MCTP 3-01C

Machine Guns and Machine Gun Gunnery

U.S. Marine Corps

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UNITED STATES MARINE CORPS

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FOREWORD

Marine Corps Tactical Publication (MCTP) 3-01C, *Machine Guns and Machine Gun Gunnery,* supports tactics, techniques, and procedures for employing machine guns in support of Marine Corps units. It describes how various machine guns are maintained and employed by Marine Corps machine gun crews and provides principles and techniques for their use when engaging and destroying enemy targets.

MCTP 3-01C is designed to educate Marines on machine gun employment, theory, advanced techniques and tactics, and training. This publication is intended to be used as a reference by units employing machine guns, regardless of unit type. It outlines a standardized way to train Marine machine gunners through the use of gunnery tables.

This publication supersedes MCTP 3-01C, *Machine Guns and Machine Gun Gunnery*, dated 2 May 2016.

Reviewed and approved this date.

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Chapter 1. Fundamentals

Machine guns are fully automatic weapons capable of rapid, sustained fire. They are belt-fed and crew-served, have quick-change barrels to provide sustained firing, and can be employed from the bipod, tripod, or vehicle mount.

Classifications of Machine Guns

Machine gun types are classified as light, medium, or heavy, which is determined by a combination of weapon characteristics that includes caliber, weight, crew size, and type of intended employment.

Light Machine Gun

Light machine gun classification generally includes .22- to .250 caliber (i.e., 5.45 mm to 6 mm) automatic weapons. The light machine gun has the following characteristics:

- Weight is typically between 15 and 30 pounds complete, and is manned by either one or two individuals, depending on the accessories being used. If manned by one person, the tripod and spare barrel are typically not used.
- Bullets usually weigh between 45 and 72 grains.

Although the Marine Corps has traditionally used the M249 light machine gun as an automatic rifle for fire and movement and close quarters battle, it is not as effective as an automatic rifle, and its roles should be limited to support by fire (SBF) during an adjacent unit's movement/maneuver.

Another example of a light caliber machine gun is the 5.56 mm North Atlantic Treaty Organization (NATO).

Medium Machine Gun

Medium machine gun classification generally includes .264 to .33 caliber (i.e., 6.5 mm to 8 mm) automatic weapons. The medium machine gun has the following characteristics:

- Weight is approximately 25 pounds or more by itself. Remaining ammunition, ground tripod, spare barrel, and other accessories can add another 25 pounds or more to the overall weight of medium machine gun systems. This requires a standard crew of three: a gunner, a team leader/assistant gunner, and an ammunition bearer.
- Bullets weigh between 140 and 220 grains, with the most popular calibers being 7.62 x 51 mm NATO or 7.62 x 54R Russian.
- Used against personnel and light materials, such as light-skinned vehicles.

The Marine Corps employs several variants of the M240 medium machine gun for both vehicle and ground use. The infantry typically uses the M240B in a supporting role for the maneuver elements of a rifle company, while the M240 and M240E1 are employed from tanks, amphibious assault vehicles, and light armored vehicles.

Another example of a medium caliber machine gun is the 7.62 mm NATO (e.g., .308 Winchester).

Heavy Machine Gun

Heavy machine gun (HMG) classification usually includes .50 caliber or larger (i.e., 12.7 mm to 21 mm) automatic weapons. Detailed planning must be done to move heavy weapon systems without the use of vehicles or pack animals. The HMG has the following characteristics:

- Weight without ammunition can be more than 125 pounds.
- Bullets weigh 700 grains or more.
- Manned by a crew of four or more; however, it can be three if a motor vehicle or draft animal transportation is available.
- Primarily employed against field fortifications and vehicles.

Typically, the HMG is used in a mounted or crew-served supporting role and is capable of defeating armored vehicles, such as armored personnel carriers (APCs) or infantry fighting vehicles (IFVs). The HMG currently employed by the Marine Corps is the M2A1 Browning .50 caliber.

The grenade machine gun—a type of HMG—is an automatic weapon that fires an explosive grenade projectile. It does not typically require a quick-change barrel because of its slow rate of fire and the nature of its ammunition. The grenade machine gun has the following characteristics:

- Usually belt-fed, it is designed to operate from an open-bolt position and typically manned by a crew of three or four because of its heavy ammunition.
- A projectile that is usually 30 mm to 40 mm.
- A relatively low muzzle velocity.

The grenade machine gun currently employed by the Marine Corps is the 40 mm MK-19. Heavy machine guns such as the .50 caliber Browning machine gun and 40 mm grenade.

> *NOTE:* The term “cannon” is typically applied to any gun firing a projectile larger than .80 caliber (i.e., 20 mm), so most automatic guns smaller than this are typically referred to as machine guns. However, this term is not applicable to the 40 mm grenade machine gun.

Automatic Rifles

The automatic rifle is not a machine gun. It is an automatic weapon that features a fixed barrel, fires from a detachable box magazine, and is designed for short-term missions against point targets. The automatic rifle is incapable of sustained automatic fire because it lacks a quick-change barrel and may be subject to overheating during sustained firing. It usually fires a projectile in the light- to mid cal range, such as 5.56 x 45 mm NATO or 7.62 x 39 mm Soviet. It is effective at a range of 500 to 600 meters.

The automatic rifle is manned by a single automatic rifleman. During an infantry squad's last 100 meters of an assault, the automatic rifleman searches to direct fire toward enemy machine gun positions, concentrations of enemy personnel, or dead space where the enemy could gather. The automatic rifleman must take care to prevent a hot barrel because it could cause a malfunction, force a cease fire, or cause the weapon system to cook off.

TYPES OF MACHINE GUN OPERATION

Machine guns operate by gas, recoil, or blowback operations.

> *NOTE:* For a description of the assembly, disassembly, operation, malfunctions, and maintenance, refer to the associated machine gun technical manual.

Gas Operation

Gas operation is an automatic weapon design in which the cycle of functioning is driven by diverting some of the exhaust gases that result from the burning of the propellant charge into a gas cylinder to drive a piston. The piston is connected mechanically to the bolt that moves rearward under the pressure of the exhaust gases, extracts and ejects the empty casing, and chambers a new round. The M249 and M240B are both gas operated.

Recoil Operation

Recoil operation is an automatic weapon design in which the cycle of functioning is driven by the recoil force resulting from firing a round. As the propellant gases push the projectile down the bore, they exert an equal amount of force forward (on the projectile) and rearward (on the barrel and bolt, since they are initially locked together). The barrel recoils under this force, initiating the cycle of functioning by allowing the bolt to unlock only after bore pressure has dropped enough to allow the action to open without rupturing the case. The bolt then continues rearward, independent of the barrel, in order to extract and eject the empty casing and chamber a new round. Recoil operation differs from blowback in that the barrel is one of the recoiling parts and the bolt is locked to the barrel during a portion of the recoil phase of the cycle of functioning. There are two types of recoil operation: short and long.

Short Recoil. A short recoil operation is characterized by recoil movement—the bolt remains locked to the barrel for only a portion of the recoil phase of the cycle of functioning. The barrel will stop after a short distance and the bolt will continue to recoil under the force of its initial momentum, which is augmented by an accelerator. The M2A1 is a short recoil-operated machine gun.

Long Recoil. A long recoil operation is characterized by recoil movement of the operating parts that is greater than the overall length of the complete cartridge. During this entire movement, the bolt remains locked to the barrel.

Blowback Operation

A blowback operation is an automatic weapon design in which the cycle of functioning is driven by the force that results from the motion of the cartridge case as it is pushed rearward out of the chamber by the pressure that is created from the explosion of the propellant charge. There is no mechanical locking of the bolt in a blowback operation. Instead, the bolt is made heavier to compensate for the momentum that is placed on it, which is equal to that placed on the projectile. Blowback operation differs from recoil operation in that the energy that drives back the bolt in blowback operation is derived solely from the explosion of the propellant charge and not the recoiling of the barrel. It differs from gas operation because it does not divert exhaust gases from the barrel to drive the cycle of functioning. There are three different types of blowback operation: plain, advanced primer ignition, and delayed.

Plain Blowback. During a plain blowback operation, the bolt is sent rearward at the instant of firing with the same momentum as that imparted to the projectile from the expansion of the propellant gases. Therefore, the bolt must be extremely heavy in relation to the size of the machine gun, which makes this type of operation impractical.

Advanced Primer Ignition Blowback. During an advanced primer ignition blowback operation, the bolt is sent forward to chamber a round. Before the bolt moves fully into battery, the primer is ignited, which allows a portion of the energy from the propellant gases not being used to force the projectile down the bore to be spent in stopping the bolt. The remaining energy is spent sending the bolt to the rear, which allows the weight of the bolt to be reduced by more than half when compared with a plain blowback system. This type of operation can only be attained with an open-bolt firing mechanism. The MK-19 is an advanced primer ignition, blowback-operated grenade machine gun.

Delayed Blowback. During a delayed blowback, the bolt is temporarily locked to the barrel until after the projectile leaves the muzzle, which allows the bore pressure to subside to a manageable level. The bolt is then unlocked to allow the residual pressure to drive the cycle of functioning. Delayed blowback requires the use of either partial gas operation or partial recoil operation to unlock the bolt. The nature of a delayed blowback system results in a lighter bolt with a high recoil velocity that produces a relatively high rate of fire.

CHARACTERISTICS OF MACHINE GUN FIRE

The machine gunner's education of the theory of machine gun fire begins with the action and effect of the projectiles when fired. The following subparagraphs discuss terms that are used to define characteristics of machine gun fire.

> *NOTE:* Specific information about a particular action of each machine gun's projectile is contained in the ammunition section of that gun's respective technical manual.

Trajectory

The term, *trajectory*, refers to the flight path of a projectile, which is a vertically curved path taken by a bullet after it leaves the barrel of a gun. The farther the bullet travels, the greater the curvature of this path. A projectile's trajectory is influenced by the following factors:

- Weight, velocity, and rotation of the bullet.
- Gravity of the earth.
- Resistance of the air.
- Variations in ammunition.

It is necessary to elevate the bore above a straight line from the muzzle of the gun to the target in order to overcome the influence of these factors. The amount of elevation for any given range is provided by graduations on the rear sight of the machine gun or through specific reference points and holds in an optic. Because of the elevation of the axis of the bore, the projectile does not travel in a straight line to the target when it leaves the muzzle. It first travels along the axis of the bore, which causes it to rise above the line of sight (LOS). Then, under the influence of gravity and air resistance, the projectile begins to fall, following a curved path until it intersects the LOS again at the target.

Bullet Drift. As a projectile leaves the muzzle of a gun, it rotates at a rate that is caused by the rifling. This rotation of the projectile furnishes stability as it travels along the flight path and gives the projectile greater accuracy than if it was not spinning. Since the axis of the bore starts the projectile off in a straight line (when visualized from above its trajectory) and the rifling imparts a stabilizing spin on it, the projectile will have very little left or right deviation from the axis of the bore at close range. At a longer range, the clockwise spin of the projectile will cause it to drift to the right.

Bullet Drop. As a projectile travels down the barrel, the axis of the bore causes it to follow a straight line (when visualized from the side). However, as soon as the projectile leaves the muzzle, the force of gravity causes it to drop. The amount of drop at a given distance from the muzzle is directly related to the bullet's time of flight (TOF) to that point; TOF is a factor of retained velocity at any given range. Since the projectile begins to drop as soon as it leaves the muzzle, the trajectory that it follows becomes more curved as its range increases and its velocity decreases due to air resistance. Because the bullet immediately drops below the axis of the bore, the sights on a machine gun must be situated at an angle to the axis of the bore so that the bore is actually tilted upward. This will cause the projectile to rise above the LOS, which is the straight line that intersects the rear sight, front sight, and target, as it leaves the muzzle.

Maximum Ordinate. The maximum ordinate, also referred to as *max ord*, is the highest point above the LOS that the projectile will reach in its trajectory. The maximum ordinate will depend on both the distance to the target and angle of elevation of the bore (see Figure 1-1). Maximum ordinate is important because it determines the amount of grazing fire and danger space that the gun will produce at any given range. The projectile of any given weapon will reach its maximum ordinate at approximately one-half to two-thirds of the distance to the target (i.e., half the distance at shorter range and two-thirds the distance at longer range). As the range to the target increases, so does the height of the maximum ordinate and the relative distance at which it occurs.

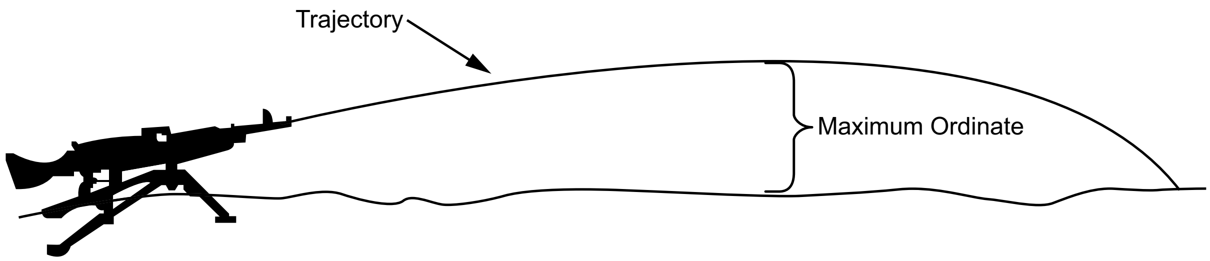


Figure 1-1. Trajectory and Maximum Ordinate.

Range

Range refers to the distance that a projectile will travel, depending upon the elevation of the gun's barrel and the effects of the environment. Range is important because it determines the distance that a machine gunner can employ their weapon. Range also has a direct relation to fire penetration. The four types of ranges important to the machine gunner are battlesight range, maximum range, maximum effective range, and maximum usable range.

Battlesight Range. The battlesight range is a setting for an optic or mechanical sight to allow effective engagement from zero out to the determined range without changing the hold or sights. This range is based on the trajectory of the round. Each battlesight range is determined by the maximum distance that the trajectory of the bullet remains within the vertical target area. This allows for minimal change in the bullet drop; therefore, the projectile will still be effective on targets at a closer range without changing the sight settings. Table 1-1 shows the battlesight ranges for the common types and classifications of machine guns.

Table 1-1. Battlesight Ranges.

Machine Gun	Type	Battlesight Range
Light	M249	300 m
Medium	M240B	500 m
Heavy	M2A1	600 m
Grenade	MK-19	200 yds (because of the high-angle trajectory of the 40 mm warhead)

Maximum Range. Maximum range is the maximum distance that a bullet will travel, given the optimal angle of elevation of the bore and ideal atmospheric conditions.

Maximum Effective Range. Maximum effective range is the distance a weapon system is capable of delivering a projectile in order to achieve desired effects on a target. Desired effects consider the mission, the target medium, the munition, the range, and the ability to observe the effects. The maximum range of a weapon is typically dependent on the limits of the affixed sights. Weapons like the HMG are capable of increased effective range through advanced aiming techniques and optics.

Maximum Usable Range. Maximum usable range is the amount of distance that is visible to either the leader or the gunner, based upon terrain and vegetation, but still within the maximum effective range of the machine gun. Maximum usable range only applies when the gun is employed in direct lay because the addition of an observer can increase the gun's usable range to its maximum extent.

Penetration

Penetration refers to the amount of any given target material through which a projectile will travel upon impact. The most important penetration information for machine gunners is projectiles through human, a human with body armor, and armored targets (see Tables 1-2 and 1-3).

Table 1-2. Heavy and Grenade Machine Gun Armored Target Penetration.

Machine Gun	Projectile	Armor Penetration (m)
Heavy	M2, ball, MMG3	8 mm (.315 in) at 500 m
	M2, API, M8	19 mm (.75 in) at 600 m
	M2, SLAP, M903	19 mm (.75 in) at 1,600 m
Grenade	MK-19, HEDP M430	50.8 mm (2 in) at 0 to 45° obliquity
	MK-19, HEDP M430A1	76.2 mm (3 in) at 0 to 45° obliquity

Table 1-3. Light and Medium Machine Gun Armored Target Penetration.

Machine Gun	Projectile	Armor Penetration (3/8-inch mild steel)	Armor Penetration (3/8-inch RHA steel)	Concrete
Light	M885, ball	200 m	0	0
	M885A1, ball	510 m	15 m	100 m
	M995, AP	380 m	280 m	170 m
Medium	M80, ball	170 m	45 m	45 m
	M80A1, ball	565 m	200 m	640 m
	M993, AP	540 m	470 m	530 m
LEGEND				
RHA rolled homogeneous armor				

Human Targets. The effects of a projectile against a human target are expressed in terms of tissue destruction (i.e., permanent cavity) and tissue displacement (i.e., temporary cavity) caused by penetration and fragmentation. When a projectile strikes a human, its degree of penetration depends on its velocity at impact, intervening material (e.g., clothing, body armor), and the composition of the target (i.e., how much flesh and bone that has to be penetrated).

When a projectile penetrates flesh, it leaves a permanent wound (known as a permanent cavity) that results from the tearing and crushing action of the projectile as it passes through the tissue. Additionally, the increased pressure and movement of the natural fluid (i.e., water) within the tissue, caused by the movement of the bullet through the tissue, creates a temporary cavity of lesser-damaged tissue. While the projectile is traveling along its trajectory, it is stabilized by the spin caused by the rifling of the bore. This stability is necessary because the center of mass of a pointed (i.e., spitzer-type) projectile is rearward. Upon entering soft tissue, a spritzer projectile has the following characteristics:

- Destabilizes and flips 180 degrees because its center of gravity is in its base. Any slight deflection of its tip caused by tissue or bone will cause a tumbling effect.
- Only remains stable for a relatively short distance after penetration.

- Destabilizes and flips end-to-end, causing an enlarged permanent cavity and a corresponding enlarged temporary cavity for a slightly longer distance.
- Stabilizes and continues to travel base first until it has either exited the flesh or expended its energy.

Burst of Fire

A burst of fire is a number of successive rounds fired with the same elevation and point of aim when the trigger is continually depressed without interruption. The number of rounds in a burst can vary, depending on the rate of fire desired. The length of the burst is determined by several factors, including the type of target, the size and shape of the target, the size of the beaten zone in relation to desired saturation, the degree of threat that the target poses to friendly units, and the ammunition supply.

Sustained Rate. Sustained rate is the rate of fire that machine guns can deliver for a period of time without a malfunction caused by overheating. The following are the sustained rates for specific machine guns:

- M249: 85 rounds per minute; 3- to 5-round bursts; 4–5 seconds apart.
- M240B: 100 rounds per minute; 6- to 8-round bursts; 4–5 seconds apart.
- M2A1: 40 rounds per minute; 6- to 8-round bursts; 10–15 seconds apart.
- MK-19: 40 rounds per minute; continuous burst.

Rapid Rate. Rapid rate is the rate of fire that machine guns can deliver for a short period of time without a malfunction caused by overheating; however, firing at this rate necessitates more frequent barrel changes. The following are the rapid rates for specific machine guns:

- M249: 100 rounds per minute; 8- to 10-round bursts; 2–3 seconds apart.
- M240B: 200 rounds per minute; 6- to 8-round bursts; 2–3 seconds apart.
- M2A1: 40: rounds or more per minute; 6- to 8-round bursts; 5–10 seconds apart.
- MK-19: 60 rounds per minute; continuous burst.

Cyclic Rate. The cyclic rate is a gun's maximum rate of fire. It is determined by design and ammunition. The following are the cyclic rates for specific machine guns:

- M249: 850 rounds per minute; continuous burst.
- M240B: 550–650 rounds per minute; continuous burst.
- M2A1: 450–600 rounds per minute; continuous burst.
- MK-19: 325–375 rounds per minute; continuous burst.

Cone of Fire

The cone of fire is the group of trajectories that results from a burst of fire (see Figure 1-2). When a burst is fired, the vibrations of the gun and tripod, variations in ammunition, and conditions of the atmosphere give each projectile a trajectory that is slightly different from the others.

For example, if the burst of fire strikes a vertical target, the rounds form an oval pattern, with the density of shots decreasing toward the outer edges of the oval. The resulting group of trajectories is known as the cone of fire. Just as the trajectory rises with increasing muzzle elevation, so does the cone of fire. The benefit of a cone of fire over individual trajectories is that the cone produces a much larger hazard than the path of an individual projectile does. The cone of fire has both vertical and horizontal dimensions.

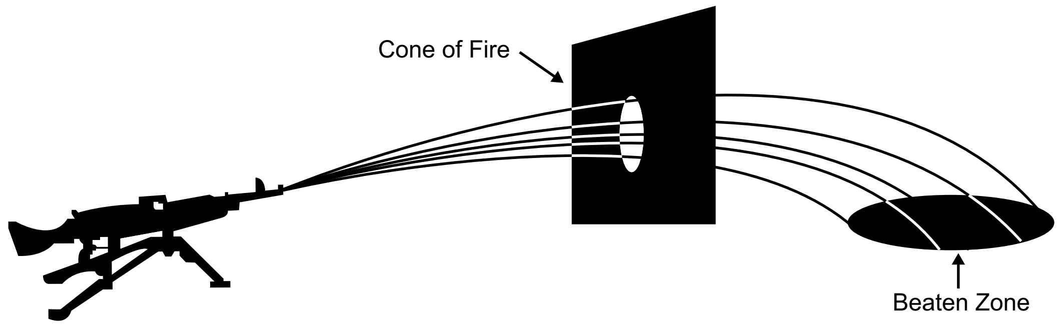


Figure 1-2. Cone of Fire.

Vertical. The vertical dimension of the cone of fire is divided into upper and lower halves, known as the upper bound and the lower bound (see Figure 1-3).

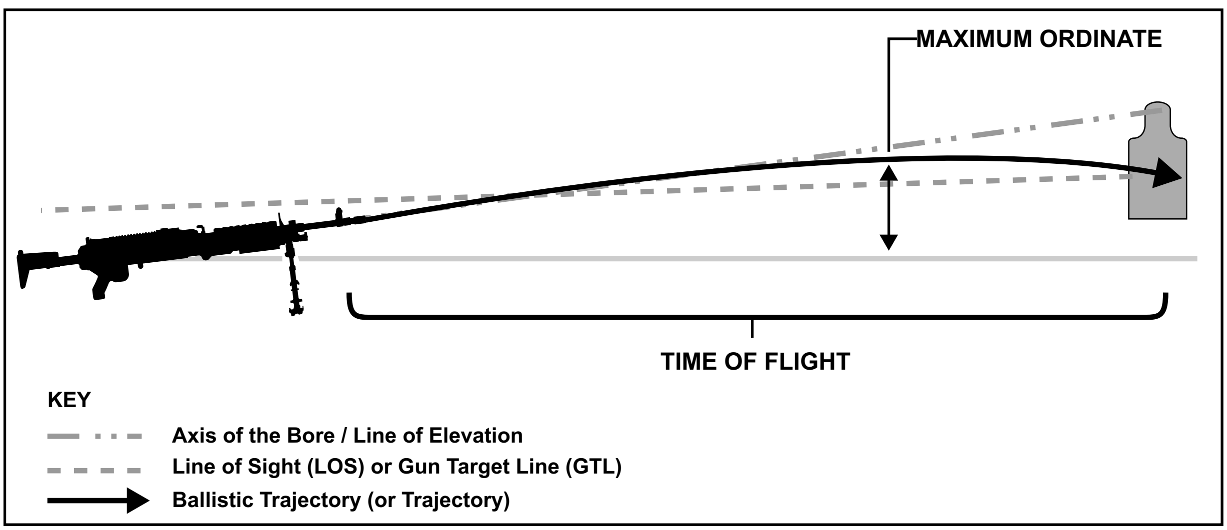


Figure 1-3. Vertical Dimension of the Cone of Fire.

The vertical dimension of the cone is always greater than the horizontal dimension—sometimes as much as seven to eight times greater at long ranges. The effects of this difference are manifested in the shape of the beaten zone at different ranges (see Figures 1-4 through 1-6). The cone of fire, in conjunction with the beaten zone, creates danger space between the muzzle of the gun and the target.

> *NOTE:* The dimensions of the lower bound will become useful when calculating the safety limits for overhead fire (see Chapter 4).

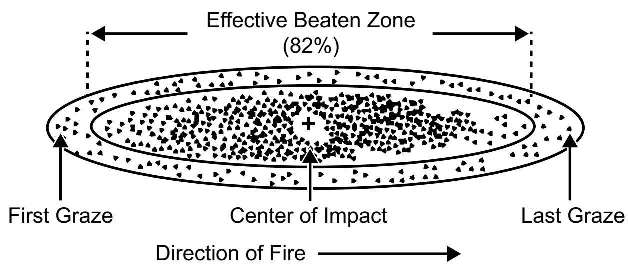


Figure 1-4. Beaten Zone.

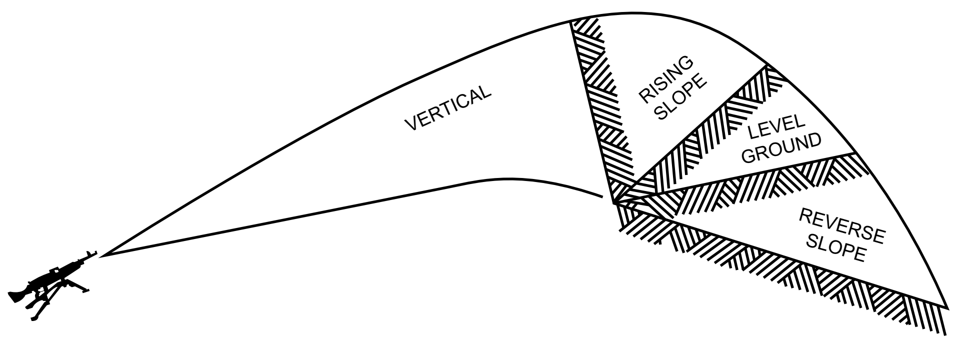


Figure 1-5. Effect of Ground Slopes on the Beaten Zone.

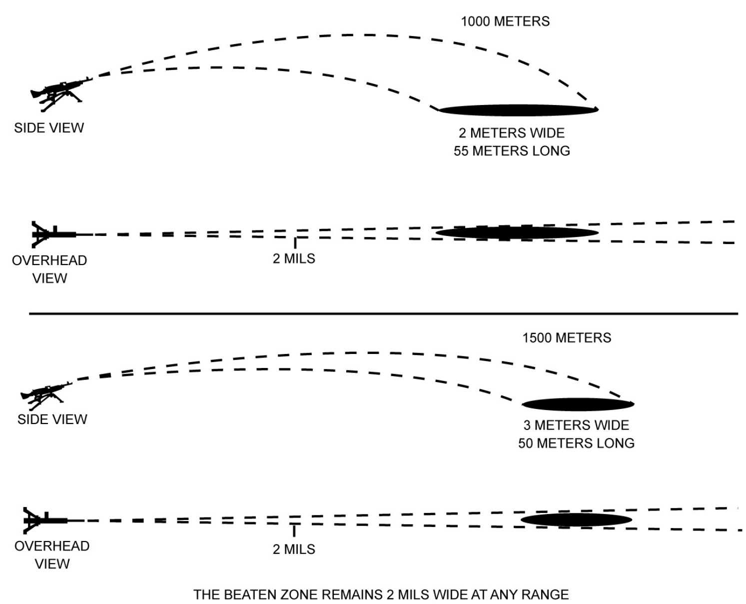


Figure 1-6. Effect of Range on the Beaten Zone (Example Shown for M240B).

Horizontal. The horizontal dimension of the cone of fire spreads out more gradually than the vertical dimension, as the latter is subject to the effects of gravity and bullet drag and to the natural dispersion resulting from the burst of fire.

Beaten Zone

The beaten zone refers to the pattern formed when the cone of fire strikes the ground. Its shape varies between cigar- and oval-shaped, depending on the range. At short ranges, the beaten zone range is long and narrow because the trajectories in the cone of fire are still fairly flat and the horizontal dimension of the cone of fire is fairly small. At longer ranges, the beaten zone becomes more oval shaped (i.e., wider and shorter) as the cone of fire continues to widen out and the trajectories in the burst become steeper.

Beaten Zone Terms. The following terms are associated with the beaten zone:

- *Center of impact*. The center of the beaten zone is called the center of impact. It has been observed that 82 percent of the shots within the center of impact are bursts of fire uniformly grouped around the center of impact. These comprise the effective beaten zone.
- *Effective beaten zone*. The effective beaten zone is the area where the majority of the rounds in a burst strike the ground. This area is termed effective because the density of shots ensures that anything within that portion of the beaten zone will be effectively suppressed or otherwise affected (i.e., hit) by the strike of the round. The remaining 18 percent of the shots are so scattered that they are considered to be outside the effective beaten zone. It is common to see the phrase “82% effective beaten zone” in machine gun fire control tables (see Appendix A).
- *First graze*. The closest point on the ground where rounds strike is known as the first graze—the lowest round in the cone of fire. When rounds impact a target, the closest impact on the target is known as the first catch.
- *Last graze*. The farthest point on the ground where rounds strike is called the last graze, which is produced by the highest round in the cone of fire. When rounds impact a target, the farthest impact on the target is known as the last catch.

Beaten Zone Considerations. The beaten zone is affected by ground slope and range. The slope of the ground will have a marked effect on the length of the beaten zone. A cone of fire striking a hillside with a steep, upward slope will cover a small area of ground and produce a correspondingly short beaten zone. If the same cone of fire strikes a gentler upward slope, it will produce a slightly longer beaten zone. If the same cone of fire strikes a gentle reverse slope, it will produce the longest beaten zone possible because the slope of the ground is similar to the angle of fall of the trajectories in the burst.

> *NOTE:* The slope of the ground only affects the vertical dimension of the cone of fire and only the length (not the width) of the beaten zone.

Knowledge of the dimensions of beaten zones at any range will prove useful to machine gunners and leaders alike when setting machine guns for either offensive or defensive employment. Table 1-4 shows how the cone of fire affects the beaten zone as distances increase for both medium machine guns and HMGs. Dimensions are presented in meters and reflect 82 percent of the effective beaten zone, not the total beaten zone.

Table 1-4. Effects of Range.

Projectile	Range (m)	Width (m)	Length (m)
M240B	500	1	85
	1,000	2	53
	1,500	3	48
	2,000	4	51
M2A1	900	0.9	180
	1,800	2.7	81
	3,200	6.4	75

Danger Space

This is the area from the muzzle of the gun, out to and including the beaten zone, where a standing person (measured as 1.8 meters, 5'10", or 70 inches tall) will be hit, somewhere on their body, by some part of the cone of fire. When firing over flat or uniformly sloping terrain at ranges less than 850 meters, the M240B's trajectory does not rise above 1.8 meters. Beyond 850 meters, the gun's trajectory does rise more than 1.8 meters. This figure of 1.8 meters is used as an estimate of the height of a standing person in tactical planning. Danger space is an important tactical consideration when planning the employment of machine guns. When setting machine guns, leaders must always seek to maximize danger space while minimizing dead space.

NOTE: The enemy will seek to exploit dead space and avoid danger space.

The likelihood of producing enemy casualties at various ranges by exploiting the concept of danger space can be estimated by using the appropriate fire control tables (see Appendix A). For example, when firing over flat or uniformly sloping terrain at ranges less than 800 meters, the M240B's lower bound does not rise above 70 inches/1.8 meters. This information is derived from a comparison of the cone of fire dimension and maximum ordinate from Table I for the M240B.

Dead Space

Dead space is an area within the maximum range of a weapon which cannot be covered by fire or observation from a particular position because of intervening obstacles, the nature of the ground, the characteristics of the trajectory, or the limitations of the pointing capabilities of the weapon. Intervening obstacles or the characteristics of the trajectory can also produce dead space. Particularly regarding a machine gun's cone of fire, dead space is any place along the gun's line of fire where the lower bound rises above 70 inches/1.8 meters (see Figure 1-7). Machine guns must be sighted to maximize danger space while minimizing dead space.

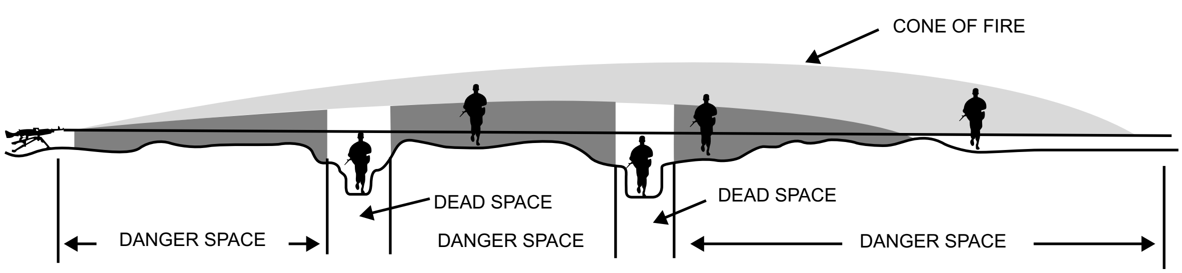


Figure 1-7. Danger Space and Dead Space.

When setting machine guns in the defense, identifying dead space on the final protective line (FPL) is particularly critical. Dead space on the FPL that is not covered by another machine gun or weapon system can provide the enemy with the opportunity to penetrate the defensive sector and threaten friendly units. Therefore, every effort should be made to cover the dead space along FPLs with grazing fire from other machine guns, direct fire from rifles, or indirect fire from mortars or grenade launchers. A machine gunner must understand and carefully consider both danger space and dead space when setting their gun in the defense (see Chapter 3).

> *NOTE:* Effective danger space is based on the average height of a person standing upright (70 inches/1.8 meters). Even over uniformly sloping terrain, sufficient dead space can exist along the line of fire because of the characteristics of the trajectory. The enemy can exploit this dead space by crouching or crawling to move under the cone of fire. For example, on uniformly sloping ground, with the M240B laid for 700 meters, the maximum dead space produced will be 55 inches. A person running in a low crouch could get lower than 55 inches, exploiting the dead space to move underneath the cone of fire. In this situation, the maximum dead space occurs at approximately half the range that the gun is sighted at. The maximum ordinate for a gun that is laid for 700 meters will occur at approximately 465 meters. The maximum dead space will occur closer to the muzzle (350 meters) because of the lower bound of the cone of fire.

CLASSIFICATIONS OF FIRE

Machine gun fire is classified with respect to the ground, target, and gun.

Ground

The first and most basic way to classify machine gun fire is with respect to the ground. This method of classification focuses on the ground over which the gun's fire will pass. Depending on its setting, the gun will produce either grazing or plunging fire with respect to the ground.

Grazing Fire. Grazing fire occurs when the center of the cone of fire does not rise more than one meter above the ground. When firing over level or uniformly sloping terrain, the maximum extent of grazing fire obtainable for the M240B is approximately 580 meters, which is rounded to 600 meters to simplify calculations in tactical planning. Rounding the range also accommodates the rear sight of the M240B, which is graduated in 100 meter increments.

The maximum extent of grazing fire obtainable for the M2A1 is approximately 680 meters, rounded to 700 meters for the same reasons. When a gun is sighted to produce grazing fire, the danger space extends from the muzzle of the gun to the point of last graze. Grazing fire is the primary consideration when assigning the FPL mission to a machine gun. It ensures a minimal amount of dead space in the trajectory of the cone of fire.

For example, when the M240B is laid for 600 meters, the maximum dead space is 31 inches on uniformly sloping ground and in ideal conditions. The maximum dead space occurs at approximately half of the range (i.e., 300 meters). Therefore, a person would have to crawl in order to move underneath the cone of fire, significantly hampering the speed of their advance. When an M240B is laid for 600 meters, the center of impact occurs at 600 meters. The effects of the cone's upper bound will extend the danger space out to 640 meters. This is because the length of the beaten zone at that range is approximately 80 meters, and the first and last graze are equidistant from the center of impact (see Figure 1-8).

SIGHTED RANGE (m)	MAXIMUM ORDINATE (m)	MAXIMUM DEAD SPACE (m)	MAXIMUM COVERAGE (m)
500	.75	.4 (15")	560
600	1.2	.8 (31")	680
700	1.8	1.4 (55")	760

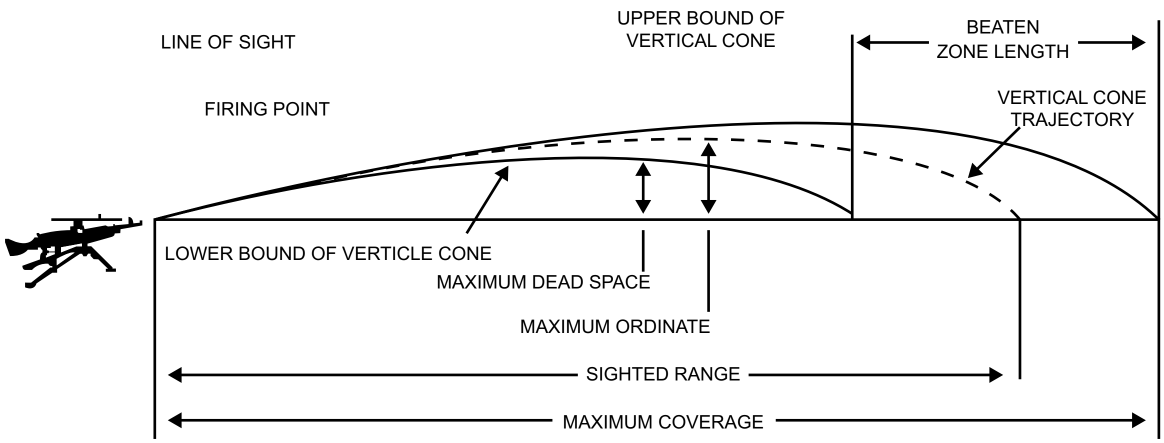


Figure 1-8. Grazing Fire.

Plunging Fire. Plunging fire occurs when the danger space is confined to the beaten zone. It is achieved because the angle fall of the rounds is at an acute angle (or nearly perpendicular) to the slope of the ground. The length of the beaten zone is significantly shortened in such instances. Plunging fire can be obtained when firing against a steep slope, from high ground into low ground (or vice versa), and at very long ranges. Because the danger space is confined to the beaten zone in plunging fire, it is inherently less efficient than grazing fire (see Figure 1-9).

Target

The most common way of classifying machine gun fire is with respect to the target. This method focuses on the effect that the machine gun is intended to have on the enemy. Therefore, the setting of a machine gun may produce any of, or any combination of, the four classes of fire—frontal, flanking, oblique, and enfilade—with respect to the target (see Figures 1-10, 1-11, and 1-12).

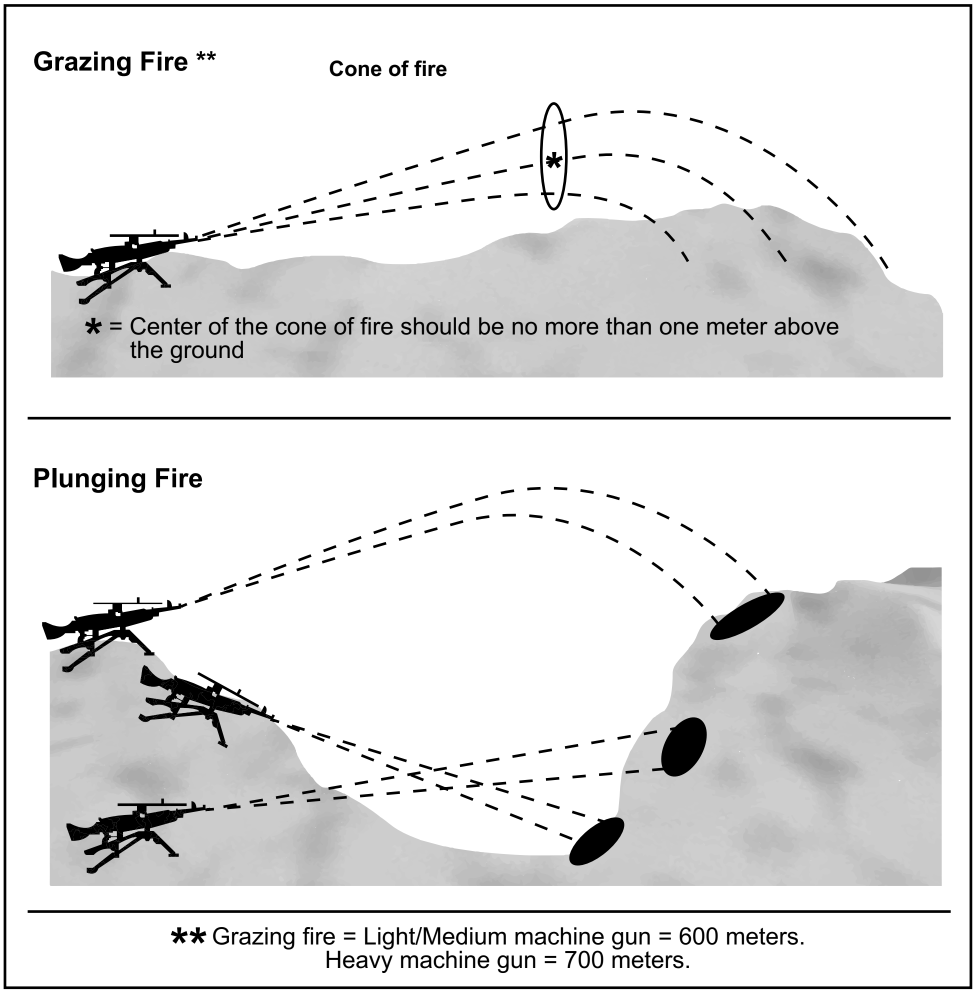


Figure 1-9. Plunging and Grazing Fire.

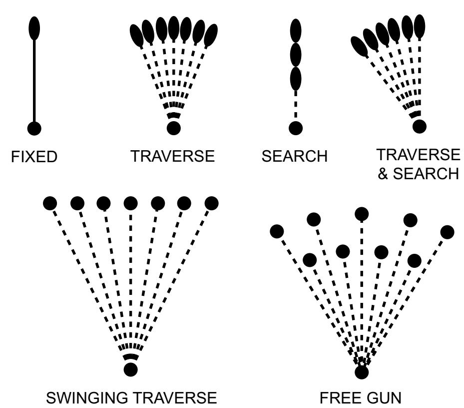


Figure 1-10. Classes of Fire with Respect to the Target.

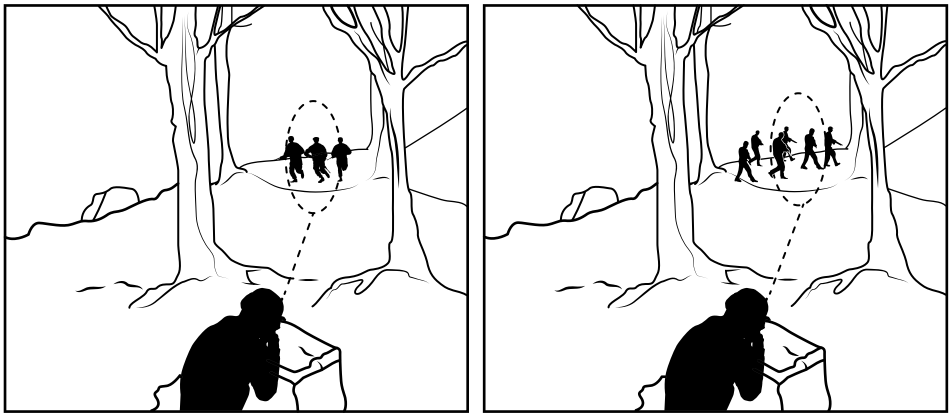


Figure 1-11. Frontal Fire and Flanking Fire.

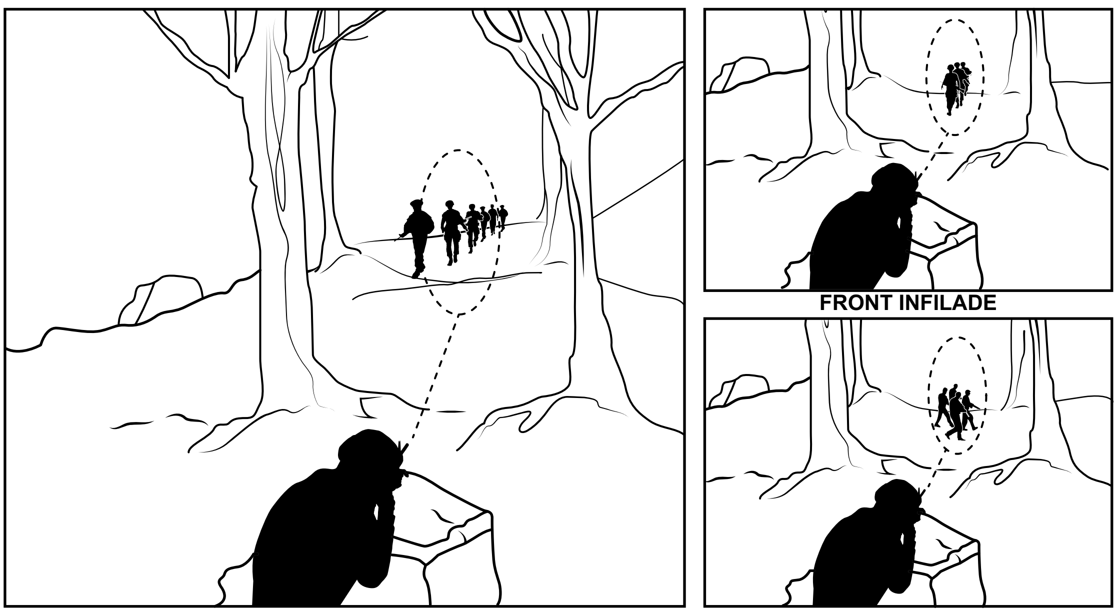


Figure 1-12. Oblique Fire and Enfilade Fire.

The distinguishing factor between frontal and flanking fire is the orientation of the target/enemy; whereas, the distinguishing factor between oblique and enfilade fire is the formation of the target/enemy. The difference between orientation and formation must be understood in order to distinguish classes of fire with respect to a target.

Frontal Fire. Frontal fire is delivered against the front of a target. The enemy likely does not have to reorient in order to return fire.

Flanking Fire. Flanking fire is delivered against the flank of a target. The enemy may need to reorient to return fire. Flanking fire may be directed at the side or rear of an enemy formation.

Oblique Fire. Oblique fire is delivered so that the long axis of the beaten zone is at an oblique angle to the long axis of the target.

Enfilade Fire. Enfilade fire is delivered so that the long axis of the beaten zone coincides (or nearly coincides) with the long axis of the target. This is often the most desirable and most efficient class of fire with respect to the target because it makes maximum use of the beaten zone. Additionally, enfilade fire can be further classified according to the first two classes of fire (frontal and flanking) with respect to the target.

Frontal Enfilade. The long axis of the beaten zone coincides with the long axis of the target. The enemy does not have to reorient in order to return fire. In the defense, this class of fire is usually achieved when setting a machine gun to fire in a principal direction of fire (PDF) because the enemy will most likely be in an approach column heading toward the gun along an avenue of approach.

Flanking Enfilade. The long axis of the beaten zone coincides with the long axis of the target. The enemy must reorient in order to return fire. In the offense, this class of fire is usually achieved when setting the gun to provide close supporting fires from the flank of an enemy position. In the defense, this class of fire is usually achieved when setting a machine gun to fire along an FPL because the enemy will most likely be deployed in the assault and present their flank to the gun.

Gun

The third way of classifying machine gun fire is with respect to the gun itself. This method of classification focuses on the means that the gunner will use to control the firing of the gun. Therefore, the actions of the gunner (under the control of the team, squad, or section leader) may produce any one of the six classes of fire with respect to the gun—fixed, traversing, searching, traversing and searching, swing traverse, and free gun (see Figure 1-13).

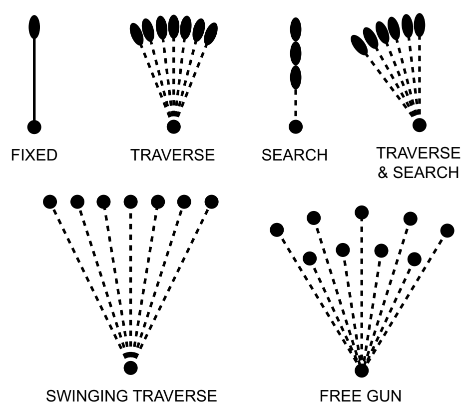


Figure 1-13. Classes of Fire with Respect to the Gun.

Fixed Fire. Fixed fire is delivered on a point target. Little or no manipulation of the traversing and elevating (T&E) mechanism is required. After the initial burst, the gunner will follow any movement of the target without command.

Traversing Fire. Traversing fire is distributed against a shallow (wide) target, requiring successive changes in the direction of the gun. When engaging a shallow target that requires traversing fire, the gunner should select successive aiming points throughout the target area. These aiming points should be close enough together to ensure adequate target coverage, but not so close to waste ammunition by concentrating a heavy volume of fire in a small area. Traversing fire is performed by manipulating the traversing hand wheel only.

> *NOTE:* A major change in traverse is one of more than 20 mils, while a minor change in traverse is 20 mils or less.

Searching Fire. Searching fire is distributed against a deep (narrow) target by successive changes in the gun's elevation. The amount of elevation change depends on the range and slope of the ground. When engaging a deep target that requires searching fire, the gunner must ensure that the beaten zones of the successive bursts overlap, but not excessively. Searching fire is performed by manipulating the elevating hand wheel only.

Traversing and Searching Fire. Traversing and searching fire is delivered in both width and depth by minor changes in direction and elevation. It is employed against a target's long axis that is oblique to the direction of the fire. Traversing and searching fire is performed by manipulating the T&E mechanism hand wheels.

Swinging Traverse Fire. Swinging traverse fire is delivered against targets that require major changes in direction, but little or no change in elevation. Targets that require engagement by swinging traverse are usually either a large troop formation that is relatively close to the gun or vehicles/mounted troops moving rapidly across the front of the gun. Swinging traverse fire is accomplished by unlocking the traversing slide lock lever to permit the gunner to swing the gun laterally while the traversing slide is still engaged on the traversing bar of the tripod.

Free Gun Fire. Free gun fire is delivered against moving targets that must be engaged quickly and that require rapid changes in both direction and elevation. Examples of targets that require engagement by free gun are aircraft, vehicles, mounted troops, or infantry that are in close formation and moving rapidly toward or away from the gun position. Free gun fire is accomplished by disengaging the T&E mechanism completely from the traversing bar to permit the gunner to swing the gun both laterally and vertically while pivoting at the pintle.

CHAPTER 2.
BASIC MACHINE GUN GUNNERY

MACHINE GUN TRAINING PHILOSOPHY

Machine gun gunnery is both technically and procedurally intensive. For machine gunners to employ their weapon systems with maximum effect, they must be properly trained (see Figure 2-1), not only in their individual roles, but also in the integration and coordination of their roles as part of crew-served weapon systems. Therefore, the key to training machine gunners is a good understanding of and strict attention to the four cornerstones and four components of machine gun training.

Figure 2-1. Machine Gun Training.

Cornerstones of Machine Gun Training

Four cornerstones of machine gun training that are recognized to enhance the machine gun leader's ability to effectively train machine gunners are: an incremental approach to training, education, standardization, and repetition.

Systems Approach to Training. The machine gun leader should seek to train machine gunners progressively—from simple training standards to difficult ones. This building block approach ensures that a solid foundation of knowledge is obtained and maintained before more advanced techniques are taught. Additionally, a crawl, walk, run approach—moving from explanation to demonstration, and finally to practical application—should be used. This method ensures a machine gunner has the opportunity to learn what is required at a rate that promotes understanding and retention. This approach should be applied at both the individual and team level. For example, the machine gunner must thoroughly understand individual billet and training standards before moving on to team and, finally, squad training.

Education. The first goal of education is to teach the machine gunner to be confident and capable with the weapon system. Before this can happen, the machine gunner must fully understand how the weapon operates. Without this essential first step, any subsequent learning may be based upon misinformation and superstition, not true knowledge. Because of the technical nature of machine guns and machine gun gunnery, it is imperative that all machine gunners have a thorough understanding of what is necessary to effectively employ their weapon systems at a level appropriate to their rank and billet. This includes both technical proficiency and tactical judgment, commensurate with billet, to properly employ the weapon system and the unit. As this process is continuous, the machine gun leader must ensure that as machine gunners progress in rank, they also progress in level of responsibility and degree of technical and tactical mastery of machine guns.

Standardization. Training must be performed in accordance with individual training standards as prescribed by Navy/Marine Corps Departmental Publication (NAVMC) 3500.44, *Infantry Training and Readiness Manual* (see Appendix B). Tasks must be trained to these standards to ensure uniform and standardized training throughout the Marine Corps. Well-trained machine gunners should be capable of performing any required task that the tactical situation might require in accordance with their billet in the machine gun unit.

Repetition. Repetition refers to both education and training. Because of the technical complexity, machine gun gunnery techniques are perishable in nature. Efficient machine gun gunnery requires the ability to manually manipulate an intricate piece of equipment with speed, accuracy, and confidence. There is no way to achieve this proficiency other than by repeated practice. The need for smooth, coordinated action as a crew-served weapon team (i.e., teamwork) further accentuates the need for repetition to be part of the fundamental approach to machine gun training.

Components of Machine Gun Training

In addition to the four cornerstones of machine gun training, the training philosophy is best understood from the perspective of the four components of machine gun training: gun drill, fundamentals of machine gun gunnery, machine gun qualification, and field firing. These components must be viewed as progressive and cyclic. Once the fourth component is completed, the first three should be trained again in order to retain proficiency in skills that make success in the fourth component possible.

Gun Drill. Gun drill is a formalized procedure that provides crewmembers with basic training in machine gun operation. The ultimate objective of the gun drill is to produce a confident gun crew with the ability to prepare the gun for action in any given situation, both precisely and quickly. Precision is achieved by instilling muscle memory in the actions of the crew through repetition. This muscle memory will result in the gun being prepared for action in the most efficient manner. When trained to a standard repeatedly, the gun drill will naturally result in speed; however, precision must be acquired before speed.

Fundamentals of Machine Gun Gunnery. Once the machine gunner has mastered the basic skill of a gun drill, but before being ready for live fire, the machine gunner must become skilled in applying the four fundamentals of machine gun gunnery. These fundamentals are the second component of machine gun training and the essence of machine gun gunnery. A machine gunner will not be able to develop skills required in advanced machine gun gunnery without mastering the following four fundamentals:

- Accurate initial burst.
- Adjustment of fire.
- Mechanical skill in manipulation.
- Speed.

Accurate Initial Burst. Obtaining an accurate initial burst of fire on the target is the first goal of a good machine gunner. This is accomplished by correctly estimating the range to the target, correctly setting the sights on the machine gun, and properly laying the gun on target with the T&E mechanism. After the estimated range has been set on the rear sight, the machine gun is manipulated until the sights intersect the target at six o'clock and a sustained rate burst (i.e., six to eight rounds) is fired. The accuracy of this initial burst and the precision of the steps that lead up to it are paramount to achieving effects on target in the least time possible. In addition to range estimation and sight setting, the essential elements of an accurate initial burst are discussed in the following subparagraphs.

When firing a machine gun, *firing position* is one of the biggest contributors to accuracy. Accuracy with a machine gun is not simply a measure of where the first-round hits; it is where the entire burst hits—the beaten zone. The size of the beaten zone is a direct reflection of the steadiness of the machine gunner's position. The recoil resulting from the first and subsequent rounds of a burst will initially disturb the orientation of the gun's muzzle—this is known as muzzle jump.

It is the gunner's job to fire as accurately as possible, which requires the proper *position* and *grip*. This will allow consistent and precise corrections to fire. The three variables affecting accuracy that can be controlled by the gunner are the left and right movement of the muzzle, the upward and downward movement of the muzzle, and the forward and backward movement. The gunner must remove these three variables on any given weapon system. This is achieved by pulling the weapon into the shoulder naturally. At this point, the gunner needs to, by any means necessary, lock that body position in and allow the gun to fire naturally. If the position is maintained and care is taken not to muscle the gun in any one direction, consistently accurate and correctable fires will be achieved. This will facilitate less muscle fatigue and allow the operation of the T&E mechanism while firing.

Proper *sight alignment* (i.e., how the front and rear sights appear in relation to each other) is the gunner's first priority when laying the gun on target. The gunner should establish a natural LOS through the center of the rear sight aperture, to the front sight post, and to the target. Then the gunner aligns the sights so the tip of the front sight post is centered both vertically and horizontally within the rear sight aperture. This sight alignment must then be combined with a proper sight picture when manipulating the T&E mechanism to ensure that the gun is properly laid on target.

Proper *sight picture* (i.e., how the aligned sights and the target appear in relation to each other) is the gunner's second priority when laying a gun on target. Once the gunner has achieved proper sight alignment, the gunner manipulates the T&E mechanism in order to place the tip of the front sight post at six o'clock to the target. As a burst is fired, the muzzle of the gun, along with the rounds, will rise. The sights are put down and corrections are made by the team leader once the gunner is on target.

Proper *trigger manipulation* is essential to control the duration of the burst. This is essential to achieve an observable beaten zone. The gunner should keep a firm grip with the firing hand and then actuate the trigger quickly and firmly. Depending on the machine gun's cyclic rate of fire and whether sustained or rapid rates are desired, the gunner may vary the amount of time actuating the trigger and the pause between bursts. Since machine guns are belt-fed, they are designed to be fired in long bursts (six to eight rounds). Firing short bursts (three to five rounds) tends to cause stoppages and prevents the weapon from leveling out or producing predictable cones of fire and beaten zones.

Adjustment of Fire. Once an accurate initial burst is attained, adjusting that burst is the next step. The sights are used to lay the gun on target and fire is adjusted by visually observing the beaten zone, not by looking through the sights. The team leader and the gunner observe the path of the tracers and then the strike of the bullets in order to determine the point of impact (i.e., the beaten zone) of the initial burst. If it is not on target, the gun is manipulated until the beaten zone impacts the target. After the effects on the target are achieved, a test of a machine gunner's skill in adjusting fire lies in the gunner's ability to adjust onto multiple, successive targets. This takes a solid understanding of range estimation, the mil relation, the capabilities and limitations of the T&E mechanism, projectile trajectory, and the beaten zone dimensions at different ranges. Two techniques of adjusting onto the target are measurement and burst to target.

When using the *measurement* technique, the team leader uses a mil-scaled optic to measure the mil distance between the impact of the beaten zone and the target location. The gunner allows for the observer target factor in the mil relation formula and applies the appropriate deflection adjustment to bring the beaten zone onto the gun-target line. Once on the gun-target line, range corrections are made using bold corrections and bracketing the target until rounds impact the target area.

The *burst to target* technique is used to adjust the impact of the beaten zone to the target and to continue the firing burst, while manipulating the traversing hand wheel until the beaten zone is on the gun-target line. Once the beaten zone is on the gun-target line, another burst is initiated while the elevation hand wheel is manipulated until the beaten zone impacts the target. This technique is faster than the measurement technique but increases the potential for a hot barrel. Economy of rounds should also be considered when employing this method.

Mechanical Skill in Manipulation. Once a machine gunner is adept at adjusting fire onto multiple targets, mechanical skill in manipulation must be developed to engage deep or shallow targets. When both traverse and search are necessary, machine gunners conduct the following procedures (manipulation is based on where the rounds impact in relation to the target; this will determine how to manipulate the T&E mechanism):

- To elevate the muzzle, the gunner turns the elevation hand wheel counterclockwise, moving their thumb to the right. To depress the gun, the gunner turns the elevation hand wheel clockwise, pulling their thumb back toward their body. Once elevation corrections have been made, the gunner moves their hand to the traversing hand wheel with their thumb on top.
- To move the barrel of the machine gun to the right, the gunner pushes their thumb up and away from their body. To move the barrel to the left, the gunner pulls their thumb down towards their body. One click, of either the traversing or elevating hand wheel, moves the muzzle of the gun one mil. Because of the standard width of a machine gun's beaten zone, manipulation of the T&E mechanism hand wheels is performed in two-mil increments. Changes in elevation or traverse of less than two mils typically do not move the beaten zone enough to change effects on target; however, given respect to the ground, target, and gun, it may be required.
- Proper mechanical manipulation of the machine gun can be remembered by the reflexive skill in mechanical manipulation (i.e., acting without having to think) that comes with repetition. Manipulation drills are essential to developing reflexive skill.

> *NOTE:* When in a training area, a method that can be used to practice reflexive skill is to fix the laser boresight onto the mandrel and place it into the muzzle while traversing and searching taped-up targets on the bulkhead or sides of a vehicle.

> *NOTE:* An indoor simulated marksmanship trainer can be used to build proficiency in the fundamentals of machine gun gunnery.

Simple drill cards can be made with a starting point and a list of corrections that will end up back at the same spot. When making these cards, gunners must take care to zero the T&E mechanism before beginning the drill. For every correction they make, they must make an equal and opposite correction during the drill to end back at the starting point.

Speed. Speed is the ultimate test of proficient machine gun gunnery. The fundamentals of delivering fire can only be combined through a complete understanding and thorough repetition of the other three fundamentals of machine gun gunnery. Speed should not be stressed to the detriment of accuracy, adjustment of fire, or skill in manipulation. Speed can only be developed once the other three skills have been mastered. It is the final proof of a machine gunner's ability to master the four fundamentals because of the time-competitive nature of combat. Therefore, once reflexive skill in manipulation has been developed, manipulation drills must be continued and intensified in order to develop speed. This will come as a natural consequence of reflexive skill.

Machine Gun Qualification. Machine gun qualification is the third component of machine gun training and is essential to establish a basic level of proficiency and further develop and maintain that proficiency. Qualification should be conducted in accordance with NAVMC 3500.44. For both the M249 and M240B, qualification consists of both the basic course (i.e., live fire at short distance) and the transition course of fire (i.e., live fire at combat distances) (see Appendix C). Because of the progressive nature of the four cornerstones of machine gun training, qualification should be conducted before proceeding to field firing.

Field Firing. Field firing is the fourth component of machine gun training. It should always be the final step in a machine gun training regimen, conducted only after the first three components have been mastered. This will ensure the gun crew is well prepared for field firing and that valuable ammunition is not wasted.

Field firing training consists of what are known as gunnery tables. A gunnery table is a course of fire that tests a machine gun crew's skill at employing the gun in a certain situation. Although the gunnery tables for the M249 are different than the M240B, the first two tables for any machine gun are the qualification tables. Therefore, Table I is always the basic course and Table II is always the transition course. Any subsequent tables will entail field firing with the gun in different scenarios, such as defensive firing or firing with night vision devices (NVDs).

Field firing is conducted only after a machine gunner has demonstrated a basic level of proficiency by qualifying on Gunnery Tables I and II. Machine gunners must fire all the gunnery tables concerning qualification and field firing in accordance with the gunnery tables found in Appendix C to maintain proficiency. Crew gunnery tables are covered in Appendix D.

BASIC MACHINE GUNNER'S MATHEMATICS

Basic machine gunner's mathematics include the mil (i.e., a unit of angular measurement), measuring mils, the mil ratio, and WERM formula [width equals range times mil].

> *NOTE:* Since there are 6,283 mils in a circle, and the Marine Corps rounds this figure to 6,400 for simplicity, the WERM formula, which solves for arc length, will not be as accurate as mathematical calculations using a tangent. However, it is accurate enough for field use.

Mil—A Unit of Angular Measurement

The machine gunner bases much work in machine gun gunnery on the measurement and application of angles. The width of a target, for example, is measured by constructing an angle with imaginary lines from the flanks of the target to the gunner's position. This angle, for purposes of simplicity and uniformity, is measured in mils. A mil, like a degree, is simply a unit of measurement used to break up a circle into smaller parts. Mils are smaller units of measurement that may be used to make more precise measurements than are possible with degrees. Since there are 6,400 mils in a circle and 360 degrees in a circle, there are approximately 17.8 mils in a degree, and 0.05625 degrees in a mil (see Figure 2-2).

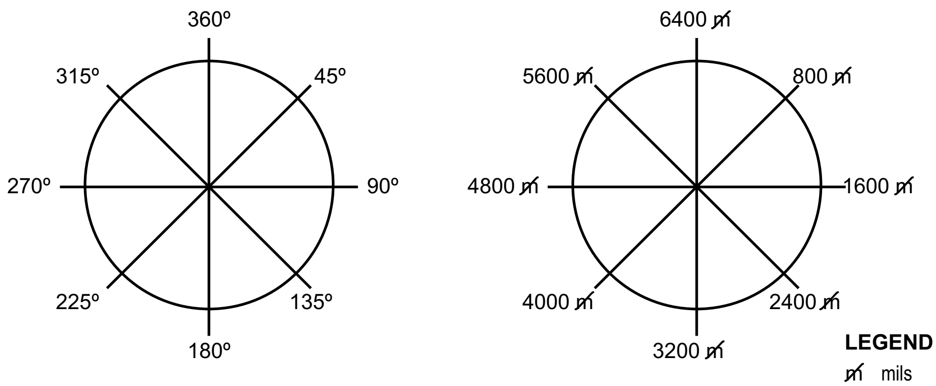


Figure 2-2. Illustration of Degrees and Mils.

Angular Measurement of Mils

The mil is used for calculating firing data and can be applied to the gun by using the T&E mechanism. Mils are always expressed in four figures; therefore, a measurement of 1,800 mils is spoken as "one eight hundred" and a measurement of 800 mils is written as 0800 and spoken as "zero eight hundred." Angular measurement of mils can be made by using the following devices:

- Optic: Optics associated with machine guns are generally graduated in 10-mil increments.
- Compass: The lensatic compass and M2 compass are both graduated in 20-mil increments, from 0 to 6,400 mils.
- T&E mechanism: 100 mils on the traversing screw of both the medium and heavy T&E mechanisms.
- Traversing bar: 800 mils on the HMG tripod, 875 mils on the light and medium machine gun tripod.
- Hand and finger method: The width of an object is measured with the hand extended at an arm's length, as shown in Figure 2-3.

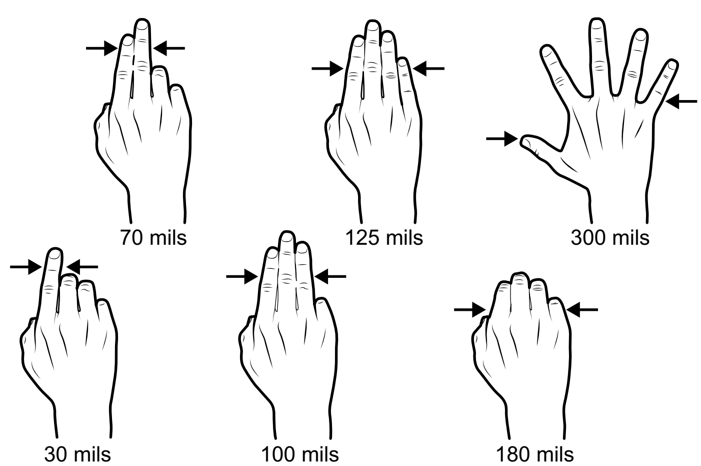


Figure 2-3. Hand and Finger Method of Mil Measurement.

The Mil Ratio

There is a constant mathematical relationship between the sides and angles of a right triangle. The mil is particularly useful for determining the lateral distance (i.e., the width of a target) when the range-to-target is known and for the range-to-target when its lateral distance is known. This constant relationship is known as the mil ratio.

The mil ratio is best expressed in the following terms: one mil at 1,000 m equals one meter. This means at a distance of 1,000 meters from an observer, one mil of angular width equals one meter of lateral distance. Therefore, if a trench line is 1,000 meters from a machine gun and the gunner measures the width of the trench line to be 150 mils wide, then the gunner knows the trench line is actually 150 meters wide.

For an example of the mil ratio, refer to Figure 2-4. The angle between points B and C measures 10 mils; the width of the line between points B and C is 10 mils wide. Since the distance (range) from point A to point B is 1,000 meters, the distance (width) between points B and C is 10 meters.

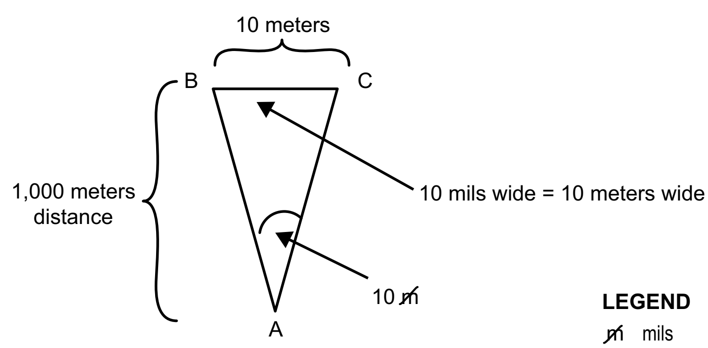


Figure 2-4. The Mil Ratio.

The WERM Formula

When using the mil ratio, the WERM formula has been developed to assist in the measurement of range when lateral distance/width is known and lateral distance when range is known. It is written as width = range (meters/1,000) × mils; it can be expressed differently, depending upon the information needed:

W = R x M (width = range [meters/1,000] x mils) when the width of the target is needed and the range and mils are known.

R = W/M (meters/1000) = width ÷ mils when the range is needed and the width and mils are known.

M = W/R (mils = width ÷ [meters/1,000]) when the number of mils is needed and the width and range are known.

Example of Using the WERM Formula to Find Range
If using the WERM formula to find range (R = W ÷ M), the result of the calculation will need to be multiplied by 1,000 to convert to meters (see Figure 2-5). For example—
M = 40 mils
W = 60 meters
R = W ÷ M = 60 ÷ 40 = 1.5 × 1,000 = 1,500 meters

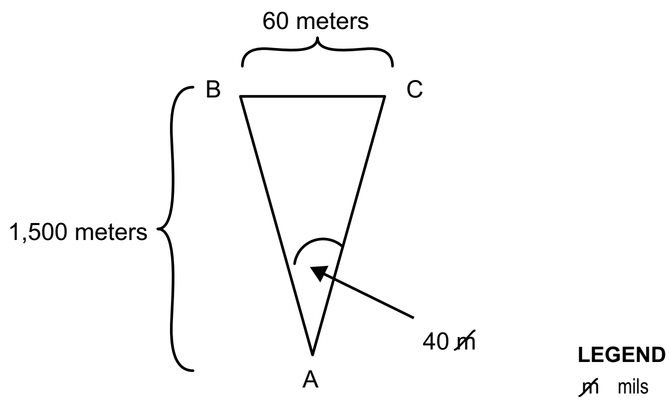


Figure 2-5. Using the WERM Formula to Determine Width.

RANGE ESTIMATION

The distance or range to a target under combat conditions will seldom be known in advance. Therefore, the effectiveness of the initial bursts of fire depends largely upon range estimation and is often the most crucial in combat. Accordingly, since the first fundamental of machine gun gunnery is the accuracy of the initial burst, range estimation is critical to the machine gunner. There are several methods for determining range:

- Estimating by eye or machine gun optic.
- Estimating by fire (i.e., firing the gun).
- Using a pair of binoculars or a laser range finder.
- Measuring range from a map or aerial photograph.
- Pacing the distance on foot.
- Receiving information from a unit that has previously occupied a position.

Ranges are determined to the nearest 100 meters for purposes of machine gun employment because mechanical sights on all machine guns are graduated in increments of 100 meters (except for the M2A1, which is 100 yards). The most commonly used methods in combat, in order of use, are:

- Estimating by eye or machine gun optic.
- Using a pair of binoculars.
- Using a laser range finder.

Although estimation by fire is an accurate method of range estimation, the tactical situation may often preclude this technique for the following reasons:

- The damp ground or poor visibility that often exists in a combat environment makes adjustment of fire by observation with the naked eye extremely difficult.
- The beaten zone, under such conditions, may miss the target completely, although the error in range would not be greater than 100 meters.

Therefore, skill in range estimation by other methods than by fire is essential for a machine gun crew to remain combat effective. Accurate range estimation is an extremely valuable fundamental skill for the machine gunner.

Estimation of Range Factors

To estimate range more accurately under a variety of conditions, the machine gunner must understand how natural conditions affect the appearance of distance between an object and the observer. The three most important factors affecting range estimation are the nature of a target, the light and weather conditions, and the nature of the terrain.

Nature of a Target. The nature of a target is determined by environmental factors, such as:

- An object of regular outline. For example, a house appears closer than one of irregular outline, such as a clump of trees.
- A target that contrasts with its background appears to be closer than it is.
- A partly exposed target appears more distant than it is.
- A large target, such as a tank or armored vehicle, appears much closer than it is.

Light and Weather Conditions. The more clearly a target can be seen, the closer it will appear:

- When obscuration (e.g., smoke, fog, rain, or snow) is present, the target will appear farther away than it is.
- When the sun is behind an observer, the target will appear to be closer than it is.
- When the sun is behind a target, the target will be more difficult to see and will appear to be farther away than it is.
- When observing from a kneeling or sitting position on a hot, humid day, the target will appear farther away than it is.

Nature of Terrain. As the observer's eye follows the contour of the terrain, the tendency to overestimate the distance to the target exists, and the following considerations should be made:

- Observing over smooth terrain, such as water, sand, or snow, causes the observer to underestimate distant targets.
- Estimating range in a wide-open environment, such as the desert, is difficult because targets are usually much farther away than they appear.
- Looking downhill, the target appears farther away; looking uphill makes a target appear closer.

Estimation by Eye

Estimation by eye is the method most often used in the field. It is important to understand how the conditions of range estimation factors affect objects' appearance. When estimation by eye is used to determine the range to a target, the observer should keep these factors in mind. There are three basic methods of estimation by eye: the football field method, the halfway method, and the appearance of objects method.

Football Field Method. To use the football field method (see Figure 2-6), the gunner must be able to visualize a 100 meter distance on the ground, which is roughly equivalent to a 100-yard football field. With this distance in mind, the gunner can mentally determine how many football fields there are between the gunner's position and the target. In training, the gunner's estimates should be checked by pacing off the distance. Familiarity with the football field unit and its appearance on different types of ground and at different distances enables the observer to apply it with relative accuracy. Since using the football field method beyond 500 m is difficult, observers should use the halfway method at greater ranges.

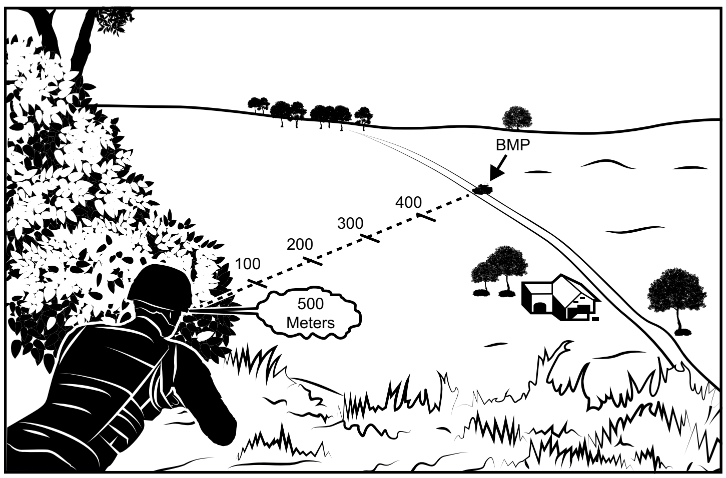


Figure 2-6. Football Field Method.

Halfway Method. The halfway method (see Figure 2-7) is a variation of the football field method of range estimation. It is most effective when the distance to the target exceeds 500 meters. With this method, the observer makes a visual estimate of a point on the ground that appears to be halfway between the observer and the target. The observer then estimates the range to that halfway point and doubles that figure to achieve a total estimated range.

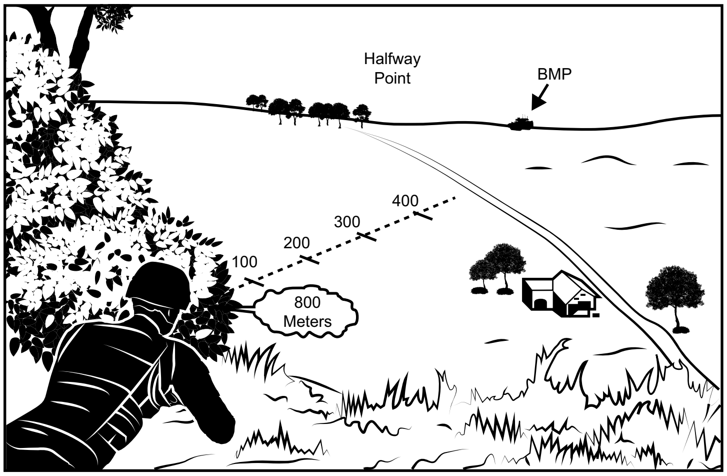


Figure 2-7. Halfway Point Method.

The Five-Degree Method. The five-degree method (see Figure 2-8) uses a range estimation that is easily accomplished and requires only a compass. The three steps in this method are:

- The observer shoots an azimuth from the start point (SP) to the target point (abbreviated here as TP).
- The observer walks at a 90-degree angle from the SP-TP line until a five-degree difference from the SP-TP azimuth is read on the compass.
- Using a 1-meter pace, the observer walks in a straight line back to the SP, counting the paces, and then multiplies the number of paces to the SP by 11. This gives the range in meters between the SP and the target point.

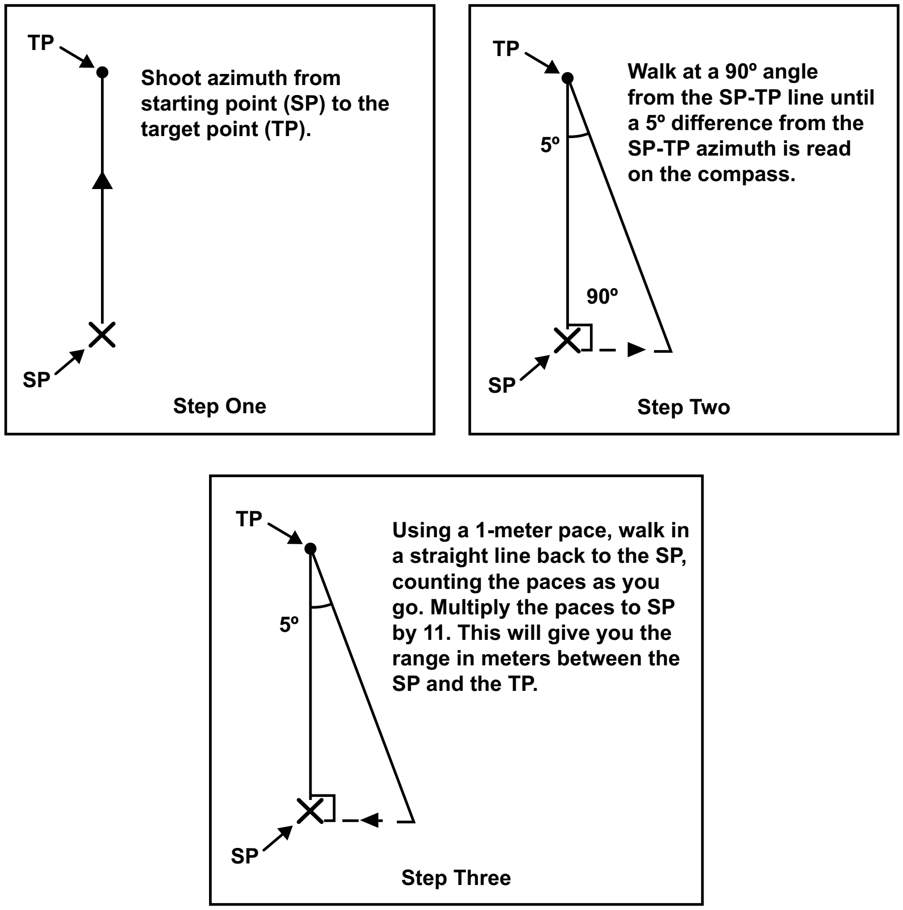


Figure 2-8. The Five-Degree Method.

Estimation by Fire

The estimation by fire (i.e., observed fire) method of range determination combines the techniques of range estimation by eye and observation of fire. The estimation by fire method can be used to register range cards. When applying the estimation by fire method, the gun crew performs the following steps:

1. The team leader estimates the range to target.
2. The gunner lays the gun on the target.
3. The gunner opens fire on the target with a rapid-rate burst.
4. The team leader observes the beaten zone, noting the offset between the target and the beaten zone, and issues corrections.
5. The gunner adjusts the T&E mechanism to move the center of impact onto the target.
6. Without disturbing the lay of the gun, the gunner resets the rear sight so the line of aim is on the target.
7. The gunner notes the sight setting on the rear sight and announces it to the team leader as being the range to target.

8. The team leader announces the range to the squad leader and that all guns are laid on the target with the appropriate range setting.
9. The unit opens fire on the unit leader's command.

   NOTE: All guns must be zeroed beforehand so that the range determined for one gun can be applied to the others.

When the ground in the vicinity of the target does not permit the observation of the strike, or when a surprise attack is desired, fire can be adjusted on a point that does offer observation and is known to have the same range as the target. The gunner may lay the gun on the target when ordered.

When engaging targets in a tree or building, fire is adjusted on the ground at the foot of the tree or building where the strike of the rounds is visible. Therefore, the range determined is given as the range to the target. The gunner announces the range, then elevates the gun until it is laid on the target.

The average vehicle dimensions (see Figure 2-9) should be committed to memory. Once memorized, they may be applied in conjunction with the reticle pattern on the M22 or M24 binoculars to determine the range of any corresponding target. For simplicity and ease of memorization, the actual dimensions of individual vehicles have not been listed; however, the following average dimensions of these items have been computed as a result of a study of vehicle dimensions in *Jane's Tanks and Combat Vehicles Recognition Guide.*

- Main battle tank: 7 meters long (hull), 3.4 meters wide, and 2.4 meters high at the turret.
- Tracked IFV/APC: 6 meters long, 2.8 meters wide, and 1.8 meters high at the hull.
- 8-wheeled armored vehicle: 7.3 meters long, 2.8 meters wide, and 2.4 meters high at the turret.
- 6-wheeled armored vehicle: 6 meters long, 2.5 meters wide, and 2.5 meters high at the highest point.
- 4-wheeled armored scout vehicle: 5.7 meters long, 2.4 meters wide, and 2.4 meters high at the turret.
- Height of a person: 70 inches/1.8 meters.

Determination by Laser Range Finder

Laser range finders can determine range more quickly and accurately than other techniques. Since accurate range estimation is crucial to an accurate initial burst, it often determines success or failure when engaging targets of opportunity or high-threat targets (e.g., armored vehicles).

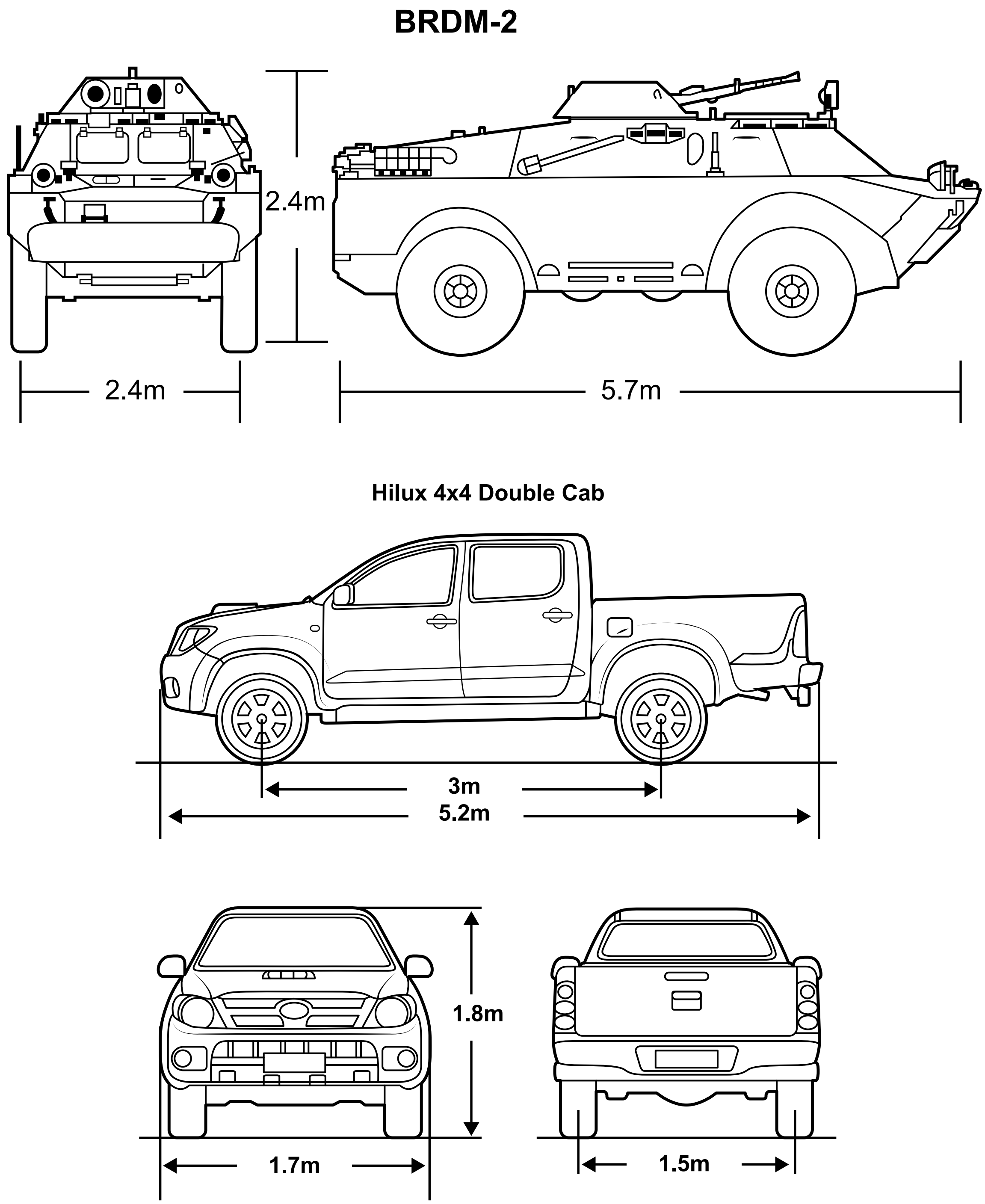


Figure 2-9. Comparative Sizes of Threat Vehicles.

Determining Range or Lateral Distance by the WERM Formula

In addition to being used to determine lateral distance or width, the WERM formula may also be used to determine range. The following subparagraphs discuss the use of the WERM formula in conjunction with binoculars to measure lateral distance and range.

Determining Range with Binoculars. When the range to target cannot be determined using a laser range finder, binoculars may be used to confirm a range estimation made by other methods. This is done by applying the WERM formula in conjunction with binoculars and the knowledge of the dimensions of certain objects, such as combat vehicles.

Example of Determining Range with Binoculars

In Figure 2-10, an HMG team leader needs to know the range to the target, which is a BRDM-2 scout car. Remembering that the length of the average 4-wheeled armored scout car is 5.7 meters, the team leader uses binoculars to measure the width (in mils) of the target, which is determined to be 30 mils. The team leader also remembers that to determine the range to target using the WERM formula, the team leader needs to adjust the formula as such: R = W ÷ M.

However, before beginning the computation, the team leader rounds the length of the target up to 6 m. This simplifies the calculation and keeps the team leader's range relatively accurate. The team leader has the following figures for computation:

R = ?
W = 6 meters
M = 30 mils

Using the modified WERM formula, the team leader calculates the range to the target as follows:

R = 6 ÷ 30
R = 0.2

Remembering that using the WERM formula directly will give the team leader the observer-to-target factor, the team leader multiplies the result by 1,000 to convert the observer-to-target factor to meters: 0.2 × 1,000 = 200 meters.

Therefore, the range to target is 200 meters.

> *NOTE:* Since the team leader was familiar with observer-to-target factors, the team leader knew intuitively that the 0.2 figure translated to 200, without having to multiply by 1,000. Similarly, if the result of the WERM formula calculation had been 0.9, the team leader would have instantly recognized this as meaning 900 meters. Also, by rounding the known dimension of the scout car to the nearest whole number, the team leader was able to simplify the calculation.

Since the team leader performed this math mentally, simplifying the calculation is important. If the team leader had kept the figure at 5.7 meters, the result of the calculation would have been 0.19, or 190 meters. This number would still need to be rounded to 200 meters, because the sights on all machine guns are graduated in 100-mil increments. Therefore, rounding figures when making calculations with the WERM formula simplifies the process without sacrificing accuracy in range determination. Review the WERM formula and observer-to-target factor earlier in this chapter.

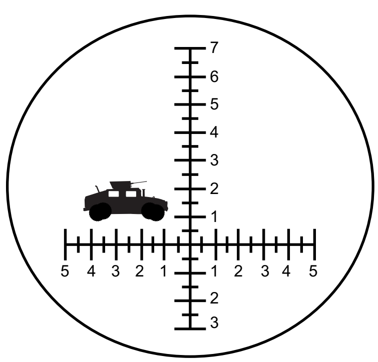


Figure 2-10. Determining Range with Binoculars.

Determining Lateral Distance with Binoculars. When the width of a target or lateral distance between two distant objects must be determined, binoculars provide the machine gunner with the most accurate means if a laser range finder is not available. To determine lateral distance with binoculars, the range to target must be acquired through any of the various means that are available (e.g., estimation by eye, by fire, by map survey).

Example of Determining Lateral Distance with Binoculars

In Figure 2-11, a machine gunner needs to measure the lateral distance between an enemy soldier and a reference point (the tree)—75 mils on the reticle scale. First, the machine gunner must figure the range to the enemy soldier, then figure the lateral distance between the soldier and the tree. Remembering that the average height of a person is 70 inches/1.8 meters, the machine gunner uses binoculars to measure the height (in mils) of the soldier, which is 10 mils. After rounding the height of the soldier to two meters to keep the calculation simple, the machine gunner uses the modified WERM formula to determine the range to the soldier:

R = W÷ M
R= 2 ÷ 10 = 0.2 × 1000 = 200 meters

Note: The machine gunner used the height of an object, not its width, to determine range with the WERM formula. Either a horizontal or vertical dimension may be used when applying this formula—the geometry is the same either way.

Now that the machine gunner knows the enemy soldier is 200 meters away, the standard can be applied. The WERM formula used to determine the lateral distance between the soldier and the tree is:

R = W÷ M
R = 200 meters (expressed as an observer-to-target factor of 0.2)
M = 75 mils
W =0.2 × 75 = 15 meters

Therefore, the lateral distance between the enemy soldier and the tree is 15 meters.

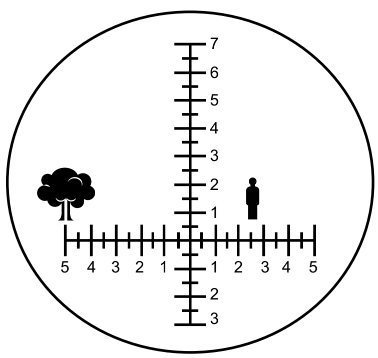


Figure 2-11. Measuring Lateral Distance with Binoculars.

Traversing and Elevating

When properly employed, the T&E mechanism—

- Enables the gunner to accurately engage targets in conditions of reduced visibility, employ the gun from defilade positions, and engage enemy positions located on reverse slopes.
- Allows stability that cannot be achieved other than by using the T&E mechanism because the machine gun is firmly locked into a desired position on the tripod.

- Measures the angle width or height of targets and terrain, which aids the gun crew in range estimation and target engagement.
- Produces T&E data, which is a combination of numbers that records the position of the gun on the tripod when it is used in conjunction with the graduated traversing bar of the tripod—the T&E mechanism. This provides a reference for the gun crew concerning the exact orientation of the gun that is required to engage any particular target. Therefore, once a gun is laid on a target and the T&E data for that target is recorded, the crew can reposition the gun at a moment's notice to engage the target. The T&E data allows a gun crew to engage a desired target and shift to other targets. Then, by reapplying the original data, the gun crew can rapidly and accurately re-engage the original target. This ability is especially useful when engaging targets in the defense and during periods of limited visibility.
- Measures safety distance when applying the leader's rule for overhead fire (see Chapter 3).
- Assists in achieving quadrant elevation when executing indirect fires or when firing from a defilade position in conjunction with the gunner's quadrant (see Chapter 3).

The T&E mechanisms provide the following amounts of controlled manipulation:

- *M240B medium machine gun*. 200 mils of elevation, 200 mils of depression, and 100 mils of controlled traverse. See Figure 2-12 for the traversing and elevating mechanism for the M240B.
- *M2A1 HMG and MK-19 grenade machine gun*. 100 mils of elevation, 250 mils of depression, and 100 mils of controlled traverse. See Figure 2-13 for the traversing and elevating mechanism for HMGs.

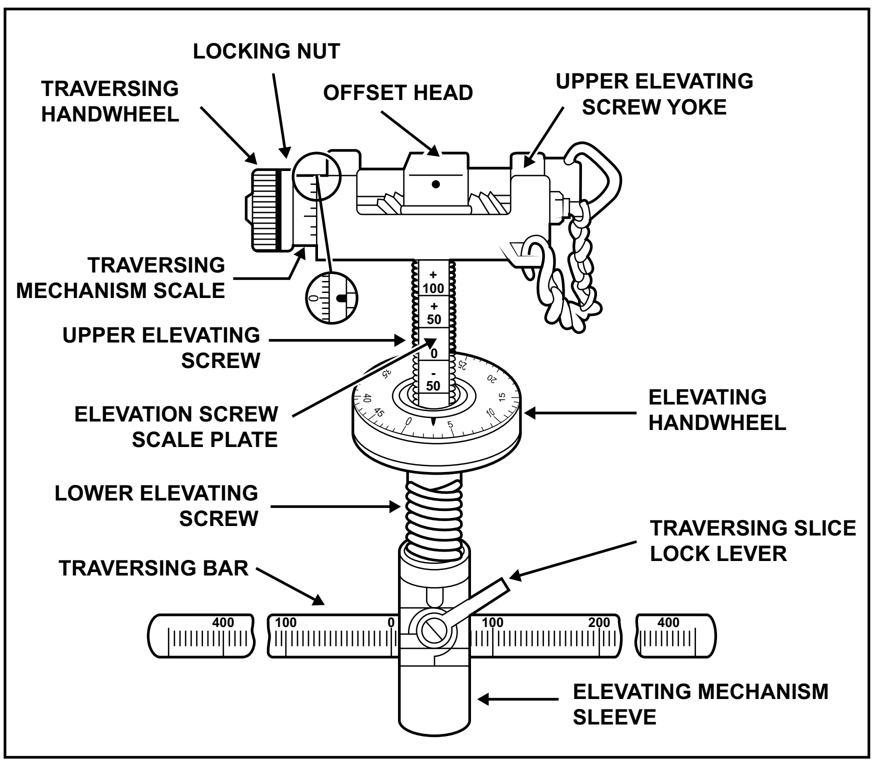


Figure 2-12. Traversing and Elevating Mechanism for the M240B.

Figure 2-13. Traversing and Elevating Mechanism for Heavy Machine Guns.

Mounting the Machine Gun on a Tripod

Mounting a machine gun on a tripod provides a stable platform to fire the gun. It also enables the crew to engage targets using both direct and indirect fire.

Machine guns are most stable when fired from a tripod, as opposed to a bipod or a vehicle mount. In the tripod-mounted configuration, a gun’s potential for continuous, stabilized, accurate fire and controlled manipulation can be maximized. Even in motorized operations, if the situation permits, an HMG should be dismounted from the vehicle and mounted on the HMG tripod in order to maximize accuracy and crew survivability. The tripod mounting with the T&E mechanism also provides the means to record firing data, which enables the crew to engage targets under all visibility conditions. In all configurations, care must be exercised not to disturb the mount once the initial readings are taken from the T&E mechanism. Disturbing the mount could produce inaccurate data, thus endangering friendly troops.

Light Machine Gun Mount. The primary employment method for the M249 is as a light machine gun mounted on a tripod. If the M249 is to be employed on a bipod, the shooter’s body must be trained to behave as the T&E mechanism:

- The elbows behave as the elevation control. Moving the elbows away from the gun raises the muzzle (by lowering the rear of the weapon) and increases elevation. Bringing the elbows in toward the weapon lowers the impact (by raising the rear of the weapon).
- The length of the body is the traversing mechanism for the M249. The body is lifted into the air, balancing on the toes of the feet and the elbows, while the toes manipulate for traverse. Once traverse is conducted, the body is laid back down on the ground to stabilize the weapon while it recoils.

Medium Machine Gun Mount. The mount for a medium machine gun is the tripod. It is a fixed height, folding tripod system that is composed of a tripod and the T&E mechanism. Since the legs on the tripod are not adjustable, there is only one configuration for mounting the M240B.

Heavy Machine Gun Mount. The ground mount for both the HMGs and grenade machine guns is the HMG tripod. It is a variable height, folding system that is composed of a tripod, pintle, and T&E mechanism. The current tripod mount weighs 44 pounds (including the pintle and T&E mechanism) and has three adjustable, telescoping, tubular legs that allow mounting at three different heights—low (8 inches), medium (12 inches), and high (16 inches).

The normal mounting configuration for a HMG mount has the front leg at a 60- degree angle to the ground and the rear leg extensions closed. Such positioning puts the tripod head 12 inches above the ground, providing stability. Also, as a matter of habit, the machine gun crew should always stack sandbags beneath the tripod head before mounting the tripod to obtain a more stable firing platform. Sandbagging the tripod head also prevents the possibility of the front tripod leg on the medium machine gun from coming loose due to vibrations during firing, especially when employing the M2A1 or the MK-19 from the low mount.

Traversing and Elevating Mechanism Usage

Prior to using the T&E mechanism during firing, it should be zeroed to maximize its utility for the crew and to prevent early grounding out of the T&E mechanism's offset head. Grounding out occurs when the offset head reaches the end of its travel on the traversing screw. When this occurs, manual traversing the gun in one direction is not possible until the T&E mechanism is adjusted.

Zeroing. To zero the T&E mechanism, perform the following steps:

1. Center the elevating mechanism by holding the traversing slide in place and turning the elevating hand wheel until approximately 1-1/2 inches (two fingers) are visible on both the upper and lower elevating screws.
2. Center the offset head on the traversing screw as follows:
    a. Turn the traversing hand wheel until the offset head is flush to one side of the traversing screw.
    b. Count the number of clicks and turn the traversing hand wheel until the offset head is on the opposite end of the traversing screw.
    c. Divide the number of clicks by two and turn the traversing hand wheel in the opposite direction that same number of clicks. The traversing screw should be approximately 100 mils (clicks) wide, so the offset head should be centered at approximately 50 clicks.
3. Zero out the traversing hand wheel micrometer by loosening the lock collar, slipping the scale to zero, and then tightening the lock collar.

Hasty Zeroing. The following steps use the "two, two, and two" method used for hasty zeroing the T&E mechanism (see Figure 2-14):

1. Center the offset head on the traversing screw. One finger should fit on each side of the offset head.

2. Holding two fingers together, adjust the elevation hand wheel until these two fingers fit on the upper elevating screw.

3. Using the same two fingers, turn the elevating mechanism until these two fingers fit on the lower elevating screw.

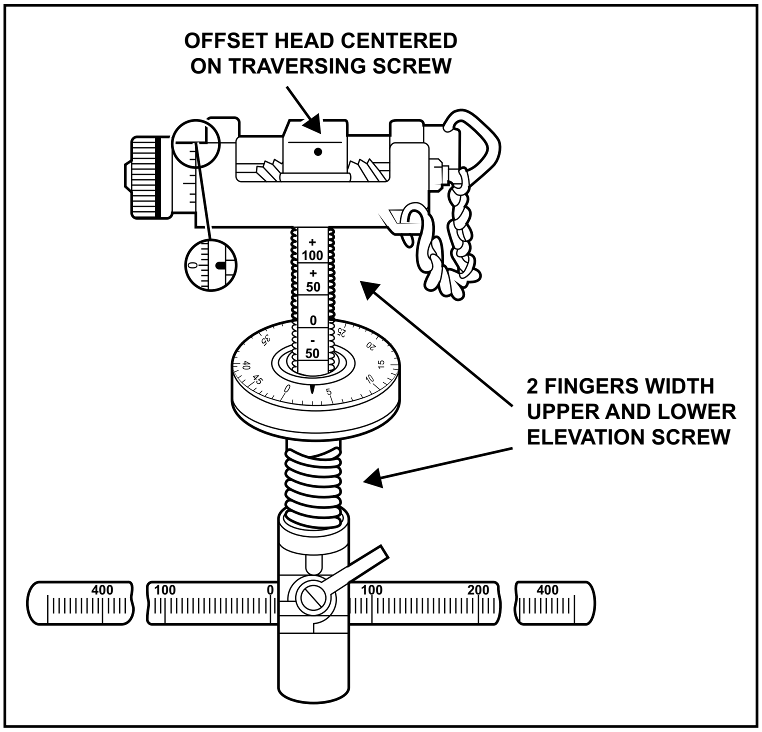


Figure 2-14. Zeroed Traversing and Elevating Mechanism.

Manipulating the Traversing and Elevating Mechanism

Traversing and elevating mechanism manipulation is performed by making elevation adjustments and elevation and direction changes.

Adjustments. All elevation adjustments are made with the elevating hand wheel as follows:

- Clockwise rotation of the hand wheel moves the muzzle down. Counterclockwise rotation moves it up.
- Major direction adjustments (more than 20 mils) are made with the traversing bar.
- Minor direction adjustments (20 mils or fewer) are made with the traversing hand wheel.

> *NOTE:* If an adjustment is called for that is not a multiple of five mils, the part that is a multiple of five should be laid off on the traversing bar and the remainder with the traversing hand wheel.

All T&E manipulation is performed with the left hand. The basic rule for T&E manipulation is "push right up, pull left down," referring to the movement of the thumb on the left hand: push on the elevating hand wheel to go up and push on the traversing hand wheel to go right. Because of the average width of a machine gun's beaten zone, manipulation of the T&E mechanism hand wheels is performed in two-mil increments. Changes in elevation or traverse of fewer than two mils are not made.

Major Traversing Adjustments. To manipulate the traversing slide and traversing bar, perform the following steps:

1. Unlock the traversing slide lock lever.
2. Move the traversing slide along the traversing bar until the gun is laid in the desired direction.
3. Lock the traversing slide lock lever.

Minor Traversing Adjustments. To manipulate the traversing hand wheel, perform the following steps:

1. Grasp the traversing hand wheel with the left thumb aligned along the top of the hand wheel.
2. Rotate (push) the thumb away from the body. The muzzle of the machine gun will move to the right.
3. Rotate (pull) the thumb toward the body. The muzzle of the gun will move to the left.

Reading and Recording Traversing and Elevating Data

The T&E mechanism is designed with T&E scales that can easily be read to permit the gun crew to lay the gun on a target and then record the T&E data for that target. This data can be used later to quickly relay the gun onto that target by reapplying the T&E data to the mechanism. Reading and applying T&E data go hand-in-hand. Once the gunner understands how to read the T&E data, the gunner applies the data by turning the hand wheels in the proper direction until the desired datum are set on the scales.

Traversing and elevating data are derived from four locations:

- The traversing scale on the traversing bar.
- The micrometer scale on the traversing hand wheel.
- The elevating scale on the upper elevating screw plate.
- The scale on the elevating hand wheel.

The data obtained from the four locations is organized into deflection data and elevation data. Deflection data comes from the traversing bar and micrometer scale, while elevation data comes from the elevating screw plate and the elevating hand wheel. Once the gun is laid on a target with a six o'clock sight picture, the gunner reads the T&E data and announces it to the team leader, who then records it in a standardized format. The standard procedure for reading, announcing, and recording T&E data includes the combination of deflection data, elevation data, and data obtained from elevating the hand wheel.

> *NOTE:* To simplify T&E mechanism readings, the micrometer scale on the traversing hand wheel should always be at zero when recording and applying T&E data.

Deflection Data. The traversing bar scale is always the first reading taken when recording T&E data. The following outlines procedures for taking the first reading:

- First, determine whether the muzzle of the machine gun is pointed to the left or to the right of the front tripod leg and record as either L or R.
- Second, look at the traversing bar and determine the data for the first increment line visible to the left of the traversing slide. The traversing bar scale is graduated in 5-mil increments and is numbered every 100 mils—from 0 in the center to 450 on the left and 425 on the right.

Example of Deflection Data
Example 1: Deflection data are announced as *right one hundred* and recorded as R 100.
Example 2: Deflection data are announced as *left one hundred* and recorded as L 100 (see Figure 2-15).

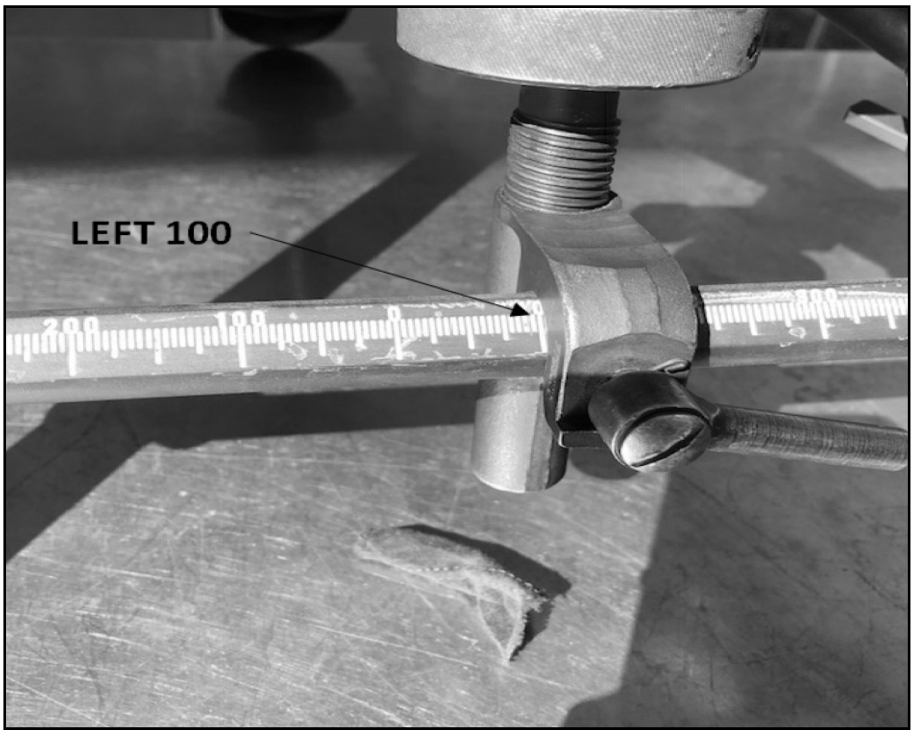


Figure 2-15. Traversing Bar Reading.

Elevation Data. The measurement on the upper elevating screw scale is always the second reading taken. Data from this scale is known as the major reading. When reading from the scale on the upper elevating screw, the elevating scale is graduated in 50-mil segments—from 0 to +200 and from 0 to -200—for a total of 400 mils. Horizontal index lines separate each 50-mil segment of the scale and each segment represents one revolution of the elevating hand wheel. Data may change as heavy, medium, and universal T&E switch out. If a number is not visible because of the position of the hand wheel, but the hand wheel is clearly below the index line on the scale, then the reading should reflect accordingly.

Examples of Elevation Data

Example 1: The elevating hand wheel is above the -100 mark, but clearly below the index line beneath the -50 mark. This will be announced as *minus fifty* and recorded as -50 (see Figure 2-16).

Example 2: The elevating hand wheel is above the +50 mark, but clearly below the index line beneath the +100 mark. This will be announced as *plus one hundred* and recorded as +100 (see Figure 2-17).

Elevating Hand Wheel Data. Data from the elevating hand wheel is the third and final reading taken and is known as the minor reading. The data from the elevating hand wheel is determined by referencing the number directly underneath the pointed indicator on the elevating hand wheel. The hand wheel scale is divided into 5-mil major divisions and 1-mil subdivisions for a total of 50 mils, with the numbers increasing in a clockwise direction.

Examples of Elevating Hand Wheel Data

Example 1: Announce as *slash, three*, and recorded as /3. Figure the complete elevation data by adding the elevating screw data and the hand wheel data—announced as *minus fifty, slash, three,* and recorded as -50/3.

Example 2: Announce as *slash, thirty*, and recorded as /30. Figure the complete elevation data by adding the elevating screw data and the hand wheel data—announced as *plus one hundred, slash, thirty,* and recorded as +100/30.

NOTE: Whenever the elevating hand wheel is below the 0-index line, the reading on the elevating hand wheel scale will be reversed but should be read the same as when it is in the positive range of the elevating scale.

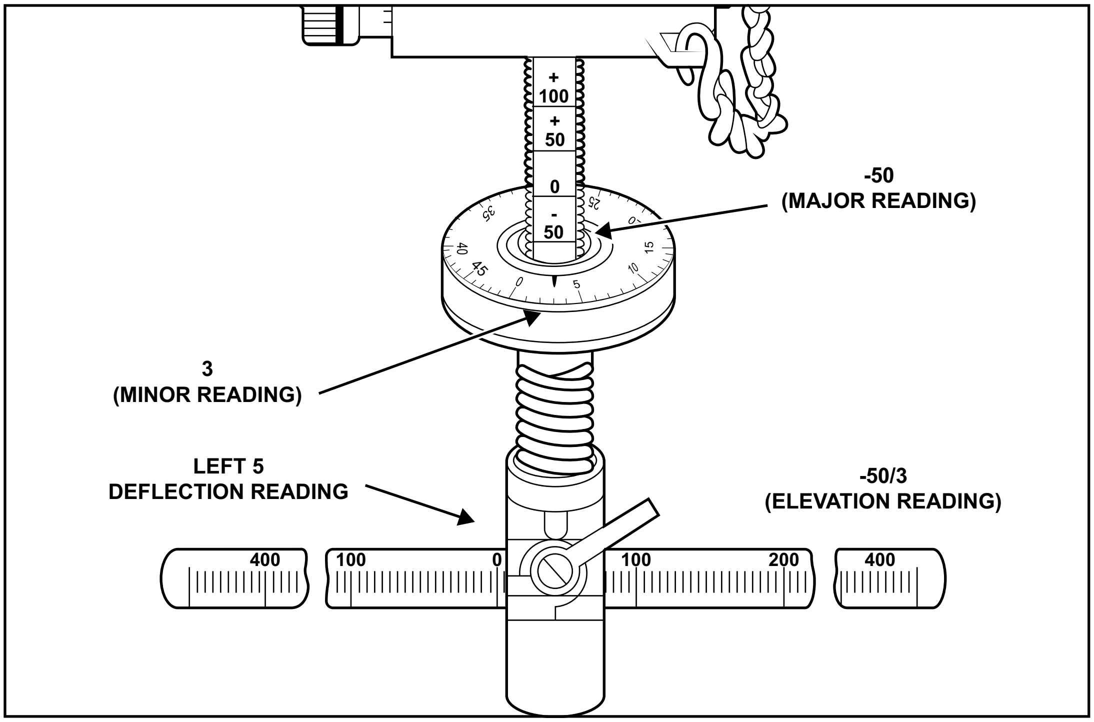


Figure 2-16. Traversing and Elevating Mechanism Readings (Example 1).

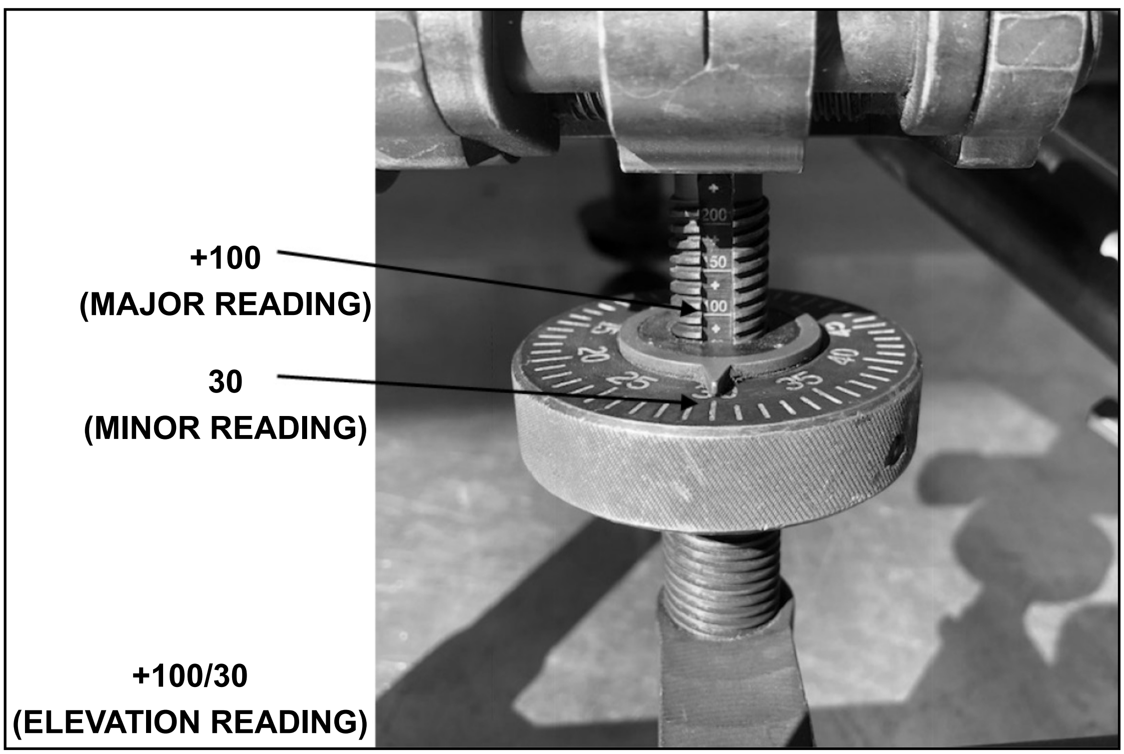


Figure 2-17. Traversing and Elevating Mechanism Readings (Example 2).

Combined Data. Once all three sets of data are determined, they are combined in the following standardized format:

- Announced as "*Right one hundred, minus fifty, slash, three*."
- Recorded as R100 -50/3.

Using the Micrometer Scale

The traversing hand wheel of the T&E mechanism, which is not used for basic T&E data, contains a micrometer scale that is divided into 25 one-mil increments. The micrometer scale can be used to augment the deflection portion of a T&E mechanism reading. Actions concerning the micrometer scale include the following:

- The gun crew should always zero the micrometer after centering the offset head on the traversing screw.
- The gunner should zero the micrometer before reading the T&E data to ensure that when the gun is re-laid on any given target using the T&E data, it is an accurate lay.
- The traversing bar deflection data provides a reading that is only accurate to the nearest five mils. If the gun crew requires more precise deflection data, the micrometer on the traversing hand wheel can be used for a minor reading that is precise to the nearest mil.

> *NOTE:* The micrometer scale can also be used to measure the width of linear targets in mils to determine proper fire distribution for the team, squad, or section of guns.

Measuring Angles and Distances with the Traversing and Elevating Mechanism

The T&E mechanism can be used for measuring safety distances for overhead fire and applying quadrant elevation for indirect or defilade fire. It is also a useful tool for measuring angles on the battlefield and for measuring distance when used in conjunction with the WERM formula.

Measuring Angles. The measurement of angles is an important tool for both the machine gunner and the machine gun leader. Therefore, familiarity with using the T&E mechanism is essential for any machine gunner. Angles are measured (in mils) with the T&E mechanism as follows:

- Lay the gun on the first reference point of the angle to be measured using the T&E mechanism. Ensure there is no external interference on the gun and that the sights are aligned properly, with the front sight blade aligned on the reference point.
- Count the number of clicks while turning the traversing hand wheel one click at a time until the front sight blade is on the second reference point of the angle to be measured. The number of clicks equals the number of mils between the two points.

Measuring Distances. Once an angle is measured in mils with the T&E mechanism, it is converted into a distance measurement in meters, as follows:

- Determine the range to the target by any means available.
- Express the range in terms of the observer-to-target factor.
- Multiply the observer-to-target factor by the number of mils measured with the T&E mechanism.

The result of this calculation provides the lateral distance between the two points.

> *NOTE:* The procedures for measuring vertical angles and distances are the same as those for horizontal measurements, except that the elevating hand wheel of the T&E mechanism is used instead of the traversing hand wheel.

Manipulating the Traversing and Elevating Mechanism for Classifications of Fire

The most important method of classifying machine gun fire is with respect to the gun, because this method focuses on how the gunner will control the firing of the gun. The T&E mechanism may be manipulated by the gunner to produce any one of the six classes of fire discussed previously.

Training for Traversing and Elevating Mechanism Manipulation

To promote proper T&E manipulation habits in gunners, machine gun squad and section leaders should conduct regular manipulation training with their teams. The purpose of manipulation training is to build reflexive habits in both accuracy and speed, which in turn, promotes the gunner's ability to manipulate the laying of the machine gun with the T&E mechanism—first with precision, and then with speed. Reflexive habits can only be accomplished through repetition. The T&E manipulation training exercises are performed with a team, squad, or section of tripod-mounted guns in the following three phases: sight setting and laying exercise, basic manipulation exercise, and advanced manipulation exercise.

Sight Setting and Laying Exercise. The purpose of the sight setting and laying exercise is to develop accuracy and speed in laying the gun on an aiming point and to practice sight setting.

This exercise promotes precision in the first fundamental of machine gun gunnery—an accurate initial burst. The sight setting and laying exercise is performed using the following actions:

- Using either a basic machine gun target or another suitable aiming point, place it at a distance of 10 meters from the pintle. The exercise begins with the gun set on the appropriate battlesight setting. The coach (e.g., the team, squad, or section leader) announces an aiming point and range, such as "*Paster number eight, one thousand.*"

  > *NOTE:* After providing the first element, the coach pauses long enough to permit the gunner to repeat it and then provides the second element. The gunner repeats both elements and sets the sights.

- Set the sights. The gunner adjusts the lay of the gun by turning the T&E mechanism hand wheels until the sights are accurately aligned at six o'clock on the designated aiming point. When adjusting machine gun fire, searching is generally conducted before traversing, the beaten zone is typically longer than it is wide and the gunner's non-firing hand should already be grasping the elevation hand wheel.
- Obtain the sight picture. Once the sight picture is obtained, the gunner maintains the correct firing position and announces "*Up*."
- Check the sight setting and sight alignment. Without having the gunner disturb the lay of the gun, the coach checks the sight setting and sight alignment (i.e., the lay of the gun).

This exercise is repeated until the unit leader is satisfied with the gunner's performance.

> *NOTE:* A tactical situation may dictate that the gun crew perform a traverse adjustment before search. For example, the beaten zone falls to the left or right of the intended target, but the elevation is correct.

Basic Manipulation Exercise. Manipulation is the process of shifting the lay of the gun from one definite point to another. This exercise promotes precision in the second fundamental of machine gun gunnery—adjustment of fire.

The coach stands approximately ten paces in front of the gun and uses hand signals to indicate the direction that the gunner should move the muzzle. The gunner manipulates the T&E mechanism hand wheels in response to the direction indicated by the coach. The coach observes the direction of the muzzle and provides the gunner any necessary corrections. Once the gunner is able to react quickly and change the lay of the gun as instructed, the gunner is ready to continue the exercise.

Advanced Manipulation Exercise. After the gunner understands and applies the principles of sighting and aiming and can assume a satisfactory firing position, the gunner learns to manipulate the gun to obtain an accurate initial lay and shift the gun to successive points. This exercise instills precision and proficiency in the third and fourth fundamentals of machine gun gunnery—mechanical skill in manipulation and speed.

The advanced manipulation exercise uses either a basic machine gun target or another set of suitable aiming points. and begins with the gun on the appropriate battlesight setting. The coach, who is the team, squad, or section leader, announces an initial aiming point, range, and method of engagement, such as, "*Paster number five to paster number six, eight hundred, traverse and search*." After giving the first element, the coach pauses long enough to permit the gunner to repeat it, then provides the second element. The gunner repeats the instruction upon receiving the command and then sets the sight, lays the gun on the designated paster, assumes the correct gunner's position, and reports "*Up*." Once the gunner reports the gun is up, the unit leader commands "*Fire*." The gunner then simulates firing a burst, shifts to the next paster, and simulates firing until the exercise is completed. The gunner aims and simulates firing a burst at each aiming space between the numbered pasters. While the gunner is performing these operations, the coach at each gun does the following:

- Checks the sight setting and initial lay.
- Ensures that the gunner simulates firing a burst before manipulating the gun.
- Checks for proper manipulation.
- Checks the lay of the gun after manipulation is completed and critiques the gunner's performance during the exercise.

After each engagement gunners shift between banks of targets and engage all banks of the target—the unit leader gives subsequent commands. The exercise is continued until the unit leader is satisfied with each gunner's performance.

> *NOTE:* Traversing and searching a target is accomplished by laying on the initial aiming paster (number 5 or 6) and then shifting to each of the other numbered pasters in order (5 through 10, or in reverse order). All major shifts in traverse (i.e., from pasters 5 to 10, 6 to 9, or the reverse) are performed by loosening the

traversing slide lock lever and moving the traversing slide to the left or right along the traversing bar. All small direction shifts, such as from pasters 5 to 6, 7 to 8, or the reverse, are performed with the traversing hand wheel. One click on the T&E mechanism hand wheels moves the strike 1 mil or 1 centimeter on the target at a 10 meter range.

METHODS OF LAYING THE GUN

Techniques of fire, which refers to methods of applying fire to a target, have two general categories: direct lay and indirect lay.

Direct Lay

The direct lay technique of fire lays a machine gun where the sights are aligned directly on the target. It is the simplest, fastest, and most effective method of engaging a machine gun target; however, it exposes the machine gun unit.

Direct Lay Techniques. Four direct lay techniques are discussed in the following subparagraphs.

Exposed Direct Lay. The exposed direct lay method is direct-laying the gun when the gun and crew are fully exposed to enemy observation and direct fire. This method of direct fire is accomplished by setting the gun on an unconcealed hilltop or forward slope. It assumes the responsibility of either establishing immediate fire superiority with the gun or suppressing the enemy by other means to reduce the enemy's ability to observe and/or return fire.

Partial Defilade. A machine gun is in partial defilade when a mask (i.e., a natural or artificial obstacle) is providing the gun and gunner some degree of protection from enemy direct fire, but the gunner is still able to engage the target using direct lay techniques. The gun is far enough up the mask so that the gunner can see the target through the sights, but the lower portion of the gunner's body and lower portion of the gun are protected by the mask. Partial defilade positions are desirable when a fire mission cannot be accomplished from a full defilade position.

Final Protective Line. The FPL method of direct laying the gun in the defense is used to place a barrier of fire between friendly positions and a close-in enemy assault. This type of lay is designed to produce flanking enfilade fire. It is usually oriented along the long axis of the tactical wire on the approaching enemy's side.

Principal Direction of Fire. The PDF method of direct laying the gun in the defense is intended for applying fire with respect to the ground along an avenue of approach. It is a specific direction within the sector of fire given to the weapon system which is designated as its primary fire mission. This type of lay is designed to produce frontal enfilade fire.

Direct Lay Components. Laying a gun consists of orienting it in a particular direction and at a specific angle to the horizon for the purpose of applying fire to a target. The three components to the lay of any machine gun are direction, elevation, and point of initial lay.

Direction. The direction component is accomplished by orienting the sights and horizontal axis of the bore in the desired direction or at a particular target. Since the projectile follows a straight line that extends from the muzzle to the bore and the sights of a gun are aligned to the vertical axis of the bore, laying a gun for direction during direct laying is simple and extremely accurate. The direction's precision is limited only by the gunner's ability to visually acquire the target and establish proper horizontal sight alignment.

Elevation. Elevation is accomplished by manipulating the T&E mechanism to impart an angle on the vertical axis of the bore. Since a projectile's curved trajectory is the result of both the angle of the bore and the effects of gravity, the axis of the bore can either be elevated to increase the range to impact or depressed to decrease it.

Since a machine gun's mechanical sights are calibrated to the trajectory of its projectile, direct laying a gun for elevation is achieved by estimating the range to target and then setting the sights to the corresponding range. Once the sights are set, the elevation component is completed by manipulating the T&E mechanism to lay the aligned sights on a six o'clock hold to the target.

Point of Initial Lay. The point of a target that a gun lays and fires its initial burst at prior to traversing or searching. Therefore, the point of initial lay is the final necessary component to the proper lay of a machine gun because it is the component that directly concerns applying fire to the target. Once the direction and elevation have been established, the lay is completed by manipulating the gun to its point of initial lay on the target.

Direct Lay Methods. The direct lay technique of fire is suited to both offensive and defensive machine gun employment. However, the methods of direct laying machine guns to support offensive maneuver are simpler than the methods employed when laying machine guns in the defense.

Offense. In the offense, machine guns are most commonly employed to suppress or neutralize enemy personnel or crew-served weapons from an SBF position. To accomplish this in direct lay, the guns should be sighted for partial defilade fire and laid according to the rules of target division and fire distribution, as explained later in this chapter.

Defense. In the defense, the long-range, close defensive, and final protective fire (FPF) of the machine gun provide an integral piece of the defensive scheme of maneuver. Machine guns laid for long-range fires can be used by either indirect laying or as a mobile defense. They are laid for close defensive fires very similar to how they are laid for offensive fires—sighted optimally in partial defilade and protected in a machine gun fighting position. However, FPFs require distinct and specific procedures for direct laying.

Indirect Lay

The indirect lay technique of fire lays a machine gun so that the target cannot be seen from the gun position, which requires some other means of aiming. The indirect lay technique offers more protection to the crew than the direct lay, but is more difficult to control. The types of indirect lay are discussed in the following subparagraphs.

Defilade Fire. Defilade fire is the application of fire from a protected position (see Figure 2-18). There are varying degrees of defilade fire, each classified by the corresponding type of defilade position—partial or full—from which the gun can be fired.

As previously discussed, partial defilade for an indirect lay is the same as it is for direct lay. Full defilade fire is delivered from a position that protects the gun and crew from enemy observation and direct fire. This protection is usually provided by a mask, which is between the muzzle of the gun and the target. The relationship of the gun to the mask requires that the gun must fire up and over the mask to apply fire to the target. Full defilade fire must be observed and adjusted by an observer, usually a squad or section leader, who can observe the target from a position to the flank or rear of the gun that is positioned on higher ground.

The two types of full defilade are *minimum* and *maximum*. Minimum defilade is a type of full defilade position in which the gun is as close to the mask as possible without exposing the gun or crew to direct fire or observation by the enemy. Maximum defilade is a type of full defilade position in which the gun is as far away from the mask as possible, offering full masking of the auditory and visual signature of the gun and allowing the crew maximum freedom of movement in and around it.

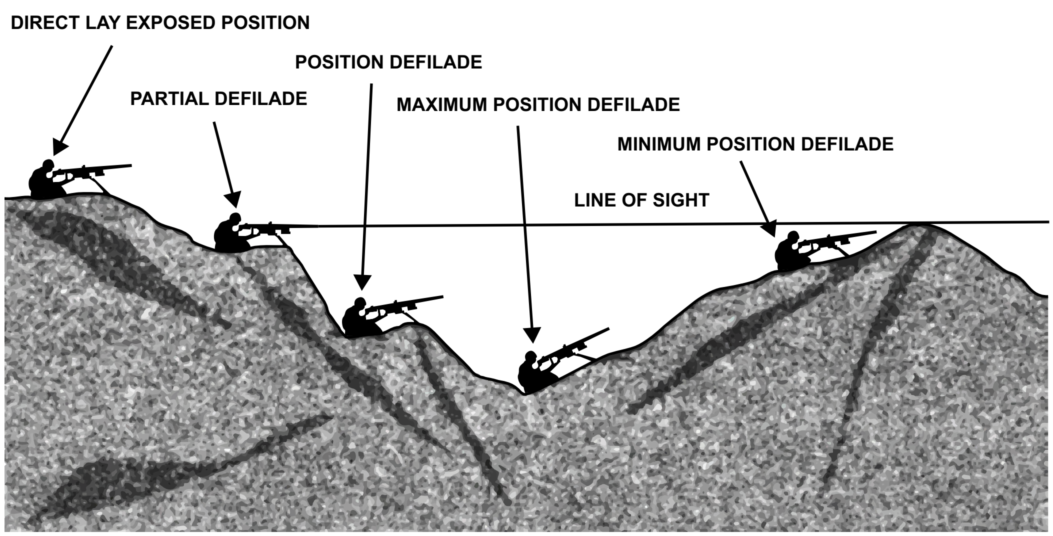


Figure 2-18. Types of Machine Gun Defilade.

Direct Alignment. Direct alignment is the method of laying the gun for direction by visual alignment with the target. See Chapter 3 for more information.

Aiming Point Lay. Aiming point lay is the method of laying a gun for direction by means of an aiming point (i.e., a natural feature) along the gun-target line or an offset aiming point that is not along the gun-target line.

Aiming Stake Lay. Aiming stake lay is the method of laying the gun for direction by means of an aiming stake that is placed along the gun-target line between the muzzle of the gun and the mask. See Chapter 3 for more information.

Compass Lay. Compass lay is the method of laying the gun for direction by means of a compass. See Chapter 3 for more information.

Classifications of Positions and Sectors of Fire

The three classifications of positions for machine guns are primary, alternate, and supplementary.

Primary. The primary position is the main fighting position for a machine gun team—the point from which the team's primary mission is fired. A primary mission can be any one of the defensive machine gun roles. The position is selected that will best support multiple roles of machine gun defensive fires. The gunner is assigned a sector of fire for a primary mission that is based on terrain, enemy capabilities, and anticipated enemy maneuver.

Alternate. The alternate position is an entirely new location, from which the machine gun team can still accomplish its primary mission. It is occupied only after the primary position becomes untenable or unsuited for carrying out that mission.

Supplementary. The supplementary position is established when a gun is given multiple missions that cannot be covered from the primary position. Therefore, the gun may need to be fired from this position.

Laying on Predetermined Targets

To engage targets in the defense, a machine gunner must be able to lay the gun during all levels of visibility. This is accomplished using predetermined targets (e.g., targets that have been determined in advance and recorded by means of firing data from the T&E mechanism and tripod [T&E data]). Direction and elevation readings are the data necessary to engage a predetermined target. These readings are taken from the traversing bar and the T&E mechanism. When possible, this data should be determined to the nearest mil. The ability to record and fire predetermined targets is a prerequisite skill for employing a machine gun in the defense and laying a gun for either an FPL or PDF.

Recording a Target. The following steps are required to record a target:

1. Estimate the range to a predetermined target and set the sights to that range.
2. Manipulate the T&E mechanism to lay the gun at 6 o'clock on the predetermined target.
3. Determine the direction to the nearest mil by reading the mil setting on the traversing bar and either adding or subtracting the mil setting on the micrometer scale of the traversing hand wheel.
4. Determine the elevation by reading the upper elevating screw and the elevating hand wheel.
5. Record the T&E data on the range card when both the direction and elevation have been determined.

Relaying the Gun on a Recorded Target. The following steps are required to relay a gun on a recorded target:

1. Acquire the T&E data for the desired target from the range card.

2. Manipulate the traversing slide or traversing hand wheel so the direction reading on the traversing bar and micrometer scale are correct.

3. Manipulate the elevating hand wheel so the elevation reading is correct.

Upon completing these steps, the gun will be layed on the target.

> *NOTE:* Once T&E data is applied for a recorded target, it is not necessary to set the sights for the range to the target in order to achieve proper effects. This is what makes this technique appropriate for all levels of visibility.

Considerations for Final Protective Fires

An FPF is an immediately available, prearranged barrier of fire that is designed to impede enemy movement across defensive lines or areas. For machine gun crews, the FPF entails firing either an FPL or a PDF. Final protective fire is employed only when the enemy has maneuvered through the close defensive fires and is only authorized by the unit commander or higher authority.

Final Protective Line. An FPL is a predetermined line of grazing machine gun fire designed to break up an enemy assault and is the basis of the defensive fires of a unit. It is optimally as close and as parallel to the defensive lines as possible, and usually produces flanking enfilade fire. A gun intended for an FPL should be sighted to produce the maximum amount of grazing fire that the terrain will permit. The FPL is the most preferred method of laying a gun for the FPF.

The fire produced by an FPL is usually fixed for direction and elevation, and it can be fired under all visibility conditions. When fixed fire is incapable of producing an optimal amount of grazing fire because of irregularities in the terrain, some searching fire that is a few mils downward may be employed to cover dead space and prevent the enemy from crawling under the cone of fire. Dead space that cannot be covered by a few mils of search should be assigned to other direct fire or indirect fire weapons in the defense. If an FPL is short because of a non-uniform slope, the gun can also be searched upward a couple of mils to extend the range of the FPL.

When a gun is assigned an FPL, the priority target in its primary sector of fire is the FPL. Therefore, except when targets of opportunity within a gun's primary sector are being engaged, the gun should be laid on the FPL.

Principal Direction of Fire. A PDF is a predetermined line of machine gun fire covering the most likely or dangerous avenue of approach. The PDF is the least preferred method of laying a gun for an FPF.

Because it is laid on an avenue of approach, a PDF usually produces frontal enfilade fire by means of either plunging or grazing fire. If grazing fire cannot be achieved by laying the gun on an FPL, then grazing fire on a PDF is the next preferred method of lay. Unlike an FPL, both searching and/or traversing fire may be employed on a PDF to the extent necessary to maximize the effect of the beaten zone on the target area.

When a gun is assigned a PDF, the priority target in that gun's primary sector of fire is the PDF. Therefore, except when targets of opportunity within a gun's primary sector are being engaged, the gun should be laid on the PDF. Methods of laying guns are discussed later in this section.

Sector of Fire and Assignment of Mission. The primary sector of fire is defined by the limits of the tripod, which are 800 mils wide for an HMG and 875 mils wide (i.e., 45 degrees) for a medium machine gun. The tripod's legs restrict elevation at the extreme right and left of center. Each team in a squad will cover the same sector. This ensures redundancy in coverage of the sector, reduces the amount of ammunition needed to cover the sector, and allows for more than one target at a time to be engaged within the sector.

Although the maximum sector that is available on the medium machine gun tripod is 875 mils, defensive sectors in excess of 800 mils should not be assigned consistently. When at all possible, both teams of a squad should be assigned the same mission (i.e., either FPL or PDF) because of limits and coverage. When the squad is assigned an FPL, the inner limit of each team's or squad's sector will be the FPL. If the squad is assigned a PDF, the zero line or center of each team's sector will be the PDF. When the sector of fire does not include a FPL, then a PDF is used.

A squad sector of fire will contain either a FPL or a PDF, but never both, for the following reasons:

- When an FPF mission (i.e., FPL or PDF) is a primary mission; a gun cannot have two primary missions.
- The assignment of a sector of fire in conjunction with the target precedence and engagement criteria issued by the company commander allows the gunner to engage targets of opportunity that are not along the FPL.
- When the command to fire the FPF is given, there can be neither doubt concerning which mission the gun is supposed to fire nor hesitation in firing the gun on that assigned mission.

Engagement. The squad is responsible for engaging the enemy within its sector and subjecting the enemy to close defensive fires as the enemy approaches based upon the target precedence and engagement criteria issued by the company commander. Unless engaging other targets within the sector, a gun will stay laid on its primary mission (i.e., FPL or PDF).

If the close defensive fires are unsuccessful at repelling the enemy's assault, the company commander will issue the command to fire the FPF. If the command to fire the FPF is given, each machine gun immediately lays on either its FPL or PDF and begins firing at the prescribed rate. Once the command to fire the FPF is given, each machine gun team continues firing its assigned mission (i.e., FPL or PDF) until either its ammunition supply is exhausted or until it is issued a subsequent fire command.

Rates of Fire. When the signal to fire the FPF is received, the gunner immediately begins firing at the rapid rate for two minutes. From the two-minute mark until a subsequent fire command is issued, the gunner fires at the sustained rate of fire unless otherwise directed.

Methods of Laying Final Protective Lines

Once the considerations for FPFs are understood, the following guidelines should be followed for laying machine guns on FPLs.

> *NOTE:* To keep the enemy beyond hand grenade range, the FPL should be located at least 50 meters forward of the line of friendly defensive positions and tied in with a proper barrier plan.

Final Protective Lines over Level or Uniformly Sloping Ground. Uniformly sloping ground is the optimal terrain for using an FPL to achieve maximum grazing fire. For example, a M240B sighted over level or uniformly sloping ground can be laid for a center of impact at 600 meters. When properly laid for this range, the center of the cone of fire will not rise above one meter, the upper bound of the cone of fire will not rise more than 1.8 meters, and the maximum dead space produced will be 31 inches (occurring at an approximate range of 300 meters from the gun). A gun that is sighted to produce an FPL over level or uniformly sloping ground should be laid as discussed in the following subparagraphs.

Direction. To determine direction, the gunner zeroes the T&E mechanism. Upon determining the limit of the sector in which the FPL is to lie, the gunner sets the traversing slide to the end of the traversing bar opposite the direction of the FPL. By doing this, the gunner obtains the maximum angle of traverse away from the FPL in the direction of the gunner's sector of fire.

Next, the gunner lifts the rear legs of the tripod and aligns the muzzle on the line of the FPL. The gunner then records the direction of the muzzle, the reading on the traversing bar scale, and the reading on the micrometer scale (which should be 0) for the T&E data.

Elevation. To determine the elevation, the gunner selects an aiming point along the FPL at a range of approximately 600 meters (for the M240B) or 700 meters (for the M2A1). The gunner manipulates the elevating hand wheel until the sights are laid at six o'clock to the aiming point and then records the combined reading from the elevating scale and elevating hand wheel (proper recording of T&E data is discussed earlier in this chapter).

Confirmation. If the tactical situation permits, the FPL should be confirmed by firing.

Final Protective Lines Over Irregularly Sloping Ground. Level ground or ground that slopes uniformly for 600 meters or 700 meters is not often available on the battlefield. A gun that is sighted to produce an FPL over irregularly sloping ground should also be laid with respect to direction, elevation, and confirmation.

Direction. The gunner lays the gun for direction and records the data as described for level ground.

Elevation. The gunner selects an aiming point on the ground and near the break in the uniform slope as follows:

- Estimate the range to this point and set the sights to that range.
- Lay the gun on the aiming point and then elevate the gun by two mils.
- Record the combined elevation data.

Confirmation. If the tactical situation permits, the FPL should be confirmed by firing.

Dead Space Considerations for Final Protective Lines. Dead space is that portion of the FPL that cannot be covered by grazing fire and exists any time that the center mass of a person's chest falls below the line of aim. Streams, ravines, and small depressions in the ground may allow the enemy to pass underneath the grazing fire along the FPL. Therefore, this dead space must be accurately determined so that it can be covered by other direct fire or indirect fire weapons. The primary and most accurate means of determining dead space along an FPL is to walk it.

> *NOTE:* Because of the importance of a machine gun's FPL to the overall defense, machine gunners should always walk the full extent of their FPL to determine what type of terrain exists along its length and familiarize themselves with other crucial areas within their sector of fire.

Walking the Final Protective Line. Once the machine gun squad leader has determined the general position for the guns, the guns should be sighted and laid immediately to ensure that they cover the assigned sector of fire and mission (i.e., PDF or FPL). The squad leader should identify definitive terrain features to each machine gun team when prescribing the sector and mission. Whenever an FPL is assigned to a gun, the crew should first walk the FPL. Walking the FPL allows the team to determine the extent of the grazing fire and danger space that are available and to locate and mark any dead space in the FPL. An FPL should be walked as follows:

- The gunner should ensure the gun is laid on the FPL and locked into place on the tripod and that the T&E data is recorded prior to walking the FPL. The gunner should also check that the sights are set to the maximum range of the FPL that the terrain permits and that the sights are set to 6 o'clock on the FPL's aiming point.
- The team leader or ammunition bearer then walks along the FPL using a standard pace. To ensure accuracy, the individual's pace count must be known beforehand.
- The gunner shouts "*Mark"* whenever the center of the walker's chest disappears from view as the walker is walking the FPL.
- The walker stops and records their pace count to that point when the gunner shouts "*Mark*."
- The walker then continues and as soon as the gunner can again see the walker's body below the center mass of the walker's chest, the gunner shouts out "*Mark"* again.
- The walker stops again and records their pace count to that point.

This procedure is continued until the walker either reaches the limit of grazing fire for the gun or reaches a break in terrain that determines the extent of available grazing fire. The pace count recorded in this manner will show the near and far limits of each section of dead space along the FPL. Once the near and far limits of each dead space zone are determined, they are annotated on the range card according to the details in Chapter 4.

> *NOTE:* Using the center mass of the chest as the point where dead space begins takes into consideration the factors of danger space, maximum ordinate, and maximum dead space. But using the gunner's view of a person's waist (an approximate measure of the 1 meter height of grazing fire) as the point where dead space begins is too limiting as a tactical measurement of fire over actual terrain. To use this as a tactical measurement would disregard the effective danger space created by the lower portion of the cone of fire. However, if dead space is not marked until only a person's head is visible to the gunner, then a significant amount of dead space would have been overlooked and unmarked prior to that point. This is based on the measure of maximum dead space at 600 meters or 700 meters.

Therefore, the use of the center mass of the chest as the measuring point for dead space is a compromise between these two considerations.

Laying the Gun for a Principal Direction of Fire

When conditions prevent the use of an FPL, guidelines with respect to direction, elevation, and confirmation should be followed for laying a machine gun on a PDF.

> *NOTE:* The gun is fired, employing traverse and search to cover the entire target. The number of mils of traverse and search necessary to cover the target should be recorded on the range card and a firing sequence established.

Direction. To determine direction, the gunner zeroes the T&E mechanism. The gunner centers the traversing slide at zero on the traversing bar scale, which is known as the zero line. The gunner then lifts the rear legs of the tripod and aligns the gun on the near end of the PDF as designated by the squad leader.

The PDF should bisect the machine gun team's sector of fire because it is established on the zero line. The traversing bar reading of zero is recorded on the range card.

Elevation. To determine elevation, the gunner selects the near end of the PDF as an aiming point and estimates the range to that point. The gunner sets the sights on the appropriate range and lays the sights at six o'clock to the aiming point. The gunner then records the combined elevation data for the aiming point and traverses/searches the extent of the target area on the PDF as designated by the squad leader. The team leader and gunner establish a set sequence for engaging the target area on the PDF. The gunner records the T&E data for the limits of the target area and the sequence of engagement on the range card.

> *NOTE:* When firing a PDF, the gunner is allowed to traverse and search over the entire target area.

Confirmation. If the tactical situation permits, the FPF should be confirmed by firing.

Field Expedient Methods of Lay

Field expedient methods of laying the gun may be necessary at times to ensure the proper employment of automatic fires against predetermined targets. The use of T&E data is always the most accurate method for engaging predetermined targets; however, this method may require the use of artificial light at the gun position during periods of reduced visibility. Field expedient methods may be used to supplement the T&E method. Five such methods are discussed in the following subparagraphs.

Base Stake Method. The base stake method is the simplest field expedient way to define both sector limits and the FPL or PDF when a sector smaller than the limits afforded by the tripod is required. This method may also be used when establishing sectors for bipod-mounted guns (i.e., primary sector for M249 or secondary sector for M240B).

If the gun's sector is smaller than the maximum limits of the tripod, the sector limits are defined as follows (see Figure 2-19):

- Lay the gun on each side of the sector and drive a stake into the ground so that the barrel will strike the stake when the gun is traversed to its sector limits.
- Ensure that the stake is planted solidly, because a weak stake may yield to the force of a machine gun team in action.
- Define the lower elevation limit of the FPL or PDF by driving a stake into the ground (under the gas cylinder of the medium machine gun or the barrel support of the HMG) to the height needed to define the elevation of the appropriate mission. This stake is known as the base stake.

  NOTE: The T&E mechanism is still used when the base stake method is employed. This field expedient method will seriously limit the ability to quickly and effectively engage targets outside of a small primary sector.

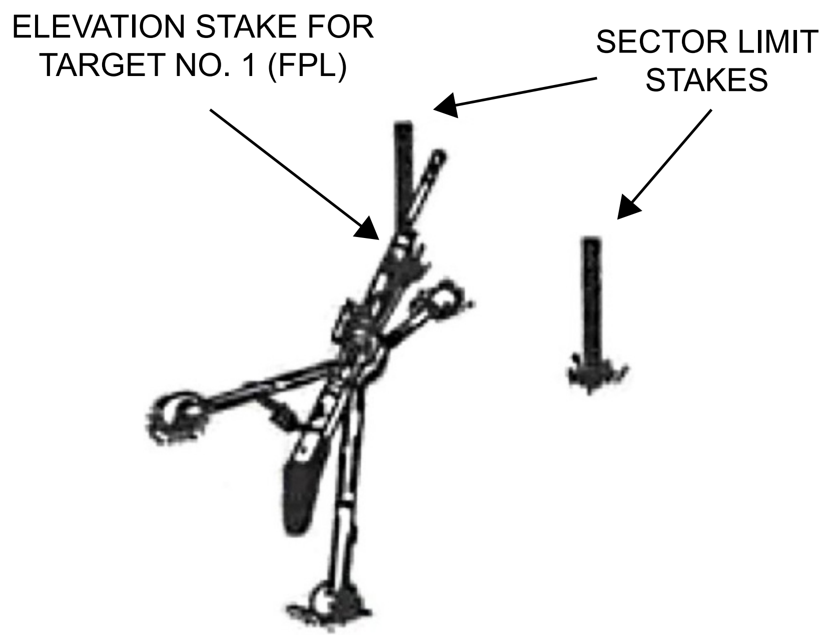


Figure 2-19. Base Stake Method.

Luminous Aiming Stake Method. The luminous aiming stake method is useful for marking the position of the gun to engage multiple targets within the team's sector of fire at night (see Figure 2-20). Luminous tape, luminous paint, or some other suitable material is required to use this technique. To perform the luminous stake method apply the following steps:

1. Place a strip of luminous tape or paint on the back edge of the front sight post (HMG or grenade machine gun) or the front sight housing (light machine gun or medium machine gun).
2. Raise the rear sight leaf and place a strip of luminous material on the backside of either of the long edges of the leaf.
3. Start at either side of the sector and lay the gun on the first target.
4. Place a strip of luminous material near the top of a stake, situated vertically and on the edge.

5. Move the head slightly to either side so that the front sight post is aligned to the outer edge of the sight leaf, adjacent to the luminous material on the leaf.

6. Have the ammunition bearer drive the stake into the ground approximately one meter in front of the gun. Align the stake so the three pieces of luminous material are adjacent and aligned for direction and the top edges of all three stakes are level (i.e., aligned for elevation). The offset between the front sight and sight leaf will not affect the lay of the gun, but will ensure that the stake does not interfere with the trajectory of the rounds.

7. Continue this process until one stake is set out for each target.

8. To engage a target during reduced visibility, raise the sight leaf and manipulate the gun until the correct sight picture is obtained.

WARNING: The luminous aiming stake method should not be used with the MK-19. The minimum arming distance of the M430 and M430A1 warheads is 18 meters. The kill radius is approximately 5 meters and the wound radius is approximately 15 meters. Death or serious injury could occur to individuals who fire the MK-19 using the luminous aiming stake method. Therefore, this laying technique should be avoided.

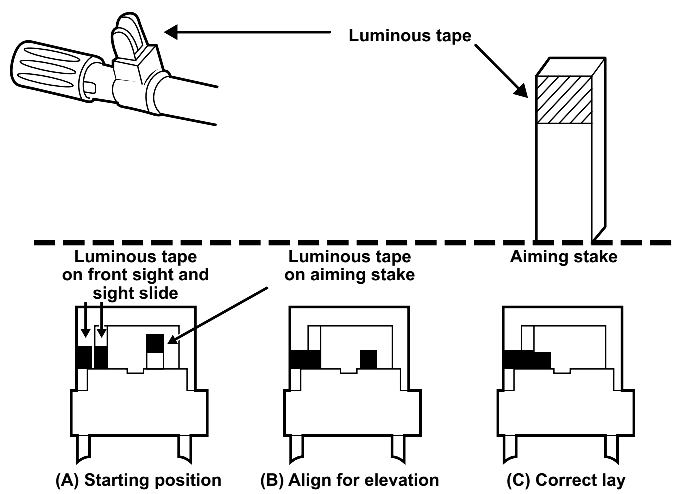


Figure 2-20. Luminous Aiming Stake Method of Field Expedient Lay.

Forked Stake Method. When the light machine gun is being used in the defense or the medium machine gun is being employed in a supplementary sector where the bipod mount is being used, the gun can be laid to engage predetermined targets by using forked stakes as follows (see Figure 2-21):

- Drive a forked stake into the ground just forward of the bipod. This will be the pivot stake.
- Drive one forked stake for each target into the ground and to the rear of the pivot stake, positioned so the notch on the underside of the buttstock will rest in the crook of the forked stake. This will be the stock stakes.

NOTE: The stock stakes are aligned to the pivot stake to provide direction. They are driven into the ground to a point that provides proper elevation. One stock stake is used for each target. Shallow trenches or grooves should be dug to accommodate the bipod feet of the light machine gun or medium machine gun.

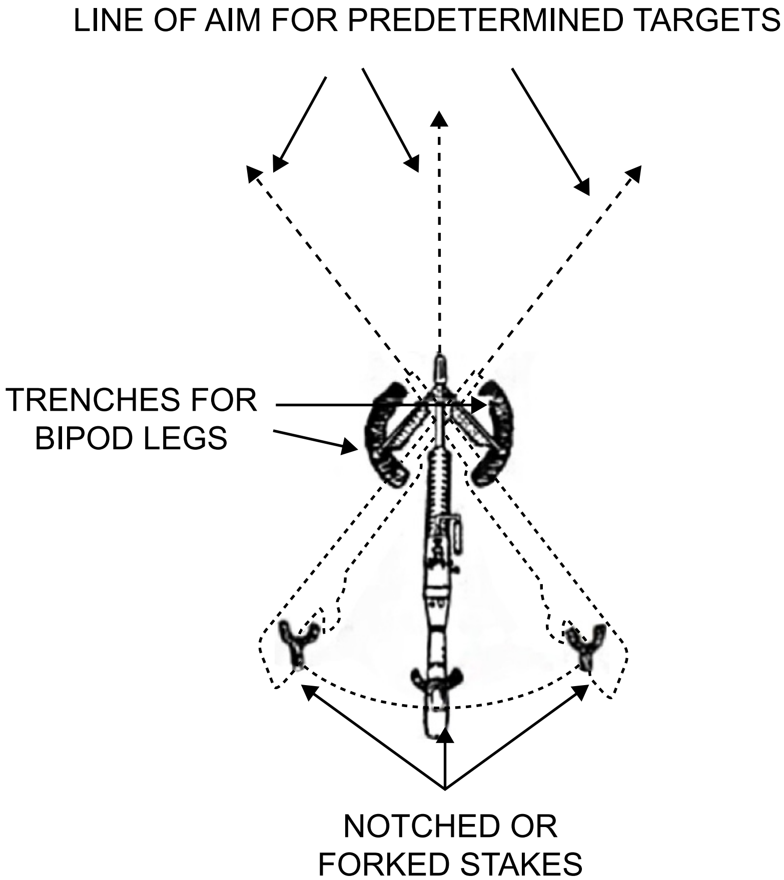


Figure 2-21. Forked Stake Method.

Sandbag Sector Method. The sandbag sector method (see Figure 2-22) is an effective and practical method for establishing a field expedient sector of fire when laying a bipod-mounted gun on a primary (M249) or secondary (M240B) sector. This method of lay clearly and accurately designates the sector of fire and improves the survivability of the position. This method is preferred to the base stake method because the crew does not have to rely on vegetation for stakes and the sandbags provide more stout and durable limits that are easily emplaced, modified, and reusable. Sandbags also enhance crew survivability. The sandbag sector method is performed as follows:

- One crew member carries seven empty sandbags in their pack.
- Sandbags are filled by the crew with the initial spoilage from the fighting position once the gun is sighted and digging has commenced.
- Dirt, sand, gravel, or any substance of similar consistency may be used in an urban environment.
- The first three sandbags are placed flat in front of the gun, with their long sides perpendicular to the direction of fire to form a triangle—two bags closest to the enemy and one bag on the friendly side.

- A two-inch gap must be left between the two forward bags and the one closest to the friendly side to accommodate the bipod legs.
- The remaining four sandbags are placed on top of the outer edge of the three-sandbag base, with the inner edge of the bags defining the sector of fire by contacting the handguard and receiver of the M249 or the barrel and receiver of the M240B.

NOTE: This is best accomplished by laying each sandbag down and positioning it along the sector of fire while one crewmember lays the gun on its right and left limits.

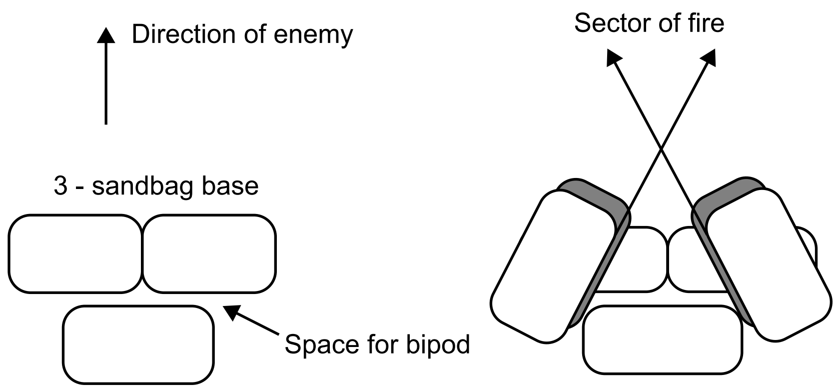


Figure 2-22. Sandbag Sector Method of Field Expedient Lay.

Reference Point Methods. When the target is invisible to the gunner or is exceptionally difficult to see during periods of normal visibility, fire may often be directed by use of a reference point (see Figure 2-23). A reference point is an easily discernible feature, whether natural or man-made, that lies either within or outside of the target area. When the selected reference point is outside the target area, the gunner is directed onto the target as follows:

- The squad leader identifies the reference point and announces it to the gunners.
- The direction and distance from the reference point to the target are announced.
- The range to the target is announced.
- The gunner measures the interval between the reference point and the target by laying the gun on the reference point, with the sights set at the range to the target, and shifting the gun the designated number of mils.

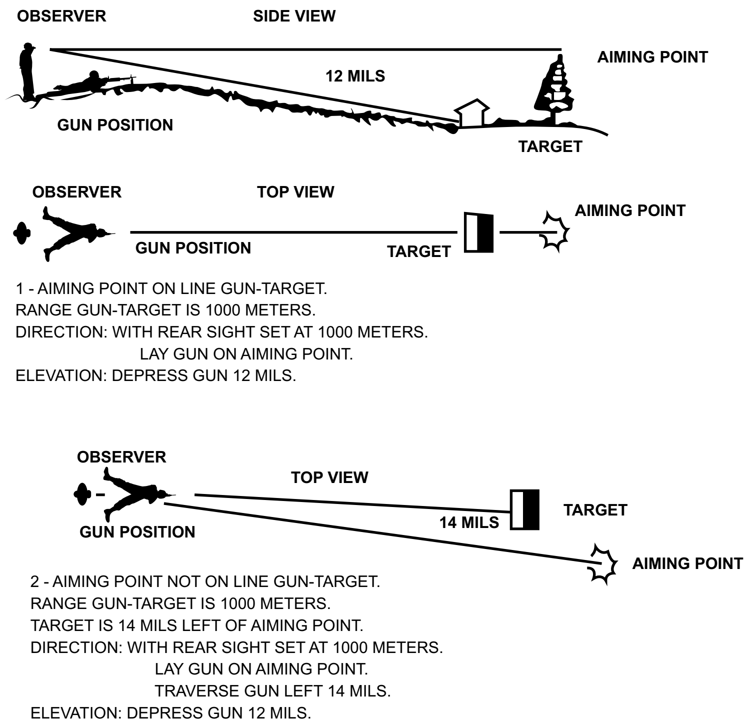


Figure 2-23. Aiming Point Method.

When the selected reference point is inside the target area, the gunner is directed onto the target as follows:

- The squad leader identifies the reference point and range to the point and announces them to the gunners.
- The gunner lays the gun on the reference point with the sights set to the announced range and engages the target.

FIRE CONTROL

Fire control for machine guns includes all actions connected with preparing to apply fire to a target. It implies the ability of the leader to open fire at the desired instant, adjust the guns' fire on the target, regulate the rate of fire, shift fire from one target to another, and cease firing. The ability to exercise correct fire control depends primarily on the discipline and correct technical training of the gun crew. Failure to exercise correct fire control will result in danger to friendly troops, the loss of surprise, the premature disclosure of the position, the misapplication of fire on unimportant targets, loss of time in securing adjustments, and waste of ammunition.

Chain of Fire Control

The chain of fire control follows the chain of command. Fire control of a machine gun unit is exercised, at the highest level, by the platoon commander or platoon sergeant for medium machine guns, or the machine gun platoon commander for HMGs. At the lowest level, it is exercised by the squad leaders. All commands from the squad leader are transmitted from the team leader to the gunner. See Figure 2-24 for the standard arrangement of a machine gun unit.

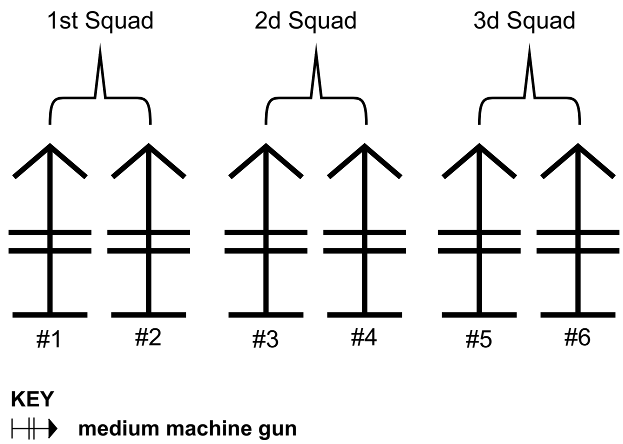


Figure 2-24. Standard Arrangement of a Medium Machine Gun Unit.

Platoon Commander. The platoon commander issues instructions to the section leaders either orally or in a written five-paragraph order. These orders accomplish the following:

- Assigns a mission to the section, or to its squads if they are to act in direct support of a unit.
- Identifies the firing position that the section or squad is to occupy and the targets to be engaged.
- Identifies the sector of fire to be covered.
- Identifies the exact location of any friendly troops that may be endangered by the fire of the machine gun unit.
- Identifies the technique to be used when engaging targets.

The section leader, in conjunction with the squad leaders, may be assembled for issuing orders or, if the situation dictates, the platoon leader may issue individual orders to the unit leaders. If the squads are widely separated in a defensive situation, the platoon leader may send written instructions to the squad leaders or may relay the transmission by radio. Platoon commanders generally do not issue fire commands orally because this responsibility lies with the section/squad leaders.

Section Leader. The machine gun section leader in the HMG platoon is responsible for both the tactical and technical employment of the section. It is the section leader's responsibility to ensure that the squads receive any direction issued by the platoon commander concerning firing position, targets to be engaged, sectors of fire, the location of friendly troops, and adjusting fire.

Squad Leader. The machine gun squad leader carries out the instructions of the section leader or platoon commander. The squad leader is responsible for directing both the fire control and fire discipline of the squad and focusing on the observation, adjustment, and rate of fire. The squad leader chooses the exact firing positions of their guns and the tactical and technical employment of their squad.

Team Leader. The machine gun team leader in the weapons platoon is the direct link between the commands of the squad leader and the actions of the gunner. The team leader is responsible for implementing commands from the squad leader by directing the gunner accordingly. The team leader ensures the quality of the gunner's machine gun gunnery and the technical employment of the gun.

Ammunition Bearer. The machine gun team's ammunition bearer is an essential link in the chain of fire control. The ammunition bearer provides ammunition and assists in the service of the gun. The ammunition bearer watches the squad/section leader for fire control signals and then passes them on to the team leader. The ammunition bearer also maintains a constant visual and verbal link between the squad/section leader and the team leader. The ammunition bearer must resist the temptation to observe the fire of the gun in order to maintain this link.

Machine Gun Fire Unit

A squad of medium machine guns is the basic machine gun fire unit. Whenever practical, at least two medium machine guns are assigned to the same mission, although occasions may arise when single guns may be efficiently employed. The assignment of a squad of guns to a single mission ensures continuous fire in case either gun is taken out of action, either temporarily or permanently. This assignment also provides a greater volume of fire on the target, reduces the amount of time required to cover the target, and economizes ammunition consumption (see Appendix E).

To ensure that the machine gunners in a squad can remain constantly aware of the portion of a given target that they might engage, positions within the squad and the section are numbered as follows:

- Guns are always numbered from left to right. Gun 1 will always be the left gun and gun 2 will always be the right gun.
- Squads will also be arranged from left to right if a section leader has arrayed the entire section for firing. The first squad will be on the left, the second squad in the middle, and the third squad on the right. The squad leader refers to the guns as gun 1 through 6, from left to right.

Sectors of Fire

A sector of fire (see Figure 2-25) is a section of terrain designated by specific boundaries and covered by the fire of the unit to which it is assigned. Sectors of fire vary in size, but are usually limited to the area that can be engaged without removing the T&E mechanism from the traversing bar or moving the tripod. These sectors of fire are a fundamental component of machine gun fighting positions and machine gun employment in the defense. A sector of fire may also refer to the portion of a target that is the responsibility of an individual machine gun team or squad.

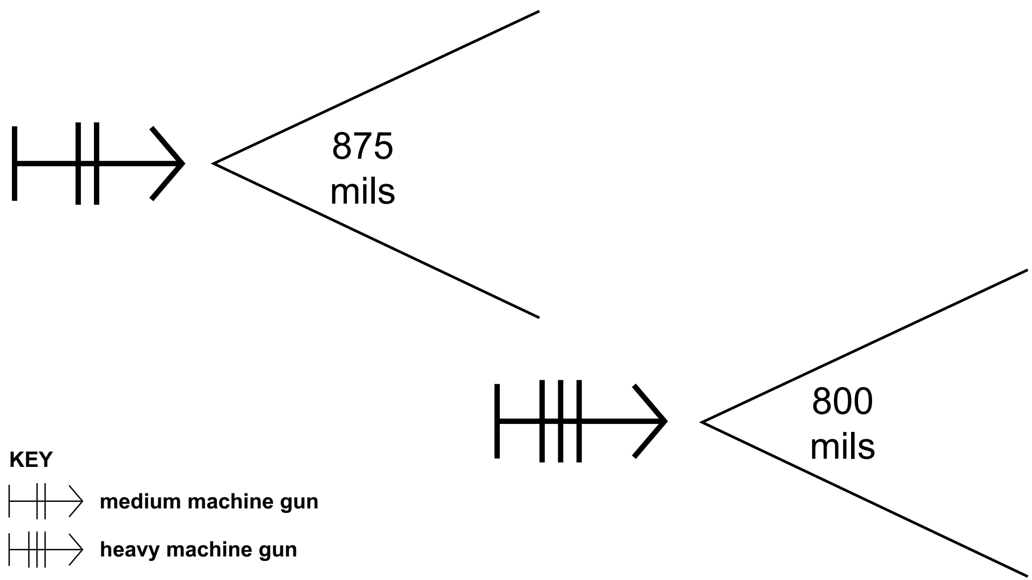


Figure 2-25. Sectors of Fire for Medium and Heavy Machine Guns.

Rates of Fire

The greatest surprise and shock effect is obtained by combining the maximum rate of fire with the simultaneous opening of the fire of all guns for at least the first few bursts. This also reduces the enemy's ability to return fire. Fleeting targets are engaged as soon as possible with the maximum fire available. The initial delivery of fire, using the rapid rate, facilitates adjusting fire onto the target because of the increased beaten zone signature that the rapid rate produces. If the unit leader does not specify the rate of fire, the rapid rate is used. In all cases, the first few bursts should be delivered at the rapid rate for shock effect and adjusting fire. Thereafter, the prescribed rate is used.

Observation and Adjustment of Fire

Observing and adjusting fire is the most important element of fire control and is continuous throughout the action. Once effects are achieved on the target, fire is adjusted through T&E manipulation to bring fire effectively onto the initial target and any subsequent targets.

Beaten Zone Dimensions. The beaten zone dimensions in Tables 2-1 and 2-2 illustrate how the cone of fire affect the beaten zone over increasing distances for both medium machine guns and HMGs. The beaten zone dimensions are provided in meters and reflect an 82 percent effective beaten zone, not a total beaten zone.

Table 2-1. Medium Machine Gun Beaten Zone Dimensions (82%).

Gun	Range (m)	Width (m)	Length (m)
M240B	500	1	85
	1,000	2	53
	1,500	3	48
	2,000	4	51

Table 2-2. Heavy Machine Gun Beaten Zone Dimensions (82%)

Gun	Range (m)	Width (m)	Length (m)
M2A1	900	0.9	180
	1,800	2.7	81
	3,200	6.4	75

Range Shifts. When firing on field targets, fire is adjusted by moving the burst onto the target. The gunner determines the number of mils that are necessary to move the center of impact onto the target and then manipulates the gun the required number of mils. Lateral shifts are easily figured, but range shifts require an understanding of trajectory at different ranges. To shift the center of impact approximately 100 meters in depth on level ground, refer to the required changes in elevation detailed in Tables 2-3 and 2-4.

Table 2-3. Range Shifts for Medium Machine Guns.

Gun	Range (m)	Elevation Change with M80 Ball (mil)
M240B	100 to 500	1
	600 to 800	2
	900 to 1,000	3
	1,100 to 1,200	4

Table 2-4. Range Shifts for Heavy Machine Guns.

Gun	Range (m)	Elevation Change with M8 API (mil)
M2A1	100 to 1,000	1
	1,100 to 1,500	2
	1,600 to 1,900	3
	2,000 to 2,500	4

Mechanical Adjustment of Fire. The machine gunner, armed with a thorough understanding of the characteristics of trajectory and the capabilities of the T&E mechanism, should quickly become adept at mechanically adjusting fire once training is commenced.

Initial Adjustment of Fire. The gunner sets the sights on the range to the target, lays on the target, and fires an aimed burst, observing the strike or tracer. If the initial burst is correct, the gunner continues to fire, manipulating as necessary until the target is covered by the beaten zone. If the initial burst is not correctly placed, the gunner determines from the strike or tracer the amount of traverse and search that is required to place the next burst on the target and then manipulates the gun accordingly with the T&E mechanism hand wheel. The gunner makes large range corrections by resetting the sights and relaying on the target.

Subsequent Corrections and Adjustments. Every gunner must be trained to observe and adjust fire without command and to check the gun laying frequently. The gunner must also be trained to anticipate the action of the enemy after opening fire and to shift fire to cover any changes in the formation or location of the target.

If the gunner fails to perform corrections and adjustments, the team leader should promptly correct the gunner by verbally announcing or signaling subsequent fire commands.

The responsibility for adjusting fire continues from the gunner, through the chain of fire command, and up through the squad leader. When subsequent fire commands are issued, the gunner makes the required corrections or adjustments and continues to engage the target without further command to fire. When firing the gun from the tripod-mounted position, subsequent commands are given as corrections in elevation and/or deflection from where the last burst was fired. Shifts and corrections have the following characteristics:

- They are provided in mils, announced or signaled as *up*, *down*, *right*, or *left*, and followed by the determined shift in mils.
- They are announced in elevation, then deflection.
- They are performed first in search (i.e., elevation), followed by shifts/corrections in traverse.

> *NOTE:* Because of the length of the beaten zone, traverse is never interrupted to correct the search.

Fire Commands

Fire commands are used to exercise fire control. They are instructions issued to the gun crews that enable them to properly engage the desired targets. The two types of fire commands are initial and subsequent.

The section leader/squad leader determines which elements of the fire command are obvious to gunners and which ones must be given to them. Some target engagements may necessitate including all elements of the fire command, while others may only be engaged with fragmentary commands and are intended to aid machine gunners. Using complete fire commands in training will cause this sequence to become second nature for machine gunners, thus preparing them to understand fragmentary fire commands in combat.

Initial Fire Command. Initial fire commands are issued to command a gun crew to engage initial targets and then shift fire to new targets. Elements in the following subparagraphs are contained in the initial fire command and used for the infantry unit leader. The mnemonic ADDRAC can be used to remember the elements.

A=Alert. The alert is the first element of the initial fire command. Its purpose is to alert the gun crews and prepare them to receive and execute the fire command as follows:

- When both guns of a squad are to fire, the squad leader announces "*Squad*."
- If only one gun is to fire, the squad leader announces "*Gun one* or *gun two*."
- When the squad leader desires to alert both guns in a squad but only wants one gun to fire, the squad leader announces "*Squad, gun one* or *squad, gun two*."

D=Direction. When the target is not obvious, gunners must be told to look in a particular direction to see the target. The direction to a distinct target is given by designating both the general and specific directions (e.g., direct front, right front, or left flank).

The direction to an indistinct target may be indicated using a reference point. The selected reference point must be an easily recognizable terrain feature or object that is in or near the target area and is announced as a reference. For clarity, the target should always precede the target description when a reference point is used. When the selected reference point is within the target area, the target may be indicated as extending so many mils, meters, or fingers from the reference point.

Examples of Using Reference Points within the Target Area

Example 1:
Reference: bunker.
Target: troops extending right two five, left two five.

Example 2:
Reference: tank.
Target: troops extending short one zero, over two zero.

An obscure target may be identified by first designating an obvious feature, such as a reference point, and then leading the gunner step-by-step to the target by naming successive reference points until their attention is directed to the target.

> *NOTE:* When using this method, the measurement of mils is always implied for tripod-mounted guns and bipod-mounted guns.

Example Use of Reference Points Outside the Target Area

Reference: lone tree, right five zero.
Target: machine gun edge of woods.

Example Use of Reference Points Within an Obscure Target Area

Reference: red roofed house-right of house, hedge, center of hedge; gate-above gate.
Target: machine gun.

D=Description. A target description is a word or two used to inform the gunner of the nature of their target. The following words are examples of target descriptions:

- Troops (any dismounted enemy personnel).
- Machine gun (any automatic weapon).
- Armored vehicle (any APC or IFV).

There are several other target descriptors that may be needed for clarification, such as the following:

- Target location: *"The edge of tree line."*
- Several targets: If several targets are in view, then the particular target or part of a target that is to be engaged may be described or announced as *"Leading truck, right building, far end of halted column."*
- Obvious target: If the target is obvious, no description is necessary. Some of the target descriptions may be *"Troops in the open* or *armored vehicles near end of moving column*."

R=Range. The range element follows the target description and is announced in meters (words range and meters are not verbalized):

- *Four five zero* indicates 450 meters.
- *Two thousand* indicates 2,000 meters.
- *One two hundred* indicates 1,200 meters.

The range is announced in even digits, hundreds, or thousands. When a reference point within the target area is used to designate the target, the range announced is to that reference point:

- A reference point within the target area is announced as *"Armored vehicle. Troops in the open. Eight hundred."*
- A reference point outside the target area and target is announced as *"Burning truck, right two hundred, up seven zero. Mortar at edge of road. Six hundred."*

A=Assignment. The assignment element of the fire command is used when specific assignments are required to divide the target among a squad's teams or a section's squads, designate the class of fire (type of manipulation), or specify a rate of fire.

NOTE: It may also be referred to as method of engagement.

Division of a target is given only when required and is discussed in detail in Chapter 2.

Examples of Announcements for Division of a Target

Example 1: If the target is 50 to 100 mils in width, it is divided in half and announced as "*Gun one, right half; gun two, left half*."

Example 2: If the target is more than 200 meters in length, it is divided in half and the range to each end of the target is announced as "*Gun one, six hundred; gun two, nine hundred. Gun one, one thousand; gun two, one four hundred."*

Example 3: If a heavier concentration of fire is desired on a portion of the target, it is announced as *"Gun one, right one-third; gun two, left two-thirds*."

The *manipulation* element of the fire command prescribes both the classification of fire and the density of fire required to effectively engage the target. These elements are given only when the required manipulations are not obvious. Its first element is announced as one of the six classes of fire with respect to the gun—fixed, traverse, search, traverse and search, swinging traverse, or free gun. Its second element is announced as either of the two concentrations of fire—dispersed or dense. Unless concentrated fire is designated, it is understood that dispersed fire will be applied.

The *rate* of fire designated by the section/squad leader may be sustained, rapid, or cyclic. If not announced, the rapid rate is used. The factors that influence selecting the rate of fire are the size and nature of the target and the ammunition supply.

The sustained rate of fire is directed by announcing "*Sustained*."

Rapid rate of fire permits a high volume of fire to be delivered for a fixed and relatively short period of time. Gunners will automatically employ the rapid rate unless another rate is announced. Therefore, unless a rate other than the rapid rate is desired, the squad or section leader omits this element from the fire command.

The cyclic rate of fire, a machine gun's maximum firing rate, is directed by announcing "*Cyclic.*"

C=Control. Initial, repeating, or correcting fire control commands are given during control, as necessary.

Initial fire control commands are for the immediate engagement of a target. The command *"Fire"*, or the hand and arm signal to fire, is given without pause. It is important that machine gun fire be withheld for surprise and maximum shock effect and that both of a squad's guns open fire at the same time. To ensure this, the section/squad leader may preface the command or signal to commence firing by saying *"At my command* or *on my signal*." When the gunners are ready to engage the target, they report *"Up"* to the team leaders, who will either announce *"Gun one (two) up"* or signal to the section/squad leader that they are ready. Once the section/squad leader has received a signal from both of the teams that the guns are up and ready to fire, the command or signal to open fire is given at the appropriate moment.

> *NOTE:* Fire commands should be as brief and concise as possible; therefore, obvious information is omitted when appropriate. All initial fire commands must contain alert, range, and control. The remaining elements may be omitted, but only if they are obvious.

Repeating and correcting is used if the gunner fails to understand any element of the fire command. When this occurs, the gunner may request a repetition of the element by announcing "*Say again*." When repeating any portion of the fire command, the leader will preface it by saying *the command was.* In fire commands, an incorrect portion is corrected by announcing "*Correction"* and then giving the correct command.

Examples of Command Corrections

Example 1: Incorrect range command.
To correct an incorrect range command of 500 to 600 meters, the squad leader announces "*Correction, six hundred*."

Example 2: Missed command.
To repeat a missed command, the squad leader would announce *"The command was, gun one, right half; gun two, left half."*

Subsequent Fire Commands. Subsequent fire commands are issued to command a gun crew to adjust fire, change the rate of fire, cease firing, and resume firing. A good fire command is as brief as clarity permits. It contains all the necessary elements of the fire command and is presented in a standardized sequence. The fire command is given by the squad leader loudly, clearly, and at a pace that can be easily understood by the team leaders and gunners. The team leader and gunner repeat each element of the fire command to ensure the command was received and understood:

- *Adjust fire*. When adjusting fire, the deflection correction must always be given first.

- Change rate of fire. If the squad/section leader desires a change in the rate of fire, they simply signal or announce *"Rapid rate* or *sustained rate*."
- Cease fire. When the squad/section leader wishes to interrupt fire for any reason, they simply signal or announce "*Cease fire*." If they only desire a short cessation of firing, they will indicate to the gun crews that they are to remain on the alert and that additional instructions will follow new fire command. If firing should be resumed on the same target, the squad/ section leader commands *"Fire"* again. To allow the gun crew to reorganize between fire missions, the termination of the alert is announced as "*Cease firing, end of mission*."

Hand and Arm Signals

For hand and arms signals utilized for machine gun fire control see Appendix F.

> *NOTE:* When an action or movement is to be executed by only one gun team, the squad leader gives a preliminary signal by pointing toward the team to execute the action. All signals are relayed from the team leader to the gunner either verbally or by physically tapping the gunner in a prescribed manner.

If the squad leader determines that the tactical situation dictates that the guns be mounted covertly, they may desire to issue all commands for placing guns into action from a position of vantage or the point where the guns will be mounted. If this tactical situation occurs, hand and arm signals may be the most advantageous way to relay all necessary information to the squad.

Alternate Methods of Fire Control

In addition to designating targets by an oral fire command or visual hand and arm signal, targets may be designated by fire or by laying the gun, depending on the situation.

Firing. Designating an indistinct target by firing a machine gun is a simple, rapid, and accurate method, although it may cause the loss of surprise and premature disclosure of the gun position. If a squad or section leader desires to designate the target by firing, they will perform the following:

- Assume firing position on a gun and announce or signal the general direction, *"Fire"*, if the direction is not obvious.
- Lay the gun on the target and command "*Watch my bursts*."
- Fire one or more bursts on the target and complete the command orally by designating *"Midpoint, right flank* or *near end*."

> *NOTE:* The minimum number of bursts necessary should be used.

A similar procedure may be accomplished by firing a rifle from the gun position. Using tracer ammunition facilitates observing fire.

Laying the Gun. Laying the gun on a target is a simple and accurate method of target designation and does not sacrifice the element of surprise. To use this method, the gunner goes to each gun, lays it on the target, and has the leaders check the lay of the gun to ensure that the target is understood. Upon the squad leader's command, the gunners open fire simultaneously.

TECHNIQUE OF FIRE FOR DIRECT LAY

Factors that govern the application of fire on a target include target division, distribution of fire, density of fire, and rate of fire. The following subparagraphs discuss the factors governing the direct lay application of fire and usage when engaging the five types of targets found on the battlefield—shallow, deep, oblique, area, and point.

Factors Governing Application of Fire to a Target

Target Division. There is no fixed rule for the maximum width of a target that can be assigned to either a single gun or a squad of guns. Usually, targets more than 50 mils wide are not assigned to a single gun. The standard procedure of zeroing the T&E mechanism before firing leaves only 50 mils of traverse in either direction on the traversing screw. Therefore, single guns are usually be assigned targets of 50 mils or less and squads are assigned targets of 100 mils or less. Wider targets require an appreciable time to traverse. An inordinate volume of fire should not be allocated to them since the amount of ammunition required for anything more than 100 mils wide is considered excessive for a machine gun squad. Therefore, machine gun unit leaders should apply the following rules for the division of targets:

- *Team*. A machine gun team covers a target of 50 mils in width or any length in depth. A team can cover any depth of target because the elevating mechanism allows a search that covers any deep target within the maximum effective range of both medium machine guns and HMGs. If the target is more than 50 mils in width, it should be assigned to a squad.
- *Squad*. When a section engages a deep target, each squad engages as if it is the only squad firing. A squad of guns covers a target of 100 mils in width or any length in depth and is considered either standard or nonstandard:
  - Standard. If the target is between 50 and 100 mils in width, it is divided in half, with each gun covering half.
  - Nonstandard. If the target is 50 mils or less in width, each gun covers the entire target.
- *Section Minus*. A section minus contains two squads and covers a target of 200 mils in width and any length in depth. When a section minus engages a deep target, each squad engages as if it is the only squad firing.
- *Section*. A section of guns covers a target of 300 mils in width or any length in depth. If a target less than 300 mils in width is to be engaged by a full section, it can be divided into thirds of less than 100 mils each, with each squad covering a third. When a section engages a deep target, each squad engages as if it is the only squad firing. Figure 2-26 depicts the correct fire distribution for a machine gun section minus (four guns) covering a target that is 200 mils in width.

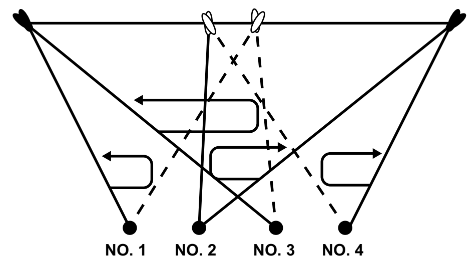


Figure 2-26. Fire Distribution for a Machine Gun Section Minus (Four Guns).

Distribution of Fire. In order to be effective, machine gun fire must be distributed over the entire target. The improper distribution of fire results in gaps between beaten zones and allows a portion of the enemy unit to either escape or use weapons against friendly units that are without effective opposition (i.e., suppression). Mechanically manipulating the gun using the T&E mechanism is essential between bursts to ensure that fire is distributed properly over a shallow, deep, oblique, area, or moving target.

Distribution of fire concerns the fire of both the squad (as the basic machine gun fire unit) and the section. To distribute fire properly, attention must be given to how the target is divided among the guns, the point of initial aim for each gun, and the direction that the guns will traverse and search across the target.

There are general rules that apply to the fires of a squad of guns for shallow, deep, oblique, or area targets. In certain circumstances, these rules may be modified to meet the tactical situation.

The point of initial lay is the point on the target that a gun fires its initial burst. The portion of the target for which they are responsible corresponds with their position in the squad or section.

Shallow Targets. The following are characteristic of shallow targets:

- *Range designation*. The range announced is to the center of the target.
- *Point of initial lay*:
  - Gun 1: Left side of target.
  - Gun 2: Right side of target.
- *Extent of manipulation*. Each gun delivers its initial burst two mils outside its corresponding flank of the target, traverses across to the center of the target (i.e., or the center of the squad's designated portion), and then reverses the direction of traverse back to the point of initial lay (see Figure 2-27). When traversing, four to five clicks are applied between bursts if dispersed fire is desired, or two clicks between bursts if dense fire is needed.

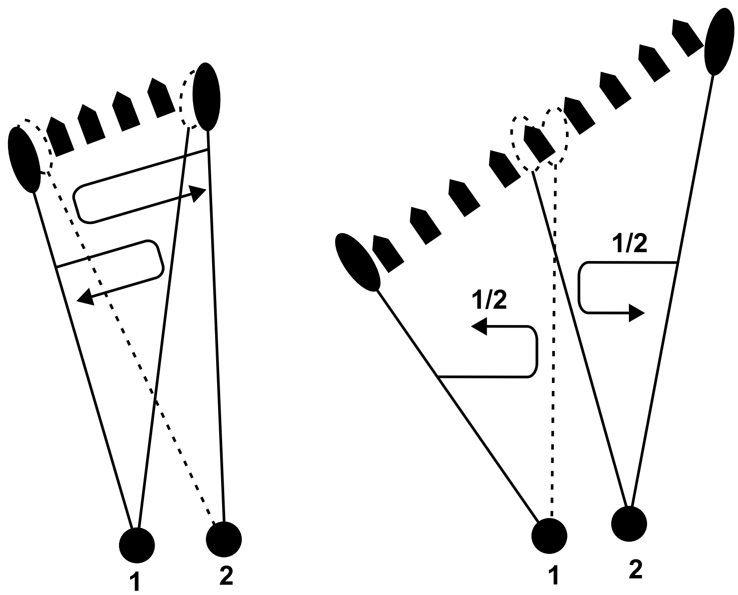


Figure 2-27. Fire Distribution for a Shallow or Oblique Target.

Each gun continues delivering traversing fire between its point of initial lay and the center of the target until a subsequent fire command is given.

Deep Targets. The following are characteristic of deep targets:

- *Range designation*. If the target is 200 meters or less in depth, the range announced is to the midpoint of the target; however, if the target is more than 200 meters in depth, the range to both the near and far ends is announced.
- *Point of initial lay*:
  - Gun 1: near end of target.
  - Gun 2: far end of target.
- *Extent of manipulation*:
  - Gun 1: searches up toward the far end of the target.
  - Gun 2: searches down toward the near end of the target.

After searching the extent of the target, each gun reverses the direction of search and continues until a subsequent fire command is given (see Figure 2-28).

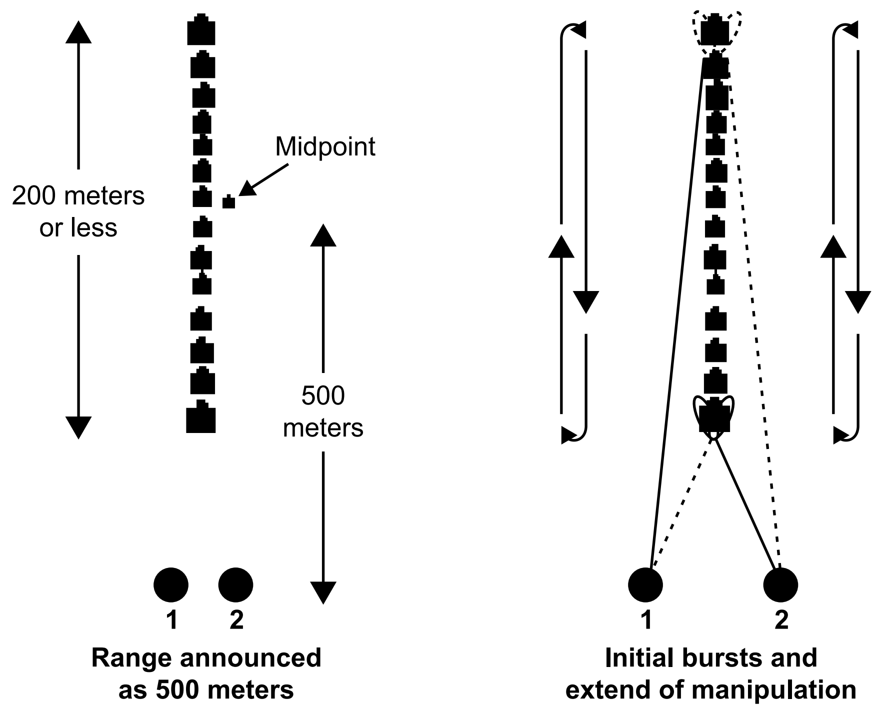


Figure 2-28. Fire Distribution for a Deep Target.

<u>*Oblique Targets.*</u> The following are characteristic of oblique targets:

- <u>*Range designation*</u>:
  - If the target is 200 meters or less in depth, the range announced is to the midpoint of the target.
  - If the target is more than 200 meters in depth, the range announced is to both the near and far ends.
- <u>*Point of initial lay*</u>:
  - Gun 1: the left side of the target, regardless of whether it is the near or far end.
  - Gun 2: the right side of the target, regardless of whether it is the near or far end.
- <u>*Extent of manipulation*</u>: each gun delivers its initial burst two mils outside its corresponding flank of the target, traverses across to the center of the target (i.e., or the center of the squad's designated portion) while maintaining enough search to keep the center of impact on the target, and then reverses the direction of traverse and search back toward the point of initial lay.

Each gun continues delivering traversing and searching fire between the point of initial lay and the center of the target until a subsequent fire command is given.

Area Targets. The following are characteristics of area targets:

- *Range designation*:
  - The range announced is to the near edge of the target.
  - The amount of search to be applied between sweeps is announced by the squad or section leader based upon the number of mils required to ensure overlapping beaten zones.
- *Point of initial lay*:
  - Gun 1: left side of the target, near the edge.
  - Gun 2: right side of the target, near the edge.
- *Extent of manipulation*: each gun delivers its initial burst on its corresponding flank of the target, traverses across to the center of the target (i.e., or the center of the squad's designated portion), then searches up to a point that ensures overlapping beaten zones and traverses back across the target toward the point of initial lay.

Once each gun has covered its portion of the target, it ceases fire and stands by for a subsequent fire command.

Density of Fire. Density of fire refers to the relative density of beaten zone impacts in relation to the overall mass of the target. Manipulation is performed in a particular manner to achieve either a dispersed or concentrated density of fire on the target.

Dispersed Fire. Dispersed fire is the standard density of fire. When dispersed fire is desired, each gun performs a four- to five-mil traverse between bursts when engaging a shallow or oblique target. This does not provide overlapping beaten zones, but will produce sufficient suppression on most targets. When engaging a deep target with dispersed fire on level or uniformly sloping ground, searching is also performed in four- to five-mil increments, firing after each manipulation.

Concentrated Fire. Concentrated fire is the nonstandard density of fire. When concentrated fire is desired, each gun performs only a two-mil traverse between bursts when engaging a shallow or oblique target. This ensures overlapping beaten zones and a densely concentrated effect on the target. When engaging a deep target on level or uniformly sloping ground with concentrated fire, searching is also performed in two-mil increments, firing after each manipulation. However, when the ground is irregular, the beaten zone is observed on the ground to determine the amount of search to apply between bursts to ensure the beaten zones overlap.

> *NOTE:* Because concentrated fire demands an inordinate amount of time and ammunition, it should not be designated unless absolutely necessary. When only basic suppression is needed, the machine gun unit leader should designate the application of dispersed fire. Therefore, unless otherwise stated, the machine gun crew should apply dispersed fire when engaging a target.

Rate of Fire. An appropriate rate of fire is as important as the proper application of fire to a target as distribution, division, and concentration. Unless otherwise ordered, the first few bursts should be delivered at the rapid rate for shock effect and adjusting fire; thereafter, the prescribed rate is used. For specific rates of fire, refer to Chapter 1.

> *NOTE:* The most important reason for applying the rapid rate of fire during initial target engagement is to gain fire superiority. After fire superiority has been gained,

the rate of fire should be adjusted based on the effects on the enemy and the sustainment of machine gun fire.

Targets

The types of targets include point, shallow, deep, oblique, and area.

Point. Point targets are no wider or deeper than the beaten zone and are engaged by fixed fire. When engaging point targets, little or no manipulation of the T&E mechanism is required. After the initial burst, the gunner follows any movement of the target without command. The command for point target fire is *fixed*.

Shallow. Shallow targets are linear targets that are wide enough to require engagement by multiple beaten zones, but shallow enough that the beaten zone of each burst will provide sufficient cover (e.g., a trench line or a column of enemy troops or vehicles that is moving laterally in front of the gun). The key identifier of a shallow target is that the long axis of the target is at a right angle to the long axis of the beaten zone. Shallow targets are engaged by either traversing or swinging traverse fire.

<u>Engaging Shallow Targets with a Squad of Guns.</u> When a squad leader desires an even concentration of fire on a shallow target, the standard engagement technique is used; whereas, if the squad leader desires a heavier concentration on a certain portion of a shallow target, then nonstandard engagement is used. In either case, gun 1 is initially laid on the right flank of the target and gun 2 is initially laid on the left.

Standard engagement is when the squad covers the entire target. When the target is 50 mils or less in width, both guns cover the entire target. For targets between 50 and 100 mils in width, the target is split in half; gun 1 covers the right half and gun 2 covers the left half. In either case, each gun fires its initial burst two mils outside its respective flank and then traverses back and forth across its assigned portion until a subsequent fire command is given. The command that is given for this type of fire is *traverse.*

Examples Engaging a Standard Shallow Target

Example 1:
Squad.
Right front.
Troops in the open.
Eight hundred.
Gun one, right half; gun two, left half (the target is between 50 and 100 mils wide).
Traverse.
At my command.
Fire.

Example 2:
Squad.
Right front.
Troops in the extending from dead tree right to clearing.
Seven five zero.
Traverse (target is 50 mils or less in width).
At my signal.
Fire.

If one portion of the target presents a greater threat than another, a *nonstandard engagement* is used. During a nonstandard engagement, if the squad leader desires a heavier concentration of fire on a certain portion of a shallow target, the squad leader assigns one gun a smaller portion of the target than the other. Such assignment will have the desired effect of concentrating fire on the smaller portion. This method of engagement is used for targets more than 50 mils in width. Once firing has begun, each gun is traversed back and forth across its designated portion until a subsequent fire command is given.

Examples Engaging a Standard Shallow Target

Example 1:
Squad.
Right front.
Troops in the open.
Eight hundred.
Gun one, right half; gun two, left half (the target is between 50 and 100 mils wide).
Traverse.
At my command.
Fire.

Example 2:
Squad.
Right front.
Troops in the extending from dead tree right to clearing.
Seven five zero.
Traverse (target is 50 mils or less in width).
At my signal.
Fire.

Engaging Indistinct Shallow Targets. When the flanks of a shallow target are not easily identifiable to the gunner, the target may be marked by—

- Firing a gun or rifle using tracer rounds to mark the target (referred to as *marking targets*).
- Laying the guns.
- Using a reference point that is visible to the gunner and in the vicinity of the target.

Once the flanks of the target are identified, the target is engaged in the same manner as a standard engagement. However, when the target is designated by a tracer (e.g., firing a gun or rifle) the gun's position may be disclosed, foregoing the element of surprise; therefore, the reference point method of designating an indistinct target should be used.

Example of Designating an Indistinct Shallow Target by Firing

Squad.
Left front.
Watch my bursts.
Left flank (lays and fires gun at left flank).
Right flank (lays and fires gun at right flank).
Troops.
Nine hundred.
Traverse.
At my command.
Fire.

Executing Reference Point Methods for Shallow Targets. Reference points for shallow targets can be either outside or inside the target area.

When the selected reference point is *outside the target area*, the gunner may be directed to the target by announcing the interval to the right or left (i.e., over or short) between the reference point and the target first.

Next, the gunner measures the interval between the reference point and the flank of the target by laying on the reference point with the sights set at the range to the target and shifting the gun the designated number of mils. Once each gun is laid on the right or left flank, fire is applied by standard target engagement.

Example of Reference Point Method: Outside the Target Area for Shallow Targets

Squad.
Right front.
Reference: dead tree, right six zero mils, drop three five zero meters.
Target: troops extending right five zero mils.
Six hundred.
Traverse.
At my command.
Fire.

The flanks of an indistinct target may be identified to the gunner as extending a prescribed number of mils from a reference point *inside the target area*. When this occurs, each gun is laid initially on the announced reference point (i.e., initial aiming point) and its fire is adjusted on this point. The guns are then traversed to the right or left, respectively. The lay of each gun is checked as it passes the reference point. The gun-prescribed distance is to its corresponding flank, then back across the target to the total distance to the other flank, with the gun firing after each manipulation.

Example of Reference Point Method: Inside the Target Area for Shallow Targets

Squad.
Front.
Reference: lone tree.
Target: troops, extending right two zero mils, left three zero mils.
Seven hundred.
Traverse.
At my command.
Fire.

Engaging Shallow Targets with a Section Minus. When a heavy concentration of fire is desired on a small shallow target (i.e., 100 mils or less in width), a section minus—two squads— is employed. A section minus may also be employed if a target is too wide for a squad, but too small for a section of guns. The section leader assigns the section minus to a target that is between 100 and 200 mils in width.

Examples of Engaging Shallow Targets with a Section Minus

Example 1:
Heavy concentration on a small shallow target.
Each of the two squads engages the entire target, as in standard engagement for a squad.

Example 2:
Too wide for a squad, but too small for a section.

The target is split in half, with each half designated separately as an individual target.

In either example, each squad covers its assigned portion of the target by either standard or nonstandard engagement, depending upon the width and nature of the target.

Engaging Shallow Targets with a Single Gun. In cases where a squad leader wants a single gun to engage a shallow target that would usually be covered by a squad, the single gun engages the target using the standard engagement technique. The leader may designate the flank where they desire fire to be placed initially (i.e., the point of initial lay).

Example Commands for Engaging Shallow Targets with a Single Gun

Gun one.
Front.
Troops, extending from dead tree, right three zero.
Five hundred.
Traverse.
At my command.
Fire.

Engaging Moving Shallow Targets by Swinging Traverse. A swinging traverse is accomplished by unlocking the traversing slide lock lever to permit the gunner to swing the gun laterally, while the traversing slide is still engaged on the traversing bar of the tripod. The swinging traverse method of T&E manipulation is used to deliver fire against targets that require major changes in direction, but little or no change in elevation. These types of targets are usually either a large formation of troops relatively close to the gun, or vehicles or mounted troops moving rapidly across the front of the gun.

Example Fire Command for Swinging Traverse Mission

Squad.
Left front.
Trucks moving from left to right.
Three hundred.
Swinging traverse.
Fire.

Deep. Deep targets are linear targets that are narrow enough to be effectively engaged by the width of a single beaten zone (e.g., a column of enemy troops or vehicles moving directly toward or away from the gun).

> *NOTE:* The key identifier of a deep target is that the long axis of the target coincides with the long axis of the beaten zone.

Deep targets are engaged using searching fire; performing successive changes in the elevation of the gun between bursts. The amount of elevation change depends on the range and the slope of the ground. When engaging a deep target that requires searching fire, the gunner should ensure that the beaten zones of successive bursts overlap, but not excessively.

Engaging Deep Targets with a Squad of Guns. Deep targets that are stationary or have limited mobility require only searching fire to cover them effectively. When the ends are visible to gunners, gun 1 is laid initially on the near end of the target and gun 2 is laid initially on the far end. Because of the length of the beaten zone and the extent of search available on the T&E mechanism, a squad can cover any depth of target.

Determining Sight Settings for a Deep Target. The squad leader determines the sight setting to be placed on the guns for engaging a deep target based on the actual depth of the target. If the target is estimated to be 200 meters or less in depth, the range announced for both guns is that to the midpoint of the target. This takes advantage of the length of the beaten zones to ensure effects on target with the initial bursts. If the target is more than 200 meters in depth, the range to the near end is announced for gun 1 and the range to the far end is announced for gun 2. In either case, the gunners acknowledge the range designated to them by the squad leader, set their sights accordingly, and then lay on their respective end of the target.

Subdividing a Deep Target. A deep target never needs to be subdivided, because the elevating mechanism allows enough search to cover any deep target within the maximum effective range of both medium machine guns and HMGs. Each gun delivers the initial burst of fire onto its corresponding end of the target. Gun 1 searches up toward the far end, while gun 2 searches down toward the near end. After searching the full extent of the target, the direction of search for each gun is reversed and they continue to search up and down between the near and far ends, covering the entire target until a subsequent fire command is given. The command for this type of fire is "*Search*."

Examples of Fire Commands Used to Engage Deep Targets

Example 1: Target is 200 meters or less in depth.
Squad.
Direct front.
Halted column of troops.
Eight hundred.
Search.
At my signal.
Fire.

Example 2: Target is more than 200 meters in depth.
Squad.
Left front.
Troops, along right edge of woods.
Gun one, six hundred; gun two, nine hundred.
Search.
On my command.
Fire.

Engaging Indistinct Deep Targets. When the ends of a deep target are not visible to the gunner, the target may be identified by firing a gun or rifle, laying the guns, or by using a reference point that is visible to the gunner and in the vicinity of the target. The first two methods are simple and accurate and, once the ends of the target are identified, the target is engaged in the same manner as a standard engagement. When designation by tracer (firing a gun or rifle) is likely to disclose the gun position or otherwise eliminate the element of surprise, the reference point method of designating an indistinct target should be used.

Example of a Reference Point Method of Designating an Indistinct Target by Firing

The following is an example of a fire command that would be used when a squad leader desires to designate the limits of an indistinct deep target by firing one of the guns of the squad:

Squad.
Left front.
Watch my bursts.
Near end (lays and fires gun at near end).
Far end (lays and fires gun at far end).
Troops in hedgerow.
Seven hundred (range to target midpoint).
Search.
At my command.
Fire.

Executing Reference Point Methods for Deep Targets. Like shallow targets, reference points for deep targets can be either outside or inside the target area.

When the selected reference point is *outside the target area*, the gunner may be directed to the target by announcing the interval—*"Over, short, right,* or *left"*—between the reference point and the target.

Next, the gunner measures the interval right or left—between the reference point and the target—by laying on the reference point with the sights set at the range to the midpoint of the target, shifting the gun the designated number of mils.

The interval over or short between the reference point and the end of the target may be measured with the gun in mils (using computed search method) or by estimating the interval in meters.

Example of a Reference Point Method: Outside Target Area for Deep Targets

Squad.
Left front.
Reference: dead tree.
Right three zero mils, add six mils.
Target: troops extending over two mils.
Nine hundred.
Search.
At my command.
Fire.

The limits of an indistinct deep target may be identified to the gunners as extending a certain number of meters (or mils) from a reference point *inside target area*. Both guns are laid initially on the announced reference point (i.e., initial aiming point), with the sights set at the range to the reference point and fire adjusted on this point.

Next, gun one is searched down, firing after each manipulation, until it has reached the near end of the target as designated in meters (or mils). Gun two is searched up, firing after each manipulation until it has reached the far end of the target.

When each gun has reached the near and far end respectively, the direction of search is reversed and both guns are searched up and down between these two limits, covering the entire target until a subsequent fire command is given.

Example of a Reference Point Method: Inside Target Area for Deep Targets

Squad.
Right front.
Reference: lone bush.
Target: troops extending short two mils, over four mils.
Six hundred (range to reference point).
Search.
At my command.
Fire.

Engaging Deep Targets. Deep targets can be engaged either with a section minus or a single gun. If a section leader determines that the massed firepower of two squads is necessary to effectively neutralize a deep target, they may choose to *employ a section minus* (two squads) against the target. If this occurs, the section minus uses the same method as a pair of guns: each squad engages the target as if it is acting alone. If it becomes necessary to switch the fires of one squad to another target, the original target will still be covered by the remaining squad.

If the squad leader desires to *employ only a single gun* against a deep target, the standard searching technique for gun 1 is used, regardless of which gun in the squad is performing the task. The single gun is laid initially on the near end of the target with a range to the midpoint. Its fire is adjusted on the near end and searched up and down, covering the entire target.

If using a reference point within the target area, the single gun is laid on the announced reference point with the range to the reference point. Fire is adjusted on this point, searched down to the near end, then searched up and down to cover the entire target until a subsequent fire command is given.

Engaging Deep Moving Targets. The coordinated engagement of rapidly moving deep targets is simpler than other deep target engagements. The squad leader determines the range to one end or the other, depending on which direction the target is moving, and designates this range for both guns. Variances of moving targets are relative to the gun position.

If the target is moving *away from the gun position*, both guns are laid on the far end, with the range to that point, and searched downward.

If the target is moving *toward the gun position*, both guns are laid on the near end, with the range to that point, and searched upward.

Example of a Command for Covering a Moving Target

Squad.
Direct front.
Troops advancing in column.
Five hundred.
Both guns: near end.
Search.
At my command.
Fire.

Searching for Deep Targets with the Computed Search Method. When the squad leader describes the depth of a target in mils and the guns are in a position where the limits of the target are not visible to the gunners, the amount of the search can be computed from the reference point (in mils) by the following method:

- Determine the ranges to the near and far ends of the target.
- Use the firing tables to find the required angle of elevation (in mils) for both ranges.
- Determine the difference between them.

NOTE: The difference between the two angles of elevation is the amount of search (in mils) required on level ground if the gun and target are at the same elevation.

However, if the fire is plunging, the amount of search should be increased to compensate for the shortened beaten zone.

NOTE: If the computed amount of search is an odd number of mils, it is increased by one to create an even amount, and the search is made in two-mil increments.

Example of a Computed Search Method for a Deep Target

This example is computed from the firing tables for 7.62 mm ball ammunition (see Appendix A). A deep target has been sighted and the ends are not visible to the gunners. A suitable reference point within the target at an 1,100 meter distance is visible. The depth of the target is estimated at 200 meters and the reference point appears to be midway between the ends. Therefore, the range to the near end is 1,000 meters and to the far end is 1,200 meters. The angle of elevation is 16.2 mils for a range of 1,000 meters and 24.1 mils for 1,200 meters—a difference of 8 mils. This target extends four mils over and four mils short of the reference point. Searching in two-mil increments, the gunners cover the target by searching four mils over and four mils short of the reference point.

The fire command is announced as follows:
Squad.
Right front.
Reference: burning vehicle.
Target: troops extending over four mils, short four mils one-one hundred (range = 1,100 meters).
Search.
At my command.
Fire.

Oblique. Oblique targets are linear targets that are arrayed at an angle to the gun (e.g., a column of enemy troops that is moving obliquely toward or away from the gun). Therefore, an oblique target is wide enough to require lateral engagement by multiple beaten zones and, since the long axis of the target is at an angle to the beaten zone, a single burst will not cover its length.

The key identifier of an oblique target is that the long axis of the target is at an oblique angle to the long axis of the beaten zone. Therefore, oblique targets are engaged with traversing and searching fire—the gunner employs enough traverse while firing to cover the width of the target and applies enough search to keep the center of impact on the target.

Engaging Oblique Targets with a Squad of Guns. Oblique targets are engaged in the same manner as shallow targets. The point of initial lay is the same as for shallow targets. Gun 1 is laid initially on the right side of the target and gun 2 is laid initially on the left side, regardless of which side of the target is nearer to the guns.

NOTE: Target division follows the same rules as for shallow targets. Any target greater than 50 mils wide is divided.

NOTE: Range designation is the same as for deep targets. Midpoint is announced for anything 200 meters or less in depth. Near and far end ranges are announced for anything more than 200 meters.

NOTE: Traverse is always performed first, followed by search. Because of the length of the beaten zone, traverse is never interrupted to clean up the search.

Oblique targets may be engaged using standard and nonstandard methods. For targets 50 mils or less in width, each gun delivers its initial burst two mils outside of its corresponding flank of the target. It then traverses across the target to a point two mils outside the other flank while maintaining enough search to keep the center of impact on the target.

NOTE: For targets between 50 mils and 100 mils in width, each gun covers half the target. In either case, after traversing its portion of the target, each gun reverses the direction of traverse and continues to traverse and search until a subsequent fire command is given.

Examples of a Command for Standard Engagement of an Oblique Target

The command for standard engagement of fire is traverse and search. Two examples of commands used to engage a standard oblique target are as follows:

Example 1:
Squad.
Right front.
Troops, extending from black stump, right to lone pine.
Seven hundred (range to target midpoint).
Search and traverse.
At my signal.
Fire.

Example 2:
Squad.
Right front.
Troops, extending from truck, left to bridge.
Gun one, seven hundred (range to near end).
Gun two, one thousand (range to far end).
Gun one, right half; gun two, left half.
Search and traverse.
On my command.
Fire.

Example 2 implies that the target is more than 50 mils in width and more than 200 meters in depth.

Nonstandard engagement is used when one portion of the target presents a greater threat than another. One gun is assigned a smaller portion than the other to increase the concentration of fire on the smaller portion. Each gun delivers its initial burst two mils outside of its corresponding flank of the target. It then traverses across its assigned portion of the target while maintaining enough search to keep the center of impact on the target.

Example of a Command for a Nonstandard Engagement of an Oblique Target

This example is for a target greater than 50 mils in width and less than 200 meters in depth.

Squad.
Right front.
Troops, extending from truck, left to bridge.
Eight hundred.
Gun one, right one-third; gun two, left two-thirds.
Search and traverse.
On my command.
Fire.

Engaging Indistinct Oblique Targets. When the flanks of an oblique target are not easily identifiable to the gunner, the target may be identified in the following ways:

- Firing a gun or rifle.
- Laying the guns.
- Using a reference point visible to the gunner and in the vicinity of the target. Once the flanks of the target are identified, the target is engaged in the same manner as standard engagement. When designation by a tracer (e.g., firing a gun or rifle) is likely to disclose the gun position or otherwise eliminate the element of surprise, the reference point method of designating an indistinct target may be used. However, a reference point within the target area is not used as an initial aiming point because of the difficulty in describing the obliquity of the target.

Example of a Designation by Firing

The following is an example of a fire command that would be used when a squad leader desires to designate the limits of an indistinct oblique target by firing one of the squad's guns:

Squad.
Left front.
Watch my bursts.
Left flank (lays and fires gun at left flank).
Right flank (lays and fires gun at right flank).
Troops in trench line.
Seven hundred (range to target midpoint).
Search and traverse.
At my command.
Fire.

Executing Reference Point Methods for an Oblique Target Outside the Target Area. When the selected reference point is outside the target area, the gunner may be directed to the target by announcing the interval to the right or left (i.e., over or short) between the reference point and the target. The gunner then measures the interval between the reference point and the flank of the target by laying on the reference point with the sights set at the range to the target and shifting the gun the designated number of mils. Once each gun is laid on the right or left flank, respectively, fire is applied by standard target engagement.

Example of a Reference Point Method: Outside Target Area for an Oblique Target

Squad.
Right front.
Reference: dead tree.
Right six zero mils; drop three five zero meters.
Target: troops extending right five zero mils.
Six hundred (range to target midpoint).
Search and traverse.
At my command.
Fire.

Engaging Oblique Targets with a Section Minus. When a section leader determines that the massed firepower of two squads is necessary to effectively neutralize an oblique target, they may choose to employ a section minus (i.e., four guns) against the target. When doing so, the section minus uses the same method as a pair of guns (i.e., each squad engages the target as if it is acting alone). If it becomes necessary to switch the fires of one squad to another target, the original target will still be covered by the remaining squad.

Engaging Oblique Targets with a Single Gun. When a squad leader uses one gun to engage an oblique target that would usually be covered by a squad, the gun engages the target using the standard engagement technique. Range to the target midpoint is announced and the gun is laid initially on the near end of the target before commencing traversing and searching.

Example of a Command for Engaging Objects with a Single Gun

Gun one.
Front.
Troops in the open.
Nine hundred (range to target midpoint).
Search and traverse.
At my command.
Fire.

Engaging Oblique Moving Targets. The coordinated engagement of rapidly moving oblique targets is similar to engaging rapidly moving deep targets. The squad leader determines the range to one end or the other, depending on which direction the target is moving, and designates this range for both guns. The targets may be moving away or toward the gun position. If the target is moving away from the guns, both guns are laid on the far end with the range to that point and then are traversed and searched downward. If the target is moving toward the gun positions, both guns are laid on the near end with the range to that point and then traversed and searched upward.

Example of a Command for an Oblique Target Moving Toward the Gun Position

Squad.
Direct front.
Troops advancing in column from right to left.
Five hundred.
Both guns: near end.
Search and traverse.
At my command.
Fire.

NOTE: When working with oblique targets, the traverse should never be interrupted to clean up the search.

Area Targets. Area targets are engaged by successive traversing fire. Because of their size, area targets cannot be properly engaged by just traversing or traversing and searching fire (e.g., a large assembly of enemy troops, a bunker complex, or a vehicle park). These targets are engaged by either a section minus or an entire section of guns.

When the enemy is known to be in a certain area (e.g., a hilltop), but the exact location is unknown, it is an area target.

Engaging Area Targets with a Squad of Guns. Engaging an area target is similar to engaging shallow targets. The difference in area target engagement is that gun 1 is laid initially on the near right flank of the target and gun 2 is laid initially on the near left flank before commencing traversing fire.

Standard engagement is employed when the flanks of an area target are visible to the gunners, the range to the near edge of the target is announced, and the guns are initially laid just outside their corresponding flanks on the near edge of the target. Each gun fires traversing fire across its assigned portion of the target, searches upward to a point that ensures the overlap of the beaten zones, traverses back to a point that is even with the point of initial lay, and ceases firing. The squad leader is responsible for determining and announcing the amount of search (either in mils or meters) necessary to overlap the beaten zones. The effect produced on the target should be similar to that of a lawn being mowed—first one row, then the next. The command for this type of fire is successive traverse.

Examples of a Command for Standard Engagement

Example 1:
Squad.
Right front.
Troops in assembly area.
One thousand.
Successive traverse.
Search up four mils.
On my command.
Fire.

Example 2:
Squad.
Direct front.
Troops in green patch.
Eight five zero.
Successive traverse.
Search up 100 meters.
At my signal.
Fire

Engaging Indistinct Area Targets. When the flanks of an area target are invisible to the gunners, the squad leader can indicate their location and the point where each gun fires its initial burst in the following ways:

- Firing one gun.
- Laying both guns.
- Firing a rifle with tracers.
- Using a reference point.

When the location of the flanks or the reference point (which may be the point of initial lay) has been announced, the procedure to cover the area is the same as when the flanks are visible.

Engaging Area Targets with a Section Minus. If an area target is more than 100 mils wide, a section minus or full section should be used, and the target should be divided accordingly.

Engaging Area Targets with a Single Gun. A single gun uses the same method of engaging an area target, except that it traverses across the entire width of the target before searching.

CHAPTER 3.
COMPUTED MACHINE GUN GUNNERY

Once Marines are proficient in the basics of machine gun gunnery, advanced machine gun gunnery training can be conducted. Advanced training includes building familiarity with data, fire control instruments, overhead fire, and techniques of indirect fire, as well as plotting and engaging moving targets.

DATA

Before machine gunners progress from basic gunnery to advanced gunnery, they need to become familiar with the data required for advanced machine gun gunnery calculations. That data includes fire control tables, LOS, line of bore, angle of sight, vertical interval, angle of elevation, and quadrant elevation. Understanding such data will prepare the machine gunner for the transition to advanced machine gun gunnery.

Fire Control Tables

For each type of machine gun, there is a set of associated fire control tables that lists the data necessary to control the fires of the gun in a variety of circumstances. The following five tables are associated with each type of machine gun:

- Table I—angles of elevation.
- Table II—overhead fire.
- Table III—mask clearance.
- Table IV—quadrant elevation for known vertical intervals.
- Table V—ordinates in meters.

The information contained in these tables can be used to calculate the data necessary to lay the gun in a certain situation or to confirm the gun is already laid properly. An explanation of how to use the information is listed at the beginning of each table. The terms used in fire control tables and addressed in this section must be understood by machine gunners before the data in the fire control tables can be interpreted properly.

Line of Sight and Line of Bore

The line of bore is the straight line between the chamber of the gun and the target. The line of bore should not be confused with the LOS, which refers to the straight line that extends through the center of the rear sight aperture to the front sight post and on to the target. The bullet begins its flight in line with the axis of the bore. However, because of the action of gravity and air resistance, the bullet will fall in a gradual curve. Therefore, it is necessary to elevate the axis of the bore above the line of sight to hit a target at a given range. When the gun and the target are at the same elevation, the line of sight is level to the horizon (see Figure 3-1).

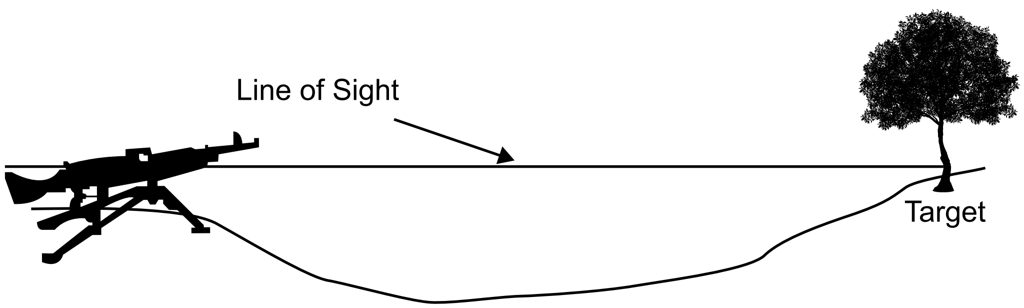


Figure 3-1. Line of Sight.

Angle of Sight

The vertical angle between the LOS and the horizon is called the angle of sight. When the target is at a higher elevation than the gun, the angle of sight is positive (see Figure 3-2). When the target is lower than the gun, it is negative.

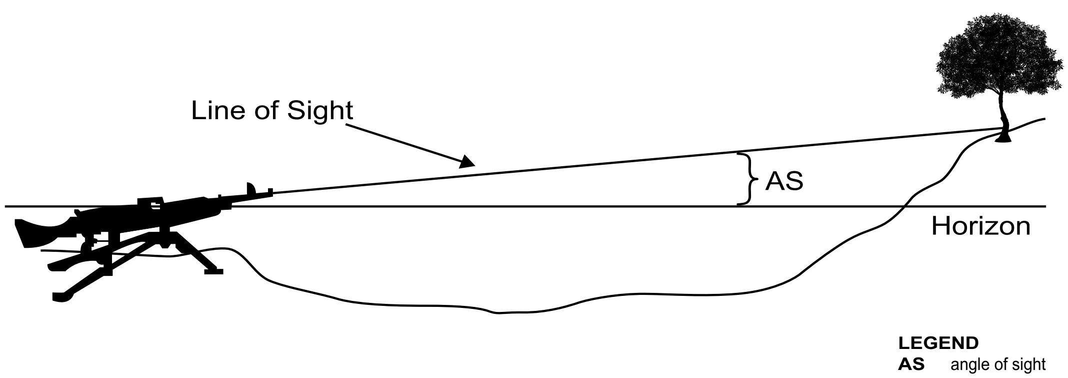


Figure 3-2. Angle of Sight.

Vertical Interval

Vertical interval is the difference (in meters) between the elevation of the gun and the elevation of the target. Vertical interval can be determined either by comparing elevations on a map using contour lines and the contour interval or by applying the WERM formula to the measured angle of sight:

- W is the vertical interval.
- R is the observer-to-target factor.
- M is the angle of sight.

Therefore, angle of sight can be found by dividing a target's vertical interval by its observer-to-target factor and vertical interval can be found by multiplying a target's angle of sight by its observer-to-target factor. For example, in Figure 3-3, the angle of sight for a target that is 1,000 meters from the gun (observer-to-target factor = 1) and has a vertical interval of +20 meters is 20 mils. Quadrant elevations for both positive and negative vertical interval are listed in Table IV of a machine gun's fire control tables.

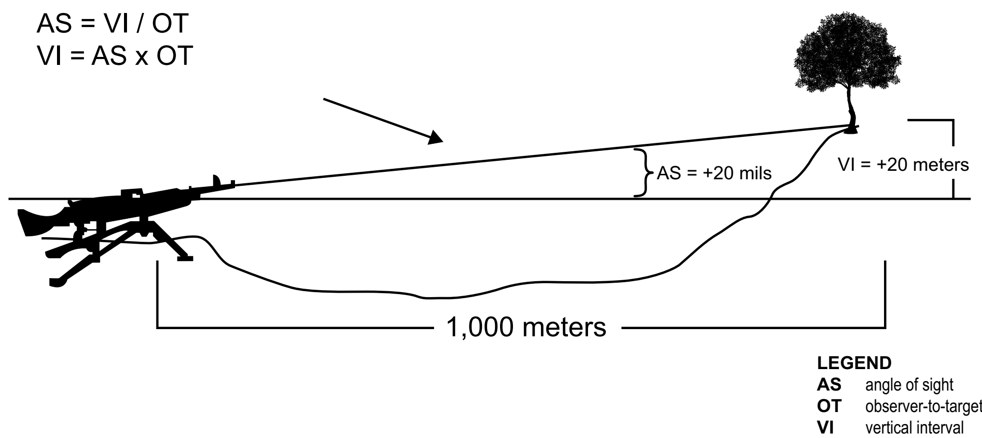


Figure 3-3. Vertical Interval.

Angle of Elevation

The angle of elevation is the angle between the LOS and the axis of the bore. Therefore, the angle of elevation is always positive, is constant for any given range, and increases as the range increases, unless conducting high angle fire with the MK-19. For example, to hit a target with the M240B at a range of 1,700 meters when the gun and target are at the same elevation (zero angle of sight), the gun must be elevated so that the axis of the bore forms an angle of +53 mils with the LOS (see Figure 3-4). Angles of elevation are listed in Table I of a machine gun's fire control tables.

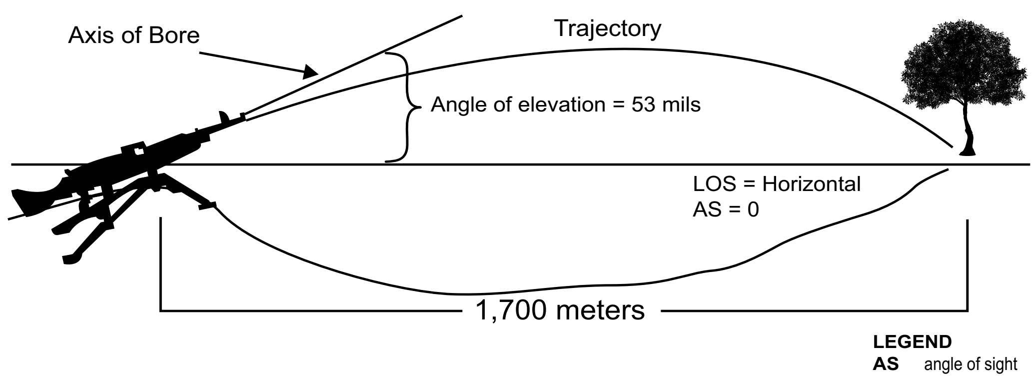


Figure 3-4. Angle of Elevation.

Quadrant Elevation

When the gun and target are at the same elevation, only an angle of elevation is necessary to put the trajectory onto the target. However, when the gun and target are not at the same elevation, both the angle of sight and angle of elevation must be considered. The result of this combined factoring is called quadrant elevation. Quadrant elevation is the angle between the horizon and the axis of the bore. Therefore, quadrant elevation is the sum of the angle of sight and the angle of elevation: quadrant elevation = angle of sight + angle of elevation. Quadrant elevations (for both positive and negative angle of sight) are listed in Table IV of a machine gun's fire control tables, but only to specific ranges: 1,500 meters for the M240B; 2,500 meters for the M2A1; and 2,200 meters for the MK-19.

Target and Gun at the Same Elevation (Zero Vertical Interval). Whenever the gun and target are at the same elevation (i.e., on the same horizontal plane), the angle of sight will be zero because the LOS is horizontal. In this circumstance, the quadrant elevation will be equal to the angle of elevation. For example, in Figure 3-5, the target is at a range of 1,000 meters and on the same horizontal plane as the gun. Therefore, the gun must be elevated to an angle of elevation of 16.7 mils (which would be rounded to 17 mils) to hit the target at 1,000 meters, according to Table I for the M240B. Whenever the angle of sight is zero, the quadrant elevation equals the angle of elevation.

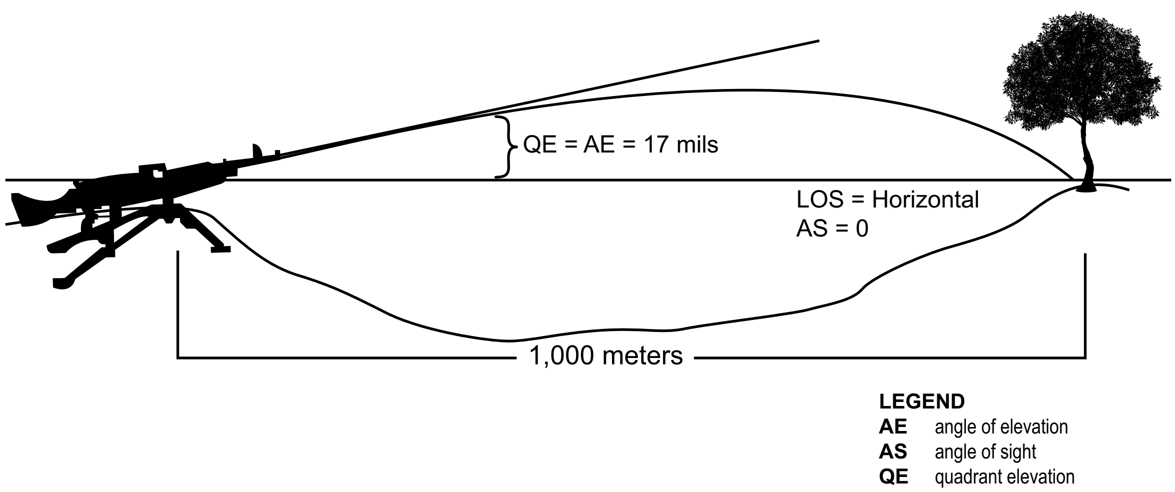


Figure 3-5. Quadrant Elevation, Target, and Gun at the Same Elevation.

Target is Above the Gun (Positive Vertical Interval). Whenever the target is at a higher elevation than the gun, the following will be true:

- Both the vertical interval and the angle of sight will be positive.
- The quadrant elevation will always be equal to the angle of sight plus the angle of elevation (quadrant elevation = angle of sight + angle of elevation).

For example, in Figure 3-6, the target is at a range of 1,000 meters and is 20 meters higher than the gun. Vertical interval is +20 meters, the observer-to-target factor is 1, and the angle of sight is 20 mils. Table I for the M240B (see Appendix A) shows that the angle of elevation at 1,000 meters is 16.7 mils, rounded up to 17 mils. Therefore, adding the 20 mils of angle of sight to the 17 mils of angle of elevation results in 37 mils of quadrant elevation to hit the target.

When confirming this data in Table IV of the M240B fire control tables, the row is indexed for a vertical interval of 20 meters in the left-most column, then the range-to-target column is read over to 1,000 meters. The result is 37.1 mils.

> *NOTE:* In the example in Figure 3-6, the exact calculation for quadrant elevation is 36.7, leaving a 0.4-mil discrepancy between the calculated quadrant elevation and the quadrant elevation listed in Table IV. The difference between the calculated quadrant elevation and the listed quadrant elevation can be attributed to the increased

effects of gravity for a projectile that is traveling upslope instead of level. Therefore, the calculated quadrant elevation should only be considered an estimate for expediently laying the gun. If an exact quadrant elevation is needed, then Table IV should be referenced.

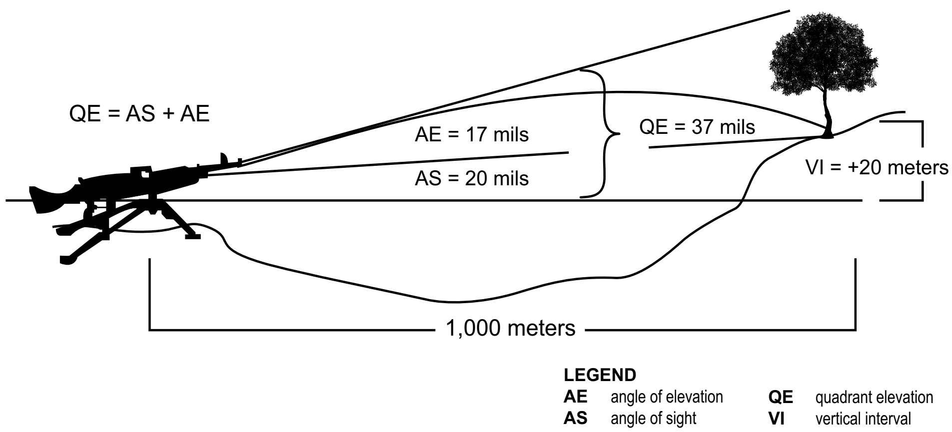


Figure 3-6. Quadrant Elevation, Target Above the Gun.

Target is Below the Gun (Negative Vertical Interval). Whenever the target is at a lower elevation than the gun, both the vertical interval and the angle of sight will be negative. The quadrant elevation is still equal to the angle of sight plus the angle of elevation. However, since the angle of sight is negative, the quadrant elevation will be less than if the target were above the gun.

For example, in Figure 3-7, the target is at a range of 1,000 meters and is 20 meters lower than the gun. The vertical interval is -20 meters, the observer-to-target factor is 1, and the angle of sight is -20 mils. Since the angle of elevation for 1,000 meters is 17 mils, it is added to the -20 mils of angle of sight to generate -3 mils of quadrant elevation to hit the target.

NOTE: The data in Table IV of the M240B fire control tables for a target at 1,000 meters with a negative vertical interval of 20 meters is -4.7 mils. In the previous example, if the angle of elevation is not rounded up to 17, but left exactly at 16.7, the resulting quadrant elevation is -3.3. This generates a 1.4-mil discrepancy between the calculated quadrant elevation and the quadrant elevation listed in Table IV. The difference between the calculated quadrant elevation and the listed quadrant elevation can be attributed to the reduced effects of gravity for a projectile that is traveling down the slope instead of being level. Therefore, when the angle of sight is negative, the calculated quadrant elevation should only be considered an estimate for expediently laying the gun. If an exact quadrant elevation is needed, then Table IV should be referenced. Negative angles of quadrant elevation are not common, but may be encountered on certain types of terrain when the angle of sight is both negative and greater than the angle of elevation.

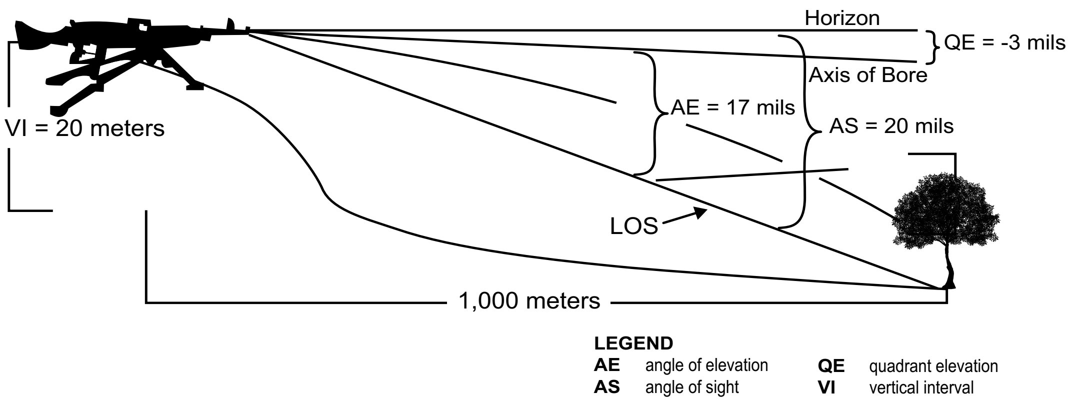


Figure 3-7. Quadrant Elevation, Target Below the Gun.

FIRE CONTROL INSTRUMENTS

Certain instruments can enhance a machine gunner's ability to perform advanced gunnery techniques. These instruments should be mastered by machine gun gunners.

Laser Range Finders

Since accurate range determination is crucial for applying advanced gunnery techniques, a laser range finder can be an irreplaceable tool.

M1A1/A2 Gunner's Quadrant

The M1A1/A2 gunner's quadrant (national stock number [NSN] 1290-00-891-9999/ 1290-00-169-1937) (see Figure 3-8) is an invaluable tool for advanced machine gun gunnery. The gunner's quadrant has the following characteristics:

- Applies the principle of a carpenter's level, permitting the user to set off vertical angles from the horizontal and apply them to a gun.
- Is used to measure quadrant elevation when laying a machine gun for elevation.
- Has a level vial filled with Tritium H3 for limited visibility.
- Is identical to the M1A1, with the exception of the vial.

Components. The components of the gunner's quadrant are as follows:

- Frame. The frame is the body of the quadrant. It has five sides and an interior arc. It is made of solid brass and houses the other components of the gunner's quadrant.
- Mating teeth. There are 80 teeth that are machined into the arc of the frame and mate to the teeth of the arm plunger.
- Shoes. The shoes are four rectangular steel blocks that steady the gunner's quadrant when in use.
- Graduated mil scales. The graduated mil scales are two steel plates for setting quadrant elevation, one on each side of the frame. Each scale measures 800 mils (0 – 800 on one scale, and 800 – 1,600 on the other) and is graduated in 10-mil increments, with numbers indicating every 50 mils.

- *Direction-of-fire indicators*. Two arrows are etched into each side of the frame for orienting the gunner's quadrant in the proper direction during use.
- *Nomenclature plate*. The nomenclature plate is a brass plate riveted to the frame that identifies the nomenclature and serial number of the quadrant.
- *Radial arm*. The radial arm is a measuring component that is machined of solid brass and is hinged to the short side of the frame to house the following:
  - *Micrometer*. The micrometer is cylindrical and knurled and is located above the plunger. It is used to measure whole mils or fractions of mils. It is graduated in 0.2-mil increments, with numbers indicating every mil. The black number scale is used when measuring quadrant elevations between 0 and 800 and the red number scale is used when measuring quadrant elevations between 800 and 1,600. The micrometer can be used to lay quadrant elevations to the nearest 0.1 mil.
  - *Index line*. A black index line is etched at the base of the micrometer for indexing the micrometer measurement.
  - *Zero line*. A black line is etched into the plunger that indicates when the micrometer is zeroed.
  - *Level*. The level is a liquid-filled glass vial fixed to the top of the plunger. When a quadrant elevation is set by means of the graduated scale and micrometer, the level is used to determine when the gun is at the corresponding elevation.

  NOTE: The liquid in the level is radioactive so that it can be used in limited visibility. Care should be taken not to crack the glass vial.
- *Plunger*. The plunger is knurled and spring-loaded. When depressed, it allows the arm to swivel freely within the frame. When released, it locks the arm to the arc of the frame with the mating teeth.
- *Mil indicator*. The mil indicator is a sharpened metal point that is machined into the plunger frame and indicates the corresponding 10-mil mark on the graduated mil scale.
- *Protective sleeve*. The protective sleeve is knurled and cylindrical and can be rotated around.

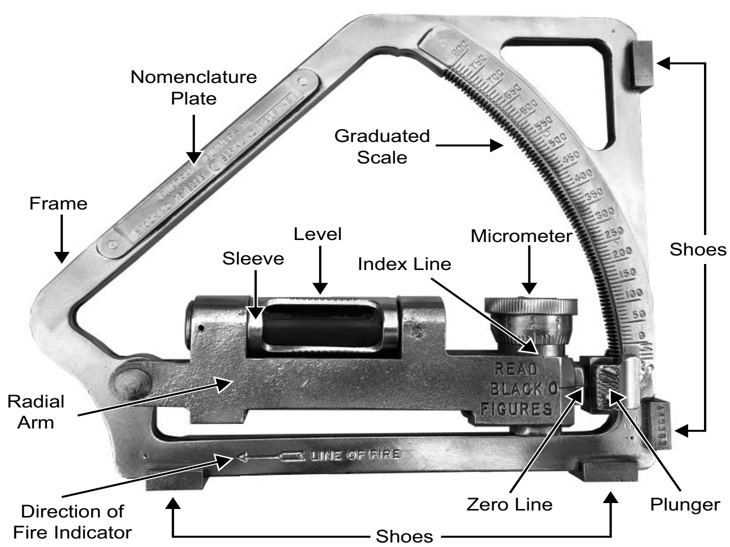


Figure 3-8. M1A1 Gunner's Quadrant.

Use of the Gunner's Quadrant. A gunner uses the gunner's quadrant to lay a machine gun for elevation and is described in the following steps:

1. Calculate the required quadrant elevation or reference the appropriate fire control table.
2. Set the quadrant elevation on the gunner's quadrant as follows:
   a. Depress the plunger, swivel the arm until the mil indicator on the plunger is aligned with the desired 10-mil mark on the graduated scale, and then release the plunger for a major reading.
   b. Rotate the micrometer until the proper mil reading is indexed for a minor reading.

   NOTE: Black numbers are used when the quadrant elevation is 800 mils or fewer and red numbers are used when the quadrant elevation is 800 mils or more.
3. Place the gunner's quadrant on the machine gun as follows:
   a. Orient the appropriate direction-of-fire indicator toward the muzzle.
   b. Place the gunner's quadrant on the feed cover of the gun, ensuring that both shoes rest squarely on the cover. The lower vertical shoe should rest against the rear sight bracket for the M2A1 (see Figure 3-9) or the rear sight housing for the MK-19. When the quadrant is situated properly, the numbers may be read from the left side of the gun.
4. Set the gun to the quadrant elevation as follows:
   a. Manipulate the elevating hand wheel until the level's bubble is centered in the vial.
   b. Confirm the setting on the graduated scale and micrometer.

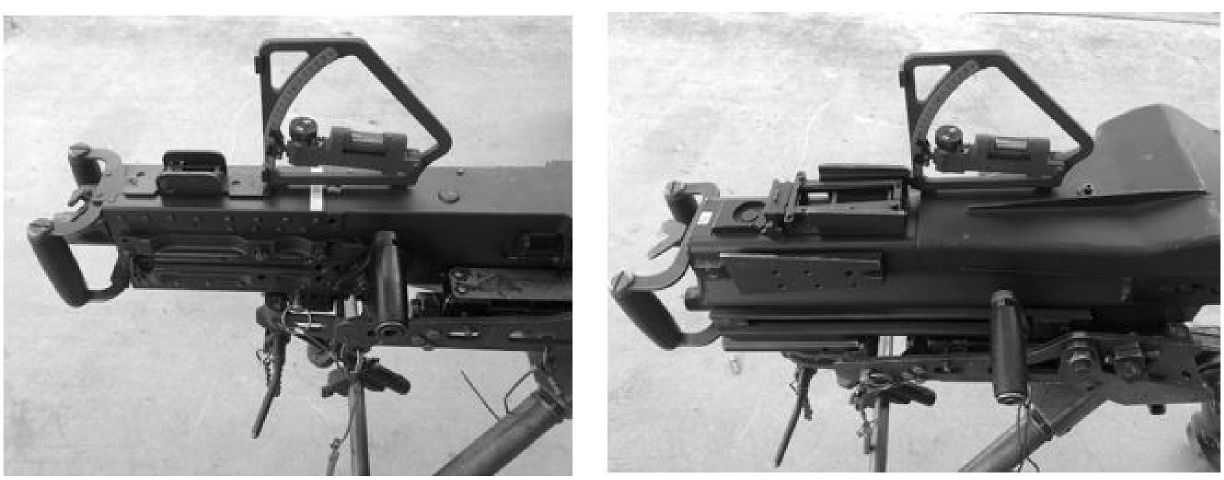


Figure 3-9. Setting Quadrant Elevation on a Gun with the M2A1.

The gunner's quadrant can also be placed on the barrel of the MK-19 as shown in Figure 3-10. This will deliver a different elevation reading than if the quadrant was placed on the top cover; however, it will be a more accurate reading since the barrel is the true axis of the bore.

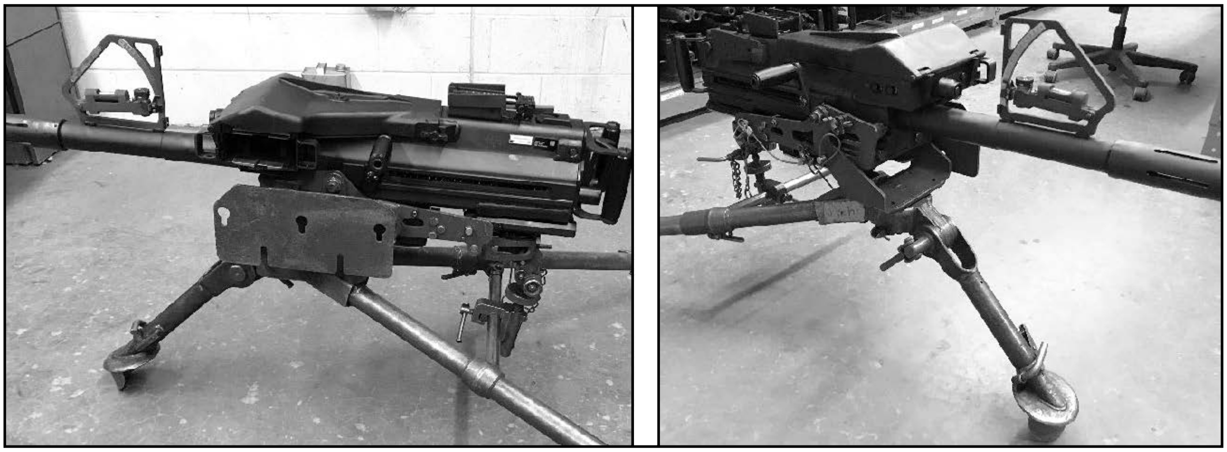


Figure 3-10. Setting Quadrant Elevation on a Gun with the MK-19.

M2 Compass

The M2 compass (NSN 1290-00-930-4260) is a valuable tool that can be used for many applications, including measuring the angle of sight to a target and the quadrant elevation for a gun. Like the gunner's quadrant it permits the setting off of vertical angles by the use of an internal clinometer. Unlike the lensatic compass, the M2 compass is graduated only in mils and not capable of giving azimuths in degrees. However, it can be declinated to provide a grid azimuth or can be used undeclinated if a magnetic azimuth is desired.

Components. The components of the M2 compass detailed in Figure 3-11 include the following:

- *Case*. The case is hardened plastic and houses all the components of the compass. It is composed of a body and a hinged cover.
- *Mirror*. The mirror is glass, fixed to the inside of the cover, and designed for reading the azimuth from the scale when looking through the rear sight.
- *Index line*. The index line is a thin black line that is superimposed on the mirror for indexing the azimuth.
- *Sighting aperture*. The sighting aperture is an oval opening at the base of the mirror that permits the user to sight through the mirror to the target when measuring azimuths.
- *Front sight*. The front sight is a hinged, plastic aperture fixed to the top of the cover. It is used in conjunction with the rear sight when measuring the angle of sight.
- *Rear sight*. The rear sight is a hinged, plastic aperture fixed to the rear sight arm that is hinged to the compass body. The rear sight aperture is used to sight through when obtaining either an azimuth or angle of sight reading.
- *Magnetic needle*. This magnetized needle pivots in the center of the body. It can be declinated to produce either a grid or magnetic azimuth. When the cover is closed, the magnetic needle is automatically lifted from its pivot and held firmly against the glass face. When the compass is open and leveled, the needle floats freely upon its pivot and points to magnetic north. The magnetic needle has two ends—one white and the other black. The white end is magnetized and attracted to magnetic north. The black end is used for reading azimuths, since all readings are taken by means of the mirror.

- *Azimuth scale*. The azimuth scale is a circular, 6,400-mil scale situated around the magnetic needle. The scale is graduated in 20-mil increments, can be read to an accuracy of 10 mils, and is numbered every 200 mils. The long, unnumbered graduations between the numbered graduations are the odd-numbered hundreds. Since the mirror and the non-magnetized end of the magnetic needle are used for reading azimuths, the azimuth scale is labeled in reverse.
- *Elevation scale*. The elevation scale is a 2,400-mil scale located inside the azimuth scale on the face of the compass. It is used in conjunction with the clinometer to measure up to 1,200 mils of positive or negative angle of sight and quadrant elevation.
- *Clinometer*. The clinometer is a device inside the compass that measures vertical angles. It is pivoted in the center underneath the magnetic needle and is composed of an elevation indexer and a liquid-filled leveling vial. The leveling vial is used to determine the horizontal when taking angle of sight readings or setting quadrant elevation on a gun.
- *Circular level*. The circular level is a round, liquid-filled leveling device within the face of the compass. It is used to ensure that the compass is level when shooting an azimuth, which ensures that the reading is as accurate as possible.
- *Azimuth scale adjuster assembly*. The azimuth scale adjuster assembly rotates the azimuth scale to introduce the declination constant. Two teeth at the adjuster engage teeth on the underside of the azimuth scale. Turning the adjuster with a screwdriver rotates the azimuth scale approximately 1,800 mils. The scale is read against a fixed index under the rear sight hinge.

Declinating the M2 Compass. The M2 compass can be declinated to provide grid azimuths instead of magnetic azimuths. This procedure should be performed at a surveyed declination station that is free from magnetic attractions. Two declination methods can be used:

- *Declination station method*. This method is as follows:
  - Set the M2 compass on an aiming circle tripod over the orienting station and center the circular level.
  - Sight in on the known, surveyed azimuth marker.
  - Using a small screwdriver to turn the azimuth scale adjuster, rotate the azimuth scale until it indicates the same azimuth as the known surveyed azimuth.
  - Recheck the sight picture and azimuth to the known point. Once the sight picture is correct and the azimuth reading is the same as the surveyed data, the M2 is declinated.
- *Field-expedient method***.** Using the azimuth scale adjuster, set off the grid-magnetic angle as indicated by the declination diagram on a topographic map of the area in which the compass will be used. Once the grid magnetic angle has been set off on the azimuth scale, the M2 compass is declinated.

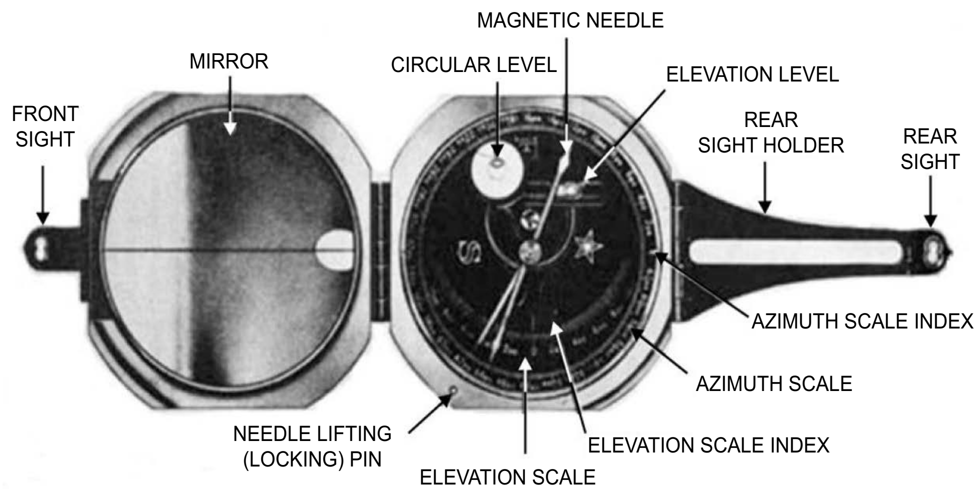


Figure 3-11. M2 Compass and Components.

Shooting an Azimuth with an M2 Compass. The following steps are taken to obtain a magnetic or grid azimuth with the M2 compass:

1. Open the cover and fold out the rear sight arm parallel with the compass face.
2. Fold the rear sight up perpendicular with its holder and fold the front sight up parallel with the mirror.
3. Fold the cover toward the compass body until the mirror is at approximately a 45-degree angle to the compass face, which allows the black end of the compass needle to be viewed in the mirror while looking through the rear sight.
4. Hold the compass in both hands at eye level, with arms braced against the body and the rear sight nearest the dominant eye.
5. Sight through the rear sight and the sighting aperture, aligning the index line on the target.
6. Center the circular level bubble to ensure the compass is level.
7. Look at the mirror reflection of the compass scale and read the azimuth where the black end of the needle is pointing when both the bubble is centered and the index line is laid on the object.

Determining Angle of Site with M2 Compass. The following steps are taken to determine the angle of sight to a target with the M2 compass:

1. Open the cover, fold out the rear sight arm that is parallel with the compass face, and then turn the compass onto its edge.
2. Adjust the cover to approximately a 45-degree angle with the face of the compass, so that the reflection of the clinometer can be seen in the mirror. With the compass on edge, the compass should face left.
3. Fold the rear sight up, perpendicular with its holder, and then adjust the cover to be able to sight through both the rear sight and the sighting aperture. Hold the compass on edge at eye level, sighting with the dominant eye.

4. Hold the compass with the left hand and manipulate the clinometer lever (on the bottom of the compass body) with the right hand.
5. Sight on the upper edge of the feature on which the angle of sight is being measured.
6. Level out the bubble in the leveling vial by turning the clinometer lever on the bottom of the compass while viewing the vial in the mirror. The clinometer will now be set to the angle of sight.
7. Bring the compass down and read the graduation on the elevation scale indicated by the elevation indexer.
8. Measure the angle of sight two more times and record the average.

Setting Quadrant Elevation with the M2 Compass. The following steps are taken to set quadrant elevation on a machine gun with the M2 compass:

1. Open the cover completely so that it is in line with the body and then fold out the rear sight arm.
2. Turn the clinometer lever on the back of the compass until the elevation indexer indicates the desired quadrant elevation.
3. Set the indexer on the rear half (as the gunner is looking at the compass) of the elevation scale (see Figure 3-12).
4. Set the compass on the cover of the machine gun with the edge down and the compass face to the left.
5. Adjust the elevating hand wheel to elevate or depress the muzzle until the bubble in the leveling vial is centered. The quadrant elevation will now be set.

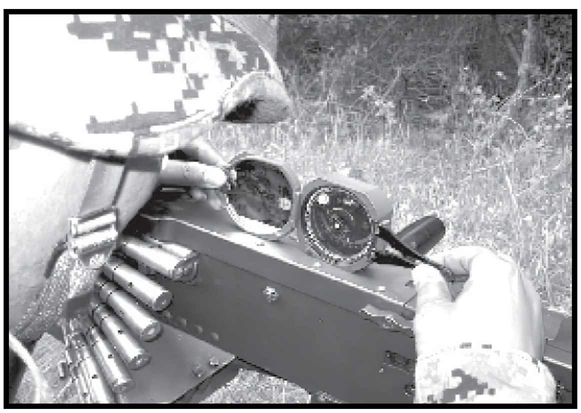


Figure 3-12. Setting Quadrant Elevation with the M2 Compass.

M16 Plotting Board

The M16 plotting board (NSN 1220-00-058-7828) is a fire-control instrument designed to help the operator compute and plot firing data for machine guns. It consists of a transparent, rotating plotting disk attached to a flat base and is carried in a durable M72 canvas case. The M16 plotting board is accurate, sturdy, simple to operate, and practical for field use.

Components. The components of the M16 plotting board include (see Figure 3-13):

- Base. The plotting board base is composed of hard, white plastic. It is square on the right side, semicircular on the left side, and has a metal rivet on the center where the plotting disk pivots.
- Background grid. Printed on the base underneath the plotting disk is a circular area marked with a rectangular grid in red—the background grid. Each large square of the grid is divided into 100 smaller squares. Each small square on the background grid of the M16 plotting board represents 50-m.
- Pivot point. The pivot point, designated by the letters *OP*, represents the location of an observation post (OP) or machine gun firing position, as required by the type of plotting method being used. As a standard practice for machine gun use, the pivot point represents the machine gun's position.
- Index line. Running up the center of the background grid is an index line with an arrowhead at the top. The arrowhead, known as the index pointer, is used with the azimuth scale (on the plotting disk) to determine azimuths and deflections to the nearest 10 mils.
- Vernier scale. The Vernier scale (named after 17th century French mathematician and inventor Pierre Vernier) is a curved, graduated scale situated along the upper, center edge of the base. It is graduated in increments of 1 mil, with 10 mils left and right of the red index mark at 0. The Vernier scale is used to measure fractions of the fixed graduations on the azimuth scale and measure azimuths to the nearest mil. Azimuths are measured with the right side of the scale; mortar deflections are measured with the left side of the scale.
- Primary range scale. The primary range scale is used most when operating the plotting board. The primary range scale is graduated in 50-m increments. It is numbered from 0 to 3,200, moving up or down from the pivot point.
- Map scale. At the bottom edge of the base is a triple map scale with a legend and representative fractions of 1:50,000; 1:25,000; and 1:5,000.
- Metric scale. The metric scale is nine centimeters long and runs along the upper edge of the base.
- Standard scale. The standard scale is seven inches long and runs along the right edge of the base.

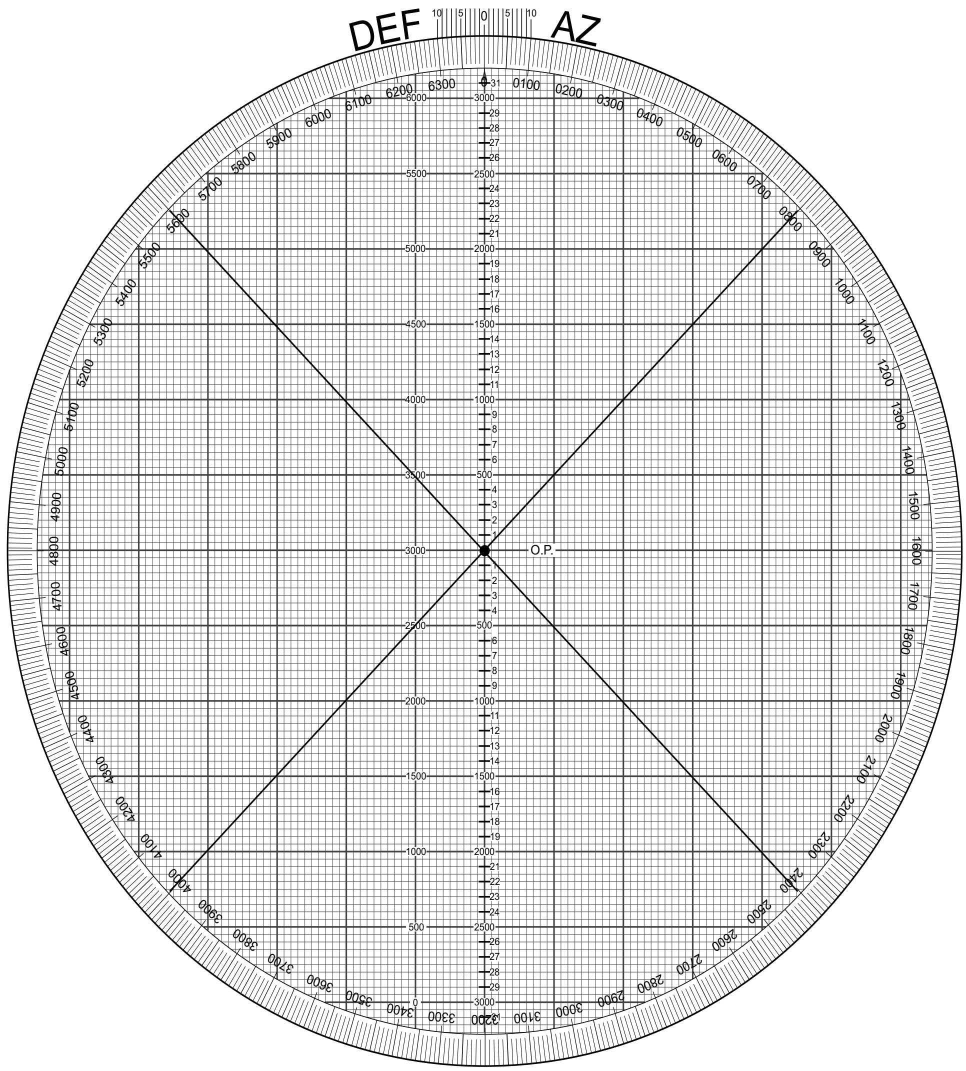


Figure 3-13. M16 Plotting Board.

Plotting Disk . The plotting disk is made of a transparent plastic material that is roughened on its upper surface so that it can be written on with a soft lead pencil. Four scales and a fine black line are printed on the disk. Additional attributes include:

- *Center line*. The center line is a thin, black line that divides the disk in half, between 0 and 3,200 mils.
- *Azimuth scale*. An azimuth scale, printed in black, runs clockwise around the outer edge of the disk to replicate the mil scale of a compass. It is divided into 10-mil increments and is numbered in hundreds of mils from 0 to 6,400. The azimuth scale is used when the plotting board is being used to figure firing data with magnetic or grid azimuths. When using the board, the azimuth scale on the plotting disk can represent either grid azimuths (as taken from a map) or magnetic azimuths (as taken from a compass). Magnetic azimuths are usually used with machine guns because guns in defilade are usually laid by a compass.

NOTE: Regardless of which azimuth is being used, the operator of the plotting board must ensure that the observer and the gun line are using the same type of azimuth.

- *Supplementary scale*. A supplementary scale (the middle scale) is printed in red, running counterclockwise from 0 to 3,200. It is numbered in hundreds of mils and is used to measure angle of sight.
- *Reverse azimuth scale*. A reverse azimuth scale (the inner scale) is printed in black and runs clockwise, starting at 3,200 and stopping at 0 on the azimuth scale. This scale is intended for use with mortars. It is not used with machine guns.

Plotting Board Operation. The theory of operating the plotting board is simple, but the accuracy of the results obtained is limited by the exactness of the operator. The plotting board is used to do the following:

- Plot the relative positions of the machine guns, observers, registration points, and targets.
- Determine the direction and distance between these points.
- Determine direction data.

OVERHEAD FIRE

Overhead fire is delivered over the heads of friendly troops. A machine gun mounted on a tripod is capable of delivering overhead fire because of the small and uniform dispersion of the cone of fire and the ability to measure vertical safety angles with the T&E mechanism. Therefore, tripod-mounted guns are the only allowable means of providing overhead fire.

Warning: Overhead fire should not be provided by bipod-mounted guns because they cannot produce fixed or controlled traversing or searching fires. Therefore, doing so could result in firing on friendly troops.

During an attack, overhead fire permits machine gun units to support advancing infantry when the tactical situation dictates that they must maneuver underneath machine gun fire. Ideally, overhead fire is delivered when a depression in the terrain exists between the gun and the target to ensure that the gunner's LOS is well above the heads of friendly troops.

Rules Governing Overhead Fire

Overhead fire can be a significant force multiplier when machine guns are supporting maneuvering infantry. However, this technique of fire can be dangerous to friendly troops if certain precautions are not taken prior to firing. The following rules must be followed when delivering overhead fire with both the M240B and the M2A1:

- Overhead fire is only delivered by guns that are mounted on a tripod with a T&E mechanism.

- Depression stops must be used to prevent the muzzle from being inadvertently depressed below the safety limit.
- The sustained rate of fire must not be exceeded during overhead fire (100 rounds per minute for the M240B; 50 rounds per minute for the M2A1).
- Excessive muzzle blast must be monitored for and, if observed, overhead fire must cease, since this is evidence of overheating.
- Worn barrels and those showing excessive overheating or evidence of previous overheating must not be used.
- Tracer ammunition must not be used for overhead fire beyond 900 m for the M240B or 1,450 m for the M2A1.
- Gun crew members must be briefed on and stay constantly aware of the overhead safety limit.
- Troops must be informed if machine guns will be firing overhead and given the location of the overhead safety limit.
- Firing must cease when troops cross the overhead safety limit.
- Cones of fire must not be allowed to cross over the heads of friendly troops.
- Overhead fire through trees that may deflect bullets into friendly troops must not be allowed.
- Guns must be zeroed if overhead fire is to be applied by use of the gunner's rule or the leader's rule; both are discussed later in this chapter. The use of the gunner's and leader's rules dictate that troops must be at least 200 m in front of the gun if located on uniformly sloping ground.
- The only 7.62 mm ammunition approved for overhead fire with the M240B is Department of Defense Identification Code A151.
- There are no overhead fire restrictions on the use of .50-caliber linked ammunition for the M2A1.
- The MK-19 is not used for overhead fire because of its explosive warhead. See Marine Corps Order 3570.1, *Range Safety*, for more details.

Minimum Clearance

When delivering overhead fire, the center of the cone of fire must clear the feet of friendly troops by a prescribed distance. This distance is known as minimum clearance (see Figure 3-14). The minimum clearance for any given range to target is found by adding together the following elements:

- The height of a standing person (1.8 meters/70 inches).
- Half the vertical dimension of the cone of fire (lower bound) at the range to the troops.
- A safety margin, measured vertically, of 5 mils or 3 meters (about 10 feet), whichever is greater.

  NOTE: For friendly distances over 600 m, 5 mils will be greater than 3 meters.
- A 15 percent compensation error in range estimation.

  NOTE: This element is disregarded when the fire has been registered.

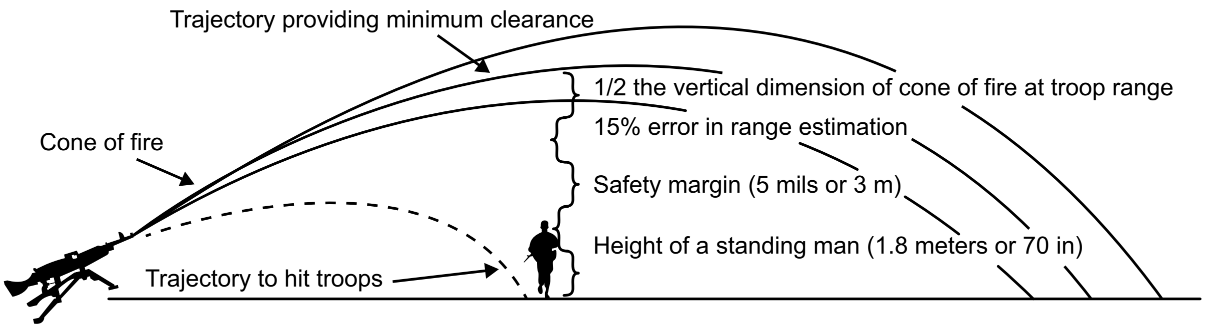


Figure 3-14. Components of Minimum Clearance.

> **Example of Determining Minimum Clearance**
>
> The M240B is going to be laid to fire overhead of friendly troops. The distance from the gun position to the point at which friendly troops will pass under the gun target line is 600m. Below are the steps to determine minimum clearance.
>
> Take the sum of 1.8 meters (height of a standing man), 0.75 meters (half the vertical dimension of the cone of fire at the range to troops), 3 meters (safety margin), and 0.15 (15% compensation error in range estimation).
>
> 1.8 meters + 0.75 meters + 3 meters = 5.5meters
>
> 5.55 meters x 0.15 = 0.83 meters (15% compensation for error in range estimation)
>
> Next, take the sum of 5.55 mils and 0.83 mils to get 6.33 meters of elevation needed to achieve minimum clearance above the heads of friendly troops.

To obtain minimum clearance, the gun is elevated to ensure that the center of the cone of fire is raised from the feet of the friendly troops to an elevation that provides minimum clearance above their heads. The amount of the elevation change that is needed to provide this minimum clearance is known as the safety angle and is the difference between the angle of elevation to hit the troops and the angle of elevation for troop safety (see Figure 3-15).

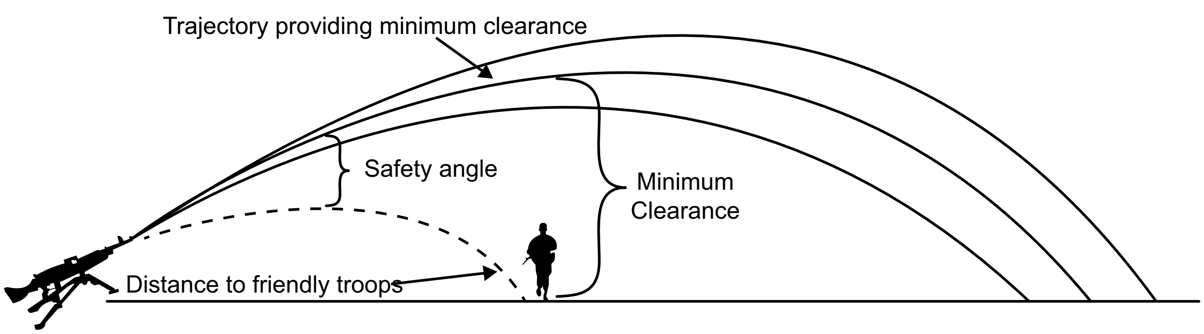


Figure 3-15. Relation Between Minimum Clearance and Safety Angle.

NOTE: When overhead machine gun fire has been registered prior to execution or if the range to the target can be accurately determined, the compensation for range estimation error can be eliminated from minimum clearance.

Safety Angle and the Overhead Safety Limit

The amount of elevation required on the gun to produce minimum clearance at any given range is known as the safety angle. The safety angle is the difference in mils between the angle of elevation that is required to hit the troops and the angle of elevation that is required for minimum clearance. The safety angle is used to establish the overhead safety limit. The overhead safety limit is the point between the target and the gun where the lower limit of the safety angle intersects the ground. The overhead safety limit is based on the minimum clearance required for the range to the target and is determined by measuring the safety angle downward from the target. The safety angle can be measured by—

- *Gunner's or leader's rules*. The gunner's and leader's rules allow the determination of the overhead safety limit by measuring the safety angle with the gun's mechanical sights. The overhead safety limit is designated by the intersection of the new line of aim and the ground. When the feet of the friendly troops reach this point on the ground, the fire must either be shifted or ceased.
- *Binoculars or M2 compass*. The overhead safety limit can be determined by measuring the safety angle as required by the leader's rule with either M22/M24 binoculars or an M2 compass.
- *Fire control tables*. In situations where the gunner's or leader's rules are either impractical or too restrictive, the overhead safety limit can be determined by figuring the safety angle prescribed in Table II of the respective gun's fire control tables. If using the tables, the safety angle is applied by using either the T&E mechanism or the M1A1 gunner's quadrant to set the minimum angle of elevation required for troop clearance on the gun.

Gunner's Rule

The gunner's rule is used to determine the overhead safety limit when the range to the target is 900 meters or less and the squad or section leader has not otherwise announced an overhead safety limit. The rule is applied as follows (see Figure 3-16):

- Estimate the range to the most accurate means available, set the sights, and lay the gun on target.
- Set the line of aim to the overhead safety limit without disturbing the lay of the gun as follows:
  - M240B: Set the sight on 1,500 meters.
  - M2A1: Set the sight on 1,600 yards (since its sights are in 100-yard increments).

    NOTE: The gunner should look through the sights and note the point where this new line of aim strikes the ground. This point is the overhead safety limit.
- When the feet of the first friendly troop pass this point, overhead fire must be ceased or shifted. It is not safe to continue firing when friendly troops have passed this point.
- Report the location of the overhead safety limit to the squad leader and reset the sights on the range to target, ensuring that the lay of the gun is not disturbed.

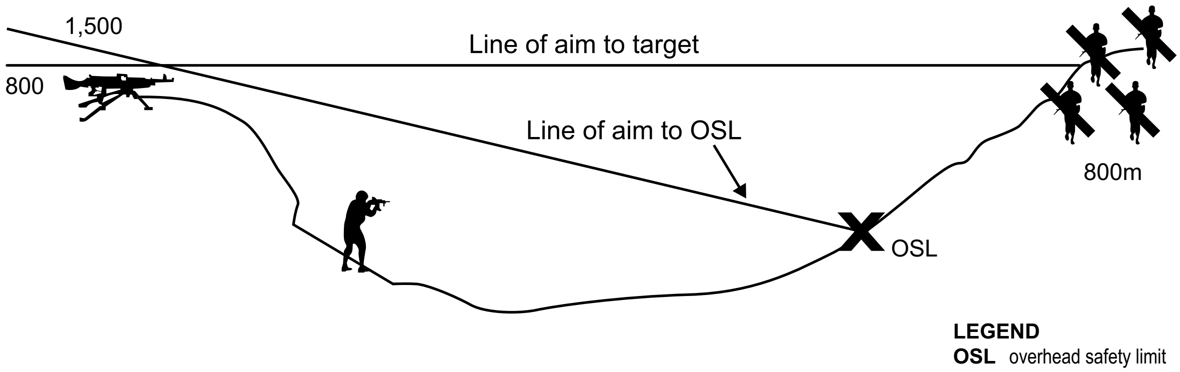


Figure 3-16. Gunner's Rule.

Leader's Rule

The leader's rule is used to determine the overhead safety limit when the range to the target is greater than 900 meters or when the squad or section leader feels that applying the gunner's rule will result in an overly-restrictive overhead safety limit. The leader's rule can be used to tailor the overhead safety limit. When using the leader's rule, an identifiable terrain feature is required to mark the overhead safety limit. Applying the leader's rule confirms whether that terrain feature is suitable for use as the overhead safety limit. The leader's rule is applied as follows (see Figure 3-17):

- The squad or section leader estimates to the most accurate means available and announces the range to target.
- The gunner sets the sights on the announced range and lays the gun on target.
- The leader selects an identifiable terrain feature (i.e., tentative overhead safety limit) where it is believed that friendly troops can safely advance to.
- The leader then expresses the range to target in hundreds, adds 20 mils, and announces this number to the gunner in mils.

Example of a Leader Expressing Range to a Gunner in Mils
If the range to the target is 1,100 meters, it is expressed as 11; then 20 mils is added. The result is announced as *depress three one mils*.

- The gunner manipulates the T&E mechanism to depress the muzzle by the number of mils announced by the leader, without adjusting the sights.
- The gunner notes the point where the new line of aim strikes the ground.
- If the line of aim intersects the selected terrain feature, the tentative overhead safety limit is safe to use, so the gunner announces "S*afe*."
- If the line of aim is above the selected terrain feature, the tentative overhead safety limit is safe to use, so the gunner announces "S*afe*."
- If the line of aim is below the selected terrain feature, then the tentative overhead safety limit is not safe to use, so the gunner announces *"Not clear*." In this case, a new terrain feature must be selected that is on or below the tentative overhead safety limit.
- If the tentative overhead safety limit is deemed safe, the leader announces it as the confirmed overhead safety limit. The gunner manipulates the T&E mechanism to lay the gun back on the target.

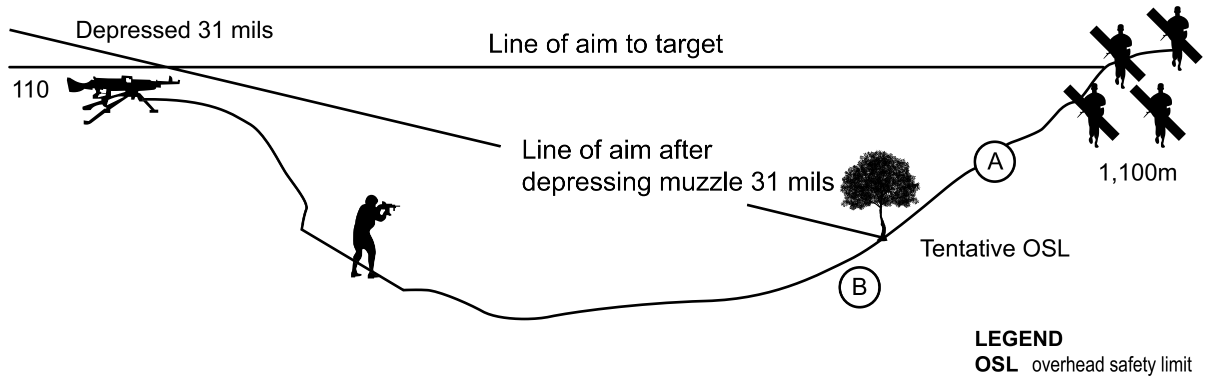


Figure 3-17. Leader's Rule.

Example of Leader's Rule
In Figure 3-17, the leader may select the pine tree as the terrain feature for a tentative overhead safety limit since its line of aim intersects with the ground at a point and is the confirmed overhead safety limit. If the line of aim, after depressing the muzzle, had intersected the ground at (A), then the tentative overhead safety limit at the pine tree could still be used because troops would still be able to move safely up to the tree. However, if the line of aim, after depressing the muzzle, had intersected the ground at (B), then the leader would have to pick a new overhead safety limit, because troops would be endangered if they moved past that point toward the pine tree.
Note: The leader may want to identify a new terrain feature if one is closer to the line of aim than the first feature selected.

Overhead Safety Limit Determination by Compass or Binoculars

In many tactical situations, it may be desirable to determine an overhead safety limit prior to the guns being placed in position. This precludes the use of a machine gun to determine the overhead safety limit. In this circumstance, the overhead safety limit may be approximated by means of either M22/M24 binoculars or an M2 compass.

> *NOTE:* In either case, the overhead safety limit can be confirmed by the gunner's or leader's rule once the guns are sighted.

M22/M24 Binoculars. The M22 or M24 binoculars can be used to measure a safety angle and establish an overhead safety limit as follows:

- Determine the position to which the guns are to be sighted and occupy that position.
- Determine the safety angle in mils, according to the steps of the leader's rule and based on the range from the prospective gun position to the target.
- Use the vertical mil scale of the binoculars and measure that angle downward from the target.
- Make a mental note of where the bottom of the safety angle intersects the ground between the target and your position. This is the overhead safety limit.
- Find a prominent terrain feature or other type of recognizable object that coincides with or identifies the overhead safety limit that will be observable from the gun position. If this feature is also observable to maneuvering troops, the description of the terrain feature should be communicated to the troops before overhead fires commence.

For example, a machine gun squad has been tasked with providing a rifle platoon with overhead fire. The machine gun squad leader wants to occupy the SBF position covertly, so they sneak into the position to determine the overhead safety limit with their binoculars. In Figure 3-18, the leader notes that a cluster of trees is near the enemy position and determines it will be their tentative overhead safety limit.

The machine gun squad leader estimates the range to target as 1,000 meters. They apply the leader's rule in their head: given a 1,000-m range to target, the muzzle will be depressed 30 mils to apply the safety angle.

The machine gun squad leader uses the binocular's reticle to measure 30 mils down from the target, notes that the cluster of trees is even with the lower limit of the 30-mil safety angle, and confirms the trees as the overhead safety limit. Once the feet of the maneuvering troops are even with the trunks of the closest trees, the machine gun leader ceases the overhead fires.

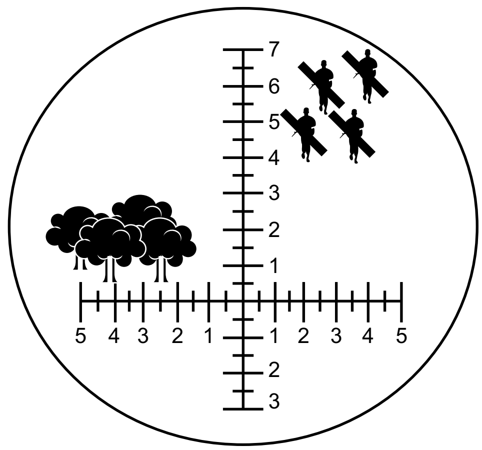


Figure 3-18. Determining Overhead Safety Limit with Binoculars.

M2 Compass. The M2 compass is used to measure a safety angle to establish an overhead safety limit (in the same manner as with binoculars) by measuring the safety angle with the vertical scale underneath the magnetic arrow.

Fire Control Tables for Overhead Fire

At times it may be necessary to deliver overhead fire even if the gunner's or leader's rule indicates that it is not safe to fire. Such conditions usually exist when the target is at long range and the guns, maneuvering troops, and target are at approximately the same elevation (level or uniformly sloping ground). In such cases, overhead fire may be safely delivered by applying the safety limits prescribed in Table II (overhead fire) of either the M240B or M2A1 fire control tables. When the ground is level or uniformly sloping between the gun and the target, the safety angle for any given troop distance will produce a corresponding range. This is obtained by converting the angle of elevation for troop safety, which is expressed in mils, into range (see Figure 3-19). The procedure for using Table II is discussed in the following subparagraphs.

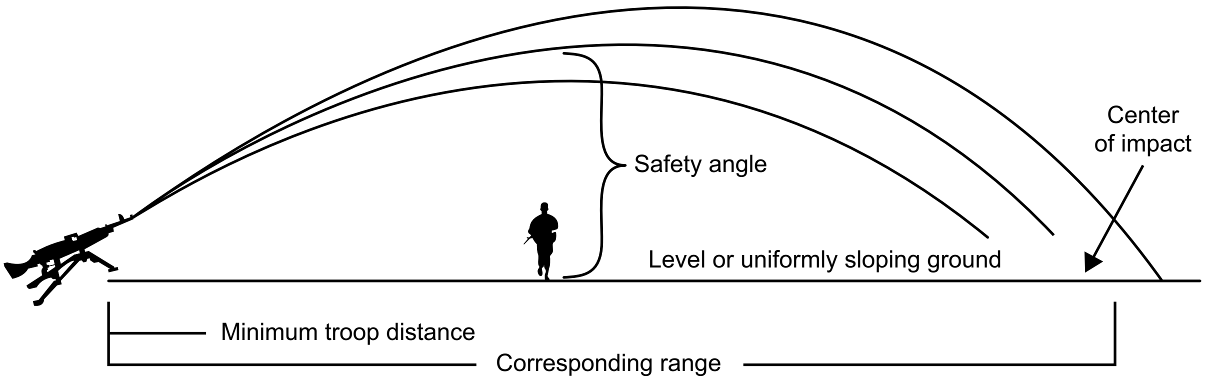


Figure 3-19. Corresponding Range and Minimum Troop Distance.

Determine Range to Target. When using Table II, the range to target must first be determined by the most accurate means possible.

Find Corresponding Range. Once the range to target has been determined, the corresponding range is referenced so the unit has the closest range that troops can be in front of the gun. The range from the gun to the center of impact is the corresponding range. When the gun is fired from the tripod with the required safety angle, the center of impact determines the shortest range that fire can be delivered over the heads of friendly troops.

Find Minimum Troop Distance. When the corresponding range is determined, that range is used to determine the minimum distance troops can occupy in front of the gun. This minimum distance is a result of the safety angle and the range to target. For each corresponding range listed in Table II, there is a corresponding minimum troop distance.

Confirm Minimum Angle of Elevation. The minimum angle of elevation for troop safety (i.e., the safety angle) is confirmed for the range to target (i.e., corresponding range) and minimum troop distance. Once the gun is laid to hit the target, this angle of elevation must be confirmed using an M1A1 gunner's quadrant or M2 compass.

> *NOTE:* Similar data can be determined for the M2A1 by using Table II of Appendix A.

Example of Determining Minimum Angle of Elevation

In Table II of the M240B fire control tables (see Appendix A), the minimum angle of elevation when troops are 600 meters in front of the gun is 23.2 mils. This angle of elevation will produce a center of impact at 1,162 meters, which is referred to as the corresponding range for that angle of elevation.

For simplicity, the corresponding range is always rounded up to the nearest 25 meters, which results in a figure of 1,175. Therefore, no target at a range closer than 1,175 meters can be engaged with the M240B over level or uniformly sloping ground when the troops are 600 meters from the gun.

Quick Reference for Troop Safety Zones

Tables 3-1 and 3-2 may be used as quick references to determine zones where troops can maneuver safely underneath overhead machine gun fire and over level or uniformly sloping ground, given a specific range to the target from the guns. This table has been derived from the data contained in Table II of the medium machine gun and HMG Tables, respectively. Note that as the range to the target increases, the safety zone for troops also increases, both toward the gun and toward the target. If troops are to maneuver over non-uniform ground, the gunner's or leader's rule should be applied to determine the limits for troop safety. All ranges are presented in meters.

Table 3-1. M240 Safety Zone Quick Reference Guide.

Range to Target	Troops Are Safe Between These Ranges (m)
1,200	400 to 700
1,300	300 to 800
1,400	300 to 900
1,500	200 to 1,000
1,600	200 to 1,100
1,700	200 to 1,200
1,800	150 to 1,300
1,900	150 to 1,400
2,000	100 to 1,500

NOTE: Because of the minimum safety angle prescribed by Table II in Appendix A, it is not safe to maneuver troops underneath 7.62 mm fires, over level or uniformly sloping ground, with a range to target of less than 1,200 meters.

Table 3-2. M2A1 Safety Zone Quick Reference Guide.

Range to Target	Troops Are Safe Between These Ranges (m)
1,600	500 to 700
1,700	400 to 900
1,800	350 to 1,000
1,900	350 to 1,200
2,000	300 to 1,300
2,100	250 to 1,400
2,200	200 to 1,500
2,300	200 to 1,700
2,400	200 to 1,800
2,500	200 to 1,900
2,600	150 to 2,000

NOTE: Because of the minimum safety angle prescribed by Table II, it is not safe to maneuver troops underneath .50-caliber fires over level or uniformly sloping ground with a range to target of less than 1,600 meters.

TECHNIQUES OF FIRE BY INDIRECT LAY

Direct fire is delivered using the target itself as the aiming point for the gun. To achieve the quickest laying and adjustment of fire, machine guns are employed by direct lay technique (see Chapter 2). However, the tactical situation often dictates that machine guns be employed indirectly from a defilade position. In these situations, indirect fire is delivered on a target that is not used as the aiming point for the gun. This usually implies positioning the gun in defilade in order to protect the gun and crew and take advantage of the projectile's trajectory to fire on targets at long range. Indirect lay is the method of laying a machine gun for direction and elevation in order to hit a target that is not visible to the gunner. Since defilade fire is delivered indirectly onto a target from the protection of a defilade position, all defilade fire is classified as indirect lay.

> *NOTE:* The machine gun is the infantry commander's organic, direct fire, fire support asset. Accordingly, the protection of these asset should be a high priority to machine gunners and commanders. Both guns should be employed from either a partial or full defilade position to protect the guns and their crews.

The enemy will prioritize destroying friendly machine guns since the machine gun produces a high volume of fire and has the ability to influence a close battle. Therefore, they should be set in secure, unexposed positions. Unlike guns, which can be replaced more easily, the machine guns are considered a more important asset, and precautions should be employed to protect them from enemy fire. The following subparagraphs discuss the basic techniques for employing and protecting machine guns and their crews located in defilade positions by indirect lay.

> *NOTE:* Another method of employing the MK-19 is indirect high-angle fire. This is achieved by switching out the front leg with the right trail leg from the M3 tripod. This method of employment allows the machine gun crew to fire from behind a prominent mask. This technique requires three individuals: the gunner who fires the MK-19, the team leader who assists with firing data, loading, and feeding ammunition, and the third pushes on the top cover to ensure the gun stays in correct position (see Figure 3-20).

Figure 3-20. MK-19 Set Up for High-Angle Fire.

Factors Affecting Defilade Fires

With a defilade position, the gun and its crew are hidden from enemy observation and direct fire by an intervening land mass, called a mask. This mask is usually a finger, hill, ridge, or bank that lies somewhere between the gun position and the target. The physical factors that could affect the focus of fires on a target from a defilade position are discussed in the following subparagraphs.

Range to Target. The distance between the gun and the target has a direct correlation to the steepness of the trajectory and the amount of mask that can be cleared to bring the impact onto the target. Accurate range estimation is essential to facilitate defilade fires.

Trajectory of Projectile. An acute understanding of projectile trajectory is essential to achieving defilade fires. The farther the target is from the gun, the higher the angle of elevation of the gun and the steeper the trajectory of the projectile. The closer and higher a mask is, the steeper the trajectory needed to clear the mask. If the mask is too close or too high to the gun and the range to target is too short, then the gun cannot be depressed enough to bring the trajectory down to the target.

Height of Mask. When a machine gun is laid in defilade, the height of the mask in relation to the gun's angle of elevation must be checked to ensure that mask clearance exists.

> *NOTE:* As a general rule, two mils of mask clearance are necessary to ensure that the cone of fire will clear any given mask. The closer the mask is to the gun position and the higher it is, the better protection it affords the gun and crew. However, this also usually means that the gun must be more elevated to ensure that its fires will clear the mask; hence, the target must be farther away.

Location of Observer. To engage a target from a defilade position, the target must first be identified by an observer who can physically see the target. The observer must provide the gun crew with the direction and elevation to the target, and then the gun crew must determine mask clearance. Once fires are initiated, the observer must have the ability to observe the effects of the fires and relay corrections to the gun crew to adjust those fires onto the target.

Components of Indirect Lay

Laying a gun for indirect lay consists of orienting it in a particular direction and at a specific angle to the horizon to apply fire to a target. However, once the angle of the gun is set, the crew must determine whether or not the gun's cone of fire will clear the mask that lies in front of the gun and whether those fires will affect any troops that may be positioned between the guns and the target. The components of indirect lay for a machine gun are discussed in the following subparagraphs.

Direction. The direction component of indirect lay should be accomplished by orienting the barrel on either a magnetic direction that is determined by a compass or by direct alignment on a reference point. The squad or section leader must be able to observe the reference point from the gun position, preferably at a greater range and higher elevation than the target.

Elevation. The elevation component of indirect lay is accomplished by adjusting the elevating hand wheel to impart an angle on the horizontal axis of the bore to manipulate the projectile's trajectory onto a target at a given range.

The accuracy of the elevation component depends upon leveling the gun. This can be accomplished by using either an M1A1 gunner's quadrant or an M2 compass. Once the gun is leveled, the angle of quadrant elevation can be measured either by a gunner's quadrant or by the T&E mechanism. Since the elevating hand wheel of a gun's T&E mechanism is graduated in one-mil increments, laying a gun for elevation during indirect laying is precise to one mil. However, since a single mil of elevation change shifts the center of impact by different amounts for different ranges, the precision of this component depends on both a proper estimation of range and an accurate setting of quadrant elevation based on the appropriate fire control tables.

Mask Clearance. The mask clearance and elevation components of indirect lay go hand-in-hand. Elevation must be set to allow the projectile's curved trajectory to reach the target, but sufficient mask clearance must exist so that the cone of fire will clear the mask. Both the quadrant elevation and the amount of mask clearance are measured in mils from the axis of the bore to the mask.

Mask clearance can be measured either visually by sighting down the bore with the operating group removed or mathematically by using Table III of the appropriate fire control tables. Usually, the gunner must have at least two mils of mask clearance before delivering indirect fires from defilade. If sighting down the bore, the gunner should position their eye in a manner where the lands and grooves on the bottom of the bore are not visible, align the bottom of the bore to the top of the mask, and elevate two mils up.

Troop Clearance. Whenever machine gun indirect fires are employed, the safety of any troops between the guns and the target must be considered. Troop clearance is an integral component of indirect lay and may be determined either by measuring the safety angle (by either the gunner's or leader's rule if the guns are in partial defilade) or by using Table II of a machine gun's fire control tables. When using Table II, the quadrant elevation that is required to hit the target is compared with the minimum quadrant elevation for troop safety to determine if sufficient clearance exists.

Types of Defilade Positions

Because of the numerous possibilities that exist for setting machine guns for indirect lay, defilade positions (see Figure 3-21) are classified in two general categories: partial and full. Full defilade positions can be further broken down into two specific categories: minimum and maximum.

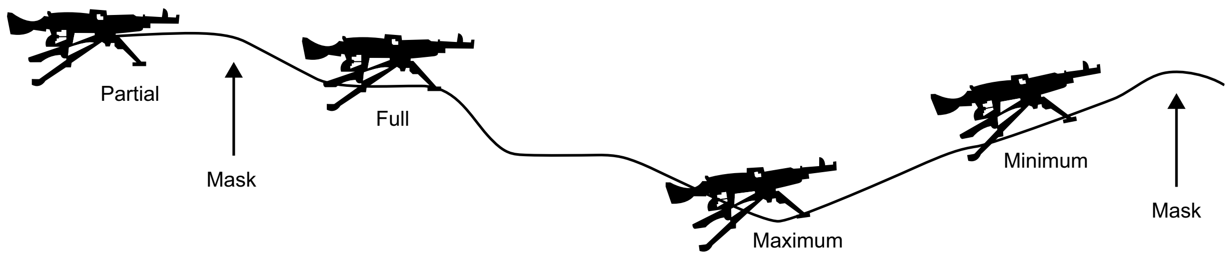


Figure 3-21. Types of Defilade Positions.

Partial Defilade. To select a partial defilade position, the squad leader, knowing the approximate height above the ground of the gunner's eyes when the gunner is in position behind the gun, moves up the slope until, sighting from that height, the squad leader has the target in view above the mask. Then, the squad leader marks that spot and moves the gun up to that point, so that the rear sight is even with the marker.

Full Defilade. Indirect laying a machine gun (full defilade) has the following advantages and disadvantages:

- Advantages:
  - Gun and crew have cover and concealment.
  - The crew has some freedom of movement in and around the position.
  - Ammunition resupply is simplified.
  - Smoke, flash, and the sound of the gun may be concealed.

  NOTE: Full defilade is conducive to a PDF in the defense.
- Disadvantages:
  - Achieving rapid effects on a target can be difficult.
  - Adjusting fire is more time consuming than with direct lay.
  - Engaging rapidly moving ground targets is more difficult.
  - Engaging targets close to the mask is more difficult and mask height can often preclude fires.

  NOTE: Full defilade does not permit FPLs in the defense.

When selecting a defilade position for a machine gun squad, the section leader designates the approximate location of the gun and then the squad leader selects the exact position.

Minimum Defilade. To select a minimum defilade position, the squad leader first moves up the slope until they have the target in view above the mask while sighting from the height of the rear sight. The squad leader then moves back down the slope at least the length of a mounted gun. The squad leader confirms (through estimation) that no part of the gun or crew will be visible from the enemy's perspective above the mask and marks the gun's position.

NOTE: The squad leader may use a cleaning rod that has been marked with the correct sighting height both as an aid to select the position for the gun and a stake to mark the selected position.

Maximum Defilade. To select a maximum defilade position, the squad leader surveys the general position and determines the lowest point on the ground that can be occupied by the guns and crew. In selecting this position, the squad leader should consider that the crew should be able to comfortably man the gun. A sufficient space should extend downslope from the rear legs of the tripod.

Gun Laying for Direction

When setting a machine gun for indirect lay, the squad leader will lay the gun for direction by one of the techniques discussed in the following subparagraphs.

Direct Alignment. When direct alignment is used to lay the gun, the squad leader posts behind the gun on the gun-target line in a position where they can see the target. The squad leader aligns the gun by having the gunner shift the rear legs of the tripod. The gunner loosens the traversing slide as directed by the squad leader and moves the slide left or right until the axis of the bore is aligned on the target.

Reference Point Lay. When reference point lay is used to lay the gun, the squad leader selects a prominent landmark that is visible to the gunner through their sights and designates it as the reference point. If the reference point is on the gun-target line, the gun is laid on the reference point, aligning it on the target. If the reference point is not on the gun-target line, the offset is measured in mils using either binoculars or a compass.

The measured offset is then laid off with the gun by the traversing micrometer or the traversing slide as follows:

- Small offsets (i.e., 20 mils or less) are laid off with the traversing micrometer.
- Large offsets (i.e., more than 20 mils) are laid off with the traversing slide.
- A reference point along the gun-target line with a range equal to or greater than the target is most desirable; however, a point on the mask can be used if needed.

For example, Figure 3-22 depicts how the squad leader uses a compass to measure a left offset of 65 mils from the water tower to the target (e.g., a communications building). Next, the squad leader commands the gunner to first lay on the water tower and then lay off 65 mils left on the traversing bar.

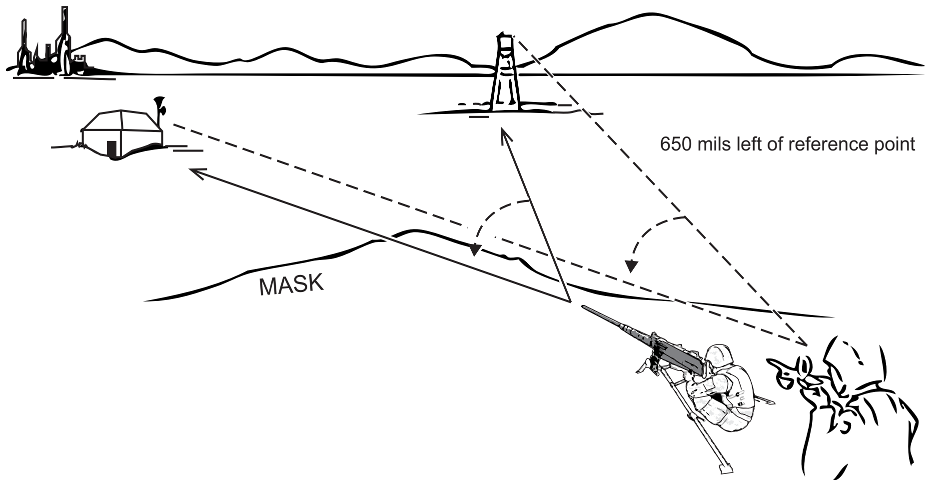


Figure 3-22. Laying the Gun for Direction by Reference Point.

Aiming Stake Lay. When no natural reference point is available, an aiming stake may be used to align the gun to the target, as follows:

- The team or squad leader moves up the mask in front of the gun to a point where they can observe the target. Then, the leader shoots an azimuth to the target with a compass, ensuring they are on the approximate gun-target line.
- The leader then moves back to a position about three meters behind the gun and orients the compass on the same azimuth.
- As directed by the leader, the ammunition bearer places a stake 10 to 30 meters in front of the gun and on the gun-target line.
- The leader, keeping the azimuth on the compass, aligns the sighting wire of the compass on the gun's rear sight and directs the ammunition bearer to place the stake so it is also aligned on the sighting wire.

  NOTE: The stake can be made of any material, such as a cleaning rod, as long as it can be seen by the gunner and is narrow enough to be used as an aiming point.
- The gunner depresses the muzzle until they can align the gun's sights on the aiming stake. The gun is now laid for direction. Elevation will be accomplished by applying quadrant elevation with the T&E mechanism or gunner's quadrant.

Compass Lay. A compass lay is performed by taking the following actions:

- Locate the gun position and target on a map and draw a line between the two points. This will be the gun-target line.
- Determine the magnetic azimuth of the gun-target line. Orient the map to the terrain and place the LOS of the compass along the gun-target line drawn on the map. The magnetic azimuth indicated by the compass index is the direction of lay (e.g., 70 degrees). See Figure 3-23.

  NOTE: Another option to perform a compass lay is to measure the grid azimuth of the gun-target line drawn on the map by means of a military protractor. Then, the resulting grid azimuth to a magnetic azimuth is converted by applying the appropriate grid-magnetic angle. The resulting magnetic azimuth is the direction of fire.

- Lay the gun on the direction of fire. The gunner should—
  - Stand at least three meters behind the gun and orient the compass on the magnetic azimuth that was determined.
  - Align the gun in the approximate direction by shifting the rear legs of the tripod.
  - Loosen the traversing slide and move the slide left or right until the axis of the bore is aligned on the aiming wire of the compass.

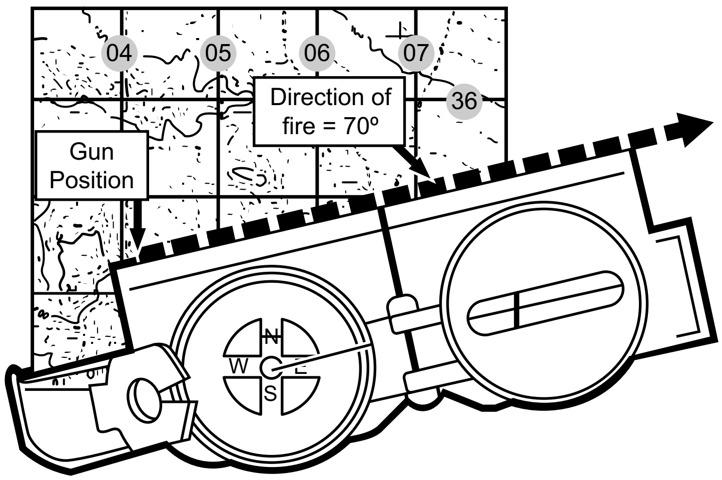


Figure 3-23. Obtaining Direction of Fire from the Map.

As shown in Figure 3-24, after obtaining a direction of fire of 70 degrees from the map, the squad leader gives the gunner corrections to lay the gun on an azimuth of 70 degrees. This will align the direction of fire line with the target. In this example, the target is the communications building.

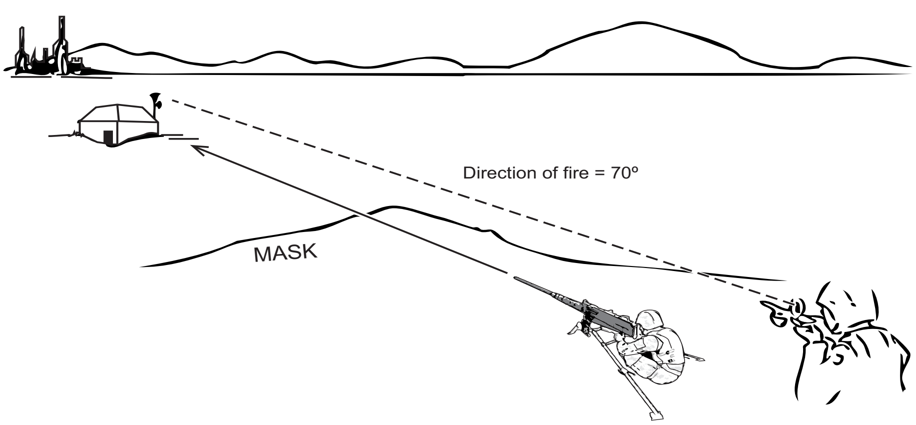


Figure 3-24. Laying the Gun on the Direction Obtained from the Map.

Gun Laying for Elevation

After the gun has been laid for direction, the next step is to lay the gun for elevation. The methods for doing this include using a reference point, a computed and measured quadrant elevation, and the T&E mechanism.

Reference Point. To establish the reference point, the squad or section leader selects a reference point that can be observed from the gun position, preferably at a greater range and higher elevation than the target, and determines the range to the target. They measure the vertical angle in mils from the reference point to the base of the target using binoculars and then directs the gunner to lay the gun on the reference point with the sight setting to hit the target. The gunner depresses the muzzle the number of mils between the reference point and the target with the elevating hand wheel and checks for mask clearance.

To lay the gun for elevation, the squad leader and gunner perform specific actions, as shown in Figure 3-25. The squad leader estimates the range to the target (the communications building) to be 2,500 meters. They read the angle from the top of the water tower down to a line even with the base of the target, determined to be 25 mils. The gunner sets the sights on the announced range to target and then lays on the top of the water tower. The gunner lays off the lateral offset and then depresses the muzzle 25 clicks.

The gun is now laid to hit the target.

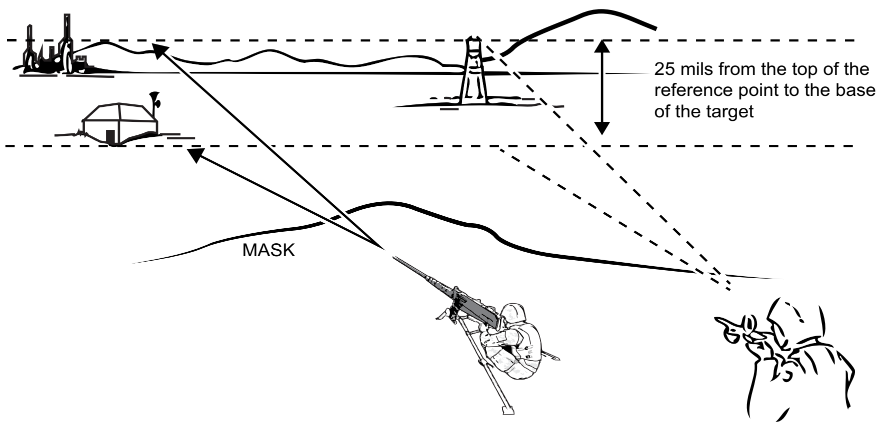


Figure 3-25. Laying a Gun for Elevation by Reference Point.

Computed Quadrant Elevation. To compute quadrant elevation, the range to the target must be determined and the corresponding angle of elevation obtained from Table I using all available range and angular measurement methods.

If using binoculars, the angle of sight is determined by measuring the vertical interval (in mils) between the target and the estimated horizontal with the binoculars' reticle scale. The horizontal is estimated by assuming the distant horizon to be at an angle of sight of zero or at the same elevation as the gun position.

If using a map, the vertical interval is determined by comparing the contour lines at the gun and target and dividing by the observer-to-target factor to produce the angle of sight. The quadrant elevation is determined by adding the angle of sight and the angle of elevation.

Traversing and Elevating. If a gunner's quadrant or M2 compass is not available, the T&E mechanism can be used as follows to measure quadrant elevation as long as the gun can be leveled:

- Use a simple carpenter's level (or what may be available) to level the gun.
- Determine quadrant elevation by the computed quadrant elevation method.

- Apply the determined quadrant elevation to the gun using the elevating hand wheel of the T&E mechanism once the gun is leveled. Each click of the hand wheel equals one mil.

Measured Quadrant Elevation. The quadrant elevation can be measured as follows:

- Locate the gun in partial defilade and lay it on the target by the direct lay method.
- Measure the amount of quadrant elevation on the gun with either the M1A1 gunner's quadrant or M2 compass.
- Move the gun into full defilade and place the measured quadrant elevation back on the gun.
- Add one mil to the quadrant elevation for each meter of difference in elevation between the partial defilade position and the full defilade position. For example, one mil would be added to the quadrant elevation when firing at a range of 1,000 meters or one-half mil when firing at 2,000 meters.

  NOTE: This calculation is not consistent with terrain that has drastic changes in elevation. Additional calculations in quadrant elevation may have to be made depending on the slope of the terrain.
- Check for mask clearance.

Mask Clearance Determination

After the gun has been laid for elevation, it is necessary to determine whether or not the entire cone of fire will clear the mask. This procedure is known as checking for mask clearance. The factors that determine mask clearance include:

- Angle of elevation to the mask.
- Angle of clearance at range to the mask.
- Angle of sight to the mask.

When a gun has mask clearance, both the upper and lower bounds of its cone of fire will clear the mask, as shown in Figure 3-26. To confirm that a gun will have mask clearance, calculations must be made before the gun is fired to compare the quadrant elevation necessary to clear the mask with the quadrant elevation necessary to hit the target.

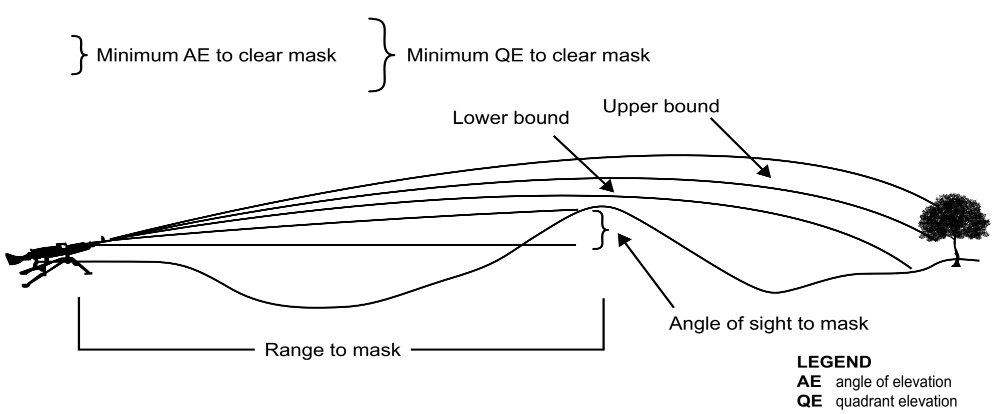


Figure 3-26. Cone of Fire Clearing the Mask.

The quadrant elevation necessary to clear the mask is the sum of the angle of sight to the mask and the minimum angle of elevation to clear the mask. To determine the necessary quadrant elevation to clear the mask, the quadrant elevation necessary to hit the mask must be determined in conjunction with the angle of clearance at the range of the mask. The quadrant elevation necessary to hit the mask—the angle of elevation to the mask plus the angle of sight to the mask—is added to the height of the lower bound of the cone of fire and expressed in mils, which produces what is referred to as the minimum quadrant elevation for mask clearance. Once the minimum quadrant elevation for mask clearance is determined, it is compared with the quadrant elevation required to hit the target. If the target quadrant elevation is equal to or greater than the minimum quadrant elevation for mask clearance, then mask clearance exists.

Mask clearance can be determined either visually or by the firing tables.

Visual Method. When the range to the mask is no more than 300 meters, mask clearance will be present when the axis of the bore is elevated two mils or more above the gun-to-mask line. Mask clearance is checked visually by the following method:

- After the gun has been laid for elevation, the gunner removes the operating group to be able to sight down the bore.
- While looking down the bore, the gunner depresses the muzzle two mils.
- If the upper edge of the mask is not visible up to the center of the bore, then mask clearance exists.

When time does not permit removing the operating group, a hasty visual check can be made by sighting along the lower edge of the barrel in line with the axis of the bore. If the sight taken clears the mask, then mask clearance exists.

Firing Table Methods. When the range to mask exceeds 300 meters and a visual mask check is not practical, mask clearance can be determined by using the appropriate fire control tables. The two methods that use Tables I through IV to determine mask clearance are expedient (using Table III) and computed (using Tables I and IV).

The expedient method of determining mask clearance using Table III also uses the gun's mechanical sights via the following procedures:

- Lay the gun for elevation by any one of the methods discussed previously in this chapter.
- Determine the range to the mask.
- Find the number closest to that range in the range to mask column of Table III.
- Index the corresponding range for the selected range to mask. Each range to mask has an associated minimum angle of elevation that also has an associated corresponding range.
- Round the corresponding range up or down to the nearest hundred meters. Without disturbing the lay of the gun, set that range on the sight.

If the new LOS clears the mask, then mask clearance exists.

The computed method of determining mask clearance requires Table III and the use of either a gunner's quadrant or M2 compass.

Example of the Expedient Method

A medium machine gun squad leader estimates the target to be level with the gun at a range of 1,500 meters and the range to mask to be 800 meters.

From Table I, the squad leader finds the quadrant elevation to hit the target to be approximately 40 mils and commands the gunner to level the gun and put 40 clicks of elevation on it. Consulting Table III, the squad leader finds the corresponding range for mask clearance to be 900 meters, given a range to mask of 800 meters.

The squad leader commands: *set the sight to 900 without disturbing the lay of the gun.*

The gunner checks the new LOS and reports: *clears the mask*.

The procedure is as follows:

- Lay the gun for elevation by one of the methods.
- Determine the range to the mask.
- Determine the minimum angle of elevation for mask clearance from Table III when given the range to mask.
- Measure the angle of sight to the mask by using binoculars, an M2 compass, or a map.
- Add the mask angle of sight to the minimum angle of elevation for mask clearance to determine the minimum quadrant elevation for mask clearance.
- Compare the minimum quadrant elevation for mask clearance with the quadrant elevation to hit the target. If the quadrant elevation to the target is equal or greater to the quadrant elevation for mask clearance, then mask clearance exists.

Example of Computed Method

In Figure 3-27, the target is 1,700 meters from the gun, the vertical interval is zero, and Tables I and IV detail that the quadrant elevation to hit the target is 53 mils. The mask is 500 meters from the gun and has a vertical interval of 20 meters. Using the WERM formula, angle of sight = vertical interval ÷ observer-to-target factor = 20 ÷ 0.5 = 40 mils. Table III shows that the minimum angle of elevation for mask clearance at a range of 500 meters is 6.7 mils. Adding the angle of sight of 40 mils to the minimum angle of elevation of 6.7 mils gives us a minimum quadrant elevation for mask clearance of 46.7 mils. Since the quadrant elevation to hit the target is more than 6 mils greater than the minimum quadrant elevation for mask clearance, the target can be engaged without interference from the mask.

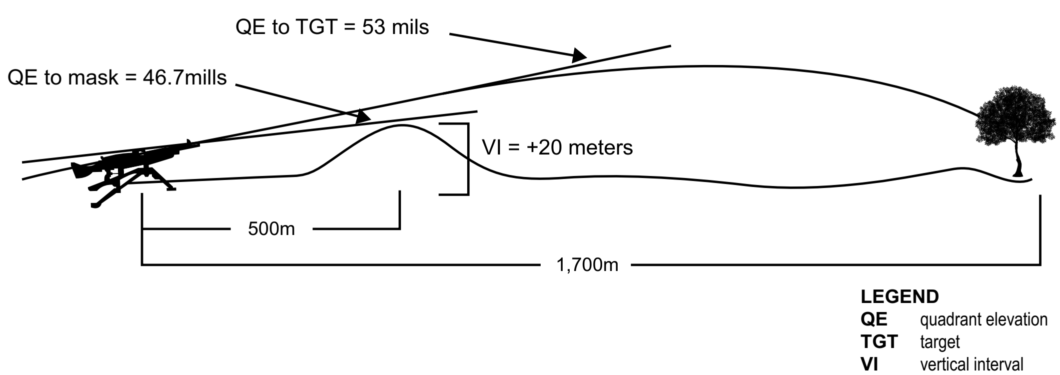


Figure 3-27. Determining Mask Clearance.

NOTE: Contour lines on maps only show the elevation of the actual ground. If trees are present on a mask, they must be factored in to the mask clearance computations.

Therefore, when computing mask clearance from map data, trees are always assumed to be 10 meters or 30 feet high.

Troop Clearance Determination

The last step in laying guns indirectly is to ensure that the fires will not endanger any friendly troops located between the guns and the target. The procedure for determining troop clearance is similar to that for determining mask clearance (i.e., the quadrant elevation necessary to clear troops is the sum of the angle of sight to the troops and the minimum angle of elevation to the troops).

Visual Method. When the guns are sighted in partial defilade, troop clearance can be determined visually using the following method:

- Gunner's rule/leader's rule. The safety angle is measured by applying techniques discussed previously in this chapter.
- Table II can be used to determine troop clearance when the guns are in partial defilade as follows:
  - Lay the gun for elevation to hit the target by any direct lay technique.
  - Determine the distance to troops and refer to the "Distance to Troops" column of Table II, Appendix A.
  - Index the corresponding range for the selected distance to the troops. Each listed range to troops has an associated minimum angle of elevation that also has an associated corresponding range.
  - Round the corresponding range up to the nearest 100 meters. Without disturbing the lay of the gun, set that range on the sight.

If the new LOS clears the troops, then clearance exists.

Firing Table Method. When the guns are sighted in full defilade, troop safety must be determined using Table II and either a gunner's quadrant or an M2 compass. The procedure is as follows:

- Determine the quadrant elevation to the target and lay the gun for elevation by any one of the methods discussed previously.
- Determine the range of the troops and their vertical interval from the gun.
- Determine the angle of sight from the troop's vertical interval using the WERM rule.
- Refer to the "Distance to Troops" column in Table II. Each range that is associated to troops has an associated minimum angle of elevation.
- Add the minimum associated angle of elevation to the angle of sight to troops to produce a minimum quadrant elevation for troop clearance.
- Compare the resultant minimum quadrant elevation for troop clearance to the quadrant elevation to hit the target. If the quadrant elevation to hit the target is greater than the quadrant elevation for troop safety, then clearance exists.

Example of Figuring Troop Clearance

In Figure 3-28, the target is 1,700 meters from the gun, the vertical interval is zero, and the quadrant elevation to hit the target is 53 mils.

The squad leader has determined that the cone of fire will clear the mask, which is 500 meters from the gun and has a vertical interval of 20 meters. However, there are now troops located on the ground 1,200 meters in front of the gun with a vertical interval of 15 meters. Therefore, the angle of sight to the troops is 12.5 mils.

Table II shows that the minimum angle of elevation for troops at 1,200 meters is 48 mils. When the angle of sight of 12.5 mils is added to this, the minimum quadrant elevation for troop clearance is 60.5 mils, 7.5 mils more than the quadrant elevation.

Therefore, mask clearance exists, but troop clearance does not.

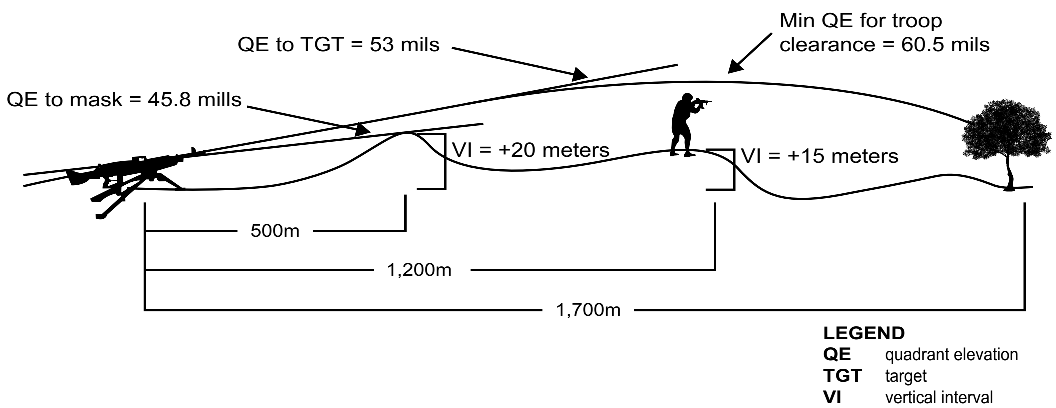


Figure 3-28. Determining Troop Clearance.

Crew Drill for Indirect Fire

When an observer is adjusting indirect fires from either a squad or section of guns, the crew must act in a standardized, efficient fashion to provide responsive and accurate fires. Prior to receiving a fire command from the observer, each gun should be laid on the same base direction of fire (i.e., the center of the sector) and either leveled or laid for elevation on a target in the center of the sector.

All fire commands and subsequent adjustments from the observer are repeated aloud and in unison by each crewmember to ensure that each command is heard and understood by the entire gun line. The gun designated to be the adjusting gun is referred to as the base gun. Usually, the base gun will be gun 1 if only a squad is firing or gun 3 if the entire section is firing. During adjustments, the base gun applies all data supplied to the gun line and then fires on command. All other guns will follow the base gun, applying the same data, but will not fire until the leader commands "*Fire for effect*." When bursts are fired during adjustment, the bursts should be longer than a standard burst to ensure that the observer can spot the burst, as follows:

- M240B: a 40- to 50-round burst should be given.
- M2A1: a 20- to 25-round burst should be given.
- MK-19: a 5- to 6-round burst should be given.

The rate of burst fired during fire for effect should be designated by the observer—either sustained or rapid.

Visual Method to Adjust Indirect Fire

Under field conditions, even the most precise method of laying the gun indirectly will not usually result in an initial burst on the target. The observer who is controlling machine gun fires must be trained to make rapid, bold, and accurate adjustments. The visual method is the simplest and quickest means of adjusting indirect fires. When time permits, the guns can be laid and adjusted by the map, target-observer-gun, or plotting board method (discussed later in this chapter).

Principles. Once fires have commenced, rapidly adjusting fire onto a target is essential to gain the maximum effect from massed machine gun fires. Fire adjustments must be bold, aggressive, and continuous.

> *NOTE:* Creeping fire should be avoided because it results in a waste of ammunition and opportunity. As a general rule, the initial burst of fire should be long enough to ensure that the observer can locate the beaten zone and make an accurate correction.

Observer Technique. To simplify adjustments, the observer should find a location on or near the gun-target line. When this is not possible, the observer must use the visualization method of fire correction—the gunner visualizes being on the gun-target line and makes all corrections accordingly. Corrections should be furnished in mils, using the WERM formula when necessary.

Making Adjustments. When firing on targets by indirect lay, fire is adjusted by moving the burst onto the target. Indirect fire adjustments are always made in direction first and then elevation. Lateral adjustments for the gun are simple: one click on the T&E mechanism equals one mil of adjustment. Range adjustments for the guns are more difficult, requiring knowledge and experience on proper mil corrections.

Commands. The commands from the observer should be standardized in the same manner as the actions on the gun line to ensure that the machine gun unit is provided the best conditions for responsive and accurate fire. The following are examples of such standardization:

- Lateral corrections are given first, followed by range corrections.
- The first command given by the observer to the gun line is the fire command.
- If a crewmember on the gun line is calculating quadrant elevation, then the observer furnishes the range to target in the fire command. If the observer is calculating quadrant elevation, it is passed as quadrant elevation during the fire command.
- The observer should designate which gun should fire the adjusting bursts and which guns follow.
- A pause should follow each command so that the crew on the gun line can repeat it.

Examples of Commands

The following is an indirect fire command for an adjust fire mission.

Section (guns to follow).

Adjust fire (type of mission).

Troops in trench line (target description).

Direction: three one hundred (gun-target line of 3,100 mils, magnetic).

Elevation: three zero (quadrant elevation of 30).

Gun three (gun to adjust).

At my command (this line may be omitted if the observer desires the gun to fire when ready).

Fire.

The following is an example adjustment that might follow the first adjusting burst from the fire command, given that the observer spots the burst to be 100 meters short and 30 mils left of the target.

Right: three zero.

Up five. Since *at my command* was not said, gun three makes the adjustment and fires when ready.

The following is an example sequence of commands for a fire for effect.

Section (guns to fire).

Fire for effect (type of mission).

One hundred rounds (each gun will fire 100 rounds).

Sustained rate (the section will fire at the sustained rate).

At my command.

Fire.

For lateral shifts, the observer measures the lateral distance between the burst and the target in mils and then relays this information directly to the gun crew. Then, the gun crew manipulates the gun with either the traversing micrometer for minor shifts of 20 mils or fewer or the traversing slide for major shifts of more than 20 mils.

For range shifts, corrections can be made by either meter or mil. For meter corrections, the observer determines the number of meters necessary to move the center of impact onto the target and proceeds as follows:

- The correction is relayed to the gun, where the crew refers to Table I of the fire control tables to determine the number of mils required to make the range shift.
- The number of mils is applied to the gun by manipulating the elevating hand wheel. When making range corrections, meter corrections are more accurate, but more time consuming.

For mil corrections, the observer determines the range shift by estimating the number of mils in search that are required to make the shift. This is quicker than determining meter corrections and, when applied by a trained observer, can be quite accurate. Making accurate corrections for range shifts in this manner requires an understanding of trajectory at different ranges.

Tables 3-3 and 3-4 list the required changes in elevation for the M240B and M2A1, respectively, to shift the center of impact 100 m in depth on level ground.

Table 3-3. M240B Elevation Changes.

Range (m)	M80 Ball (mils)
100–500	1
600–800	2
900–1,000	3
1,100–1,200	4
1,300–1,500	5
1,600–1,700	6
1,800–1,900	7
2,000	8

Table 3-4. M2A1 Elevation Changes.

Range (m)	M8 API
100–1,000	1
1,100–1,500	2
1,600–1,900	3
2,000–2,500	4
2,600–3,000	5
3,100–3,500	6

ADVANCE TECHNIQUES FOR INDIRECT FIRE

Indirect fires by machine guns have advantages and disadvantages compared to those of mortars. Some advantages of indirect machine gun fire include the following:

- Nonexplosive ordnance (e.g., 7.62 mm, .50 cal) is less likely to endanger nearby troops; instead, it allows them to get closer to fires than with mortars, provided that the fires are not overhead.
- High explosive dual purpose (HEDP) warheads from the MK-19 have better armor penetration capabilities than mortars.
- Machine gun ammunition may be used instead of mortars if mortar ammunition supply is limited.
- The TOF of machine gun projectiles is minimal, making even indirect machine gun fires more responsive than mortar fires. Planned and registered interdiction fires on an avenue of approach can be very effective.
- The effective beaten zone of a properly employed machine gun section may be larger than a mortar barrage.

Achieving rapid effects on target from indirect machine gun fire can be difficult because of the following disadvantages:

- Visually adjusting indirect fires from medium machine guns is problematic because of the minimal impact signature of 7.62 mm ball projectiles; however, visually adjusting .50-caliber armor-piercing incendiary (API) and 40 mm HEDP is not a problem.
- A high expenditure of machine gun ammunition may sometimes be necessary to achieve the desired effects.
- Accurate and responsive indirect fires require highly trained machine gunners; time and ammunition resources may not be sufficient to achieve the level of training needed.

Advanced techniques used to maximize the advantages of indirect machine gun fire include becoming proficient at gathering gun data and using the target-observer gun method and M16 plotting board.

Gun Data for Indirect Fire

The data necessary to measure and apply the components of indirect lay—direction, elevation, mask clearance and troop clearance—are referred to as gun data.

> *NOTE:* Since mask and troop clearance are used to confirm whether the elevation component is viable, they are not considered actual data. However, they are the product of certain data that comes from actual measurement. This data, since it is not actually applied to the guns, is differentiated from the data that is applied. Gun data is categorized as either terminal or intermediate.

Both terminal and intermediate data come from specific sources. Since indirect machine gun fire can be difficult to adjust, it is imperative that gun data be obtained and computed accurately. Doing this requires knowledge of the characteristics of fire, the indirect fire crew drill, fire control instruments, the mil formula, and fire control tables. The computation of gun data demands exactness and close attention to detail that is only acquired by practice solving indirect lay problems. Once gun data is obtained, extreme accuracy is demanded in applying data to the gun because a small error in measurement at the gun produces a large error in the delivery of its fires.

> *NOTE:* A detailed explanation of vertical interval, angle of sight, angle of elevation, quadrant elevation, and the fire control instruments available to machine gunners is provided at the beginning of this chapter.

Terminal Gun Data. Terminal gun data—direction and quadrant elevation—are applied to the gun. Direction is derived from measurement in mils by either a compass or a map and protractor. Quadrant elevation is the sum of the angle of sight and angle of elevation. It is obtained by adding the measured angle of sight to the angle of elevation for the desired range found in Table I. It can also be obtained by referring to Table IV and the measured vertical interval of the target.

Once the intermediate gun data is obtained from Table I and by measurement from the map or fire control instruments, it can be used to compute the terminal gun data by any one of the following methods:

- The map method is most practical for expediently computing gun data if a map is available, but it is less accurate than the target-observer gun method.
- The target-observer gun method is more accurate than the map method, but more complex to compute. It can be used either with or without a map, but requires fire control instruments.
- The plotting board method is as accurate as the target-observer gun method, but more conducive to computing gun data for targets of opportunity that are spotted by an observer. It is similar to a mortar or artillery call-for-fire.

Intermediate Data. Intermediate data is obtained by various types of measurement for the purpose of computing the terminal gun data. Intermediate data includes the vertical interval, angle of sight, angle of elevation, mask clearance, and troop clearance. The following information applies to these factors:

- Vertical interval is obtained by comparing contour lines on a topographic map or by measuring the angle of sight with a clinometer and then using the WERM formula to convert the angle of sight to the vertical interval.
- Angle of sight is obtained by physical measurement with a clinometer or by converting the vertical interval derived from a map into angle of sight using the WERM formula.
- Angle of elevation is obtained from Table I of a gun's fire control tables. This is precise data derived from extensive testing by the Army's Firing Tables Branch at Aberdeen Proving Ground, Maryland.
- Mask clearance is obtained by comparing quadrant elevation to the target with data from Table II.
- Troop clearance is obtained by comparing quadrant elevation to the target with data from Table III.

  NOTE: Extreme accuracy is demanded in securing all measurements for both intermediate and terminal gun data because a small error in measurement at the gun produces a large error in the delivery of fires at longer distances.

Target-Observer Gun Method

The target-observer gun method of laying guns for indirect fire is similar to the map method, but does not require the use of a map. This method has the following characteristics:

- Substitutes an OP for the initial aiming point.
- Requires an M2 compass to measure the azimuth and angle of sight to the gun position, the target, and any masks that lie along the gun-target line.
- Requires some means of accurate range determination, such as a laser range finder. All direction computation is performed using a pencil, paper, and map protractor.

The target-observer gun method can be used to determine a compass azimuth to lay the guns for direction or in a manner similar to the map method (the guns lay off a base angle from the OP). Elevation computation is derived from angle of sight readings and the gun's appropriate fire control tables. Application of the target-observer gun method produces a converged sheaf.

For example, as shown in Figure 3-29, an HMG platoon is located in the dry creek bed at point G and its flank guns have been plotted. An OP has been established on the hilltop northeast of the gun position and a target has been identified at the road intersection east of the OP. The target is not visible from the gun position, but both the target and the guns are visible from the OP. The observer is in radio contact with the gun position and it has been confirmed that all gun crews can visually identify the OP. This is critical for the target-observer gun method because the OP will be used as an initial aiming point for the guns to lay off a base angle to the target. A mask lies between the guns and the target.

> *NOTE:* Since the target-observer gun method does not require using a map, Figure 3-29 is used only as a reference to help the reader understand the terrain and the positions of the target, observer, and guns in relation to one another. All readings for the target-observer gun method will be taken by compass and range finder.

The target-observer gun method of determining gun data for indirect lay is performed as discussed in the following sub paragraphs.

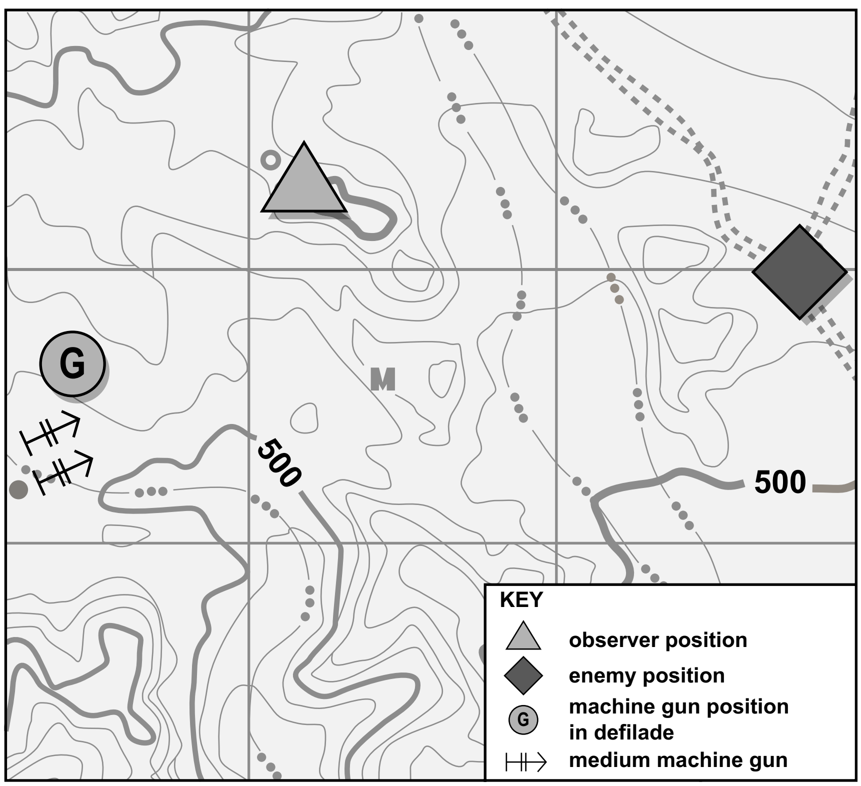


Figure 3-29. Location of the Flank Guns, Observer, and Target.

Obtain Preliminary Data with Compass and Range Finder. To obtain preliminary data with a compass and range finder, the following data must be determined:

- The range from the OP to the flank guns, target, and mask:
  - Gun 1: 1,400 meters.
  - Gun 6: 1,400 meters.

- Target: 1,580 meters.
- Mask: 1,680 meters.

- The azimuth from the OP to the flank guns, target, and mask:
  - Gun 1: 4,020 mils.
  - Gun 6: 4,100 mils.
  - Target: 1,780 mils.
  - Mask: 2,700 mils.
- The angle of sight of the gun position, the target, and the mask:
  - Gun 1: -71 mils.
  - Gun 6: -71 mils.
  - Target: -51 mils.
  - Mask: -31 mils.

Perform Target-Observer-Gun Plotting. To perform target-observer gun plotting—

- Draw a line on a blank sheet of paper that represents a north-south line. Select a point near the center of this line to represent the OP. Label this point O (see Figure 3-30).
- Lay a map protractor on the paper with the center over the point O and place tick marks on the azimuths to the flank guns, target, and mask.
- Draw lines from the OP through the tick marks to the flank guns. These are the base lines.
- Draw a line from the OP through the tick marks to both the target and mask. Ensure that the lines extend far enough to facilitate future measurement (see Figure 3-31).
- Measure the distances from the OP to each flank gun, target, and mask along their azimuths, using a convenient scale (e.g., 1:50,000; 1:25,000), and annotate each of these points accordingly (see Figure 3-32).
- Draw gun-target lines from each flank gun to the target (see Figure 3-33).

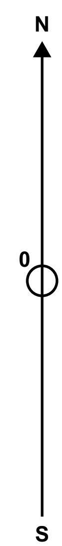
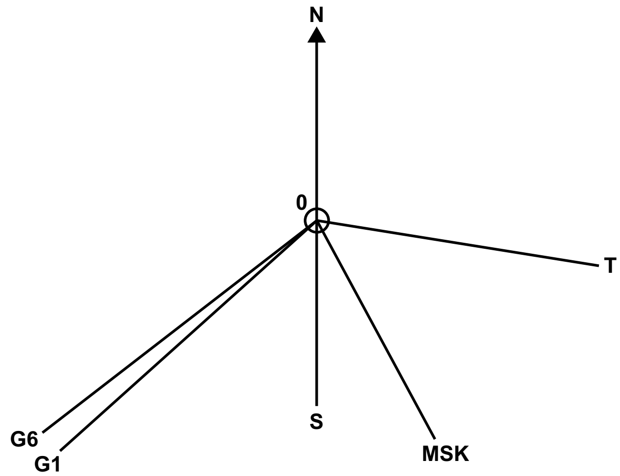


Figure 3-30. Plotting North-South Line and Observer Position.



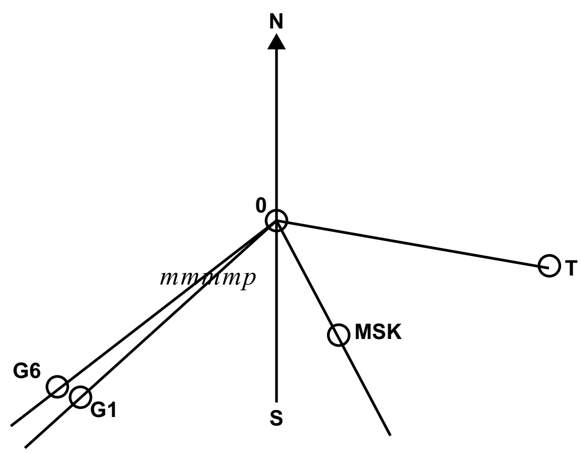
LEGEND

G1	flanking gun position	**MSK**	mask
G6	flanking gun position	**T**	target

KEY

◯ **distance to associated point on map**
0 **observer**

Figure 3-31. Plotting Azimuths from the Observation Position.



LEGEND

G1	flanking gun position	**MSK**	mask
G6	flanking gun position	**T**	target

KEY

◯ **distance to associated point on map**
0 **observer**

Figure 3-32. Plotting Distances along the Azimuths.

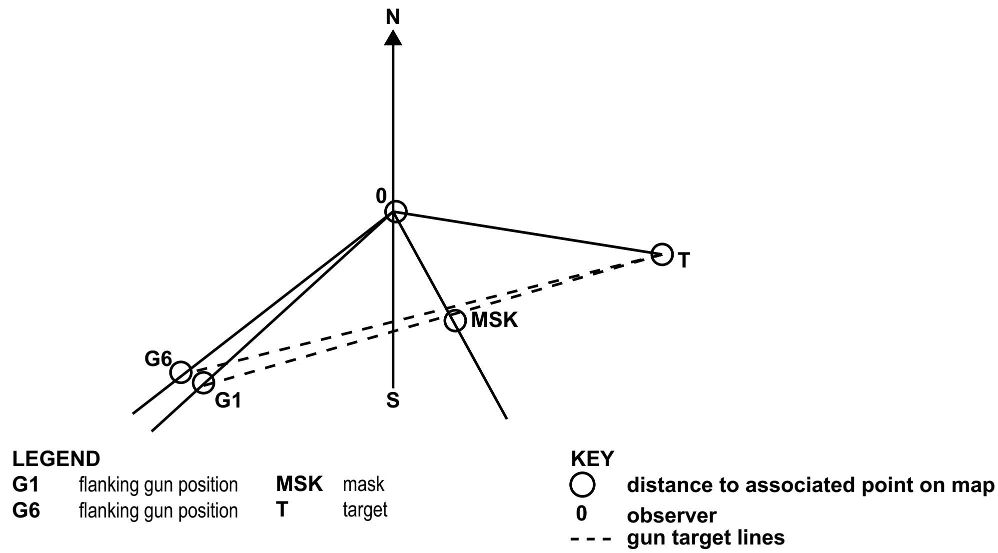


Figure 3-33. Plotting Gun Target Lines.

Measure the Base Angles to the Flank Guns. Using a map protractor, measure the base angles between the OP and the target for the flank guns:

- Gun 1: Right 500 mils.
- Gun 6: Right 440 mils.

Interpolate the Base Angles for the Interior Guns. For each of the interior guns, interpolate the base interval by dividing the difference in base angles for the flank guns (60 mils) by the number of intervals (5), which equals 12 mils. To determine its base angle, subtract the base interval (12 mils) sequentially from each gun:

- Gun 1: Right 500 mils.
- Gun 2: Right 488 mils.
- Gun 3: Right 476 mils.
- Gun 4: Right 464 mils.
- Gun 5: Right 452 mils.
- Gun 6: Right 440 mils.

Calculate Angle of Sight from Flank Guns to Target. To calculate the angle of sight from the flank guns to the target, perform the following:

- Gun 1:
  - Determine the vertical interval. The angle of sight from the OP to gun 1 is -71 mils and from the OP to the target is - 51 mils. Therefore, the vertical interval between gun 1 and the target is +20 meters.
  - Determine range. Using the same scale that was used to plot the distances above, measure the distance from gun 1 to the target to determine the range—2,700 meters.
  - Determine angle of sight. Using the WERM formula, angle of sight = vertical interval ÷ observer-to-target = 20 ÷ 2.7 = 7.4 mils.

- Gun 6:
  - Determine vertical interval. Since both guns 1 and 6 are at the same elevation, their vertical interval is the same.
  - Determine range. Using the same scale, range is determined to be 2,760 meters.
  - Determine angle of sight. Angle of sight = vertical interval ÷ observer-to-target factor = 20 ÷ 2.76 = 7.2 mils.

Calculate Quadrant Elevation to Target for Flank Guns. To calculate the quadrant elevation to the target for the flank guns, perform the following:

- Gun 1: Determine the angle of elevation for 2,700 meters—
  - Table I for the M2A1 shows that the angle of elevation equals 63.9 mils.
  - The quadrant elevation to the target is determined by adding the angle of sight of 7.4 to the angle of elevation of 63.9 to get 71.3 mils.
- Gun 6: Interpolate the angle of elevation for 2,760 meters from Table I for the M2A1—
  - The difference in angle of elevation between 2,700 and 2,800 meters is 5 mils (see column 3).
  - Multiply 5 by 0.6 to determine the change in angle of elevation for 60 meters, which equals 3 mils.
  - Add 3 mils to the angle of elevation for 2,700 meters (63.9 mils), for the interpolated angle of elevation of 66.9 mils.
  - Adding the angle of sight of 7.2 to the angle of elevation of 66.9 determines a quadrant elevation to target of 74.1 mils.

Interpolate Quadrant Elevations for Interior Guns. To interpolate quadrant elevations for interior guns, leaders should divide the difference in quadrant elevations for the flank guns (2.8 mils) by the number of intervals (five). This equals 0.56 mils, but is rounded up to 0.6 for simplicity. Then, the quadrant elevation interval (0.6 mils) is added sequentially to each gun to determine its quadrant elevation:

- Gun 1: 71.3 mils.
- Gun 2: 71.9 mils.
- Gun 3: 72.5 mils.
- Gun 4: 73.1 mils.
- Gun 5: 73.7 mils.
- Gun 6: 74.1 mils.

Determine Mask Clearance. First, the vertical interval from the guns to the mask should be determined. The angle of sight from the OP to the guns is -71 mils and from the OP to the mask is -31 mils. Therefore, the vertical interval between the guns and the mask is +40 meters. To determine mask clearance—

- Determine the range from the nearest gun to the mask. Using the same scale, the distance from gun 1 to the mask is 1,400 meters.

- Determine the angle of sight. The angle of sight = the vertical interval ÷ the observer-to-target factor = 40 ÷ 1.4 = 28.6 mils.
- Determine the minimum angle of elevation for mask clearance. Table III indicates that the angle of elevation is 19.5 mils for a mask at 1,400 meters.
- Determine the minimum quadrant elevation for mask clearance. Adding the angle of sight of 28.6 to the minimum angle of elevation of 19.5 equals a minimum quadrant elevation for mask clearance of 48.1 mils.

Since the lowest quadrant elevation to target (71.3 mils) is greater than the minimum quadrant elevation for mask clearance (48.1 mils), mask clearance exists. Each gun, once issued a base angle, will lay on the OP and set off the base angle by means of the traversing bar and traversing micrometer. All guns will lay for elevation on their individual quadrant elevations by means of a gunner's quadrant or M2 compass. This completes the target-observer gun method of indirect lay.

M16 Plotting Board

Indirect machine gun fire is adjusted by the plotting board method using the M16 plotting board in conjunction with the fire control tables. The use of the plotting board permits accurate firing under all visibility conditions on any target that has a location recorded on the board or that can be determined by other means, such as grid or polar mission.

> *NOTE:* The M16 plotting board should be maintained by the section leader or a designated fire direction noncommissioned officer, who should be located at the gun position and have positive communications (by radio or wire) with the observer.

M16 Plotting Board Capabilities. The plotting board can be used to—

- Plot the location of OPs that may submit fire requests.
- Plot registration points or targets by one of three techniques—grid, polar, or shift-from-a-known-point.
- Determine special corrections for each machine gun to fit a target of special shape.
- Mass the section's fires on any known target location.
- Plot the location of friendly troops that are forward of the gun position.

M16 Plotting Board Methods. There are two basic methods of using the M16 plotting board—the observed firing chart, in which the pivot point represents the location of the base gun, and the modified observed firing chart, in which the location of the base gun is offset from the pivot point.

M16 Plotting Board Setup as a Modified Observed Firing Chart. Prior to using any of the plotting techniques, the M16 plotting board must be set up for use as either an observed firing chart or a modified observed firing chart.

Figure 3-34 illustrates the M16 plotting board set up to show that the HMG position (G) is located in the dry creek bed at 042343, an observer (O) is located on the ridgeline at 057337, and a registration point (R) has been planned at the road intersection at 068350.

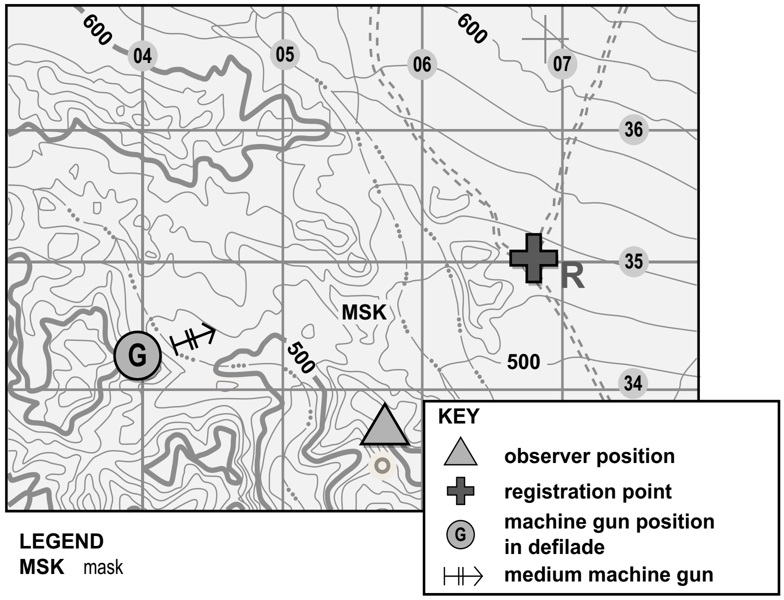


Figure 3-34. Map Locations of Guns, Observer, and Registration Point.

To use the M16 plotting board as an observed firing chart, the information in the following sub paragraphs applies for all three (i.e., polar, grid, and shift-from-a-known-point) plotting techniques.

Determine Gun Position. The gun position is determined when the plotting board operator selects the pivot point to represent the machine gun position. Although the pivot point is marked OP, it will always represent the gun position when using the plotting board. The plotting board operator then determines the six-digit grid coordinate to the gun position (in this case, it is 042343).

Mark Map Coordinates. Map coordinates should be marked as follows (the reference is Figure 3-35):

- Index the plotting disk to 0.
- Draw a vertical tick mark 2,000 meters below the pivot point on the centerline, using the primary range scale.
- Annotate the X coordinates of the gun position below this tick mark (042).
- Draw four more vertical tick marks, two on both sides of the first tick mark, at 1,000-m intervals.
- Annotate the X coordinates accordingly (i.e., 052 and 062 to the right and 032 and 022 to the left).
- Draw a horizontal tick mark 2,000 meters to the left of the pivot point.
- Annotate the Y coordinates of the gun position to the left of this tick mark (343).
- Draw four more horizontal tick marks, two above and two below that tick mark, at 1,000-m intervals.
- Annotate the Y coordinates accordingly (353 and 363 above and 333 and 323 below).

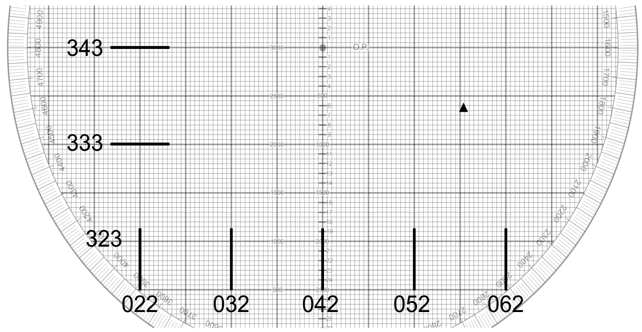


Figure 3-35. Marking X Coordinates.

Mark the Location of the Observer. Using the primary range scale and the map coordinates as established (see Figure 3-36), the observer's location coordinates (i.e., 057337) should be marked on the plotting disk as follows:

- Count ten small squares (500 m) to the right of the 052 tick mark. This is the 057 X coordinate.
- Count eight small squares (400 m) up from the 333 tick mark. This is the 337 Y coordinate.
- Mark the intersection of these grid lines with a dot, then surround that dot with a triangle.

  NOTE: Since the size of the dots placed on the board affects the accuracy of the data determined, the dots must be made as small as possible.

Now the plotting board is set up and ready for use by any of the three plotting techniques.

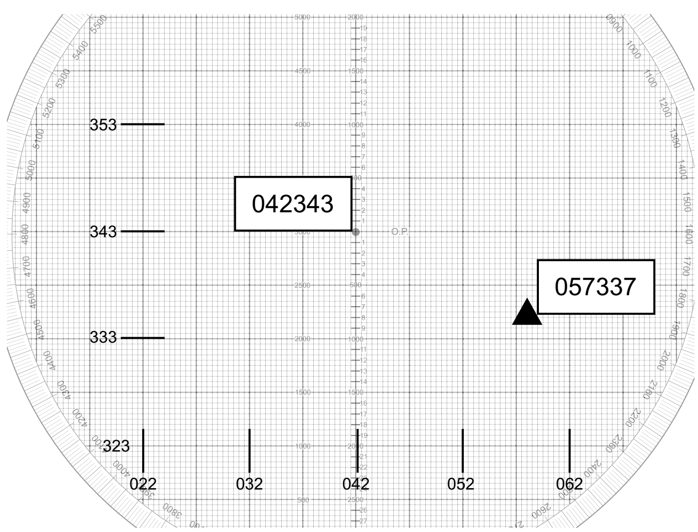


Figure 3-36. Marking the Y Coordinates and Observer Position—Board Setup Complete.

Establishing the Registration Point. Once the plotting board has been set up, the first step in planning indirect fires is to establish a registration point. The purpose of this registration point is to confirm that the guns are properly laid and that an identifiable point on the ground has been established where targets of opportunity can be readily engaged.

The registration point should be located near the center of the section's sector of fire. For this example, the observer identifies a registration point for the machine guns with the road intersection at 068350. The grid plot technique will be used to establish the registration point (068350) on the plotting disk as follows (see Figure 3-37):

- Count twelve small squares (600 meters) to the right of the 062 tick mark. This is the 068 X coordinate.
- Count fourteen small squares (700 meters) up from the 343 tick mark. This is the 350 Y coordinate.
- Mark the intersection of these grid lines.

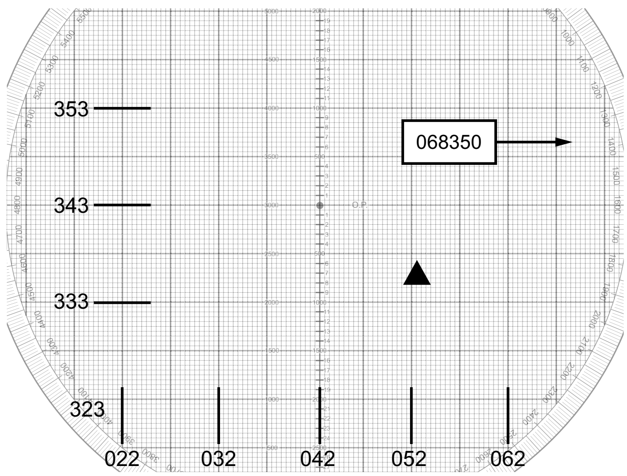


Figure 3-37. Plotting the Registration Point.

- Index the plotted point by rotating the plotting disk until the dot is centered over the index line (see Figure 3-38).

NOTE: The right side of the scale is used when reading azimuths.

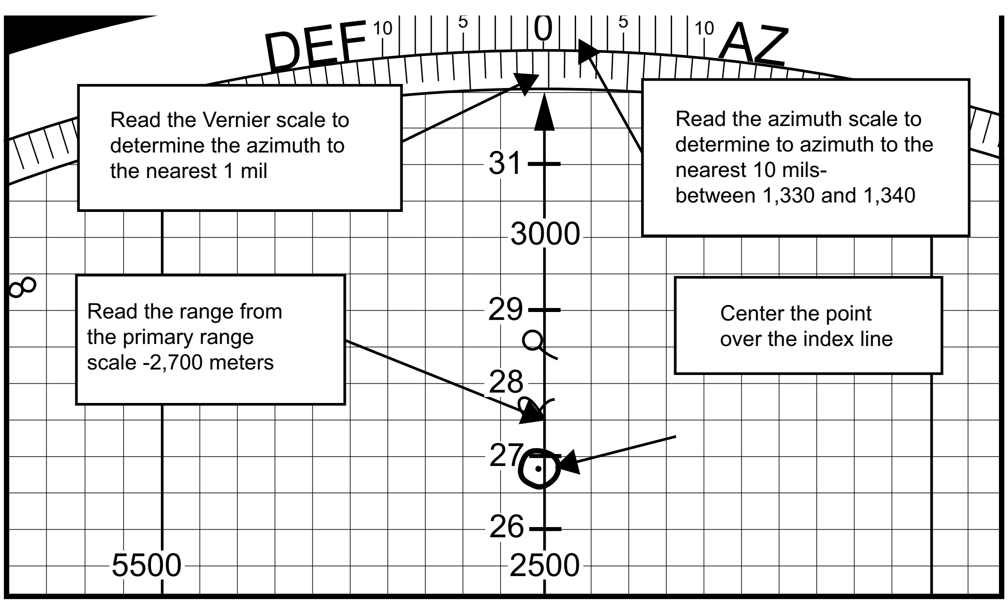


Figure 3-38. Indexing the Point to Determine Azimuth and Range.

- Read the azimuth to the nearest 10 mils from the azimuth scale. In this case, it reads between 1,330 and 1,340 mils.
- If the zero-index line of the Vernier scale lies between two graduations of the azimuth scale, then the Vernier scale is used to determine the fraction between those graduations.
- Compare the graduated lines of the Vernier scale to the graduated lines of the azimuth scale. Two of these are going to line up exactly, while those to their left and right will line up approximately.
- In Figure 3-39, the 7-mil line of the Vernier scale matches exactly with the 1,400-mil line of the azimuth scale. The azimuth reads 1,337 mils.

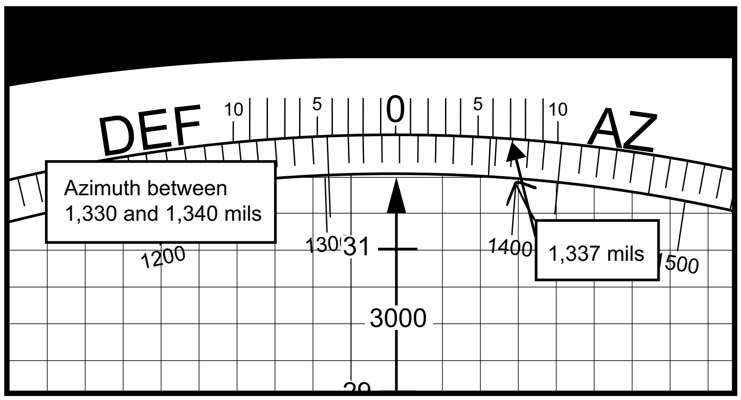


Figure 3-39. Reading the Azimuth from the Vernier Scale.

- Read the range. Once the azimuth is determined, the distance from the gun position to the target is determined by reading the primary range scale. In this case, it reads 2,700 meters.
- Determine the quadrant elevation to the target. Once the range is determined from the plotting board, it must be converted to a usable quadrant elevation for the guns. The gun is at an elevation of 510 meters and the registration point is at 530 meters (elevation is in meters and contour interval is 20 meters). The vertical interval is +20 meters. To determine the quadrant elevation, the following steps are performed:

  1. Find the elevation of a point between two contour lines: first, find the elevation of the contour line below the point (in this case, 520 meters); second, add half the contour interval. Since the contour interval is 20 meters, add 10 to 520 to provide an elevation of 530 meters.
  2. Find the angle of sight for 2,700 meters: use the WERM formula to find angle of sight (angle of sight = vertical interval ÷ observer-to-target factor = 20 ÷ 2.7 = 7.4 mils).
  3. Determine the angle of elevation: using Table I for the M2A1, the angle of elevation for 2,700 meters is 63.9 mils.
  4. Determine the quadrant elevation; adding the angle of sight of 7.4 mils to the angle of elevation of 63.9 mils, the quadrant elevation to target is 71.3 mils.
  5. Determine the quadrant elevation to the mask. Before the quadrant elevation to the target can be issued as gun data, it must be compared with the quadrant elevation to the mask to ensure the cone of fire will clear the mask. From the map, the plotting board operator determines that three hill masses lie along the gun-target line. The operator, with the

knowledge of projectile trajectory, reasons that only the mask in the middle might interfere with firing, and designates this as mask one. Mask one is at a range of 1,400 meters and a maximum elevation of 570 meters. Therefore, the vertical interval is +60 meters, and the angle of sight is 60 ÷ 1.4 = 42.9 mils.

NOTE: To determine the maximum elevation of a mask, add half the contour interval to the elevation of the highest marked contour line on the mask (in this case, 560 meters). Since the contour interval is 20 meters, add 10 to 560 to determine a maximum mask of 570 meters.

The minimum angle of elevation for mask clearance at a range of 1,400 meters in Table III for the M2A1 is 19.5 mils. Adding the angle of sight of (42.9) to the minimum angle of elevation (19.5) yields a minimum quadrant elevation to clear the mask of 62.4 mils. Since the quadrant elevation to target is 71.3 mils, clearance exists for the mask.

- Issue gun data. The superimposed deflection reading underneath the azimuth of 1,337 and the quadrant elevation of 71.3 are issued to the gun crew.
- Make adjustments. Once the gun data is applied to the base gun and the adjusting burst is fired, the observer will make any necessary corrections to obtain the burst on target.

NOTE: To make any adjustments after the initial burst, the observer must provide the plotting board operator with the observer-to-target direction. In this case, the observer-to-target direction is 0700 mils.

- Record the target. When the burst is on target, the operator records the target by circling the last dot plotted for adjustment and erasing the others. For this example, assume that the initial adjusting burst was on target (see Figure 3-40).

NOTE: The confirmed plot should be marked on the plotting disk once the plot is confirmed and it is assumed that the registration point has been recorded.

NOTE: Plotting techniques fall under the category of the observed firing chart method because the pivot point is being used to represent the location of the base gun.

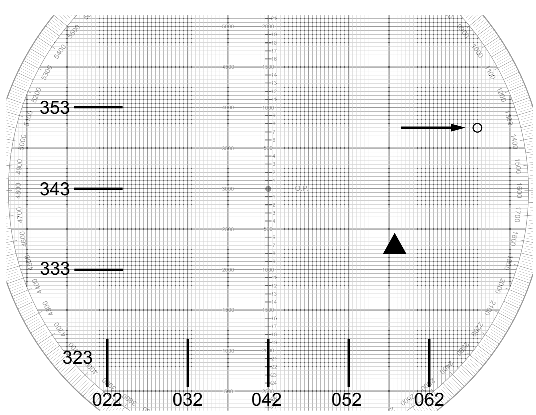


Figure 3-40. Registration Point Recorded.

PLOT TECHNIQUES

Grid Plot Technique

The grid plot technique is used when the observer wants to provide target location in terms of a six, eight, or ten-digit grid coordinate, as derived from a topographic map with the military grid reference system. The grid plot technique is part of the observed firing chart method—the pivot point represents the base gun's location.

Example of the Grid Plot Technique

This example uses the same information as for the registration point starting at Figure 3-34. The gun position is located in the dry creek bed at 042343 (the elevation is 510 meters). An observer is located on the ridgeline at 057337 and a registration point (1) has been recorded at the road intersection at 068350. The observer has now identified a target near the bend in the road, approximately three kilometers north of their position (see Figure 3-41). The target is a motorized reconnaissance element that has stopped on the road. It makes a favorable target. The observer estimates the grid position to be 056364 and submits a grid mission to the gun line. The gun crew would receive its fire mission from the observer as follows.

Warning order to the gun crew for a grid mission: *Fire mission, grid*.

Grid location of 056364: *Zero five six, three six four*.

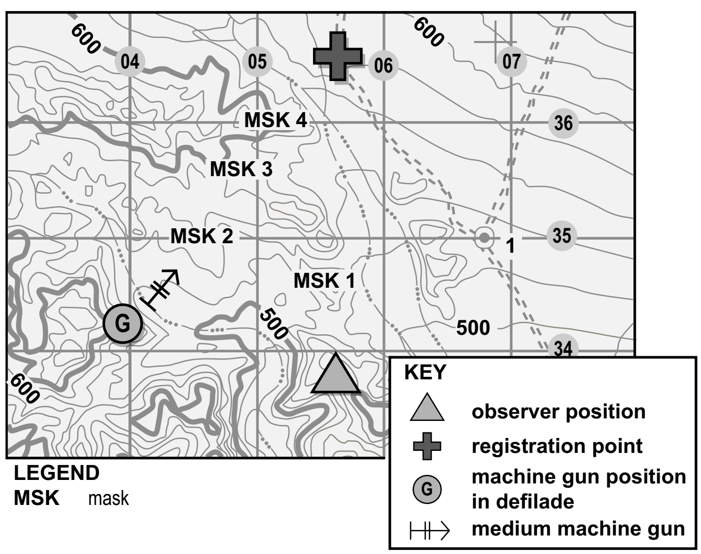


Figure 3-41. New Target Located at Bend in Road—Grid M.

Plot the New Target. The grid plot method is used to plot the new target, 056364 (see Figure 3-42) in the following manner:

- Count eight small squares (400 meters) to the right of the 052 tick mark. This is the 056 X coordinate.
- Count two small square (100 meters) up from the 363 tick mark. This is the 364 Y coordinate.
- Mark the intersection of these grid lines with a small dot and annotate it with a "2" because this is the second target on the board.

- Index the plotted point by rotating the plotting disk until the dot is centered over the index line.
- Read the azimuth to the nearest mil from the Vernier scale (0600 mils) (see Figure 3-43).
- Read the range from the primary range scale (2,525 meters) and index the plotted point (see Figure 3-44).

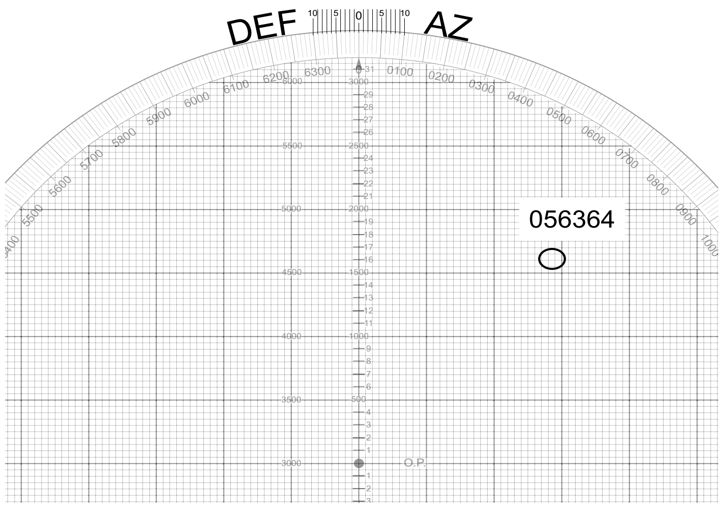


Figure 3-42. Plotting New Target at 056364.

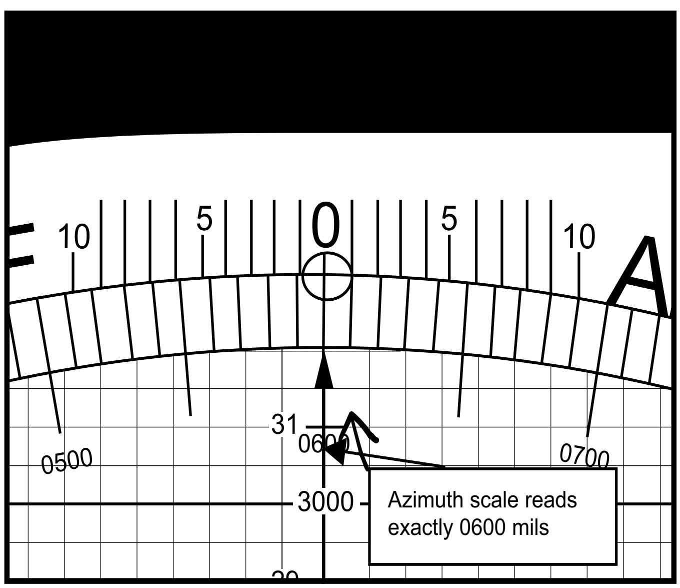


Figure 3-43. Reading Azimuth of 0600 Vernier Scale.

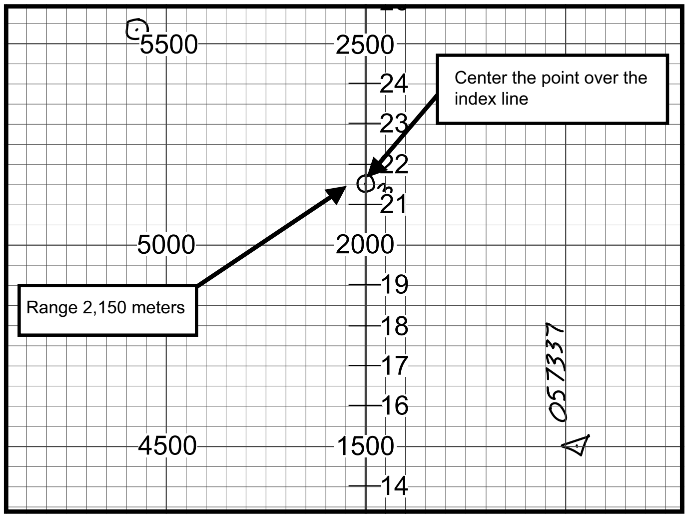


Figure 3-44. Index Plotted Point.

Determine Quadrant Elevation to the Target. The range from the plotting board is converted to a usable quadrant elevation for the guns as follows:

- Find the vertical interval. Since the gun is at an elevation of 510 meters and the new target is at 580 meters, the vertical interval is +70 meters.
- Use the WERM formula (angle of sight = vertical interval ÷ observer-to-target factor) to find the angle of sight for 2,525 meters: angle of sight = 70 ÷ 2.5 = 28 mils.
- Use Table I for the M2A1 to interpolate the angle of elevation for 2,525 meters as follows:
  - Refer to column three for the difference in angle of elevation. The difference in angle of elevation between 2,500 and 2,600 meters is 4.6 mils.
  - Multiply 4.6 by 0.25 to determine the change in angle of elevation for 25 meters. This change equals 1.15 or 1.2 mils.
  - Add 1.2 mils to the angle of elevation for 2,500 meters (i.e., 54.4 mils) to determine an interpolated angle of elevation of 55.6 mils.
  - Add the angle of sight (28) to the angle of elevation (55.6) to determine the quadrant elevation to target of 83.6 mils.

Determine the Quadrant Elevation to the Mask. From the map, the plotting board operator determines that three masks lie along the gun-target line and may interfere with firing. Therefore, the plotting board operator designates them as masks two, three, and four, from nearest to farthest. Each mask has the following characteristics:

- Mask two has a range of 800 meters and a maximum elevation of 570 meters. The vertical interval is +60 meters and the angle of sight is 60 ÷ .8—75 mils. The minimum angle of elevation for mask clearance at 800 meters, as listed in Table III, is 9.7 mils. The angle of sight (75) is added to the minimum angle of elevation of 9.7. Since the minimum quadrant elevation of 84.7 mils is required to clear mask two and the quadrant elevation to the target is 1.1 mils less than the quadrant elevation needed to clear the mask, mask clearance does not exist. However, if clearance is lacking by just one or two mils, firing can be justified for the following reasons:

- No point on the mask is higher than what has been calculated.
- The upper bound would clear the mask.
- No friendly troops would be endangered.

- Mask three is at a range of 1,300 meters and a maximum elevation of 590 meters. The vertical interval is +80 meters and the angle of sight is 80÷1.3—61.5 mils. The minimum angle of elevation for mask clearance at 1,300 meters, as listed in Table III, is 17.5 mils. The angle of sight (61.5) is added to the minimum angle of elevation (17.5). Since the sum equals a minimum quadrant elevation of 79 mils to clear mask three, clearance exists.
- Mask four is at a range of 200 meters and an elevation of 600 meters. The vertical interval is +90 meters and the angle of sight is 90÷2—45 mils. The minimum angle of elevation for mask clearance at 2,000 meters, as listed in Table III, is 36.1 mils. The angle of sight (45 mils) is added to the minimum angle of elevation (36.1). Since the sum equals a minimum quadrant elevation of 81.1 mils to clear mask four, clearance exists.

Issue Gun Data. The superimposed deflection reading underneath the azimuth of 0600 and quadrant elevation of 84.7 are issued to the gun crew.

Make Corrections to Adjusting Burst. Once the gun data is applied to the base gun and the adjusting burst is fired, the observer realizes that the burst is 150 meters short and 100 meters to the left of the center of the target and commands the correction:

Direction, six three eight zero (observer-to-target direction—6,380 mils).

Right one hundred. Add one five zero.

> *NOTE:* The observer must provide the plotting board operator with the observer-to-target direction before the operator can apply the observer's adjustments to the plotting board.

Plot the Correction. Plot the correction on the plotting disk as follows (see Figure 3-45):

- Index the observer-to-target direction of 6,380 mils.
- From the original plot, count 100 meters (two grid squares) to the right and 150 meters (two- and one-half squares) up.
- Mark this point with a dot, but do not annotate it otherwise.

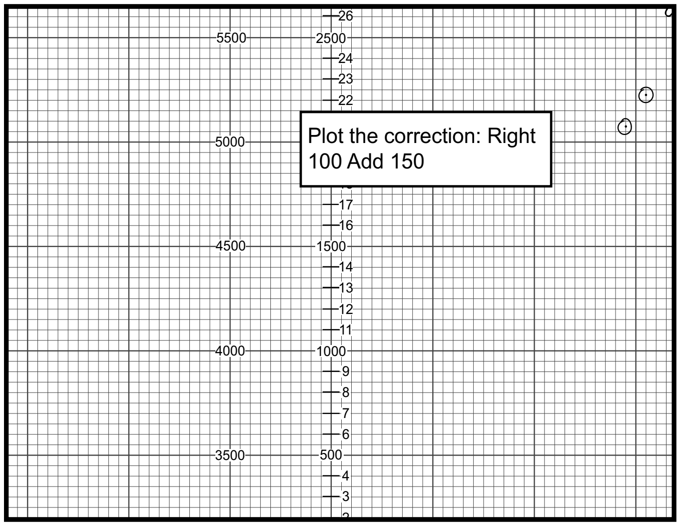


Figure 3-45. Plotting the Correction.

Index the Correction. Index the correction by rotating the plotting disk until the new dot is centered over the index line (see Figure 3-46).

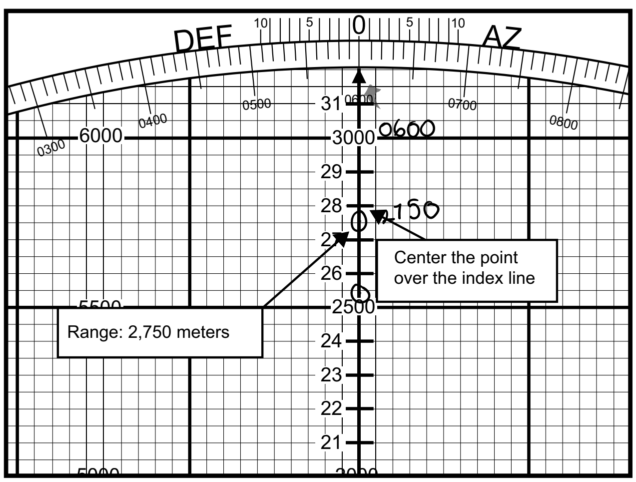


Figure 3-46. Indexing the Correction.

Read the Azimuth. Read the azimuth to the nearest mil from the Vernier scale (0590 mils) (see Figure 3-47).

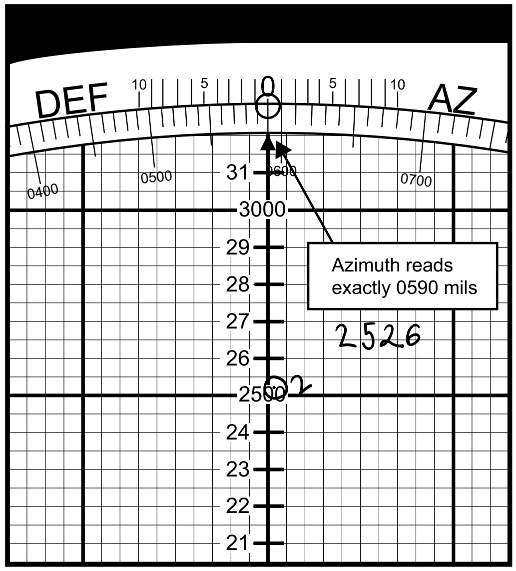


Figure 3-47. Reading an Azimuth of 0590 with the Vernier Scale.

Read the Range. Read the range from the primary range scale of 2,750 meters.

Determine the Quadrant Elevation to the Target. Determine the quadrant elevation to the target as follows:

- Begin with a vertical interval that equals +70 meters, as determined from previous calculations.
- Find the angle of sight for 2,750 meters. Angle of sight = vertical interval ÷ observer-to-target factor = 70 ÷ 2.8 = 25 mils.
- Use Table I for the M2A1 to interpolate the angle of elevation for 2,750 meters as follows:
  - Refer to Table I, column three, to determine that the difference in angle of elevation between 2,700 and 2,800 meters is 5 mils.
  - Divide 5 in half to determine the change in angle of elevation for 50 meters, which equals 2.5 mils.
  - Add 2.5 mils to the angle of elevation for 2,700 meters (i.e., 63.9 mils) to determine an interpolated angle of elevation of 66.4 mils.
  - Add the angle of sight of 25 to the angle of elevation of 66.4 to determine a quadrant elevation to the target of 91.4 mils.

Compare the Quadrant Elevation to the Mask. Since the new target quadrant elevation is 91.4 mils and the previous quadrant elevation that allowed mask clearance was 83.6, mask clearance will exist for the new quadrant elevation.

Issue the Gun Data and Fire for Effect. The superimposed deflection reading underneath the azimuth of 0590 and quadrant elevation of 91.4 is issued to the gun crew. In this example, if the second adjusting burst is on target, the observer would call for the HMG squad to fire for effect. Since gun 2 was following the gun data for the base gun, both guns will be ready to fire the same data. Unless the observer requests otherwise, a parallel sheaf will be fired, with both guns firing on the same azimuth. For an explanation of sheaves and converged sheaf calculations, see the “Data Computation for a Sheaf” section later in this chapter.

Record the Target. The observer confirms whether the fires had the desired effect and asks the plotting board operator to record it as a target. The operator records the target by circling the last dot plotted for adjustment and erasing the others (see Figure 3-48).

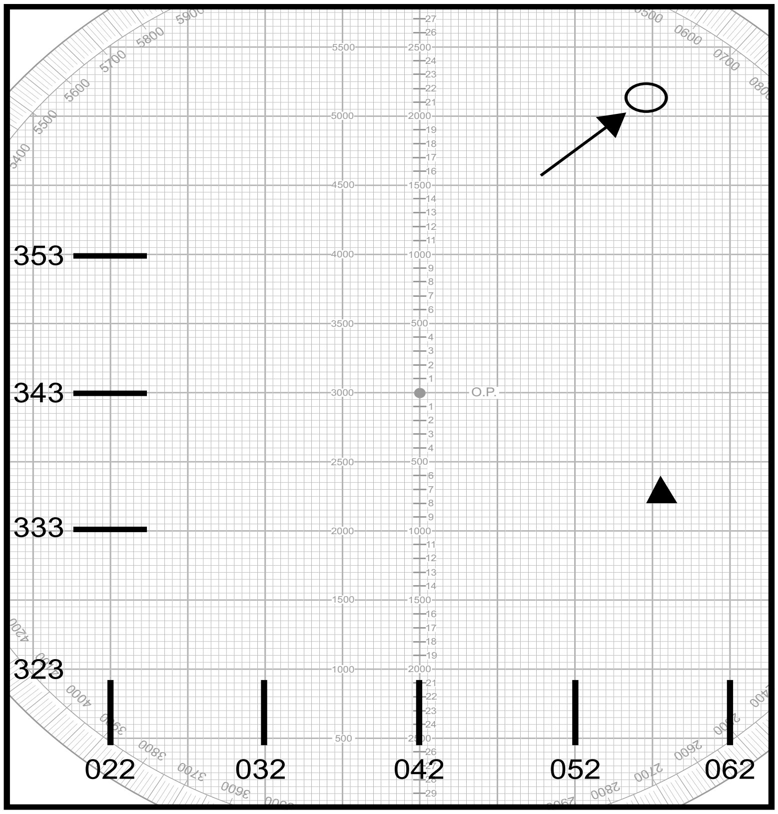


Figure 3-48. Record the Second Target.

Polar Plot Technique

The polar plot technique is used when the observer provides the target location in terms of a direction and distance from their location. The direction should be given in magnetic azimuth, because the guns are being laid by compass, and the distance should be given in meters. The last requirement provided by the observer for the polar plot technique, in addition to the direction and distance to the target, is the grid coordinates of their location. This information is essential to apply the polar plot technique.

This explanation of the polar plot technique falls under the category of the observed firing chart method; the pivot point represents the base gun's location.

Example of the Polar Plot Technique

This example uses the same observer and gun locations as in the grid plot exercise. The gun position is at 042343 (elevation equals 510 meters) and the observer is at 057337. Both a registration point (1) and another target (2) have been recorded. The observer has now identified a new target (T) on the finger, approximately one meter northeast of the observer's position (see Figure 3-49). The target is an enemy reconnaissance team in the process of establishing an OP that threatens the friendly OP. Because the observer is uncertain of the target's exact grid location, they chose to submit a polar mission to the gun line. Since the operator already has the observer's location, they do not need to provide it again. The gun crew would receive the fire command from the observer as follows.

Warning order to gun crew for a polar mission: *Fire mission, polar*.

Observer-to-target direction—0820 mils: *Direction, zero eight two zero.*

Observer-to-target distance—900 meters: *Distance, nine hundred.*

Note: The observer underestimates the distance to the target because it is located on a finger. If the estimated range is too great, the burst will fall on the reverse slope and may not be visible to the observer for adjustment.

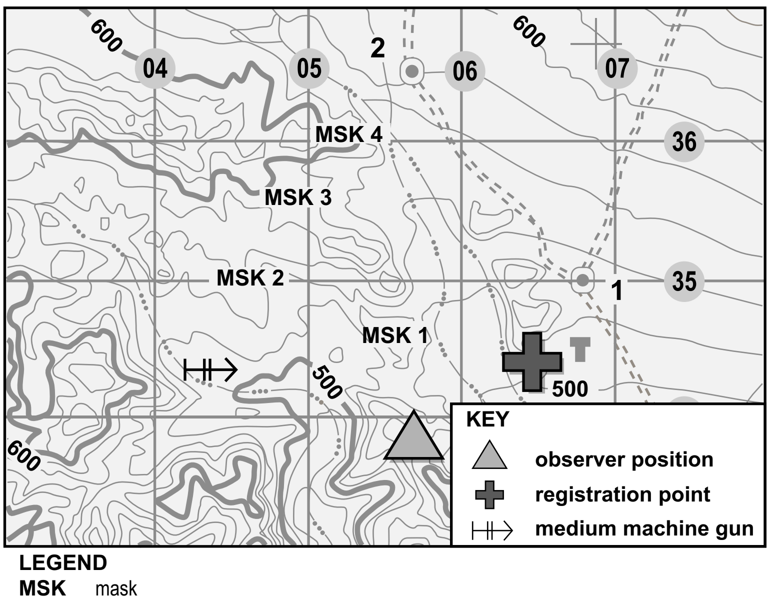


Figure 3-49. New Target Located on Finger—Polar Mission.

Plot the Target. The target should be plotted—direction 0820 and distance 900—by the polar plot method, as follows (see Figure 3-50):

- Index the disk to the observer-to-target direction—0820.
- Count eighteen small squares (900 meters) from the observer's plot.
- Provide the target plot the same offset if the observer's plot lies between two grid lines.
- Mark this point with a small dot and then annotate it with a 3, because this is the third target on the board.

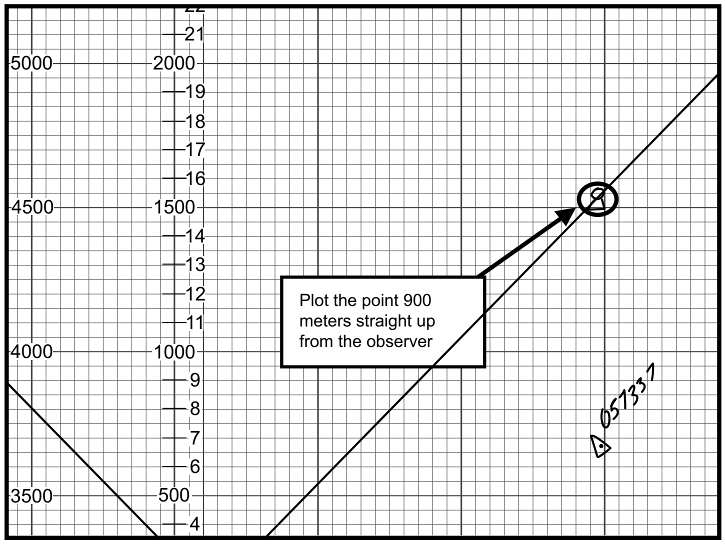


Figure 3-50. Plotting New Target—Direction 0820, Distance 900.

Index the Plotted Point. The plotted point should be indexed by rotating the plotting disk until the dot is centered over the index line (see Figure 3-51).

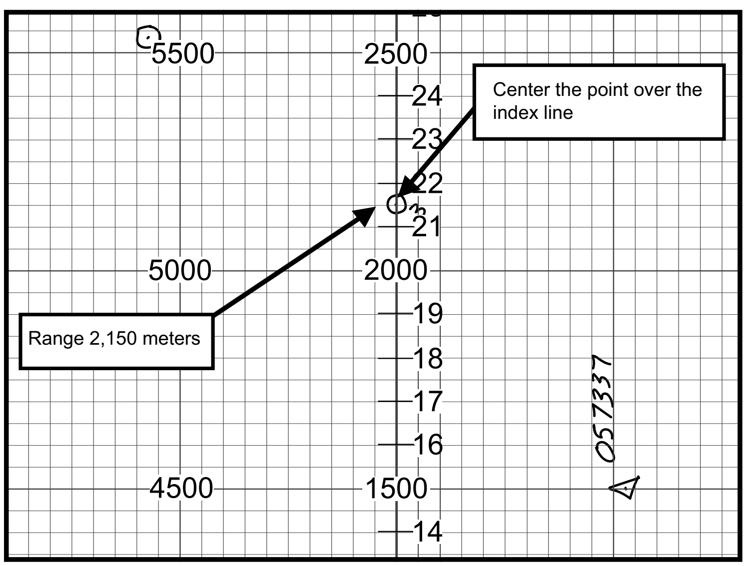


Figure 3-51. Index the Plotted Point.

Read the Azimuth. The azimuth is read to the nearest mil from the Vernier scale (1,595 mils) (see Figure 3-52).

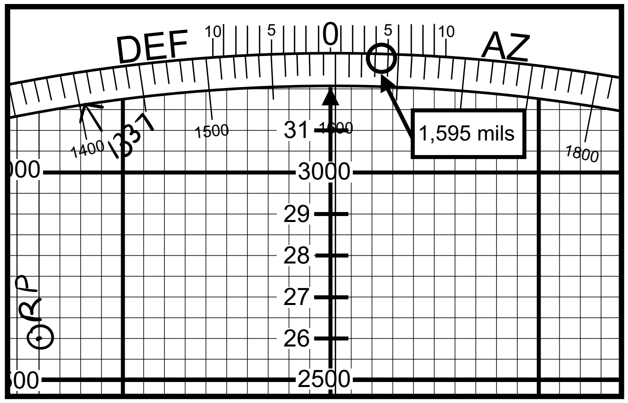


Figure 3-52. Reading an Azimuth of 1,595 with the Vernier Scale.

Read the Range. The range is read from the primary range scale of 2,150 meters.

Determine Quadrant Elevation to the Target by the Computed Method. The gun's elevation is 510 meters and the new target is at 530 meters, so the vertical interval is +20 meters. The angle of sight for 2,140 meters is 20 divided by 2.1—9.5 mils. Using Table I for the M2A1, the angle of elevation for 2,140 meters is interpolated as follows:

- Find the difference in the angle of elevation between 2,100 and 2,200 meters—3.8 mils.
- To determine the change in the angle of elevation for 40 meters, multiply 3.8 by 0.4. This equals 1.48 or 1.5 mils when rounded up.
- Add 1.5 mils to the angle of elevation for 2,100 meters (37.8 mils) to obtain an interpolated angle of elevation of 39.3 mils.
- Add the angle of sight (9.5) to the angle of elevation (39.3) to determine the computed quadrant elevation to target to be 48.8 mils.

Determine Quadrant Elevation to Target by the Table IV Method. A simpler way to determine quadrant elevation for shorter ranges (1,500 meters for the M240B; 2,500 meters for the M2A1; and 2,200 meters for the MK-19) is to refer to Table IV and use the quadrant elevation included in that table. Using Table IV for the M2A1, the quadrant elevation for 2,140 meters is interpolated as follows:

- Since the difference in quadrant elevation (for a vertical interval of +20) between 2,100 and 2,200 meters is 4 mils, multiply 4 by 0.4 to determine the change in quadrant elevation for 40 meters—1.6 mils.
- Add 1.6 mils to the quadrant elevation for 2,100 meters (47 mils) to determine an interpolated quadrant elevation to target of 48.6 mils.

Determine Quadrant Elevation to Mask. From the map, the plotting board operator determines that the only mask along the line of fire is the southern-most portion of mask one, which is at a range of 1,400 meters and a maximum elevation of 545 meters.

- The vertical interval is +35 meters and the angle of sight is 35 divided by 1.4—25 mils.
- The minimum angle of elevation for mask clearance at a range of 1,400 meters in Table III for the M2A1 is 19.5 mils.
- Add the angle of sight of 25 to the minimum angle of elevation of 19.5 to determine a minimum quadrant elevation to clear mask one of 44.5 mils.

Since the quadrant elevation to target is 48.8 mils, clearance exists for mask one.

Issue Gun Data. The superimposed deflection reading underneath the azimuth of 1,594 and quadrant elevation of 48.8 are issued to the gun crew.

Make Corrections to the Adjusting Burst. Once the gun data is applied to the base gun and the adjusting burst is fired, the observer notices that the burst is 150 meters short of the target and will command the following correction.

Add one five zero.

Fire for effect.

> *NOTE:* Since the adjusting burst was in line with the target and the observer was confident that the adjustment for range would be accurate, the fire for effect command was given with the correction. This will increase the chances of hitting a moving target because it decreases the time spent on adjustments.

Plot the Correction. The correction is plotted on the plotting disk (see Figure 3-53):

- Index the observer-to-target direction of 0820 mils.
- Count 150 meters (2-1/2 squares) up from the original plot.
- Mark this point with a dot, but do not annotate otherwise.

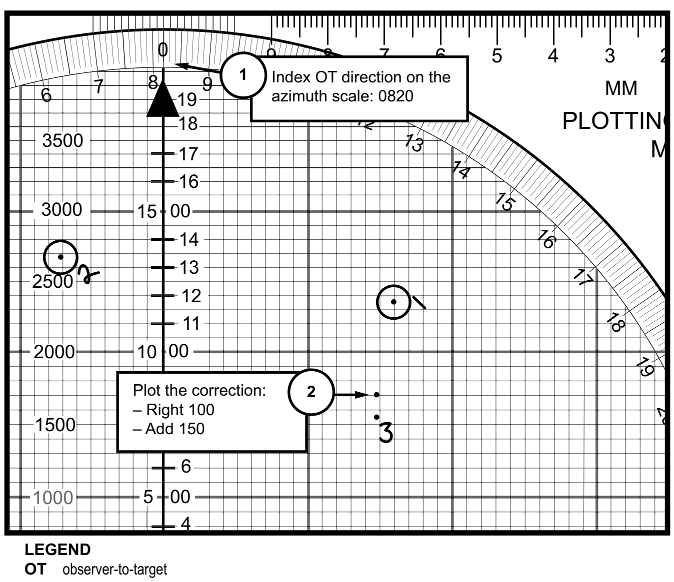


Figure 3-53. Plotting the Correction.

Index the Correction. The correction is indexed by rotating the plotting disk until the new dot is centered over the index line (see Figure 3-54).

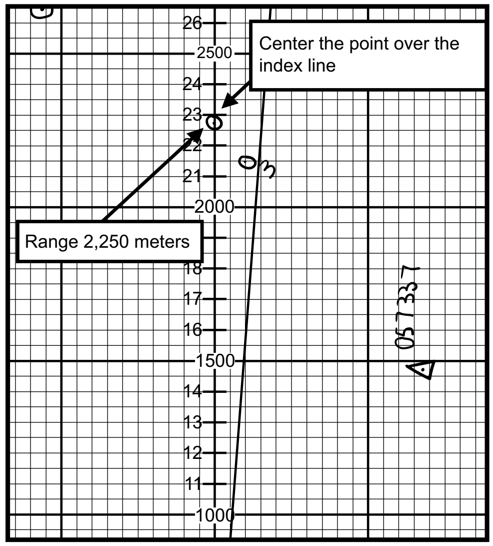


Figure 3-54. Indexing the Correction.

Read the Azimuth and Range. The azimuth is read to the nearest mil from the Vernier scale (1,551 mils) (see Figure 3-55). The range is read from the primary range scale of 2,225 meters.

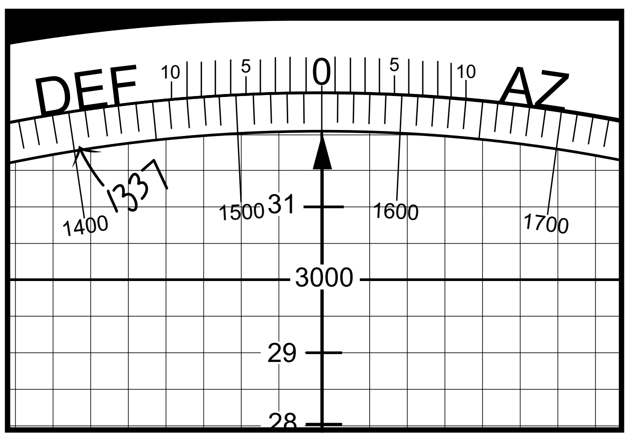


Figure 3-55. Reading an Azimuth of 1,551 Mils with the Vernier Scale.

Determine Quadrant Elevation to Target by the Computed Method. If the vertical interval is +20 meters from the previous calculations, the quadrant elevation is determined using the following steps:

1. Find the angle of sight for 2,225 meters: 20 divided by 2.2, which equals 9.1 mils.
2. Find the angle of elevation for 2,225 meters using Table I for the M2A1 (see Appendix A) and the following steps:

a. Find the difference in angle of elevation between 2,200 and 2,300 meters: 4.0 mils (column 3).

b. Find the change in angle of elevation for 25 meters by multiplying 4 by 0.25—1 mil.

c. Compute an interpolated angle of elevation of 42.6 mils by adding 1 mil to the angle of elevation for 2,200 meters.

d. Add the angle of sight of 9.1 to the angle of elevation of 42.6 to determine computed quadrant elevation to target of 51.7 mils.

Determine Quadrant Elevation to the Target Using the Table IV Method. Using Table IV for the M2A1, the quadrant elevation for 2,225 meters is interpolated using the following steps:

1. Find the difference in quadrant elevation (for a vertical interval of +20) between 2,200 and 2,300 meters—3 mils.
2. Find the change in quadrant elevation for 25 meters by multiplying 3 times 0.25— 0.6 mils.
3. Compute the interpolated quadrant elevation to target of 51.6 mils by adding 0.6 mils to the quadrant elevation for 2,200 meters—51 mils.

Compare Quadrant Elevation to Mask. Since the new target quadrant elevation is 51.6 mils and the previous quadrant elevation of 48.6 allowed a mask clearance, the mask clearance will exist for the new quadrant elevation.

Issue Gun Data and Fire for Effect. The superimposed deflection reading underneath the azimuth of 1,551 and quadrant evaluation of 51.6 is issued to the gun crew. Since the observer commanded *fire for effect* with the correction and gun two was following the gun data for the base gun, both guns will fire as soon as they are up and the squad leader gives the command. Since the observer did not request otherwise, a parallel sheaf (discussed under "Index the Correction" in this chapter) will be fired, with both guns firing on the same azimuth.

Record the Target. The observer confirms whether the fires had the desired effect and requests *record as target*. The plotting board operator records the target by circling the last dot plotted for adjustment and erasing the others (see Figure 3-56).

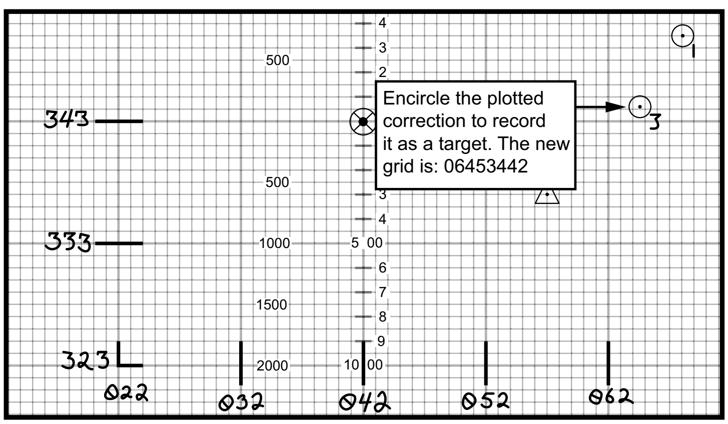


Figure 3-56. Third Target Recorded.

Data Computation for a Sheaf. A sheaf is an arrangement of multiple beaten zones. There are two basic types of sheaves: parallel and converged. A parallel sheaf (see Figure 3-57) is the standard sheaf—all guns fire on the same azimuth and produce multiple beaten zones that are parallel to each other and evenly spaced (i.e., the same distance apart as the guns). The parallel sheaf is preferable for harassing, interdicting, and suppressive fires, and is exemplified in the previous plotting exercises. However, sometimes it is necessary to maximize the effects of indirect fires for certain targets by overlapping the beaten zones of all guns to produce a single, smaller, heavily concentrated beaten zone. This effect is called a converged sheaf (see Figure 3-58). A converged sheaf is achieved by modifying the direction of each gun in order to overlap the beaten zones at the target. When computing data for a converged sheaf, either of the following methods may be used:

- Observed firing chart plotted method.
- Modified observed firing chart method.

The observed firing chart plotting method is used when time is critical and the plotting board is already set up for use as an observed firing chart. Since this method uses the pivot point as the location of the base gun, it is impractical to plot the location of the flank guns because of the size of the pivot. In addition, this method is less accurate than the modified observed firing chart method because it assumes that the guns are laid on a line exactly perpendicular to the target (as assumed by use of the WERM formula). Therefore, when the observed firing chart method is used and the gun line is at any angle other than 90 degrees to the target, the angles of shift that are computed will be greater than those actually required. The result of this inherent inaccuracy will be a more dispersed sheaf than what the modified observed firing chart method would produce.

The most accurate method of computing data for a converged sheaf is by using the modified observed firing chart method—when the location of the base gun is offset from the pivot point. The modified observed firing chart method allows the location of both flank guns to be plotted, which is not practical when using the standard observed firing chart method because of the size of the pivot and the reduced range when using the secondary scale.

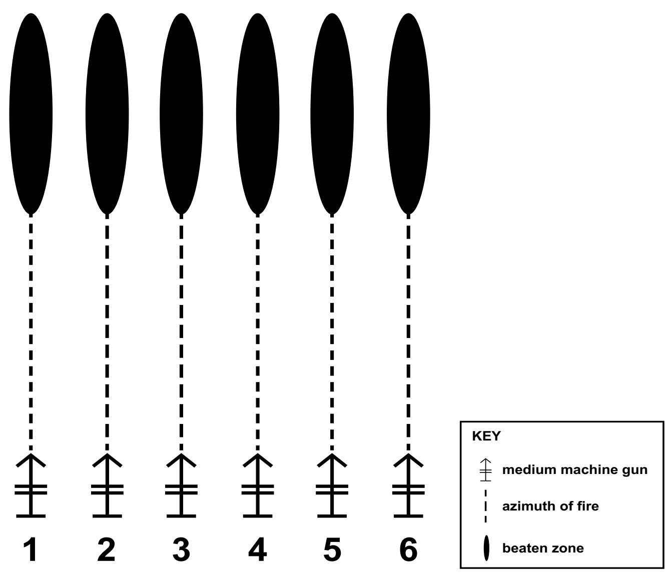


Figure 3-57. Parallel Sheaf.

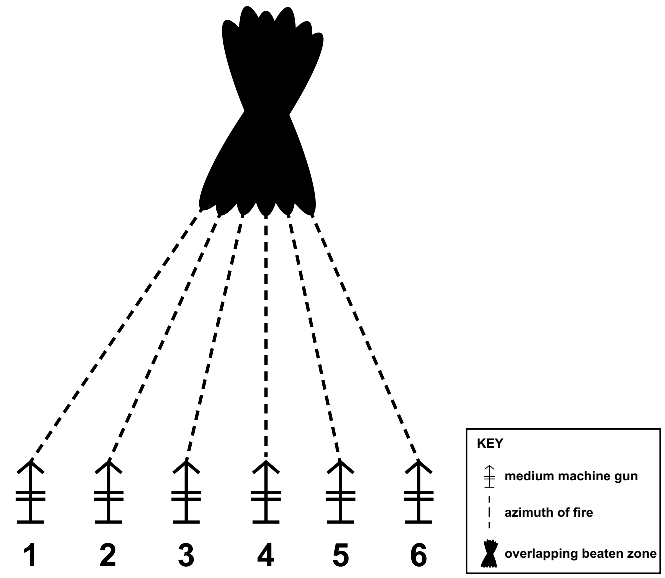


Figure 3-58. Converged Sheaf.

> **Example Computing a Converged Sheaf**
>
> The entire HMG platoon is laid in the dry creek bed at 042343 (see Figure 3-59). The platoon will be firing a converged sheaf on the registration point. The platoon is arranged in an echelon formation, with the direction from gun 1 to gun 6 at 5,700 mils, which coincides with the orientation of the creek bed. The distance between flank guns is 100 meters and the base gun is located at 042343. Since the entire platoon is laid and firing, gun 3 will be the base gun for the observed firing chart. Guns 1 and 6 will be the flank guns when computing direction with the modified observed firing chart.

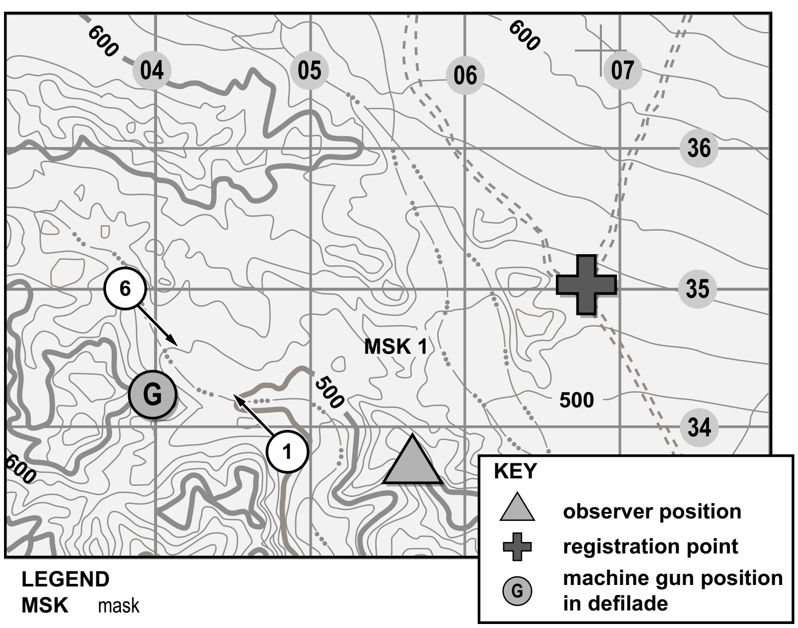


Figure 3-59. Location and Orientation of the Flank Guns.

Data Preparation. Prior to performing either of the methods for computing sheaf convergence, observed firing chart or modified observed firing chart, the following data preparation must be made:

- Ensure the guns are sighted so that they are aligned either in a row or in echelon. The guns should also be evenly spaced along the line to ensure the accuracy of base angles when data is computed.
- Move to the outside of the right flank gun to negate all magnetic influence from the guns.
- Shoot an azimuth across the pintles of the guns' tripods with a lensatic or M2 compass and record the azimuth.

  NOTE: If guns are not laid in a perfect line, the azimuth between the pintles of the flank guns should be measured, because these are the two gun positions that will be plotted on the board. This step does not apply to the observed firing chart method because it assumes this angle is square to the target.
- Measure the distance between the two flank guns—100 meters for this example.
- Determine the number of intervals between all of the guns. In this example, the entire platoon is laid. The number of intervals is five because there are six guns.

  NOTE: This step assumes the guns have been sighted at regular intervals.
- Preparation is now complete, except for setting up the board as a modified observed firing chart if that method is to be used.

Executing the Plotting Methods. Regardless of whether executing the observed firing chart method or the modified observed firing chart method, specific steps for each should be taken.

Observed Firing Chart Method. When the observed firing chart method is being used, the concept of the base gun is employed. Direction data from the plotting board is applied to only one gun and direction data for the other five guns is interpolated. When gun data for a squad is being computed, then gun one is the base gun; for a section or platoon, then gun three is the base gun. This ensures that the parallel sheaf will cover both flanks of a target and a converged sheaf will be most concentrated. If gun one is computed as the base gun for a section or platoon, the converged sheaf would be elongated from right to left and be less effective.

To compute data for sheaf convergence by the observed firing chart method, plotters must, once a fire mission is received, plot the target and index the plot to find the azimuth and range for gun three, which is the base gun. The azimuth for the base gun is 1,337 mils in this example and the distance is 2,700 meters.

To interpolate the base interval for each gun by using the WERM formula, the plotter must follow these steps:

1. Find the distance between flank guns—100 meters—and divide the distance by the number of intervals (5); hence, there is a 20-m interval between each gun. Therefore, if a parallel sheaf is fired (i.e., all guns laid on 1,337 mils), the beaten zones would be 20 meters apart at the target.
2. Use the WERM formula to compensate for the interval between guns if firing a converged sheaf. Since the width and range are known, the computation to obtain the base interval for

each gun is as follows:

Width = range x mils.

20 = 2.7 x mils.

20 ÷ 2.7 = 7.4 mils (base interval).

a. Subtract the base interval (7.4 mils) sequentially from gun 3 and then round the number to get the azimuth of fire for guns 1 and 2 as follows:
   - Gun 3 = 1,337 mils.
   - Gun 2 = 1,329.6 = 1,330 mils.
   - Gun 1 = 1,322.2 = 1,322 mils.

b. Add the base interval of 7.4 mils sequentially to guns 3, 4, and 5, and then round the number to determine the azimuth of fire for guns 4, 5 and 6 as follows:
   - Gun 3 = 1,337 mils.
   - Gun 4 = 1,344.4 = 1,344 mils.
   - Gun 5 = 1,351.8 = 1,352 mils.
   - Gun 6 = 1,359.2 = 1,359 mils.

c. Issue direction data to each gun individually to converge the sheaf.

   NOTE: The superimposed deflection scale will correlate with the readings obtained from the formula described above when shooting a converged sheaf. The superimposed deflection will be what is issued to the gun crew along with the remainder of the gun data.

Modified Observed Firing Chart Method. When the modified observed firing chart method is used, the azimuth is computed from the plotting board for the flank guns and interpolated for the other four guns. Therefore, when using the modified observed firing chart method, there is no requirement for a base gun; corrections will be made from either of the two flank guns, usually Gun 1.

The procedure for computing data for sheaf convergence by the modified observed firing chart method is similar to the plotting described for the observed firing chart with the following exceptions:

- When marking map coordinates, the intersection of the grid lines that are two large squares below and to the left of the center point are used as the location of the right flank gun (i.e., Gun 1).

  NOTE: For example, the tick marks in Figure 3-37 that read 022 (X coordinates) and 323 (Y coordinates) would now read 042 and 343, respectively. Instead of using tick marks, mark the location of the base gun (Gun 3) with only a single dot.

- Plot the flank guns as follows:
  - On the plotting board, index the azimuth obtained between the flank guns (in this case, 5,700 mils).
  - If the gunline was not straight, index the azimuth between the base gun and left flank gun.

- Measure the distance between the base gun and left flank gun using the secondary scale. In this case, measure 60 meters up from the base gun's plot; mark this point. This is the location of Gun 6.
- Next, measure the distance between the base gun and right flank gun. In this case, measure 40 meters down from the base gun's plot; mark this point. This is the location of Gun 1.

- Index the target parallel to Gun 1 as follows:
  - Rotate the plotting board until the plot for the target is in line directly above Gun 1's plot.

    NOTE: Use the vertical lines of the background grid to perform this step. A straight edge is helpful for determining when the two points are parallel.
  - The azimuth should read 1,323 mils. Record this azimuth for the right flank gun.
- Index the target parallel to Gun 6 as follows:
  - The azimuth should read 1,357 mils. Record this azimuth for the left flank gun.
  - Subtract gun 1's azimuth (1,323) from gun 6's azimuth (1,357). The result is 34 mils—the difference in the azimuth to target between the flank guns.
  - Interpolate the base interval by dividing the difference in flank guns' azimuths (34) by the number of intervals (5). The result is 6.8 mils.
  - Add the base interval (6.8 mils) sequentially to each gun and round up to determine its azimuth of fire. The result is as follows:
    - Gun 1: 1,323 mils.
    - Gun 2: 1,329.8=1,330 mils.
    - Gun 3: 1,336.6=1,337 mils.
    - Gun 4: 1,343.4=1,343 mils.
    - Gun 5: 1,350.2=1,350 mils.
    - Gun 6: 1,357 mils.
    - Issue direction data to each gun individually to converge the sheaf.

Machine Gun Fire Adjustment by Observed Fire Fan

The observed fire fan is a graphic training aid (reference GTA [Graphic Training Aid] 06-07-003, *Observed Fire Fan*, and Figure 3-60) in the form of a transparent template containing both mil and meter graduations. The observed fire fan is a useful tool for adjusting indirect machine gun fire when a plotting board is not available. It can be used to facilitate the rapid engagement of targets within the machine gun unit's sector of fire.

When the observed fire fan is placed over a 1:50,000 topographic map, it produces a graphic representation of the range and azimuth of fire for all points on the map that lie within the fan. The observed fire fan has 17 radial arms that are 100 mils apart and cover an arc of 1,600 mils (i.e., 45 degrees). The observer-to-target distance is represented by arcs marked on the radial arms every 500 meters, starting at 1,000 meters and extending to 6,000 meters. Once the observer has determined an observer-to-target direction, the observed fire fan can be used to help determine an observer-to-target distance on the map. The method of determining direction and elevation data with the observed fire fan is discussed in the following subparagraphs.

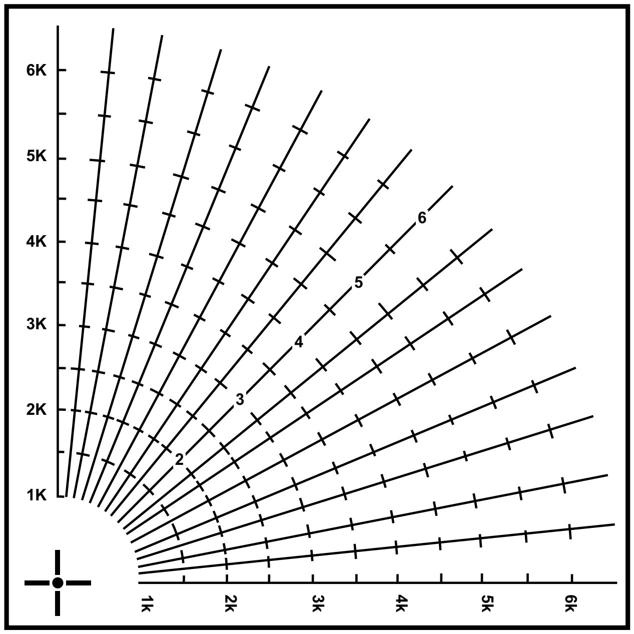


Figure 3-60. Observed Fire Fan.

Preparation. Prior to use, the observed fire fan should be oriented to the map to facilitate rapid use and responsive fires as follows:

- Place the vertex of the fan over the machine gun unit's location on a 1:50,000 topographic map.
- Rotate the fan until one of the radial lines is parallel to a grid line. The direction of the radial is now the same direction as the grid line (i.e., 1,600; 3,200; 4,800; or 6,400 mils).

  NOTE: For example, in Figure 3-62, the third radial line from the right of the fan is parallel to the 34 northing and the fan is oriented generally east, so the direction of the third radial is 1,600 mils. The center radial should be on the direction of fire or at the center of the sector of fire.

- Using an erasable pen on the observed fire fan template, number the radial of the known azimuth. Since labeling each radial is unnecessary and makes the fan too cluttered, every other radial should be labeled with its corresponding azimuth. The radial lines are 100 mils apart.

Use of the Observed Fire Fan. The observed fire fan can be used by an observer who is not located near the guns or on the gun-target line to determine direction and distance data for the guns directly from the map. If the observer has fire control tables, it will be possible to convert the distance data to a usable quadrant elevation and transmit fire commands directly to the guns as follows:

- Determine the location of the target on the map. In this example the registration point is 068350.
- Determine the direction to the target by visual interpolation. Figure 3-61 shows the azimuth as 1,330 mils.
- Estimate the distance to the target at 2,700 meters.

- Determine the vertical interval (20 meters), angle of sight (20 ÷ 2.7 = 7.4 mils), and angle of elevation (63.9 mils) from Table I for M2A1. Therefore, quadrant elevation = angle of sight + angle of elevation = 7.4 + 63.9 = 71.3 mils.

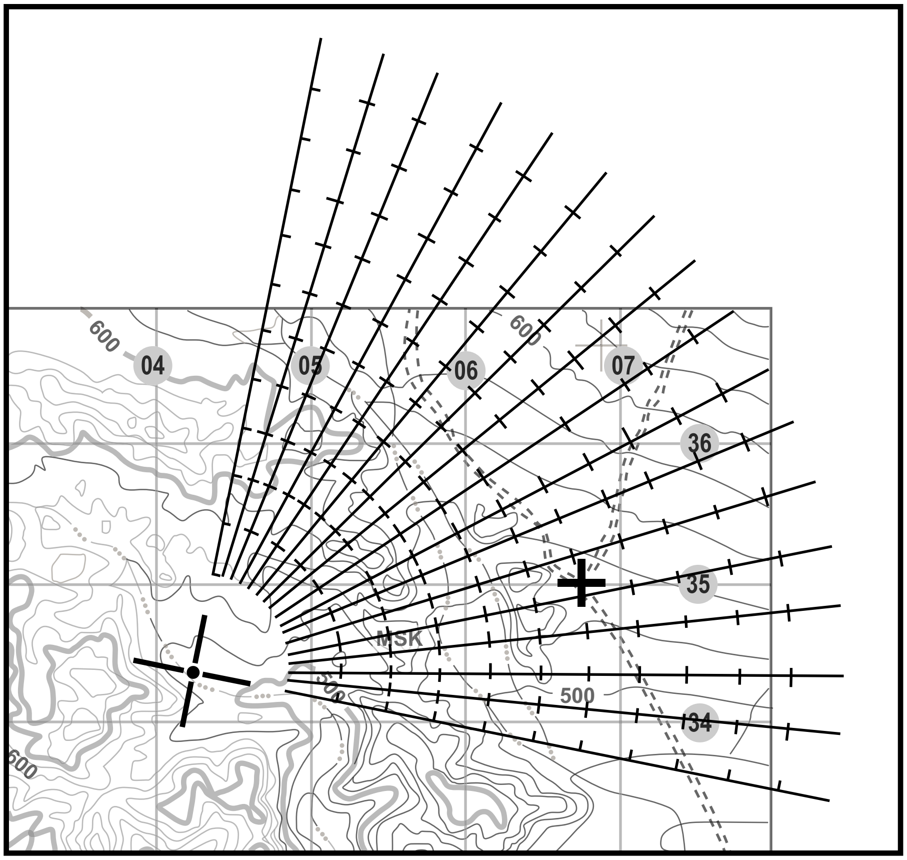


Figure 3-61. Using the Observed Fire Fan with a Map.

Terrain Profile Construction

A terrain profile is a side view (i.e., cross section) of the ground along a selected line or direction of fire that is used to determine where friendly and enemy forces can see each other and where to deliver direct fires. A terrain profile can be used in the following ways:

- To plan fires when deciding where to place the guns to obtain grazing fire and where dead space is located.
- When employing machine guns from defilade when determining positions for full and partial defilade and requirements for mask clearance.
- When employed in conjunction with the map and compass technique of lay. It permits machine guns to be employed from maximum defilade positions and allows the observer to move off the gun-target line.

To construct a terrain profile:

- Locate your position on the map and determine the line of fire (see Figure 3-62).

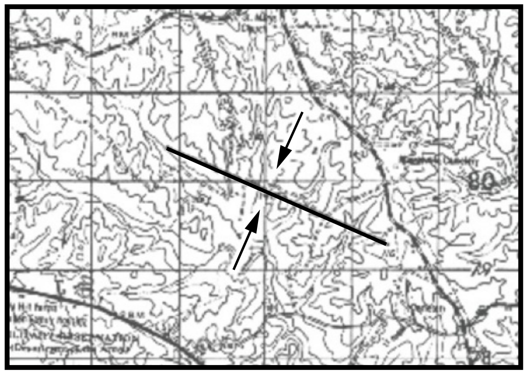


Figure 3-62. Mark Line of Fire.

- Place the edge of a lined piece of paper along the line of fire and annotate the elevations of each contour line that crosses the line of fire, from highest to lowest (see Figure 3-63).

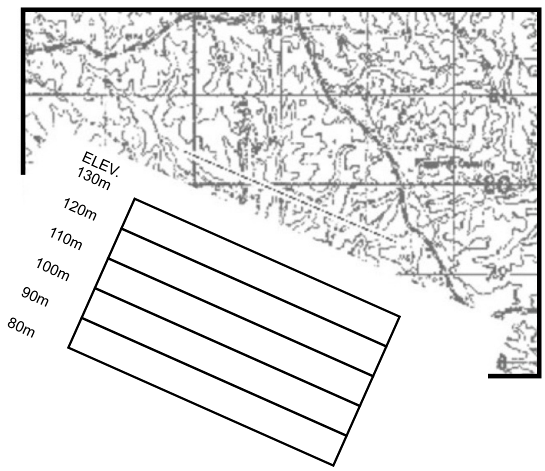


Figure 3-63. Horizontal Lines and Corresponding Elevations.

NOTE: Any paper with evenly spaced horizontal lines, such as graph or notebook paper, may be used. The wider the spacing of the lines, the greater the vertical exaggeration in the profile.

- Draw perpendicular lines from each point where the line of fire crosses a contour line on the map, down to its corresponding elevation line (see Figure 3-64).

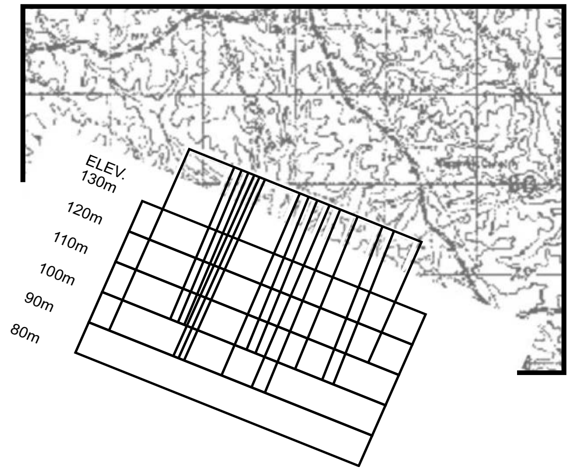


Figure 3-64. Perpendicular Lines Between Contour Lines and Elevation Lines.

- Connect all of the contour points (i.e., ends of the perpendicular lines) with a smooth curve (see Figure 3-65).

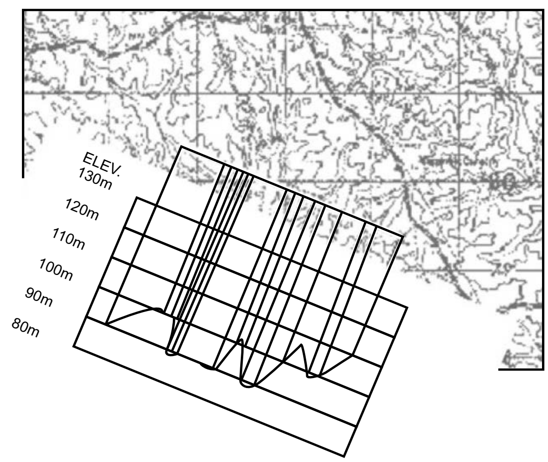


Figure 3-65. Connect the Contour Points with a Smooth Curve.

Based on the sample terrain profile in Figure 3-66, it is possible to obtain maximum grazing fire for either an M240B or M2A1 by placing a machine gun squad at an elevation of approximately 80 meters. The remainder of the defense can be laid on this anchor point. Profiles for the section's other guns can be constructed in the same manner. If a profile of the entire defensive frontage is required, several profile lines should be taken and the data applied to a map.

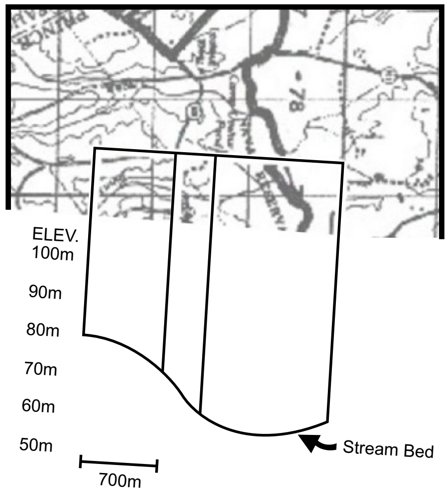


Figure 3-66. Terrain Profile Illustrating Potential Grazing Fire.

Reverse Slope Searching

The machine gun has the following reverse slope searching abilities:

- To search reverse slope, an observer must take an angle of sight reading to a visible point on the crest of the hill. The quadrant elevation to that point is computed with an adjustment made for an increase of 75 meters. This will result in placing the beaten zone just beyond the crest.
- To adjust the fires of a machine gun unit onto a reverse slope and then sweep that slope from one side to the other because of the length of the beaten zone. This is more practical and efficient.
- To make a minute adjustment of the beaten zone onto a reverse slope once those fires are adjusted onto the crest. This is simple and effective because of the lower trajectory of machine gun fire. However, since fires that search a reverse slope are unobserved, the best effect that should be expected is harassment or interdiction, not suppression or neutralization.

NOTE: At long ranges, it is improbable that any reverse slope will be defiladed from fire, since the angles of fall—beyond 2,500 meters for the M240B and 3,500 meters for the M2A1—are very steep. The steep trajectory of a MK-19's explosive warhead makes it the most suitable machine gun for searching reverse slopes; however, the search is limited to its maximum range of 2,045 meters. Refer to Figure 3-67 for an illustration of the three classifications of slopes.

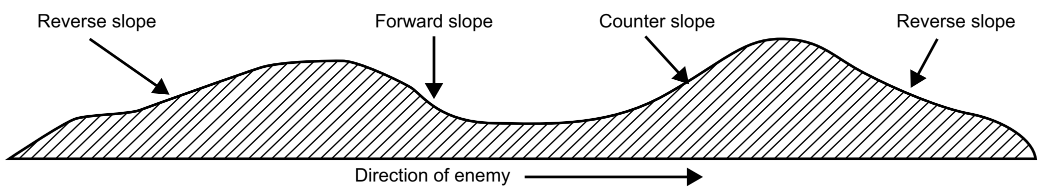


Figure 3-67. Classifications of Slopes.

NOTE: Constructing a terrain profile may be helpful to determine the angle and extent of a reverse slope. This will also provide the user with the knowledge to determine whether the trajectory may be brought down sufficiently to cover the entire slope or just a portion of it.

Example of Computing Quadrant Elevation for Searching a Reverse Slope

In this example (referring to Figure 3-68), gunners must determine the angle of sight to the crest at point A, by either map survey or M2 compass:

- Angle of sight = vertical interval ÷ observer-to-target factor = 20 ÷ 2.7 = 7.4 mils.
- Angle of evaluation for 2,700 meters = 157.5 mils.
- Quadrant elevation to crest = Angle of sight + angle of elevation = 164.9, or 165 mils.

At a range of 2,700 meters, it takes 17.2 mils to shift the center of impact 100 meters. Interpolate the angle of elevation for 2,775 mils by multiplying 17.2 by 0.75 to compute the change in angle of elevation for 75 meters, which equals 12.9 mils. Add 13 mils to the quadrant elevation of 165 mils to compute the quadrant elevation needed to search the reverse slope at B—178 mils.

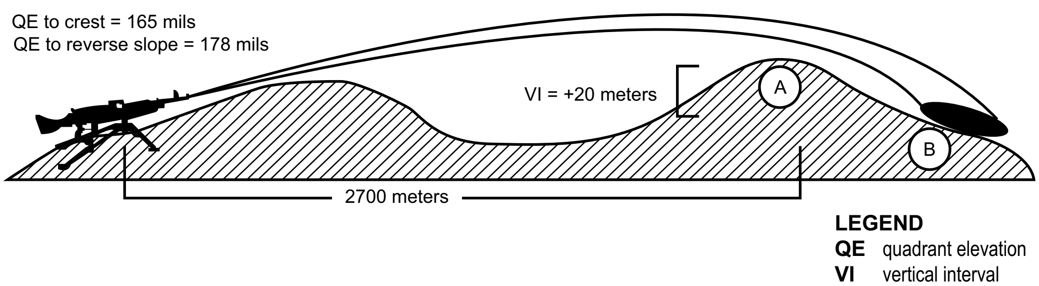


Figure 3-68. Calculating Quadrant Elevation to Search a Reverse Slope.

MOVING TARGET GUNNERY

The fundamentals necessary to hit moving targets with a machine gun are the same as those needed to hit stationary targets:

- Proper firing position and shoulder pressure.
- Sight alignment and sight picture.
- Trigger control.

However, the fundamentals that are necessary for engaging moving targets differ because the angle, speed, and range of the targets vary. For example, targets moving directly at the gunner are engaged in the same manner as a stationary target, with no change in the application of the four fundamentals of machine gun gunnery. On the other hand, fast-moving targets at varying ranges and angles (e.g., crossing or quartering the position of the gun, moving uphill, or moving downhill toward or away from the gun) require changes in the placement of the initial burst (i.e., lead) and a deliberate method of applying fire with a lead (i.e., engagement technique).

Fundamentals of Leading

The primary purpose of establishing a lead is to lay the gun ahead of the target a sufficient distance to cause the bullet and target to arrive simultaneously at the same point in space. This distance is known as lead and is measured in target lengths. Since machine guns have no sighting devices for setting initial lead on a moving target, the unit of lead for any particular engagement is the length of the target being engaged. One target length, as seen by the gunner, is referred to as one lead.

Because the target is moving, leads are measured from the leading edge of the target. When laying the gun to engage a moving target, the lead between the front sight and the target is always established in relation to the target's direction of movement and its speed and range. The three components of a target lead are range, angle, and speed.

Range. Engaging a moving ground target requires proper range estimation. Range estimation determines sight setting and initial laying of the gun. Range will have an effect on how long it takes the burst to travel to the target and will require a different amount of lead at different ranges.

Angle. Once the range of a target has been estimated, its angle of approach that is relative to the gun must be gauged. Vehicles moving straight across the front of a gun are referred to being on a crossing approach and require a full lead, which is the length of the vehicle. The number of full leads depends on speed (see Figure 3-69). A vehicle that is moving at an oblique angle to the gun is on a quartering approach. It only requires half the lead necessary for a vehicle that is on a crossing approach, traveling at the same speed. To simplify leading for all approaches, the rule is to consider the visible length of the vehicle as a full lead. Since a vehicle on a quartering approach is traveling slower in relation to the gun than it is on a crossing approach, the length of the necessary lead is reduced accordingly.

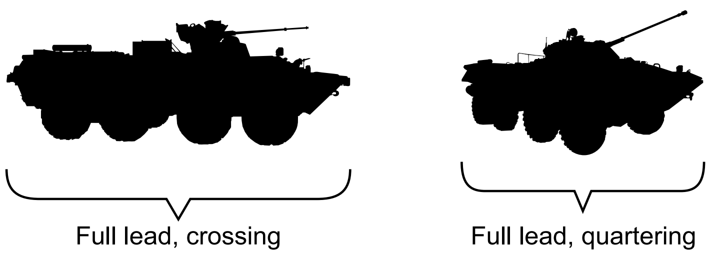


Figure 3-69. Crossing and Quartering Leads.

Speed. Once range and angle have been determined, the speed of a target is the final and most important determinant for establishing a proper lead. The ability to gauge the speed of a moving vehicle with a reasonable degree of accuracy is crucial to the ability of a machine gunner to engage moving targets. When using speed to gauge a lead, the following information is needed (see Figure 3-70):

- Reference points to gauge the distance that a vehicle is covering over a given amount of time.
- The assumption that the standard combat vehicle is six meters long.

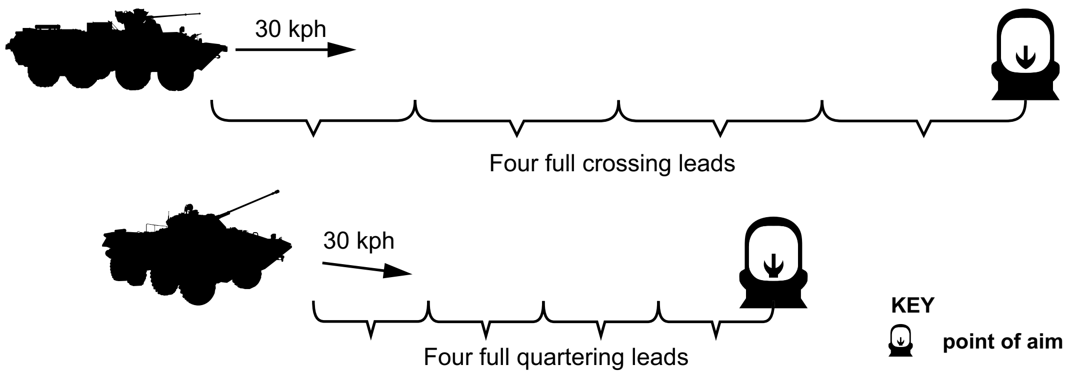


Figure 3-70. Crossing Leads and Quartering Leads for a Vehicle Moving 30 kph, 900 Meters from the Gun.

NOTE: For ease of computation, vehicle speed in kilometers per hour (kph) can be reduced to meters per second and be expressed in leads per second.

Example of Estimating Vehicle Speed

If a vehicle is moving down a road on which a gunner has previously established a series of reference points, the gunner can determine the vehicle's speed. First, the gunner must know the distance between any two reference points. In Figure 3-71, the distance between the tree (target reference point [TRP] 1) and the rubble building (TRP 2) is 250 meters. The gunner observes that the vehicle takes 30 seconds to cover the distance between these two TRPs. Using a simple calculation (velocity = distance ÷ time), the gunner determines that the vehicle is moving at a speed of 250 meters per 30 seconds, or 500 meters per minute, which equals 30 kph.

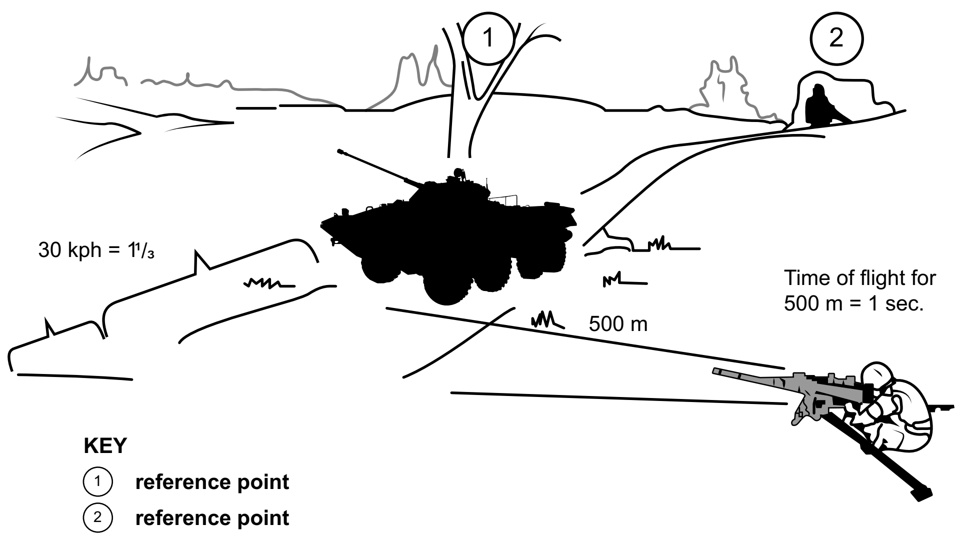


Figure 3-71. Estimating the Speed of a Moving Vehicle.

Techniques of Leading

There are several leading techniques—tracking, trapping, leading troop targets, leading targets with the MK-19, and leading targets with a bipod-mounted gun.

Example of Estimating Lead, Given Vehicle Speed

Since the gunner in the previous example knows that the vehicle is traveling at 30 kph, they remember from the M2A1 vehicle lead table that this speed equates to 1-1/3 leads per second. Knowing that the gunner is approximately 500 m from TRP 1 and that it takes a .50-caliber projectile just one second to travel that distance, the gunner figures that a 1-1/3 lead must be applied to hit the vehicle.

NOTE: When engaging moving targets, too much lead is better than too little because it is easier to make adjustments if the target is moving toward the beaten zone than if it is moving away and because the duration of the burst will usually make up for an overestimated lead.

Tracking. To employ the tracking technique of moving target engagement, the gunner aims at a point ahead of the target equal to the estimated number of leads. The gunner maintains this lead by tracking the target (manipulating the T&E mechanism to keep the gun aligned at the same angle as the target is moving and with the appropriate lead), and then fires controlled bursts. The benefit of the tracking technique is that it puts the gunner in position for a second burst if the first one misses. The drawback is that it can be more difficult to establish a proper lead with this technique.

Trapping. To employ the trapping technique, the gunner establishes an aiming point along the target's path, far forward of the lead distance appropriate to the target's range and speed. The gunner then fires a controlled burst as the target reaches proper lead distance. The advantage of this technique is that it enables the gunner to visualize the lead distance more accurately than the tracking technique. It is, however, not conducive to following the progress of the target, as in the tracking technique.

Leading Troop Targets. The fundamentals of leading troops with a machine gun are no different than those for leading vehicles, with the exception that moving troops do not require as much of a lead as vehicles. The procedure for establishing leads is the same for troops as it is for vehicles—the width of a person is used as the standard lead distance. However, the difference with troop targets is that they are narrower on a crossing approach than they are on an angled approach. For this reason, the width of a person facing the gun should be used as the standard lead distance (see Figure 3-72): a person on a crossing approach would get a full body's width lead; whereas, someone on an angled approach would only get half body's width lead. The troop lead in Table 3-5 lists the leads necessary for engaging dismounted troops.

NOTE: An average person walks at a speed of two meters per second; an individual with a combat load can run as fast as six to eight meters per second for short periods.

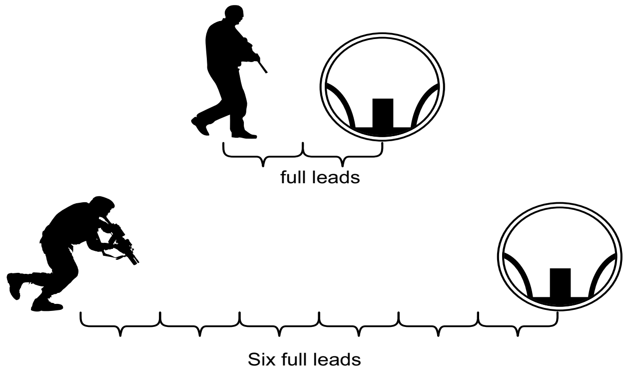


Figure 3-72. Proper Straight Lead for Walking and Running Targets at 300 Meters.

Leading Targets with the MK-19. When engaging moving targets with the MK-19, problems may occur because of the slow velocity of the round compared with other machine guns. As a field-expedient rule, leads must be tripled when using the MK-19 as opposed to the M2A1 when engaging moving vehicles.

Leading Targets with the Bipod-Mounted Gun. Trapping is the preferred technique when engaging moving targets from a bipod-mounted gun. When firing from a fighting position, the gunner must be able to adjust their position quickly depending on the range, angle, and speed of the target in order to track or trap a target in their sector. To apply this technique, the bipod legs must be positioned to move freely. If lead cannot be achieved, the legs need to be shifted to regain the proper lead for tracking or to establish a proper interval for trapping. When firing from a prone position, the gunner needs to rely on their ability to adjust fire through body position. To make changes in direction or elevation, the following should be performed:

- Direction:
  - Minor changes. To make minor changes in direction, the gunner shifts their shoulders to the right or left to select successive aiming points in the target area.
  - Major changes. To make major changes in direction, the gunner redistributes their weight to the elbows and the toes, and then raises their body off the ground. Using the toes, the gunner shifts their body to the right or left and pivots on the elbows until aligned with the target. The gunner rapidly assumes a steady position, obtains the proper sight picture, and engages the target.
- Elevation:
  - Minor changes. To make minor changes in elevation, the gunner either breathes in to lower the muzzle or breathes out to raise the muzzle.
  - Major changes. To make major changes in elevation, which would correspond to a significant range shift, the gunner moves their elbows closer together to lower the muzzle or farther apart to raise the muzzle.

Lead Tables. Tables 3-5 and 3-6 are a reference for figuring lead distances for the various machine guns listed. The tables list the amount of lead needed to hit a moving ground target with a straight lead for the speed and ranges indicated. To determine the number of angled leads required for a quartering approach, the same number is used as for straight leads. The difference is automatically adjusted by reducing the length of the lead to the visible length of the vehicle.

Example of Using Lead Tables

A heavy machine gunner observes the BTR-70 (see Figure 3-71) at a range of 1,000 meters and moving at what appears to be a speed of 25 kph or one lead per second. If the vehicle had a crossing approach to the gunner's line of fire, the gunner would apply two full leads or the length of the vehicle, as visible to the gunner. However, if the vehicle had a quartering approach, the gunner would cut the length of the lead in half, applying the same number of half leads.

Note: Although the BTR-70 is actually seven meters long versus the standard six meters used in the vehicle lead chart, the difference will be negligible because the burst of fire will conform.

Table 3-5 should be used for the M249 and M240B and is based upon a 0.5-m body width, a walking speed of two meters per second, a running speed of six meters per second, and the TOF for M855 and M80 ball ammunition.

Table 3-5. M249 and M240B Troop Lead Table.

Approach	Troop Speed (leads per second)	Range to Target			
		300 m	600 m	900 m	1,200 m
		Projectile TOF			
		1/2 s	1 s	2 s	3 s
Walking (straight)	4	2 leads	4 leads	8 leads	12 leads
Walking (angled)	2	1 lead	2 leads	4 leads	6 leads
Running (straight)	12	6 leads	12 leads	24 leads	36 leads
Running (angled)	6	2 leads	6 leads	12 leads	18 leads

Table 3-6 is for use with only the M240B. It is based upon straight leads for a standard six-meter vehicle length and the TOFs for the M80 ball, as derived from table one of the 7.62 mm fire control table.

Table 3-6. M240B Vehicle Lead Table.

			Range to Target			
			500 m	**1,000 m**	**1,500 m**	**2,000 m**
			Projectile TOF			
Kilometers per hour	**Meters per second**	**Leads per second**	**1 s**	**2 s**	**4 s**	**6 s**
15	4	?	⅔ lead	1⅓ leads	2⅔ leads	2⅔ leads
20	6	1	1 lead	2 leads	4 leads	6 leads
25	7	1	1 lead	2 leads	4 leads	6 leads
30	8	1⅓	1⅓ leads	2⅔ leads	5⅓ leads	8 leads
35	10	1½	1½ leads	3 leads	6 leads	9 leads
40	11	2	2 leads	4 leads	8 leads	12 leads
45	12	2	2 leads	4 leads	8 leads	12 leads
50	14	2	2 leads	4 leads	8 leads	12 leads
55	15	2½	2½ leads	5 leads	10 leads	15 leads
60	17	3	3 leads	6 leads	12 leads	18 leads

CHAPTER 4.
MACHINE GUN EMPLOYMENT

Machine gun employment should not be confused with machine gun gunnery. Employment refers to the tactical use of machine guns in situations; whereas, gunnery refers to the techniques and procedures for operating machine guns in various circumstances, such as direct or indirect lay. Therefore, it is important to understand the difference between tactics, techniques, and procedures:

- A tactic is the application of a particular technique to a unique situation in order to solve the challenge at hand (e.g., the occupation of an SBF position by stealth or force and whether the target should be engaged using searching or traversing fires).
- A technique is a particular manner in which a procedure is accomplished (e.g., who carries the T&E mechanism and when it is attached to the weapon).
- A procedure is a specific means of executing a task (e.g., attaching the T&E mechanism to the machine gun).

While the differences between tactics, techniques, and procedures may appear to be subtle, it is important to understand that there are differences. This understanding allows the machine gun unit leader to analyze a task or tactical situation; make an educated judgment of the essential elements of that task; and determine what tactics, techniques, or procedures should be applied to resolve it.

This chapter focuses on the various aspects of machine gun employment that should be understood and employed by both machine gunners and infantry Marines to maximize the use of machine guns in all tactical situations.

ROLES OF THE MACHINE GUN

When properly employed, the machine gun provides a high volume of accurate fire in support of the infantry in the offense and defense. In the offense, the machine gun provides fires in support of isolation, maneuver, assault, and consolidation to support the offensive scheme of maneuver. In the defense, the long-range, close defensive fires and FPFs of the machine gun provide an integral piece of the defensive scheme against attack by enemy infantry.

Offensive Roles of Machine Guns

The roles of machine guns in the offense are best learned and remembered in the sequence they are most likely to be performed in—fires in support of isolation, maneuver, assault, and consolidation. For more information about the offense, refer to Marine Corps Warfighting Publication 3-01, *Offensive and Defensive Tactics*.

Fires in Support of Isolation. Fires in support of isolation are delivered on a known, likely, or suspected enemy location other than the maneuver unit's immediate objective during the assault. These fires are planned when it is expected that the unit's advance will create an open or exposed flank or front to another enemy position. They are most useful against enemy units that pose a threat of reinforcement or counterattack. Fires in support of isolation may transition directly into fires in support of consolidation after the assault is complete. They may also become fires in support of maneuver or assault, depending on the situation and if the commander wishes to attack the position being fired upon.

Fires in Support of Maneuver. Fires in support of maneuver are delivered against enemy units on the immediate objective that are beyond the maneuver element's ability to address (internal fire and maneuver, fire and movement, or direct fires). They allow the maneuver element to close with the objective and conduct the final assault. For example, during an infantry platoon's movement to an object that is 1,500 meters away, a section of HMGs could provide fires in support of maneuver up to where the maneuver element transitions into the assault.

Fires in Support of the Assault. Fires in support of the assault are delivered against enemy units that either oppose the advance of a supported maneuver unit or present the most immediate and serious threat. This type of fire is designed to provide the closest form of support controlled by the maneuver commander. Fires in support of the assault are employed from an SBF position that maximizes the geometry of fire to provide suppression and neutralization until the last possible moment. These types of fires can also be provided by a machine gun traveling with the assault, providing fires against previously unknown concentrations of enemy or enemy fire.

Fires in Support of Consolidation. Fires delivered against targets that threaten a friendly unit's consolidation on an objective are fires in support of consolidation. These fires are employed when units are most vulnerable to enemy counterattack—following the seizure of an objective. If possible, these fires can be delivered from the same SBF position that was employed during the unit's attack because displacing the guns to the objective puts them out of action until they actually reach the objective. However, if the guns cannot provide the support necessary from their position, they should be displaced to the objective or to another SBF position. A machine gun with an assault element can also provide this type of fire. Upon consolidation, the machine gun occupies the most favorable position to deliver fires against an enemy counterattack. Examples of machine gun employment in the offense are provided later in this chapter.

Defensive Roles of Machine Guns

The defensive roles of machine guns are best remembered in the sequence they are most likely to be performed in—long-range fires, close defensive fires, and FPFs. For more information about the defense, refer to MCWP 3-01.

Long-Range Fires. Long-range fires are delivered against enemy units for the purpose of interdicting and disrupting them before the supported unit is deployed in the attack. Long-range fires can be employed to harass the enemy in their assembly area, preempt the enemy's attack, disrupt enemy formations, or interrupt their timing and sequencing. Long-range fires can be delivered from full defilade positions, up to the maximum range of the weapon system, or mobile positions forward of the main defense.

Close Defensive Fires. Close defensive fires are delivered against targets that present an immediate threat to the unit's defense. They are employed in conjunction with other direct and indirect fires in the defense to create an impenetrable network of fires in a unit's defensive engagement area. They are the main effort of the defense.

Final Protective Fires. Final protective fires provide an immediately available, prearranged barrier of fire designed to impede enemy movement across defensive lines or areas. For machine gun crews, the FPF involves firing either an FPL or a PDF. Final protective fires are employed only when the close defensive fires have failed; they can only be authorized by the immediate commander or higher authority.

Final Protective Line. An FPL is a predetermined line of grazing fire designed to stop an enemy assault. It is fired across the frontage of a defensive line and is optimally as close and as parallel to the defensive lines as possible, usually producing flanking enfilade fire.

Principal Direction of Fire. A PDF is a predetermined line of machine gun fire that covers the most dangerous avenue of approach to a defensive position with either plunging or grazing fire, when possible, to produce frontal enfilade fire.

Eight Principles of Machine Gun Employment

Machine guns can be employed to maximum efficiency by applying the eight principles of machine gun employment during planning. Most tactical situations benefit from employing all eight principles simultaneously; however, these principles are prioritized according to the tactical situation, and some may be omitted in favor of more crucial ones. While these principles are not meant to serve as absolutes, they are ideas that entice plans of action, which have been proven in combat and should be understood and considered by all personnel involved in operating and employing machine guns. The eight principles of machine gun employment are discussed in the following subparagraphs.

A mnemonic for the eight principles of machine gun employment is PICMDEEP, which stands for the following:

- Pairs.
- Interlocking fires.
- Coordination of fire.
- Mutual support.
- Defilade.
- Enfilade.
- Economy.
- Protection.

Pairs

Machine guns should not be employed in isolation. When siting machine guns for either the offense or defense, they should be employed in pairs and assigned the same mission. The benefits of employing machine guns in pairs include—

- Ensuring a continuous high volume of fire.

- Giving the capability to efficiently engage targets of a larger width or depth than one machine gun could effectively engage alone.
- Providing the opportunity for continued fire from one machine gun while the other machine gun is reloading, correcting a malfunction, or reducing a stoppage.

Two types of pairing methods that can be employed are standard and nonstandard. The standard method sets similar guns in pairs, whether as a squad of M240Bs or two squads of HMGs, which provides simplicity in control and resupply for the machine gun because of the commonality of ammunition (i.e., one gun can reload with ammunition from the other gun) (see Figure 4-1).

Figure 4-1. Heavy Guns Employed in Pairs.

The nonstandard method of pairing machine guns involves setting dissimilar guns in pairs. An advantage of employing dissimilar guns in a pair is producing multiple effects against a target. A disadvantage is that ammunition cannot be transferred between guns if needed.

Examples of Nonstandard Methods of Pairing Machine Guns

Example 1

Pairing an M240B with an M2A1 allows the HMG to neutralize/suppress APCs while the medium machine gun engages the dismounted infantry. The maximum economy is achieved in this manner of employment by using the heavy armor-piercing ammunition against armored vehicles instead of dismounted troops. This allows the medium machine gun to conserve its ammunition and not waste it trying to suppress an APC.

Example 2

Pairing an M2A1 with a MK-19 provides an HMG section maximum lethality. This requires the enemy to seek cover in dead space to avoid the flat trajectory of the M2A1, while the MK-19 focuses on providing fires into those same dead spaces.

Interlocking Fires

Interlocking fires ensure that the fire from one machine gun position interlocks sectors of fire with other machine gun positions. This is used while in defense to prevent gaps that the enemy can easily close to attack friendly positions. Machine gun fire that is properly augmented with obstacles and other weapons' effects should form a wall of steel between friendly positions and the enemy.

Figure 4-2 illustrates how the fires of two HMG squads would interlock in an example scenario. Note that the fires of the squads are interlocked, but not those of the individual guns. This is an important point that reinforces the employment of guns in pairs. Whenever practical, the guns of a pair should fire the same mission, whether it is an FPL or a PDF. Therefore, the fires of each two-gun squad would be parallel; however, when tied in with the fires of another squad, they form interlocking fires.

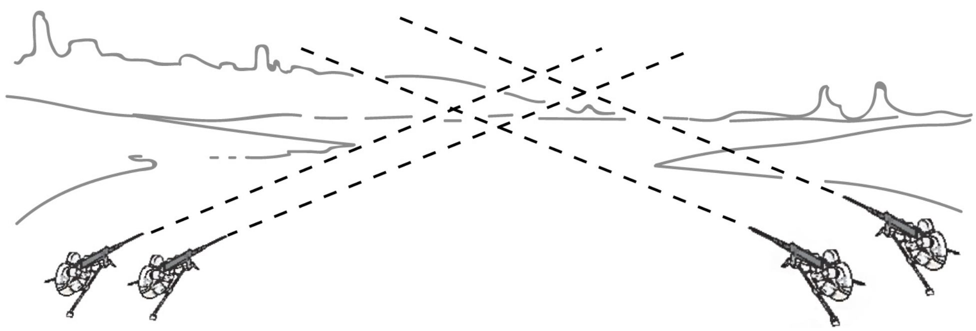


Figure 4-2. Heavy Guns Sighted to Produce Interlocking Fires.

Figure 4-3 illustrates what a simplified fire plan sketch might look like and depicts the interlocking fires of two medium machine gun squads.

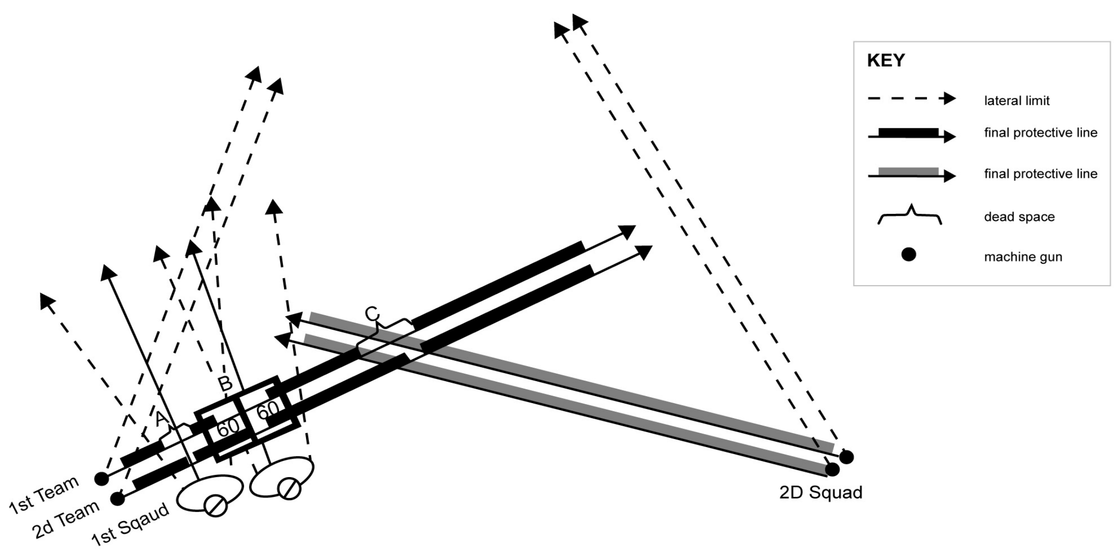


Figure 4-3. Simplified Fire Plan for Coordination of Defensive Fires.

Coordination of Fire

Whether in the offense or defense, leaders at all levels must ensure that machine gun fire is coordinated with the fires of adjacent machine guns, other weapons, and infantry units.

Offense. When in the offense, machine guns play a vital role in the coordination of both direct and indirect fire, the integration of supporting fires, and maneuvering the infantry. As infantry Marines close with an objective, fires should be coordinated with maneuver so that the enemy is continually suppressed by a schedule of fires ranging from the highest caliber munitions to the lowest caliber munitions. Close supporting machine gun fire is the final means of suppressing an enemy's position before the maneuvering infantry needs to use organic small arms. In the offense, machine gun fire must be coordinated with other weapon systems to ensure complementary or additional effects against the enemy during all phases (i.e., preparation firing, final assault, consolidation, and pursuit by fire).

Defense. When in the defense, the machine gun forms the backbone for the organization of other infantry weapons. The section leader must prioritize the machine gun fire plan and then plan other fires to complement it. Other indirect and direct fire weapons cover dead space in a machine gun's FPL.

Indirect fire should be planned to concentrate along the line where the machine gun's FPL is expected to stop the enemy, hitting the enemy when they seek cover.

Example of Defense

In Figure 4-3, the interlocking FPLs of two medium machine gun squads have been plotted in a simplified fire plan sketch. Notice how the farthest dead space along the first machine gun squad's FPL (C) is covered by the FPL from the second machine gun squad. Also, the closer portions of dead space on the first machine gun squad's FPLs (A and B) are covered by the light machine guns from the infantry fire teams that are located adjacent to that squad. In addition, a 60 mm mortar barrage from two lightweight company mortars has been planned to help cover the dead space at B.

Mutual Support

Mutual support is achieved by positioning pairs of machine guns in relation to one another to ensure survivability. These redundant fields of fire make the enemy that much more vulnerable to the fires of the machine guns. If one pair is attacked by the enemy, the other pair will still be able to inflict direct fire onto the enemy that is attacking the other pair.

Defilade

Whenever possible, machine guns should be positioned in defilade (see Figure 4-4) because the enemy will quickly target gun positions to neutralize or destroy them. Setting the machine guns in defilade provides more substantial cover between them and the enemy's direct fire weapons, which could prove essential to their survival.

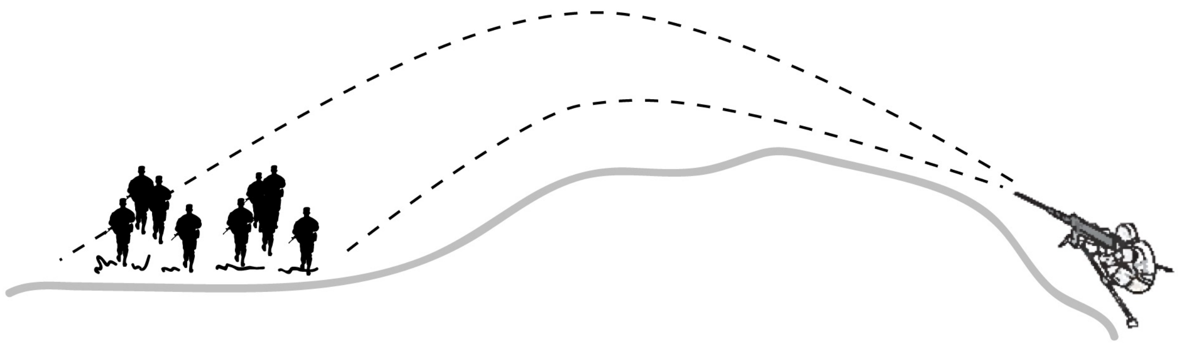


Figure 4-4. Heavy Machine Gun Positioned in Defilade.

Enfilade

To achieve the greatest effect, a machine gun should be sighted to produce enfilade fire (see Figure 4-5). This is to ensure that the long axis of the beaten zone coincides or nearly coincides with the long axis of the target. Enfilade fire causes the maximum number of rounds to be concentrated on the most targets, significantly increasing chances of hitting the targets. In a defensive scenario, machine guns sighted to fire along a PDF achieve frontal enfilade fire, while those sighted to fire along an FPL produce flanking enfilade fire.

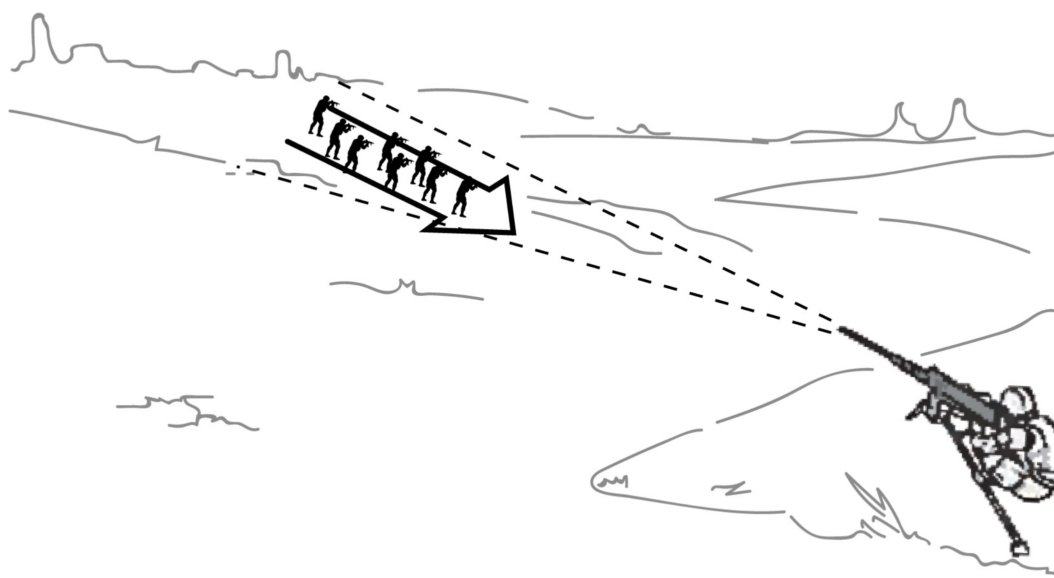


Figure 4-5. Heavy Machine Gun Sighted to Produce Enfilade Fire.

Economy

A machine gun's high rate of fire makes excessive ammunition consumption a concern for both machine gunners and infantry leaders. Wasteful use of ammunition can severely jeopardize the success of an operation if resupply is delayed or halted by enemy action, weather, terrain, and/or other factors beyond friendly control. Therefore, an accurate, detailed mission analysis should be conducted to plan for those types and amounts of ammunition that will effectively cripple or destroy the enemy. Balancing rates of fire, duration of fire, and ammunition supply are essential when conducting mission analysis.

Machine gunners should employ a method referred to as "talking guns." With this method, guns employed in pairs alternate bursts at a rate that achieves the desired effects on the enemy while controlling ammunition consumption and the wear/overheating of the operating parts.

Protection

Use of the other seven principles of machine gun employment enhances the protection of the machine gun. Protection of machine guns should always be a priority for a commander because they inflict devastating fire upon the enemy. Consequently, machine guns are likely to come under concentrated enemy attack. The use of additional forces, such as small units or an individual rifleman whose mission is to protect the machine guns, helps machine guns accomplish their missions. For example, forces can be provided to secure an SBF position to allow machine guns to safely occupy a position. Also, positioning machine gun units in relation to friendly forces or the enemy can increase their level of protection. Talking guns are used when there are multiple machine guns firing on a single point/area target (i.e., not alternating fires between guns covering multiple targets).

Examples of How Gun Locations Determine the Necessary Protection Level

Example 1: Gun Location in Relation to Friendly Forces

Machine guns should be placed on the flank's defense to provide an FPL, but not in the farthest position out, since this will leave them vulnerable to a flanking attack. A fire team or larger element should be positioned outboard of the gun position. This tucks the machine guns securely into the defense with protection on both sides.

Example 2: Gun Location in Relation to the Enemy

By placing a machine gun unit in a position that has substantial standoff, the weapon system may have the ability to out-range an enemy weapon (i.e., the maximum effective range of an M240B is 1,800 meters, while it is 800 meters for an RPD, which is a common threat weapon system). If a commander knows the enemy's composition and disposition, the machine guns can be positioned at standoff to achieve protection.

EMPLOYMENT CONSIDERATIONS

The capabilities and limitations of every available weapon must be considered to achieve effectiveness when employed together to achieve a synergistic effect. When developing a tactical plan, consideration should be given to how the fires of one weapon complement or augment the fires of another. The machine gun has unique employment considerations for the light, medium, heavy, and grenade machine guns.

Light Machine Gun

Some employment options for the M249 light machine gun include offensive and defensive fire, including ambushes. The primary employment method for a light machine gun is on a tripod.

Offense. The M249 has the following characteristics in the offense:

- It can augment a base of fire, adding its high volume of fire to help suppress and destroy enemy personnel on an objective.
- It can move with assault elements, adding considerable firepower to a unit during the assault and immediately upon consolidation on the objective. This frees medium machine guns to be more effectively employed from a SBF position, rather than trying to keep up with the assault, which severely limits their ability to effectively engage targets.
- It should be employed against sources of concentrated enemy fire.
- When employed properly, the M249 can support a rifle squad's offensive actions.

Compared with medium machine guns and HMGs, the M249's lighter weight and portability make it suitable for ambush patrols because of the need for speed of movement and stealth. Previously, when small units lacked a weapon with the capabilities of the M249, medium machine guns were considered essential to the conduct of a squad- or platoon-sized ambush, ensuring success through their high volume of accurate fire. Unit leaders should carefully consider the mission of the ambush patrol before arbitrarily assigning machine guns to participate. Medium machine guns must be pulled out of the defense to accompany an ambush patrol, which weakens that part of the defense for the duration of the patrol. However, heavier machine guns may be needed for certain ambush situations, such as those specifically targeting vehicles or requiring the fixed fire of a tripod-mounted gun. Otherwise, the high volume of accurate fire the M249 produces is typically sufficient.

Defense. The M249 has the following characteristics in the defense:

- It can augment the FPL (when employed on a tripod) and PDF of medium machine guns or cover dead space in those FPLs with direct fire.
- It can be assigned its own PDF to cover likely avenues of approach or other priority target areas.

Medium Machine Gun

The M240B (see Figure 4-6) is a general-purpose machine gun which provides a high volume of accurate fire beyond the range capabilities of the M249 and other small arms found in the rifle company.

Figure 4-6. M240B Medium Machine Gun Team.

The M240B is most efficient when it is tripod mounted. Mounting the gun provides the most accurate means of delivering fire, especially at the maximum effective range. Employing the medium machine gun from the tripod allows the precise manipulation of effective fires and allows for the assaulting forces to maneuver further into the attack. This is due to the more defined cone of fire, facilitated by being tripod mounted, before the shift fire criteria has been met. The M240B may be employed from a bipod during hasty situations or by specified guns within the unit during occupation of a SBF position by force. The other guns will mount M240Bs and lay on target under the suppression from bipods. Once accurate fire is achieved from mounted medium machine guns, M240Bs on bipods will transition to tripod employment. When assuming an SBF position by stealth, the medium machine gun unit is afforded the ability to mount all guns on tripods and T&E mechanisms.

> *NOTE:* Refer to Chapter 3 for information on firing from a defilade position and adjusting indirect machine gun fire, and to Appendix A for the M240B fire control tables.

The M240B can be employed in both the offense and the defense.

Offense. In the offense, the preferred method for employing the M240B is by section, from an SBF position where guns can mass their fires with a continuous, accurate, and heavy volume. Applying these elements produces a noticeable effect against enemy personnel and equipment.

Massed and fragmented fires contribute to the employment and success or failure of the M240B during offense.

The weight of massed medium machine gun fire is significant and must not be underestimated. The goal is to mass the fires from numerous guns. The principles of dispersion, employment in pairs, and cover and concealment should not be compromised to mass machine gun fire. Guns may be positioned in defilade for greater protection; therefore, an observer should direct and adjust the fires whenever possible. When contact is initiated, machine gunners must move rapidly into a position that allows them to achieve the desired effects against the enemy.

Defense. When in the defense, the machine gun section should be employed in general support of the overall unit. Contrary to use in the offense, the section's fires are usually best employed by setting squads in positions to produce overlapping fields of fire for both close defensive fires and FPFs.

Whenever grazing fire can be attained, the M240B should be assigned the mission of firing an FPL. The guns should generally be positioned on the flanks with interlocking FPLs and sectors of fire across the unit's front. All dead space in an FPL should be covered by other weapon systems. When terrain or mission prevents effective use of an FPL, a PDF is assigned. The PDFs are typically designed to cover the most likely avenues of approach or areas where the enemy may mass. Often, a mix of FPLs and PDFs are assigned to a section of guns in the defense to best cover the frontage. However, only one mission (i.e., an FPL or a PDF) can be assigned per gun squad.

Heavy Machine Gun

The M2A1 HMG and MK-19 (see Figure 4-7) grenade machine gun provide a high volume of accurate fire at ranges beyond the capabilities of small arms and medium machine guns. The lethality of ammunition make them ideal for engaging troop concentrations, lightly armored vehicles, unarmored vehicles, fortified positions, aircraft, and other equipment. The current infantry battalion table of organization allows for the employment of two weapon systems per HMG team. The personnel assigned to these weapon systems are capable of employing either system, but not simultaneously. Non-infantry unit leaders should confirm the current alignment of weapons and crew to determine employment practices. All commanders should consider the following criteria when determining operational methodology.

Figure 4-7. MK-19 Heavy Machine Gun.

Effectiveness Against Armor. The MK-19 with its HEDP round is effective against light armor. Its M430A1 warhead will penetrate three inches of homogeneous steel with zero degrees obliquity out to the gun's maximum range. However, it is difficult to effectively engage moving vehicles with the MK-19 because its 40 mm warhead has a high angle of trajectory, slow TOF, and can suffer adverse aerodynamics (drift) that becomes especially pronounced at ranges greater than 1,000 meters.

The M2A1, when firing the sabot light armor penetrator round, is highly effective against light armor targets at ranges up to 1,600 meters. At that range, the sabot light armor penetrator round will penetrate three-quarters of an inch of high hardened armor at zero degrees obliquity or three-quarters of an inch high hardened armor at 300 meters at 57 degrees obliquity. Therefore, the M2A1 can be employed effectively against moving, lightly-armored vehicles (e.g., BTR-90 APCs, BRDM-2 reconnaissance vehicles, BMP-1 IFVs [hull], 2S3 self-propelled howitzers, and ZSU 23-4 air defense vehicles) within 2,000 meters.

Effectiveness Against Personnel. The MK-19's HEDP round makes it very effective against personnel, with an effective casualty radius of 15 meters. The M2A1 is also an effective weapon against personnel because of its high volume of fire and 700 meters of grazing fire. These characteristics make the M2A1 well suited for the assignment of an FPL in the defense against infantry attack.

Offense. The mix of HMGs employed in the offense depends on the nature of the enemy's type and degree of protection, terrain, and vegetation. Some guns may need to remain mounted in order to keep up with an attack (e.g., a mechanized unit). If mobility is not an issue, the unit leader may want to dismount the guns to take advantage of the added accuracy of tripod-mounted guns.

Commanders can employ machine gun squads on a mobile platform that encompasses the light machine gun, medium machine gun, HMG, grenade machine gun, and antiarmor capabilities (specific to infantry units). When combined in this manner, they become a combined antiarmor team (CAAT). Additionally, commanders can create a mobile assault platoon that employs mobile machine gun squads only. Each configuration allows the commander to adapt to terrain, enemy composition, and specific mission requirements. More information on these organizations is available in Marine Corps Reference Publication 3-10A.1, *Infantry Battalion Operations*.

Defense. The MK-19, with its high trajectory, is not suitable for an FPL in the defense. It should usually be assigned a PDF to cover an avenue of approach, an obstacle, a defile, a choke point, or dead space in the FPL that is created by a flatter trajectory machine gun. However, the M2A1 can be assigned either an FPL or PDF with good effect. Depending on the protection and mobility of the enemy, vehicle-mounted HMGs may be included in a counterattack force (see Figure 4-8).

Figure 4-8. Vehicle-Mounted M2A1 Heavy Machine Gun with Heavy Machine Gun Sight System.

Heavy machine guns may be employed with antiarmor weapons and other elements in task-organized CAATs that have missions involving the following:

- Conducting antiarmor ambushes forward of the forward edge of the battle area.
- Supporting a combat outpost.
- Reinforcing a counterattack force.
- Supporting convoy security, point defense of rear area facilities, and other rear area security missions.

Effectiveness Against Aircraft. The M2A1 has limited effectiveness against armored rotary-wing aircraft (e.g., the Russian Mi-24, with the NATO reporting name "Hind"). The most effective .50 cal ammunition for engaging aircraft is armor-piercing (AP), API, and sabot light armor penetrator. Even armored aircraft have vulnerable points (e.g., the turbine intakes on the Mi-24), but a well-trained heavy machine gunner can pose a legitimate threat to this type of aircraft. While the MK-19 fragmentation-producing ammunition could be effective against stationary aircraft, such as helicopters in a landing zone, the ammunition's slow TOF makes the weapon ineffective against moving aircraft.

Effect of Firing Through Vegetation. The M2A1 can be employed effectively through light vegetation, while the 40 mm round fired from the MK-19 may detonate prematurely when fired through the same vegetation.

Indirect and Defilade Fire. The MK-19, with its relatively high trajectory, is the best-suited machine gun for employing from a defilade position. Because of its high trajectory, the MK-19 can be effectively employed against most defilade enemy positions and from its own defilade firing positions.

Firing from a defilade position is often most effective in a defensive situation in which the guns can be carefully laid and fires registered on likely targets. In this manner, the MK-19 can be employed effectively in a reverse-slope defense. Indirect firing requires that guns be laid for deflection on some reference point other than the target. There should be an observer in communication with the guns who can adjust rounds on the target.

For example, when using OPs on the military crest to adjust rounds, the MK-19 can be employed effectively in a reverse-slope defense to engage the advancing enemy on the forward slope. The M2A1 can also be employed from defilade firing positions and effectively engage in indirect fire. With the M2A1, proper use of firing tables and indirect fire techniques can yield effective fire against targets at considerably greater distances than the listed maximum effective range of the weapon.

Complementary Effects. The high angle of fire of the MK-19 and the flatter trajectory of the M2A1 can be employed effectively in tandem, with the capabilities of one complementing the other. For example, the M2A1 can be used to pin down enemy troops, while the MK-19 uses HEDP to create fragmentation effects like a mortar barrage. Other examples of pairing guns for complementary effects are covered earlier in this chapter.

Offensive Employment

During offensive operations, machine guns are best employed in a fire support role during the attack (e.g., movement to contact or ambush) because they are capable of providing support long after artillery and mortars are required to cease. This support is best used during the final stages of the assault and while fighting through the objective. Under normal circumstances, machine guns should be employed in accordance with the roles of the machine gun in the offense as discussed previously in this chapter.

Example of Machine Gun Employment During an Attack

All Machine Gun Employment Principles Covered

Heavy Machine Gun 1:
Heavy Machine Gun 1 consists of two M2A1 machine guns on tripods, initially providing fires in support of maneuver. The M2A1s will provide suppression on (A) to allow the maneuver unit to close with the enemy (see Figure 4-9).

Situation. A deliberate company attack on a fortified position occurring as follows:
- The enemy is arrayed in two defensive positions facing to the south.
- The company commander is given three sections of HMGs attached for this attack.
- The terrain is desert and visibility is as far as the human eye can see.
- The company commander has planned for artillery and mortar fire to support maneuver and allow the HMG sections to occupy their SBF positions.

Considerations. The following is a list of considerations for the guns used in this particular mission:
- *Fires in support of maneuver.*
  - The section leader will suppress the maneuver unit's immediate objective (A) to allow the unit to maneuver until it is in a position to conduct the assault.
  - The fires search and traverse across the entire objective or this section's portion of the objective. Rates of fire may be at or slower than the sustained rate, depending on their effectiveness.
  - The implication is that machine guns in this role are prepared to provide fire in support of the assault as maneuver continues to close.
  - The section leader must consider at which points the rates of fire will need to be increased or decreased based on when the unit is exposed to the effects of the enemy. Ammunition must be conserved to support the entire movement based on these considerations (i.e., coordination and economy).
  - The section would be in general support of the company because the fires support the entirety of the company and the control of fires and coordination resides with the company commander.
  - The commander may decide to put the guns in direct support of a specific platoon if the commander believes that the platoon will need greater responsiveness and has the ability to control the guns.
- *Pairs.* The position assigns two machine guns the same mission to facilitate engaging the depth and width of the target, to reduce the likelihood of a gun failure (because of a high rate of fire for a sustained period), and to be redundant.
- *Interlocking fires.* The fires of this section are interlocked with machine gun section 3, which will significantly enhance the effectiveness of suppression.
- *Coordination.* The squad will coordinate its fires with machine gun section 3 and may act as an observer for the MK-19s that are located in that position. Coordination will allow effective suppression at a decreased rate of fire and enable both sections to focus on the portion of the trenches that are in enfilade. Additional fire control measures or coordination will be required to ensure that fires from this position adequately support the maneuver element as follows:
  - Mutual support. LOS between machine gun 1 and gun 3 may provide the ability for mutual support.
  - Defilade. Based on terrain, the guns are usually laid directly on the target, with the position in partial defilade.
  - Enfilade. The position of these guns allows enfilade fires onto the eastern trench.
  - Economy. Understanding ammunition consumption (see Appendix E) and what constitutes suppression is essential for these guns. Target precedence and engagement criteria are critical to limit wear on the guns, conserve ammunition for the unit's entire task, and maximize the effects of its fires based on the target.
  - Protection. The distance from the object (i.e., standoff) provides protection.

Example of Machine Gun Employment During an Attack (continued)

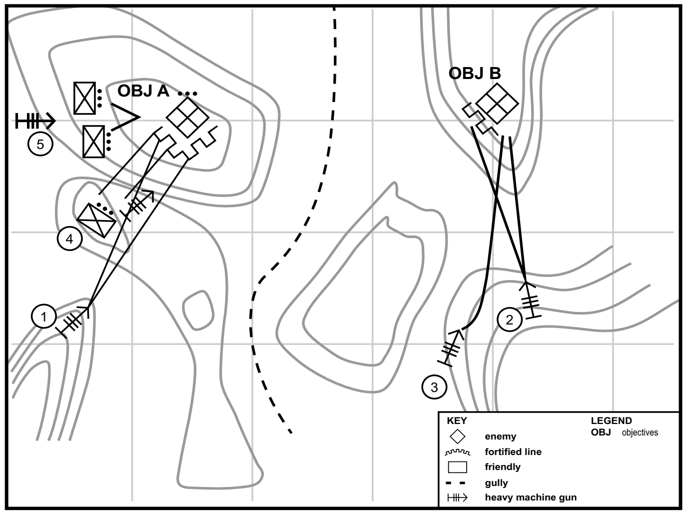


Figure 4-9. Heavy Machine Gun 1 Employment Example.

Heavy Machine Gun 3:
The heavy machine gun 3 section consists of two MK-19 machine guns on tripods, initially providing fires in support of maneuver. They also provide suppression on (A) to allow the maneuver unit to close with the enemy (see Figure 4-10). The following is a list of considerations for these guns for that particular mission:

- *Fires in support of maneuver*. The following considerations for the guns used in this particular mission apply:
  - The section leader will suppress the maneuver unit's immediate objective (A) to allow the unit to maneuver until it is in a position to conduct the assault.
  - The fires search and traverse across the entire objective of this section's portion of the objective. Rates of fire may be at the sustained rate or slower, depending on effectiveness.
  - It is implied that machine guns in this role are prepared to provide fire in support of the assault as the maneuver continues to close.
  - The section leader must consider at which points the rates of fire will need to be increased or decreased based on when the unit is exposed to the effects of the enemy. Ammunition must be conserved to support the entire movement based on these considerations (i.e., coordination and economy).

Note: With this mission, the section would probably be in general support of the company since the fires support the entire company and the control of fires and coordination resides with the company commander. The commander may decide to put the guns in direct support of a specific platoon.

- *Interlocking*. Special consideration was taken to provide interlocking fires with HMG 1.
- *Coordination*. Coordination is critical to this unit because the machine guns cannot see the target, so adjustment from an observer is required. Coordination is also critical to maximize the synergistic effects of 40 mm grenade rounds on the same objective as the .50 cal M2A1. This unit will require communication with the maneuver element to provide responsive fires because of the extensive TOF.
- *Defilade*. This position will achieve maximum or minimum defilade, an advantage of the MK-19 weapon system, allowing this squad to engage the enemy on (A) without exposing the position to enemy observed direct fires.
- *Enfilade*. The placement of this unit allows it to achieve enfilade fires on the west objective.
- *Economy*. Because there is another section firing on the same objective, economy can be maximized through coordination with HMG section 1, with respect to rates of fire and placement of fires.
- *Protection*. Protection is provided based on positioning that is relative to the enemy (i.e., standoff) and defilade.
- *Situation continued*. The company has established an internal SBF position to provide additional fires in support of the maneuver unit and is currently assaulting the enemy.

Example of Machine Gun Employment During an Attack (continued)

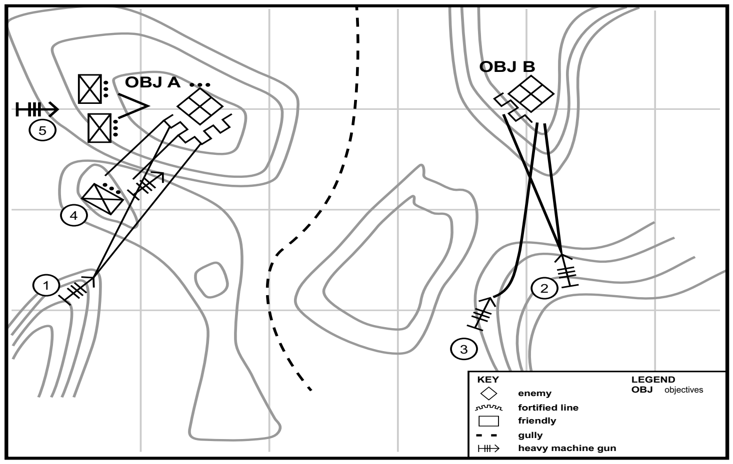


Figure 4-10. Other Machine Gun Employment Example.

Heavy Machine Gun 1:
Heavy machine gun 1 will transition its two M2A1 machine guns to provide fires in support of the assault. The M2A1s will provide suppression on (A) to allow the maneuver unit to conduct the final assault and destroy the enemy (see Figure 4-10). The following is a list of considerations for these guns for that particular mission:

- *Fires in support of the assault.* The section will suppress the maneuver unit's immediate objective (A). These fires will be focused on the portion of the objective that provides the largest threat to the maneuver elements. The rate of fire should be close to or at the rapid rate, with the desired effect that the enemy is unable to affect the assault element. Initially, the volume of fire will be greater to allow the maneuver element to establish fire superiority. The sector's fires for this specific gun have narrowed to provide the maximum amount of fire on the portion of the trench that immediately opposes the assault.

Note: These fires may be fixed fire instead of searching and traversing. Searching fires, when possible, will need to stay in line with or past the line of troops, because shorter rounds could cause ricochets to impact the troops.

Note: It is implied with this role of fires that the section is prepared to transition to fires in support of consolidation. The support relationship of these guns could be in direct support of the lead maneuver element and/or main effort. This would facilitate responsiveness when shifting and ceasing fires by giving control of fires to the unit most affected by their use. This section could remain in general support to allow the company commander to control their fires if threats to the entire unit require fires or to allow the main effort platoon commander to focus on controlling their maneuver element.

- *Interlocking.* This section will lose interlocking fires with the HMG section 3. Fires will still be interlocking with the fires from the section of medium machine guns that are located at its SBF position. Communications between the two units may be necessary to facilitate coordination.
- *Coordination.* Coordination is critical to the successful delivery of effective fires.
- *Communication*. Communication with the lead element/main effort or support unit should be the main concern. Radio communication, visual, or pyrotechnic signals need to be clearly implemented and understood for shifts and ceases and must provide redundancy. A plan for terminal control of the fires needs to be coordinated (e.g., increasing and decreasing rates of fire and targeting specific enemy locations).
- *Enfilade.* By firing on the west trench, the unit loses enfilade; however, they gain fires on the position that most directly affects the maneuver. This may be an example of a commander not using one of the machine gun principles of employment because they do not understand the risk versus gain of its implementation.

Example of Machine Gun Employment During an Attack (continued)

Heavy Machine Gun 2:
Heavy machine gun 2 will continue the mission (see Figure 4-10). This section must coordinate fires with HMG section 3 and may act as observers for that section to ensure economy of ammunition (i.e., interlocking fires and direct rates of fires).

Heavy Machine Gun 3:
Heavy machine gun 3 will displace by vehicle to provide on-call additional fires in support of isolation on (B) to facilitate the maneuver element assault on (A) (see Figure 4-10). The following is a list of considerations for these guns for that particular mission.

- *Fires in support of isolation*. Although redundant to the mission of HMG 2, this section of machine guns allows for increased fires in support of isolation at the most critical point for the assault. These machine guns could be in general support of the company because their fires support the entire company and retain control with the company commander.
- *Displacement*. The displacement of guns is considered using the mnemonic, MORT:
  - Method: the machines will move by unit.
  - Objective: establish a defilade position to deliver fires on objective B.
  - Route: the most direct route to the SBF position.
  - Time: when the maneuver unit reaches its assault position.
- *Coordination*. These guns are going to establish their position and adjust and register fires; however, they may not immediately provide suppressive fires. The section leader must have communications with the maneuver element and HMG 2 to provide the fires needed to accomplish the mission.
- *Economy defilade*. This machine gun section will attempt to fire from full defilade. This provides additional protection for the squad, although it may take more time to become involved in the action than if fired from partial defilade.

Medium Machine Gun Section (-) 4:
This section consists of four M240B machine guns that will provide fires in support of the assault. They will provide suppression on (A) to allow the maneuver unit to conduct the final assault and destroy the enemy (see Figure 4-10). The following is a list of considerations for these guns for that particular mission:

- *Fires in support of the assault.* Considerations for machine guns in this role are the same as for the HMG 1, with the following additional points:
  - The range to the target can provide more responsive and potentially more effective fires than the M2A1 can at 1,800 meters. This is based on the ability to acquire targets and the characteristics of the beaten zone as range increases.
  - The high rate of fire is ideal to support the suppression and neutralization of enemy infantry. The support relationship of these guns could be in direct support of the lead maneuver element or main effort. It could also facilitate the most immediate shifting and ceasing of fires with the unit that is most affected by them. Additionally, this section could remain in general support to allow the company commander to either control its fires if there are other threats to their entire unit or to allow the main effort platoon commander to focus on controlling their maneuver element.
- *Interlocking*. The two squads will interlock fires with each other to provide overlapping fire on the portion of the objective that can affect the friendly maneuver.
- *Coordination*. With the two squads in the same SBF position, either the section leader is going to be present to coordinate fires, or one squad leader will be put in charge of coordinating both squads' fires. The section must also coordinate with the rifle platoon that is occupying the SBF with them. To facilitate the massing of the machine gun section minus to suppress the northwest portion of the trench, the commander has given the section TRPs, dividing up the objective and maximizing the rates of fires of both squads (giving them two objectives).
- *Communication*. Communication with the lead element and/or main effort or support unit should be the main concern. Radio communication, visual, or pyrotechnic signals need to be clearly implemented and understood for shifts and ceases. Redundancy should be provided. A plan for terminal control of the fires needs to be coordinated, such as increasing and decreasing rates of fire or targeting specific enemy locations.
- *Economy*. The commander made the decision to divide the objectives for each squad. If both squads fired at the rapid rate, the mission would require 280 rounds per minute, as opposed to if they had been employed as a section minus with only one objective, consuming 160 rounds a minute. The commander's estimate of the situation determines how to employ multiple machine guns when engaging the same objective.
- *Protection*. The protection provided is based on the machine gun's position on the battlefield relative to other friendly forces on the battlefield.

Example of Machine Gun Employment During an Attack (continued)

Medium Machine Gun 5:
Medium machine gun 5 is traveling with a maneuver element to provide fires against concentrations of enemy or enemy fire that may become unmasked during the assault (see Figure 4-10). At the end of the assault, this machine gun will transition to fires in support of consolidation, giving the commander flexibility in the assault against unknown enemy dispositions and providing for the rapid transition of machine guns into consolidation. The commander must weigh this against the implications of another unit providing dedicated fires from an SBF position.

Note: The situation continues with the company transitioning into the consolidation and exploitation phases of the attack (see Figure 4-10).

Heavy Machine Gun 1:
Heavy machine gun 1 transitions to fires in support of consolidation to prevent the enemy from counterattacking against the company during consolidation (see Figure 4-10). The following is a list of considerations for these guns for that particular mission:

- *Fires in support of consolidation.* This position on the battlefield enables the unit to provide fires from its current position. These fires are on order and are usually only fired if the enemy actually counterattacks.

Note: It is implied that fires may be required to support the unit during exploitation, which may involve all of the other offensive roles of machine guns. If the commander decides to stay in this position, then the squad should be prepared to provide fire in support of one of the defensive roles. This section could be placed in general support of the company because its current position allows it to support a large portion of the company's frontage. It could also be placed in direct support of the unit for which it can provide the most responsive fire.

- *Coordination.* The location of friendly units as they position themselves for consolidation needs to be coordinated to ensure these fires are employed effectively. Because of the distance, control of these fires should be coordinated with the company. The section leader may not be able to effectively acquire targets.
- *Economy.* In this role, machine guns will deliver fires if a threat presents itself, in accordance with the engagement criteria.

Heavy Machine Guns 2 and 3:
Heavy machine guns 2 and 3 may continue their mission or cease fires, depending on the company commander's decision to exploit the situation with another attack or stay in consolidation (see Figure 4-10).

Medium Machine Gun 4:
Medium machine gun 4 will displace by foot to the objective (A) to provide fires in support of consolidation, considering the following:

- *Fires in support of consolidation.* It is implied that machine guns in this role might need to support the unit's transition in the exploitation and may involve all of the other offensive roles of machine guns. If the commander decides to stay in this position, then the squad should be prepared to provide fire in support of one of the defensive roles of machine guns. This squad could be placed in general support of the company and direct support of the unit that requires (and it can provide) the most responsive fire, as appropriate.
- *Displacement.* The mnemonic, MORT, is considered as follows:
  - Method: the machine guns will move by unit.
  - Objective: establish a position in between 1st and 2d platoon.
  - Route: go due north from the SBF until you reach objective A, then enter our consolidation from the west.
  - Time: begin displacement immediately after ceasing fire for the assault.
- *Interlocking.* This squad will attempt to interlock fires with the HMG 1 and medium machine gun 5.
- *Coordination.* Upon consolidation, the squad leader will need to coordinate the position of the squad. The squad leader will also coordinate with adjacent units to determine the exact location of the guns. The squad should receive priority in the actual consolidation formation for the purpose of establishing its firing position and sector of fire.

Example of Machine Gun Employment During an Attack (continued)

Medium Machine Gun 5:
Medium machine gun 5 will move directly into a position to provide fires in support of consolidation, considering the following:

- *Fires in support of consolidation*. This gun was assigned to the maneuver unit to allow it to rapidly transition into fires in support of consolidation. It is implied that machine guns in this role might need to support the unit's transition in the exploitation that may involve all of the other offensive roles of machine guns. If the commander decides to stay in this position, then the squad should be prepared to provide fire in support of one of the defensive roles of machine guns. This squad could be placed in general support of the company and direct support of (or be attached to) the unit to which it can provide the most responsive fire.
- *Coordination.* This unit will need to coordinate with the 1st platoon as it travels behind it.
- *Interlocking.* This squad will attempt to interlock its fires with HMG 1 and medium machine gun 4.
- *Protection.* These machine guns will be protected by their position in relation to friendly units. They will not be on the flank alone, but will be tucked into the 1st platoon.

Medium Machine Gun 6:
Medium machine gun 6 will remain in reserve with the 3d platoon to allow the company commander maximum flexibility. The company commander can use this unit to counterattack against any unit that threatens consolidation or that exploits the attack by assaulting objective B (see Figure 4-10).

DEFENSIVE EMPLOYMENT

Sectors of Fire in the Defense

Machine gun squads in the defense are assigned sectors of fire. The inner limits are usually the bands of grazing fire placed along the FPL. The sector of fire should not exceed the limits of the traversing bar. The machine gun fire unit is responsible for engaging the enemy within its sector, subjecting the enemy to fire as they approach, and forcing them to pass through coordinated bands of grazing fire before they can make their assault. When the sector of fire does not include an FPL, a zero line is used. It is desirable that the zero line approximately bisects the sector and points toward a clearly defined landmark in the area. As time permits, machine gun crews prepare primary, alternate, and supplementary fighting positions, in that order.

Rates of Fire

Machine gun FPLs are usually fired at the rapid rate for the first two minutes and then a sustained rate thereafter. When the signal to fire the FPL is received, the gunner immediately begins firing on the FPL at the rapid rate for two minutes. From the two-minute mark until the signal to cease fire is given, the gunner fires at the sustained rate of fire unless otherwise directed.

Final Protective Lines

An FPL is a predetermined line where grazing fire is placed to stop an enemy assault. The fire is usually a fixed direction and elevation and can be fired under all conditions of visibility. When fixed fire is incapable of producing the maximum effective grazing fire because of irregularities in the terrain, some searching fire may be used in conjunction with the fire of other weapons to ensure that all of the FPL is covered. The gun is laid on the FPL unless targets are being engaged. The following subparagraphs discuss the three characteristics of effective FPLs.

Flanking Fire. Final protective lines should provide as much flanking fire as possible. Flanking enfilade fire is highly desirable for FPLs. Terrain and obstacles should be used to force enemy formations into positions where the fires of the FPL will be flanking and enfilade.

For example, every attempt should be made to position guns toward the flank of the defense and align FPLs along the enemy side of tactical wire. When the attacking enemy encounters the tactical wire and slows or stops to negotiate it, flanking, they will be engaged by enfilade fire from machine guns.

Interlocking Fire. Final protective lines should be interlocking. Interlocking fire will—

- Add to the effectiveness of the fire plan by eliminating gaps in the FPLs.
- Maximize the coverage by fire across as much of the frontage as possible.
- Provide mutual support between adjacent units.

Grazing Fire. Final protective lines should be located to obtain maximum grazing fire. Grazing fire places a wall of bullets between an advancing enemy and friendly positions by forming a cone of fire. A cone of fire is formed by sighting the weapon on the farthest range possible where the center of the cone of fire will remain approximately one meter above the ground. This ensures that the lower bound of the cone of fire is as close to the ground as possible to minimize the enemy's opportunity to move underneath it without being hit. Six hundred meters is the maximum range that grazing fire can be maintained with the M240B.

Metal on Metal. The gunner centers the traversing hand wheel mechanism and zeroes the traversing micrometer. Upon determining along which limit of the sector the FPL is to lie, the gunner sets the traversing slide toward that end of the traversing bar which is opposite the direction of the FPL. The gunner then lifts the rear legs of the tripod and aligns the muzzle in the approximate direction of the line. By doing this, the gunner obtains the maximum angle of traverse away from the FPL in the direction of the targets in their sector.

Dead Space

It is critical to identify any gaps that exist in the FPL. These gaps, or dead space, indicate which areas on the FPL cannot be engaged by the machine gun's fires. Dead space may require the assignment of other weapon systems to cover the space.

Example of a Dead Space Situation

In perfect conditions on uniformly sloping ground and with the gun sighted at 600 meters, the maximum dead space on an FPL would be 0.8 meters (i.e., 31 inches) and would occur at a range of approximately 300 meters.

This space would be difficult to move under without resorting to a low crawl, which would seriously impede the enemy's momentum in the attack. Since terrain is seldom uniformly sloping, any depressions in the ground along the FPL will aid the enemy in moving underneath it more quickly.

The example situation represents why dead space in the FPL must be identified and marked. The FPL is indicated on maps, fire plan sketches, or overlays in the following ways:

- A wide black line to indicate grazing fire and effective danger space.

- A thin line when grazing fire is lost, the danger space is diminished, and dead space occurs.
- A section of dead space that is drawn to scale shows the exact width of the gap on the FPL.

These indications are important when determining the type of weapon that will be used to cover dead space.

The effectiveness of machine gun fire might not be completely canceled by sections of dead space as determined by continuous fire and grazing fire. Continuous firing along the FPL will keep the enemy confined to areas of dead space, impede movement, and allow other weapon systems time to engage them. If the gun is laid for 600 meters on the FPL with grazing fire, a danger space exists along that entire distance. Danger space encompasses the entire cone of fire, not just the center (as with grazing fire). It is a measure of the entire kill zone created by the cone of fire that will hit a standing person (i.e., 1.8 meters/70 inches) at a prescribed range.

For example, the M240B's cone of fire does not rise above the height of a standing person to a range of 700 meters. At this range on uniformly sloping ground, the maximum dead space would be 1.4 meters/55 inches, and would occur at half of that range (350 meters). Although this dead space could allow the enemy to move under the FPL, enemy personnel who attempt to advance while standing could still be hit at any point along the 700 meter line of fire.

The grazing fire measurement of 600 meters is used as the maximum range for an FPL instead of the 700 meter measurement of effective danger space because the 31-inch maximum dead space encountered when sighted at 600 meters is far more restrictive to enemy movement than the 55-inch maximum dead space encountered when sighted at 700 meters.

Although the FPL is a fixed firing mission, two clicks of elevation, either up or down, of searching manipulation with the T&E mechanism is permitted and encouraged during firing. This technique maintains a fixed line of fire while continually changing the height of the cone of fire and the location of the beaten zone. It provides better coverage of the area along the line, including any sections of dead space.

> *NOTE:* Once the machine gun unit leader has ensured that the positions are occupied properly, machine guns are immediately set in firing positions to cover assigned sectors of fire and PDF or FPLs. The squad leader identifies definitive terrain features to each machine gun team when prescribing sectors of fire, PDFs, and FPLs.

Walking the Final Protective Line

Once assigned, and if the situation allows, the FPL should be walked. Walking the FPL allows the team to determine the extent of the grazing fire and any danger space. The team locates and marks any dead space. The following approach should be observed when walking the FPL:

- Prior to walking the FPL, the gunner should ensure that the gun is positioned correctly and locked into place on the tripod in the same manner that it will be when firing the FPL.
- The gunner should be situated in a good firing position behind the gun, sighted at 600 meters on the machine gun optic and aimed at a point along the FPL estimated to be 600 meters away.

- The team leader or ammunition bearer walks along the FPL using a standard pace. For accuracy, the length of the individual's pace must be measured.
- The gunner should shout *"Mark"* when they can no longer observe the walker below the center mass of their chest.
- The walker records the number of paces that were taken to that point on a pace card and continues to walk the FPL.
- The gunner shouts *"Mark"* when they see the walker's body below the center mass of their chest again.
- The walker records the number of paces that they took to reach that spot again. This procedure is continued until the walker reaches the limits of grazing fire—which is 600 meters for the M240B or 700 meters for the M2A1. Pace counts recorded in this manner indicate the distance each section of dead space is from the gun position and how wide the dead space is from near side to far side.

One of the following approaches can be used to determine dead space:

- The center mass of the chest as the point where dead space begins to take into consideration the measure of grazing fire, danger space, maximum ordinate, and maximum dead space.
- The gunner's view of a person's waist (an approximate measure of the 1 m height of grazing fire) as the point where dead space begins is too limiting as a tactical measurement of fire over actual terrain. It disregards the effective danger space created by the lower portion of the cone of fire. However, if dead space is not marked until only a person's head is visible to the gunner, then a significant amount of dead space would have been overlooked and unmarked prior to that point (based on the measure of maximum dead space at 600 meters). The use of the center mass of the chest as the measuring point for dead space is a compromise between these two considerations.

Preparation of Range Cards

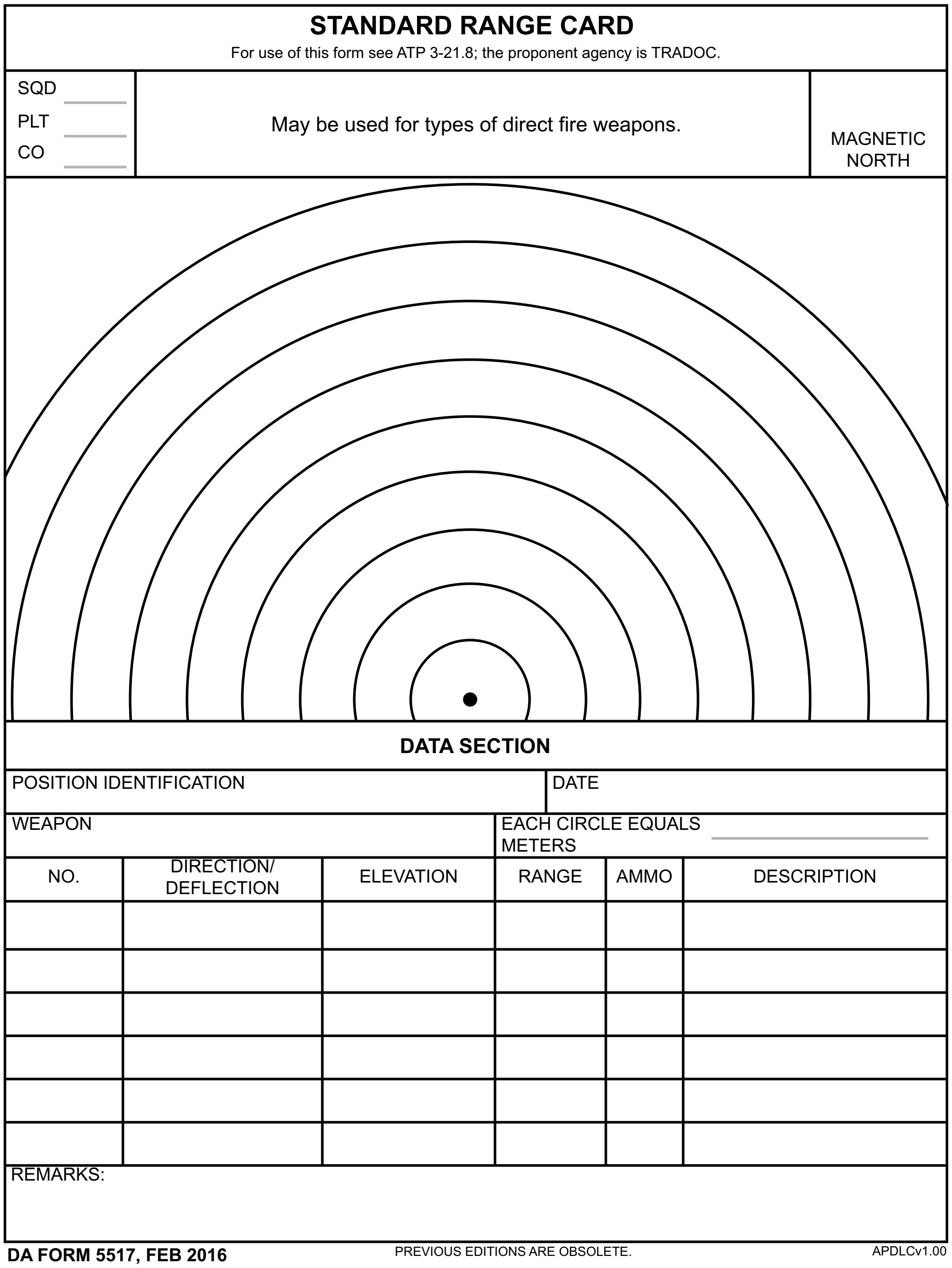
Each team leader prepares two range cards containing information concerning the extent of dead space, grazing fire along the FPL, and the location of any likely targets. Both machine gun teams in a squad are usually assigned the same sector of fire and fire at the same FPL. Therefore, each FPL is a double band of machine gun fire. If both teams are positioned properly (i.e., approximately 35 to 50 meters apart), then both teams' range cards will be similar, but not exactly alike. One copy of the range card along with the pace card is given to the squad leader. The squad leader, from the information provided and in conjunction with the section leader, determines the amount of dead space within each team's FPL. They also determine the number and position of mortar barrages required to cover dead space in the squad FPL.

Range Cards

A range card is a sketch or diagram of the terrain that a weapon is assigned to cover by fire. It shows possible target areas and terrain features plotted in relation to a firing position. The range card is used for planning and controlling fires and rapidly detecting and engaging targets in a defensive situation. Range cards are extremely useful for orienting replacement personnel or units to a defensive position because it serves as a record of firing data for a given position and sector.

Department of the Army Form 5517-R

When occupying a defensive position, each machine gunner should make a duplicate range card (see Figure 4-11) using Department of the Army (DA) Form 5517-R, *Standard Range Card*. If the gun crew does not have the standard form, the range card should be drawn on any material that is available.



STANDARD RANGE CARD

For use of this form see ATP 3-21.8; the proponent agency is TRADOC.

SQD ____
PLT ____
CO ____

May be used for types of direct fire weapons.

MAGNETIC NORTH

DATA SECTION

POSITION IDENTIFICATION | DATE

WEAPON | EACH CIRCLE EQUALS ____ METERS

NO.	DIRECTION/ DEFLECTION	ELEVATION	RANGE	AMMO	DESCRIPTION

REMARKS:

DA FORM 5517, FEB 2016 PREVIOUS EDITIONS ARE OBSOLETE. APDLCv1.00

Figure 4-11. DA Form 5517, Standard Range Card.

Duplication and Submission

The two copies of each range card should be distributed as follows:

- A copy remains at the gun position to be a record of firing data. The gunner uses the range card data to fire on predetermined targets, and to help estimate ranges to other targets during good visibility.
- A copy is given to the squad leader, who determines any gaps in the machine gun squad's sector of fire that must be covered by other company direct fire or indirect fire weapons.

The range card is then forwarded to the next higher headquarters (the company or battalion), where it is used to identify gaps in defensive fires, organize the defense, and complete the company or battalion fire plan sketch.

Regardless of the length of time the gun crew expects to occupy a position, preparation of a range card should begin immediately upon laying the gun. Revisions and improvements should be made as necessary. When constructing a range card, the data must be computed first. Next, the terrain sketch of the area may be constructed.

Components of a Range Card

Regardless of whether the range card is completed on a DA Form 5517-R or another available material, such as a cardboard box, it should contain the following graphics and information:

- Symbol for the weapon covering the sector.
- Boundaries of the area assigned to be covered by observation and fire (i.e., sector of fire).
- TRPs and target data pertaining to those points.
- Areas designated as dead space (i.e., areas that cannot be observed or covered by fire).
- Azimuth and distance of the firing position from an easily recognizable terrain feature.
- Direction of magnetic north when the range card is properly oriented.
- Identification data, such as the unit designation, time and date of preparation, and type of firing position (i.e., primary, alternate, or supplementary).

Preparation of a Range Card

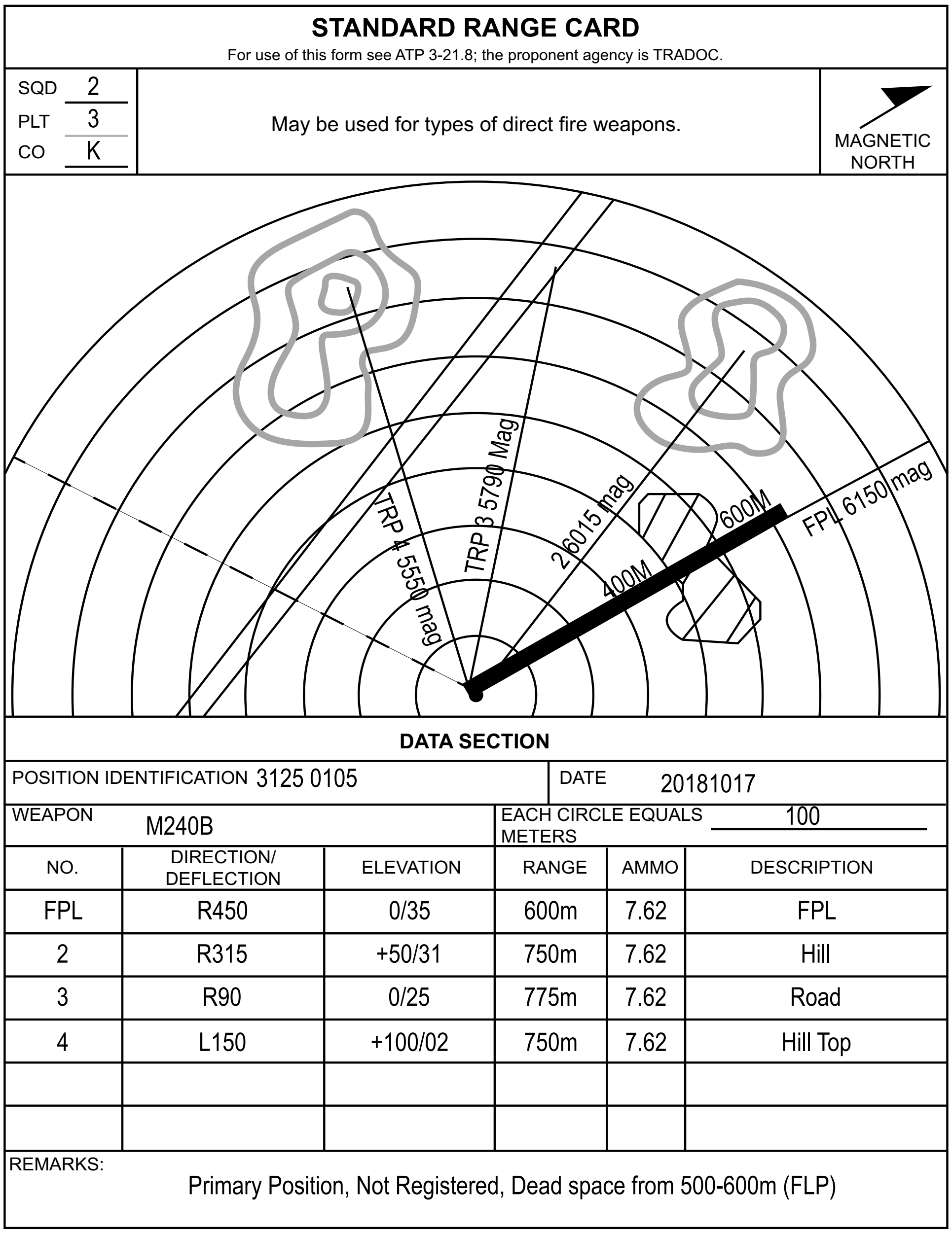
Before drawing on the range card, the maximum range of visible terrain and the maximum range of targets to be engaged must be determined. Next, the crew should determine how many meters each concentric ring on the range card should represent. The range rings will assist the crew in illustrating the range card to scale.

> *NOTE:* See Figure 4-12 for a completed range card on DA Form 5517-R. The following sub paragraphs identify items that should be observed when preparing a range card.

Sector of Fire. The first item that is drawn on the range card is the sector of fire. The primary sector of fire should be depicted with plain dashed lines with open-ended arrows to show that they do not end and be labeled either LLL (i.e., left lateral limit) or RLL (i.e., right lateral limit). They will be associated with a magnetic azimuth in degrees to ensure that the sector interlocks within the adjacent unit's firing positions. If assigned, the secondary sector should be depicted as dashed lines with circles at their ends.

Primary Mission. The next item to be drawn on the range card is the primary mission, whether it is an FPL or a PDF. An FPL is depicted as follows:

- A solid line with an arrow at the end. Since the FPL is laid at either the extreme right or left of the traversing bar, it should take the place of either the right or left sector limit on the range card.
- The extent of grazing fire is depicted by widening the black line of the FPL. Dead space is illustrated by leaving a gap in the widened line.
- The range (in meters) to the far limit of grazing fire and to the near and far end of each segment of dead space is annotated along the FPL.


STANDARD RANGE CARD

For use of this form see ATP 3-21.8; the proponent agency is TRADOC.

SQD 2
PLT 3
CO K

May be used for types of direct fire weapons.

MAGNETIC NORTH

DATA SECTION

POSITION IDENTIFICATION 3125 0105 | DATE 20181017

WEAPON M240B | EACH CIRCLE EQUALS 100 METERS

NO.	DIRECTION/ DEFLECTION	ELEVATION	RANGE	AMMO	DESCRIPTION
FPL	R450	0/35	600m	7.62	FPL
2	R315	+50/31	750m	7.62	Hill
3	R90	0/25	775m	7.62	Road
4	L150	+100/02	750m	7.62	Hill Top

REMARKS: Primary Position, Not Registered, Dead space from 500-600m (FLP)

DA FORM 5517, FEB 2016

Figure 4-12. Completed Range Card.

A PDF is depicted as a solid line with an arrow at the end, with no illustration of grazing fire or dead space. Since the PDF is on the zero line of the traversing bar, it should bisect the sector of fire on the range card.

Target Data. Once the primary mission and TRPs are drawn on the range card, the target data (shown as range in meters, magnetic azimuth, and T&E data) to each one is annotated as follows:

- DA Form 5517-R. When the standard range card is being used, target data is annotated in the bottom portion of the card.
- Field expedient range cards. If the standard range card is not being used, the range to each target is written on one side of the line and the T&E information for the target is written on the other side. This also applies when recording the data for the primary mission of FPL or PDF.
- Maximum engagement line. A graphic that depicts the maximum usable range for that gun position should be included on the range card. This is the amount of distance visible to either the leader or the gunner, based upon terrain and vegetation, but still within the maximum effective range of the machine gun. The maximum engagement line is illustrated by drawing a line across the sector of fire and annotating the range in meters to that line.
- Dead space. Areas where targets cannot be engaged with direct fire from the gun should be illustrated by drawing diagonal lines across these areas and annotating the area as dead space.

Prominent Terrain Features. Once the primary mission has been determined and drawn, any prominent terrain features should be sketched with as much detail as possible without cluttering the card in an effort to best orient both the crew and higher echelons to the area in and around the sector of fire. Any prominent natural and man-made features that could be likely targets should be included.

Target Reference Points. Once the terrain is sketched, the location of TRPs as designated by the squad leader should be illustrated by what the TRP is and a corresponding number. Additionally, any other locations where a target is likely to appear should be planned and annotated and the target number should be annotated at the end of the line to each TRP. To provide consistency in target numbering, the following rules should be observed:

- Final protective line card. When an FPL is used, the targets are numbered from either right to left or left to right, starting with the FPL. Therefore, the FPL will always be target number one, regardless of whether it is on the right or left of the sector.
- Principal direction of fire card. When a PDF is used, the targets are numbered from left to right, with the number of the PDF, depending on where it falls in the order.

Orientation Diagram. One of the final components to be added to the range card is the orientation diagram. The purpose of the orientation diagram is to assist higher echelons in determining the location of the gun for fire plan sketches and inspecting the position. The position of the gun should be related to a prominent terrain feature (e.g., a hilltop, road junction, or building). If there is a prominent terrain feature within 1,000 meters of the gun, that feature should be used.

If no feature exists, the eight-digit map coordinates of the gun position should be annotated. Orientation is accomplished as follows:

- Use a compass to determine the azimuth to the prominent terrain feature. Compute the back azimuth from the terrain feature to the firing position.
- Determine the distance between the gun and the feature by either pacing or using a map.
- Sketch in the terrain feature on the card in the lower left or right corner (whichever is closest to its actual direction on the ground) and identify it.
- Connect the sketch of the position and the terrain feature with a barbed line extending from the feature to the gun.
- Annotate the distance in meters above the barbed line and the azimuth (in mils) from the feature to the gun below the barbed line.

Weapon Symbol. Once the orientation diagram is completed, the weapon symbol for the gun should be added to the card, with the tip of the symbol's arrow ending at the dot that represents the actual gun position. Reference MIL-STD-2525 *Department of Defense Interface Standard Joint Military Symbology* for current weapons symbols.

Remarks. The remarks for the range card should include the following:

- The team and squad designation of the gun.
- Shoulder pressure used, weather, time of day, registered or unregistered, back azimuth to the gun, distance in meters from the terrain feature to the gun location, and a description of the terrain feature/designated position.
- The time and date the range card was prepared.

APPENDIX A.
FIRE CONTROL TABLES

FIRE CONTROL TABLES FOR THE M240B

Table I: Angle of Elevation

The angle of elevation (AE) is required to engage a target on flat or uniformly sloping ground and is listed for the ranges as indicated.

Angle of Elevation Examples

Example 1

The AE required to hit a target that is level with the gun at a range of 1,700 meters is 53 mils. The change in elevation and range for each 100 meters in range has been calculated to permit subsequent changes in the quadrant elevation without recalculation.

Example 2

The AE for a target at 2,000 meters is 76.1 mils and the angle of sight (AS) to the target is 14 mils. The quadrant elevation for the target is AS + AE = 90.1 mils. At a range of 2,000 meters, it takes 8.9 mils to shift the center of impact 100 meters.

The AE can be interpolated for 2,075 mils by multiplying 8.9 by 0.75 to obtain the change in AE for 75 meters. The result is 6.675 mils, which is rounded up to 6.7 mils. Add 6.7 mils to the quadrant elevation of 90.1 mils to obtain the quadrant elevation for a target at 2,075 meters with an AS of 14 mils. The result is 96.8 mils.

Note: For ranges not in even hundreds and for ranges not tabulated, the desired information must be determined by interpolation—the method of estimating a number that exists between two other numbers.

Example 3

A medium machine gunner needs to know the AE for a target at a range of 1,645 meters. The AE for 1,600 meters is 46.4 mils and for 1,700 meters is 53 mils. The difference is 6.6 mils. At this range, 6.6 mils correspond to a range shift of 100 meters. A change of 45 meters requires .45 × 6.6 mils = 2.97 mils. Therefore, the AE for 1,645 meters is 46.4 + 2.97 = 49.37 mils.

Table A-1 contains the AE, cone of fire, effective beaten zone dimensions, angle of fall, TOF, maximum ordinate, and drift to assist in determining the effect on the target.

Table A-1. M240B Table I: Angle of Elevation.

Firing Table 7.62-A-2													
Cartridge, Ball, M80													
			Vertical 100% Cone of Fire		Effective 82% Beaten Zone					Maximum Ordinate			
					Width		Length						
Range (m)	AE (mils)	Difference (mils)	(mils)	(m)	(mils)	(m)	(m)	Angle of Falls (mils)	Time of Flight (seconds)	Height (m)	Range (m)	Drift to the Right (m)	Range (m)
100	0.8							1	0.12	0	53	0	100
200	1.6	0.8						2	0.26	0	104	0	200
300	2.6	1						3	0.41	0	163	0	300
400	3.7	1.1						5	0.58	0	218	0	400
500	5	1.3			2	1	85	7	0.77	1	284	0.1	500
600	6.6	1.6						10	0.99	1	345	0.1	600
700	8.5	1.9						14	1.24	2	402	0.1	700
800	10.8	2.3						20	1.52	3	465	0.2	800
900	13.5	2.7						27	1.83	4	534	0.3	900
1,000	16.7	3.2			2	2	53	34	2.16	6	598	0.4	1,000
1,100	20.5	3.8						43	2.51	8	664	0.5	1,100
1,200	24.8	4.3						52	2.88	11	726	0.6	1,200
1,300	29.5	4.7						62	3.27	14	782	0.8	1,300
1,400	34.7	5.2						73	3.67	18	836	1	1,400
1,500	40.3	5.6			2	3	48	85	4.09	22	887	1.2	1,500
1,600	46.4	6.1						98	4.55	28	943	1.5	1,600
1,700	53	6.6						113	5	33	997	1.7	1,700

Table A-1. M240B Table I: Angle of Elevation. (Continued)

Firing Table 7.62-A-2 Cartridge, Ball, M80			Vertical 100% Cone of Fire		Effective 82% Beaten Zone					Maximum Ordinate			
					Width		Length						
Range (m)	AE (mils)	Difference (mils)	(mils)	(m)	(mils)	(m)	(m)	Angle of Falls (mils)	Time of Flight (seconds)	Height (m)	Range (m)	Drift to the Right (m)	Range (m)
1,800	60.1	7.1						129	5.48	40	1,050	2.1	1,800
1,900	67.8	7.7						146	5.99	47	1,107	2.4	1,900
2,000	76.1	8.3			2	4	51	165	6.52	55	1,169	2.8	2,000
2,100	85	8.9						186	7.08	64	1,223	3.2	2,100
2,200	94.6	9.6						209	7.67	74	1,282	3.7	2,200
2,300	105	10.4						234	8.28	85	1,344	4.2	2,300
2,400	116.3	11.3						262	8.92	97	1,405	4.8	2,400
2,500	128.6	12.3			3	6	56	293	9.61	111	1,465	5.4	2,500
2,600	142.2	13.6						327	10.35	126	1,527	6.1	2,600
2,700	157.5	15.3						366	11.15	143	1,588	6.9	2,700
2,800	174.7	17.2						411	12.02	162	1,652	7.7	2,800
2,900	193.9	19.2						460	12.95	183	1,713	8.6	2,900
3,000	215.1	21.2			3	9	62	513	13.95	206	1,777	9.6	3,000
3,100	238.9	23.8						571	15.04	231	1,844	10.7	3,100
3,200	266.7	27.8						638	16.27	259	1,907	11.9	3,200
3,300	300.7	34						714	17.68	291	1,976	13.3	3,300
3,400	344.4	43.7						804	19.43	326	2,042	14.7	3,400
3,500	411.9	67.5			3	12	68	926	21.93	365	2,109	16.3	3,500

Table II: Overhead Fire

The information contained in Table A-2 includes the distance to troops, the minimum AE to clear troops, and corresponding range. The distance to troops is the distance in meters from the gun to the friendly troops where there will be overhead fire. It is the quadrant elevation required to strike the ground where the troops stand, plus a definite angle of safety given the minimum quadrant elevation that can be fired over the troops without danger. The minimum AE to clear troops is the safety angle plus the AE that can be fired over the heads of troops at the given troop distance. The corresponding range is the minimum range that gives the required clearance. Both the exact and even figures to the nearest 25 meters over are given. When troops are firing over visible troops, the safety angle can be measured by setting the corresponding range using even figures.

Examples of Corresponding Range

Example 1

In Table II, the minimum AE when troops are 700 meters in front of the gun—whether on level or uniformly sloping ground—is 25.2 mils. This AE will produce a center of impact at 1,209 meters and is referred to as the corresponding range for that AE.

To simplify, the corresponding range is always rounded up to the nearest 25 meters, which results in a figure of 1,225. Therefore, no target at a range closer than 1,225 meters can be engaged with the M240B over level or uniformly sloping ground when the troops are 700 meters from the gun.

For all situations where the troops on the ground have a positive or negative vertical interval, the following equation is true: the minimum quadrant elevation for troop clearance equals the AS plus the minimum AE for troop clearance.

Example 2

The target is at 1,700 meters with no vertical interval, but the troops are on top of a hill 900 meters from the gun that has a vertical interval of +20 meters. Solving for the minimum quadrant elevation requires the following:

Add the AS of the troops to the minimum AE for 900 meters.

The AS equals the vertical interval divided by the observer-target factor (20 ÷ .9) = 22.2 mils.

Add this AS to the minimum AE for 900 meters (32) to get a minimum quadrant elevation for troop clearance of 54.2 mils. Since the AE for a target at 1,700 meters (with zero AS) is 53 mils, troop clearance does not exist.

Table A-2. M240B Table II: Overhead Fire.

Firing Table 7.62-A-2 Cartridge, Ball, M80			Corresponding Range	
Distance to Troops (m)	Minimum AE to Clear Troops (mils)	Difference (mils)	Exact Figure (m)	Even Figure (to nearest 25 above) (m)
100	76.2		2,001	2,025
200	40.2	-36	1,498	1,500
300	29.5	-10.7	1,299	1,300
400	25	-4.5	1,205	1,225
500	23.3	-1.7	1,165	1,175
600	23.2	-0.1	1,162	1,175
700	25.2	2	1,209	1,225
800	28.3	3.1	1,275	1,275
900	32	3.7	1,348	1,350
1,000	36.4	4.4	1,431	1,450
1,100	41.9	5.5	1,526	1,550
1,200	48	6.1	1,624	1,625
1,300	54.8	6.8	1,725	1,725
1,400	62.3	7.5	1,829	1,850
1,500	70.8	8.5	1,936	1,950
1,600	80.1	9.3	2,045	2,050
1,700	90.2	10.1	2,154	2,175
1,800	101.3	11.1	2,264	2,275
1,900	113.5	12.2	2,375	2,375
2,000	127	13.5	2,487	2,500
2,100	142.2	15.2	2,600	2,600

Table A-2. M240B Table II: Overhead Fire. (Continued)

Firing Table 7.62-A-2				
Cartridge, Ball, M80				
			Corresponding Range	
Distance to Troops (m)	Minimum AE to Clear Troops (mils)	Difference (mils)	Exact Figure (m)	Even Figure (to nearest 25 above) (m)
2,200	159.7	17.5	2,713	2,725
2,300	179.5	19.8	2,825	2,825
2,400	202	22.5	2,938	2,950
2,500	226.8	24.8	3,049	3,050
2,600	255.9	29.1	3,161	3,175
2,700	291.2	35.3	3,272	3,275
2,800	337.8	46.6	3,385	3,400
2,900	441.9	104.1	3,500	3,500

Table III: Mask Clearance

The information contained in Table A-3 includes the range to mask, the minimum AE to clear the mask, and corresponding range. Mask distance is the distance in meters from the gun to the highest point of the mask. The minimum quadrant elevation that will clear a mask is defined by the lowest shot in the cone that will just graze the highest point on the mask. Such a quadrant elevation is composed of the following factors:

- The angle of clearance corresponding to the mask distance.
- The AE corresponding to the mask distance.
- The AS to the mask.

The angle of clearance is based on the lower bound of the cone of fire. The angle of clearance plus the AE constitutes the minimum AE that will afford clearance at any given mask distance. The minimum AE to clear the mask is calculated and, if the quadrant elevation to the target equals or exceeds the minimum quadrant elevation for mask clearance, then clearance exists.

The corresponding range is the mil angle of required mask clearance expressed in meters. When the mask is visible, the required mask clearance can be measured by rounding the corresponding range to the nearest hundred, setting it on the rear sight, and then looking through the sight to see if the LOS clears the mask. If it does, then mask clearance exists.

Example of Corresponding Range

A target is 1,200 meters from the gun, the vertical interval is zero, and Table I shows that the quadrant elevation to hit the target is 24.8 mils. The mask is 500 meters from the gun and has a vertical interval of +10 meters. Using the WERM formula—AS = VI ÷ OT (10 ÷. 5) = 20 mils, [OT = observer-to- target]. Table A-3 shows that the minimum AE for mask clearance at a range of 500 meters is 6.7 mils. Adding the AS of 20 mils to the minimum AE of 6.7 mils gives us a minimum quadrant elevation for mask clearance—26.7 mils. Since the quadrant elevation to hit the target is approximately two mils less than the minimum quadrant elevation for mask clearance, the target cannot be engaged without interference from the mask.

If mask clearance is lacking by just one or two mils, firing may still be justified if the following conditions exist:

- No point on the mask is higher than what has been calculated.
- The upper bound will clear the mask.
- No friendly troops would be endangered.

NOTE: Determination of the height of the cone of fire is essential when deciding whether fires can be delivered. Table I for the M240B indicates that the entire cone of fire is only 2.4 mils high at 500 meters. Since mask clearance is lacking by two mils, the cone of fire would have to be four mils high before determining that the upper bound would clear the mask. This does not occur for the M240B until a range of 1,100 meters.

Table A-3. M240B Table III: Mask Clearance.

Firing Table 7.62-A-2				
Cartridge, Ball, M80				
			Corresponding Range	
Range to Mask (m)	Minimum AE to Clear Mask (mils)	Difference (mils)	Figure (m)	Round up (to nearest 10) (m)
100	2.41		289	290
200	3.37	1	370	370
300	4.47	1	454	460

Table A-3. M240B Table III: Mask Clearance. (Continued)

Firing Table 7.62-A-2				
Cartridge, Ball, M80				
			Corresponding Range	
Range to Mask (m)	Minimum AE to Clear Mask (mils)	Difference (mils)	Figure (m)	Round up (to nearest 10) (m)
400	5.57	1	538	540
500	6.7	1	625	630
600	8.67	1	717	720
700	10.56	1	810	810
800	12.94	4	896	900
900	15.76	3	986	990
1,000	19.23	4	1,082	1,090
1,100	22.71	3	1,176	1,180
1,200	27.57	5	1,274	1,280
1,300	32.44	5	1,370	1,370
1,400	37.7	5	1,465	1,470
1,500	43.54	6	1,562	1,570
1,600	50.11	6	1,658	1,660
1,700	56.68	7	1,756	1,760
1,800	64.08	8	1,853	1,860
1,900	72.35	8	1,953	1,960
2,000	81.47	9	2,054	2,060
2,100	91.56	10	2,156	2,160
2,200	102.8	11	2,260	2,260
2,300	114.8	12	2,362	2,370
2,400	127.91	13	2,465	2,470
2,500	142.36	15	2,569	2,570

Table A-3. M240B Table III: Mask Clearance. (Continued)

Firing Table 7.62-A-2				
Cartridge, Ball, M80				
			Corresponding Range	
Range to Mask (m)	Minimum AE to Clear Mask (mils)	Difference (mils)	Figure (m)	Round up (to nearest 10) (m)
2,600	158.41	16	2,674	2,680
2,700	176.44	18	2,779	2,780
2,800	196.11	20	2,884	2,890
2,900	218.46	22	2,990	2,990
3,000	242.49	24	3,092	3,100

Table IV: Quadrant Elevation for Known Vertical Intervals

Table A-4 combines the AS with the AE when the target is both above and below the gun and provides the quadrant elevation in mils. For ranges that are not provided in even hundreds and for vertical intervals that are not tabulated, the elevation must be interpolated.

Examples of Vertical Interval

Example 1: Positive Vertical Interval

The range to the target is 1,240 meters and the vertical interval is +30 (i.e., the target is 30 meters above the gun). From Table IV, the quadrant elevation for a target at 1,200 meters with a vertical interval of +30 is 50.4 mils. A target with the same vertical interval, but at 1,300 meters, is 5 3.1mils. The difference between the vertical intervals is 2.7 mils, meaning that it takes 2.7 mils of elevation change to shift the center of impact 100 meters at that range and vertical interval.

To interpolate the quadrant elevation for 1,240 meters, multiply the difference in quadrant elevations (2.7 mils) by 0.4 to get the change in quadrant elevation for 40 meters. The result is 1.1 mils, which is added to the quadrant elevation of 50.4 to obtain a quadrant elevation to hit the target of 51.5 mils.

Example 2: Negative Vertical Interval

The range to the target is 1,375 m and the vertical interval is -15 (i.e., the target is 15 meters below the gun). From Table IV, the quadrant elevation for a target at 1,300 meters with a vertical interval of -15 is 16.3 mils. A target with the same vertical interval but at 1,400 meters is 22.3 mils. The difference between vertical intervals is 6 mils, meaning that it takes 6 mils of increased elevation change to shift the center of impact 100 meters at that range and vertical interval.

To interpolate the quadrant elevation for 1,375 meters, multiply the difference in quadrant elevations (6 mils) by 0.75 to get the change in quadrant elevation for 75 meters. The result is 4.5 mils, which is added to the quadrant elevation of 16.3 mils to obtain a quadrant elevation to hit the target of 20.8 mils.

Table A-4. M240B Table IV: Quadrant Elevation for Known Vertical Intervals Part 1—Target Above the Gun.

Firing Table 7.62-A-2															
Cartridge, Ball, M80															
Vertical Interval (m)	Horizontal Distance from the Gun (m)														
	100	200	300	400	500	600	700	800	900	1,000	1,100	1,200	1,300	1,400	1,500
100	800.7	473.9	330.4	253.4	206.4	175.2	153.5	138.2	127.2	119.5	114.2	110.9	109.2	108.9	109.8
95	774.6	453.3	314	241.4	196.5	166.9	146.4	131.9	121.6	114.4	109.5	106.6	105.2	105.2	106.3
90	747.2	432.3	299.5	229.3	186.7	158.6	139.2	125.6	115.9	109.2	104.9	102.3	101.3	101.5	102.9
85	718.3	411	283.9	217.1	176.8	150.3	132	119.3	110.3	104.2	100.2	98	97.3	97.6	99.4
80	688	389.2	268.1	204.9	166.9	141.9	124.8	112.9	104.6	99	95.5	93.7	93.3	94.1	95.9
75	656.2	367.1	252.2	192.6	156.9	133.6	117.6	106.6	99	93.9	90.9	89.4	89.3	90.3	92.4
70	622.8	344.6	236.1	180.3	146.9	125.2	110.4	100.2	93.3	88.8	86.2	85.1	85.3	86.6	88.9
65	587.8	321.7	220	167.9	136.9	116.8	103.1	93.9	87.6	83.7	81.5	80.8	81.3	82.9	85.4
60	551.2	298.5	203.7	155.5	126.8	108.3	95.9	87.5	81.9	78.5	76.8	76.4	77.3	79.1	81.9
55	512.9	275	187.3	143	116.8	99.9	88.6	81.1	76.2	73.4	72.1	72.1	73.3	75.4	78.4
50	473	251.1	170.8	130.5	106.7	91.5	81.4	74.7	70.5	68.2	67.4	67.8	69.2	71.6	74.9
45	430.65	226.9	154.2	117.9	96.6	83	74.1	68.35	64.8	63.05	62.65	63.45	65.2	66.85	71.35
40	388.3	202.7	137.6	105.3	86.5	74.5	66.8	62	59.1	57.9	57.9	59.1	61.2	64.1	67.8
35	343.7	178.1	120.9	92.7	76.3	66.1	59.5	55.5	53.4	52.7	53.2	54.7	57.1	60.3	64.3
30	297.6	153.3	104.1	80	66.1	57.6	52.2	49.1	47.6	47.5	48.5	50.4	53.1	56.6	60.8
25	250.3	128.3	87.3	67.3	56	49.1	44.9	42.7	41.9	42.3	43.7	46	49	52.8	57.2
20	201.8	103.1	70.4	54.6	45.8	40.5	37.6	36.2	36.1	37.1	39	41.6	45	49	53.7
15	152.4	77.8	53.5	41.9	35.6	32	30.2	29.8	30.4	31.9	34.2	37.2	40.9	45.2	50.1
10	102.2	52.5	36.5	29.1	25.4	23.5	22.9	23.3	24.6	26.7	29.4	22.8	36.8	41.4	46.5
5	51.6	27	19.5	16.4	15.2	15	15.6	16.8	18.8	21.5	24.7	28.4	32.7	37.6	43
0	0.8	1.6	2.6	3.7	5	6.6	8.5	10.8	13.5	16.7	20.5	24.8	29.5	34.7	40.3

Table A-5. M240B Table IV: Quadrant Elevation for Known Vertical Intervals Part 2—Target Below the Gun.

Firing Table 7.62-A-2															
Cartridge, Ball, M80															
Vertical Interval (m)	Horizontal Distance from the Gun (m)														
	100	200	300	400	500	600	700	800	900	1,000	1,100	1,200	1,300	1,400	1,500
0	0.8	1.6	2.6	3.7	5	6.6	8.5	10.8	13.5	16.7	20.5	24.8	29.5	34.7	40.3
-5	-50.1	-23.3	-14.4	-9	-5.2	-2	0.9	3.9	7.3	11	15.1	19.6	24.6	30	35.8
-10	-100.8	-49.2	-31.3	-21.7	-15.4	-10.5	-6.3	-2.4	1.5	5.7	10.3	15.2	20.4	26.1	32.2
-15	-150.9	-74.6	-48.3	-34.7	-25.5	-19	-13.6	-8.8	-4.2	0.4	5.4	10.7	16.3	22.3	28.6
-20	-200.3	-99.9	-65.2	-47.2	-35.7	-27.5	-20.9	-15.2	-9.9	-4.7	0.6	6.3	12.2	18.4	25
-25	-248.8	-125	-82.1	-59.9	-45.9	-35.9	-28.1	-21.5	-15.5	-9.8	-4.1	1.8	8	14.5	21.4
-30	-296.1	-150	-98.9	-72.5	-56	-44.4	-35.4	-27.9	-21.2	-14.9	-8.7	-2.6	3.9	10.6	17.7
-35	-342.2	-174.8	-115.7	-85.2	-66.2	-52.9	-42.7	-34.2	-26.8	-19.9	-13.3	-6.8	-0.3	6.7	14.1
-40	-386.8	-199.4	-132.4	-97.8	-76.3	-61.3	-49.9	-40.6	-32.5	-25	-17.9	-11	-4.2	2.8	10.4
-45	-429.9	-223.8	-149	-110.4	-86.5	-69.8	-57.2	-46.9	-38.1	-30.1	-22.5	-15.3	-8.1	-1	6.7
-50	-471.5	-247.9	-165.6	-122.9	-96.5	-78.2	-64.4	-53.3	-43.8	-35.2	-27.2	-19.5	-12.1	-4.7	3
-55	-511.4	-271.7	-182.1	-135.5	-106.6	-86.6	-71.6	-59.6	-49.4	-40.3	-31.8	-23.7	-16	-8.3	-0.7
-60	-549.7	-295.2	-198.4	-147.9	-116.6	-95	-78.9	-65.9	-55	-45.3	-36.4	-28	-19.9	-11.9	-4
-65	-586.3	-318.4	-214.7	-160.3	-127.7	-103.4	-86.1	-72.3	-60.7	-50.4	-41	-32.2	-23.8	-15.5	-7.4
-70	-621.3	-341.3	-230.9	-172.7	-136.7	-111.8	-93.3	-78.6	-66.3	-55.5	-45.6	-36.4	-27.7	-19.2	-10.8
-75	-654.7	-363.8	-246.9	-185.1	-146.6	-120.2	-100.5	-84.9	-71.9	-60.5	-50.2	-40.6	-31.6	-22.8	-14.2
-80	-686.5	-385.9	-262.8	-197.3	-156.6	-128.5	-107.6	-91.2	-77.3	-65.6	-54.8	-44.9	-35.5	-26.4	-17.6
-85	-716.8	-407	-278.6	-209.5	-166.5	-136.8	-114.8	-97.5	-83.2	-70.6	-59.4	-49.1	-39.4	-30	-20.9
-90	-745.6	-429	-294.2	-221.7	-176.4	-145.1	-122	-103.8	-88.7	-75.7	-64	-55.3	-43.2	-33.6	-24.3
-95	-773.1	-450	-309.8	-233.8	-186.2	-153.4	-129.1	-110	-94.3	-80.7	-68.6	-57.5	-47.1	-37.3	-27.7
-100	-779	-470.6	-325.1	-245.8	-196	-161.7	-136.3	-116.3	-99.9	-85.7	-73.2	-61.7	-51	-40.9	-31.1

Table V: Ordinates in Meters

The information in Table A-6 should be used as follows:

- Positive figures in Table V indicate the height in meters of the center of the cone above the LOS at any distance from the gun.
- Negative figures in Table V indicate the distance of the center of the cone below the line of sight any distance from the gun.

To read the table, first index the range to impact in the left-most column. Then, following across to the right, find the distance from the gun at the ordinate desired.

Example of Ordinates in Meters

At a range to impact of 1,000 meters, the projectile will be 6 meters above the LOS when it reaches a distance of 700 meters from the gun.

Table A-6. M240-6 Table V: Ordinate in Meters.

Firing Table 7.62-A-2

Cartridge, Ball, M80

Range to Impact (m)	Horizontal Distance from the Gun (m)																																		
	100	200	300	400	500	600	700	800	900	1,000	1,100	1,200	1,300	1,400	1,500	1,600	1,700	1,800	1,900	2,000	2,100	2,200	2,300	2,400	2,500	2,600	2,700	2,800	2,900	3,000	3,100	3,200	3,300	3,400	3,500
0	0	-1	-1	-1	-3	-4	-6	-8	-12	-16	-21	-27	-33	-42	-54	-66	-79	-94	-112	-131	-153	-178	-205	-236	-269	-305	-346	-397	-440	-494	-552	-618	-692	-772	-859
100	0	0	-1	-1	-2	-3	-5	-7	-11	-15	-20	-26	-33	-42	-53	-65	-78	-94	-111	-131	-153	-178	-205	-236	-269	-307	-348	-393	-443	-498	-558	-625	-699	-780	-869
200	0	0	0	-1	-2	-3	-5	-7	-10	-14	-19	-25	-33	-42	-52	-64	-78	-93	-111	-131	-153	-178	-206	-236	-270	-308	-350	-396	-446	-502	-564	-632	-706	-788	-879
300	0	0	0	0	-1	-2	-4	-6	-9	-13	-18	-24	-32	-41	-51	-63	-77	-93	-111	-131	-153	-178	-206	-237	-272	-310	-353	-399	-451	-508	-570	-640	-716	-800	-893
400	0	0	0	0	-1	-2	-3	-5	-8	-12	-17	-23	-31	-40	-50	-62	-76	-92	-110	-130	-153	-178	-206	-238	-273	-312	-355	-402	-455	-512	-576	-647	-725	-811	-906
500	0	1	1	0	0	-1	-2	-4	-7	-11	-16	-22	-30	-38	-49	-61	-75	-91	-109	-129	-152	-177	-206	-238	-273	-312	-356	-404	-457	-515	-580	-652	-731	-819	-916
600	1	1	1	1	1	0	-1	-3	-6	-10	-14	-21	-28	-37	-47	-59	-73	-89	-107	-127	-150	-176	-204	-236	-272	-311	-355	-403	-457	-516	-582	-654	-734	-823	-922
700	1	1	2	2	2	1	0	-2	-4	-8	-13	-18	-26	-34	-45	-56	-70	-86	-103	-124	-147	-173	-201	-233	-269	-309	--352	-401	-455	-515	-581	-654	-734	-824	-923
800	1	2	2	3	3	2	2	0	-2	-6	-10	-16	-23	-31	-42	-53	-67	-82	-100	-120	-143	-169	-197	-229	-265	-305	-349	-397	-451	-511	-577	-651	-732	-822	-922
900	1	2	3	4	4	4	3	2	0	-3	-7	-13	-20	-28	-38	-49	-63	-78	-96	-116	-138	-164	-192	-224	-260	-299	-343	-392	-446	-506	-572	-646	-728	-818	-919
1,000	2	3	4	5	6	6	6	5	3	0	-4	-9	-16	-24	-33	-45	-58	-73	-90	-110	-132	-158	-186	-218	-253	-293	-337	-386	-440	-500	-567	-640	-722	-813	-914
1,100	2	4	5	7	8	8	8	8	6	4	0	-5	-11	-19	-28	-39	-52	-67	-84	-103	-126	-151	-179	-210	-246	-285	-329	-378	-432	-492	-559	-633	-715	-807	-909
1,200	2	5	7	8	10	11	11	11	10	8	5	0	-6	-13	-22	-33	-45	-60	-76	-96	-118	-142	-170	-202	-237	-276	-320	-369	-423	-483	-550	-625	-707	-799	-901
1,300	3	5	8	10	12	13	14	15	14	12	9	5	0	-7	-15	-26	-38	-52	-68	-87	-109	-133	-161	-192	-227	-266	-310	-359	-413	-473	-540	-615	-697	-790	-892
1,400	3	6	9	12	14	16	18	19	18	17	15	11	6	0	-8	-18	-30	-43	-59	-78	-99	-123	-151	-182	-216	-255	-299	-347	-401	-461	-528	-603	-686	-778	-882
1,500	4	8	11	14	17	20	22	23	23	23	21	18	13	8	0	-9	-21	-34	-49	-68	-88	-112	-139	-170	-204	-242	-286	-334	-388	-448	-515	-589	-672	-765	-868
1,600	4	9	13	17	20	23	26	28	29	29	27	25	21	16	9	0	-11	-24	-39	-56	-77	-100	-126	-156	-190	-229	-271	-319	-373	-433	-500	-574	-657	-750	-853
1,700	5	10	15	19	24	27	30	33	35	35	34	33	29	25	18	10	0	-12	-27	-44	-64	-86	-112	-142	-175	-213	-256	-303	-356	-416	-482	-557	-639	-732	-835
1,800	6	12	17	22	27	31	35	39	41	42	42	41	38	34	29	21	12	0	-14	-30	-49	-72	-97	-126	-159	-196	-238	-285	-338	-397	-463	-537	-619	-712	-815
1,900	7	13	19	25	31	36	41	45	48	50	50	50	48	45	40	33	24	13	0	-16	-34	-56	-81	-109	-141	-178	-219	-266	-318	-377	-442	-516	-598	-689	-792
2,000	7	15	22	28	35	41	46	51	55	58	59	60	58	56	52	46	38	27	15	0	-18	-39	-63	-90	-122	-158	-199	-245	-296	-354	-419	-492	-573	-664	-767
2,100	8	16	24	32	39	46	52	58	63	66	69	70	70	68	65	59	52	43	31	17	0	-20	-43	-70	-101	-136	-176	-222	-273	-330	-394	-466	-547	-637	-739
2,200	9	18	27	36	44	52	59	66	71	76	79	81	82	81	79	74	68	60	49	35	19	0	-22	-49	-79	-113	-152	-197	-247	-303	-367	-438	-518	-608	-709
2,300	10	20	30	40	49	58	66	74	80	86	90	93	95	95	94	90	85	77	68	55	40	22	0	-25	-55	-88	-127	-170	-220	-275	-338	-409	-488	-577	-677
2,400	11	23	34	44	55	65	74	83	90	97	102	107	109	111	110	108	103	97	88	77	62	45	24	0	-28	-61	-99	-141	-190	-245	-307	-377	-455	-544	-643
2,500	13	25	37	49	61	72	83	92	101	109	116	121	125	127	128	127	124	118	110	100	87	70	51	27	0	-32	-69	-111	-158	-213	-274	-343	-421	-509	-608
2,600	14	28	41	55	68	80	92	103	113	123	131	137	142	146	148	148	146	142	135	126	114	98	80	57	31	0	-36	-77	-124	-178	-238	-307	-385	-472	-571

Table A-6. M240-6 Table V: Ordinate in Meters. (Continued)

Firing Table 7.62-A-2																																			
Cartridge, Ball, M80																																			
Range to Impact (m)	Horizontal Distance from the Gun (m)																																		
	100	200	300	400	500	600	700	800	900	1,000	1,100	1,200	1,300	1,400	1,500	1,600	1,700	1,800	1,900	2,000	2,100	2,200	2,300	2,400	2,500	2,600	2,700	2,800	2,900	3,000	3,100	3,200	3,300	3,400	3,500
2,700	16	31	46	61	75	89	103	115	127	138	147	155	162	167	170	171	171	168	163	155	144	129	112	91	65	35	0	-40	-87	-140	-200	-268	-346	-433	-532
2,800	17	34	51	68	84	100	115	129	143	155	166	175	184	190	195	198	199	197	193	187	177	164	148	127	103	74	40	0	-46	-98	-158	-226	-304	-391	-491
2,900	19	38	57	75	94	111	128	145	160	174	187	198	208	217	223	228	230	230	228	223	214	203	188	169	145	117	84	45	0	-52	-112	-180	-257	-345	-445
3,000	21	42	63	84	104	124	143	162	179	195	210	223	235	246	254	260	265	267	266	262	256	246	232	215	193	166	134	96	51	0	-59	-127	-204	-292	-392
3,100	24	47	71	94	117	139	161	181	201	219	237	252	266	279	290	298	305	309	310	308	303	295	283	267	246	221	190	153	109	59	0	-67	-144	-233	-333
3,200	27	53	80	106	131	156	181	204	227	248	268	286	303	318	331	343	351	358	361	362	359	353	342	328	309	284	255	219	176	126	68	0	-77	-166	-268
3,300	30	60	90	120	149	178	206	233	258	283	306	328	348	366	382	396	408	417	423	426	426	422	414	401	384	361	332	297	255	205	147	79	0	-91	-195
3,400	35	70	105	139	173	206	239	270	300	329	357	383	407	429	449	467	483	495	505	511	513	512	506	495	480	458	431	396	354	304	244	175	94	0	-109
3,500	43	85	127	169	211	251	291	330	367	403	438	470	501	530	556	579	600	618	632	643	649	651	649	640	626	606	579	544	500	447	384	309	222	119	0

Fire Control Tables for the M2A1

Table I: Angle of Elevation

The tables in this appendix are for the M2A1 armor-piercing (AP) round, not the M8 armor-piercing incendiary (API); however, since the steel penetrators for both rounds are identical, this is the closest possible match for fire control tables. The M8 API round has existed since 1943 and, to date, there has not been an official requirement to produce more up-to-date fire control tables. The AE required to engage a target on flat or uniformly sloping ground is listed for the indicated ranges.

Examples of Angle of Elevation

Example 1

The AE to hit a target that is level with the gun, at a range of 1,700 meters, is 24.7 mils. The change in elevation and range for each 100 meters in range has been calculated to permit subsequent changes in the quadrant elevation without recalculation.

Example 2

Since the AE for a target at 2,700 meters is 63.9 mils and the AS to the target is 14 mils, then the quadrant elevation for the target is AS + AE = 77.9 mils. t a range of 2,700 meters, it takes 5 mils to shift the center of impact 100 meters (see Table A-7). Interpolate the AE for 2,775 mils by multiplying 5 by 0.75 to get the change in AE for 75 meters. The result is 3.75 mils, which is rounded up to 3.8 mils. Add 3.8 mils to the quadrant elevation of 77.9 mils to obtain the quadrant elevation for a target at 2,775 meters with an AS of 14 mils. The result is 81.7 mils.

Note: For ranges that are not in even hundreds and for ranges not tabulated, the desired information must be determined by interpolation—the method of estimating a number that exists between two other numbers.

Example 3

A heavy machine gunner needs to know the AE for a target at a range of 1,785 meters. Since the AE for 1,700 meters is 24.7 mils and the AE for 1,800 meters is 27.7 mils, the difference is 3 mils. At this range, 3 mils correspond to a range shift of 100 meters. A change of 85 meters requires 0.85 × 3 mils—2.55 mils. The AE for 1,785 meters—24.7 + 2.55 = 27.25 mils. The TOF, maximum ordinate, angle of fall, remaining velocity, and drift are listed to assist in determining the effect on target.

Table A-7. M2/M2A1 Table I: Angles of Elevation.

Firing Table .50-H2 Cartridge, AP, M2									
Range (m)	AE (mils)	Difference (mils)	Effect of a 1-mil Change on Range (m per mil)	Angle of Fall (mils)	Time of Flight (seconds)	Max Ordinate (m)	Drift to the Right (mils)	Remaining Velocity (m per second)
100	0.7		140	1	0.1	0	0	813
200	1.5	0.8	130	1	0.2	0	0	772
300	2.3	0.8	121	3	0.4	0	0	733
400	3.1	0.8	112	4	0.5	0	0.1	694
500	4.1	1	103	5	0.7	1	0.1	656
600	5.1	1	95	6	0.8	1	0.1	618
700	6.2	1.1	87	8	1	1	0.1	582
800	7.4	1.2	79	10	1.2	2	0.1	547
900	8.7	1.3	72	12	1.4	2	0.2	514
1,000	10.1	1.4	66	15	1.6	3	0.2	482
1,100	11.7	1.6	60	18	1.8	4	0.2	452
1,200	13.4	1.7	55	21	2	5	0.2	424
1,300	15.2	1.8	50	25	2.2	6	0.3	398
1,400	17.3	2.1	46	30	2.5	8	0.3	374
1,500	19.5	2.2	42	35	2.8	10	0.3	353
1,600	22	2.5	39	41	3.1	12	0.4	335
1,700	24.7	2.7	36	48	3.4	14	0.4	323
1,800	27.7	3	33	51	3.7	17	0.4	313
1,900	30.8	3.1	31	62	4	21	0.5	304
2,000	34.2	3.4	29	70	4.3	25	0.5	297
2,100	37.8	3.6	27	78	4.7	29	0.6	290
2,200	41.6	3.8	25	86	5	34	0.7	284
2,300	45.7	4.1	24	95	5.4	39	0.7	278
2,400	49.9	4.2	23	104	5.8	45	0.8	272
2,500	54.4	4.5	22	113	6.1	51	0.8	267

Table A-7. M2/M2A1 Table I: Angles of Elevation. (Continued)

Firing Table .50-H2									
Cartridge, AP, M2									
Range (m)	AE (mils)	Difference (mils)	Effect of a 1-mil Change on Range (m per mil)	Angle of Fall (mils)	Time of Flight (seconds)	Max Ordinate (m)	Drift to the Right (mils)	Remaining Velocity (m per second)
2,600	59	4.6	21	123	6.5	58	0.9	262
2,700	63.9	4.9	20	133	6.9	66	0.9	257
2,800	68.9	5	19	143	7.3	74	1	252
2,900	74.2	5.3	18	154	7.7	83	1.1	247
3,000	79.7	5.5	18	166	8.1	92	1.2	242
3,100	85.4	5.7	17	178	8.6	102	1.3	237
3,200	91.3	5.9	17	190	9	113	1.4	233
3,300	97.4	6.1	16	203	9.4	124	1.5	229
3,400	103.8	6.4	16	216	9.9	137	1.6	224
3,500	110.4	6.6	15	230	10.3	150	1.7	220

Table II: Overhead Fire

Table II for overhead fire includes information regarding the distance to troops, the minimum AE to clear troops, and corresponding range. Distance to troops is the distance in meters from the gun to the friendly troops where overhead fire is desired. The minimum AE to clear troops requires the following:

- The quadrant elevation required to strike the ground where the troops stand, plus a definite angle of safety given the minimum quadrant elevation that can be fired without danger over the troops.
- Since the safety angle varies with the range, the minimum quadrant elevation that can be fired with safety over the heads of friendly troops depends on the following factors:
  - Safety angle (corresponding to troop distance).
  - AE (corresponding to troop distance).
  - AS.
- The safety angle plus the AE constitutes the minimum AE that can be fired over the heads of troops at the given troop distance. Minimum angles of elevation are listed in Tables A-8 and A-9, Column 2.

Corresponding range is the minimum range that will give the required clearance. Both the exact and even figures to the nearest 25 meters over are given. When troops to be fired over are visible, the safety angle can be measured by setting the corresponding range. Even figures should be used.

Examples of Overhead Fire

Example 1

In Table A-8, the minimum AE when troops are 600 meters in front of the gun on level or uniformly sloping ground is 22 mils. This AE will produce a center of impact at 1,562 meters—the corresponding range for that AE. For simplicity, the corresponding range is always rounded up to the nearest 25 meters, resulting in 1,575. Therefore, no target at a range closer than 1,175 meters can be engaged with the M2A1 over level or uniformly sloping ground when the troops are 600 meters from the gun.

For all situations where the troops are on ground that has a positive or negative vertical interval, the following equation is true: minimum quadrant elevation (QE) for troop clearance = AS) + minimum AE for troop clearance.

Example 2

The target is at 2,500 meters with no vertical interval, but the troops are on top of a hill 900 meters from the gun that has a vertical interval of +20 meters. The AS of the troops to the minimum AE for 900 meters = vertical interval ÷ observer-to-target factor (20 ÷ 0.9) = 22.2 mils. Add this AS to the minimum AE for 900 meters (24.26) to get a minimum quadrant elevation for troop clearance of 46.5 mils. Since the AE for a target at 2,500 meters (with zero AS) is 54.4 mils, troop clearance does exist. For a detailed explanation on using Table II to determine troop clearance, refer to Chapter 3.

Table A-8. M2/M2A1 Table II: Overhead Fire.

Firing Table .50-H2				
Cartridge, AP, M2				
			Corresponding Range	
Distance to Troops (m)	Minimum AE to Clear Troops (mils)	Difference (mils)	Figure (m)	Even Figure (to nearest 25 above) (m)
100	76.68		2,944	2,950
200	40.39	36	2,165	2,175

Table A-8. M2/M2A1 Table II: Overhead Fire. (Continued)

Firing Table .50-H2				
Cartridge, AP, M2				
			Corresponding Range	
Distance to Troops (m)	Minimum AE to Clear Troops (mils)	Difference (mils)	Figure (m)	Even Figure (to nearest 25 above) (m)
300	32.4	8	1,946	1,950
400	24	9	1,671	1,675
500	21.74	2	1,586	1,600
600	21.1	0	1,562	1,575
700	21.56	0	1,579	1,600
800	22.7	1	1,625	1,625
900	24.26	2	1,681	1,700
1,000	26	1	1,743	1,750
1,100	28.16	3	1,814	1,825
1,200	30.48	2	1,887	1,900
1,300	33.04	2	1,964	1,975
1,400	35.84	3	2,044	2,050
1,500	38.87	3	2,127	2,150
1,600	42.19	4	2,314	2,325
1,700	45.87	3	2,304	2,325
1,800	49.9	4	2,400	2,400
1,900	54.29	5	2,495	2,500
2,000	58.95	4	2,595	2,600
2,100	63.94	5	2,701	2,725
2,200	69.31	4	2,808	2,825
2,300	75.02	5	2,915	2,925
2,400	81	6	3,022	3,025
2,500	87.31	7	3,132	3,150
2,600	93.9	6	3,274	3,275
2,700	100.8	7	3,387	3,400

Table A-8. M2/M2A1 Table II: Overhead Fire. (Continued)

Firing Table .50-H2 Cartridge, AP, M2				
Distance to Troops (m)	Minimum AE to Clear Troops (mils)	Difference (mils)	Corresponding Range Figure (m)	Corresponding Range Even Figure (to nearest 25 above) (m)
2,800	108	7	3,500	3,500
2,900	115.5	8	3,615	3,625
3,000	123.4	8	3,730	3,750
3,100	131.7	8	3,845	3,850
3,200	140.3	9	3,960	3,975
3,300	149.3	9	4,076	4,100
3,400	158.8	9	4,192	4,200
3,500	168.8	10	4,308	4,325
3,600	179.4	11	4,424	4,425
3,700	190.5	11	4,540	4,550
3,800	202	11	4,656	4,675
3,900	213.9	12	4,772	4,775
4,000	226.4	13	4,888	4,900
4,100	239.4	13	5,005	5,025
4,200	253	13	5,122	5,125
4,300	267.5	15	5,238	5,250
4,400	283.1	16	5,353	5,375
4,500	299.4	16	5,469	5,475
4,600	316.9	17	5,585	5,600
4,700	335.7	19	5,702	5,725
4,800	355.8	20	5,818	5,825
4,900	377.7	22	5,933	5,950
5,000	401.8	24	6,047	6,050
5,100	428.4	27	6,161	6,175
5,200	458.4	30	6,276	6,300

Table A-8. M2/M2A1 Table II: Overhead Fire. (Continued)

Firing Table .50-H2				
Cartridge, AP, M2				
			Corresponding Range	
Distance to Troops (m)	Minimum AE to Clear Troops (mils)	Difference (mils)	Figure (m)	Even Figure (to nearest 25 above) (m)
5,300	493.5	35	6,391	6,400
5,400	539.6	46	6,505	6,525

Table III: Mask Clearance

Table III contains information regarding the range to mask, the minimum AE to clear the mask, and the corresponding range.

Mask distance in Column 1 of Table A-9 is the distance in meters from the gun to the highest point of the mask. The minimum quadrant elevation that will clear a mask is when the lowest shot in the cone will just graze the highest point on the mask. This quadrant elevation consists of the following factors:

- Angle of clearance (corresponding to mask distance).
- AE (corresponding to mask distance).
- AS to the mask.

The angle of clearance is based on the lower bound of the cone of fire. The angle of clearance plus the AE constitutes the minimum AE that will afford clearance at any given mask distance. Minimum angles of elevation are listed in Column 2. If the quadrant elevation to the target equals or exceeds the minimum quadrant elevation for mask clearance, then clearance exists.

The corresponding range in Column 3 is the mil angle of required mask clearance expressed in meters. When the mask is visible, the required mask clearance can be measured by rounding the corresponding range to the nearest hundred, setting it on the rear sight, and then looking through the sight to see if the LOS clears the mask. If it does, then mask clearance exists.

Example of Mask Clearance

A target is 1,700 meters from the gun, the vertical interval is zero, and Table II indicates that the quadrant elevation to hit the target is 24.7 mils. The mask is 500 meters from the gun and has a vertical interval (VI) of +20 meters. Using the WERM formula, AS = VI ÷ OT (20 ÷. 5) = 40 mils. Table III indicates that the minimum AE for mask clearance at a range of 500 meters is 6.3 mils. Adding the AS of 40 mils to the minimum AE of 6.3 mils equals a minimum quadrant elevation for a mask clearance of 46.3 mils. Since the quadrant elevation to hit the target is more than 20 mils less than the minimum quadrant elevation for mask clearance, the target cannot be engaged without interference from the mask.

Note: If mask clearance is lacking by just one or two mils, firing may still be justified. If no point on the mask is higher than what has been calculated, the upper bound will clear the mask, and no friendly troops would be endangered.

Determining the height of the cone of fire is essential when deciding whether fires can be delivered in such situations. Since Table I for the M2 does not list cone of fire dimensions, the machine gun unit leader must rely on their experience and knowledge of trajectory to help make this decision.

Table A-9. M2/M2A1 Table III: Mask Clearance.

Firing Table .50-H2				
Cartridge, AP, M2				
			Corresponding Range	
Range to Mask (m)	Minimum AE to Clear Mask (mils)	Difference (mils)	Exact Figure (m)	Round Up (to nearest 10) (m)
100	3		388	390
200	3.6	4	450	450
300	4.4	1	530	530
400	5.3	1	618	620
500	6.3	1	708	710
600	7.4	1	800	800
700	8.5	1	885	890
800	9.7	1	971	980
900	11	1	1,057	1,060

Table A-9. M2/M2A1 Table III: Mask Clearance. (Continued)

Firing Table .50-H2				
Cartridge, AP, M2				
			Corresponding Range	
Range to Mask (m)	Minimum AE to Clear Mask (mils)	Difference (mils)	Exact Figure (m)	Round Up (to nearest 10) (m)
1,000	12.4	2	1,141	1,150
1,100	13.9	1	1,228	1,230
1,200	15.6	2	1,319	1,320
1,300	17.5	2	1,409	1,410
1,400	19.5	2	1,500	1,500
1,500	21.6	2	1,584	1,590
1,600	24	2	1,674	1,680
1,700	26.7	3	1,767	1,770
1,800	29.6	3	1,861	1,870
1,900	32.8	3	1,959	1,960
2,000	36.1	4	2,052	2,060
2,100	39.7	3	2,150	2,150
2,200	43.5	4	2,246	2,250
2,300	47.6	4	2,345	2,350
2,400	51.9	4	2,444	2,450
2,500	56.5	5	2,547	2,550
2,600	61.2	5	2,668	2,670
2,700	66.1	5	2,768	2,770
2,800	71.1	5	2,868	2,870
2,900	76.4	5	2,968	2,970
3,000	81.9	5	3,069	3,070
3,100	87.7	6	3,171	3,180
3,200	93.6	6	3,273	3,280

Table A-9. M2/M2A1 Table III: Mask Clearance. (Continued)

Firing Table .50-H2				
Cartridge, AP, M2				
			Corresponding Range	
Range to Mask (m)	Minimum AE to Clear Mask (mils)	Difference (mils)	Exact Figure (m)	Round Up (to nearest 10) (m)
3,300	99.7	6	3,376	3,380
3,400	106.2	7	3,478	3,480
3,500	113	7	3,580	3,580
3,600	120	6	3,682	3,690
3,700	127.3	8	3,784	3,790
3,800	135	7	3,886	3,890
3,900	142.8	8	3,988	3,990
4,000	151.1	9	4,089	4,090
4,100	159.5	8	4,190	4,190
4,200	168.2	9	4,291	4,300
4,300	177.2	9	4,392	4,400
4,400	186.4	9	4,493	4,500
4,500	195.9	9	4,594	4,600
4,600	205.7	10	4,695	4,700
4,700	216.1	11	4,796	4,800
4,800	226.9	10	4,897	4,900
4,900	238.3	12	4,998	5,000
5,000	250.2	12	5,098	5,100
5,100	262.5	12	5,198	5,200
5,200	275.3	13	5,297	5,300
5,300	288.7	13	5,396	5,400
5,400	302.8	14	5,494	5,500

Table A-9. M2/M2A1 Table III: Mask Clearance. (Continued)

Firing Table .50-H2				
Cartridge, AP, M2				
			Corresponding Range	
Range to Mask (m)	Minimum AE to Clear Mask (mils)	Difference (mils)	Exact Figure (m)	Round Up (to nearest 10) (m)
5,500	317.8	15	5,592	5,600
5,600	333.6	16	5,690	5,700
5,700	350.3	17	5,788	5,790
5,800	368.1	18	5,884	5,890
5,900	387.2	19	5,980	5,980
6,000	407.7	20	6,076	6,080
6,100	430	22	6,171	6,180
6,200	454.7	25	6,265	6,270
6,300	482.7	28	6,359	6,360
6,400	514.9	32	6,452	6,460

Table IV: Quadrant Elevation for Known Vertical Interval

The quadrant elevation for known vertical interval table (see Tables A-10 and A-11) combines the AS with the AE when the target is both above and below the gun and gives the quadrant elevation in mils. For ranges not in even hundreds and for vertical intervals not tabulated, the elevation must be determined by interpolation.

Examples of Positive and Negative Vertical Interval

Positive Vertical Interval

The range to the target is 1,860 meters and the vertical interval is +35 (target is 35 meters above the gun). From Table IV, the quadrant elevation for a target at 1,800 meters with a vertical interval of +35 is 47 mils. A target with the same vertical interval, but at 1,900 meters, is 50 mils. The difference between vertical intervals is 3 mils, meaning that it takes 3 mils of elevation change to shift the center of impact 100 meters at that range and vertical interval. Therefore, to interpolate the quadrant elevation for 1,860 meters, multiply the difference in quadrant elevations (3 mils) by 0.6 to get the change in quadrant elevation for 60 meters. The result is 1.8 mils, which is added to the quadrant elevation of 47 to determine a quadrant elevation of 48.8 to hit the target.

Negative Vertical Interval

The range to the target is 2,475 meters and the vertical interval is -80 (target is 80 meters below the gun). From Table IV, the quadrant elevation for a target at 2,400 meters with a vertical interval of -80 is 16 mils. A target with the same VI, but at 2,500 meters, is 22 mils. The difference between vertical intervals is 6 mils, meaning that it takes 6 mils of increased elevation change to shift the center of impact 100 meters at that range and vertical interval. Therefore, to interpolate the quadrant elevation for 2,475 meters, multiply the difference in quadrant elevations (6 mils) by 0.75 to get the change in quadrant elevation for 75 meters. The result is 4.5 mils, which is added to the quadrant elevation of 16 mils to determine a quadrant elevation of 20.5 mils to hit the target.

Table A-10. M2/M2A1 Table IV: Part 1—Quadrant Elevation for Vertical Intervals (Target Above Gun).

Firing Table .50-H2
Cartridge, AP, M2

VI (m)	100	200	300	400	500	600	700	800	900	1,000	1,100	1,200	1,300	1,400	1,500	1,600	1,700	1,800	1,900	2,000	2,100	2,200	2,300	2,400	2,500	VI (m)
+100	801	474	330	253	205	173	151	134	121	112	104	98	93	90	87	86	85	84	84	85	86	88	90	92	95	+100
+95	775	453	315	241	195	165	144	128	116	107	99	94	90	86	84	82	82	81	82	83	84	86	88	90	93	+95
+90	747	432	299	229	185	157	136	121	110	102	95	90	86	83	81	79	79	79	79	80	81	83	85	88	91	+90
+85	718	411	283	216	176	148	129	115	105	96	90	85	82	79	77	76	76	76	76	77	79	81	83	86	90	+85
+80	688	389	268	204	166	140	122	109	99	91	86	81	78	75	74	73	73	73	74	75	77	79	81	84	87	+80
+75	656	367	252	192	156	132	115	103	93	86	81	77	74	72	70	70	70	70	71	72	74	76	79	82	85	+75
+70	623	344	236	180	146	123	108	96	88	81	76	73	70	68	67	67	67	67	68	70	72	74	77	80	83	+70
+65	588	321	220	167	136	115	100	90	82	76	72	68	66	65	64	63	64	64	66	67	69	72	74	77	81	+65
+60	551	298	203	155	126	107	93	84	76	71	67	64	62	61	60	60	61	62	63	65	67	69	72	75	79	+60
+55	513	275	187	142	116	98	86	77	71	66	63	60	58	57	57	57	58	59	60	62	64	67	70	73	77	+55

Table A-10. M2/M2A1 Table IV: Part 1—Quadrant Elevation for Vertical Intervals (Target Above Gun). (Continued)

Firing Table .50-H2																										
Cartridge, AP, M2																										
VI (m)	100	200	300	400	500	600	700	800	900	1,000	1,100	1,200	1,300	1,400	1,500	1,600	1,700	1,800	1,900	2,000	2,100	2,200	2,300	2,400	2,500	VI (m)
+50	473	251	170	130	106	90	79	71	65	61	58	56	54	54	53	54	55	56	58	60	62	65	68	71	75	+50
+45	431	227	154	117	95	81	72	65	60	56	53	51	50	50	50	51	52	53	55	57	60	62	66	69	73	+45
+40	388	202	137	105	85	73	64	58	54	51	49	47	47	46	47	47	49	50	52	55	57	60	63	67	71	+40
+35	344	178	121	92	75	64	57	52	48	46	44	43	43	43	43	44	46	47	50	52	55	58	61	65	69	+35
+30	298	153	104	79	65	56	50	46	43	41	39	39	39	39	40	41	43	45	47	49	52	55	59	63	67	+30
+25	250	128	87	67	55	47	43	39	37	36	35	35	35	35	36	38	40	42	44	47	50	53	57	60	64	+25
+20	202	103	70	54	45	39	35	33	31	30	30	30	31	32	33	35	37	39	41	44	47	51	54	58	62	+20
+15	152	78	53	41	35	31	28	26	26	25	25	26	27	28	30	32	34	36	39	42	45	49	52	56	60	+15
+10	102	52	36	29	24	22	21	20	20	20	21	22	23	25	26	28	31	33	36	39	43	46	50	54	58	+10
+5	52	27	19	16	14	14	13	14	14	15	16	18	19	21	23	25	28	30	33	37	40	44	48	52	56	+5
0	1	2	2	3	4	5	6	7	9	10	12	13	15	17	20	22	25	28	31	34	38	42	46	50	54	0

Table A-11. M2/M2A1 Table IV: Part 2—Quadrant Elevation for Vertical Intervals (Target Below Gun).

Firing Table .50-H2																										
Cartridge, AP, M2																										
VI (m)	100	200	300	400	500	600	700	800	900	1,000	1,100	1,200	1,300	1,400	1,500	1,600	1,700	1,800	1,900	2,000	2,100	2,200	2,300	2,400	2,500	VI (m)
0	1	2	2	3	4	5	6	7	9	10	12	13	15	17	20	22	25	28	31	34	38	42	46	50	54	0
-5	-50	-24	-15	-10	-6	-3	-1	1	3	5	7	9	11	14	16	19	22	25	28	32	35	39	43	48	52	-5
-10	-101	-49	-32	-22	-16	-12	-8	-5	-3	0	2	5	7	10	13	16	19	22	25	29	33	37	41	46	50	-10
-15	-151	-75	-49	-35	-26	-20	-16	-12	-8	-5	-2	1	3	6	9	12	16	19	23	27	31	35	39	43	48	-15
-20	-200	-100	-65	-48	-37	-29	-23	-18	-14	-10	-7	-4	0	3	6	9	13	16	20	24	28	32	37	41	46	-20
-25	-249	-125	-82	-60	-47	-37	-30	--24	-20	-15	-11	-8	-4	-1	3	6	10	13	17	21	26	30	35	39	44	-25
-30	-296	-150	-99	-73	-57	-46	-37	-31	-25	-20	-16	-12	-8	-4	-1	3	7	11	15	19	23	28	32	37	42	-30
-35	-342	-175	-116	-86	-67	-54	-45	-37	-31	-25	-21	-16	-12	-8	-4	0	4	8	12	16	21	25	30	35	40	-35
-40	-387	-200	-133	-98	-77	-63	-52	-43	-36	-31	-25	-21	-16	-12	-8	-3	1	5	9	14	18	23	28	33	38	-40
-45	-430	-224	-149	-111	-87	-71	-59	-50	-42	-36	-30	-25	-20	-15	-11	-7	-2	2	7	11	16	21	26	31	36	-45
-50	-472	-248	-166	-123	-97	-80	-66	-56	-48	-41	-35	-29	-24	-19	-14	-10	-5	-1	4	9	14	18	24	29	34	-50
-55	-511	-272	-182	-136	-107	-88	-74	-62	-53	-46	-39	-33	-28	-23	-18	-13	-8	-3	1	6	11	16	21	27	32	-55
-60	-550	-295	-199	-148	-118	-96	-81	-69	-59	-51	-44	-37	-32	-26	-21	-16	-11	-6	-1	4	9	14	19	24	30	-60
-65	-586	-319	-215	-161	-128	-105	-88	-75	-65	-56	-48	-42	-36	-30	-24	-19	-14	-9	-4	1	6	12	17	22	28	-65
-70	-621	-341	-231	-173	-138	-113	-95	-81	-70	-61	-53	-46	-39	-34	-28	-22	-17	-12	-7	-1	4	9	15	20	26	-70
-75	-655	-364	-247	-186	-148	-122	-102	-88	-76	-66	-58	-50	-43	-37	-31	-26	-20	-15	-9	-4	1	7	12	18	24	-75

Table A-11. M2/M2A1 Table IV: Part 2—Quadrant Elevation for Vertical Intervals (Target Below Gun). (Continued)

Firing Table .50-H2 Cartridge, AP, M2																										
VI (m)	100	200	300	400	500	600	700	800	900	1,000	1,100	1,200	1,300	1,400	1,500	1,600	1,700	1,800	1,900	2,000	2,100	2,200	2,300	2,400	2,500	VI (m)
-80	-687	-386	-263	-198	-157	-130	-110	-94	-82	-71	-62	-54	-47	-41	-35	-29	-23	-17	-12	-6	-1	5	10	16	22	-80
-85	-717	-408	-279	-210	-167	-138	-117	-100	-87	-76	-67	-59	-51	-44	-38	-32	-26	-20	-15	-10	-3	2	8	14	20	-85
-90	-746	-429	-295	-222	-177	-146	-124	-107	-93	-81	-71	-63	-55	-48	-41	-35	-29	-23	-17	-11	-6	0	6	12	18	-90
-95	-773	-450	-310	-234	-187	-155	-131	-113	-98	-86	-76	-67	-59	-52	-45	-38	-32	-26	-20	-14	-8	-2	4	10	16	-95
-100	-799	-471	-325	-246	-197	-163	-138	-119	-104	-91	-81	-71	-63	-55	-48	-41	35	-29	-23	-17	-11	-5	1	7	14	-100

Table V: Ordinates

The positive figures in Table V (see Tables A-12 and A-13) indicate the height in meters of the center of the cone above the LOS at any distance from the gun. The negative figures indicate the distance of the center of the cone below the LOS any distance from the gun. To read the table, first index the range to impact in the left-most column. Then, following across to the right, find the distance from the gun that the ordinate is desired.

Example of Ordinates

At a range to impact of 2,000 meters, the projectile will be 23 meters above the LOS when it reaches a distance of 1,000 meters from the gun.

Table A-12. M2/M2A1 Table V: Part 1—Ordinate in Meters.

Firing Table .50-H2 Cartridge, AP, M2																												
	Horizontal Distance from the Gun (m)																											
Range to Impact	100	200	300	400	500	600	700	800	900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300	2400	2500	2600	2700	Range to Impact
100	0	0	-1	-1	-1	-2	-3	-5	-7	-9	-12	-15	-18	-22	-28	-34	-40	-47	-55	-64	-74	-86	-100	-114	-129	-147	-165	100
200	0	0	0	0	-1	-2	-3	-5	-7	-9	-11	-14	-17	-21	-26	-32	-38	-45	-53	-62	-73	-85	-98	-112	-128	-145	-163	200
300	0	0	0	0	0	-1	-3	-4	-6	-8	-10	-13	-16	-20	-25	-31	-37	-44	-52	-61	-71	-83	-97	-111	-126	-143	-161	300
400	0	0	0	0	0	-1	-2	-3	-5	-7	-9	-12	-15	-19	-24	-30	-36	-43	-51	-60	-69	-81	-95	-109	-124	-140	-158	400
500	0	0	0	0	0	-1	-2	-3	-4	-6	-8	-11	-14	-18	-23	-28	-34	-41	-49	-58	-67	-79	-92	-106	-122	-138	-156	500

Table A-12. M2/M2A1 Table V: Part 1—Ordinate in Meters. (Continued)

Firing Table .50-H2 Cartridge, AP, M2																												
	Horizontal Distance from the Gun (m)																											
Range to Impact	100	200	300	400	500	600	700	800	900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300	2400	2500	2600	2700	Range to Impact
600	0	1	1	1	0	0	-1	-2	-3	-5	-7	-9	-13	-17	-21	-26	-32	-39	-47	-56	-65	-77	-90	-104	-119	-135	-153	600
700	0	1	1	1	1	1	0	-1	-2	-4	-6	-8	-11	-15	-20	-25	-30	-37	-45	-54	-63	-75	-88	-101	-116	-132	-150	700
800	0	1	2	2	2	2	1	0	-1	-2	-4	-6	-9	-13	-18	-23	-28	-35	-43	-52	-61	-72	-85	-98	-113	-129	-147	800
900	0	1	2	2	2	2	2	1	0	-1	-3	-5	-8	-11	-16	-20	-26	-33	-41	-50	-59	-70	-82	-95	-110	-126	-144	900
1,000	1	2	3	3	3	3	3	2	1	0	-2	-4	-6	-9	-13	-18	-23	-31	-39	-48	-57	-67	-79	-92	-106	-122	-140	1,000
1,100	1	2	3	3	4	4	4	3	3	2	0	-2	-4	-7	-11	-16	-21	-28	-36	-45	-54	-64	-75	-88	-102	-118	-136	1,100
1,200	1	2	3	4	5	5	5	4	4	3	2	0	-2	-5	-9	-13	-18	-25	-33	-41	-50	-60	-71	-83	-98	-114	-132	1,200
1,300	1	3	4	5	6	6	6	6	6	5	4	2	1	-3	-6	-10	-15	-22	-29	-37	-46	-56	-67	-79	-93	-109	-126	1,300
1,400	1	3	4	5	6	7	8	8	8	7	6	5	3	1	-3	-7	-12	-18	-25	-33	-42	-51	-62	-75	-88	-104	-120	1,400
1,500	2	3	5	6	7	9	9	10	10	9	8	7	5	3	2	-4	-9	-14	-21	-29	-37	-46	-57	-69	-83	-98	-115	1,500
1,600	2	4	6	7	9	10	11	12	12	12	11	10	9	6	3	2	-5	-10	-17	-24	-32	-41	-51	-63	-77	-92	-108	1,600
1,700	2	5	7	9	10	11	13	14	14	14	14	13	12	10	7	4	2	-6	-12	-19	-27	-36	-46	-57	-71	-85	-101	1,700
1,800	3	5	8	10	11	13	15	16	16	17	17	16	15	14	11	8	5	2	-6	-13	-20	-29	-39	-51	-64	-78	-94	1,800
1,900	3	6	9	11	13	15	17	18	19	20	20	20	19	18	16	13	10	5	2	-7	-14	-23	-33	-44	-57	-71	-86	1,900
2,000	3	6	10	12	15	17	19	21	22	23	23	24	24	23	21	19	15	11	6	1	-7	-16	-26	-37	-49	-62	-77	2,000
2,100	4	7	10	13	16	19	21	23	25	26	27	28	29	28	27	24	21	17	13	7	0	-8	-18	-29	-41	-53	-67	2,100
2,200	4	8	11	15	18	21	24	26	28	30	31	32	33	33	32	30	27	24	20	15	8	1	-9	-19	-31	-43	-58	2,200
2,300	4	8	12	16	20	24	27	29	32	34	36	37	38	38	38	37	34	31	27	23	16	9	2	-10	-21	-33	-47	2,300
2,400	5	9	14	18	22	26	30	32	35	38	40	42	44	44	44	43	41	38	35	30	24	18	10	4	-11	-23	-36	2,400
2,500	5	10	15	20	24	28	33	36	39	43	45	47	49	50	50	50	49	46	43	38	33	27	20	11	5	-12	-25	2,500
2,600	5	11	16	22	26	31	36	39	43	47	51	53	55	56	57	57	57	54	51	47	43	37	30	21	11	6	-13	2,600
2,700	6	12	18	24	29	34	39	43	47	52	56	59	61	63	65	65	65	63	60	56	52	47	41	33	23	12	6	2,700
2,800	7	13	19	25	31	37	43	47	52	57	61	65	68	70	72	73	73	71	69	66	62	58	52	44	35	25	13	2,800
2,900	7	14	21	27	34	40	46	52	57	62	66	70	74	77	79	81	81	80	79	76	73	69	64	56	48	38	27	2,900
3,000	8	15	22	29	36	43	49	56	61	67	72	76	81	84	87	89	90	90	89	87	84	81	76	69	61	51	41	3,000

Table A-12. M2/M2A1 Table V: Part 1—Ordinate in Meters. (Continued)

Firing Table .50-H2																												
Cartridge, AP, M2																												
	Horizontal Distance from the Gun (m)																											
Range to Impact	100	200	300	400	500	600	700	800	900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300	2400	2500	2600	2700	Range to Impact
3,100	8	16	24	32	39	46	53	60	66	72	78	83	88	92	95	98	99	100	100	98	96	93	89	82	75	65	55	3,100
3,200	8	17	26	34	42	50	57	64	71	78	84	89	95	100	103	106	108	109	110	110	108	105	101	95	88	80	70	3,200
3,300	9	18	27	36	45	53	61	69	76	83	90	96	102	108	112	116	118	120	121	122	120	117	114	109	102	95	86	3,300
3,400	9	19	29	39	48	56	65	74	82	89	97	104	110	116	121	125	129	131	133	133	132	130	127	123	117	110	102	3,400
3,500	10	20	31	42	51	61	70	79	88	96	104	112	118	125	130	136	140	143	145	145	145	144	141	138	133	127	119	3,500
3,600	11	22	33	44	55	65	75	85	94	102	111	120	127	134	140	146	151	155	158	159	160	159	156	153	149	144	137	3,600
3,700	12	23	35	47	58	69	80	91	100	110	119	128	136	144	151	157	162	167	171	173	175	174	172	169	166	162	156	3,700
3,800	13	25	38	50	62	74	85	96	107	117	127	136	145	154	162	169	175	180	184	187	190	190	189	186	184	180	175	3,800
3,900	14	27	40	53	66	78	90	102	113	125	135	145	155	164	172	180	187	193	198	201	205	206	206	204	202	199	194	3,900
4,000	14	28	42	56	69	82	95	107	120	133	144	155	165	175	184	192	199	206	212	217	220	222	223	223	222	219	214	4,000
4,100	15	30	45	59	73	87	101	114	128	141	153	164	175	186	196	205	213	220	227	232	236	239	242	242	241	239	235	4,100
4,200	16	32	48	63	77	92	107	121	135	149	162	174	186	198	209	218	227	235	242	248	253	257	260	261	262	260	258	4,200
4,300	16	33	50	66	82	98	113	128	143	158	172	185	197	209	221	232	241	250	258	266	272	276	279	282	283	283	281	4,300
4,400	17	35	52	69	86	103	119	135	151	166	182	196	209	222	235	246	257	267	276	284	291	296	300	303	305	305	303	4,400
4,500	18	37	55	73	81	108	126	143	159	176	192	207	221	235	249	262	273	284	294	303	310	316	321	325	328	328	328	4,500

Table A-13. M2/M2A1 Table V: Part 2—Ordinate in Meters.

Firing .50-H2																												
Cartridge, AP, M2																												
	Horizontal Distance from the Gun (m)																											
Range to Impact	2800	2900	3000	3100	3200	3300	3400	3500	3600	3700	3800	3900	4000	4100	4200	4300	4400	4500	4600	4700	4800	4900	5000	5100	5200	5300	5400	Range to Impact
100	-185	-206	-229	-254	-280	-308	-338	-371	-405	-442	-481	-523	-567	-614	-663	-716	-772	-832	-895	-961	-1,031	-1,105	-1,185	-1,270	-1,360	-1,456	-1,557	100
200	-183	-204	-227	-252	-278	-306	-336	-369	-403	-440	-488	-526	-564	-610	-660	-713	-769	-829	-892	-958	-1,028	-1,102	-1,182	-1,266	-1,356	-1,451	-1,552	200
300	-181	-202	-225	-249	-275	-303	-334	-366	-401	-437	-512	-540	-560	-607	-656	-709	-765	-825	-887	-954	-1,024	-1,098	-1,177	-1,262	-1,351	-1,446	-1,547	300
400	-178	-199	-222	-246	-272	-300	-331	-363	-397	-433	-472	-513	-557	-603	-653	-706	-761	-820	-882	-949	-1,019	-1,093	-1,172	-1,257	-1,346	-1,440	-1,541	400
500	-176	-196	-219	-243	-269	-297	-327	-360	-393	-429	-468	-509	-553	-599	-649	-701	-757	-815	-877	-944	-1,014	-1,088	-1,167	-1,251	-1,340	-1,435	-1,535	500
600	-173	-193	-216	-240	-265	-293	-323	-355	-389	-425	-464	-505	-549	-595	-644	-696	-752	-810	-872	-939	-1,009	-1,083	1,162	-1,246	-1,335	-1,429	-1,529	600
700	-170	-190	-212	-236	-262	-289	-318	-351	-385	-421	-459	-500	-544	-591	-639	-691	-747	-805	-867	-933	-1,004	-1,078	-1,156	-1,240	-1,328	-1,423	-1,523	700
800	-166	-187	-208	-232	-258	-285	-314	-347	-381	-416	-454	-495	-539	-585	-634	-686	-741	-799	-861	-927	-997	-1,071	-1,150	-1,233	-1,321	-1,416	-1,516	800
900	-162	-183	-204	-228	-254	-281	-310	-342	-376	-411	-449	-490	-534	-579	-628	-680	-735	-794	-855	-921	-990	-1,064	-1,143	-1,226	-1,314	-1,408	-1,508	900
1,000	-158	-179	-200	-224	-250	-277	-305	-336	-370	-406	-444	-405	-529	-574	-623	-675	-729	-787	-849	-914	-983	-1,057	-1,137	-1,218	-1,306	-1,400	-1,499	1,000
1,100	-154	-175	-196	-219	-245	-272	-300	-331	-365	-401	-439	-480	-523	-568	-617	-668	-722	-780	-842	-907	-976	-1,049	-1,127	-1,209	-1,297	-1,391	-1,490	1,100
1,200	-150	-170	-191	-214	-239	-266	-295	-326	-359	-395	-433	-473	-516	-561	-609	-660	-714	-773	-834	-899	-968	-1,041	-1,119	-1,201	-1,288	-1,381	-1,480	1,200
1,300	-145	-165	-186	-209	-234	-260	-289	-320	-353	-388	-426	-466	-509	-553	-601	-652	-706	-765	-826	-890	-959	-1,031	-1,109	-1,190	-1,277	-1,370	-1,469	1,300
1,400	-139	-159	-180	-203	-228	-254	-283	-313	-346	-381	-418	-458	-500	-545	-592	-643	-698	-756	-817	-881	-949	-1,021	-1,098	-1,179	-1,266	-1,359	-1,457	1,400
1,500	-133	-152	-174	-197	-221	-247	-276	-306	-339	-373	-409	-449	-491	-536	-583	-634	-688	-746	-807	-870	-938	-1,010	-1,086	-1,168	-1,255	-1,347	-1,447	1,500
1,600	-126	-145	-166	-189	-214	-240	-268	-298	-331	-365	-401	-439	-481	-526	-573	-623	-677	-735	-796	-859	-926	-997	-1,074	-1,155	-1,241	-1,333	-1,431	1,600
1,700	-119	-138	-158	-181	-205	-231	-258	-289	-321	-355	-391	-429	-471	-515	-562	-612	-665	-722	-782	-846	-912	-983	-1,060	-1,141	-1,227	-1,318	-1,415	1,700
1,800	-111	-130	-150	-172	-196	-221	-248	-278	-310	-344	-380	-418	-460	-502	-550	-600	-653	-709	-768	-832	-898	-969	-1,045	-1,125	-1,211	-1,301	-1,397	1,800
1,900	-103	-121	-140	-162	-185	-210	-237	-267	-298	-332	-368	-407	-448	-492	-537	-586	-639	-694	-753	-816	-883	-954	-1,030	-1,109	-1,193	-1,283	-1,379	1,900
2,000	-93	-111	-130	-151	-174	-199	-226	-256	-287	-319	-355	-394	-435	-478	-524	-572	-624	-679	-738	-800	-867	-937	-1,012	-1,091	-1,174	-1,264	-1,360	2,000

Table A-13. M2/M2A1 Table V: Part 2—Ordinate in Meters. (Continued)

Firing .50-H2
Cartridge, AP, M2

Horizontal Distance from the Gun (m)

Range to Impact	2800	2900	3000	3100	3200	3300	3400	3500	3600	3700	3800	3900	4000	4100	4200	4300	4400	4500	4600	4700	4800	4900	5000	5100	5200	5300	5400	Range to Impact
2,100	-83	-101	-120	-140	-163	-188	-215	-244	-274	-307	-342	-380	-421	-463	509	-557	-608	-663	-721	-783	-849	-919	-913	-1,071	-1,154	-1,244	-1,339	2,100
2,200	-73	-91	-109	-130	-152	-176	-202	-231	-261	-293	-328	-365	-405	-447	-492	-540	-591	-646	-703	-765	-831	-900	-974	-1,051	-1,134	-1,223	-1,317	2,200
2,300	-62	-80	-98	-118	-140	-163	-188	-216	-246	-279	-313	-350	-389	-430	-475	-523	-573	-627	-684	-746	-811	-880	-953	-1,030	-1,113	-1,201	-1,294	2,300
2,400	-51	-68	-86	-106	-127	-149	-174	-201	-231	-264	-298	-334	-372	-413	-457	-504	-555	-608	-665	-726	-791	-859	-932	-1,008	-1,090	-1,177	-1,269	2,400
2,500	-39	-55	-72	-92	-113	-136	-160	-187	-216	-248	-281	-317	-355	-395	-439	-485	-535	-588	-645	-705	-769	-837	-909	-985	-1,066	-1,152	-1,244	2,500
2,600	-27	-42	-58	-77	-98	-121	-146	-172	-200	-231	-263	-299	-336	-377	-420	-466	-515	-567	-623	-683	-747	-814	-885	-961	-1,041	-1,127	-1,219	2,600
2,700	-13	-28	-44	-63	-83	-106	-130	-156	-183	-213	-245	-280	-318	-357	-400	-445	-494	-546	-601	-661	-724	-790	-861	-936	-1,016	-1,100	-1,191	2,700
2,800	6	-14	-30	-48	-68	-90	-113	-138	-166	-195	-227	-261	298	-337	-379	-424	-473	-524	-578	-637	-699	-766	-836	-910	-989	-1,073	-1,163	2,800
2,900	14	5	-16	-33	-52	-73	-96	-120	-147	-177	-209	-242	-278	-316	-358	-403	-450	-501	-555	-613	-674	-740	-809	-883	-962	-1,046	-1,135	2,900
3,000	28	15	4	-17	-35	-55	-78	-102	-129	-158	-189	-221	-257	-295	-336	-380	-427	-478	-531	-587	-648	-712	-781	-855	-934	-1,017	-1,105	3,000
3,100	43	30	16	3	-18	-37	-59	-83	-110	-138	-168	-200	-235	-273	-313	-357	-403	-453	-506	-562	-621	-685	-753	-827	-905	-987	-1,074	3,100
3,200	59	46	33	17	0	-19	-40	-64	-90	-117	-146	-178	-212	-250	-289	-332	-377	-428	-480	-535	-595	-658	-725	-797	-874	-955	-1,043	3,200
3,300	75	64	51	36	19	3	-21	-44	-68	-95	-124	-155	-189	-226	-265	-307	-352	-401	-453	-508	-566	-630	-696	-767	-843	-923	-1,009	3,300
3,400	92	82	69	55	39	20	6	-22	-47	-73	-101	-132	-165	-201	-239	-281	-325	-373	-424	-478	-537	-600	-665	-735	-810	-889	-974	3,400
3,500	110	100	88	75	59	41	21	8	-24	-49	-77	-107	-140	-175	-213	-254	-298	-344	-394	-448	-506	-568	-633	-702	-776	-855	-939	3,500
3,600	128	119	107	94	79	62	43	42	10	-25	-52	-82	-114	-148	-186	-226	-269	-315	-364	-418	-475	-535	-559	-668	-741	-820	-904	3,600
3,700	148	138	127	114	100	84	65	45	24	11	-26	-55	-87	-121	-157	-197	-239	-284	-333	-386	-442	-502	-565	-633	-705	-783	-866	3,700
3,800	167	59	148	136	122	106	89	69	48	26	12	-28	-59	-92	-128	-166	-208	-253	-300	-352	-408	-467	-530	-596	-668	-745	-827	3,800
3,900	188	180	170	159	146	131	113	95	75	53	28	12	-30	-62	-97	-136	-176	-220	-267	-318	-373	-431	-493	-559	-629	-705	-786	3,900
4,000	208	202	193	182	170	156	139	121	102	80	56	29	11	-32	-66	-103	-143	-186	-232	-283	-337	-394	-455	-520	-590	-665	-745	4,000
4,100	231	224	216	206	195	181	166	149	130	108	84	59	31	8	-34	-70	-109	-152	-197	-247	-300	-357	-417	-481	-551	-624	-703	4,100
4,200	254	248	240	231	221	208	194	177	159	138	115	90	62	33	4	-36	-74	-116	-161	-209	-262	-317	-377	-441	-509	-582	-660	4,200
4,300	277	273	266	257	248	236	222	207	189	169	147	122	96	67	35	2	-38	-79	-123	-170	-222	-277	-336	-398	-465	-537	-614	4,300

Table A-13. M2/M2A1 Table V: Part 2—Ordinate in Meters. (Continued)

Firing .50-H2																												
Cartridge, AP, M2																												
	Horizontal Distance from the Gun (m)																											
Range to Impact	2800	2900	3000	3100	3200	3300	3400	3500	3600	3700	3800	3900	4000	4100	4200	4300	4400	4500	4600	4700	4800	4900	5000	5100	5200	5300	5400	Range to Impact
4,400	301	297	292	284	276	265	252	237	221	202	181	157	131	102	71	37	7	-40	-83	-130	-181	-236	-293	-354	-420	-491	-567	4,400
4,500	327	324	318	313	305	295	283	269	253	235	216	193	167	139	108	75	39	13	-42	-88	-138	-192	-248	-309	-374	-444	-519	4,500

Table VI: Searching Reverse Slopes

To find a position to search a reverse slope, the following steps should be taken:

1. From the map, compute the average drop in meters in 100 meters of slope to be searched.

2. In the column of Table A-14 headed by this gradient, note the range opposite a vertical interval of zero. This is the range to search the slope when the gun and target are on the same level.

3. On the map, measure this range back from the target and find the vertical interval of this point.

4. Below or above the zero line in the same column, depending on whether the target is below or above this point, find the range opposite the vertical interval. Move forward or back to this range. If the vertical interval is not materially changed, then the position is suitable.

If the vertical interval is materially changed, repeat the operation until a suitable position is found. A movement to the right or left will often secure the proper vertical interval.

Example of Searching Reverse Slopes

It is desired to search a slope with an average drop of 10 meters in 100 meters.

In the column under that gradient and opposite a vertical interval of zero is found the range of 2,862 meters. On the map, measure 2,862 meters from the target. Assume that the target is 30 meters below the position found. In the same column, opposite a vertical interval of 30 meters below the gun, shows the range of 2,756 meters. Move forward to a point 2,756 meters from the target and determine the quadrant elevation for that range. Set that quadrant elevation on the gun and engage the target.

Table A-14. M2/M2A1 TableVI: Searching and Reverse Slopes.

Firing Table .50-H-2																	
Cartridge, AP, M2																	
Vertical Interval	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**Vertical Interval**
+90	2,225	2,321	2,417	2,513	2,609	2,702	2,789	2,876	2,959	3,014	3,124	3,201	3,279	3,352	3,422	3,490	+90
+80	2,179	2,280	2,377	2,475	2,571	2,667	2,758	2,846	2,933	3,015	3,097	3,176	3,254	3,328	3,402	3,470	+80
+70	2,129	2,235	2.336	2,436	2,534	2,630	2,723	2,814	2,903	2,987	3,069	3,151	3,229	3,307	3,380	3.450	+70
+60	2,079	2,188	2,291	2,393	2,494	2,592	2,688	2,781	2,873	2,960	3,042	3,124	3,204	3,282	3,357	3,430	+60
+50	2,026	2,138	2,246	2,353	2,454	2,555	2,563	2,749	2,840	2,930	3,015	3,097	3,179	3,257	3,335	3,410	+50
+40	1,968	2,085	2,198	2,311	2,411	2,515	2,615	2,711	2,805	2,897	2,987	3,072	3,154	3,232	3,310	3,387	+40
+30	1,905	2,027	2,145	2,259	2,366	2,475	2,575	2,674	2,774	2,865	2,957	3,044	3,136	3,207	3,288	3,362	+30
+20	1,836	1,963	2,090	2,208	2,321	2,431	2,535	2,639	2,740	2,835	2,927	3,014	3,100	3,182	3,264	3,341	+20
+10	1,758	1,898	2,031	2,154	2,272	2,386	2,495	2,600	2,701	2,801	2,982	2,994	3,070	3,157	3,239	3,317	+10
0	1,673	1,824	1,966	2,094	2,217	2,336	2,451	2,560	2,665	2,766	2,862	2,954	3,045	3,127	3,214	3,292	0
-10	1,565	1,738	1,891	2,033	2,162	2,286	2,401	2,515	2,625	2,726	2,827	2,923	3,015	3,102	3,185	3,267	-10
-20	1,410	1,634	1,809	1,961	2,101	2,230	2,351	2,470	2,581	2,691	2,792	2,888	2,980	3,072	3,159	3,242	-20
-30		1,491	1,712	1,879	2,034	2,170	2,299	2,424	2,540	2,649	2,756	2,853	2,949	3,042	3,130	3,217	-30
-40			1,585	1,787	1,957	2,107	2,243	2,342	2,493	2,606	2,716	2,818	2,916	3,012	3,103	3,190	-40
-50				1,675	1,870	2,034	2,180	2,317	2,443	2,564	2,676	2,783	2,884	2,982	3,073	3,160	-50
-60				1,473	1,763	1,954	2,113	2,257	2,390	2,516	2,633	2,746	2,849	2,949	3,043	3,133	-60
-70					1,610	1,854	2,037	2,192	2,332	2,463	2,585	2,703	2,811	2,914	3,010	3,105	-70
-80						1,731	1,947	2,124	2,272	2,408	2,539	2,661	2,774	2,879	2,979	3,075	-80
-90							1,836	2,042	2,208	2,353	2,490	2,617	2,735	2,844	2,945	3,045	-90

FIRE CONTROL TABLES FOR THE MK-19

Table I: Angle of Elevation

The tables in this section are for use with the M430 HEDP round. Since overhead fire with explosive warheads is also in Table I, the change in elevation and range for each 100 meters in range has been calculated to permit subsequent changes in the quadrant elevation without recalculation.

> **Example of Angle of Elevation**
>
> The AE to hit a target that is level with the gun at a range of 1,000 meters is 131.2 mils.

NOTE: For ranges that are not in even hundreds or have not been tabulated, the desired information must be determined by interpolation. Interpolation is the method of estimating a number that exists between two other numbers.

> **Example of Calculation of Angle of Elevation**
>
> The AE for a target at 1,750 meters is 357.1 mils and the AS to the target is 15 mils, so the quadrant elevation for the target is AS + AE = 372.1 mils.
>
> At a range of 1,750 meters, it takes 26 mils to shift the center of impact 50 m (Table A-I, Column 3). Interpolate the AE for 1,775 mils by multiplying 26 by 0.5 to get the change in AE for 25 meters. The result is 13 mils. Add 13 mils to the quadrant elevation of 372.1 mils to get the quadrant elevation for a target at 1,775 meters with an AS of 15 mils. The result is 385.1 mils.

Therefore, the AE for 1,220 meters = 174 + 4.96 = 178.96, rounded up to 179 mils. Table A-15 lists the AE, range and mil shifts, wind deflection, angle of fall, TOF, maximum ordinate, drift, and remaining velocity to assist in determining effect on target. For a detailed explanation on AE, see Chapter 3.

> **Example of Interpolation**
>
> A grenade machine gunner needs to know the AE for a target at a range of 1,220 meters.
>
> The AE for 1,200 meters is 174 mils and the AE for 1,300 meters is 198.8 mils. The difference is 24.8 mils. At this range, 24.8 mils correspond to a range shift of 100 meters. A change of 20 meters requires .20 × 24.8 mils—4.96 mils.

Table A-15. MK-19 Table I: Angle of Elevation.

FCI 40 Meters 430											
Cartridge, HEDP, M430											
							Maximum Ordinate				
Range (m)	AE (m)	Difference (m)	Effect of a 1-mil Change on Range (m per mil)	Deflection of a 10 kph Crosswind (mils)	Angle of Fall (mils)	Time of Flight (seconds)	Height (m)	Range (m)	Drift to the Right (mils)	Remaining Velocity (m per second)	Range (m)
50	4.4		11	0.2	4	0.21	0.1	25	0.2	234	50
100	9	4.6	11	0.3	9	0.43	0.2	51	0.4	228	100
150	13.7	4.7	11	0.5	14	0.65	0.5	76	0.6	222	150
200	18.6	4.9	10	0.7	20	0.88	0.9	102	0.8	215	200
250	23.7	5.1	10	0.9	26	1.11	1.5	128	1.1	209	250
300	29	5.3	9	1	32	1.36	2.3	154	1.3	204	300
350	34.5	5.5	9	1.2	39	1.61	3.2	181	1.5	198	350
400	40.2	5.7	9	1.4	47	1.86	4.3	208	1.8	192	400
450	46.2	6	8	1.6	55	2.13	5.5	235	2.1	187	450
500	52.4	6.2	8	1.8	63	2.4	7.1	262	2.4	182	500
550	58.9	6.5	8	2	72	2.68	8.8	289	2.7	177	550
600	65.6	6.7	7	2.2	82	2.97	10.8	317	3	172	600
650	72.6	7	7	2.4	93	3.27	13.1	345	3.4	167	650
700	80	7.4	7	2.7	104	3.57	15.7	373	3.7	163	700
750	87.6	7.6	6	2.9	116	3.89	18.6	401	4.1	158	750
800	95.6	8	6	3.1	128	4.21	21.9	430	4.5	154	800
850	103.9	8.3	6	3.3	142	4.55	25.5	459	5	150	850
900	112.6	8.7	6	3.6	157	4.89	29.5	488	5.4	146	900
950	121.7	9.1	5	3.8	172	5.25	34	517	5.9	143	950
1,000	131.2	9.5	5	4	189	5.62	39	546	6.4	139	1,000
1.050	141.2	10	5	4.3	206	6	44.5	576	7	135	1.050
1,100	151.6	10.4	5	4.5	225	6.39	50.5	605	7.6	132	1,100
1,150	162.5	10.9	4	4.8	245	6.8	57.2	635	8.2	129	1,150
1,200	174	11.5	4	5.1	266	7.22	64.5	665	8.8	126	1,200

Table A-15. MK-19 Table I: Angle of Elevation. (Continued)

FCI 40 Meters 430											
Cartridge, HEDP, M430											
							Maximum Ordinate				
Range (m)	AE (m)	Difference (m)	Effect of a 1-mil Change on Range (m per mil)	Deflection of a 10 kph Crosswind (mils)	Angle of Fall (mils)	Time of Flight (seconds)	Height (m)	Range (m)	Drift to the Right (mils)	Remaining Velocity (m per second)	Range (m)
1,250	186	12	4	5.4	289	7.65	72.6	696	9.5	123	1,250
1,300	198.8	12.8	4	5.6	313	8.1	81.5	726	10.3	120	1,300
1,350	212.2	13.4	4	5.9	339	8.57	91.2	757	11.1	117	1,350
1,400	226.3	14.1	3	6.2	366	9.06	102	788	11.9	115	1,400
1,450	241.4	15.1	3	6.6	395	9.57	113.9	819	12.9	112	1,450
1,500	257.3	15.9	3	6.9	426	10.1	127	851	13.9	110	1,500
1,550	274.4	17.1	3	7.2	459	10.66	141.6	882	14.9	108	1,550
1,600	292.7	18.3	3	7.6	494	11.25	157.8	914	16.1	106	1,600
1,650	312.4	19.7	2	8	532	11.87	175.8	946	17.4	104	1,650
1,700	333.7	21.3	2	8.4	572	12.53	196.1	979	18.8	103	1,700
1,750	357.1	23.4	2	8.8	615	13.24	219.1	1,011	20.4	101	1,750
1,800	383.1	26	2	9.3	661	14.01	245.5	1,044	22.2	100	1,800
1,850	412.4	29.3	2	9.9	711	14.85	276.3	1,077	24.3	99	1,850
1,900	446.3	33.9	1	10.5	767	15.81	313.1	1,110	26.8	99	1,900
1,950	487.6	41.3	1	11.2	830	16.93	359.4	1,144	30	99	1,950
2,000	543.4	55.8	1	12.2	908	18.39	423.9	1,178	34.5	99	2,000

Table II: Maximum Ordinate and Effects on Range

In Table A-16, the first column lists the range to target, followed by the AE and maximum ordinate for that range. Range effects are listed for a decrease/increase of one meter per second in muzzle velocity, a head/tail wind of 1 kph, and variations from standard air density of 1,225 grams per cubic meter at sea level.

Table A-16. MK-19 Table II: Maximum Ordinate and Effects on Range.

FCI 40-430									
Cartridge, HEDP, M430									
			Effects on Range						
	Quadrant Elevation		Muzzle Velocity (1 mps)		Wind (1 kph)		Air Density (1%)		
Range (m)	(mils)	Maximum Ordinate (m)	Decrease (m)	Increase (m)	Headwind (m)	Tailwind (m)	Decrease (m)	Increase (m)	
759	88.5	19	-4.8	4.4	-0.6	0.4	1.9	-1.8	
1,216	177	67	-6.5	5.9	-1.4	1.1	4.6	-4.2	
1,528	265.5	135	-7.3	6.6	-2.1	1.8	6.9	-6.2	
1,747	354	218	-7.7	6.9	-2.7	2.5	8.8	-7.9	
1,898	442.5	311	-7.9	7.1	-3.3	3.1	10.3	-9.1	
1,993	531	412	-8	7.1	-3.8	3.6	11.4	-10	
2,039	619.5	518	-7.9	7	-4.2	4.1	12.1	-10.7	
2,045	672.6	576	-7.8	6.9	-4.4	4.3	12.3	-10.9	

Table III: Effects on Muzzle Velocity Because of Ammunition Temperature

Table A-17 shows the following:

- Column 1 lists the temperature in degrees Fahrenheit (F), computed on a baseline temperature of 70 degrees F.
- Column 2 lists the amount of muzzle velocity that will be lost, given the temperatures listed in Columns 1 and 3.
- Column 3 lists the temperature in degrees Centigrade, computed on a baseline temperature of 21 degrees Centigrade.

Example of Effects on Muzzle Velocity Because of Ammunition Temperature

A grenade machine gunner needs to know how short the rounds will land if the target is at 1,200 m and the temperature is -10 degrees F.

First, the gunner refers to Table III and indexes the temperature in Column 1 to find that Column 2 lists the decrease in muzzle velocity of 2.9 meters per second. Given this data, the gunner refers back to Table II to find the negative range shift for this decrease in muzzle velocity. The gunner finds that for a target at a range of 1,216 meters (close enough to the target range) a drop of one meter per second in muzzle velocity will decrease the range by 6.5 meters. The gunner multiples 6.5 meters by 3 (2.9 meters per second, rounded up) to obtain a total range shift of 19.5—20 mils. With the sights set on 1,200 and the gun laid to hit the target, the gunner adds 20 clicks of elevation with the T&E mechanism to hit the target.

Table A-17. MK-19 Table III: Effects on Muzzle Velocity Because of Ammunition Temperature.

FCI 40 Meters 430		
Cartridge, HEDP, M430		
Temperature of Ammunition	Effect on Velocity	Temperature of Ammunition
-40	-4.8	-40
-30	-4.1	-34.4
-20	-3.4	-28.9
-10	-2.9	-23.3
0	-2.4	-17.8
10	-2	-12.2
20	-1.6	-6.7
30	-1.3	-1.1
40	-1	4.4
50	-0.7	10
60	-0.3	15.6
70	0	21.1
80	0.4	26.7
90	0.8	32.2
100	1.3	37.8
110	1.9	43.3
120	2.6	48.9
130	3.4	54.4

Table A-18. MK-19 Table IV: Indirect Fire Table (Provisional Data).

Range to Target	Quadrant Elevation (mils)	Time of Flight (seconds)	Max Ord	Initial Danger Space	Dead Space	Target Danger Space
900	1253	33.1	1201.8	0-2	2-899	899-900*
1000	1230	32.9	1188.2	0-2	2-998	998-1000*
1100	1210	32.9	1175.6	0-2	2-1098	1098-1100*

Table A-18. MK-19 Table IV: Indirect Fire Table (Provisional Data). (Continued)

Range to Target	Quadrant Elevation (mils)	Time of Flight (seconds)	Max Ord	Initial Danger Space	Dead Space	Target Danger Space
1200	1189	32.8	1161.3	0-2	2-1199	1199-1200*
1300	1170	32.8	1147.5	0-2	2-1299	1299-1300*
1400	1147	32.8	1130.2	0-2	2-1399	1399-1400*
1500	1124	32.8	1111.2	0-2	2-1499	1499-1500*
1600	1097	32.7	1088.2	0-3	3-1598	1598-1600*
1700	1063	32.5	1056.9	0-3	3-1698	1698-1700*
1800	1024	32.1	1018	0-3	3-1798	1798-1800*
1900	980	31.5	970.3	0-3	3-1898	1898-1900*
2000	928	30.7	910.9	0-4	4-1998	1998-2000*

* Target danger space is stated in terms of trajectory of the M430 round in relationship to a safety height of five meters. It is <u>not</u> based on the effective casualty radius of the bursting round. However, the commander must consider the 14 meters effective casualty radius when integrating target suppression and troop movement.

Table A-19. MK-19 Table V: Quadrant Elevation for Vertical Intervals Part 1.

Horizontal Distance from the Gun – Target Above the Gun																						
VI (m)	100	200	300	400	500	600	700	800	900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200
100	809.1	491.1	356.8	289.2	252.4	232	222.6	219.2	220.8	226.9	235.9	248.3	263.5	282	303.5	329.1	358.3	393.5	434.4	490.8	570.2	
95	782.9	470.5	341.4	277.1	242.6	223.7	215.4	212.9	215.1	221.7	231.2	243.9	259.4	278.1	299.9	325.4	354.9	390.2	430.9	487.1	565.6	
90	755.5	449.5	325.9	265	232.7	215.4	208.2	206.5	209.4	216.6	226.5	239.5	255.4	274.3	296.2	321.9	351.5	386.8	427.5	483.5	561.1	
85	726.7	428.1	310.2	252.9	222.7	207	201	200.1	203.7	211.4	221.8	235.1	251.3	270.4	292.5	318.4	348	383.4	424.1	480.4	556.7	
80	696.3	406.3	294.4	240.6	212.8	198.6	197.2	195.9	198	206.3	217	230.8	247.2	266.6	288.9	314.9	344.6	380	420.7	476.2	552.3	
75	664.5	384.1	278.5	228.3	202.9	190.2	186.5	187.3	192.3	201	212.3	226.4	243.1	262.7	285.2	311.4	341.2	376.7	417.3	472.6	547.9	
70	631.1	361.6	262.4	215.9	192.8	181.8	179.2	181	186.6	195.9	207.6	222	239	258.9	281.6	307.8	337.8	373.3	413.9	468.9	543.6	
65	596.1	338.7	246.2	203.5	182.7	173.4	171.9	174.6	180.9	190.7	202.9	217.6	234.9	255	277.9	304.3	334.4	370	410.5	465.4	539.4	
60	559.5	315.5	229.9	191.1	172.7	165	164.7	168.2	175.3	185.6	198.1	213.2	230.8	251.2	274.3	300.9	331	366.6	407.1	461.8	535.2	720.5
55	521.2	292	213.5	178.5	162.6	156.5	157.4	161.8	169.5	180.4	193.4	208.9	226.8	247.3	270.6	297.4	327.6	363.3	403.7	458.3	531.1	700.4
50	481.3	268.1	197	166	152.5	148	151.1	155.4	163.8	175.2	188.6	204.5	222.7	243.5	267	293.8	324.2	359.1	400.4	454.7	527	687.4
45	439.7	244.1	180.4	153.4	142.4	139.5	142.8	149	158	170	183.9	200.1	218.6	239.7	263.3	290.4	320.9	356.6	398	451.2	522.9	676.8
40	396.5	219.7	163.8	140.8	132.3	131	135.5	142.5	152.3	164.9	179.1	195.8	214.5	235.8	259.7	286.9	317.5	355.3	393.7	447.6	518.9	667.6

Table A-19. MK-19 Table V: Quadrant Elevation for Vertical Intervals Part 1. (Continued)

	Horizontal Distance from the Gun – Target Above the Gun																					
VI (m)	100	200	300	400	500	600	700	800	900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200
35	351.9	195.1	147	128.2	122.1	22.6	128.3	136.1	146.5	159.7	174.4	191.4	210.4	232	256.1	283.4	314.1	350	390.4	444.2	514.9	659.2
30	305.9	170.2	130.2	115.5	111.9	114	120.9	129.8	140.9	154.5	169.7	187	206.4	228.1	252.4	279.9	310.7	347.6	387	440.8	510.9	651.5
25	258.5	145.2	113.4	102.8	101.7	105.6	113.6	123.3	135.1	149.3	164.9	182.6	202.3	224.3	248.8	276.4	307.4	343.3	383.7	437.3	507	644.3
20	210	120.1	96.5	90.1	91.5	97	106.3	116.9	129.4	144.1	160.2	178.2	198.2	220.5	245.2	272.9	304	340	380.4	433.9	503.1	637.6
15	160.6	94.8	79.6	77.4	81.3	88.5	99	110.5	123.7	139	155.5	173.9	194.1	216.7	241.5	269.4	300.6	336.7	377.1	430.4	499.2	631.1
10	110.4	69.4	62.6	64.6	71.1	80	91.7	104.1	117.9	133.8	150.7	169.5	190.1	212.8	237.9	266.4	297.3	333.4	373.8	427	495.4	624.9
5	59.9	44	45.6	58.9	60.9	71.4	84.3	97.7	112.2	128.6	146.1	165.1	186	209	234.3	262.5	293.9	230.2	370.5	423.6	491.6	618.9

Table A-20. MK-19 Table V: Quadrant Elevation for Vertical Intervals Part 2.

	Horizontal Distance from the Gun in Meters – Target Below the Gun																					
VI (m)	100	200	300	400	500	600	700	800	900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200
-5	-41.9	-7.2	11.6	26.4	40.5	54.4	69.7	84.8	100.7	118.3	136.6	156.4	177.9	201.4	227	255.6	287.2	323.6	365.6	416.9	484.1	607.6
-10	-92.6	-32.2	-5.5	13.6	30.3	45.9	62.4	78.4	95.0	113.0	130.8	152	173.8	197.5	223.4	252.1	283.9	320.3	362.4	413.5	480.3	602.2
-15	-142.8	-58.0	-22.5	.9	20.1	37.4	55.1	71.9	89.3	107.9	127.0	147.7	169.7	193.7	219.8	248.7	280.6	317.1	359.1	410.1	476.6	596.9
-20	-192.2	-83.3	-39.4	-11.4	9.8	28.9	47.8	65.5	83.6	102.7	122.4	143.3	165.7	189.9	216.2	245.2	277.2	313.8	355.9	407.1	473	591.8
-25	-240.6	-108.4	-56.3	-24.1	0.0	20.4	40.4	59.1	77.9	97.6	117.7	138.9	161.6	186.1	212.6	241.7	273.9	310.6	352.6	403.4	469.3	586.7
-30	-288.0	-133.4	-73.1	-36.8	-10.1	11.9	33.1	52.7	72.2	92.5	112.9	134.6	157.3	182.3	209	238.3	270.6	307.3	349.4	400.1	465.7	581.8
-35	-344.0	-158.2	-89.9	-49.4	-20.2	3.4	25.8	46.3	66.5	87.3	108.2	130.4	153.3	178.5	205.4	234.8	267.3	304.1	346.2	396.8	462.1	572.2
-40	-378.7	-182.8	-106.6	-62.1	-30.4	-4.4	18.5	39.9	60.8	82.0	103.5	125.9	149.2	174.7	201.8	231.4	263.9	300.8	342.9	393.5	458.5	577
-45	-421.8	-207.2	-123.3	-74.7	-40.5	-13.0	11.3	33.5	55.1	76.9	98.8	121.5	145.2	170.9	198.2	227.9	260.6	297.6	339.7	390.2	454.9	567.6
-50	-463.4	-231.3	-139.9	-87.3	-50.6	-21.4	4.0	27.2	49.3	71.8	94.0	117.2	141.2	167.1	194.6	224.5	257.3	294.3	336.5	386.9	451.4	563
-55	-503.3	-255.1	-156.4	-100.0	-60.7	-29.9	-3.3	20.8	44.7	66.6	89.4	113	137.3	163.3	191	221.1	254	291.1	333.3	383.7	447.8	558.5
-60	-541.6	-278.6	-172.7	-112.2	-70.7	-38.2	-10.7	14.4	38.0	61.5	84.7	108.5	133.3	159.5	187.4	217.7	250.7	287.9	330.1	380.4	444.3	554.1
-65	-578.2	-301.8	-189.0	-124.7	-80.8	-46.7	-17.8	8.0	32.3	56.3	79.9	104.2	129.2	155.7	183.8	214.2	247.4	284.7	326.9	377.1	440.8	549.7
-70	-613.2	-324.7	-205.1	-137.1	-90.8	-55.1	-25.0	.8	26.6	51.2	75.3	99.8	125.2	151.9	180.3	210.8	244.1	281.5	323.7	373.9	437.4	545.4
-75	-646.5	-347.2	-221.2	-149.4	-100.8	-63.5	-32.2	-4.7	20.9	46.0	70.6	95.5	121.2	148.2	176.7	207.4	240.8	278.3	320.6	370.7	433.9	541.1
-80	-678.4	-369.3	-237.1	-161.7	-110.8	-71.9	-39.5	-11.0	15.3	41.0	65.9	91.2	117.2	144.4	173.1	204	237.6	275.1	317.4	367.4	430	536.9
-85	-708.6	-391.1	-252.9	-173.9	-120.7	-80.2	-46.7	-17.4	9.6	35.9	61.2	85.9	113.1	140.6	169.5	200.6	234.3	271.9	314.2	364.2	427	532.8
-90	-737.5	-412.4	-268.6	-186.0	-130.6	-88.5	-53.8	-23.7	4.0	39.7	56.6	82.6	109.1	136.8	166	197.2	231	268.7	311.1	361	423.6	528.7

Table A-20. MK-19 Table V: Quadrant Elevation for Vertical Intervals Part 2. (Continued)

Horizontal Distance from the Gun in Meters – Target Below the Gun																						
VI (m)	**100**	**200**	**300**	**400**	**500**	**600**	**700**	**800**	**900**	**1000**	**1100**	**1200**	**1300**	**1400**	**1500**	**1600**	**1700**	**1800**	**1900**	**2000**	**2100**	**2200**
-95	-764.9	-433.4	-284.1	-198.2	-140.5	-96.9	-61.0	-30.0	-1.7	25.1	51.9	78.2	105.1	133.1	162.4	193.8	227.7	265.5	307.9	357.8	420.3	524.6
-100	-791.0	-453.9	-299.4	-210.2	-150.3	-105.1	-68.2	-36.3	-7.2	20.5	47.2	73.9	101.1	129.3	158.8	190.4	224.5	262.3	304.8	354.6	416.9	520.6

Appendix B. Training Standards

There are several basic standards that a machine gun crew must meet in order to achieve and maintain combat efficiency. Some of these standards only apply to individual members of the crew (e.g., assistant gunner, gunner, or ammunition bearer) and are referred to as individual training standards. Others apply to the entire gun crew and are referred to as collective training standards. The authoritative source of these training standards is NAVMC 3500.44.

Individual Training Standards for the M249 and M240B

The individual training standards for the M249 light machine gun and M240B medium machine gun consist of the following tasks:

- Perform operator maintenance for an M249 light machine gun/M240B medium machine gun and associated components.
- Operate an M249 light machine gun/M240B medium machine gun.
- Perform immediate action on an M249 light machine gun/M240B medium machine gun.
- Perform remedial action for an M249 light machine gun/M240B medium machine gun.
- Field zero an M249 light machine gun/M240B medium machine gun.
- Zero a machine gun day optic to an M240B medium machine gun.
- Zero a squad day optic to an M249 light machine gun.
- Zero the image intensified optic for the M249 light machine gun/M240B medium machine gun.
- Zero the thermal optic for a machine gun.
- Mount an M249 light machine gun/M240B medium machine gun on a tripod with T&E mechanism.
- Mount an M249 light machine gun/M240B medium machine gun on a tactical vehicle with T&E mechanism.
- Zero a night aiming device for an M249 light machine gun/M240B medium machine gun.
- Conduct the basic course of fire (Gunnery Table I).
- Conduct the transition course of fire (Gunnery Table II).
- Conduct the range card course of fire (Gunnery Table III).
- Conduct the NVD course of fire (Gunnery Table IV).

- Conduct the vehicle-mounted course of fire (Gunnery Table V).
- Conduct the bipod multiple engagement course of fire (Gunnery Table VI).

INDIVIDUAL TRAINING STANDARDS FOR THE M2A1

The individual training standards for the M2A1 HMG consist of the following tasks:

- Perform operator maintenance for an M2A1 HMG and associated components.
- Mount an M2A1 HMG on an M3 tripod with T&E mechanism.
- Mount an M2A1 HMG on a tactical vehicle with T&E mechanism.
- Operate an M2A1 HMG.
- Perform immediate action on an M2A1 HMG.
- Perform remedial action for an M2A1 HMG.
- Field zero an M2A1 HMG.
- Zero the thermal optic for a machine gun.
- Conduct the basic course of fire (Gunnery Table I).
- Conduct the transition course of fire (Gunnery Table II).
- Conduct the range card course of fire (Gunnery Table III).
- Conduct the NVD course of fire (Gunnery Table IV).
- Conduct the vehicle-mounted course of fire (Gunnery Table V).

INDIVIDUAL TRAINING STANDARDS FOR THE MK-19 HMG

The individual training standards for the MK-19 grenade machine gun consist of the following tasks:

- Perform operator maintenance for a MK-19 grenade machine gun and associated components.
- Mount a MK-19 grenade machine gun on an M3 tripod with T&E mechanism.
- Mount a MK-19 grenade machine gun on a tactical vehicle with T&E mechanism.
- Operate a MK-19 grenade machine gun.
- Perform immediate action on a MK-19 grenade machine gun.
- Perform remedial action for a MK-19 grenade machine gun.
- Field zero a MK-19 grenade machine gun.
- Zero the thermal optic for a machine gun.

- Register a range card for a MK-19 grenade machine gun.
- Conduct the transition course of fire (Gunnery Table II).
- Conduct the NVD course of fire (Gunnery Table IV).
- Conduct the vehicle-mounted course of fire (Gunnery Table V).

INDIVIDUAL TRAINING STANDARDS FOR MACHINE GUNNERS

The individual training standards for machine gunners consist of the following tasks:

- Construct a machine gun fighting position.
- Prepare a machine gun range card.
- React to machine gun fire commands.
- Direct the occupation of a machine gun firing position.
- Inspect a machine gun fighting position.
- Lay the machine gun for overhead fire.
- Engage targets from a defilade position.
- Direct the acquisition of machine gun targets.
- Prepare a terrain profile.
- Direct the employment of a machine gun unit in an offensive operation.
- Direct the employment of a machine gun unit in a defensive operation.
- Advise the commander on the employment of a machine gun unit.
- Identify armored vehicles.
- Direct the employment of a motorized machine gun unit.

Appendix C. Gunnery Tables

A gunnery table is a course of fire that tests a machine gunner's skill at employing the gun in a certain situation. Tables I and II are qualification tables, while Tables III, IV, V, and VI are field firing tables. Field firing is conducted only after a machine gunner has demonstrated a basic level of proficiency by qualifying on Gunnery Tables I and II. Machine gunners should fire all of the gunnery tables (i.e., qualification and field firing) every six months to maintain proficiency. Prior to firing any gunnery tables, machine guns should be zeroed using either the laser bore sight at 10 meters or by firing the respective zeroing course or the field-zeroing course.

Gunnery Tables I-VI are as follows:

- Gunnery Table I: Basic Course of Fire.

  NOTE: Table I cannot be fired with the MK-19 grenade machine gun.

- Gunnery Table II: Transition Course of Fire.
- Gunnery Table III: Range Card Course of Fire.

  NOTE: Table III cannot be fired with the MK-19 grenade machine gun.

- Gunnery Table IV: NVD Course of Fire.
- Gunnery Table V: Vehicle-mounted Course of Fire.
- Gunnery Table VI: Bipod Multiple Engagement Course of Fire.

  NOTE: Table VI is only fired with the M249 light machine gun and M240B medium machine gun.

Gunnery Table I: Basic Course of Fire

The basic course (Table I) is the first half of qualification for the machine gunner. It is fired in two phases (practice and scored firing) on the basic machine gun target while wearing a fighting load. The range to target is 12.7 meters for the M240B and 10 meters for the M249 and M2A1. The ammunition requirement is 192 rounds.

Description and Layout

The basic machine gun target (NSN 6920-00-078-5123) is a standardized paper target (see Figure C-1) used for zeroing and firing of Table I for both medium machine guns and HMGs. It consists of four target sections—A, B, C, and D—each identical and consisting of banks of scoring spaces called pasters. Pasters resemble tombstones and are four centimeters wide and five centimeters high. Each numbered paster contains a 1-cm black aiming square. During firing, the proper sight picture is six o'clock to the aiming square. Because Table I only uses two sections, each target can accommodate two machine guns. There are 17 pasters in three banks (1-4, 5-6, and 7-8) within each section:

- Bank 1-4 consists of four separated pasters, each requiring fixed fire engagement.
- Bank 5-6 consists of five pasters, arranged in echelon and requiring search and traverse engagement.
- Bank 7-8 consists of eight pasters, arranged in both line and echelon, requiring both traversing and search and traverse engagement.

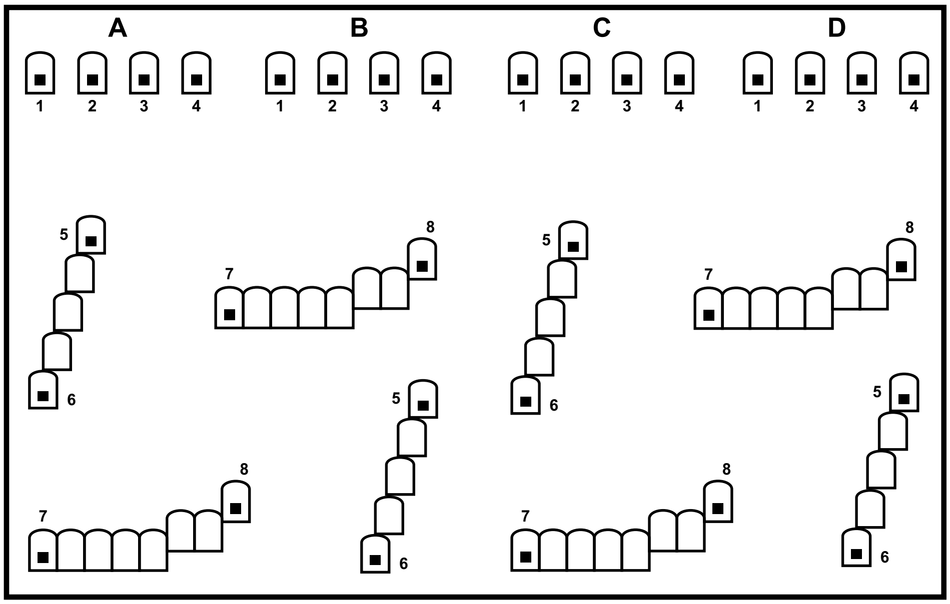


Figure C-1. Basic Machine Gun Target.

Practice Firing

The practice portion of Table I will familiarize gunners with applying the following four fundamentals of machine gun gunnery:

- Accurate initial burst.
- Adjustment of fire.
- Mechanical skill in manipulation.
- Speed.

Practice firing also reinforces the importance of proper zeroing techniques and the techniques required to properly manipulate the T&E mechanism for accurate traversing and searching fire. Practice firing introduces the gunner to the string of fire that will be used during scored firing. There are no time limits on any of the following three strings of fire during practice firing, which is fired only after successful zeroing:

- First string (12 rounds). The first string of fire uses pasters 3 and 4 in sections A or C with two 6-round belts, one for each paster. These are fixed-fire pasters with no manipulation of the T&E mechanism required, other than to obtain proper sight alignment and picture before firing the 6-round burst.

- Second string (30 rounds). The second string of fire uses banks 5-6 in sections A or C with a 30-round belt. The gunner aims at paster 5 and fires the initial 6-round burst; traverse and search manipulation (two mils left and four mils down) is then required for each subsequent 6-round burst. The gunner repeats this action four times, ending the string of fire on paster 6.
- Third string (48 rounds). The third string of fire uses banks 7-8 in sections A or C with a 48-round belt. The gunner aims at paster 7 and fires the initial 6-round burst; traverses (four mils right) and fires another 6-round burst, repeating this traversing action four times. The next three squares require traverse and search manipulation (four mils right and two mils up) after each 6-round burst, ending the string of fire on paster 8.

Scored Firing

The scored firing portion of Table I tests the level that the machine gunner has mastered using the techniques required in practice firing. It consists of the same three strings of fire as practice firing, with the addition of 12 rounds for pasters B1 and B2 or D1 and D2 for fixed fire. Unlike practice firing, the strings of fire in scored firing are timed. Gunners must complete the string of fire within the designated time limit. Bursts that are fired past the time limit are not scored. Scored firing requires 102 rounds. The following strings of fire are included:

- First string (24 rounds). The first string of fire uses bank 1-4 in sections B or D with four belts of six rounds each—one for each paster. These are fixed-fire pasters, with no manipulation of the T&E mechanism required other than to obtain proper sight alignment and picture before firing the six-round burst. The loading of the second, third, and fourth belts are performed automatically within the time limit of 45 seconds.
- Second string (30 rounds). The second string of fire uses bank 5-6 in sections B or D with a 30-round belt. The gunner aims at paster 5 and fires the initial six-round burst. Traverse and search manipulation (two mils left and four mils down) is then required for each subsequent six-round burst. The gunner repeats this action four times, ending the string of fire on paster 6. The time limit is 30 seconds.
- Third string (48 rounds). The third string of fire uses bank 7-8 in sections B or D with a 48-round belt. The gunner aims at paster 7 and fires an initial six-round burst. The gunner then traverses (four mils right) and fires another six-round burst, repeating this traversing action four times. The next three pasters require traverse and search manipulation (four mils right and two mils up) after each six-round burst, ending the string of fire on paster 8. The time limit is 45 seconds.

Scoring

The total possible score for Table II is 102 points, with a minimum of 70 points for a passing score. Scoring criteria is as follows:

- Shot holes touching the boundary of a paster are considered hits, but can only be counted in one paster.
- Only rounds that impact on or within the line of the paster are scored.
- Each hit is scored as one point.
- Only six rounds per paster will be scored for a total of six points per paster.

> *NOTE:* The Table I score does not constitute complete qualification for the light, medium, or heavy machine gunner. Table II (Transition Course) must also be fired and the two scores added together in order to achieve a qualification score.

Table C-1. Qualification Ratings and Scores for Gunnery Table II.

Qualification Rating	Score	Percentile
Second-class gunner	70–80	68-78
First-class gunner	81–91	79-89
Expert machine gunner	92-102	90-100

GUNNERY TABLE II: TRANSITION COURSE OF FIRE

The transition course of fire completes qualification for the light, medium, and heavy machine gunner. It also provides the experience necessary to progress from the basic course (Table I) to field firing (Tables III through VI). This course should be fired on an automated target range with target distances between 400 and 1,000 meters. If an automated target range is not available, the course can be fired on any field firing range that can accommodate the appropriate target distances. The course is fired from a tripod and requires a single ammunition belt of 252 rounds (224 for the MK-19).

Crew Responsibilities

Although the gunner receives the score for Table II, it depends upon the combined efforts of every member of the crew. It is incumbent on each Marine in the team to exert a maximum effort to help the gunner obtain a qualifying score. The crew has the following responsibilities:

- *Team leader*. During this course, the team leader is responsible for estimating range, giving the gunner fire commands to engage the targets at their respective ranges, and moving the beaten zone onto the target.
- *Gunner*. The gunner is responsible for setting the rear sight to the appropriate range, laying the gun on target (sights at six o'clock to the target), firing controlled six-round bursts, manipulating the T&E mechanism until the beaten zone is adjusted onto the target, and performing immediate and remedial action as necessary.
- *Ammunition bearer*. The ammunition bearer is responsible for preparing the belt of ammunition and supplying it to the team leader for the exercise.

Target Engagement

The transition course of fire consists of 21 targets arranged in 13 separate target series. The last four are engaged while wearing chemical, biological, radiological, and nuclear (CBRN) protective equipment (i.e., gloves and field protective mask). Each target—

- Consists of either an E-type silhouette or a vehicle silhouette.
- Series is timed and requires the engagement of one, two, or three of these targets at different ranges from 400 – 1,000 meters.
- Engagement is conducted at the sustained rate six- to eight-round bursts (three to five for the MK-19) within the specified time limit. The goal during each engagement is to obtain first-burst effects on the target. The ammunition belt of 252 rounds (or 224 for the MK-19) allows two bursts for each of the 21 targets. Any leftover bursts resulting from a first-burst hit may be

applied to a target that was not hit with the first or second burst; however, no more than three bursts are allowed for any target. A penalty is applied for any target not hit during the exercise.

The targets are engaged in the following order:

- In a time limit of 60 seconds, engage 4 targets at a range within 500–600 meters, using fixed fire.
- In a time limit of 45 seconds, engage 3 targets at a range within 400–600 meters, using traversing fire.
- In a time limit of 45 seconds, engage 3 targets at a range within 600–1,000 meters, using searching fire.
- In a time limit of 45 seconds, engage 3 targets at a range within 600–1,000 meters, using searching and traversing fire.
- In a time limit of 45 seconds, engage 3 targets at a range within 400–500 meters, using swinging traverse fire.
- While in a CBRN posture wearing a field protective mask and gloves, in a time limit of 15 seconds, engage 1 target at a range within 500–600 meters, using fixed fire.
- While in a CBRN posture wearing a field protective mask and gloves, in a time limit of 30 seconds, engage 2 targets at a range within 400–800 meters, using searching and traversing fire.
- While in a CBRN posture wearing a field protective mask and gloves, in a time limit of 30 seconds, engage 2 targets at a range within 400–500 meters, using swinging traverse fire.

> *NOTE:* Because of the disparity in training ranges throughout the Marine Corps, trainers must be prepared to be flexible on setting up for the transition course of fire. A difference in target distances (up to 50 meters either long or short) is acceptable. Also, target banks (of four E-type silhouettes) may be substituted for the stationary vehicle silhouettes.

Scoring Procedures

The total possible score for Table II is 63 points, with a minimum of 42 points for a passing score. Points are given for each burst on target. The target must have at least one hit (multiple shot holes are not counted) as follows:

- Three points for a first-burst hit on a target.
- Two points for a second-burst hit on a target.
- One point for a third-burst hit on a target.
- Minus one point for any target not hit.

The crew can score a possible three points on each target. However, since the goal when conducting these courses is to achieve beaten zone on each target, a penalty of one point is incurred for each target not hit during the course of the exercise.

If the crew scored first-burst hits on the first three targets, 18 rounds (3 bursts) will remain on the ammunition belt and can be used for a third-burst attempt on any subsequent target that was not hit with the two allotted bursts for that target. No points are given for a fourth-burst hit on a target.

Table C-2. Qualification Ratings and Scores for Gunnery Table II.

Qualification Rating	Score	Percentile
Second class gunner	43-49	68-78
First class gunner	50-56	79-89
Expert machine gunner	57-63	90-100

Table C-3. Qualification Ratings and Associated Aggregate Scores for Gunnery Tables I and II.

Qualification Rating	Score	Percentile
Second class gunner	113-129	68-78
First class gunner	130-147	79-89
Expert machine gunner	148-165	90-100

GUNNERY TABLE III: RANGE CARD COURSE OF FIRE

This course is conducted on any field firing range with target distances between 400 and 900 meters and requires 168 rounds of ammunition. The course is designed to develop and test the machine gun team's ability to record and fire targets in a defensive situation. During target engagement, this course consists of three target series—four point targets, two linear targets, and an FPL. The targets are not automated and presented in a series; instead, they are fixed for the purposes of registration.

Each point target consists of either a double-E silhouette or a target bank of four single-E silhouettes and each linear target is delineated at its ends by double-E silhouettes. One linear target should be 100 mils wide and the other 100 mils deep. There is no time limit for target engagements.

Target engagements are conducted at the sustained rate of fire except for engagements on the FPL, which are fired at the rapid rate. The goal during each engagement is to get first-burst effects on the target. The ammunition load of 168 rounds allows 48 rounds for registering the FPL and 72 rounds for registering the 4 point and 2 linear targets, plus 12 rounds for engaging the FPL and 36 rounds for engaging the point and linear targets. Therefore, during the engagement (tested) portion of Table III, only one 6-round burst is allotted for the point or linear targets and a 12-round burst for the FPL. A penalty is applied for any target not hit during the tested portion. Target engagement occurs by registration first, then engagement. Registration has the following steps:

- With a 48-round belt of ammunition, register the FPL using 12-round bursts. This is not scored. Record the T&E data for the FPL on the range card.
- With a 48-round belt of ammunition, register the two double-E silhouette targets (one at 400 and one at 600 meters), and the two 4-silhouette target banks (one at 800 and one at 900 meters). This is not scored. Record the T&E data for the point targets on the range card.

- With a 24-round belt of ammunition, register the two linear targets; one shallow target at 500 meters and one deep target centered at 900 meters. Each of the targets is 100 mils wide or 100 mils deep. This is not scored. Record the T&E data for the linear targets on the range card.

Engagement has the following steps:

- Engage the two linear targets using T&E data from the range card, with a 12-round belt, firing at the sustained rate. If the gunner is not effective with their first burst on a target, they receive no score for that target and must move on to the next target. The team leader may designate either the shallow or deep target to be engaged first. This is scored.
- Engage the four point targets using T&E data from the range card, with a 24-round belt, firing at the sustained rate. If the gunner is not effective with the first burst on a target, they receive no score for that target and must move on to the next target. The squad leader designates the order to engage the point targets. This is scored.

Fire the FPL using T&E data from the range card with a 12-round belt, firing at the rapid rate. This burst must achieve grazing fire, as evidenced by the beaten zone striking a reference point determined during registration. This is scored.

Scoring Procedures

The total possible score for Table III is seven points, with a minimum of five points for a passing score. Points are given for hits as follows:

- One point for effects on the near linear target.
- One point for effects on the deep linear target.
- One point for effects on each point target with a total of four points possible.
- One point for effects of grazing fire on the FPL.

If the crew fails to achieve effects on the targets with their first-burst, they must move on to the next engagement. No points are given for a second-burst on a target.

GUNNERY TABLE IV: NIGHT VISION DEVICE COURSE

This course is conducted on any field firing range with targets between 300 and 800 meters and requires 144 rounds of ammunition. It is designed to test the machine gun team's ability to engage targets in a non-illuminated environment with the use of one of the following devices:

- Night aiming devices.
- Thermal optics.
- Image intensified optics.

During target engagement, the course consists of 10 targets arranged in 4 separate target series. Each target series is timed and consists of either a single-E silhouette or a vehicle silhouette target. Target engagements are conducted at the sustained rate within the specified time limit.

The goal during each engagement is to get first-burst effects on target. The ammunition belt of 144 rounds (or 96 for the MK-19) allows two 6–8 round bursts (3–5 for the MK-19) for each of the 10 targets. Any leftover bursts (resulting from a first-burst hit) may be applied to a target that was not hit with the first or second burst, but no more than three bursts are allowed for any target. A penalty is applied for any target not hit during the exercise.

Target engagement occurs in the following order:

- In a time limit of 15 seconds, engage 1 target at a range within 300–400 meters, using fixed fire.
- In a time limit of 45 seconds, engage 3 targets at a range within 400–500 meters, using traversing fire.
- In a time limit of 45 seconds, engage 3 targets at a range within 500–600 meters, using searching fire.
- In a time limit of 45 seconds, engage 3 targets at a range within 600–800 meters, using searching and traversing fire.

Scoring Procedures

The total possible score for Table IV is 30 points, with a minimum of 20 points for a passing score. Points are given for each burst on target. The target must have at least one hit (multiple shot holes are not counted) as follows:

- Three points for a first-burst hit on a target.
- Two points for a second-burst hit on a target.
- One point for a third-burst hit on a target.
- Minus one point for any target not hit.

The crew can score a possible three points on each target. However, since the goal when conducting these courses is to achieve beaten zone on each target, a penalty of one point is incurred for each target not hit during the course of the exercise.

The ammunition load allows for an allotment of two bursts for each of the 10 targets. Any leftover bursts (resulting from a first-burst hit) may be applied to a target that was not hit with the first or second burst, but no more than three bursts are allowed for any target.

GUNNERY TABLE V: VEHICLE-MOUNTED COURSE OF FIRE

This course is conducted on any field firing range with targets between 400 and 1,000 meters. It requires 192 rounds of ammunition for the M2A1 and 128 rounds for the MK-19. It is designed to test the operation of the machine gun team and their ability to engage targets while firing from a vehicle mounted platform.

During target engagement, this course consists of 13 targets and arranged in 4 separate target series. Each target series is timed and consists of a tank hulk target pre-positioned inside hazardous impact areas. For ranges that do not have a hazardous impact area, vehicle silhouettes can be used, or 4-E silhouettes to mimic a vehicle target. Target engagements are conducted at the sustained rate within the specified time limit.

The goal during each engagement is to get first-burst effects on target. The ammunition allotment allows for two bursts for each of the 13 targets. Any leftover bursts (resulting from a first-burst hit) may be applied to a target that was not hit with the first or second burst, but no more than three bursts are allowed for any target. A penalty is applied for any target not hit during the exercise.

Target engagement occurs in the following order:

- In a time limit of 60 seconds, engage 4 targets at a range within 500–600 meters, using fixed fire.
- In a time limit of 45 seconds, engage 3 targets at a range within 400–500 meters, using traversing fire.
- In a time limit of 45 seconds, engage 3 targets at a range within 600–1,000 meters, using searching fire.
- In a time limit of 45 seconds, engage 3 targets at a range within 600–1,000 meters, using searching and traversing fire.

Scoring Procedures

The total possible score for Table V is 48 points, with a minimum of 32 points for a passing score. Points are given for each burst on target. The target must have at least one hit (multiple shot holes are not counted) as follows:

- Three points for a first-burst hit on a target.
- Two points for a second-burst hit on a target.
- One point for a third-burst hit on a target.
- Minus one point for any target not hit.

The crew can score a possible three points on each target. However, since the goal when conducting these courses is to achieve beaten zone on each target, a penalty of one point is incurred for each target not hit during the course of the exercise.

The ammunition load allows for two bursts for each of the 13 targets. Any leftover bursts (resulting from a first-burst hit) may be applied to a target that was not hit with the first or second burst, but no more than three bursts are allowed for any target.

GUNNERY TABLE VI: BIPOD MULTIPLE-ENGAGEMENT COURSE

The bipod multiple-engagement course is conducted on any field firing range with targets between 100 and 400 meters and requires 132 rounds of ammunition. It is designed to further develop the machine gunner's skills when firing from the bipod. During target engagement, this course consists of 11 targets, arranged in seven separate target series. The last three targets are engaged while wearing CBRN protective equipment (i.e., gloves and field protective mask). Each target consists of either a single-E silhouette or a double-E silhouette target. The target series is timed and requires the engagement of one, two, or three of these targets at different ranges. Target engagement is conducted at the sustained rate within the specified time limit.

The goal during each engagement is to obtain first-burst effects on target. The ammunition belt of 132 rounds allows for two bursts for each of the 11 targets. Any leftover bursts resulting from a first-burst hit may be applied to a target that was not hit with the first or second burst. No more than three bursts are allowed for any target. A penalty is applied for any target not hit during the exercise.

Target engagement occurs in the following order:

- In a time limit of 10 seconds, engage a target at a range within 100–200 meters.
- In a time limit of 10 seconds, engage a target at a range within 200–400 meters.
- In a time limit of 20 seconds, engage two targets at a range within 100–400 meters.
- In a time limit of 30 seconds, engage three targets at a range within 300–500 meters.
- While wearing a field protective mask and gloves, and in a time limit of 10 seconds, engage a target at a range within 100–200 meters.
- While wearing a field protective mask and gloves, and in a time limit of 10 seconds, engage a target at a range within 200–400 meters.
- While wearing a field protective mask and gloves, and in a time limit of 20 seconds, engage two targets at a range within 100–400 meters.

Scoring Procedures

The total possible score for Table VI is 33 points, with a minimum of 22 points for a passing score. Points are given for each burst on target. The target must have at least one hit (multiple shot holes are not counted) as follows:

- Three points for a first-burst hit on a target.
- Two points for a second-burst hit on a target.
- One point for a third-burst hit on a target.
- Minus one point for any target not hit.

The crew can score a possible three points on each target. However, since the goal when conducting these courses is to achieve beaten zone on each target, a penalty of one point is incurred for each target not hit during the course of the exercise.

The ammunition load allows two bursts for each of the 13 targets. Any leftover bursts (resulting from a first-burst hit) may be applied to a target that was not hit with the first or second burst, but no more than three bursts are allowed for any target.

APPENDIX D.
CREW GUNNERY TABLES

A crew gunnery table is a course of fire that tests a machine gun crew's skill at employing the gun in a certain situation. These Tables should be conducted only after a machine gunner has demonstrated a basic level of proficiency by qualifying on gun-specific tables. Crew gunnery tables provide standardized training applicable to team level and higher machine gun events. Prior to firing any crew gunnery tables, machine guns should be collimated, zeroed, laser bore sighted, or the respective field-zeroing course fired. Crew gunnery tables provide the necessary training and qualification to progress from machine gun specific training to supporting maneuver units. Each table should be well rehearsed prior to live-fire qualification.

Gunnery tables VII-XII are as follows:

- Gunnery Table VII: Bipod to tripod transition course of fire.

  NOTE: Table VII cannot be fired with the MK-19 grenade machine gun or M2A1 HMG.

- Gunnery Table VIII: Support a dismounted assault by fire.
- Gunnery Table IX: Mounted antiarmor (counter-mechanized/motorized) attack by fire.
- Gunnery Table X: Engagement area course of fire.
- Gunnery Table XI: Antiarmor (counter-mechanized/motorized) engagement area (forward) course of fire.
- Gunnery Table XII: Anti armor (counter-mechanized/motorized) engagement area (main) course of fire.

GUNNERY TABLE VII: BIPOD-TO-TRIPOD TRANSITION COURSE OF FIRE

This course is conducted on any field firing range with a 20 m-wide target array at a distance within 600–800 meters. The ammunition requirement is 500 rounds. The targets can be automated or fixed; however, automated targets assist in scoring and assessing effects. The course is designed to develop and test the machine gun unit's ability to rapidly occupy an SBF position in an offensive situation engaging targets initially from the bipod and transitioning to the tripod without gapping continued suppression for a maneuvering force.

Target engagements are conducted at the rapid rate of fire for the first minute, then slowed to the sustained rate of fire. The goal during the sustained engagement is to achieve effects on the target array while transitioning the machine gun unit from bipod to tripod with no gaps in suppression.

This simulates a hasty occupation of an SBF with a need to support maneuver. The ammunition load of 500 rounds allows for 200 rounds to be fired in the first minute, using talking guns, resulting in a maximum of 20 bursts. The remaining ammunition allows for 300 rounds to be fired in the last three minutes, using talking guns, at the sustained rate, resulting in a maximum of 50 bursts. The engagement is conducted in the following order:

- Unit leader conducts a leader's reconnaissance and issues the initial fire command.

  NOTE: The evaluator begins time when the unit is put into action.
- Upon occupation, the unit engages the target array from the bipod at the rapid rate for one minute. During the first minute, the transition of the guns to employment from a tripod is made without degrading the assigned rate of fire or effects.
- The unit continues to engage the target array, dropping down to the sustained rate of fire for three minutes using traversing fire.

Scoring Procedures

The total possible score for Table VII is 70 points, with a minimum of 54 points for a passing score. A unit must achieve a minimum of 14 out of 20 for the rapid rate (initial minute) and 40 out of 50 for the sustained rate (final three minutes):

- Each crew being evaluated starts with a maximum score of 70, which represents the maximum bursts available at one point per burst.
- Each burst missed is a penalty of one point.
- Each burst that is less than the required rate of fire burst (less than 10 for rapid or 6 for sustained) is a miss, thus penalizing the crew by one point.
- Crews must sustain fire for a minimum of four minutes; failure to meet the time constitutes a lack of crew control, thus failing the course of fire.
- Any gap of more than 10 seconds between bursts constitutes a penalty of one point.
- Any crew not on target by the third burst fired fails automatically.
- Failure to traverse the target array throughout the engagement constitutes failure.

The crew can score 20 possible points during the first minute and 50 possible points in the final three minutes. However, since the goal when conducting this course is to maintain effects on target, a penalty of one point is incurred for every 10 seconds a target is not hit during the course of the exercise.

Gunnery Table VIII: Support a Dismounted Assault by Fire Course of Fire

This course is conducted on any field firing range with two groups of targets, referred to as objectives. The ammunition requirement is 1,300 rounds. Table VIII trains and qualifies a machine gun section in offensive employment in support of a maneuvering unit. The section must occupy a SBF position by force with procedures that would provide their own supporting fires during daylight. When executed during limited visibility, the SBF is occupied by stealth. Occupation by force requires that the machine gun unit provide either direct or indirect suppressive fires against an enemy position to occupy the SBF position. Occupation by stealth is conducted when the machine gun unit can occupy the SBF position unopposed and unaffected by enemy direct or indirect fire assets. The section is evaluated on their ability to accurately engage enemy defensive positions, manage ammunition consumption, manage the dispersion of fires, shift fires, adjust rates of fire, issue and follow initial and follow-on fire commands, and displace by unit. Table I is timed to evaluate rates of fire and the ability to occupy and displace in a controlled, efficient manner. The targets can be automated or fixed; however, automated targets assist in scoring and assessing effects. The target layout is as follows:

- Group 1 is a 20 m target array at 600–800 meters (referred to as objective 1).
- Group 2 is a 30 m target array at 900–1,100 meters (referred to as objective 2).

Prior to target engagement, the unit leader organizes the section, conducts a leader's reconnaissance, and issues the initial fire command (assigning five minutes of suppression on both objectives). The goal during the engagement is to occupy the SBF position with the ability to immediately provide fires, achieving effects on the target array in order to retain the position while transitioning the machine gun unit from bipod to tripod with no gaps in suppression. This simulates the opposed occupation of an SBF position with a need to support maneuver. The ammunition load of 1,300 rounds allows for 400 rounds to be fired in the first minute, using talking guns, resulting in a maximum of 40 bursts split between objectives, for a total of 40 points, with 36 points being the minimum. After the initial minute, 600 rounds are allotted for 3 minutes of suppression at the sustained rate on both objectives, using talking guns, resulting in a maximum of 72 bursts for 72 points, with a minimum score of 68 to pass. The remaining ammunition of 300 rounds allows for a final 3-minute engagement, firing at the sustained rate, using talking guns, with all guns firing on objective 2, resulting in a maximum of 36 bursts.

> *NOTE:* The final engagement of this drill should focus on the gunnery required to cover a 30 meters target at 900 – 1,100 meters, which is roughly 30 mils of traverse. One gun firing on this at a time allows for the ammunition to last for the duration. The intent is for the section leader to appropriately distribute fires across the entirety of the object. Knowing that one machine gun can cover 50 mils of traverse will determine how the section leader employs the entire section against a target that is roughly 30 mils wide. The inability to traverse the entirety of the objective should be focused on.

GUNNERY TABLE IX: MOUNTED ANTIARMOR (COUNTER-MECHANIZED/ MOTORIZED) ATTACK BY FIRE COURSE OF FIRE

This course of fire is conducted with the HMG/grenade machine gun section with three distinct mechanized/motorized enemy vehicles. Table IX trains and qualifies the HMG section in offensive machine gun employment to neutralize/destroy enemy vehicles and materiel. The table allows the section to move from a defilade position, engage vehicle-type targets using fixed fire, and displace by echelon to continue the attack by fire. The target layout is as follows:

- Target 1 is at 1,200–1,500 meters.
- Target 2 is at 1,800–2,100 meters.
- Target 3 (separate from target 1) is at 1,200–1,500 meters.

The ammunition load for a section or mixed section of heavy/grenade machine guns is 360 rounds of .50 caliber ammunition, 352 rounds of HE or target practice (abbreviated as TP) 40 mm ammunition, or a combination of both .50 caliber and 40 mm ammunition that provides the section with 360 rounds. The total time for the course of fire is 12 minutes. Once the section has been organized and detailed rehearsals have been conducted, the initial fire command should be issued. The evaluator begins the time when the section is put into action. Targets 1 and 2 are simultaneously engaged at the rapid rate for no more than 30 seconds, or the time it takes to get effective fires on targets 1 and 2 by the third burst of fire. The total score for this part is 10 points, with 6 being the minimum to pass. At this point, the rate of fire should transition to sustained fire on targets 1 and 2 for 3 minutes, for a total of 24 points. Upon announcement from the evaluator of "*Target 1 destroyed/neutralized*" at the end of 3 minutes, the section should displace by echelon and engage target 3 with the displaced squad for 1 minute at the rapid rate, for a score of 8 out of 10 to pass. At this time, the evaluator announces that target 2 has been destroyed, which triggers the remaining squad to displace and join to form the section on target 3, engaging as a section now at the sustained rate for 3 minutes. After 3 minutes, the evaluator announces "*Target 3 destroyed*." A total score of 12 out of 12 is required to pass. At this time, the unit displaces to a position of cover and time stops. To pass the drill, 12 minutes must be met.

Scoring Procedures

A minimum score of 50 out of a possible 56 must be achieved while providing offensive fires.

Administrative Instructions

The following administrative instructions apply:

- The target array must represent three separate vehicles.
- A beaten zone that lands on the target is considered a hit and is scored one point.
- The section is evaluated as a whole to achieve the minimum score.
- The section can be M2A1 pure, MK-19 pure, or a mixture of M2A1 and MK-19.
- If range restrictions do not allow displacement to another firing point, the squad/section can prepare the weapon and vehicle for movement and then put the gun back into action.

Prerequisite Events

Table II (M2A1/MK-19).
Table IV (M2A1/MK-19).

Gunnery Table X: Engagement Area Course of Fire

This course is conducted on any field firing range with six groups of targets, one of which demonstrates an FPL. The ammunition requirement is 656 rounds. The course is designed to develop and test the machine gun unit's ability to provide defensive fires using the different classes of fire with respect to the gun. This focuses specifically on the crew's leadership with regards to assigning TRPs and the follow-on crew's ability to engage targets under commands to evaluate and correct range cards. The targets can be automated or fixed; however, automated targets assist in scoring and assessing effects. The target layout is as follows:

- Group 1 is a linear series of targets 30 meters wide, parallel to the gun line, at a range of 900–1,100 meters.
- Group 2 is a linear series of targets 20 meters long, perpendicular to the gun line, at a range of 800–1,000 meters.
- Group 3 is a linear series of targets 30 meters long, oblique to the gun line, at a range of 600–800 meters.
- Group 4 is a single target at a range of 300–400 meters and placed along the FPL.
- Group 5 is a linear series of targets 10 meters wide, parallel to the gun line, at a range of 200–300 meters.
- Group 6 is three E-silhouette targets at a range of 100–200 meters.

Prior to target engagement, the unit leader assigns a mission, position, and TRPs to the subordinate units. Team or squad leaders develop range cards and submit a copy to the unit leader. The section or squad leader directs the registration of the range card by firing a 6- to 8-round burst from each gun onto each target. Target engagements are conducted with 6- to 8-round bursts for the course of fire. The engagement is conducted in the following order:

- Engage target 1 with six 6- to 8-round bursts of traversing fire per gun, overlapping the sector of fire for a score of 11 out of a possible 12.
- Engage target 2 with four 6- to 8-round bursts of searching fire, overlapping sector of fire for a score of 7 out of a possible 8.
- Engage target 3 with six 6- to 8-round bursts of searching and traversing fire, overlapping sector of fire for a score of 11 out of a possible 12.
- Engage target 4 (FPL) with six 6- to 8-round bursts of fixed fire for a score of 11 out of a possible 12.
- Engage target 5 with four 6- to 8-round bursts of swinging traverse, overlapping sector of fire for a score of 7 out of a possible 8.
- Engage target 6 with three 6- to 8-round bursts of free gun for a score of 6 out of a possible 6.

Scoring Procedures

The unit must achieve a minimum score of 53 out of a possible 58 while providing defensive fires utilizing different classes of fire in respect to the gun.

GUNNERY TABLE XI: ANTIARMOR (COUNTER-MECHANIZED/MOTORIZED) ENGAGEMENT AREA (FORWARD) COURSE OF FIRE

Table XI trains and qualifies the heavy/grenade machine gun section in defensive machine gun employment to disrupt, delay, destroy, or neutralize enemy vehicles and dismounted personnel. The table allows the section to create and register a range card, move from a cold to hot position, engage vehicle and personnel targets using fixed fire, traversing fire, and displace by unit. Efforts should be made to focus on neutralizing enemy vehicles and subsequently dismounting enemy troops. The ammunition requirement is 496 rounds of .50 caliber ammunition, 480 rounds of HE or target practice 40 mm ammunition, or if using a mixed section, then a combination of both .50 caliber and 40 mm ammunition totaling 496 rounds.

Prior to target engagement, the section is organized as either pure HMG, pure grenade machine gun, or mixed. The unit then assigns a PDF mission, positions, and TRPs. After machine guns are laid, the squad leaders should develop and submit range cards. The section leader then directs the registration of the range card. A six-to-eight or three-to-five round burst per target is expected. An evaluator should be assigned to paint the vehicle target exposures. Once the squad leader updates the data section on the range card, the section leader directs the engagement as follows:

- Engage target 1 with five 6- to 8-round bursts of fixed fire for a score of 4 out of a possible 5.
- Engage target 2 with five 6- to 8-round bursts of fixed fire for a score of 4 out of a possible 5.
- Engage target 3 with five 6- to 8-round bursts of fixed fire for a score of 4 out of a possible 5.
- Engage target 4 with five 6- to 8-round bursts of fixed fire for a score of 4 out of a possible 5 (the evaluator exposes or paints the silhouette targets).
- Engage target 1 with eight 6- to 8-round bursts of traversing fire, overlapping sectors of fire for a score of 7 out of a possible 8.
- Engage target 2 with eight 6- to 8-round bursts of traversing fire, overlapping sectors of fire for a score of 7 out of a possible 8.
- Engage target 3 with eight 6- to 8-round bursts of traversing fire, overlapping sectors of fire for a score of 7 out of a possible 8.
- Engage target 4 with eight 6- to 8-round bursts of traversing fire, overlapping sectors of fire for a score of 7 out of a possible 8 (the evaluator gives the signal for displacement). Then the section displaces by unit.

Scoring Procedures

The unit must achieve a minimum score of 44 out of a possible 52 while providing defensive fires utilizing different classes of fire with respect to the gun.

Administrative Instructions

The following administrative instructions apply:

- The target array must represent four separate vehicles.
- A beaten zone that lands on the target is considered a hit and is scored one point.
- The section is evaluated as a whole to achieve the minimum score.

- The section can be M2A1 pure, MK-19 pure, or a mixture of M2A1 and MK-19.
  A 6- to 8-round burst is made for HMGs or 3- to 5-round bursts for grenade machine guns.

Prerequisite Events
Table II (M2A1/MK-19).
Table III (M2A1).
Table IV (M2A1/MK-19).
Table IX (M2A1/MK-19).

GUNNERY TABLE XII: ANTIARMOR (COUNTER-MECHANIZED/MOTORIZED) ENGAGEMENT AREA (MAIN) COURSE OF FIRE

Table XII trains and qualifies the HMG section (both heavy and grenade machine guns) in defensive machine gun employment to disrupt, destroy, or neutralize enemy vehicles and dismounted personnel after the dismount point. The table allows the section to create and register a range card, engage vehicle and personnel targets using fixed fire, traversing fire, searching fire, and searching and traversing fire. This table requires 480 rounds of ammunition, either ball, HE or TP in support of pure or mixed sections. The following information applies to the target layout:

- Target group 1 is a 200 meters wide vehicle target array at 1,600–2,000 meters, designated as target 1.
- Target group 2 is a 200 meters deep vehicle target array at 800–1,200 meters, designated as target 2.
- Target group 3 is a 100 meters wide target array of vehicle and silhouette target arrays at 400 meters, designated as target 3.
- Target group 4 is a 100 meters wide target array of vehicle and silhouette targets at 300 meters, designated as target 4.

Prior to target engagement, the section is organized as either pure HMG, pure grenade machine gun, or mixed. The unit is then assigned a PDF mission, positions, and TRPs. After the machine guns are laid, the squad leaders should develop and submit range cards. The section leader then directs the registration of the range card. A six-to-eight or three-to-five-round burst per target is expected. An evaluator should be assigned to paint the vehicle target exposures. Once the squad leader updates the data section on the range card, the section leader directs the engagement as follows:

- Engage target 1 with 12 six-to-eight-round bursts of traversing fire, with overlapping sectors of fire for a score of 11 out of a possible 12 (the evaluator exposes or paints target 2).
- Engage target 2 with 12 six-to-eight-round bursts of searching fire, with overlapping sectors of fire for a score of 11 out of a possible 12 (the evaluator exposes or paints target 3).
- Engage target 3 with 14 six-to-eight-round bursts of traversing fire, with overlapping sectors of fire for a score of 13 out of a possible 14.
- Engage target 4 with 8 six-to-eight-round bursts of swinging traverse fire for a score of 7 out of a possible 8.

Scoring Procedures

The unit must achieve a minimum score of 42 out of a possible 46 while providing defensive fires utilizing different classes of fire with respect to the gun.

Administrative Instructions

The following administrative instructions apply:

- The target array must represent three separate vehicles closing to the blocking obstacle (400 meters range).
- A beaten zone that lands on the target is considered a hit and is scored one point.
- The section is evaluated as a whole to achieve the minimum score.
- The section can be M2A1 pure, MK-19 pure, or a mixture of M2A1 and MK-19.

Prerequisite Events

Table II (M2A1/MK-19).
Table III (M2A1).
Table IV (M2A1/MK-19).
Table IX (M2A1/MK-19).
Table XI (M2A1/MK-19).

APPENDIX E.
ROUND CONSUMPTION CHARTS

Table E-1. M240G/M249.

(The rate of fire for the M240 and the M249 is so close for the ease of the user only one chart is used.)																				
Time Interval	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Rounds per Min	**240**	**160**	**120**	**96**	**80**	**69**	**60**	**53**	**48**	**44**	**40**	**37**	**34**	**32**	**30**	**28**	**27**	**25**	**24**	**23**
Rounds																				
100	0.25	0.38	0.50	1.03	1.15	1.28	1.40	1.53	2.05	2.18	2.30	2.43	2.55	3.08	3.20	3.33	3.45	3.58	4.10	4.23
200	0.50	1.15	1.40	2.05	2.30	2.55	3.20	3.45	4.10	4.35	5.00	5.25	5.50	6.15	6.40	7.05	7.30	7.55	8.20	8.45
300	1.15	1.53	2.30	3.08	3.45	4.23	5.00	5.38	6.15	6.53	7.30	8.08	8.45	9.23	10.00	10.38	11.15	11.53	12.30	13.08
400	1.40	2.30	3.20	4.10	5.00	5.50	6.40	7.30	8.20	9.10	10.00	10.50	11.40	12.30	13.20	14.10	15.00	15.50	16.40	17.30
500	2.05	3.08	4.10	5.13	6.15	7.18	8.20	9.23	10.25	11.28	12.30	13.33	14.35	15.38	16.40	17.43	18.45	19.48	20.50	21.53
600	2.30	3.45	5.00	6.15	7.30	8.45	10.00	11.15	12.30	13.45	15.00	16.15	17.30	18.45	20.00	21.15	22.30	23.45	25.00	26.15
700	2.55	4.23	5.50	7.18	8.45	10.13	11.40	13.08	14.35	16.03	17.30	18.58	20.25	21.53	23.20	24.48	26.15	27.43	29.10	30.38
800	3.20	5.00	6.40	8.20	10.00	11.40	13.20	15.00	16.40	18.20	20.00	21.40	23.20	25.00	26.40	28.20	30.00	31.40	33.20	35.00
900	3.45	5.38	7.30	9.23	11.15	13.08	15.00	16.53	18.45	20.38	22.30	24.23	26.15	28.08	30.00	31.53	33.45	35.38	37.30	39.23
1000	4.10	6.15	8.20	10.25	12.30	14.35	16.40	18.45	20.50	22.55	25.00	27.05	29.10	31.15	33.20	35.25	37.30	39.35	41.40	43.45
1100	4.35	6.53	9.10	11.28	13.45	16.03	18.20	20.38	22.55	25.13	27.30	29.48	32.05	34.23	36.40	38.58	41.15	43.33	45.50	48.08
1200	5.00	7.30	10.00	12.30	15.00	17.30	20.00	22.30	25.00	27.30	30.00	32.30	35.00	37.30	40.00	42.30	45.00	47.30	50.00	52.30
1300	5.25	8.08	10.50	13.33	16.15	18.58	21.40	24.23	27.05	29.48	32.30	35.13	37.55	40.38	43.20	46.03	48.45	51.28	54.10	56.53

Table E-1. M240G/M249. (Continued)

(The rate of fire for the M240 and the M249 is so close for the ease of the user only one chart is used.)

Time Interval	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Rounds per Min	**240**	**160**	**120**	**96**	**80**	**69**	**60**	**53**	**48**	**44**	**40**	**37**	**34**	**32**	**30**	**28**	**27**	**25**	**24**	**23**
Rounds																				
1400	5.50	8.45	11.40	14.35	17.30	20.25	23.20	26.15	29.10	32.05	35.00	37.55	40.50	43.45	46.40	49.35	52.30	55.25	58.20	61.15
1500	6.15	9.23	12.30	15.38	18.45	21.53	25.00	28.08	31.15	34.23	37.30	40.38	43.45	46.53	50.00	53.08	56.15	59.23	62.30	65.38
1600	6.40	10.00	13.20	16.40	20.00	23.20	26.40	30.00	33.20	36.40	40.00	43.20	46.40	50.00	53.20	56.40	60.00	63.20	66.40	70.00
1700	7.05	10.38	14.10	17.43	21.15	24.48	28.20	31.53	35.25	38.58	42.30	46.03	49.35	53.08	56.40	60.13	63.45	67.18	70.50	74.23
1800	7.30	11.15	15.00	18.45	22.30	26.15	30.00	33.45	37.30	41.15	45.00	48.45	52.30	56.15	60.00	63.45	67.30	71.15	75.00	78.45
1900	7.55	11.53	15.50	19.48	23.45	27.43	31.40	35.38	39.35	43.33	47.30	51.28	55.25	59.23	63.20	67.18	71.15	75.13	79.10	83.08
2000	8.20	12.30	16.40	20.50	25.00	29.10	33.20	37.30	41.40	45.50	50.00	54.10	58.20	62.30	66.40	70.50	75.00	79.10	83.20	87.30
2100	8.45	13.08	17.30	21.53	26.15	30.38	35.00	39.23	43.45	48.08	52.30	56.53	61.15	65.38	70.00	74.23	78.45	83.08	87.30	91.53
2200	9.10	13.45	18.20	22.55	27.30	32.05	36.40	41.15	45.50	50.25	55.00	59.35	64.10	68.45	73.20	77.55	82.30	87.05	91.40	96.15
2300	9.35	14.23	19.10	23.58	28.45	33.33	38.20	43.08	47.55	52.43	57.30	62.18	67.05	71.53	76.40	81.28	86.15	91.03	95.50	100.38
2400	10.00	15.00	20.00	25.00	30.00	35.00	40.00	45.00	50.00	55.00	60.00	65.00	70.00	75.00	80.00	85.00	90.00	95.00	100.00	105.00
2500	10.25	15.38	20.50	26.03	31.15	36.28	41.40	46.53	52.05	57.18	62.30	67.43	72.55	78.08	83.20	88.33	93.45	98.58	104.10	109.23
2600	10.50	16.15	21.40	27.05	32.30	37.55	43.20	48.45	54.10	59.35	65.00	70.25	75.50	81.15	86.40	92.05	97.30	102.55	108.20	113.45
2700	11.15	16.53	22.30	28.08	33.45	39.23	45.00	50.38	56.15	61.53	67.30	73.08	78.45	84.23	90.00	95.38	101.15	106.53	112.30	118.08
2800	11.40	17.30	23.20	29.10	35.00	40.50	46.40	52.30	58.20	64.10	70.00	75.50	81.40	87.30	93.20	99.10	105.00	110.50	116.40	122.30
2900	12.08	18.12	24.16	30.20	36.25	42.02	48.33	54.71	60.41	65.90	72.5	78.37	85.29	90.62	96.66	103.57	107.40	116	120.83	126.08
3000	12.30	18.45	25.00	31.15	37.30	43.45	50.00	56.15	62.30	68.45	75.00	81.15	87.30	93.45	100.00	106.15	112.30	118.45	125.00	131.15
3100	12.55	19.23	25.50	32.18	38.45	45.13	51.40	58.08	64.35	71.03	77.30	83.58	90.25	96.53	103.20	109.48	116.15	122.43	129.10	135.38

Table E-2. M2 .50 Caliber.

Time Interval	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Rounds per Min	**180**	**120**	**90**	**72**	**60**	**51**	**45**	**40**	**36**	**33**	**30**	**28**	**26**	**24**	**23**	**21**	**20**	**19**	**18**	**17**
Rounds																				
100	0.33	0.50	1.07	1.23	1.40	1.57	2.13	2.30	2.47	3.03	3.20	3.37	3.53	4.10	4.27	4.43	5.00	5.17	5.33	5.50
200	1.07	1.40	2.13	2.47	3.20	3.53	4.27	5.00	5.33	6.07	6.40	7.13	7.47	8.20	8.53	9.27	10.00	10.33	11.07	11.40
300	1.40	2.30	3.20	4.10	5.00	5.50	6.40	7.30	8.20	9.10	10.00	10.50	11.40	12.30	13.20	14.10	15.00	15.50	16.40	17.30
400	2.13	3.20	4.27	5.33	6.40	7.47	8.53	10.00	11.07	12.13	13.20	14.27	15.33	16.40	17.47	18.53	20.00	21.07	22.13	23.20
500	2.47	4.10	5.33	6.57	8.20	9.43	11.07	12.30	13.53	15.17	16.40	18.03	19.27	20.50	22.13	23.37	25.00	26.23	27.47	29.10
600	3.20	5.00	6.40	8.20	10.00	11.40	13.20	15.00	16.40	18.20	20.00	21.40	23.20	25.00	26.40	28.20	30.00	31.40	33.20	35.00
700	3.53	5.50	7.47	9.43	11.40	13.37	15.33	17.30	19.27	21.23	23.20	25.17	27.13	29.10	31.07	33.03	35.00	36.57	38.53	40.50
800	4.27	6.40	8.53	11.07	13.20	15.33	17.47	20.00	22.13	24.27	26.40	28.53	31.07	33.20	35.33	37.47	40.00	42.13	44.27	46.40
900	5.00	7.30	10.00	12.30	15.00	17.30	20.00	22.30	25.00	27.30	30.00	32.30	35.00	37.30	40.00	42.30	45.00	47.30	50.00	52.30
1000	5.33	8.20	11.07	13.53	16.40	19.27	22.13	25.00	27.47	30.33	33.20	36.07	38.53	41.40	44.27	47.13	50.00	52.47	55.33	58.20
1100	6.07	9.10	12.13	15.17	18.20	21.23	24.27	27.30	30.33	33.37	36.40	39.43	42.47	45.50	48.53	51.57	55.00	58.03	61.07	64.10
1200	6.40	10.00	13.20	16.40	20.00	23.20	26.40	30.00	33.20	36.40	40.00	43.20	46.40	50.00	53.20	56.40	60.00	63.20	66.40	70.00
1300	7.13	10.50	14.27	18.03	21.40	25.17	28.53	32.30	36.07	39.43	43.20	46.57	50.33	54.10	57.47	61.23	65.00	68.37	72.13	75.50
1400	7.47	11.40	15.33	19.27	23.20	27.13	31.07	35.00	38.53	42.47	46.40	50.33	54.27	58.20	62.13	66.07	70.00	73.53	77.47	81.40
1500	8.20	12.30	16.40	20.50	25.00	29.10	33.20	37.30	41.40	45.50	50.00	54.10	58.20	62.30	66.40	70.50	75.00	79.10	83.20	87.30
1600	8.53	13.20	17.47	22.13	26.40	31.07	35.33	40.00	44.27	48.53	53.20	57.47	62.13	66.40	71.07	75.33	80.00	84.27	88.53	93.20
1700	9.27	14.10	18.53	23.37	28.20	33.03	37.47	42.30	47.13	51.57	56.40	61.23	66.07	70.50	75.33	80.17	85.00	89.43	94.27	99.10

Table E-2. M2 .50 Caliber. (Continued)

Time Interval	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Rounds per Min	**180**	**120**	**90**	**72**	**60**	**51**	**45**	**40**	**36**	**33**	**30**	**28**	**26**	**24**	**23**	**21**	**20**	**19**	**18**	**17**
Rounds																				
1800	10.00	15.00	20.00	25.00	30.00	35.00	40.00	45.00	50.00	55.00	60.00	65.00	70.00	75.00	80.00	85.00	90.00	95.00	100.00	105.00
1900	10.33	15.50	21.07	26.23	31.40	36.57	42.13	47.30	52.47	58.03	63.20	68.37	73.53	79.10	84.27	89.43	95.00	100.17	105.33	110.50
2000	11.07	16.40	22.13	27.47	33.20	38.53	44.27	50.00	55.33	61.07	66.40	72.13	77.47	83.20	88.53	94.27	100.00	105.33	111.07	116.40
2100	11.40	17.30	23.20	29.10	35.00	40.50	46.40	52.30	58.20	64.10	70.00	75.50	81.40	87.30	93.20	99.10	105.00	110.50	116.40	122.30
2200	12.13	18.20	24.27	30.33	36.40	42.47	48.53	55.00	61.07	67.13	73.20	79.27	85.33	91.40	97.47	103.53	110.00	116.07	122.13	128.20
2300	12.47	19.10	25.33	31.57	38.20	44.43	51.07	57.30	63.53	70.17	76.40	83.03	89.27	95.50	102.13	108.37	115.00	121.23	127.47	134.10
2400	13.20	20.00	26.40	33.20	40.00	46.40	53.20	60.00	66.40	73.20	80.00	86.40	93.20	100.00	106.40	113.20	120.00	126.40	133.20	140.00
2500	13.53	20.50	27.47	34.43	41.40	48.37	55.33	62.30	69.27	76.23	83.20	90.17	97.13	104.10	111.07	118.03	125.00	131.57	138.53	145.50
2600	14.27	21.40	28.53	36.07	43.20	50.33	57.47	65.00	72.13	79.27	86.40	93.53	101.07	108.20	115.33	122.47	130.00	137.13	144.27	151.40
2700	15.00	22.30	30.00	37.30	45.00	52.30	60.00	67.30	75.00	82.30	90.00	97.30	105.00	112.30	120.00	127.30	135.00	142.30	150.00	157.30
2800	15.33	23.20	31.07	38.53	46.40	54.27	62.13	70.00	77.47	85.33	93.20	101.07	108.53	116.40	124.27	132.13	140.00	147.47	155.33	163.20
2900	16.11	24.16	32.22	40.27	48.33	56.86	64.44	72.5	80.55	87.87	96.66	103.57	11.53	120.83	126.08	138.09	145	152.63	161.11	170.58
3000	16.40	25.00	33.20	41.40	50.00	58.20	66.40	75.00	83.20	91.40	100.00	108.20	116.40	125.00	133.20	141.40	150.00	158.20	166.40	175.00
3100	17.13	25.50	34.27	43.03	51.40	60.17	68.53	77.30	86.07	94.43	103.20	111.57	120.33	129.10	137.47	146.23	155.00	163.37	172.13	180.50
3200	17.47	26.40	35.33	44.27	53.20	62.13	71.07	80.00	88.53	97.47	106.40	115.33	124.27	133.20	142.13	151.07	160.00	168.53	177.47	186.40

Table E-3. MK-19 32-Round Can.

Time Interval	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Rounds per Min	**180**	**120**	**90**	**72**	**60**	**57**	**45**	**40**	**36**	**33**	**30**	**28**	**26**	**24**	**23**	**21**	**20**	**19**	**18**	**17**
Rounds																				
32	0.11	0.16	0.21	0.27	0.32	0.37	0.43	0.48	0.53	0.59	1.04	1.09	1.15	1.20	1.25	1.31	1.36	1.41	1.47	1.52
64	0.21	0.32	0.43	0.53	1.04	1.15	1.25	1.36	1.47	1.57	2.08	2.19	2.29	2.40	2.51	3.01	3.12	3.23	3.33	3.44
96	0.32	0.48	1.04	1.20	1.36	1.52	2.08	2.24	2.40	2.56	3.12	3.28	3.44	4.00	4.16	4.32	4.48	5.04	5.20	5.36
128	0.43	1.04	1.25	1.47	2.08	2.29	2.51	3.12	3.33	3.55	4.16	4.37	4.59	5.20	5.41	6.03	6.24	6.45	7.07	7.28
160	0.53	1.20	1.47	2.13	2.40	3.07	3.33	4.00	4.27	4.53	5.20	5.47	6.13	6.40	7.07	7.33	8.00	8.27	8.53	9.20
192	1.04	1.36	2.08	2.40	3.12	3.44	4.16	4.48	5.20	5.52	6.24	6.56	7.28	8.00	8.32	9.04	9.36	10.08	10.40	11.12
224	1.15	1.52	2.29	3.07	3.44	4.21	4.59	5.36	6.13	6.51	7.28	8.05	8.43	9.20	9.57	10.35	11.12	11.49	12.27	13.04
256	1.25	2.08	2.51	3.33	4.16	4.59	5.41	6.24	7.07	7.49	8.32	9.15	9.57	10.40	11.23	12.05	12.48	13.31	14.13	14.56
288	1.36	2.24	3.12	4.00	4.48	5.36	6.24	7.12	8.00	8.48	9.36	10.24	11.12	12.00	12.48	13.36	14.24	15.12	16.00	16.48
320	1.47	2.40	3.33	4.27	5.20	6.13	7.07	8.00	8.53	9.47	10.40	11.33	12.27	13.20	14.13	15.07	16.00	16.53	17.47	18.40
352	1.57	2.56	3.55	4.53	5.52	6.51	7.49	8.48	9.47	10.45	11.44	12.43	13.41	14.40	15.39	16.37	17.36	18.35	19.33	20.32
384	2.08	3.12	4.16	5.20	6.24	7.28	8.32	9.36	10.40	11.44	12.48	13.52	14.56	16.00	17.04	18.08	19.12	20.16	21.20	22.24
416	2.19	3.28	4.37	5.47	6.56	8.05	9.15	10.24	11.33	12.43	13.52	15.01	16.11	17.20	18.29	19.39	20.48	21.57	23.07	24.16
448	2.29	3.44	4.59	6.13	7.28	8.43	9.57	11.12	12.27	13.41	14.56	16.11	17.25	18.40	19.55	21.09	22.24	23.39	24.53	26.08
480	2.40	4.00	5.20	6.40	8.00	9.20	10.40	12.00	13.20	14.40	16.00	17.20	18.40	20.00	21.20	22.40	24.00	25.20	26.40	28.00
512	2.51	4.16	5.41	7.07	8.32	9.57	11.23	12.48	14.13	15.39	17.04	18.29	19.55	21.20	22.45	24.11	25.36	27.01	28.27	29.52
544	3.01	4.32	6.03	7.33	9.04	10.35	12.05	13.36	15.07	16.37	18.08	19.39	21.09	22.40	24.11	25.41	27.12	28.43	30.13	31.44

Table E-3. MK-19 32-Round Can. (Continued)

Time Interval	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Rounds per Min	**180**	**120**	**90**	**72**	**60**	**57**	**45**	**40**	**36**	**33**	**30**	**28**	**26**	**24**	**23**	**21**	**20**	**19**	**18**	**17**
Rounds																				
576	3.12	4.48	6.24	8.00	9.36	11.12	12.48	14.24	16.00	17.36	19.12	20.48	22.24	24.00	25.36	27.12	28.48	30.24	32.00	33.36
608	3.23	5.04	6.45	8.27	10.08	11.49	13.31	15.12	16.53	18.35	20.16	21.57	23.39	25.20	27.01	28.43	30.24	32.05	33.47	35.28
640	3.33	5.20	7.07	8.53	10.40	12.27	14.13	16.00	17.47	19.33	21.20	23.07	24.53	26.40	28.27	30.13	32.00	33.47	35.33	37.20
672	3.44	5.36	7.28	9.20	11.12	13.04	14.56	16.48	18.40	20.32	22.24	24.16	26.08	28.00	29.52	31.44	33.36	35.28	37.20	39.12
704	3.55	5.52	7.49	9.47	11.44	13.41	15.39	17.36	19.33	21.31	23.28	25.25	27.23	29.20	31.17	33.15	35.12	37.09	39.07	41.04
736	4.05	6.08	8.11	10.13	12.16	14.19	16.21	18.24	20.27	22.29	24.32	26.35	28.37	30.40	32.43	34.45	36.48	38.51	40.53	42.56
768	4.16	6.24	8.32	10.40	12.48	14.56	17.04	19.12	21.20	23.28	25.36	27.44	29.52	32.00	34.08	36.16	38.24	40.32	42.40	44.48
800	4.27	6.40	8.53	11.07	13.20	15.33	17.47	20.00	22.13	24.27	26.40	28.53	31.07	33.20	35.33	37.47	40.00	42.13	44.27	46.40
832	4.37	6.56	9.15	11.33	13.52	16.11	18.29	20.48	23.07	25.25	27.44	30.03	32.21	34.40	36.59	39.17	41.36	43.55	46.13	48.32
864	4.48	7.12	9.36	12.00	14.24	16.48	19.12	21.36	24.00	26.24	28.48	31.12	33.36	36.00	38.24	40.48	43.12	45.36	48.00	50.24
896	4.59	7.28	9.57	12.27	14.56	17.25	19.55	22.24	24.53	27.23	29.52	32.21	34.51	37.20	39.49	42.19	44.48	47.17	49.47	52.16
928	5.09	7.44	10.19	12.53	15.28	18.03	20.37	23.12	25.47	28.21	30.56	33.31	36.05	38.40	41.15	43.49	46.24	48.59	51.33	54.08
960	5.20	8.00	10.40	13.20	16.00	18.40	21.20	24.00	26.40	29.20	32.00	34.40	37.20	40.00	42.40	45.20	48.00	50.40	53.20	56.00

Table E-4. MK-19 48-Round Can.

Time Interval	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Rounds per Min	180	120	90	72	60	51	45	40	36	33	30	28	26	24	23	21	20	19	18	17
Rounds																				
48	0.16	0.24	0.32	0.40	0.48	0.56	1.04	1.12	1.20	1.28	1.36	1.44	1.52	2.00	2.08	2.16	2.24	2.32	2.40	2.48
96	0.32	0.48	1.04	1.20	1.36	1.52	2.08	2.24	2.40	2.56	3.12	3.28	3.44	4.00	4.16	4.32	4.48	5.04	5.20	5.36
144	0.48	1.12	1.36	2.00	2.24	2.48	3.12	3.36	4.00	4.24	4.48	5.12	5.36	6.00	6.24	6.48	7.12	7.36	8.00	8.24
192	1.04	1.36	2.08	2.40	3.12	3.44	4.16	4.48	5.20	5.52	6.24	6.56	7.28	8.00	8.32	9.04	9.36	10.08	10.40	11.12
240	1.20	2.00	2.40	3.20	4.00	4.40	5.20	6.00	6.40	7.20	8.00	8.40	9.20	10.00	10.40	11.20	12.00	12.40	13.20	14.00
288	1.36	2.24	3.12	4.00	4.48	5.36	6.24	7.12	8.00	8.48	9.36	10.24	11.12	12.00	12.48	13.36	14.24	15.12	16.00	16.48
336	1.52	2.48	3.44	4.40	5.36	6.32	7.28	8.24	9.20	10.16	11.12	12.08	13.04	14.00	14.56	15.52	16.48	17.44	18.40	19.36
384	2.08	3.12	4.16	5.20	6.24	7.28	8.32	9.36	10.40	11.44	12.48	13.52	14.56	16.00	17.04	18.08	19.12	20.16	21.20	22.24
432	2.24	3.36	4.48	6.00	7.12	8.24	9.36	10.48	12.00	13.12	14.24	15.36	16.48	18.00	19.12	20.24	21.36	22.48	24.00	25.12
480	2.40	4.00	5.20	6.40	8.00	9.20	10.40	12.00	13.20	14.40	16.00	17.20	18.40	20.00	21.20	22.40	24.00	25.20	26.40	28.00
528	2.56	4.24	5.52	7.20	8.48	10.16	11.44	13.12	14.40	16.08	17.36	19.04	20.32	22.00	23.28	24.56	26.24	27.52	29.20	30.48
576	3.12	4.48	6.24	8.00	9.36	11.12	12.48	14.24	16.00	17.36	19.12	20.48	22.24	24.00	25.36	27.12	28.48	30.24	32.00	33.36
624	3.28	5.12	6.56	8.40	10.24	12.08	13.52	15.36	17.20	19.04	20.48	22.32	24.16	26.00	27.44	29.28	31.12	32.56	34.40	36.24
672	3.44	5.36	7.28	9.20	11.12	13.04	14.56	16.48	18.40	20.32	22.24	24.16	26.08	28.00	29.52	31.44	33.36	35.28	37.20	39.12
720	4.00	6.00	8.00	10.00	12.00	14.00	16.00	18.00	20.00	22.00	24.00	26.00	28.00	30.00	32.00	34.00	36.00	38.00	40.00	42.00
768	4.16	6.24	8.32	10.40	12.48	14.56	17.04	19.12	21.20	23.28	25.36	27.44	29.52	32.00	34.08	36.16	38.24	40.32	42.40	44.48
816	4.32	6.48	9.04	11.20	13.36	15.52	18.08	20.24	22.40	24.56	27.12	29.28	31.44	34.00	36.16	38.32	40.48	43.04	45.20	47.36
864	4.48	7.12	9.36	12.00	14.24	16.48	19.12	21.36	24.00	26.24	28.48	31.12	33.36	36.00	38.24	40.48	43.12	45.36	48.00	50.24
912	5.04	7.36	10.08	12.40	15.12	17.44	20.16	22.48	25.20	27.52	30.24	32.56	35.28	38.00	40.32	43.04	45.36	48.08	50.40	53.12
960	5.20	8.00	10.40	13.20	16.00	18.40	21.20	24.00	26.40	29.20	32.00	34.40	37.20	40.00	42.40	45.20	48.00	50.40	53.20	56.00

Table E-4. MK-19 48-Round Can. (Continued)

Time Interval	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Rounds per Min	180	120	90	72	60	51	45	40	36	33	30	28	26	24	23	21	20	19	18	17
Rounds																				
1008	5.36	8.24	11.12	14.00	16.48	19.36	22.24	25.12	28.00	30.48	33.36	36.24	39.12	42.00	44.48	47.36	50.24	53.12	56.00	58.48
1056	5.52	8.48	11.44	14.40	17.36	20.32	23.28	26.24	29.20	32.16	35.12	38.08	41.04	44.00	46.56	49.52	52.48	55.44	58.40	61.36
1104	6.08	9.12	12.16	15.20	18.24	21.28	24.32	27.36	30.40	33.44	36.48	39.52	42.56	46.00	49.04	52.08	55.12	58.16	61.20	64.24
1152	6.24	9.36	21.48	16.00	19.12	22.24	25.36	28.48	32.00	35.12	38.24	41.36	44.48	48.00	51.12	54.24	57.36	60.48	64.00	67.12
1200	6.40	10.00	13.20	16.40	20.00	23.20	26.40	30.00	33.20	36.40	40.00	43.20	46.40	50.00	53.20	56.40	60.00	63.20	66.40	70.00
1248	6.56	10.24	13.52	17.20	20.48	24.16	27.44	31.12	34.40	38.08	41.36	45.04	48.32	52.00	55.28	58.56	62.24	65.52	69.20	72.48
1296	7.12	10.48	14.24	18.00	21.36	25.12	28.48	32.24	36.00	39.36	43.12	46.48	50.24	54.00	57.36	61.12	64.48	68.24	72.00	75.36
1324	7.28	11.12	14.56	18.40	22.24	26.08	29.52	33.36	37.20	41.04	44.48	48.32	52.16	56.00	59.44	63.28	67.12	70.56	74.40	78.24
1392	7.44	11.36	15.28	19.20	23.12	27.04	30.56	34.48	38.40	42.32	46.24	50.16	54.08	58.00	61.52	65.44	69.36	73.28	77.20	81.12
1440	8.00	12.00	16.00	20.00	24.00	28.00	32.00	36.00	40.00	44.00	48.00	52.00	56.00	60.00	64.00	68.00	72.00	76.00	80.00	84.00

APPENDIX F.
HAND AND ARM SIGNALS

PREPARATORY COMMANDS

Preparatory commands provide the gun crews with information specific to the action that they are about to perform (e.g., when the squad is preparing to occupy a position covertly before opening fire). These commands can be performed with the squad leader facing either toward or away from the members of the squad. This appendix discusses and displays the common hand and arm signals.

Battlesight/Range to Follow

To command the guns to prepare battlesights, the squad leader extends a fist straight toward the gun or squad (see Figure F-1). This signal means that either the target will be engaged with the guns on their battlesight setting (there will not be a follow-on signal) or that the range to target signal/command will be given next.

Figure F-1. Battlesight or Range to Follow.

Concentrated Fire

To designate the need for concentrated fire, the squad leader holds their hands, palms inward, against the sides of their helmet (see Figure F-2). This signal implies two mil shifts between bursts, either traversing or searching.

Figure F-2. Concentrated Fire.

Direction

To signal the direction of the target, the squad leader, with a knife-edge hand, points in the direction of the target (see Figure F-3).

Figure F-3. Direction.

Machine Gun Squad

To designate a particular squad to come forward, the unit leader first executes the *machine guns up* signal (see Figure F-4) and then executes the standard infantry signal for *squad*. The unit leader holds up the number of fingers that indicates which squad is requested (see Figure F-5).

Figure F-4. Machine Guns Up.

Figure F-5. Squad (Second).

Machine Gun Team

To designate a particular team to come forward, the standard infantry signal for team (see Figure F-6) should follow the signal for the squad (see Figure F-5).

Figure F-6. Team (1st).

Machine Guns Up

All unit leaders should be able to call up machine guns by hand and arm signal. To signal a machine gun unit to come forward, cup the fingers of one hand at the shoulder, and with a curving motion, sweep the hand down toward the waist, mimicking a slung bandoleer of linked ammunition (see Figure F-4).

TYPES OF TARGETS

The descriptions below are of hand and arm signals for targets.

Area Target

The squad leader makes a circle of their arms by placing their hands on top of their head (see Figure F-7). This signal implies engagement by a squad of guns using traversing and searching fire or free gun.

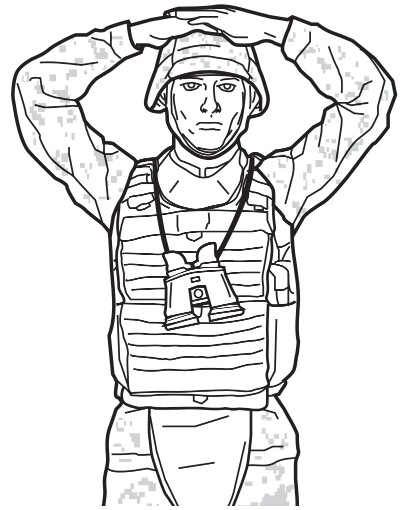


Figure F-7. Area Target.

Deep Target

The squad leader, with the edge of their hand facing forward and fingers upward, runs their hand up and down in a straight line in front of and above their head (see Figure F-8). This signal implies engagement by searching fire.

Figure F-8. Deep Target (Searching Fire).

Oblique Target

The squad leader, starting with the edge of their hand facing forward and fingers pointing upward, runs their hand diagonally down across their front. The diagonal motion should be the same as the orientation of the target—in an echelon right or echelon left (see Figure F-9). This signal implies engagement by traversing and searching fire.

Figure F-9. Oblique Target.

Point Target

To signal to the team or squad that they are about to engage a point target, the squad leader holds one arm straight out to the side above the shoulder, hand in a fist (see Figure F-10). This signal implies engagement by fixed fire.

Figure F-10. Point Target (Fixed Fire).

Shallow Target

The squad leader extends an arm either in front of their chest (if facing the squad) or above their head (if facing away). With the edge of their hand facing forward and fingers upward, they sweep their hand from side to side in short, up and down chopping motions (see Figure F-11). This signal implies engagement by traversing fire.

Figure F-11. Shallow Target.

Range to Target

To designate a range to target beyond battlesight range, the squad leader, after giving the battlesight command (see Figure F-1), opens their fist and indicates the range in hundreds of meters with their fingers (see Figure F-12).

Figure F-12. Range to Target (800 Meters).

TYPES OF FIRE

The descriptions below are of hand and arm signals for types of fire.

Dispersed Fire

To designate dispersed fire, the squad leader extends both arms outward at shoulder level, with palms inward (see Figure F-13). To designate the number of mils between shifts, the squad leader follows this signal by holding up the number of fingers that they desire the guns to shift in mils between bursts (see Figures F-14 and F-15).

Figure F-13. Dispersed Fire.

Figure F-14. Shift Fire (Mils and Direction) Example 1 (Up 25 Mils).

Figure F-15. Shift Fire (Mils and Direction)
Example 2 (Left 50 Mils).

Sustained Rate of Fire

To designate commencement of fire at the sustained rate, the squad leader, with elbow tucked into their side, extends a hand out from their side, palm facing out, and moves their hand up and down in a slow arc (see Figure F-16).

Figure F-16. Sustained Rate of Fire.

Rapid Rate of Fire

To designate the rapid rate of fire, the squad leader performs the same signal for the sustained rate, but moves their hand up and down in a fast arc (see Figure F-17).

> *NOTE:* A description of the execution of these commands by the gun teams should be captured in the unit's standing operating procedure. Minimal commands are needed to assign teams their responsibilities (e.g., rates of fire, which team begins firing on a specific end of a shallow target, the direction of traverse, and whether the target is halved or covered by the squad as a whole).

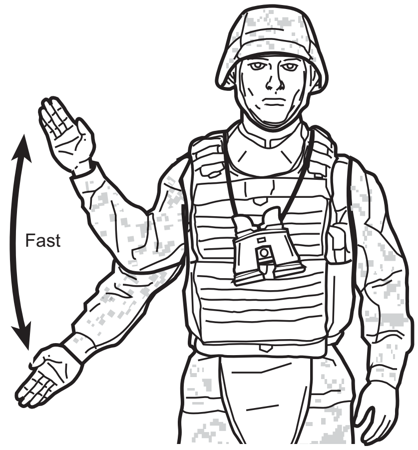


Figure F-17. Rapid Rate of Fire.

Commands of Execution

Commands of execution are those given to command a team or squad to perform a specific action as soon as the command is signaled. In some circumstances, one or more preparatory commands may be necessary before a command of execution is given. In other instances, the execution command alone suffices. The items below discuss commands of execution.

Cease Firing

To signal to cease firing, the squad leader waves their hand with palm outward, pivoting at the elbow, up and down in front of their face (see Figure F-18).

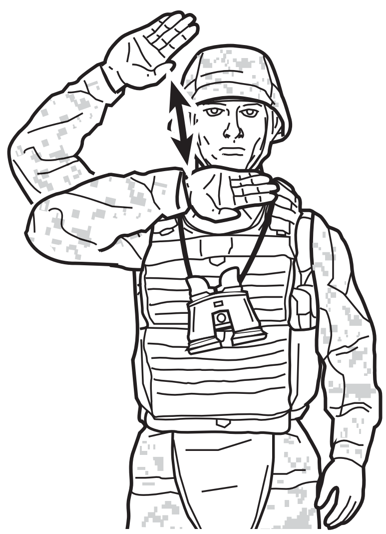


Figure F-18. Cease Fire.

Change Barrels

When the tactical situation permits the squad leader to designate barrel changes for their teams, they point to the team to execute the change and then grasp a forearm with the opposite hand (see Figure F-19).

Figure F-19. Change Barrels.

Commence Firing

The commence firing signal is used when the leader desires their unit to begin firing. The squad leader brings their hand, palm down, to the front of their body at approximately waist level and moves it horizontally, left to right, pivoting at the elbow, in front of their body (see Figure F-20).

Figure F-20. Commence Firing.

Disregard/As You Were

To signal disregard/as you were, raise both arms and cross the wrists above the head, palms forward (see Figure F-21).

Figure F-21. Disregard.

Fire

To signal a gun, squad, or section to open fire, the squad leader points to the gun to fire, extends one arm toward the gun, palm facing down, and then makes a single, large sweep with the arm toward the ground (see Figure F-22). This signal is used when surprise fire is desired. All guns should commence firing only at the exact moment the signal is given.

Figure F-22. Fire.

Fire a Single Burst

To signal a gun to fire a single spotting or ranging burst, the squad leader points to the gun to fire, extends one arm toward the gun, palm facing down, and then flips their hand down at the wrist (see Figure F-23).

Figure F-23. Fire a Single Burst.

Freeze

To signal the members of a squad to freeze in place, the squad leader holds up a clenched fist (see Figure F-24).

Figure F-24. Freeze.

Get Down, Take Cover

To signal this command, the squad leader, with arm extended to the side and palm down, makes a swinging motion toward the ground (see Figure F-25).

Figure F-25. Get Down, Take Cover.

Guns Into Action

To put the guns into action (i.e., mounted and prepared to fire), the squad leader, with forearm parallel to the deck, thrusts their fist forward and back in the direction toward where they want the guns put into action (see Figure F-26).

Figure F-26. Guns Into Action.

Guns Out of Action

To put the guns out of action (i.e., dismounted, with the squad prepared to move out), the squad leader strikes the closed fist of one hand repeatedly against the open palm of the other hand (see Figure F-27).

Figure F-27. Guns Out of Action.

Gun Up, Ready to Fire

The team leader signals that the gunner is ready to fire by raising their right hand and arm above their head, palm toward the squad leader (see Figure F-28).

Figure F-28. Gun Up, Ready to Fire.

Halt

To signal the members of a squad in a tactical or administrative movement to halt, the squad leader holds one hand above the shoulder with the palm away and hand open with the fingers together (see Figure F-29).

Figure F-29. Halt.

Increase/Decrease Rate of Fire

To increase the squad's rate of fire, the squad leader uses the commence firing signal, but performs the lateral hand movement in a rapid fashion (see Figure F-30). To decrease the rate of fire, they move their hand back and forth in an exaggerated slow motion (see Figure F-31). If the squad leader desires a single team to increase or decrease its rate of fire, they first point at the respective team leader and then give the appropriate signal.

Figure F-30. Increase Rate of Fire.

Figure F-31. Decrease Rate of Fire.

Load Carts

To reload dismounted guns and ammunition on a utility cart, the squad leader raises both elbows laterally to shoulder height and, with palms inward, touches the fingers of both hands to their shoulders.

Out of Ammunition

When the gun is almost out of ammunition, the team leader should give the signal to alert the ammunition bearer to secure more ammunition for the gun by slapping the top of their helmet repeatedly (see Figure F-32).

Figure F-32. Out of Ammunition.

Shift Fire Left or Right

To signal a shift in direction, the squad leader holds up their hand, with elbow at shoulder level, swings their hand outward in the direction of the desired shift, and then indicates the number of mils to be shifted by showing that number of fingers (see Figure F-14). If the squad leader is facing the direction of fire and wishes the guns to shift to the left, they make the signal with their left hand. If the shift is to the right, they make the signal with their right hand.

Shift Fire Up or Down

To signal a shift in elevation, the squad leader makes an upward pushing motion with an open palm to signal an upward shift or downward to signal a downward shift, and indicates the number of mils to be shifted by showing that number of fingers (see Figure F-14).

Standby

To advise the team leaders to standby and wait for their next signal, the squad leader extends their hand toward the gun or squad at arm's length with palm facing forward (see Figure F-33).

Figure F-33. Standby.

Unload Carts

When the guns are being transported by utility cart, the squad leader may desire to give their squad a signal to unload the guns and ammunition from the carts in anticipation of putting them into action. They raise one elbow laterally to shoulder height and, with fingers touching the shoulder, makes a downward sweeping motion with the hand.

GLOSSARY

Section I: Acronyms and Abbreviations

AE ... angle of engagement
AP ... armor-piercing
APC ... armored personnel carrier
API ... armor-piercing incendiary
AS ... angle of sight

CAAT ... combined antiarmor team
cal. ... caliber
CBRN ... chemical, biological, radiological, and nuclear
cm ... centimeter(s)

DA ... Department of the Army

F ... degree Fahrenheit
FPF ... final protective fire
FPL ... final protective line

HEDP ... high explosive dual purpose
HMG ... heavy machine gun

IFV ... infantry fighting vehicle

kph ... kilometer(s) per hour

LOS ... line of sight

m ... meter(s)
M ... mils (formulaic symbol)
MCTP ... Marine Corps tactical publication
MCWP ... Marine Corps warfighting publication
mils ... thousanth of an inch
mm ... millimeters

NATO ... North Atlantic Treaty Organization
NAVMC ... Navy/Marine Corps departmental publication
NSN ... national stock number
NVD ... night vision device

OP ... observation post

PDF....principal direction of fire

R....range in meters (formulaic symbol)

SBF....support by fire
SP....start point

T&E....traversing and elevating
TOF....time of flight
TRP....target reference point

WERM.... width equals range (meters/1000) times mils *(formula)*
W....lateral distance in meters

Section II: Terms and Definitions

battlesight

The predetermined sight setting in elevation and windage that will result in an intersection of the trajectory of the bullet and the line of sight at a range of 274 meters (300 yards). (USMC Dictionary)

cone of fire

The pattern formed on the way to the target by several rounds fired in a burst. (USMC Dictionary)

defilade

1. Protection from hostile observation and fire provided by an obstacle such as a hill, ridge, or bank. (DOD Dictionary, part 1 of a 3-part definition)

defilade fire

1. Fire delivered on a target in such a manner that the range pattern of the fall of shot generally aligns with the short axis of the target. See also enfilade fire. (USMC Dictionary, part 1 of a 2-part definition)

destroy

1. To physically render an enemy force combat ineffective unless it can be reconstituted. 2. In the context of defeat mechanisms, to apply lethal combat power on an enemy capability so that it can no longer perform any function and cannot be restored to a usable condition without being entirely rebuilt. (USMC Dictionary)

direct fire

Fire delivered on a target using the target itself as a point of aim for either the weapon or the director. (DOD Dictionary)

displace

To leave one position and take another while remaining in contact with the enemy. Forces may be displaced laterally to concentrate combat power in threatened areas. (USMC Dictionary)

enfilade fire

Fire delivered on a target in such a manner that the range pattern of the fall of shot generally aligns with the long axis of the target. See also defilade fire. (USMC Dictionary)

engagement area

An area where the commander intends to contain and destroy an enemy force with the effects of massed weapons and supporting systems. (USMC Dictionary)

final protective fire

An immediately available, prearranged barrier of fire designed to impede enemy movement across defensive lines or areas. Also called **FPF**. (DOD Dictionary)

final protective line

A line of fire selected where an enemy assault is to be checked by interlocking fire from all available weapons. A final protective line may be parallel with, or oblique to, the front of the position. Also called **FPL**. (USMC Dictionary)

fire and maneuver

The process of one or more elements establishing a base of fire to engage the enemy, while the other element(s) maneuver to an advantageous position from which to close with and destroy or capture the enemy. (USMC Dictionary)

fire and movement

A technique primarily used in the assault wherein a unit or element advances by bounds or rushes, with supplements alternately moving and providing covering fire for other moving supplements. Fire and movement may be done by individuals (personnel or vehicles) or units (such as fire teams or squads). Usually, fire and movement is used only when under effective fire from the enemy because it is relatively slow and difficult to control. (USMC Dictionary)

fire command
A specific sequence of information given by a control authority that causes a crew to begin performing a sequence of actions and provides detailed direction to choose the ammunition type, aim the weapon, and engage the target. Each element given by the controller requires a response from a crewmember to ensure correct aiming and engagement. After the initial fire command, subsequent fire commands using the same sequence of information can be used to adjust the point of impact to ensure the desired target effect. (USMC Dictionary)

fire control
The control of all operations in connection with the application of fire on a target. (USMC Dictionary)

fires
(See DOD Dictionary for core definition. Marine Corps amplification follows.) Those means used to delay, disrupt, degrade, or destroy enemy capabilities, forces, or facilities as well as affect the enemy's will to fight. Fires is one of the seven warfighting functions. See also warfighting functions. (USMC Dictionary)

general support
1. Support given to the supported force as a whole and not to any particular subdivision thereof. See also close support; direct support; mutual support; support. (DOD Dictionary, part 1 of a 2-part definition)

gun-target line
An imaginary straight line from gun to target. Also called **GTL**. (DOD Dictionary)

indirect fire
Fire delivered on a target that is not itself used as a point of aim for the weapons or the director. (USMC Dictionary)

kill zone
That part of an ambush sight where fire is concentrated to isolate, fix, and destroy the enemy. (USMC Dictionary)

line of sight
The unobstructed path from a Marine, weapon, weapon sight, electronic-sending and receiving antennas, or piece of reconnaissance equipment to another point. Also called **LOS**. (USMC Dictionary)

neutralize
(See DOD Dictionary for core definition. Marine Corps amplification follows.) To render the enemy or enemy resources ineffective or unusable. (USMC Dictionary)

overhead fire
Fires delivered over the heads of friendly troops. (USMC Dictionary)

plunging fire
Fires that strike the ground at a high angle so that the danger space is particularly confined to the beaten zone and the length of the beaten zone is shortened. (USMC Dictionary)

point target
1. A target of such small dimension that it requires the accurate placement of ordnance in order to neutralize or destroy it. (USMC Dictionary, part 1 of a 2-part definition)

principal direction of fire
The direction of fire assigned or designated as the main direction in which a weapon will be oriented. It is selected based on the enemy, mission, terrain, and weapons' capability. Also called **PDF**. (USMC Dictionary)

sector of fire
A defined area that is required to be covered by the fire of individual or crew- served weapons or the weapons of a unit. (USMC Dictionary)

support by fire

To engage the enemy by direct fire to support a maneuvering force using overwatch or by establishing a base of fire. The supporting force does not capture enemy forces or terrain. (USMC Dictionary)

supporting fire

Fire delivered by supporting units to assist or protect a unit in combat. (DOD Dictionary)

suppress

To temporarily degrade an opposing force or the performance of a weapons system below the level needed to fulfill its mission objectives. (USMC Dictionary)

suppressive fire

Fires on or about a weapons system to degrade its performance below the level needed to fulfill its mission objectives, during the conduct of the fire mission. (USMC Dictionary)

References and Related Publications

Department of Defense Publications

Department of Defense Dictionary of Military and Associated Terms
MIL-STD-2525_ Department of Defense Interface Standard: Joint Military Symbology

Navy Marine Corps Departmental Publications (NAVMC)

3500.44_ Infantry Training and Readiness Manual

Army Publications

Training Circulars (TCs)

3-22.19	Grenade Machine Gun MK-19 MOD 3
3-22.50	Heavy Machine Gun M2 Series
3-22.240	Medium Machine Gun
3-22.249	Light Machine Gun M249 Series

Miscellaneous Army Publications
DA Form 5517, Feb 2016 Standard Range Card
GTA 06-07-003, Aug 1983 Observed Fire Fan

Marine Corps Publications

Marine Corps Warfighting Publication (MCWP)
3-01 Offensive and Defensive Tactics

Marine Corps Reference Publication (MCRP)
3-10A.1 Infantry Battalion Operations

Marine Corps Order (MCO)
3570.1_ Range Safety

Technical Manuals (TMs)
08521A-OR/1 Operator’s Manual for Machine Gun, 40 mm, MK19 MOD 3, NSN 1010-01-126-9063 (EIC 4AE); Machine Gun, 40 mm, MK19 MOD 3, with Sight Bracket NSN 1010-01-490-9697; Machine Gun, 40 mm, MK19, Upgunned Weapons Station (UGWS) NSN 1010-01-362-6513

08670A/09712A-10/1B Operator's Manual for Machine Gun, 7.62 mm, M240 (1005-01-025-8095); M240B (1005-01-412-3129); M240C (1005-01-085-4758); M240D (1005-01-418-6995); M240E1 (1005-01-252-4288); M240H (1005-01-518-2410); M240L (1005-01-549-5837); M240N (1005-01-493-1666)

08671A-10/1A w/ CH 1-2 Operator's Manual Machine Gun, 5.56 mm, M249 w/Equip (NSN 1005-01-127-7510) (EIC: 4BG) (AR Role); (NSN 1005-01-451-6769) (EIC: 4BK) (LMG Role)

1005-10/1 Technical Manual for Machine Gun, Caliber .50: M2A1, with Fixed Headspace and Timing (NSN 1005-01-511-1250) (EIC: 4AZ); Machine Gun, Caliber .50: M2, Heavy Barrel, Flexible, with Equipment (NSN 1005-00-322-9715) (EIC: 4AG); Fixed M48 Turret Type (NSN 1005-00-957-3893) (EIC: 4BB); Flexible without Equipment (NSN 1005-00-726-5636) (Navy/USMC); Up Gunned Weapons Station (UGWS) (NSN 1005-01-362-6237) (USMC); Navy Variant (NSN 1005-01-343-0747) (Navy); Machine Gun, Caliber .50: M2A1 with Fixed Headspace and Timing, Flexible (NSN 1005-01-642-7437) (Navy)

Miscellaneous Marine Corps Publications

Marine Corps Supplement to the DOD Dictionary of Military and Associated Terms

Miscellaneous

Foss, Christopher F. *Jane's Tanks and Combat Vehicles Recognition Guide*. HarperCollins Publishers, 2000.