The Theory Of The Group

A group is usually defined as a series of 3 or more shots which form a pattern on the target.

This theory establishes that when a series of shots are fired from a rifle at the same point of aim, they will seldom, if ever, pass through the same hole but will produce a pattern on the target. This pattern is known as a group.

It also provides a simple rule, which although not strictly accurate, enables the size of group which a firer will achieve at any distance to be estimated once his/her grouping capacity is known.

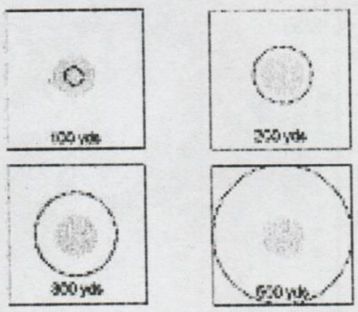
The size of the group is determined by a combination of:

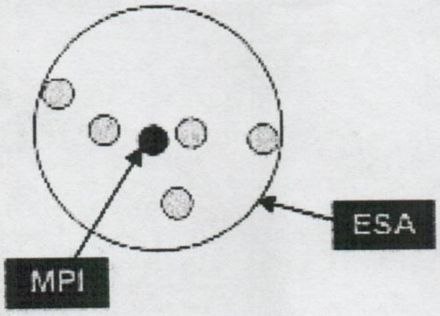
The ammunition

The rifle

The firer applying the four principles of marksmanship.

The size of the group will expand in direct proportion to the distance. This means that the size of the group at any distance (Expected Scoring Area ESA) can be calculated from the original group size value.





The centre of the group is known as the MPI (Mean Point of Impact).

Reasons why a firer may not fire a tight group can be attributed to:

a. Faults within the firer's control

- Failure to apply the marksmanship principles
- Failure to prepare the rifle
- Failure to ensure ammunition is clean and dry.
- Lack of determination.

b. Faults outside the firer's control

- Weather
- Physical limitations
- Inefficient training and coaching.

The purpose of zeroing is to superimpose the MPI on the correct zero position (CZP) so that with the appropriate sight setting and wind allowance (where necessary), the group will form centrally at all distances.

Firing Positions

Gallery Rifles

Gallery rifles are divided into two broad groups:

those that fire small bore rimfire ammunition (.22" calibre) and those that fire full bore pistol calibre ammunition.

Both groups involve relatively short barrels and are magazine fed, where the magazines may be fixed, detachable or tubular. As such they require great vigilance where novices are concerned.

The small bore gallery rifles may be self loading, but both groups may be fired from the standing, or sitting positions. They are normally fired on short ranges up to 50 yd/m, often on what are termed No Danger Area ranges.

Service and Military Rifles

Such rifles are magazine fed and are normally bolt action firearms. They may be fired from the standing, kneeling, sitting, or prone positions.

Lever Action Rifles

Such rifles can have a variety of "safety features", a safety catch, a grip safety, and the half cock method. None of these should be trusted if there is a round in the chamber because a hard jolt can cause the hammer to strike the firing pin.

There are two types of under lever the first and most popular is the modern, which has a safety. The second is the original which does not have a safety. With no safety its down to the shooter. With modern rifles, the half cock and the safety catch provide the best method due to the two piece firing pin system so that if it gets a hard jolt the hammer can only strike to first pin. Note: Marlins are now coming with a single piece firing pin.

Loading

After checking that the rifle is clear, operate the lever action and look in the chamber and magazine, close the action, apply safety (if fitted) and ease the hammer forward to half cock.

With the gun pointing in a safe direction (toward the target), load rounds into the magazine, ensuring the last round is fully inserted to prevent any possible jam when the action is operated.

Once loaded, the rifle can be made ready on the firing point (providing permission has been given to fire) by operating the action and changing the safety to FIRE.

Unloading

With the rifle pointed in a safe direction (toward the target), apply safety and half cock.

Operate the action at least three times to ensure all rounds have been ejected.

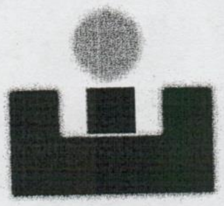
Check magazine and chamber. The magazine follower on most modern rifles is brightly coloured to aid a visual check, however it may be faded/grubby and not easy to see..

Insert breech flag if required to do so.

Remove the rifle to a rack or gun bag.

Iron Sights

The term iron sights refers to the open, unmagnified system used to assist the aiming of a guns/devices, usually those intended to launch projectiles, such as firearms, airguns, and crossbows; they are also used on many telescopes to help point at a desired target. Iron sights typically comprise metal blades and usually have two parts, a rear sight mounted vertically crosswise to the line of sight and consisting of some form of notch or aperture, and a post, bead or ring front sight. Civilian defensive and hunting firearms and police weapons usually feature open sights, while military small arms of the Western armies (meaning the NATO bloc) are most often outfitted with aperture sights. On many firearms the rear sight is adjustable for elevation and/or windage.



A sight picture with focus on the front sight; the out of focus grey dot represents the target

In the case of firearms, where the bullet follows a Newtonian trajectory, front and rear sights must be aligned with the line of sight of the shooter, calibrated to the distance of the target and the trajectory of the bullet, so that the bullet hits the target. Iron sights provide horizontal and vertical reference points that allow the shooter to aim the gun.

Rear sights are usually mounted in a dovetail on the barrel or receiver, closer to the eye of the shooter, allowing for easy visual pick-up of the notch. Front sights are mounted to the barrel by dovetailing, sweat soldering, screwing, or staking close to the muzzle, frequently on a ramp. Some front sight assemblies include a detachable hood intended to reduce glare.

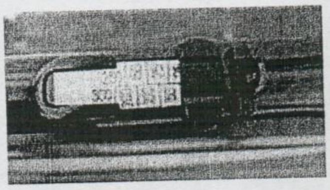
With typical blade iron sights, the shooter should centre the front post in the notch of the rear sight and the tops of both sights should be level. Since the eye is only capable of focusing on one plane, and the rear sight, front sight, and target are all in separate planes, only one of those three planes can be in focus. Which plane is in focus depends on the type of sight, and one of the challenges to a shooter is to keep the focus on the correct plane to allow for best sight alignment. Even a tiny error in the angle of sight alignment results in a trajectory that diverges from the target on a trajectory directly relative to the distance from the target, causing the bullet to miss the target; for example with an Olympic-class air rifle shooter trying to hit the 10 ring, which is merely a dot on the card at 10 meters and with a 4.5 mm diameter pellet, an error of only 0.2 mm in sight alignment can mean a complete miss. At 1000 meters, that same 0.2 mm misalignment would be magnified 1500 times, giving an error of over 300 mm. (Calculations assume a 660 mm sight radius).

Sights for shotguns used for shooting small, moving targets (wing shooting or clay shooting) work quite differently. The rear sight is completely discarded, and the rear reference point is provided by the correct and consistent positioning of the shooter's head. A brightly coloured (generally brass or silver coloured, white, or a fluorescent shade) round bead is placed at the end of the barrel. Often this bead will be placed along a raised, flat rib, which is usually ventilated to keep it cool and reduce mirage effects from a hot barrel. Rather than being aimed like a rifle or handgun, the shotgun is pointed — the focus is always on the target, and the unfocused image of the barrel and bead are placed below the target (the amount below depends on whether the target is rising or falling) and slightly ahead of the target if there is lateral movement. This method of aiming is not as precise as that of a front sight/rear sight combination, but it is much faster, and the wide spread of shot allows a hit even if there is some error in aim. Some shotguns also provide a mid-bead, which is a smaller bead located halfway down the rib, which allows more feedback on barrel alignment.

Fixed Iron Sights

The earliest and simplest iron sights are fixed and cannot be easily adjusted for variables such as target distance, the effect of wind, or variations between different cartridges. However, many supposedly 'non-adjustable' sights can actually be adjusted, for example the rear sight can often be drifted to compensate for windage if it is mounted in a dovetail, or the rear sight or channel mentioned above can be filed on one side to alter its alignment with the front sight. In other cases the front sight can be very carefully bent to offset it to one side, filed down, or the blade can be replaced with one of a different height. Any of the aforementioned techniques will result in a successful change to the firearm's point of impact, however in taxing situations such as these the services of a professional gunsmith would be well advised.

Adjustable Iron Sights



A tangent sight on a CZ 452 rimfire rifle, with calibrated markings for ranges out to 300 meters

Many iron sights are designed to be adjustable, so that the sights can be adjusted for windage and elevation. In addition, adjustable sights allow compensation for varying cartridge bullet weights or propellant loadings, which alter the round's velocity and external ballistics and thus its trajectory and point of impact.

Sight adjustments are orthogonal, so the windage can be adjusted without impacting the elevation, and vice versa. If the firearm is held canted instead of level when fired, the adjustments are no longer orthogonal, so it is essential to keep the firearm level for best accuracy.

The most common is a rear sight that adjusts in both directions, though military rifles often have a tangent sight in the rear, which a slider on the rear sight has pre-calibrated elevation adjustments for different ranges. With tangent sights, the rear sight is often used to adjust the elevation, and the front the windage. The later M16 series and HK rifles have a dial adjustable range calibrated rear sight, and use an elevation adjustable front sight to 'zero' the rifle at a given range. The rear sight is used for windage adjustment and to change the zero range.

Types Of Iron Sights

Iron sights are broken into two basic categories that include most types. Open sights use a notch of some sort as the rear sight, while aperture sights use a circular hole. Wing and clay-shooting shotgun sights are called shotgun beads, or simply beads.

Open Sights

Open sights generally are used where the rear sight is at significant distance from the shooter's eye. They provide minimum occlusion of the shooter's view, but at the expense of precision. Open sights generally use either a square post or a bead on a post for a front sight. The post or bead is placed in the rear sight notch, and the target is placed above and centred on the aligned sights. From the shooter's point of view, there should be a noticeable space between each side of the front sight and the edges of the notch; the

spaces are called light bars, and the brightness of the light bars provides the shooter feedback as to the alignment of the post in the notch. Vertical alignment is done by lining up the top of the front post with the top of the rear sight, or by placing the bead just above the bottom of the V or U-notch.
If the post isn't centred in the V or U notch, the shot will not be accurate. If the post extends over the V or U-notch it will result in a high shot. If the post does not reach the top of the V or U-notch it will result in a low shot.

Patridge sights consisting of a square or rectangular post and a flat-bottomed square notch are the most common form of open sights and are preferred for target shooting, as the majority of shooters find the vertical alignment is more precise than other open sights. V-notch and U-notch sights are a variant of the patridge which substitute a 'V' or 'U' shaped rear notch.

Other common open sight types include the buckhorn, semi-buckhorn, and express. Buckhorn sights have extensions protruding from either side of the rear sight forming a large ring which almost meets directly above the 'V' of the notch. The semi-buckhorn is similar but has a wider gently curving notch with the more precise 'V' at its centre and is standard on classic Winchester and Marlin lever-action rifles. Express sights are most often used on heavy calibre rifles intended for the hunting of dangerous big game, and are in the form of a wide and large 'V' with a heavy white contrast line marking its bottom and a big white or gold bead front sight. In cases where the range is close and speed far outweighs accuracy (e.g. the shooter is being charged by a Cape Buffalo), the front sight is used like a shotgun bead; the rear sight is ignored, and the bead is placed on the target. When more time is available, the bead is placed in the 'V' of the rear sight.

Advantages And Disadvantages Of Open Sights

Open sights have many advantages; they are very common, inexpensive to produce, uncomplicated to use, sturdy, lightweight, and resistant to severe environmental conditions. On the other hand, they are not as exact as other forms of sights, and are hard or unfeasible to adjust. Open sights also take much more time to use - the buckhorn type is the slowest, partridge, 'U' and 'V' type notch sights are only a bit quicker; only the express sight is relatively fast. In addition, open sights tend to block out the lower portion of the shooter's field of view by nature, and because of the depth of field limitations of the human eye, don't work as well for shooters with less than perfect vision.

Aperture Sights

Pictures taken under identical conditions through large (left) and small (right) diameter aperture sights, with camera focused on front sight.

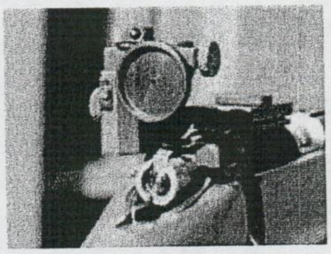
Aperture sights, also known as peep sights, range from the ghost ring sight, whose thin ring blurs to near invisibility (hence ghost), to target aperture sights that use large disks with pinhole-sized apertures. In general, the thicker the ring, the more precise the sight, and the thinner the ring, the faster the sight. The image to the right shows a shooter's eye view of the sight picture taken through large and small diameter apertures. The large diameter aperture provides a much brighter image of the target, and the ghosting of the rear ring is evident. The smaller aperture, while providing a much darker image of the target, provides a much greater depth of field, yielding a much sharper image of the target. The theory of operation behind the aperture sight is that the human eye will automatically centre the front sight when looked through the rear aperture, thus ensuring accuracy.

Ghost Rings

For many shooters, the ghost ring sight is the fastest type of aperture sight. It is fairly accurate, easy to use, and obscures the target less than nearly all other non-optical sights. Because of this, ghost ring sights are commonly installed on combat shotguns and sub-machine guns (and to a much lesser extent, rifles). The ghost ring is a fairly recent innovation, and differs from traditional aperture sights in the extreme thinness of the rear ring, and the slightly thicker front sight. The thin ring minimizes the occlusion of the target, while the thicker front post makes it easy to find quickly.

A ghost ring can also take form of a tube ranging from 3-6 cm long, with the post mounted at the inside end of the tube. This type of ghost ring is used when there can be no front sight at the front end of the barrel. It is slightly slower to use, because the shooter's eye has to focus close on the post, then the target. However, in situations when extremely fast sighting is required, the shooter can simply look through the tube, and it is simple to see if the view is straight down the tube.

Target Aperture Sights



Rear aperture of a BRNO target sight. Note large disk and small aperture.

Target aperture sights are designed for maximum precision. The rear sight element (often called diopter) is usually a large disk (up to 1 inch or 2.5 cm in diameter) with a small hole in the middle, and is placed close to the shooter's eye. High end target diopters normally accept accessories like adjustable diopter aperture and optical filter systems to ensure optimal sighting conditions for match shooters. Typical modern target shooting diopters offer windage and elevation corrections in 2 mm (0.079 in) to 4 mm (0.157 in) increments at 100 m (109.4 yd). Some ISSF (Olympic) shooting events require this precision level for sighting lines, since the score of the top competitors last 10 shots is expressed in 0.1s of scoring ring points.

The complementing front sight element may be a simple bead or post, but is more often a globe type sight, which consists of a cylinder with a threaded cap, which allows differently shaped removable front sight elements to be used. Most common are posts of varying widths and heights or rings of varying diameter – these can be chosen by the shooter for the best fit to the target being used. Tinted transparent plastic insert elements may also be used, with a hole in the middle; these work the same way as an opaque ring, but provide a less obstructed view of the target. Many target front sight tunnels normally also accept accessories like adjustable aperture and optical systems to ensure optimal sighting conditions for match shooters. Some target sight manufacturers also offer front sights with integrated aperture mechanisms.

The use of round rear and front sighting elements for aiming at round targets, like used in ISSF match shooting, takes advantage of the natural ability of the eye and brain to easily align concentric circles (circles all having a common centre). Even for the maximum precision, there should still be a significant area of white visible around the bullseye and between the front and rear sight ring (if a front ring is being used). Since the best key to determining centre is the amount of light passing through the apertures, a narrow, dim ring of light can actually be more difficult to work with than a larger, brighter ring. The precise sizes are quite subjective, and depend on both shooter preference and ambient lighting, which is why target rifles come with easily replaceable front sight inserts, and adjustable aperture mechanisms.

Rifles from the late 1800s often featured one of two types of aperture sight called a tang sight or a ladder sight. Since the black powder used in muzzleloaders and early cartridges was not capable of propelling a bullet at high velocity, these sights had very large ranges of vertical adjustments, often on the order of several degrees, allowing very long shots to be made accurately. The .45-70 cartridge, for example, was tested by the military for accuracy at ranges of up to 1500 yards, which required 3 1/3 degrees of elevation. Both ladder and tang sights folded down when not in use to reduce the chance of damage to the sights. Ladder sights were mounted on the barrel, and could be used as sights in both the folded and unfolded states. Tang sights were mounted behind the action of the rifle, and provided a very long sight radius, and had to be unfolded for use, though rifles with tang sights often had open sights as well for close range use. Tang sights often had vernier scales, allowing adjustment down to a single minute of arc over the full range of the sight.

Aperture sights on military rifles use a larger aperture with a thinner ring, and generally a simple post front sight. The extreme case of this is the ghost ring sight, a relatively recent innovation that may be the fastest type of iron sight to use, while still providing a degree of precision comparable to or better than most open sights. Ghost ring sights are commonly found on riot and combat shotguns and customized handguns, and they are also gaining ground as a backup sighting system on rifles.

Shotgun Beads

Since shotgun beads are only used by the peripheral vision, generally a larger, brighter bead works best. Fibre optic sights are becoming popular for shotguns, as they greatly increase the brightness of the bead by collecting light and directing it to the shooter's eye. Since the "rear sight" in the case of a shotgun is the shooter's eye position, adjusting the "sights" on a shotgun consists primarily of adjusting the stock to fit the shooter as well as possible.

Bead sights are inferior in practical accuracy compared to rifle and ghost-ring sights, as they provide no rear sight to verify correct alignment with the front sight. While bead sights may be acceptable on sporting shotguns, they are best avoided for use on combat shotguns.

The primary advantage of bead sights is that they are less expensive than rifle and ghost-ring sights.

Iron Sight Enhancements

While iron sights are basically very simple, that simplicity also leads to a staggering variety of different implementations. In addition to the purely geometric considerations of the front blade and rear notch, there are some factors that need to be considered when choosing a set of iron sights for a particular purpose.

Glare Reduction

Glare, particularly from the front sight, can be a significant problem with iron sights. The glare from the front sight can increase the apparent brightness of the light bar on one side of the sight, causing windage errors in aiming, or lower the apparent height of the front sight, causing elevation errors in aiming. Since the direction of the ambient light is rarely constant for a shooter, the resulting changing glare can significantly affect the point of aim.

The most common solution to the problem of glare is a matte finish on the sights. Serrating or bead blasting the sight is a common solution for brightly finished sights, such as blued steel or stainless steel. Matte finishes such as parkerizing or matte black paint can also help. 'Smoking' a sight by holding a match or cigarette lighter under the sight to deposit a fine layer of soot is a common technique used by many shooters, and in fact special soot producing cigarette type lighters are sold for use by competition shooters.

Many target sights are designed with vertical or even undercut front sight blades, which reduces the angles at which light will produce glare off the sight. The disadvantage of these sights is that they tend to snag on clothing, branches, and other materials, so they are only common on target guns. Sight hoods reduce the chances of snagging an undercut sight and are common on some types of rifles, particularly lever action rifles, but they are prohibited in some shooting disciplines.

Fixed Vs. Adjustable Sights

The downside to adjustable sights is the inherent fragility of the moving parts. A fixed sight is a solid piece of metal, usually steel, and if firmly attached to the gun, little is going to be able to damage it beyond usefulness. Adjustable sights, on the other hand, are bulkier, and have parts that must move relative to the gun. solid impact on an adjustable sight will usually knock it out of adjustment, if not knock it right off the gun. Because of this, guns for self defence or military use either have fixed sights, or sights with "wings" on the sides for protection. Iron sights used for hunting guns tend to be a compromise. They will be adjustable, but only with tools--generally either a small screwdriver or an allen wrench. They will be compact and heavily built, and designed to lock securely into position. Target sights, on the other hand, are much bulkier and easier to adjust. They generally have large knobs to control horizontal and vertical movement without tools, and often they are designed to be quickly and easily detachable from the gun so they can be stored separately in their own protective case.

Contrast Enhancements

While target shooters generally prefer a matte black finish to their sights, to reduce the chance of glare and increase the contrast between the sights and the light bars, black sights don't offer good visibility with dark targets or in low light conditions, such as those often encountered in hunting, military, or self defence situations. A variety of different contrast enhancements to the basic Patridge type sight and others have been developed to address this deficiency.

- White outline rear
  A contrast variation which uses a dot front sight with a thick and bright white outline around the rear sight notch.[4]
- Straight Eight
  High visibility sights in which a single dot front sight and a rear notch with a dot below can be lined up vertically to form a figure 'eight'.
- Sight inserts
  This enhancement consists of a coloured plastic insert in the front sight blade, usually red or orange in colour.
- Bar/Dot or Express sight
  Similar to the Straight Eight type, this type of sight is traditional on express rifles and is also found on some handguns. The open, V-shaped rear allows for faster acquisition and wider field of view, though less accurate for longer range precision type shooting. The dot on the front sight is aligned or set directly above the vertical bar on the rear sight, commonly referred to as "dotting the 'I'".

- Gold bead
  Preferred by many competitors in IPSC and IDPA shooting.
- Night sights
  On tactical firearms, the contrast enhancements can consist of trasers containing tritium gas and fluorescent material, which emit a dim light due to the radioactive decay of the tritium. Tritium sights provide vital visibility in extremely low light situations where normal sights would be degraded or even useless.
- Fibre optic
  A growing trend, started on air rifles and muzzleloaders, is the use of short pieces of optical fibre for the dots, made in such a way that ambient light falling on the length of the fibre is concentrated at the tip, making the dots slightly brighter than the surroundings. This method is most commonly used in front sights, but many makers offer sights that use fibre optics on front and rear sights. Fibre optic sights can now be found on handguns, rifles, and shotguns, both as aftermarket accessories and a growing number of factory guns.

Other Types Of Sights

For precision applications such as hunting the iron sights are usually replaced by a telescopic sight, and for short range target shooting low-power magnified or unmagnified optical sights such as red-dot or reflex sights are increasingly common.

Adjusting An Iron Sight's Point Of Impact (Zeroing)

If the sights are not aligned correctly, then the sights should be adjusted to bring the line of sight to meet the point of impact. Theoretically, this can be done with a single shot--clamp the firearm into a vice, fire one shot, then adjust the sights so they are pointing at the hole in the target. In fact, it requires several shots to establish a group, then the sights are adjusted to move the line of sight closer to the group, and the process is repeated iteratively until the sights are correctly aligned.

The general rule is the rear sight is moved in the SAME direction you wish to move the point of impact. In the illustration at right, the point of impact was LEFT and BELOW the target. To move the point of impact to the centre, move the rear sight RIGHT and UP. The front sight moves the opposite direction, so it would move LEFT and DOWN.

Detailed instructions for adjusting the sights:

- To move the line of sight DOWN (the shot hit BELOW the point of aim) the REAR sight is RAISED or the FRONT sight is LOWERED.
- To move the line of sight UP (the shot hit ABOVE the point of aim) the REAR sight is LOWERED or the FRONT sight is RAISED. (Example below)
- To move the line of sight LEFT (the shot hit LEFT of the point of aim) the REAR sight is moved RIGHT, or the FRONT sight is moved LEFT.
- To move the line of sight RIGHT (the shot hit RIGHT of the point of aim) the REAR sight is moved LEFT, or the FRONT sight is moved RIGHT.

Many target sights have click adjustments, where a detent in the adjustment screws allows the sight to move the line of sight a certain angular distance with each click. This distance is usually specified in minutes of arc, which translate to approximately 1 inch at 100 yards. On a firearm with 1 minute clicks, then, it would take 1 click to move 1 inch at 100 yards, 2 clicks to move 1 inch at 50 yards, 4 clicks to move 1 inch at 25 yards. If click adjustments are not available, or the click interval is not known, then the distance to lengthen or shorten the sight for a given point of aim adjustment is:

D1 / R1 = D2 / R2

For rear sight adjustments:

- **D1** is the distance between point of aim and point of impact.
- **R1** is range from front sight to target.
- **D2** is the length the rear sight must change by.
- **R2** is the distance between front and rear sights.

For front sight adjustments:

- **D1** is the distance between point of aim and point of impact.
- **R1** is range from rear sight to target.
- **D2** is the length the front sight must change by.
- **R2** is the sight radius distance between front and rear sights.

This formula calculates the MAGNITUDE ONLY of the sight height change, and not the direction which was described above. All distances must be in the same units. That is, if a change in inches to the sight height is desired, and one is shooting on a 100 yard range, then R1 (100 yd) must be converted to inches (100 x 36 = 3600 inches) before using this distance in the equation.

Example:
Consider a rifle with a distance between front and rear sights of 26.25 inches, firing on a 50 yard (1800 inches) range, with point of impact 5.3 inches too high on the target, having a front sight blade that is 0.505 inches high mounted in a dovetail.

How much must the front sight blade height be changed by to fix this problem? (It will be assumed that the rear sight is 50 yards from the target.)

D2 = R2(D1/R1) = 26.25(5.3/1800) = 0.077" (magnitude of change to front sight height)

Since the gun is hitting too high, the front sight must be lengthened by this much per the instructions cited previously; hence, the front sight must be replaced with a blade that is 0.505" + 0.077" = 0.582" high. With this correction, the rifle will hit the desired point of impact, all other factors being equal.

Measurement Of Angles

The arcminute is commonly found in the firearms industry and literature, particularly that concerning the accuracy of rifles, though the industry tends to refer to it as **minute of angle**. It is popular because 1 MOA subtends approximately one inch at 100 yards, a traditional distance on target ranges. A shooter can easily readjust his rifle scope by measuring the distance in inches the bullet hole is from the desired impact point, and adjusting the scope that many MOA in the same direction. Most target scopes designed for long distances are adjustable in quarter (¼) or eighth (1/8) MOA "clicks". One eighth MOA is equal to approximately an eighth of an inch at 100 yards or one inch at 800 yards.

Calculating the physical equivalent group size equal to one minute of arc can be done using the equation: equivalent group size = tan(MOA / 60)*distance. In the example previously given and substituting 3600 inches for 100 yards, tan(1 MOA / 60)· 3600 inches = 1.0471975511966 inches.

In metric units 1 MOA at 100 meters = 2.90888208665722 centimeters.

Sometimes, a firearm's accuracy will be measured in MOA. This simply means that under ideal conditions, the gun is capable of repeatedly producing a group of shots whose center points (center-to-center) fit into a circle, the diameter of which can be subtended by that amount of arc. (E.g.: a "1 MOA rifle" should be capable, under ideal conditions, of shooting a 1-inch group at 100 yards, a "2 MOA rifle" a 2-inch group at 100 yards, etc.) Some manufacturers offer actual guarantees of real-world MOA performance.

Rifle manufacturers and gun magazines often refer to this capability as "Sub-MOA", meaning it shoots under 1 MOA. This is typically a single group of 3 to 5 shots at 100 yards, or the average of several groups. If larger samples are taken, i.e. more shots per group, then group size typically increases.

Many telescopic sights used on rifles have reticles that are marked in angular mils, and these are generally called **mil dot scopes**. The mil dots serve two purposes, range estimation and trajectory correction. By determining how many angular mils an object of known size subtends, the distance to that object can be estimated with a fair degree of accuracy. Once the distance is known, the drop of the bullet at that range (see external ballistics), converted back into angular mils, can be used to adjust the aiming point. Generally mil dot scopes have both horizontal and vertical crosshairs marked; the horizontal and vertical marks are used for range estimation and the vertical marks for bullet drop compensation. Skilled shooters, however, can also use the horizontal dots to compensate for bullet drift due to wind. Mil dot scopes are most suited for long shots under uncertain conditions. In such cases, the range to the target is not fixed and shots are taken at extreme ranges, so accurate compensation for bullet drop is required.

The Four Definitions Of The Angular Mil

There are 2000 milliradians (≈ 6283.185 mrad) in a circle. So a milliradian is just over 1/6283 of a circle. Each of the definitions of the angular mil are similar to that value but are easier to divide into many parts.

- 1/6400 of a circle in NATO countries.
- 1/6283 The "real" trigonometric unit of angular measurement of a circle in use by telescopic sight manufacturers using (stadiametric) rangefinding in reticles.
- 1/6000 of a circle in the former Soviet Union and Finland (Finland phasing out the standard in favour of the NATO standard).
- 1/6300 of a circle in Sweden.

Telescopic Sights

A telescopic sight, commonly called a scope, is a device used to give additional accuracy using a point of aim for firearms, airguns and crossbows. Other sighting systems are iron sights, reflex sights, and laser sights.

Scope Types

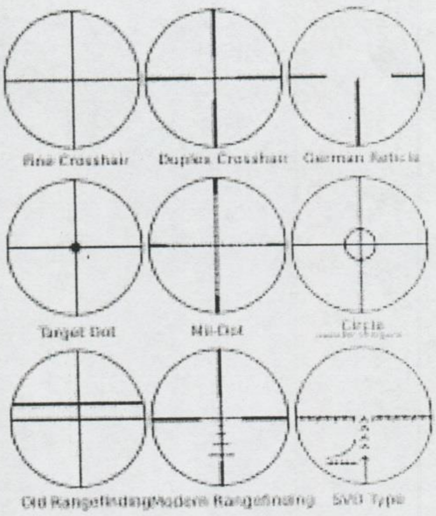
Telescopic sights are classified in terms of the optical magnification and the objective lens diameter, e.g. 10×50. This would denote 10 times magnification with a 50 mm objective lens. In general terms, larger objective lens diameters are better (collect more light and give a wider field of view). On fixed magnification sights the magnification power and objective diameter should be chosen on the basis of the intended use.

There are also telescopic sights with variable magnification. The magnification can be varied by manually operating a zoom mechanism. Variable sights offer more flexibility regarding shooting at varying ranges and targets and offer a relative wide field of view at lower magnification settings. The syntax for variable sights is the following: minimal magnification – maximum magnification × objective lens, for example, 3–9×40.

Confusingly, some older telescopic sights, mainly of German or other European manufacture, have a different classification where the second part of the designation refers to 'light gathering power.' In these cases, a 4×81 (4× magnification) sight would be presumed to have a brighter sight picture than a 2.5×70 (2.5× magnification), but the objective lens diameter would not bear any direct relation to picture brightness, as brightness is affected also by the magnification factor. Typically objective lenses on early sights are smaller than modern sights, in these examples the 4×81 would have an objective approximately 32mm diameter and the 2.5×70 might be approximately 25mm.

Reticles

Telescopic sights come with a variety of different reticles, ranging from the traditional crosshairs to complex reticles designed to allow the shooter to estimate accurately the range to a target, to compensate for the bullet drop, and to compensate for the windage required due to crosswinds. A user can estimate the range to objects of known size, the size of objects at known distances, and even roughly compensate for both bullet drop and wind drifts at known ranges with a reticle-equipped scope.



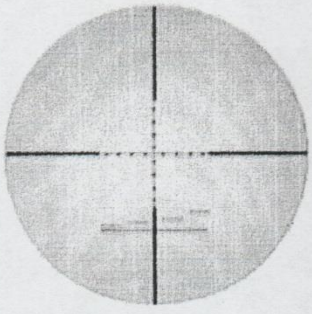
For example, with a typical Leupold brand duplex 16 MOA reticle on a fixed power scope, the distance from post to post (that is, between the heavy lines of the reticle spanning the centre of the scope picture) is approximately 32 inches (81.3 cm) at 200 yards (183 m), or, equivalently, approximately 16 inches (40.65 cm) from the centre to any post at 200 yards. With a known target of a diameter of 16 inches that fills just half of the total distance post-to-post distance, filling from scope centre to post, the distance to target is approximately 200 yards (183 m). With a known target of a diameter of 16 inches that fills the entire sight picture from post to post, the range is approximately 100 yards. Other ranges can be similarly estimated accurately in an analogue fashion for known target sizes through proportionality calculations. Holdover, for estimating vertical point of aim offset required for bullet drop compensation on level terrain, and horizontal windage offset (for estimating side to side point of aim offsets required for wind effect corrections) can similarly be compensated for through using approximations based on the wind speed (from observing flags or other objects) by a trained user through using the reticle marks. The less-commonly used hold under, used for shooting on sloping terrain, can even be estimated by an appropriately-skilled user with a reticle-equipped scope, once the slope of the terrain and the slant range to target are both known.

There are two main types of reticles:

- Wire reticles
- Etched reticles

Wire reticles are the oldest type of reticles and are made out of metal wire. They are mounted in an optically appropriate position in the telescopic sight's tube. Etched reticles are images of the desired reticle layout that are etched on an optic element. This optical element (lens) with the etched reticle is then mounted in the telescopic sights tube as an integrated part of the optics chain of the sight. When backlit through the ocular a wire reticle will reflect incoming light and not present a black contrast reticle. An etched reticle will stay black if backlit. Etched reticles are by most considered to be a more refined solution and offer greater reticle lay out flexibility. Because of this some manufacturers can provide client designed custom reticles on special order. In the more expensive and high end contemporary telescopic sights etched reticles dominate the market. In cheaper telescopic sights wire reticles are still often mounted to avoid a rather specialized and costly production step.

Mil-dot reticles



Perhaps the most flexible ranging reticle is the "Mil-dot" reticle, which consists of duplex crosshairs with small dots at milliradian (mil) intervals in the field of view. A milliradian equates to 3.43774677078493 MOA, that is, approximately 21.6 inches at 600 yards; each MOA equates to 1.0471975511966 inch at 100 yards, often rounded to 1 inch at 100 yards for fast mental calculations.

Users who use the metric system are better off with a Mil-dot reticle, since they do not have to hassle with the unnecessary complications of a non metric system of measurement during mental calculations. Also the Mil-dot measurements and ranging calculations are always exact in the metric system.

A trained user can relatively accurately measure the range to objects of known size, the size of objects at known distances, and compensate for both bullet drop and wind drifts at known ranges with a Mil-dot reticle-equipped scope.

Reticle focal plane

The reticle may be located at the front or rear focal plane First Focal Plane (FFP) or Second Focal Plane (SFP) of the telescopic sight. On fixed power telescopic sights there is no significant difference, but on variable power telescopic sights the front plane reticle remains at a constant size compared to the target, while rear plane reticles remain a constant size to the user as the target image grows and shrinks. Front focal plane reticles are slightly more durable, but most American users prefer that the reticle remains constant as the image changes size, so nearly all modern American variable power telescopic sights are rear focal plane designs. European high end optics manufacturers often leave the customer the choice between a FFP or SFP mounted reticle.

Variable power telescopic sights with front focal plane reticles have no problems with point of impact shifts. Variable power telescopic sights with rear focal plane reticles can have slight point of impact shifts through their magnification range caused by the positioning of the reticle in the mechanical zoom mechanism in the rear part of the telescopic sight. Normally these impact shifts are insignificant but make accuracy oriented users, that wish to use their telescopic sight trouble-free at several magnification levels, often opt for front focal plane reticles. Around the year 2005 Zeiss was the first high end European telescopic sight manufacturer who brought out variable magnification military grade telescopic sight models with rear focal plane mounted reticles. They get around impermissible impact shifts for these sights by laboriously hand adjusting every military grade telescopic sight. The American high end telescopic sight manufacturers also offer variable magnification military grade telescopic sight models with rear focal plane mounted reticles.

Reticle illumination

Either type of reticle can be illuminated for use in low-light or daytime conditions. With any illuminated low-light reticle, it is essential that its brightness can be adjusted. A reticle that is too bright will cause glare in the operator's eye, interfering with his ability to see in low-light conditions. This is because the pupil of the human eye closes quickly upon receiving any source of light. Most illuminated reticles provide adjustable brightness settings to adjust the reticle precisely to the ambient light.

Illumination is usually provided by a battery powered LED, though other electric light sources can be used. The light is projected forward through the scope, and reflects off the back surface of the reticle. Red is the most common colour used, as it least impedes the shooter's night vision. This illumination method can be used to provide both daytime and low-light conditions reticle illumination.

Radioactive isotopes can also be used as a light source, to provide an illuminated reticule for low-light condition aiming. In sights like the SUSAT or Elcan C79 Optical Sight tritium-illuminated reticles are used for low-light condition aiming. Trijicon Corporation uses tritium in their combat and hunting-grade firearm optics, including the ACOG. The (radioactive) tritium light source has to be replaced every 8-12 years, since it gradually loses its brightness due to radioactive decay.

With fibre optics ambient light (daylight) can be collected and directed to an illuminated daytime reticle. Fibre optics reticles automatically interact with the ambient light level that dictates the brightness of the reticle. Trijicon uses fibre optics combined with other low-light conditions illumination methods in their AccuPoint telescopic sights and some of their ACOG sights models.

Parallax compensation

Parallax problems result from the image from the objective not being coincident with the reticle. If the image is not coplanar with the reticle (that is the image of the objective is either in front of or behind the reticle), then putting your eye at different points behind the ocular causes the reticle crosshairs to appear to be at different points on the target. This optical effect causes parallax induced aiming errors that can make a telescopic sight user miss a small target at a distance for which the telescopic sight was not parallax adjusted.

To eliminate parallax induced aiming errors, telescopic sights can be equipped with a parallax compensation mechanism which basically consists of a movable optical element that enables the optical system to project the picture of objects at varying distances and the reticle crosshairs pictures together in exactly the same optical plane. There are two main methods to achieve this.

- By making the objective lens of the telescopic sight adjustable so the telescopic sight can compensate parallax errors. These models are often called AO or A/O models, for adjustable objective.
- By making an internal lens in the internal optical groups mounted somewhere in front of the reticle plane adjustable so the telescopic sight can compensate parallax errors. This method is technically more complicated to build, but generally more liked by parallax adjustable telescopic sight users—unlike AO models, which are read from the top, the sidewheel's setting can be read with minimal movement of the head. These models are often called side focus or sidewheel models.

Most telescopic sights lack parallax compensation because they can perform very acceptably without this refinement. Telescopic sights manufacturers adjust these scopes at a distance that best suits their intended usage. Typical standard factory parallax adjustment distances for hunting telescopic sights are 100 yd or 100 m to make them suited for hunting shots that rarely exceed 300 yd/m. Some target and military style telescopic sights without parallax compensation may be adjusted to be parallax free at ranges up to 300 yd/m to make them better suited for aiming at longer ranges. Scopes for rimfires, shotguns, and muzzleloaders will have shorter parallax settings, commonly 50 yd/m[8] for rimfire scopes and 100 yd/m[for shotguns and muzzleloaders. Scopes for airguns are very often found with adjustable parallax, usually in the form of an adjustable objective, or AO. These may adjust down as far as 3 yards (2.74 m).

The reason why scopes intended for short range use are often equipped with parallax compensation is that at short range (and at high magnification) parallax errors become more noticeable. A typical scope objective has a focal length of 100 mm. An optical ideal 10x scope in this example has been perfectly parallax corrected at 1000 m and functions flawlessly at that distance. If the same scope is used at 100 m the target-picture would be projected (1000 m / 100

m) / 100 mm = 0.1 mm behind the reticle plain. At 10x magnification the error would be 10 * 0.1 mm = 1 mm at the ocular. If the same scope was used at 10 m the target-picture would be (1000 m / 10 m) / 100 mm = 1 mm projected behind the reticle plain. When 10x magnified the error would be 10 mm at the ocular.

Bullet Drop Compensation

Bullet Drop Compensation (BDC) (sometimes referred to as ballistic elevation) is a feature available on some rifle scopes. The feature compensates for the effect of gravity on the bullet at given distances (referred to as "bullet drop"). The feature must be tuned for the particular ballistic trajectory of a particular combination of rifle and cartridge at a predefined air density. Inevitable BDC induced errors will occur if the environmental and meteorological circumstances deviate from the circumstances the BDC was calibrated for. Marksmen can be trained to compensate for these errors.

Adjustment controls

A telescopic sight can have several adjustment controls.

- Focusing control at the ocular end of the sight - meant to obtain a sharp picture of the object and reticle.
- Elevation or vertical adjustment control of the reticle.
- Windage or horizontal adjustment control of the reticle.
- Magnification control - meant to change the magnification by turning a ring that is generally marked with several magnification power levels.
- Illumination adjustment control of the reticule - meant to regulate the brightness level of the lit parts of the reticles crosshairs.
- Parallax compensation control.

Most contemporary telescopic sights offer the first three adjustment controls. The other three are found on telescopic sights that offer a variable magnification, an illuminated reticle and/or parallax compensation. A rather common problem with the elevation and windage adjustment controls is that once smooth working adjustment turrets 'get stuck' over the years. This is generally caused by long time lack of movement in the lubricated turret mechanisms.

Older telescopic sights often did not offer windage and elevation adjustments in the scope, but rather used adjustable mounts to provide adjustment. Some modern mounts also allow for adjustment, but it is generally intended to supplement the scope adjustments. For example, some situations require fairly extreme elevation adjustments, such as very short range shooting common with airguns, or very long range shooting, where the bullet drop becomes very significant. In this case, rather than adjusting the scope to the extremes of its elevation adjustment, the scope mount can be adjusted. This allows the scope to operate near the centre of its adjustment range. Some companies offer adjustable bases, while others offer bases with a given amount of elevation built in. The adjustable bases are more flexible, but the fixed bases are more durable, as adjustable bases may loosen and shift under recoil

Telescopic Sights

If the scope has an eyepiece with a lock ring the shooter needs to adjust the focus of the reticle before fitting the scope on the rifle. To do this:

Unscrew the eyepiece away from the lock ring.

Look through the scope from a distance of about 3" to 4" when it is pointed at the sky (do NOT point it at the sun) and take a few quick glances at the reticle which should appear sharp and clear.

If the reticle is not clear, farsighted people should turn the eyepiece anticlockwise three or four turns while nearsighted people need to turn the eyepiece clockwise three or four turns.

This process should be repeated until the reticle is clear and sharp.

Once the adjustment is correct, the lock ring should be locked against the eyepiece.

Eye Relief

With the scope as far forward in the mounts as possible, the rifle should be held in the normal shooting position. With variable power scopes, the highest magnification should be set.

The scope should then be moved to the rear until a full field of view can be seen, at which point the scope mounts should be locked.

Parallax

This is the apparent movement of the target relative to the recticle when the eye is moved away from the centre point of the eyepiece. It will occur when the target does not fall on the same optical plane as the reticle. At short distances, parallax effect does not affect the accuracy and, at long range, parallax will have little effe3ct when sighting straight through the middle of the scope. Most higher power scopes (x12 or more) have parallax adjustment either at the objective end of the scope or on the side of the scope. The adjustment moves a lens within the scope causing the image and recticle to fall in the same optical plane, ensuring optimal accuracy at the distance of the target.

To eliminate parallax in adjustable scopes the following procedure should be used.

The reticle should be focussed before adjustment.

Determine the distance to the target.

Turn the focus adjustment to match the number to the distance (usually in yards) to the target.

With the rifle in a stable, supported position, look through the scope.

Move your head slightly up and down.

The aiming point should remain in exactly the same position against the target.

If the aiming point does move, adjust the focus slightly then repeat until the aiming point does not move.

Checking Scope And Mounts

The method known as "completing the square" can be used to check where the optics, reticle adjustment or mounts are suspect.

On the range, set the sights for the centre of the target.

Fire one shot.

Adjust the sights ten minutes to the right.

Fire one shot.

Adjust the sights ten minutes down.

Fire one shot.

Adjust the sights ten minutes left.

Fire one shot.

Adjust the sights ten minutes up.

Fire one shot.

Ideally, the last shot should be superimposed on the position of the first shot.

Reflex Sights

These use refractive or reflective optical collimators to generate a collimated image of a luminous or reflective reticle. The collimated image is reflected off a beam splitter to allow the viewer to see the field of view and a reflection of the projected reticle (often a red dot) simultaneously. If no magnification is utilised, this gives the viewer a theoretically parallax free image of the reticle superimposed over the field of view at infinity.

A reflex sight with no magnification can be held at any distance from the eye and at almost any angle without distorting the image of the target or reticle, and without causing the reticle to move relative to the target. However, parallax compensation is not perfect and, depending on the sight's design, the range to the target, and the magnitude of angle at which it is looked into, aiming error can be experienced. Magnified reflex sights do suffer from parallax and fixed eye relief in the same way as with telescope sights.

Because reflex sights provide an illuminated reticle, they are often used with both eyes open giving the shooter normal depth perception and full field of view.

Reticles

Sights using dot reticles are almost invariably measured in minutes of angle. One of the most common reticles used in red dot sights is a small dot covering 5 moa (or 1.5 mil) and illuminated by a red LED, hence the term red dot sight. This dot is small enough not to obscure most targets, and large enough to quickly acquire a proper sight picture.

In some forms of action shooting, a larger dot is preferred, with 7 moa (2.0 mil), 10 moa (2.9 mil), 15 moa (4.4 mil) and 20 moa (5.8 mil) to be found. These dots will also be combined with horizontal and/or vertical lines providing a level.

Reticle shapes are not limited to dots. Some reflex sights use a chevron or triangular pattern instead, and others may provide selectable patterns, all to assist precision aiming and range estimation.

BORESIGHTING

Boresighting aligns the optical sight on top of the gun barrel with the axis of the bore, and should be the first priority after mounting the scope. This ensures that your first shot will be on a large piece of target paper at a distance of about fifty yards. Boresighting not only provides a reference point from which to actually start sighting in the gun, but saves time and ammunition expense.

Bore sighting will NOT sight in a gun. This must be done by firing a specific type of ammunition at a certain distance.

Boresighting is done by several different methods.

The oldest way is to remove the bolt on a bolt action rifle and look down the bore. Secure the gun so it does not move, and position it so that when looking through the bore, the bullseye of a target about fifty yards away can be seen. Now look through the scope, and without moving the gun, carefully adjust the elevation and windage turrets until the reticle is centered on the bullseye. Simple at that. You are sighted through the bore, or "bore sighted." Of course, this is not possible with many guns such as semi-autos, pumps, lever guns, and most handguns.

The next oldest way to boresight is with a collimator and arbors. Arbors are sometimes called spuds. A collimator is a device with a graph-paper-like grid in it that is seen when looking through your scope. It is held in place by arbors inserted into your barrel from the muzzle end. They are sized for your caliber, and held in place by a spring or an expanding plug. The user then looks through his scope and adjusts the windage and elevation turrets so the crosshair is centered on the grid you see. The spuds must be sized accordingly, and although many collimating boresights come with several arbors, some calibers such as .17, or shotgun gauges require their own sizes and may not be available.

Another way to boresight, and the most convenient way, is to use a magnetic boresighter. These simply attach to your muzzle with strong magnets instead of inserting arbors into your barrel. Some people frown upon inserting anything into their barrels besides a cleaning rod. Magnetic bore sighters fit all calibers and gauges, and no other parts are required that can get lost or damaged. Magnetic boresighters can also be used to check zero after transporting your guns, or after a drop or hard use. To do this, sight in your gun by attaching the magnetic boresighter, look through the scope and see where your crosshairs end up on your boresighter's grid. Remember the placement or write it down to check zero any time.

The third and final way to boresight is with laser boresighters. Some of these project a laser beam from an arbor or spud inserted into your muzzle, and some have the dimensions of a specific cartridge case that you simply insert into your gun's chamber and close the action. Laser bore sighters do require a somewhat reflective target set some distance away to reflect your laser beam, and a steady hold or a gun vice to more easily center the scope's crosshairs onto the laser's dot.

Points to remember when you are about to use a bore sight:

- No boresighter will zero the sights in a gun. This can only be done by shooting the gun with a specific type of ammo at a certain distance. Every different kind of ammo will have a different point of impact.
- Remember to remove your boresight arbor before shooting.
- Boresighting alerts you immediately to problems with mounting and scope adjustments saving time and ammunition expense.

SCOPE ADJUSTMENT CHART IN MOA		
NOTES:		
CARTRIDGE: .223 REMINGTON (5.56MM NATO)		
BULLET: 55-GRAIN BOATTAIL SPITZER		
VELOCITY: 3,200 FPS		
RANGE	+ ELEV -	10 mph
IN YARDS	IN MINUTES	L WIND R
100	0.0	1.0
200	+1.5	2.5
300	+4.0	3.75
350	+5.5	4.5
400	+7.0	5.5
450	+9.0	6.5
500	+11.25	7.5
550	+13.75	8.75
600	+16.5	10.0
650	+19.75	11.25
700	+23.25	12.5

SCOPE ADJUSTMENT CHART IN MOA		
NOTES: AR-15 1-IN-9 TWIST		
CARTRIDGE: .223 REMINGTON (5.56MM NATO)		
BULLET: 69-GRAIN BOATTAIL HOLLOWPOINT		
VELOCITY: 2,850 FPS		
RANGE	+ ELEV -	10 mph
IN YARDS	IN MINUTES	L WIND R
100	0.0	2.25
200	+.75	3.25
300	+3.25	3.5
350	+9.75	4.25
400	+6.75	5.0
450	+8.5	5.75
500	+11.0	6.5
550	+13.25	7.5
600	+16.0	8.25
650	+19.0	9.25
700	+22.25	10.25
750	+26.0	11.25
800	+30.0	12.5

SCOPE ADJUSTMENT CHART IN MOA		
NOTES:		
CARTRIDGE: .223 REMINGTON (5.56MM NATO)		
BULLET: 52-GRAIN BOATTAIL HOLLOWPOINT		
VELOCITY: 3,300 FPS		
RANGE	**+ ELEV -**	**10 mph**
IN YARDS	**IN MINUTES**	**L WIND R**
100	0.0	1.25
200	+1.5	2.5
300	+3.75	4.25
350	+5.25	5.0
400	+7.0	6.0
450	+9.0	7.25
500	+11.5	8.5
550	+14.0	9.75
600	+17.25	11.25

SCOPE ADJUSTMENT CHART IN MOA		
NOTES: AR-15		
CARTRIDGE: .223 REMINGTON (5.56MM NATO)		
BULLET: 55-GRAIN FMJ BOATTAIL		
VELOCITY: 3,000 FPS		
RANGE	**+ ELEV -**	**10 mph**
IN YARDS	**IN MINUTES**	**L WIND R**
100	0.0	1.0
200	+2.5	2.5
300	+3.0	4.25
350	+4.75	5.25
400	+6.75	6.25
450	+9.0	7.5
500	+11.5	8.5
550	+14.5	9.75
600	+17.75	11.0

SCOPE ADJUSTMENT CHART IN MOA		
NOTES:		
CARTRIDGE: 7.62MM NATO (.308 WINCHESTER)		
BULLET: 147-GRAIN FMJ BOATTAIL		
VELOCITY: 2,820 FPS		
RANGE	+ ELEV -	10 mph
IN YARDS	IN MINUTES	L WIND R
100	0.0	.75
200	+1.75	1.5
300	+4.25	2.5
350	+6.0	3.0
400	+7.5	3.5
450	+9.25	4.0
500	+11.25	4.5
550	+13.25	5.0
600	+15.25	5.75
650	+17.5	6.25
700	+20.0	7.0
750	+22.5	7.5
800	+25.5	8.5
850	+28.5	9.0
900	+31.75	9.75
950	+35.25	10.5
1,000	+39.25	11.5

SCOPE ADJUSTMENT CHART IN MOA		
NOTES:		
CARTRIDGE: 7.62MM NATO (.308 WINCHESTER)		
BULLET: 155-GRAIN BOATTAIL HOLLOWPOINT		
VELOCITY: 2,800 FPS		
RANGE	+ ELEV -	10 mph
IN YARDS	IN MINUTES	L WIND R
100	0.0	.75
200	+1.75	1.5
300	+4.5	2.25
350	+6.0	2.75
400	+7.5	3.25
450	+9.25	3.75
500	+11.0	4.25
550	+13.0	4.75
600	+15.0	5.25
650	+17.25	6.0
700	+19.5	6.5
750	+22.25	7.25
800	+25.0	7.75
850	+27.75	8.5
900	+31.0	9.25
950	+34.5	10.0

SCOPE ADJUSTMENT CHART IN MOA		
NOTES:		
CARTRIDGE: .303 BRITISH		
BULLET: 174-GRAIN BOATTAIL HOLLOWPOINT		
VELOCITY: 2,460 FPS		
RANGE	+ ELEV -	10 mph
IN YARDS	IN MINUTES	L WIND R
100	0.0	.75
200	+2.25	1.5
300	+5.5	2.5
350	+7.5	3.0
400	+9.5	3.5
450	+11.5	4.0
500	+14.0	4.5
550	+16.25	5.0
600	+19.0	5.5
650	+21.75	6.25
700	+24.5	6.75
750	+27.75	7.5
800	+31.25	8.25
850	+34.75	9.0
900	+38.75	9.5
950	+42.5	10.25
1,000	+46.5	11.0

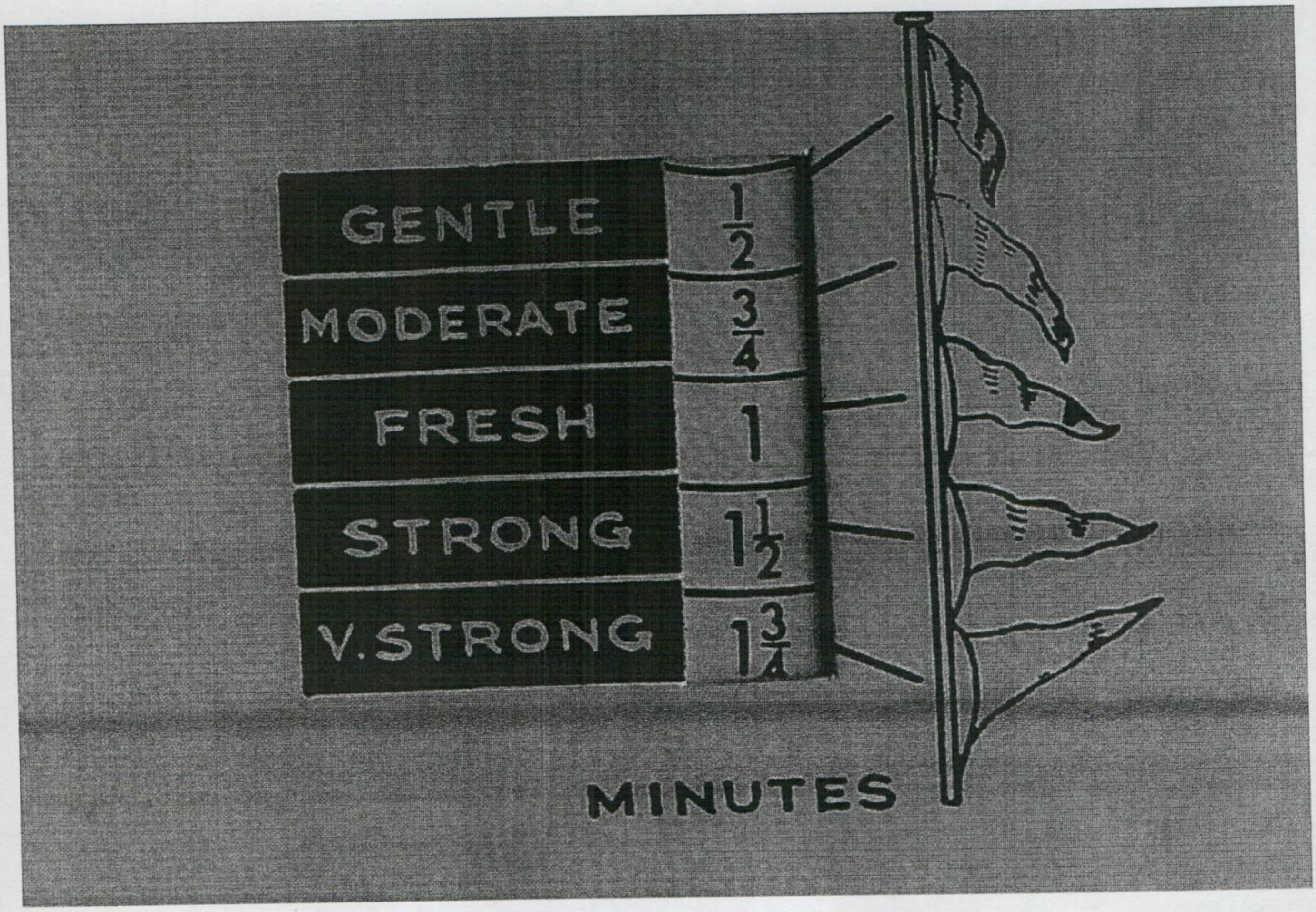
SCOPE ADJUSTMENT CHART IN MOA		
NOTES:		
CARTRIDGE: 8MM X 57 MAUSER		
BULLET: 175-GRAIN SPITZER		
VELOCITY: 2,600 FPS		
RANGE	+ ELEV -	10 mph
IN YARDS	IN MINUTES	L WIND R
100	0.0	1.0
200	+2.25	2.0
300	+5.5	3.0
350	+7.5	3.75
400	+9.5	4.5
450	+11.75	5.0
500	+14.25	5.75
550	+16.75	6.5
600	+19.5	7.25
650	+22.5	8.25
700	+25.75	9.0
750	+29.5	10.0
800	+33.5	10.75
850	+37.5	11.75
900	+42.25	12.5
950	+47.0	13.5
1,000	+52.25	14.5

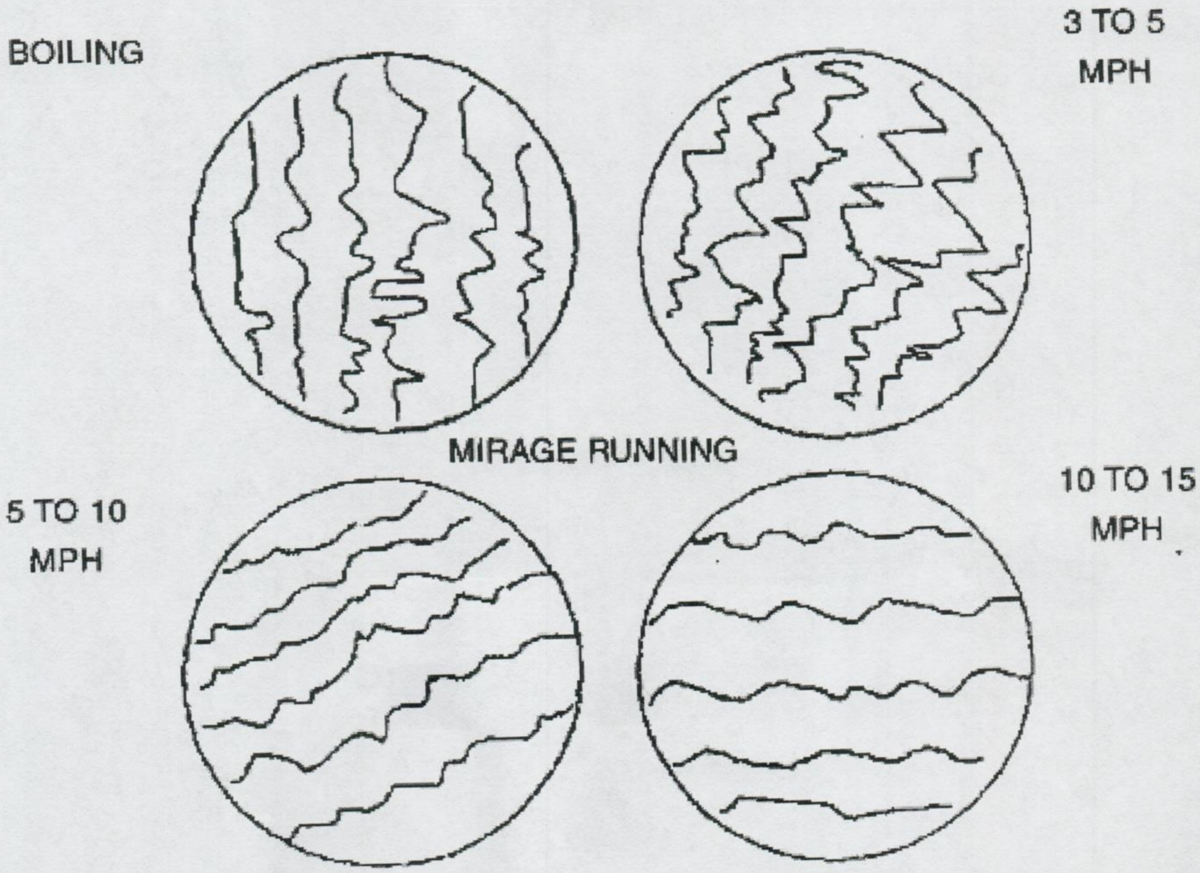
NRA RADIO CODE MESSAGES

Message	1	Firing about to commence.
"	2	No spotting disc visible.
"	3	Spotting disc unmistakably disagrees with signalled value. Check that the spotting disc shows LAST shot and signal its correct value*. Range Conducting Officer is to view target before passing message.
"	4	A shot has been fired but no signal has been made. Examine target carefully and signal the shot if found or a miss*.
"	5	Firer has challenged for a higher value for his shot. Examine the whole target and signal correct value*.
"	6	Radio the number of hits as Score Board figures are not clear (SR and Cadets only).
"	7	A miss has been signalled but Firer has challenged for a scoring shot. Re-examine the target carefully and signal the hit if found or a miss*.
"	8	Firer has challenged his score. Re-examine the target and radio the correct number and value of shots*.
"	9	Marking/shooting appears to be unduly slow. Butt/ Range Conducting Officer to check and correct where necessary.
"	10	Stand easy. Half-mast target.
"	11	It is suspected that the wrong shot hole has been patched out. Butt Officer is to consult marker and confirm correct value*†.
"	12	Stand easy. Lower target, patch out and put target back up.
"	13	Blow off shots are about to be fired (MR only). Ensure that all targets are fully lowered until Message 1 is given.
"	14	It is suspected that there is a second shot on the target: inspect the target and indicate any further shot found in addition to the shot presently shown.*

* The result must also be confirmed by radio.

† This message may only be sent after Message 4 or Message 7 has been sent.

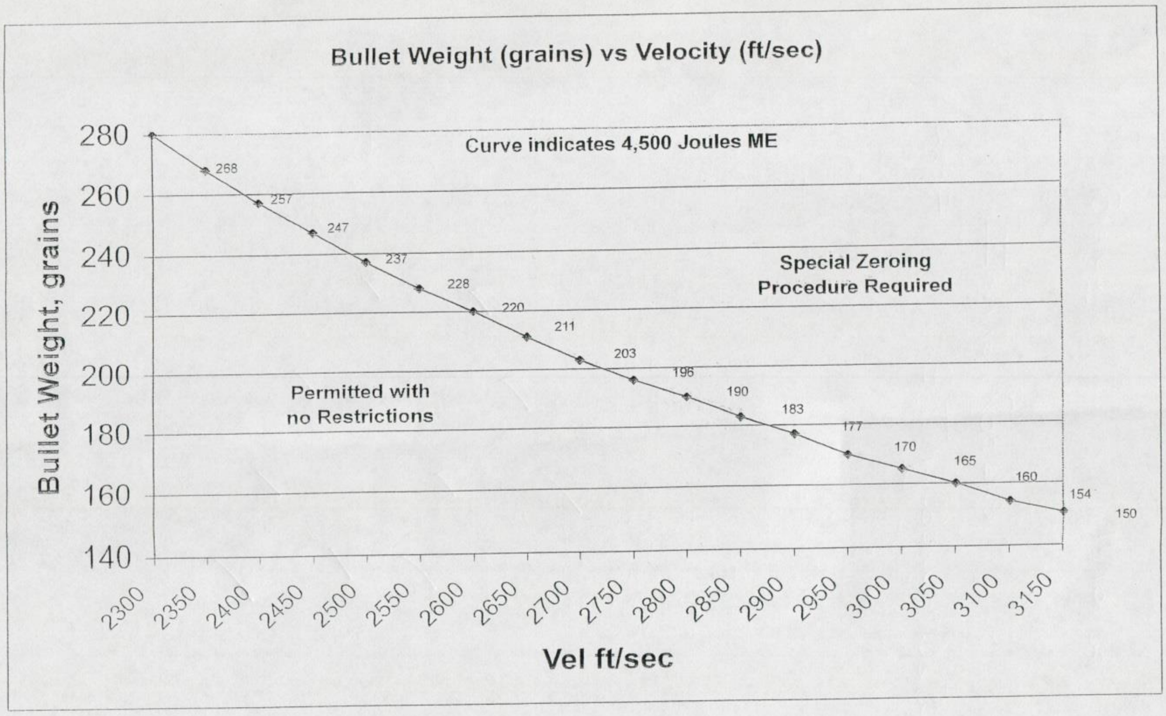

GENTLE
1/2
MODERATE
3/4
FRESH
1
STRONG
1 1/2
V. STRONG
1 3/4
MINUTES


BOILING
3 TO 5
MPH
MIRAGE RUNNING
5 TO 10
MPH
10 TO 15
MPH

FOR 7.62 mm. RIFLES
(NATO 7.62 mm. CARTRIDGE)

ELEVATION TABLE
FOR APERTURE SIGHT USERS (7.62)

Rise From	To 300	400	500	600	700	800	900	1000
200	2½	5½	9	13	17½	23	29	36½
300	—	3	6½	10½	15	20½	26½	34
400	—	—	3½	7½	12	17½	23½	31
500	—	—	—	4	8½	14	20	27½
600	—	—	—	—	4½	10	16	23½
700	—	—	—	—	—	5½	11½	19
800	—	—	—	—	—	—	6	13½
900	—	—	—	—	—	—	—	7½



Bullet Weight (grains) vs Velocity (ft/sec)
Curve indicates 4,500 Joules ME
Special Zeroing
Procedure Required
Permitted with
no Restrictions
Bullet Weight, grains
280
260
240
220
200
180
160
140
268
257
247
237
228
220
211
203
196
190
183
177
170
165
160
154
150
2300
2350
2400
2450
2500
2550
2600
2650
2700
2750
2800
2850
2900
2950
3000
3050
3100
3150
Vel ft/sec