U.S. system, calibre (or caliber) is measured in inches for cannons and hundredths of an inch for small guns. Thus, the bore diameter of a .30-calibre rifle is 30/100 of an inch, and that of a .50-calibre weapon is 1/2 inch. In Great Britain it has been common practice to carry the figure to another decimal point, as in the caliber .303 Lee-Enfield rifle, which was widely used in both World Wars. In the armed forces of both Britain and the United States, however, the trend since 1950 has been to follow the metric system, in which millimeters and occasionally centimeters are the units of measurement. The use of this system allowed NATO weapons of various makes and national origins to use ammunition of standardized size. In comparing the two systems, a rifle or pistol with a caliber of 7.62 mm corresponds to one of caliber .30 in the old Anglo-U.S. system.

An increase in the use of the gun barrel will cause wear of the inner wall, which reduces the muzzle velocity and the spin rate of the projectile. The off-bore flight attitude and trajectory of the projectile also change, affecting the shooting power and the accuracy.

Because of interior roughness or smoothness and variances in internal dimensions, seemingly identical barrels of like caliber and chamber vary considerably in the velocity they produce. There are “fast” barrels and “slow” barrels.

Longer barrels are not more accurate. If anything, it’s quite the opposite. Shorter, stiffer barrels tend to vibrate more consistently and are probably more accurate on average. Remember that when a barrel heats up, the gun becomes less accurate. Loading one round at a time allows for the chamber to cool down so heat doesn’t transfer to the next round from the chamber…again a matter of burn rate of the powder.

Accuracy and bore characteristics:

Nearly all small-bore firearms, with the exception of shotguns, have rifled barrels. The rifling imparts a spin on the bullet, which keeps it from tumbling in flight. The rifling is usually in the form of sharp-edged grooves cut as helices along the axis of the bore, anywhere from 2 to 16 in number. The areas between the grooves are known as lands. Another system, polygonal rifling, gives the bore a polygonal cross section. Polygonal rifling is not very common, used by only a few European manufacturers as well as the American gun manufacturer Kahr Arms. The companies that use polygonal rifling claim greater accuracy, lower friction, and less lead and/or copper buildup in the barrel. Traditional land and groove rifling is used in most competition firearms, however, so the advantages of polygonal rifling are unproven.

There are three common ways of rifling a barrel, and one emerging technology:

- The most basic is to use a single point cutter, drawn down the bore by a machine that carefully controls the rotation of the cutting head relative to the barrel. This is the slowest process, but as it requires the simplest equipment, it is often used by custom gunsmiths, and can result in superbly accurate barrels.
- The next method is button rifling. This method uses a die with a negative image of the rifling cut on it. This die is drawn down the barrel while carefully rotated, and it swages the inside of the barrel. This "cuts" all the grooves at once (it does not really cut metal), and so is faster than cut rifling. Detractors claim that the process leaves considerable residual stress in the barrel, but world records have been set with button-rifled barrels, so again there is no clear disadvantage.
- The last common method used is hammer forging. In this process, a slightly oversized, bored barrel is placed around a mandrel that contains a negative image of the entire length of the rifled barrel. The barrel and mandrel are rotated and hammered by power hammers, which forms the inside of the barrel all at once. This is the fastest (and in the long run, cheapest) method of making a barrel, but the equipment is prohibitively expensive for all but the largest gun

makers. Hammer-forged barrels are strictly mass-produced, so they are generally not capable of top accuracy as produced, but with some careful hand work, they can be made to shoot far better than most shooters are capable of.

- A new technique being applied to barrel manufacture is electrical machining, in the form of Electrical discharge machining (EDM) or Electro chemical machining (ECM). These processes use electricity to erode away material, a process which produces a highly consistent diameter and very smooth finish, with less stress than other rifling methods. EDM is very costly and primarily used in large bore, long barrel cannon, where traditional methods are very difficult, while ECM is used by some smaller barrel makers.

The purpose of the barrel is to provide a consistent seal, allowing the bullet to accelerate to a consistent velocity. It must also impart the right spin, and release the bullet consistently, perfectly concentric to the bore. The residual pressure in the bore must be released symmetrically, so that no side of the bullet receives any more or less push than the rest. The muzzle of the barrel is the most critical part, since that is the part that controls the release of the bullet. Some rimfires and air-guns actually have a slight constriction, called a choke, in the barrel at the muzzle. This guarantees that the bullet is held securely just before release.

To keep a good seal, the bore must be a very precise, constant diameter, or have a slight decrease in diameter from breech to muzzle. Any increase in bore diameter will allow the bullet to shift. This can cause gas to leak past the bullet, affecting the velocity, or cause the bullet to tip, so that it is no longer perfectly coaxial with the bore. High quality barrels are lapped to remove any constrictions in the bore which will cause a change in diameter.

A lapping process known as "fire lapping" uses a lead "slug" that is slightly larger than the bore and covered in fine abrasive compound to cut out the constrictions. The slug is passed from breech to muzzle, so that as it encounters constrictions, it cuts them away, and does no cutting on areas that are larger than the constriction. Many passes are made, and as the bore becomes more uniform, finer grades of abrasive compound are used. The final result is a barrel that is mirror-smooth, and with a consistent or slightly tapering bore. The hand-lapping technique uses a wooden or soft metal rod to pull or push the slug through the bore, while the newer fire-lapping technique uses specially loaded, low-power cartridges to push abrasive-covered soft-lead bullets down the barrel.

Another issue that has an effect on the barrel's hold on the bullet is the rifling. When the bullet is fired, it is forced into the rifling, which cuts or "engraves" the surface of the bullet. If the rifling is a constant twist, then the rifling rides in the grooves engraved in the bullet, and everything is secure and sealed. If the rifling has a decreasing twist, then the changing angle of the rifling in the engraved grooves of the bullet causes the rifling to become narrower than the grooves. This allows gas to blow by, and loosens the hold of the bullet on the barrel. An increasing twist, however, will make the rifling become wider than the grooves in the bullet, maintaining the seal. When a rifled-barrel blank is selected for a gun, careful measurement of the inevitable variations in manufacture can determine if the rifling twist varies, and put the higher-twist end at the muzzle.

The muzzle of the barrel is the last thing to touch the bullet before it goes into ballistic flight, and as such has the greatest potential to disrupt the bullet's flight. The muzzle must allow the gas to escape the barrel symmetrically; any asymmetry will cause an uneven pressure on the base of the bullet, which will disrupt its flight. The muzzle end of the barrel is called the "crown", and it is usually either beveled or recessed to protect it from bumps or scratches that might affect accuracy. A sign of a good crown will be a symmetric, star-shaped pattern on the muzzle end of the barrel, formed by soot deposited, as the powder gases escape the barrel. If the star is uneven, then it is a sign of an uneven crown, and an inaccurate barrel.

Before the barrel can release the bullet in a consistent manner, it must grip the bullet in a consistent manner. The part of the barrel between where the bullet exits the cartridge, and engages the rifling, is called the "throat", and the length of the throat is the freebore. In some firearms, the freebore is all but nonexistent — the act of chambering the cartridge forces the bullet into the rifling. This is common in low-powered rimfire target rifles. The placement of the bullet in the rifling ensures that the transition between cartridge and rifling is quick and stable. The downside is that the cartridge is firmly held in place, and attempting to extract the unfired round can be difficult, to the point of even pulling the bullet from the cartridge in extreme cases. With high-powered cartridges, there is an additional disadvantage to a short freebore. A significant amount of force is required to engrave the bullet, and this additional resistance can raise the pressure in the chamber by quite a bit. To mitigate this effect, higher-powered rifles tend to have more freebore, so that the bullet is allowed to gain some momentum, and the chamber pressure is allowed to drop slightly, before the bullet engages the rifling. The downside is that the bullet hits the rifling when already moving, and any slight misalignment can cause the bullet to tip as it engages the rifling. This will, in turn, mean that the bullet does not exit the barrel coaxially. The amount of freebore is a function of both the barrel and the cartridge. The manufacturer or gunsmith who cuts the chamber will determine the amount of space between the cartridge case mouth and the rifling. Setting the bullet further forward or back in the cartridge can decrease or increase the amount of freebore, but only within a small range. Careful testing by the ammunition loader can optimize the amount of freebore to maximize accuracy, while keeping the peak pressure within limits.

Revolver-specific issues:

The defining characteristic of a revolver is the revolving cylinder, separate from the barrel, that contains the chambers. Revolvers typically have 5 to 10 chambers, and the first issue is ensuring consistency among the chambers, because if they aren't consistent then the point of impact will vary from chamber to chamber. The chambers must also align consistently with the barrel, so the bullet enters the barrel the same way from each chamber.

The throat in a revolver is part of the cylinder, and like any other chamber, the throat should be sized so that it is concentric to the chamber and very slightly over the bullet diameter. At the end of the throat, however, things change. First, the throat in a revolver is at least as long as the maximum overall length of the cartridge, otherwise the cylinder cannot revolve. The next step is the cylinder gap, the space between the cylinder and barrel. This must be wide enough to allow free rotation of the cylinder even when it becomes fouled with powder residue, but not so large that excessive gas is released. The next step is the forcing cone. The forcing cone is where the bullet is guided from the cylinder into the bore of the barrel. It should be concentric with the bore, and deep enough to force the bullet into the bore without significant deformation. Unlike rifles, where the threaded portion of the barrel is in the chamber, revolver barrels threads surround the breech end of the bore, and it is possible that the bore will be compressed when the barrel is screwed into the frame. Cutting a longer forcing cone can relieve this "choke" point, as can lapping of the barrel after it is fitted to the frame.

Twist Rate:

Twist rate is the rate of spin inside your barrel. For instance, a twist rate of 1:8, which is common in AR-15 rifles, means that the rifle will spin the bullet once over every 8-inches of rifling. If that rate isn't fast enough, your bullet may not travel with much stability. This can lead to tumbling and inaccuracy down range.

Twist rate is expressed as a ratio. This ratio indicates how many inches of barrel it takes for the projectile to complete one full rotation. The smaller the second number in the ratio, the faster the bullet spins. A larger second number indicates a slower rate of spin.

The barrel of your firearm must put adequate spin on projectiles to properly stabilize the bullets you're shooting. In general, a longer bullet requires a tighter rate for sufficient flight stability. Because heavier bullets are naturally longer, if you're shooting a projectile with a heavier grain weight, you'll want to shoot it from a barrel with a faster twist rate.

How can you measure the twist rate of the barrel:

If are unsure of the twist rate of the barrel, you can measure it yourself in a couple of minutes. You need a good cleaning rod with a rotating handle and a jag with a fairly tight-fitting patch. Utilize a rod guide if you are accessing the barrel through the breech or a muzzle guide if you are going to come in from the muzzle end. *Make sure the rod rotates freely in the handle under load.* Start the patch into the barrel for a few inches and then stop. Put a piece of tape at the back of the rod by the handle (like a flag) or mark the rod in some way. Measure how much of the rod is still protruding from the rod guide. You can either measure from the rod guide or muzzle guide back to the flag or to a spot on the handle. Next, continue to push the rod in until the mark or tape flag has made one complete revolution. Re-measure the amount of rod that is left sticking out of the barrel. Use the same reference marks as you did on the first measurement. Next, subtract this measurement from the first measurement. This number is the twist rate. For example, if the rod has 24 inches remaining at the start and 16 inches remain after making one revolution, you have 8 inches of travel, thus a 1:8 twist barrel.

The advent of elongated bullets called for some kind of mathematical rule of thumb for determining twist rates, as utilizing the trial-and-error solution for every bullet weight for every caliber would be onerous indeed. Enter Professor Sir Alfred George Greenhill of the British Royal Military Academy, who devised a formula for determining twist rate which, simplified here, multiplies the square of the bullet diameter by 150 and then divides the result by the length of the bullet, and looks like this: $(C \times D^2) \div L = T$.
C is a constant, 150; D^2 is bullet diameter multiplied by itself, L is bullet length and T is the result, twist rate. Using it is simple; let's stick with our 5.56 mm/.223 Rem. example. The bullet diameter is .244" and length of a 55 grainer is .740". Following Greenhill:

- Step 1—Finding D^2: .244 x .244 = .05953

- Step 2—Finding C x D^2: 150 x .05953 = 8.9295
- Step 3—Divide result by bullet length: 8.9295 ÷ .740 = 12.06

So, 1:12.06-inch, rounded to 1:12-inch, is our standard twist rate for the .223 Rem. 55-grain bullet.

Doing the same for an 80-grain bullet 1.075" long:

- Step 1—Finding D^2: .244 x .244 = .05953
- Step 2—Finding C x D^2: 150 x .05953 = 8.9295
- Step 3—Divide result by bullet length: 8.9295 ÷ 1.075 = 8.306

Rounded, 1:8-inch twist is Greenhill's indicated twist rate for 80-grain bullets. As shooters have discovered, the reality is that a 1:8-inch twist can be marginal for a .223 Rem. 80-grain bullet, working better with some makes than others, and that a 1:7-inch twist may work better. What's up with that?

The shortcoming of Greenhill's formula is that the professor developed it for elliptical (football-shaped) subsonic lead projectiles (he was more into rifled cannons). Though it applies surprisingly well for rifle bullets with muzzle velocities up to about 2,800 fps (for higher velocities, we can substitute 180 for 150 in the constant C, which results in slower twist rates), it isn't perfect. Others have offered their own (pardon the pun) twists on Greenhill.

The Miller twist rule, formulated by Don Miller and published in 2005, refines Greenhill a bit by including bullet weight. The tweak takes into account the lighter-for-length jacketed, hollow point and homogeneous metal bullets invented since Greenhill developed his formula.

It's surprisingly hard to get barrel twist rate data from manufacturers. 45 ACP barrels tend to have a twist rate of 1/16. The slower twist rate should perform better with lead bullets. 9MM barrels tend to have a twist rate of 1/10. The more aggressive twist rate should perform better with the harder jacketed bullets. When it comes to handguns and hunting rifles, the rate chosen by the rifle maker is usually appropriate for the intended cartridge. Some manufacturers of custom, "match" barrels, specify a 1/16 twist rate for all calibers. Again, most don't specify twist rate. Most shooters don't even realize they might have a choice, so manufacturers rarely give them one.

LINKS FOR TWIST RATE CALCULATORS:

The Barrel Outlet's Barrel Twist Calculator

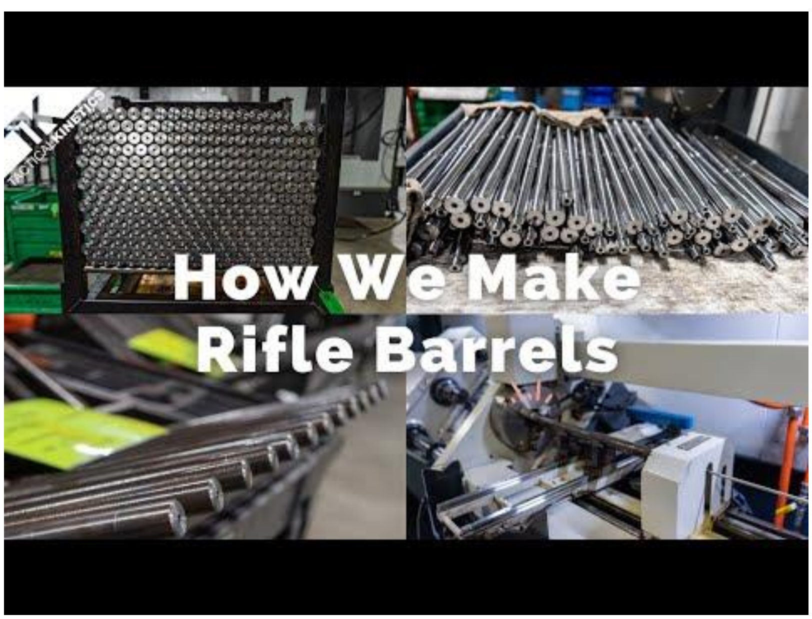
JBM Ballistics

Twist Rate Calculator

Twist Rate Stability Calculator

VIDEO:


IV8888
HOW TO
MEASURE TWIST RATE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Rifle Barrels

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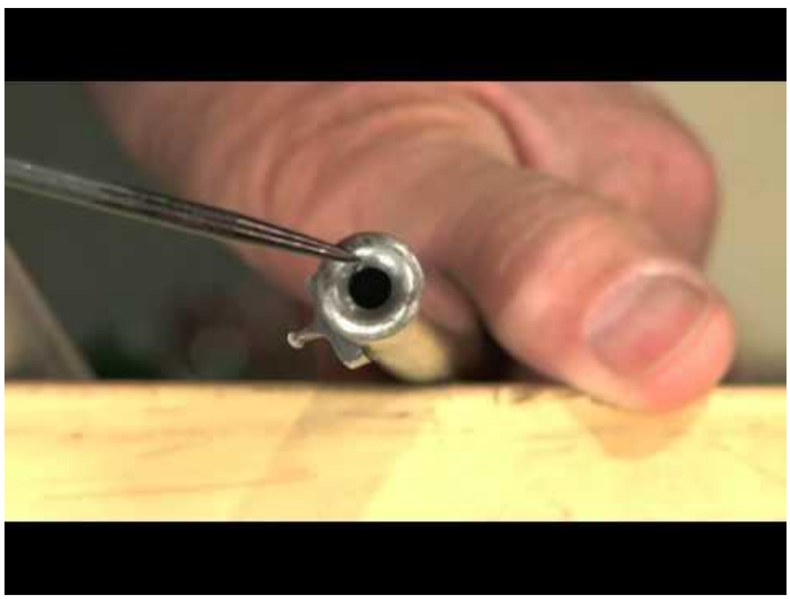

Rifle Barrel Install Tools, Hacks, and Tips!

Bullet Weight vs Twist Rate test

How Bullet Weight Affects Accuracy and Point of Impact Presented by Larry Potterfield of MidwayUSA

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