TC 3-20.31-044

MASTERY: FIRING TABLES

JANUARY 2026

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Preface

This training circular introduces the firing tables and structures the calculations necessary to accurately describe the characteristics of projectile flight. The processes described in this training circular are required by any user of firing tables for understanding and applying table data.

The principal audience for TC 3-20.31-044 is master gunners, candidates for attendance to the Master Gunner school, and any member of the profession of arms. Additional audience may include all Army personnel and commanders and their staffs for use at any level of leadership and expertise. Trainers and educators throughout the Army will also use this publication.

Commanders, staffs, and subordinates ensure that their decisions and actions comply with applicable United States, international, and, in some cases, host-nation laws and regulations. Commanders at all levels ensure that their Service members operate in accordance with the law of armed conflict and the rules of engagement. (See FM 6-27 for legal compliance.).

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Chapter 1
Introduction

TC 3-20.31-044 provides a structured method for training weapon system operators, master gunners, and leaders to utilize firing tables during the training, execution, and recovery of direct fire operations. With continuously improving automated ballistic fire control software, weapon systems, algorithms, methodologies, and fire control data computing, expertise with hard-copy data is becoming exponentially more important. In the event of failures during direct fire operations, analog computations must be performed to verify hazard zones and impacts.

This publication is designed to assist all personnel operating direct fire weapon systems in their understanding of ballistics, projectile flight characteristics, the establishment of battlesight ranges, and how to accurately determine the location of rounds out of impact. It describes the history of ballistic data collection, the reduction of that data into readable data, and how it is applied in training and austere environments.

HISTORY

1-1. It is important to know the history of firing tables to understand their significance in modern-day ballistic study. As ballistics and attributes of our weapon systems, ammunition, and capabilities evolve, knowing why those changes occurred and how to apply the lessons learned is paramount.

WORLD WAR I

1-2. The development of firing tables in the U.S. Army began during World War I, when ballistics tests were conducted, including computations of firing tables. Rapid demand for ballistic data led the Army's Chief of Ordnance to establish the Ballistics Branch on April 6, 1918. Firing tables enabled gunners to manually calculate aiming solutions, such as elevation (EL), azimuth, and fuse settings to engage targets under various conditions. Known as tabular firing tables (TFT), these products were developed by the Ballistics Branch through trajectory analysis and experiments to improve weapon system range and accuracy.

1-3. The Ballistics Branch was tasked with preparing accurate TFT and evolving the quickly aging targeting systems of World War I by conducting mathematical analysis of trajectories and experimenting with concepts designed to increase the range and accuracy of weapon systems.

1-4. As firing table development began during World War I, Congress moved ordnance testing facilities from Sandy Hook, NJ, to Aberdeen, MD, due to range limitations. The transition started in late 1917, and the first test round was fired at Aberdeen Proving Ground on January 2, 1918. Nine divisions were eventually established at the new proving ground, comprising the proof department. Ballistics work was primarily assigned to three sections: range firing, development, and instrument. The range firing section prepared all firing tables, performed mathematical analyses of ballistic problems, and conducted experiments designed to increase projectile range and accuracy. The organization of the proof department remained unchanged until July 1922.

1-5. In 1925 after the post-World War I personnel reduction, the mathematical unit of the Ballistic Section, Gun Testing Division, and Proof Department prepared the ballistic and firing tables. By 1935, the first major reorganization incorporated the withdrawal of the Ballistic Section from the Gun Testing Division and established as the Research Division. The new research division of 30 people was organized into six sections, of which two were involved in the development of firing and bombing tables. The exterior ballistics section studied trajectories and flight characteristics of projectiles and bombs. The computing section prepared the firing and bombing tables for standard ammunition and bombs, computed fundamental ballistic tables, and prepared ballistic data to be used in improving fire control equipment. The results of the exterior ballistics section's work were used as the basis for computing firing and bombing tables and for designing new projectiles. In December of 1938, the research division was renamed the Ballistic Research Laboratory (BRL).

THE COMPUTER AGE

1-6. Between 1930 and 1931, the burden of firing table computation was reduced by the development of the Bush Differential Analyzer. The machine solved differential equations by means of mechanical integration with speed and accuracy. However, it soon became overpowered by the demand to accomplish more volume and scope of work than it was designed to do, leading the BRL to arrange access to larger analyzers of the same type. Simultaneously, considerable progress was made in substituting electrical components for mechanical, allowing newer analyzers to obtain greater speed of operation and accuracy.

1-7. By 1937, advancements in electrical calculation devices revolutionized ballistic computation. Early comparisons between automated firing table calculations and traditional methods demonstrated significant improvements in accuracy and efficiency, leading to the adoption of punch-card machines for ballistic work by 1941. Subsequent developments, such as IBM's relay calculator, further enhanced computational speed, performing addition and subtraction twice as fast and multiplication three times faster than earlier systems.

1-8. World War II created an immense demand for firing tables, requiring around-the-clock computation. Large rooms of workers, primarily women, performed millions of numerical integration calculations using hand-crank calculators to compute trajectories for firing tables. Despite advances in computing technology, the need for greater speed, accuracy, and operational flexibility grew as the war progressed and demand increased.

1-9. Two computers, the electronic numerical integrator and computer (also called ENIAC) and the Electronic Discrete Variable Computer (also called EDVAC), were designed during World War II to address the growing need for firing table computation but were completed after the war. The electronic numerical integrator and computer's development in 1947 marked the start of the computer age, driven by the need to efficiently compute firing table trajectories. Follow-on systems, such as the Ordnance Discrete Variable Automatic Computer (also called ORDVAC) and Ballistic Research Laboratory electronic scientific computer (also called BRLESC), further advanced trajectory calculations. The BRL electronic scientific computer remained in use into the late 1970s, but improvements in commercial computer technology eventually surpassed the requirements for firing table development, eliminating the need for in-house systems.

MODERN ERA

1-10. After World War II, firing and bombing tables were divided between the U.S. Army and U.S. Air Force, with bombing tables relocated to Eglin Air Force Base and firing tables remaining at Aberdeen Proving Ground. Despite expectations of reduced emphasis, the Cold War, Korean Conflict, and Vietnam War sustained the need for firing tables and ballistic work. Advancements in computing technology accelerated development, but improvements in trajectory models for simulating projectile flight remained essential.

1-11. In the 1960s, the trajectory model was upgraded from a basic point mass simulation to the modified point mass (also called MPM) model, developed in 1966 to better represent spin-stabilized artillery shells by incorporating yaw of repose. Over time, the modified point mass model has been modified to simulate direct fire rounds, base-burn shells, and rocket-assisted projectiles. Widely recognized, it serves as the basis for the North Atlantic Treaty Organization (NATO) standard in ballistic fire control.

1-12. The development of the modified point mass trajectory model marked a breakthrough in firing table methodology, reducing the number of test rounds needed while maintaining accuracy. Interior ballistic modeling addressed muzzle velocity (MV) issues from propellant temperature and projectile weight variations, while improvements in test design and aerodynamic coefficient development further enhanced efficiency. By the 1970s, advancements in computing technology enabled field use of devices for training and combat, producing more accurate firing tables at lower costs.

1-13. Early field computers were unsophisticated by today's standards but represented significant technological advancements for their time. The field artillery digital automatic computer (also called FADAC) integrated point mass equations of motion and used polynomial fits to calculate drift. Similarly, tank and helicopter ballistic computers applied fitting techniques to incorporate firing table data into fire control systems. These devices functioned as advanced calculators, processing polynomial fits to support ballistic computations.

1-14. Advances in miniaturized components allowed for smaller devices and increased computation speed, driven by improvements in processing technology and more efficient hardware designs. As computational speeds reached acceptable levels and the devices became small enough with sufficient memory and storage capability, field computers could solve the equations of motion that simulate projectile flight without relying on polynomial fitting techniques. This process provided more accurate gunnery solutions.

1-15. By this time, the Firing Tables Branch was providing databases and computational methodologies for field computers such as tactical fire (also called TACFIRE) and the battery computer system (also called BCS) for artillery applications. Similar efforts supported fire control computers for tanks, helicopters, and mortars. In the early 1990s, the Firing Tables Branch (now the Firing Tables and Ballistics [FTaB] Division) partnered with Norway's Forsvarets Forshningsinsitutt (FFI), to plan the next generation of ballistic processing for field artillery technical fire control systems.

1-16. Advancements in computing speed, memory size, and programming flexibility made a standard, layered set of software modules for ballistic processing appealing to NATO AC/225 Panel IV, Sub-Panel 2 (now Land Capabilities Group 3 on Fire Support, Sub-Group 2). FTaB, co-leading with Norway's Forsvarets Forskningsinsitutt (FFI), developed the NATO armament ballistic kernel (NABK), designed for shareability and reusability. Fifteen NATO nations are implementing country-specific versions of NABK for artillery fire control systems, enabling trajectory and MV simulations and ammunition interchangeability during multinational exercises. The first application of the ballistic kernel (BK) was its inclusion in the improved mortar ballistic computer (IMBC) in May 1995, with subsequent IMBC BK versions supporting new munitions and the Mortar Fire Control System. Lessons from IMBC BK development were pivotal to the NABK effort.

1-17. Another recent effort within FTaB is the meteorological kernel, a weather forecasting model that improves accuracy while reducing reliance on labor-intensive weather balloon collection. Accurate weather data is critical for generating precise gunnery solutions. FTaB has collaborated with NATO and academia to develop and test meteorological kernel prototypes, including live-fire exercises in Denmark (2003), Turkey's high desert (2006), and planned testing in southern France to evaluate its performance across diverse terrains.

1-18. Through involvement in international forums such as NATO, The Technical Cooperation Program, and the Joint Ballistic Working Group, FTaB has become a global training hub for firing table data reduction, software development, and ballistics studies. Over the past 25 years, FTaB has trained personnel from numerous countries, including Australia, Germany, and Japan, while its staff has traveled internationally for meetings and tests. Since the late 1970s, FTaB has conducted artillery accuracy tests with Army and Marine Corps units under quasi-combat conditions, building a database for fire delivery techniques. Tests in the 1990s confirmed that weather data inaccuracies are the largest source of delivery errors.

1-19. For more than 20 years, FTaB has collaborated with the U.S. Army Materiel Systems Analysis Activity to develop and refine artillery models for predicting ammunition and weapon accuracy. These models have become the standard for accuracy estimates used by groups like the Joint Munitions Effectiveness Manual and the Joint Technical Coordinating Group for Munitions Effectiveness.

1-20. In 1992, BRL was reorganized into the Army Research Laboratory, consolidating all Army research under one umbrella. The firing table mission, the original purpose of BRL's formation in 1938, was reassigned to the Army's armament research, development and engineering center (ARDEC), ending BRL's role in firing table development. Over its history, FTaB employed a diverse team of engineers, scientists, and military personnel, including mathematicians, statisticians, ballisticians, and computer scientists.

1-21. FTaB, responsible for firing tables, ballistic fire control data, and BKs as specified by Army materiel command regulation, is divided into two teams: the aiming data technology team and the ballistic software engineering team. The aiming data technology team develops aiming data products, interior ballistics methodologies, aerodynamic parameters, accuracy estimates, and foreign ammunition exploitation. The ballistic software engineering team focuses on BK development, enhancements, and internal software generation and maintenance.

1-22. The software team collaborates with NATO allies to improve and expand the NABK, recently fielding version 8.0 derivative BKs for U.S.-specific weapon systems. They maintain and update internal software codes, including trajectory models and firing table preparation tools, while developing reliable code for

ballistic technologies. The team also trains government personnel, contractors, and foreign scientists in BK software creation, database design, documentation, and quality assurance procedures.

DATA COLLECTION

1-23. Today, FTaB is responsible for developing aiming data, ballistic fire control information, ballistic control software, and calculating the data for all unguided, and certain guided, combat weapons systems for small-caliber Infantry weapons, mortars, tank-fired munitions, artillery, missiles, and rockets.

FIRING TABLES AND BALLISTICS MAJOR RESPONSIBILITIES

1-24. The FTaB is responsible for the following:

- Characterizing projectile ballistic performance.
- Developing, maintaining, and testing of shareable ballistic fire control software for U.S. and multinational weapon systems and training platforms.
- Developing ballistic algorithms, methodologies, and data relating to fire control computers and manual backups.
- Providing ballistic expertise and support to the Department of Defense and industry for munitions and fire control equipment in the development cycle.
- Developing a rational basis for NATO and multinational standardization agreements involving interior and exterior ballistic simulation models, ballistic algorithms, firing table elements, and fire control methodology.
- Ensuring interchangeability of fire control information for U.S Forces regarding NATO ammunition.

FACILITIES

1-25. Aberdeen Proving Ground's aerodynamics range was the world's first large-scale, fully instrumented ballistic range producing data on the aerodynamic characteristics of missiles in free flight. For more than 40 years, its data has been integral to the development of supersonic aerodynamic designs. The facility's unique technology became the foundation of similar installations worldwide.

1-26. The Transonic Range of BRL is part of the Free Flight Aerodynamics Branch of the Exterior BRL. Designed in 1944, primary construction was completed in 1947, and instrumentation was completed for full-scale operation in the summer of 1950. Projectiles traveling through this enclosed spark photography range are not restrained or affected by any forces other than those normally encountered in flight.

Aerodynamics Range

1-27. During the 1930s, research into advanced ballistic measurement techniques began at Aberdeen Proving Ground. Before the German Army entered Poland, exceptional data on the flight of projectiles was already being provided. The crisis of World War II gave incentive to incorporate this pioneering research into the design and construction of the aerodynamics range at the BRL. The facility was unique for its time and established the capability to study, in detail, the aerodynamics of bodies in supersonic free flight.

1-28. The range's sequential, high-speed photographic instrumentation has recorded the flight of projectiles, missiles, and aircraft important to national defense. Personnel working in this original installation have contributed to technical disciplines ranging from photography and high-speed circuit design to the theory of flight. The range is recognized as the prototype for similar installations in the United States and abroad.

Transonic Free Flight Range

1-29. The purposes of this range are threefold:

- To provide data for determining the aerodynamic coefficients of projectiles up to 8 inches in diameter or wingspan.
- To provide an accurate instrument with which to investigate the causes of dispersion of projectiles.
- To provide data on flow characteristics from the subsonic through the transonic and on into the higher regions of velocity.

1-30. The Transonic Range has many predecessors and contemporaries as a free-flight range. The first such range is believed to have been built at the National Physical Laboratory in England.

1-31. The Transonic Range is 1,173 feet in length. The part of the building nearest the gun position is reinforced concrete while the remainder is sheet metal on a steel frame. The first 750 feet of the range is 24x24 feet in a cross section and is fully instrumented. The remaining 423 feet has never been instrumented but does facilitate the extension of roll histories using yaw card techniques. The metal sections of the building are insulated and have an aluminum covering. The instrumented section has radiant heating.

1-32. The tested projectile is usually launched from a gun. Projectiles pass through the opening in the large concrete blast shield and then into the enclosed range. Projectiles travel through an array of 25 spark photographic stations, arranged in five groups of five stations each. These stations each capture a tiny chapter in the motion history of projectiles as they pass through the range.

1-33. To study causes of dispersion of projectiles, researchers must understand the following:

- The motion of the projectile in the launcher.
- Any reaction between the launcher and the projectile before and during emergence.
- The reaction of the projectile in the muzzle region or while it is affected by muzzle gases.
- A timed history of projectile motion until some target or measure of dispersion is reached at the conclusion of its recorded flight.

1-34. The capabilities of this facility allow for the testing of full-scale projectiles up to 8 inches in diameter. The collection of data that gives a history of the motion of those projectiles and permits study of their aerodynamic properties in free flight, and the recording of flow patterns about the projectiles for aerodynamic considerations. A 1,000-yard target is incorporated with the range facilities to make the study of dispersion possible through a close study of initial conditions and results on the target.

1-35. The third purpose of the range, to provide data on detailed flow characteristics, is partially satisfied by regular spark records, however, another piece of specialized instrumentation called a mosaic has been developed to further this purpose. As the name indicates, mosaics consist of a series of large 11 x 14-inch photographic plates laid out together on a tabletop, placed just below the calculated trajectory. A spark source, located above these plates, is triggered in the same way as the standard stations and the large mosaic picture is obtained. This picture shows flow detail in such a size as to be easily studied for small effects. When trajectories can be closely estimated, the distance from spark to plates in this setup can be shortened to as little as 5 feet, allowing the use of a fast and less intense spark that results in sharper detail than the usual shadow stations.

Preparation for and Firing of a Program

1-36. After model shops receive approved designs for projectiles, the models are manufactured and taken to the physical measurements laboratory for measurements. The moments of inertia, both transverse and axial, are determined on a torsion pendulum and compared with known test masses. The periods are measured by means of electronic timing. The timing signal is produced and recorded through a photocell, optical-counter combination.

1-37. While the manufacture and measurements are being completed, the means of launching must be determined. To date, all launchings except for some rockets have been made from breech-loading guns. Some projectiles, because of external configuration, desired initial angle of launch, maximum pressure limits, required spin, and protection of surface finish may require special, individual launching devices.

1-38. The expected trajectory or flight path of a test projectile is calculated by standard methods and the optimum spark height is selected to best fit this path. Each spark unit contains a delay system which must be adjusted to the expected velocity, which allows the projectile to proceed to a point opposite the center of the reflective screen before the spark is discharged.

1-39. After all preparations have been made, a systematic firing procedure is carried out. The cameras are loaded with photographic plates and the high-speed motion picture cameras with film. All personnel are cleared from the possible danger areas. The projectile and propellant are loaded into the gun. From the instrument shelter, a facility separated about 1,000 feet from the range itself, the round number and station designation are exposed on the plates, the cameras are opened, and a bias control is operated which allows

the spark stations to operate on the pulse from the photocell trigger units. The gun is fired, cameras are closed, and the range personnel collect the plates for processing in a photographic dark room. The basic records obtained in the Transonic Range are spark shadowgraphs, direct or micro-flash photographs, film from high-speed motion picture cameras, time reports, met reports, and large mosaics or multi-shadow graphs.

DATA REDUCTION AND COMPUTATION

1-40. One of the free flight range technique's basic problems is data reduction. Data reduction is the process of selecting, focusing, simplifying, abstracting, and transforming data to reduce the amount of capacity required to store it. For firing tables, only some aerodynamic, met, physical characteristics, and time-of-flight data is required from the amount collected during free flight testing.

1-41. Achieving successful data reduction is difficult primarily because free flight ranges only work with the actual motion of a projectile in flight; aerodynamic forces and moments during must be inferred from that motion. Due to the importance of making large amounts of data palatable to the average reader, ranges like the free flight aerodynamics and Transonic Range are limited in how they can output their data; a large bulk of the experimentation time is spent analyzing and simplifying the data. For this reason, great effort is constantly being made to refine the process and make as much use of large-scale computing machines as possible.

1-42. The simplified data used in firing tables is employed to compute a ballistic coefficient or to produce final values for each listed ammunition. A ballistic coefficient is a numerical representation of how well a projectile retains its initial velocity over any distance. Once the ballistic coefficient is determined, a value for design MV and in-flight weight of the round is obtained. This information is then coupled with the aerodynamic and physical characteristics data to compute the firing tables.

Chapter 2

Terms of Reference

This publication and the firing tables use complex terms and abbreviations. This chapter provides basic definitions of the most used.

ABBREVIATIONS

2-1. Firing tables utilize the symbols and abbreviations presented in figure 2-1. Understanding the principles of firing tables requires a comprehensive understanding of these abbreviations, acronyms, or symbols.

ABBREVIATIONS	
deg or °	Degrees. 360 degrees in a circle; 17.78 mils in a degree.
DH/DR	Change in height for every 100–meter change in range (D = change or delta)
DR/DSE	Change in range for every 1 mil change in superelevation (or tangent elevation)
FT	Firing table
in or “	Inches
Km/h	Kilometers per hour
lb or lbs	Pound or pounds
m	meters
mm	Millimeters
m/s	Meters per second (velocity)
pct or %	percent
SE	superelevation
sec	seconds
m	mils or milliradians (1/6400th of a circle)
F	Fahrenheit
C	Celsius
QE	quadrant elevation
APFSDS-T	armor piercing, fin stabilized, discarding sabot with tracer
HEAT-MP-T	high explosive antitank, multi–purpose with tracer
HEAT-TP-T	high explosive antitank, target practice with tracer
PIP	product improvement program
TP-T	target practice with tracer
TPCSDS-T	target practice, cone stabilized, discarding sabot with tracer
TPFSDS-T	target practice, fin stabilized, discarding sabot with tracer

Figure 2-1. Commonly used abbreviations within firing table publications

TERMS OF REFERENCE

2-2. Basic terms in chapter 2 are not directly involved with reading the firing tables but provide for understanding how they work and what they provide. The following terms are defined in this chapter for reference:

- Aeroballistics.
- Aerodynamic characteristics.
- Axis of the bore (AoB).
- Azimuth.
- Ballistics.
- Ballistic drift.
- Ballistic trajectory.
- Caliber.
- Commencement of rifling.
- Exterior or external ballistics.
- Jump.
- Kinetic energy.
- Line of sight (LOS).
- Line of elevation (LoE).
- Line of departure (LoD).
- Maximum ordinate (MAX ORD).
- MV.
- Mach number (MACH).
- Obscuration.
- Super elevation (SE), tangent elevation, (TE), and quadrant elevation (QE).
- Time of flight.
- Yaw.

AEROBALLISTICS

2-3. Aeroballistics (see figure 2-2) is the science of ballistics combined with that of aerodynamics, dealing primarily with the flight path of projectiles, rockets, and guided missiles, among others, through the atmosphere.

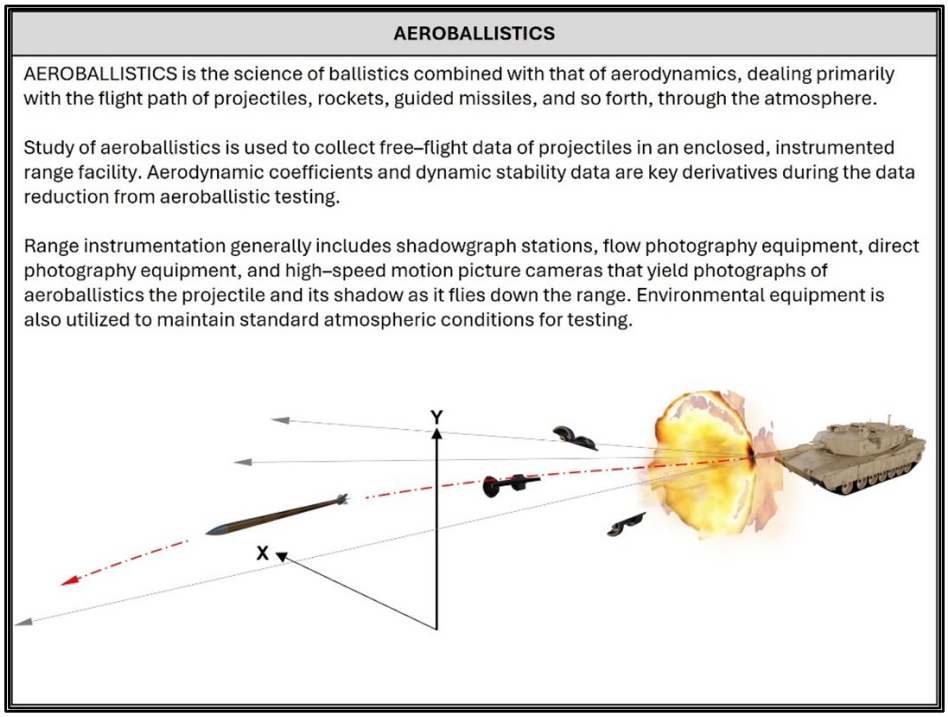


Figure 2-2. Aeroballistics

AERODYNAMIC CHARACTERISTICS

2-4. Aerodynamic characteristics is the branch of mechanics that deals with the motion of air and other gases and with the effects of such motion on objects in such media. (Figure 2-3 describes the basic tenets of aerodynamic characteristics.)

AERODYNAMIC CHARACTERISTICS

AERODYNAMIC CHARACTERISTICS is the branch of mechanics that deals with the motion of air and other gases and with the effects of such motion on objects in such a media.

Physical characteristics of projectiles and sub-projectiles heavily impact the way they interact with air and gases during free flight. Because of this, all ammunition variants and models are scrutinized through free-flight testing to understand how they perform when influenced by external forces.

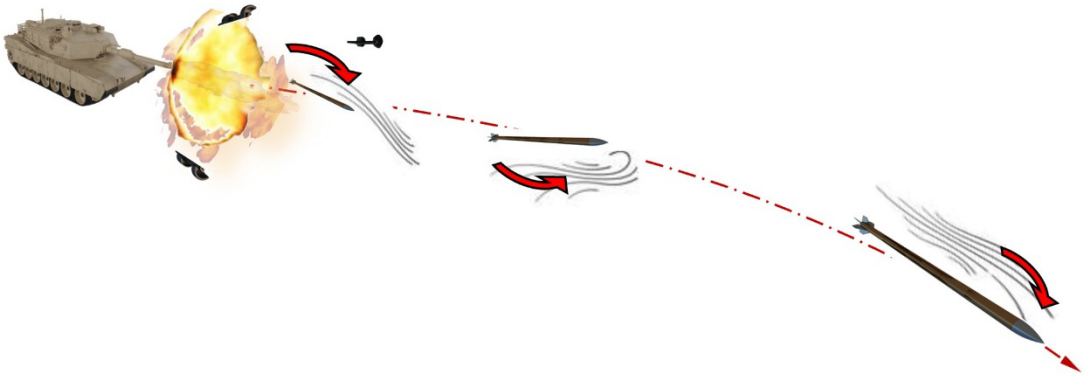


Figure 2-3. Aerodynamic characteristics

AXIS OF THE BORE

2-5. AoB is the line passing through the center of the bore. Figure 2-4 describes the relationship between the AoB and the ballistic trajectory, LOS, and the LoD.

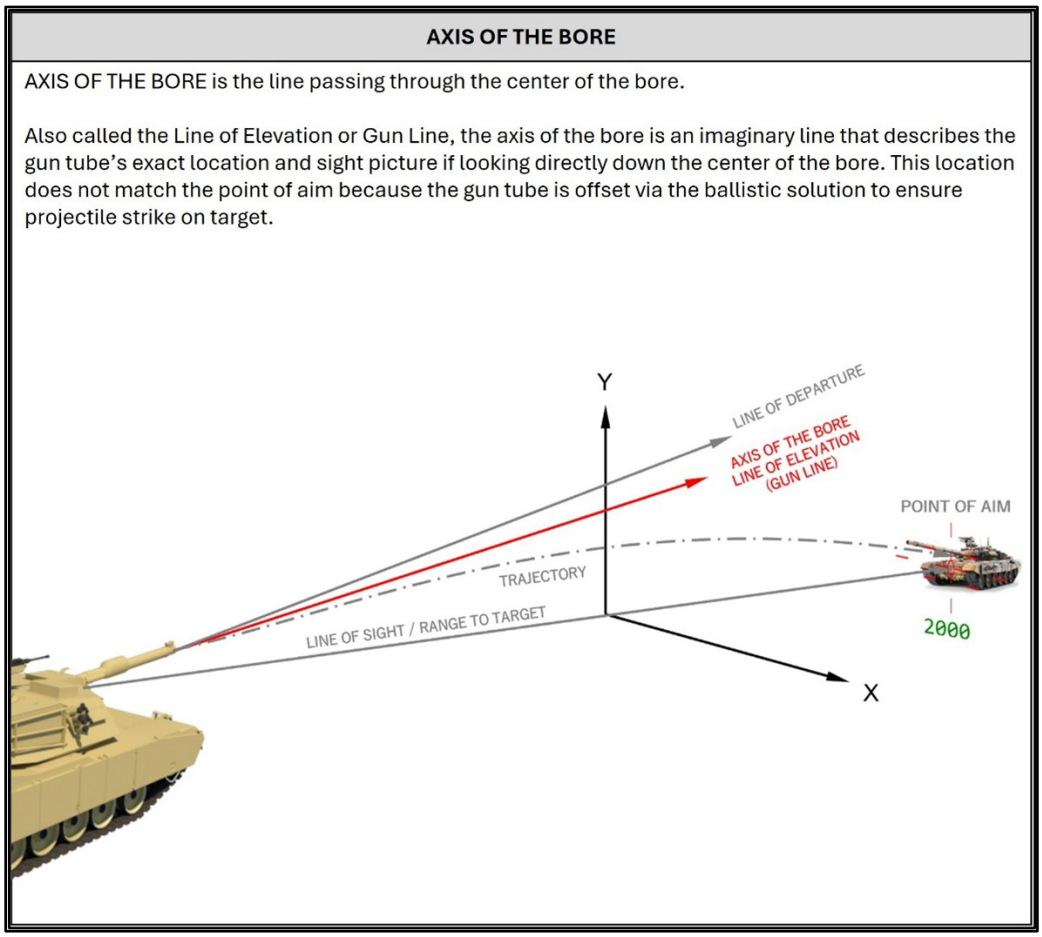


Figure 2-4. Axis of the bore

AZIMUTH

2-6. For fire control systems, AZ is the rotation of a weapon about the pintle, or turret ring (side to side) as opposed to EL, which is up and down.

2-7. AZ (see figure 2-5) also indicates direction in degrees (°) or mils (indicated with an m̓ symbol). It can be measured using a compass, optic, or sensor to determine the angular relationship between two or more points.

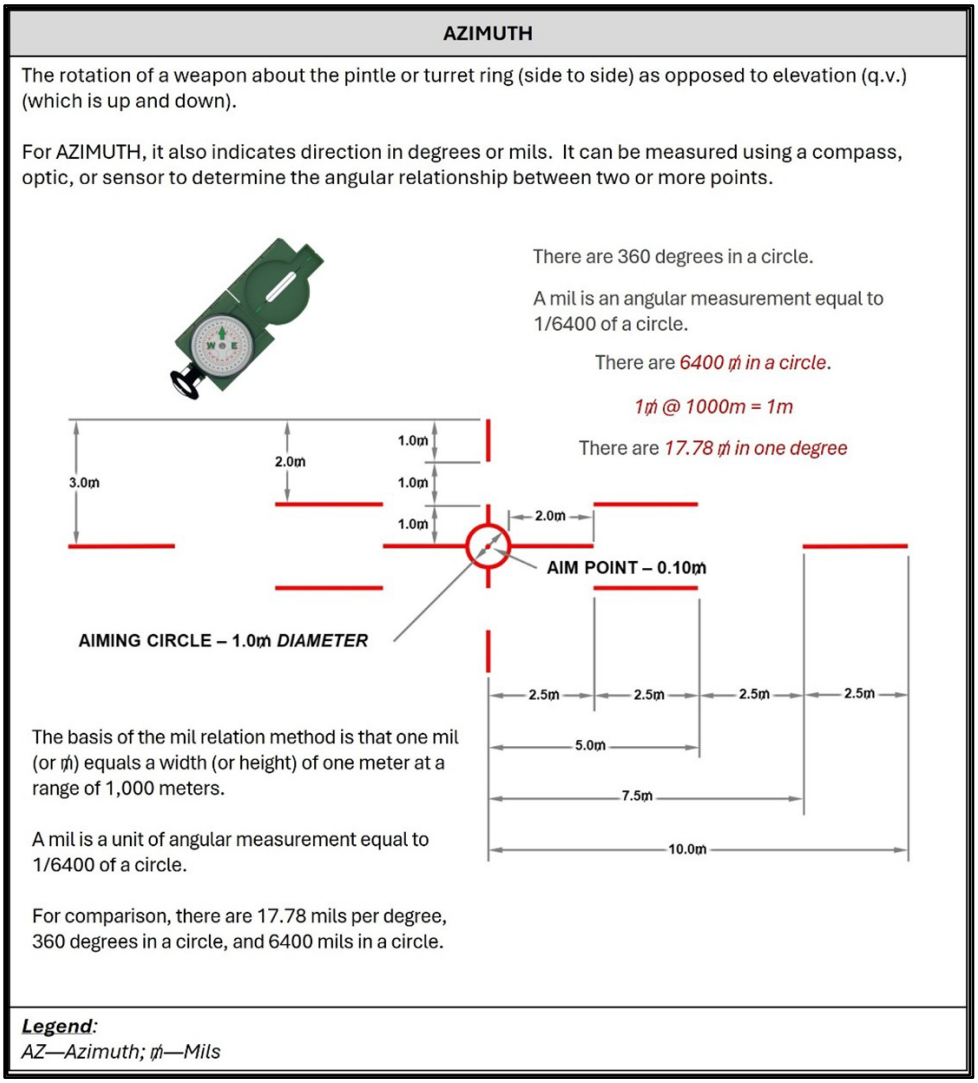


Figure 2-5. Azimuth

BALLISTICS

2-8. Ballistics is the science or study of the motion, propulsion, flight, and impact of projectiles. It is also the art or science of designing projectiles for maximum flight or terminal effects performance. Figure 2-6 describes the phases of ballistics for the purposes of large-caliber direct-fire cannons.

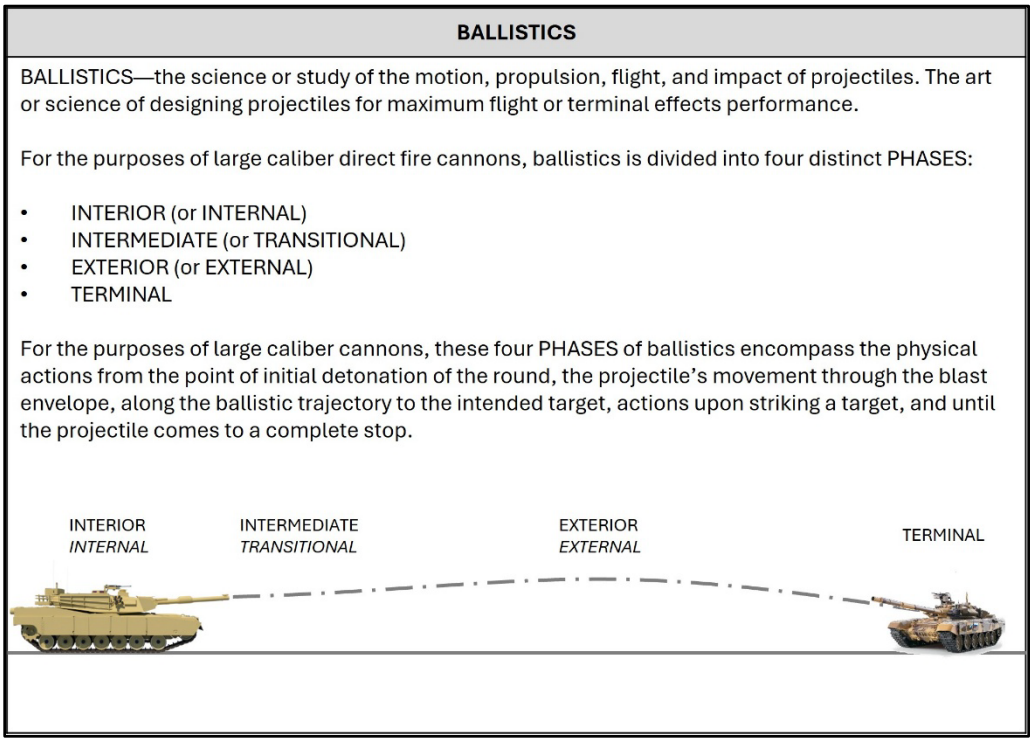


Figure 2-6. Ballistics

BALLISTIC DRIFT

2-9. Ballistic drift is the lateral departure of spin-stabilized ammunition from the gun-target line (also called GTL). Only spin-stabilized rounds are affected. Figure 2-7 describes how ballistic drift is created and its behaviors.



Figure 2-7. Ballistic drift

Note. Ballistic drift is not to be confused with emergency or normal mode drift.

BALLISTIC TRAJECTORY

2-10. Ballistic trajectory is the path of a projectile when influenced only by external forces such as gravity and atmospheric friction. Figure 2-8 illustrates the relationship between the ballistic trajectory and the LOS, AoB, and the LoD.

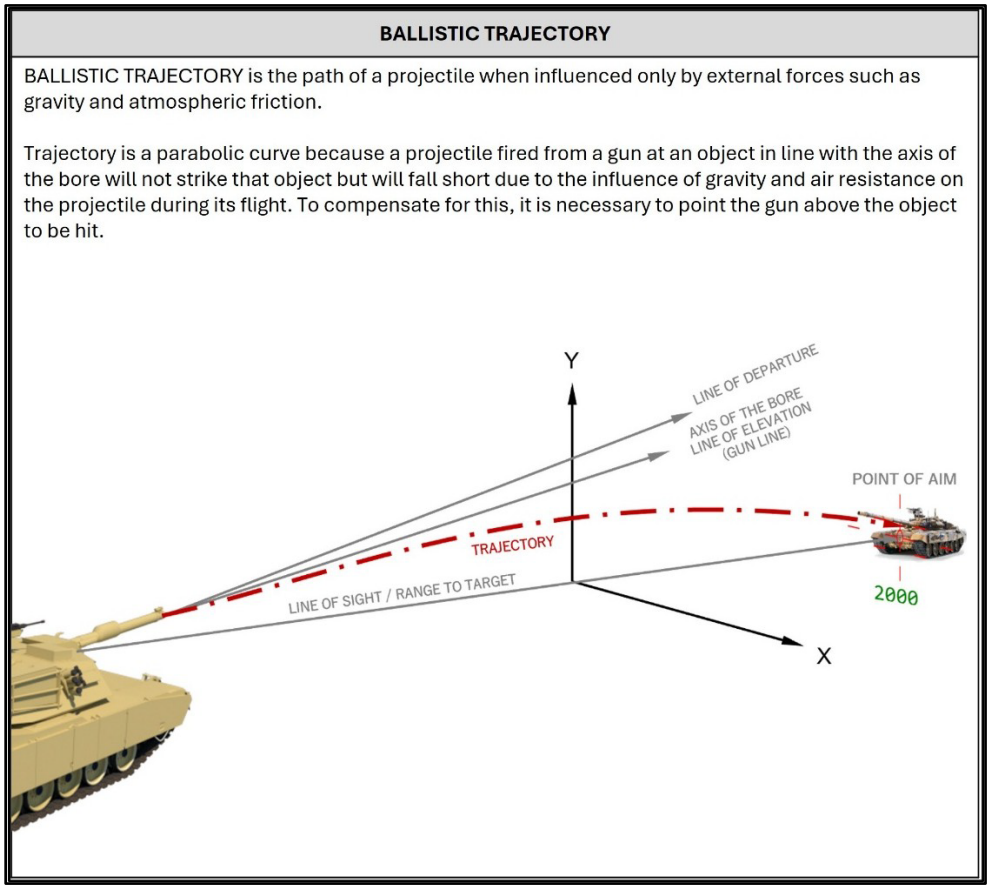


Figure 2-8. Ballistic trajectory

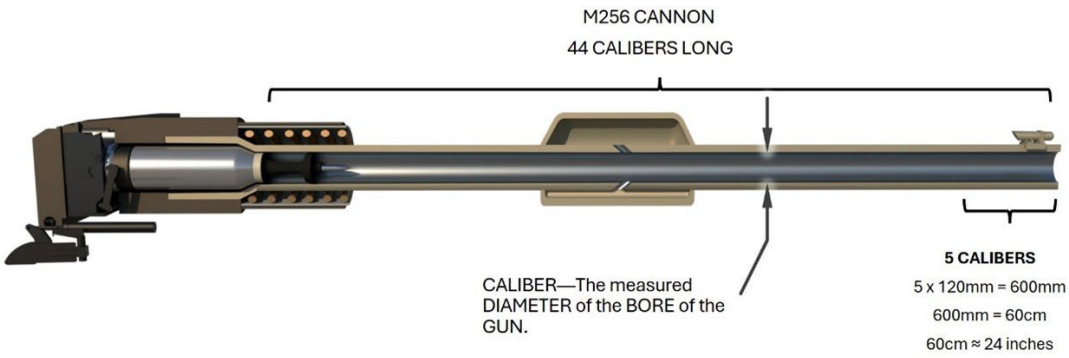
CALIBER

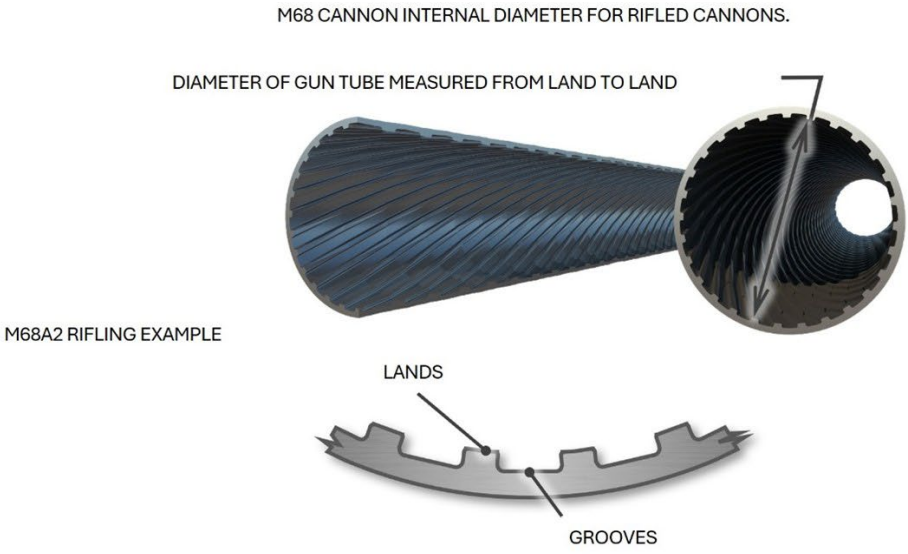
2-11. Caliber is the measurement of the diameter of the bore of the gun. This measurement is also used as a relational distance; for example, the last 5 calibers of the gun. Figure 2-9 describes caliber in detail.

CALIBER

CALIBER is the measured diameter of the bore of the gun.

This measurement is also used as a relational distance:
- the last five (5) calibers of the gun.
- The M256 cannon is 44 calibers long (comparable to the German L44 cannon).
- The LEO2A6 uses the extended L55 cannon (55 calibers long, rather than 44 calibers).





Legend:
cm—Centimeter; in—Inches; L—Length; m—Meters; mm—Millimeter

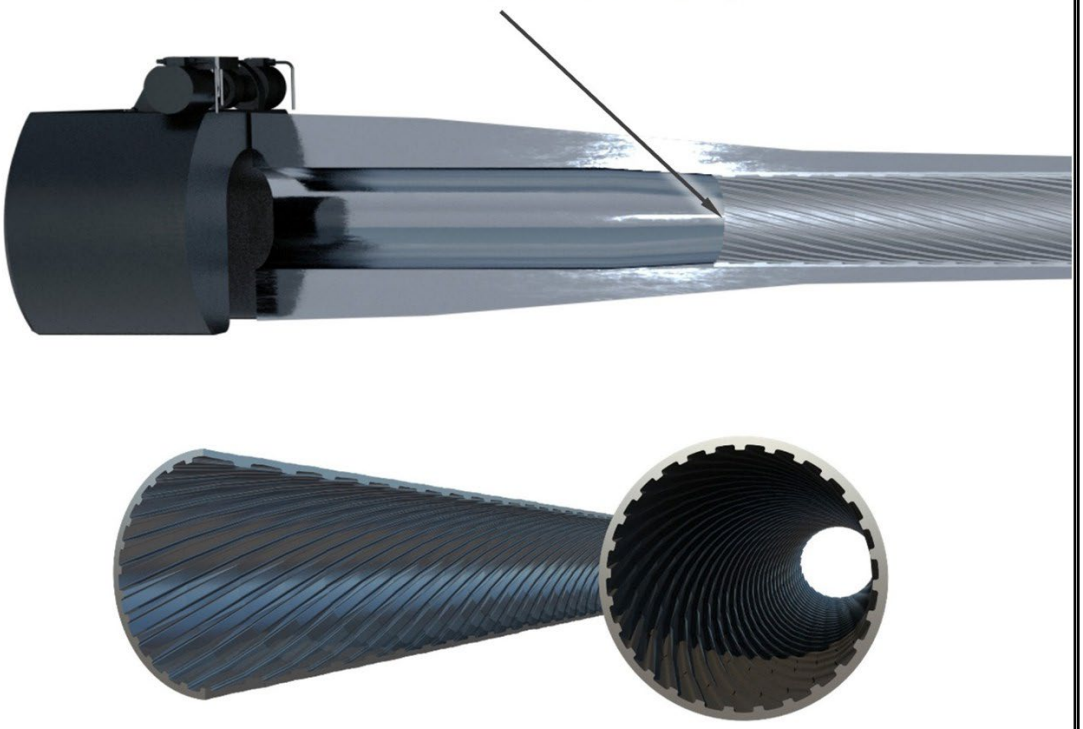
Figure 2-9. Caliber

COMMENCEMENT OF RIFLING

2-12. Commencement of rifling (see figure 2-10) is the point in a rifled gun tube at which the lands have attained full size.

COMMENCEMENT OF RIFLING

COMMENCEMENT OF RIFLING—The point in a RIFLED gun tube at which the lands have attained full size / height.



Legend:
mm—Millimeter

Figure 2-10. Commencement of rifling

EXTERIOR/EXTERNAL BALLISTICS

2-13. Exterior/external ballistics (see figure 2-11) encompasses the period from when the projectile has left the muzzle, and any sabot pedal discard has occurred until impact with the target. It includes projectile MV, projectile dynamics and stability, the predicted flight path, time of flight, and the angle, velocity, and location of impact. It is the study of projectiles in flight.

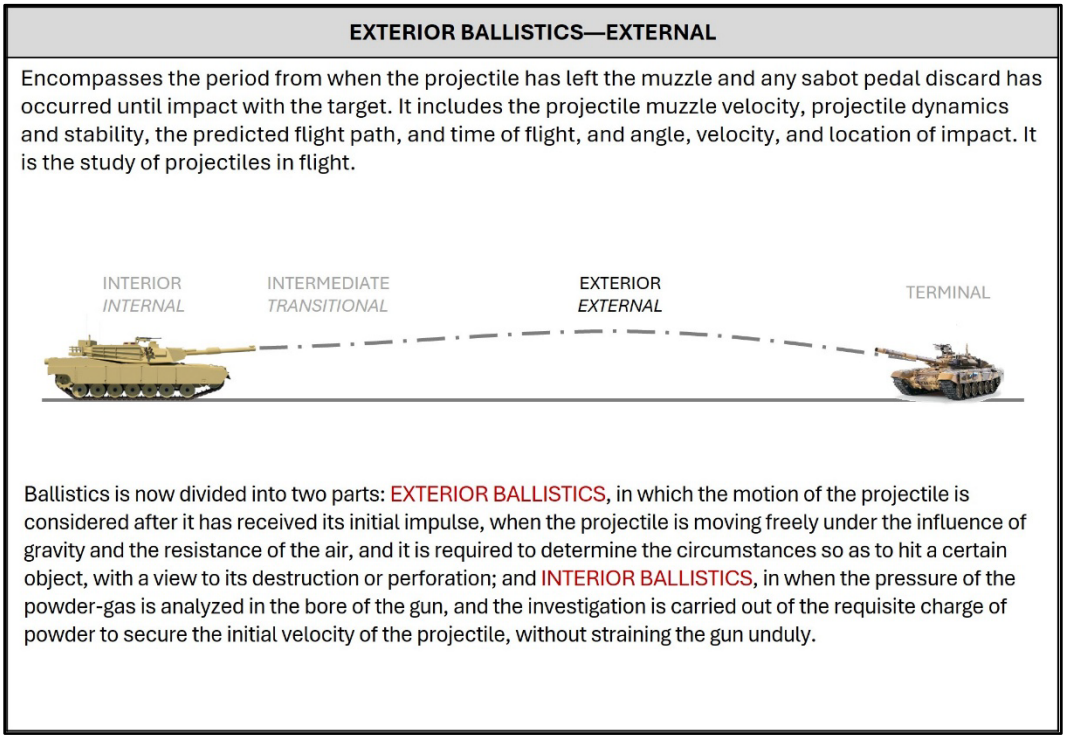


Figure 2-11. Exterior and external ballistics

JUMP

2-14. Vertical jump is the angle, measured in mils, between the LoD and the LoE (see figure 2-12).

JUMP

Vertical JUMP is the angle, measured in mils (m), between the line of departure and the line of elevation.

Due to the impact of interior ballistics on the projectile as it travels through the bore and movement of the gun during firing, the projectile will not exit the muzzle exactly in line with the line of elevation. The jump angle will vary depending on the gun and type of ammunition being fired.

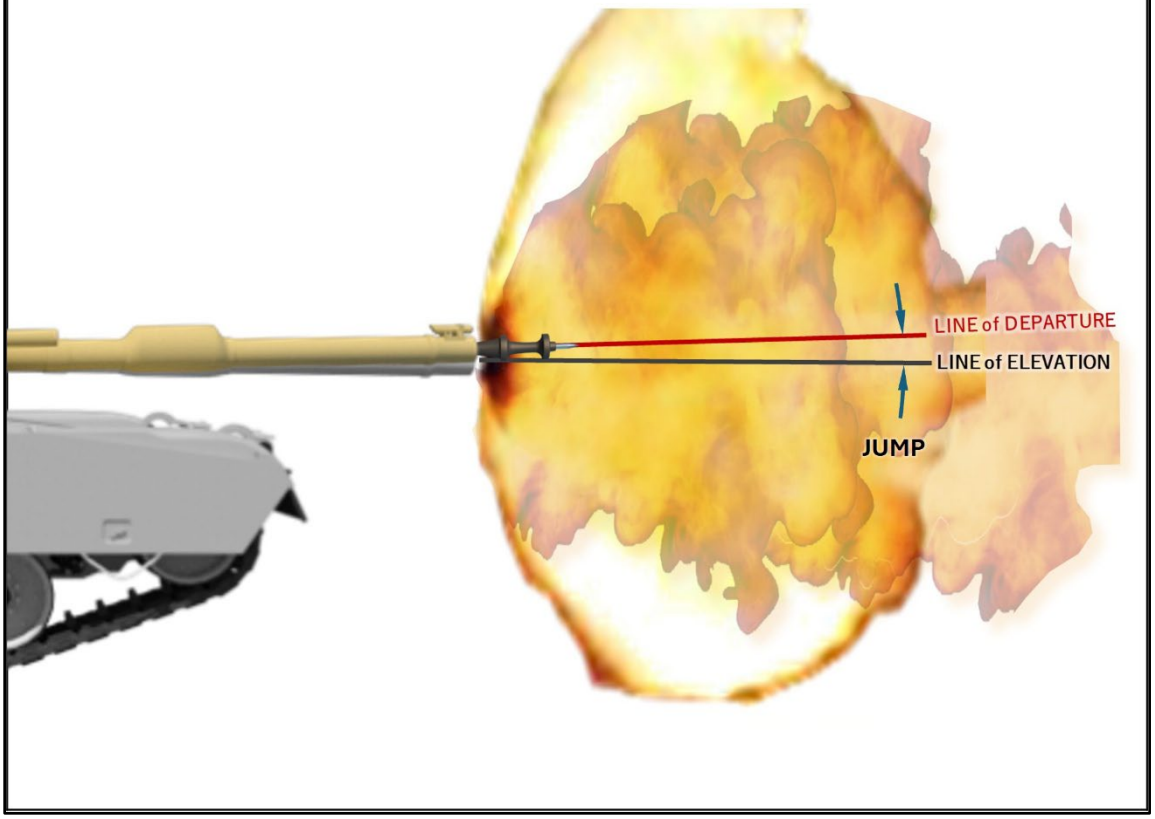


Figure 2-12. Jump

KINETIC ENERGY

2-15. Kinetic energy (see figure 2-13) is energy due to mass and velocity. It can be calculated by taking half the mass and multiplying it by the velocity squared (1/2 mv^2).

KINETIC ENERGY

Energy due to mass and velocity. It can be calculated by taking half the mass and multiplying it by the velocity squared (1/2 mv2).

- Kinetic Energy (KE) rounds concentrate maximum force onto a single point to achieve the greatest possible penetration.
- Kinetic Energy can be calculated with the following formula:

$$KE = \frac{mass \times velocity^2}{2}$$

- The kinetic energy unit of measurement for large caliber munitions is megajoules (mJ)
- The larger the KE value in MJ, the greater the penetration capability.
- As MASS (m) increases, KE increases.
- Doubling velocity increases KE by 4.

Figure 2-13. Kinetic energy

LINE OF SIGHT

2-16. The LOS is a straight line between the gun sight and the target. Figure 2-14 describes the relationship between LOS and the ballistic trajectory, AoB, and LoD.

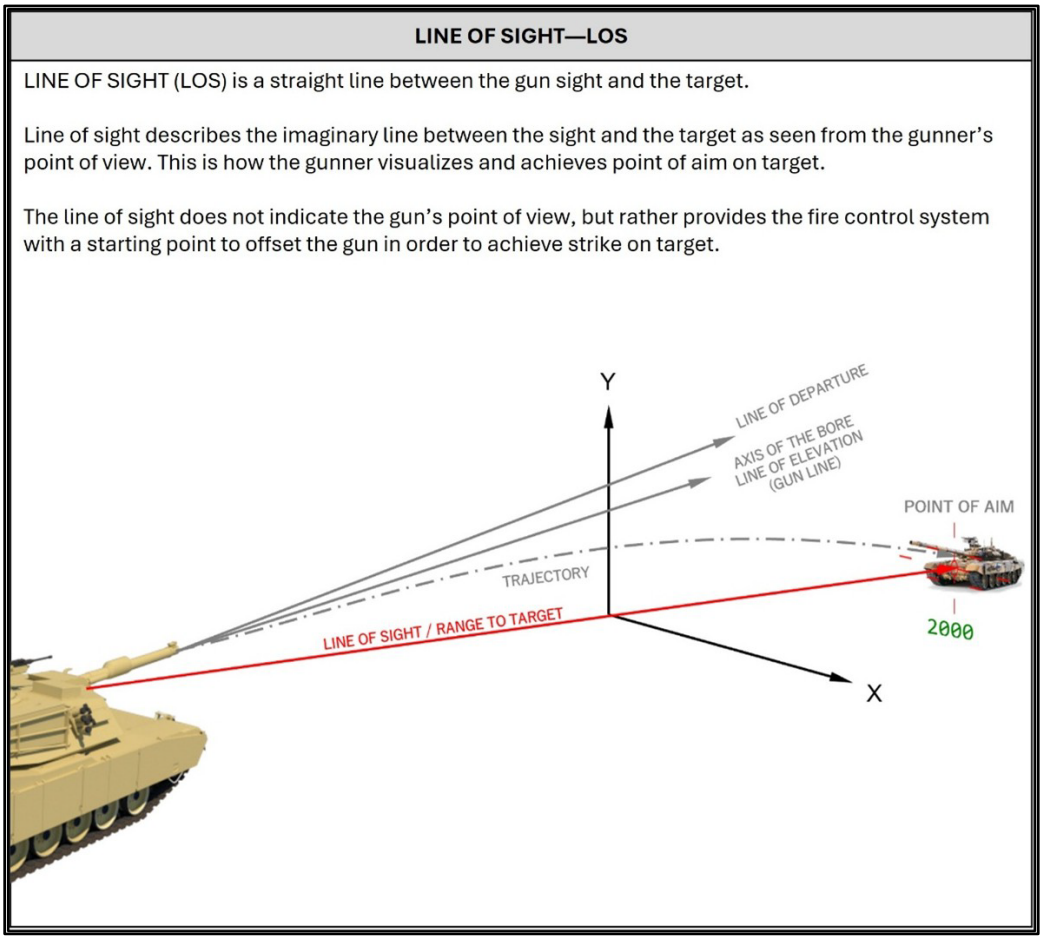


Figure 2-14. Line of sight

LINE OF ELEVATION

2-17. LoE is the center of the AoB. The LoE describes the exact bore centerline from the chamber region to the muzzle, and onward indefinitely. Figure 2-15 describes the relationship between the LoE and the ballistic drift, LOS, and LoD.

LINE OF ELEVATION

LINE OF ELEVATION is the center of the axis of the gun bore.

Also known as the axis of the bore, the line of elevation describes the exact bore centerline from the chamber region, to the muzzle, and onward indefinitely. The line of elevation is not the same as the line of sight or line of departure. If the line of sight is on the point of aim on target, the line of elevation is the line directly offset by values determined by the ballistic computer. This is done in order to counter aerodynamic forces' effects on the fired munition and ensure first round strike on target.

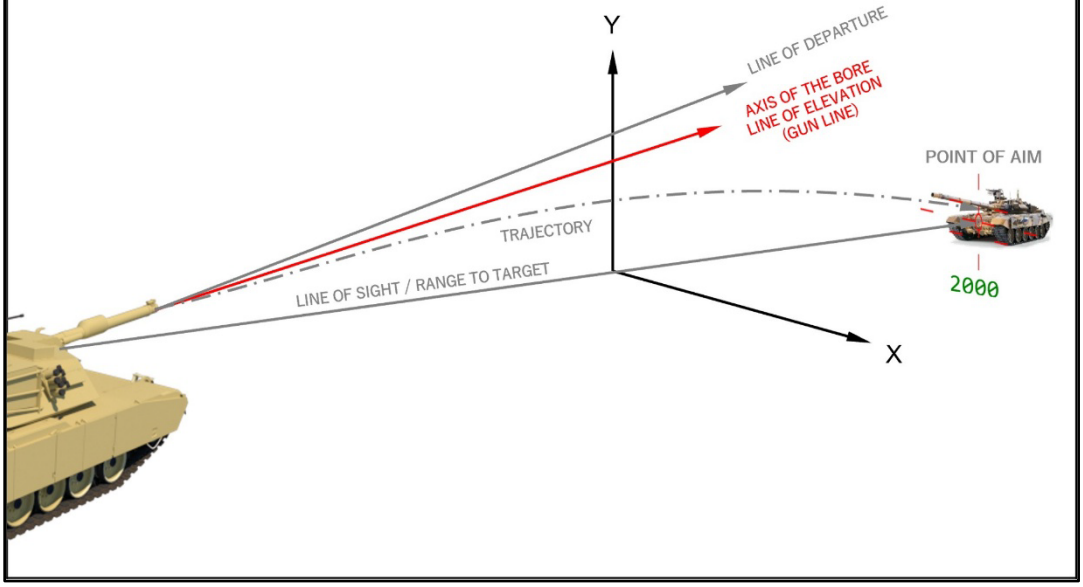


Figure 2-15. Line of elevation

LINE OF DEPARTURE

2-18. LoD is the center of the axis as the projectile leaves the muzzle. Figure 2-16 describes how LoD is created and its relationship to the ballistic trajectory, AoB, and LOS.

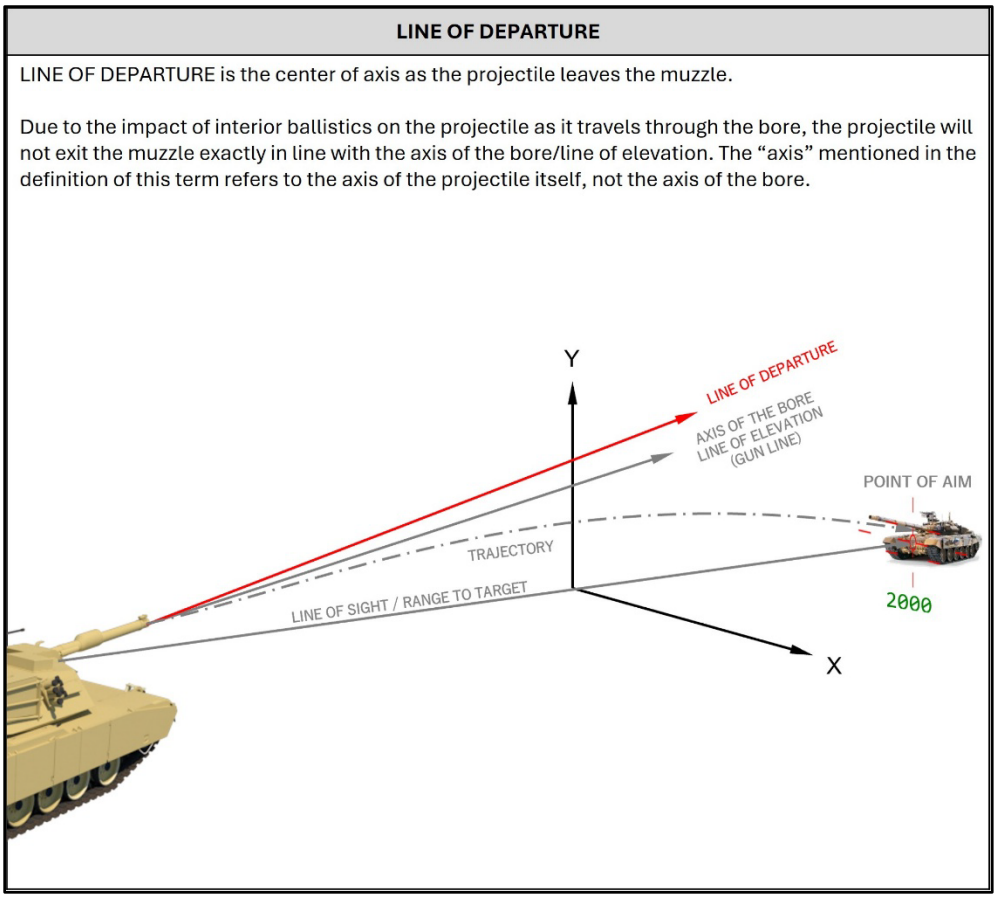


Figure 2-16. Line of departure

MAXIMUM ORDINATE

2-19. MAX ORD is the maximum height the projectile travels above the gun LOS on its path to the point of impact. Associated with this term is "range to MAX ORD," which is the distance along the projectile's trajectory from the muzzle where the MAX ORD occurs. Figure 2-17 describes MAX ORD, its associated range, and its relationship to ballistic trajectory and the LOS.

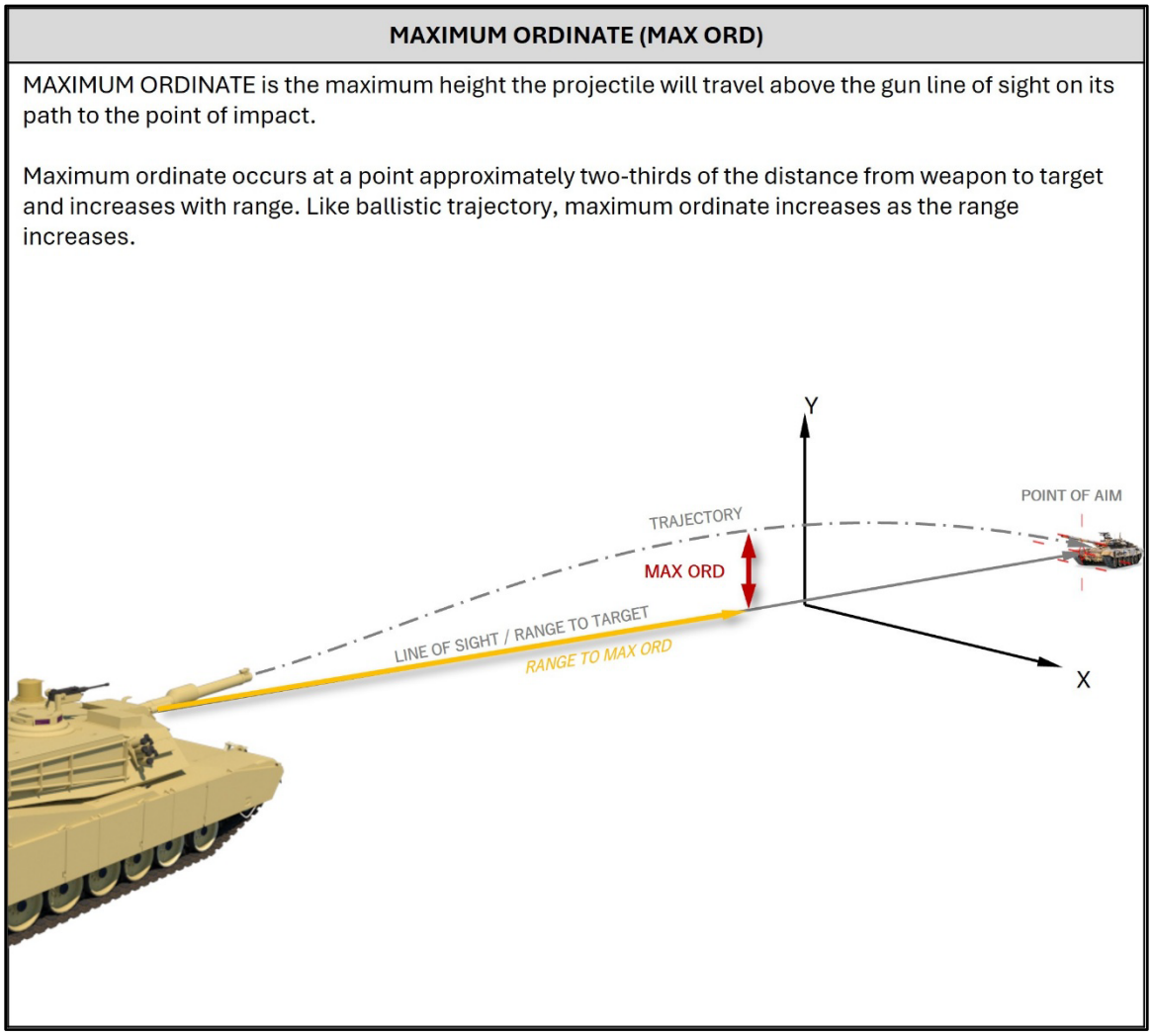


Figure 2-17. Maximum ordinate

MUZZLE VELOCITY

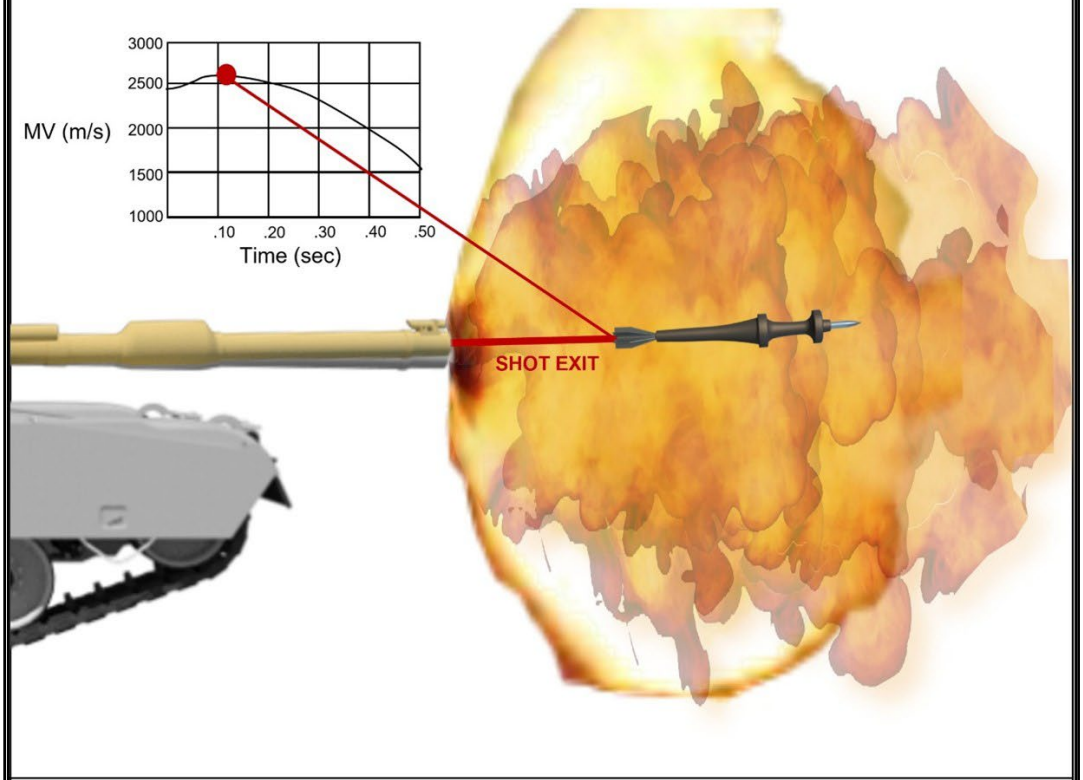
2-20. MV is the speed (velocity) of the projectile approximately 2 feet beyond the muzzle of the gun (after shot exit). Figure 2-18 describes the importance of MV and its susceptibility to both external and internal influences.

MUZZLE VELOCITY (MV)

MUZZLE VELOCITY (MV) is the speed (velocity) of the projectile measured approximately two feet beyond the muzzle of the gun (after shot exit).

Muzzle velocity is a factor that directly affects how elevation is applied to a weapon system to achieve strike on target. A projectile with low MV requires a larger angle of projection than one with a high MV due to gravity and air resistance acting on the projectile in flight for a longer duration of time.

Changes in muzzle velocity that are not immediately compensated for by the firer or fire control system result in a projectile travelling too far or falling short of target. Factors that can affect muzzle velocity include gun wear and charge temperature, both of which can be compensated for by the fire control system.



Legend:
m/s—Meters per Second; sec—Second

Figure 2-18. Muzzle velocity

MACH NUMBER

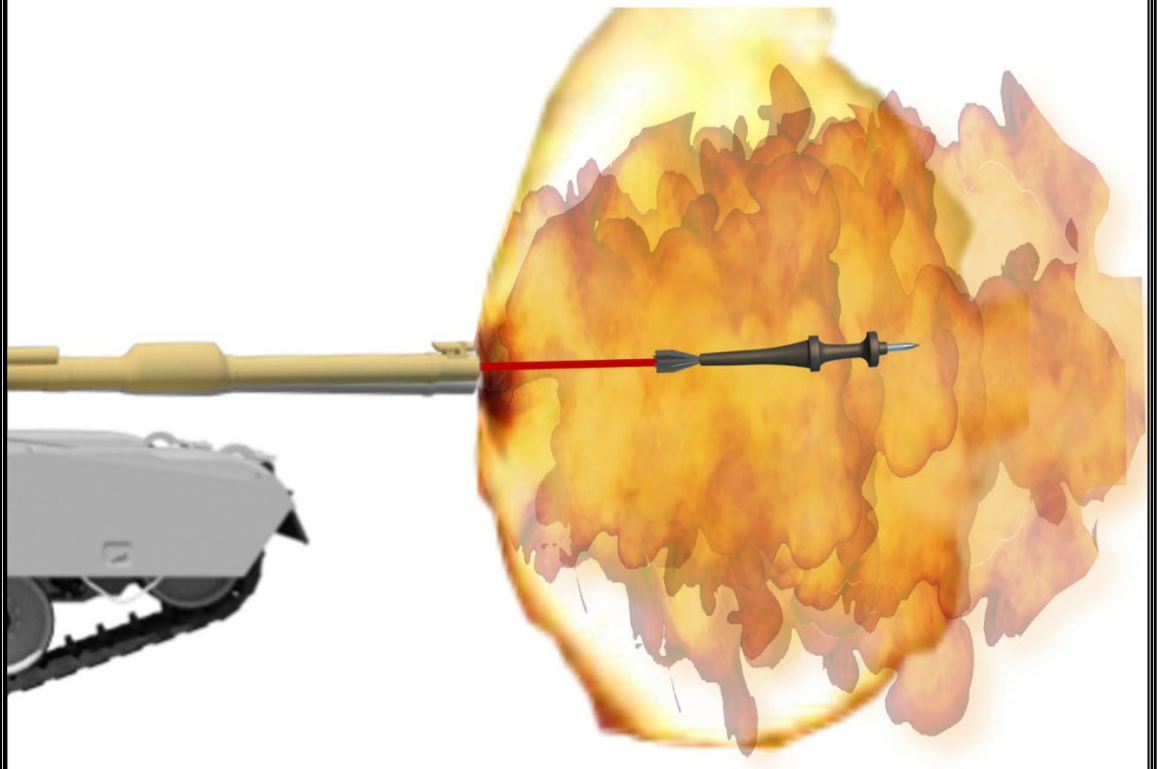
2-21. MACH is the speed (velocity) of the projectile in relation to the speed of sound (343 meters-per-second [m/s]). Figure 2-19 describes MACH and how they are used to categorize projectiles.

MACH NUMBER

MACH NUMBER is the speed (velocity) of the projectile in relation to the speed of sound (343m/s)

Mach number is determined by dividing object speed by the speed of sound. The resulting number allows for categorizing projectiles in one of four flight regimes:

- *SUBSONIC* conditions occur for Mach numbers less than one, or M < 1.
- As the speed of the object approaches the speed of sound, the flight Mach number is nearly equal to one, M = 1, and the flow is said to be *transonic*.
- *SUPERSONIC* conditions occur for Mach numbers greater than one, or M > 1.
- For speeds greater than five times the speed of sound, M > 5, the flow is said to be *HYPERSONIC*.



$$\frac{muzzle\ velocity\ (MV)}{speed\ of\ sound\ (\frac{343m}{s})} \qquad \frac{MV}{343m/s} \qquad \frac{1700m/s}{343m/s} \qquad 4.95 \simeq \text{MACH 5}$$

Legend:
m/s—Meters per Second; s—Second

Figure 2-19. Mach number

OBSCURATION

2-22. Obscuration is the effects of firing which hinder observation (see figure 2-20).

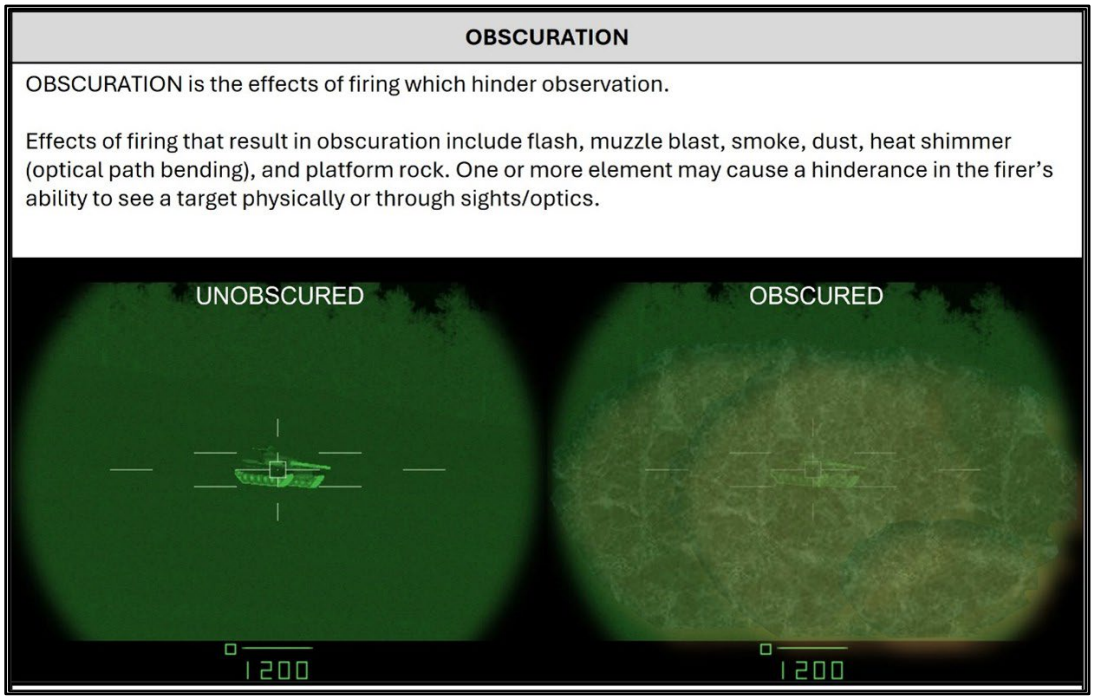


Figure 2-20. Obscuration

SUPERELEVATION/TANGENT ELEVATION

2-23. SE/TE (see figure 2-21) is the gun angle between the LOS and AoB measured in ṁ. Figure 2-21 describes SE/TE.

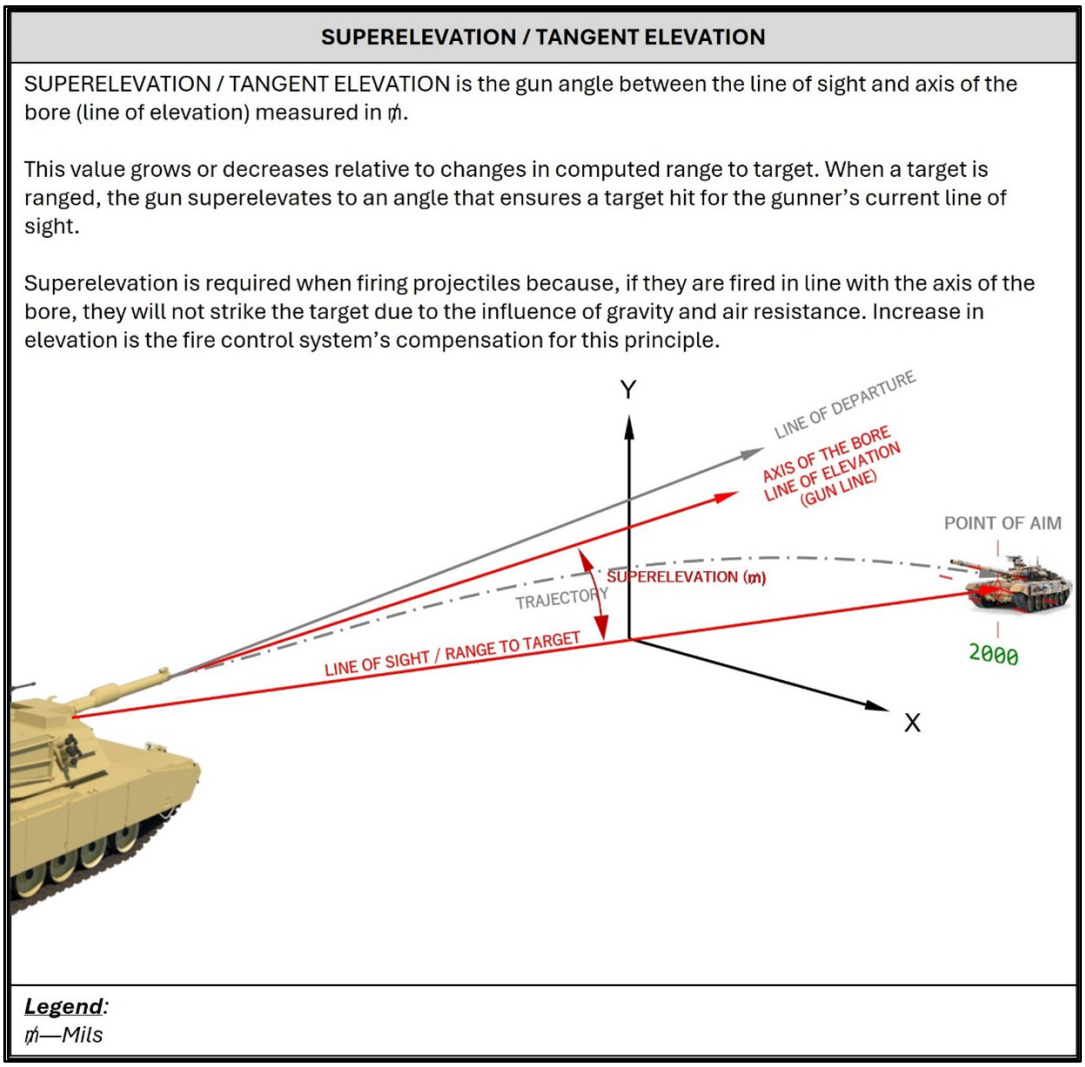


Figure 2-21. Superelevation/tangent elevation

TIME OF FLIGHT

2-24. Time of flight is the time taken for a projectile to reach a given range after firing. Figure 2-22 describes the time of flight in relation to the trajectory and strike on impact.

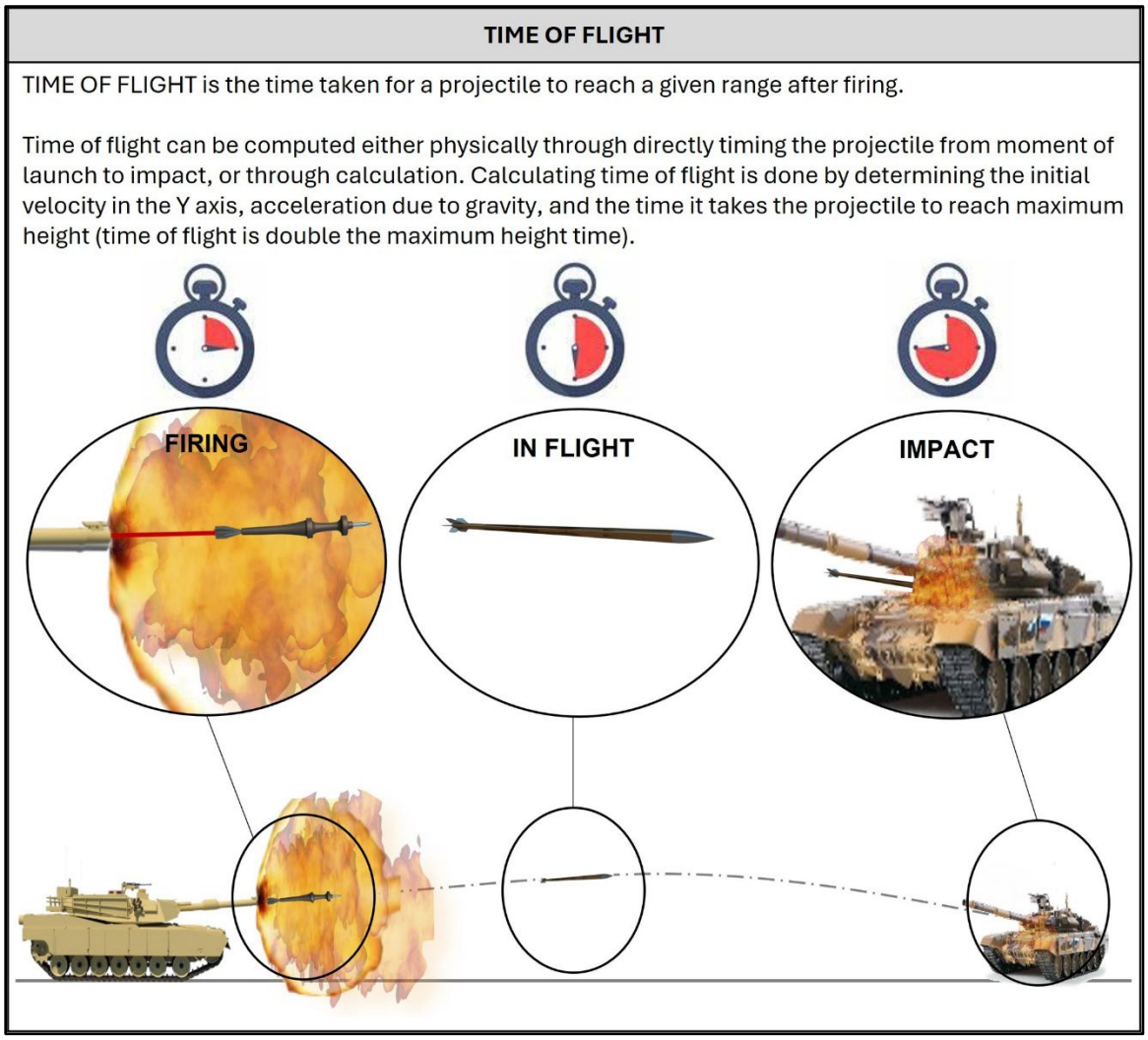


Figure 2-22. Time of flight

YAW

2-25. Yaw is the rotation of the nose of a projectile away from the line of flight in the Y-axis. Figure 2-23 describes yaw at the point of shot exit through stabilization.

YAW

YAW refers to the rotation of the nose of a projectile away from the line of flight in the Y axis (left/right of the trajectory in the horizontal plane).

Yaw is most heavily impactful when the projectile initially leaves the muzzle and is exposed to gases that are no longer contained by the obturator in the gun tube. This is referred to as INITIAL YAW. When gases breach the obturator during initial yaw, they rush past the projectile from its base to the ogive, which causes it to experience a brief tailwind and try to tumble back *towards* the muzzle. However, because the gases only affect the projectile for a short time, the ogive does not tumble completely over to face the expelling gases.

Throughout most of the projectile's flight, air flows smoothly over the ogive to the projectile's base. Once outside of the blast envelope, the projectile will pitch and yaw at a decreasing rate until it reaches "stable" flight to continue along its intended flight path.

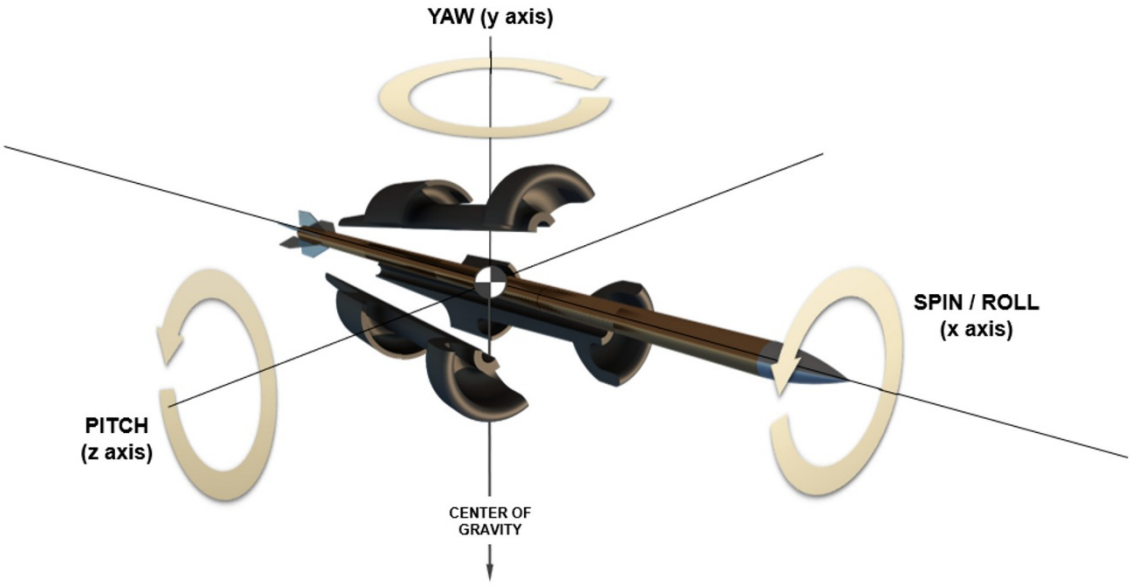


Figure 2-23. Yaw

Chapter 3

Firing Table Administrative Information

Firing Tables A through D are understandable using the terms, abbreviations, and conversions from chapter 2. Additionally, conclusions, solutions, and battlesight ranges can be drawn from that data. This chapter covers how to read and utilize firing tables to reach desired outcomes for smoothbore main gun ammunition. Information on how to access firing table publications is available in appendix A. For purposes of the examples in this publication, appendix B contains examples of firing tables from 120 millimeters (mm) to 7.62-mm ammunition.

STRUCTURE

3-1. Firing tables include 12 key sections to indicate all the ballistic information for the munitions they describe. They are the following:

- Cover.
- Table of Contents.
- Introduction with symbols and abbreviations.
- Conversion factors.
- General information.
- Explanation of tables.
- Sample problems.
- Ammunition Cartridge Cover Sheet.
- Table A, Basic Data.
- Table B, Maximum Ordinate, Range and Effects on Range.
- Table C, Effects on Muzzle Velocity due to Ammunition Temperature.
- Table D, Effects on Air Density due to Altitude.

3-2. This chapter discusses administrative information only. Ballistic information for Tables A through D is included in subsequent chapters.

COVER

3-3. When firing tables are published in a book, the labels of its weapon systems and ammunition are clearly articulated on the front cover. It is important to be equipped with, and use, the appropriate firing tables for the weapon and/or ammunition that are intended to be studied. (Figure 3-1 shows an example of a 120mm M256 tank gun ammunition front cover.)

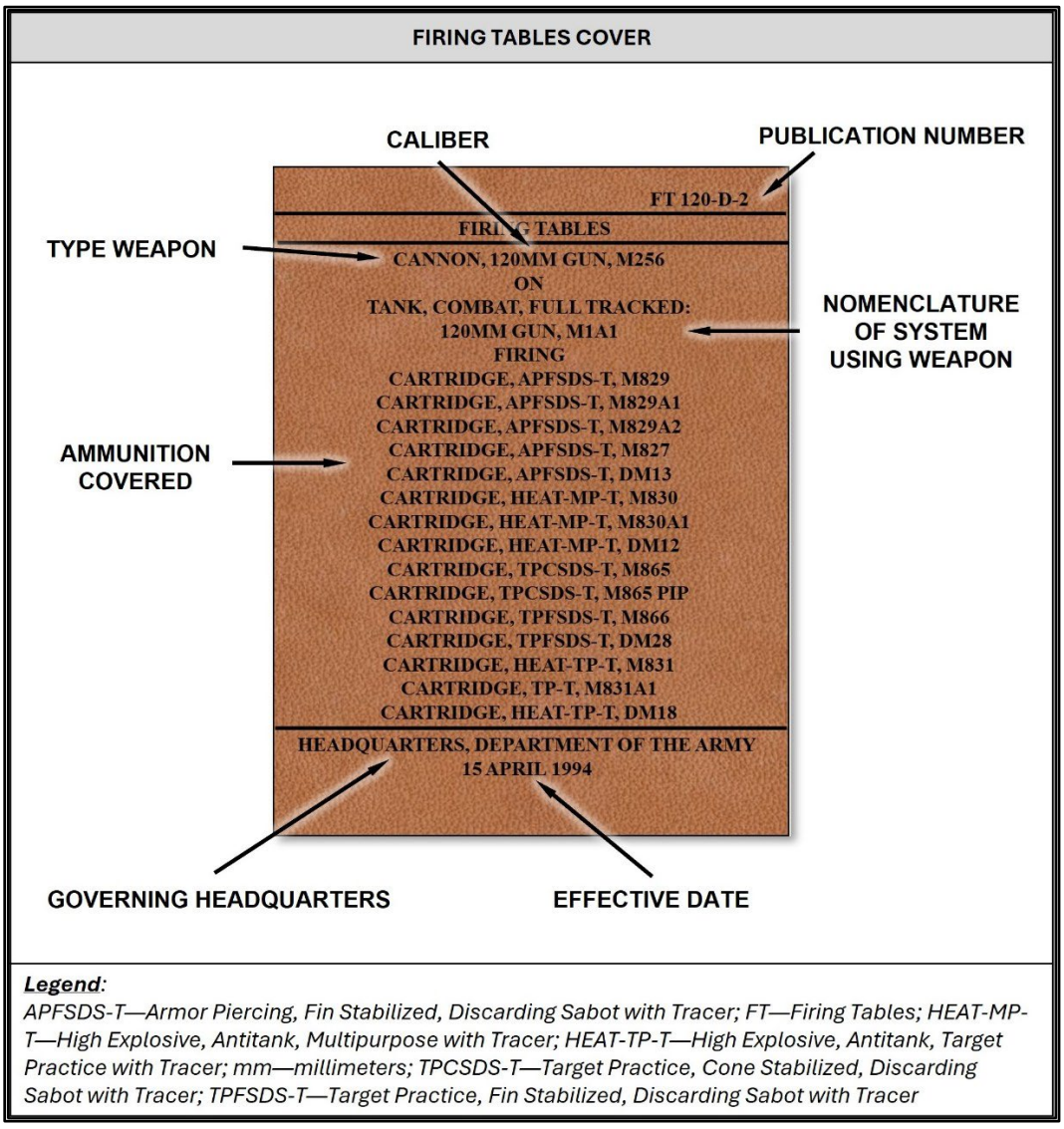


Figure 3-1. Firing tables cover page

3-4. From top to bottom, the cover page lists the type of weapon, its caliber, its ammunition types, the governing headquarters/issuance authority of the firing tables, and the book's effective date. Ensure that all these elements match the intended area of study. It is also important to ensure that the book's effective date reflects the most recent edition.

TABLE OF CONTENTS

3-5. Firing tables books begin with three key components. First is a table of contents followed by a brief introduction that presents symbols and abbreviations used throughout the publication. Lastly, a chart of conversion factors is provided. Figure 3-2 shows an example table of contents.

FIRING TABLES
TABLE OF CONTENTS

FT 120-D-2

TABLE OF CONTENTS

	PARAGRAPH	PAGE
INTRODUCTION		III
SYMBOLS AND ABBREVIATIONS	1	III
CONVERSION FACTORS	2	III
GENERAL INFORMATION	3	IV
EXPLANATION OF TABLES	4	IV
SAMPLE PROBLEMS	5	VII
CARTRIDGE, APFSDS-T, M829		1
CARTRIDGE, APFSDS-T, M829A1		9
CARTRIDGE, APFSDS-T, M829A2		17

Legend:
APFSDS-T—Armor Piercing, Fin Stabilized, Discarding Sabot with Tracer; FT—Firing Tables

Figure 3-2. Table of contents

INTRODUCTION WITH SYMBOLS AND ABBREVIATIONS

3-6. Figure 3-3 shows an example list of symbols and abbreviations seen throughout firing tables publications. When used in a graphic or figure, they are listed accordingly in the respective legend.

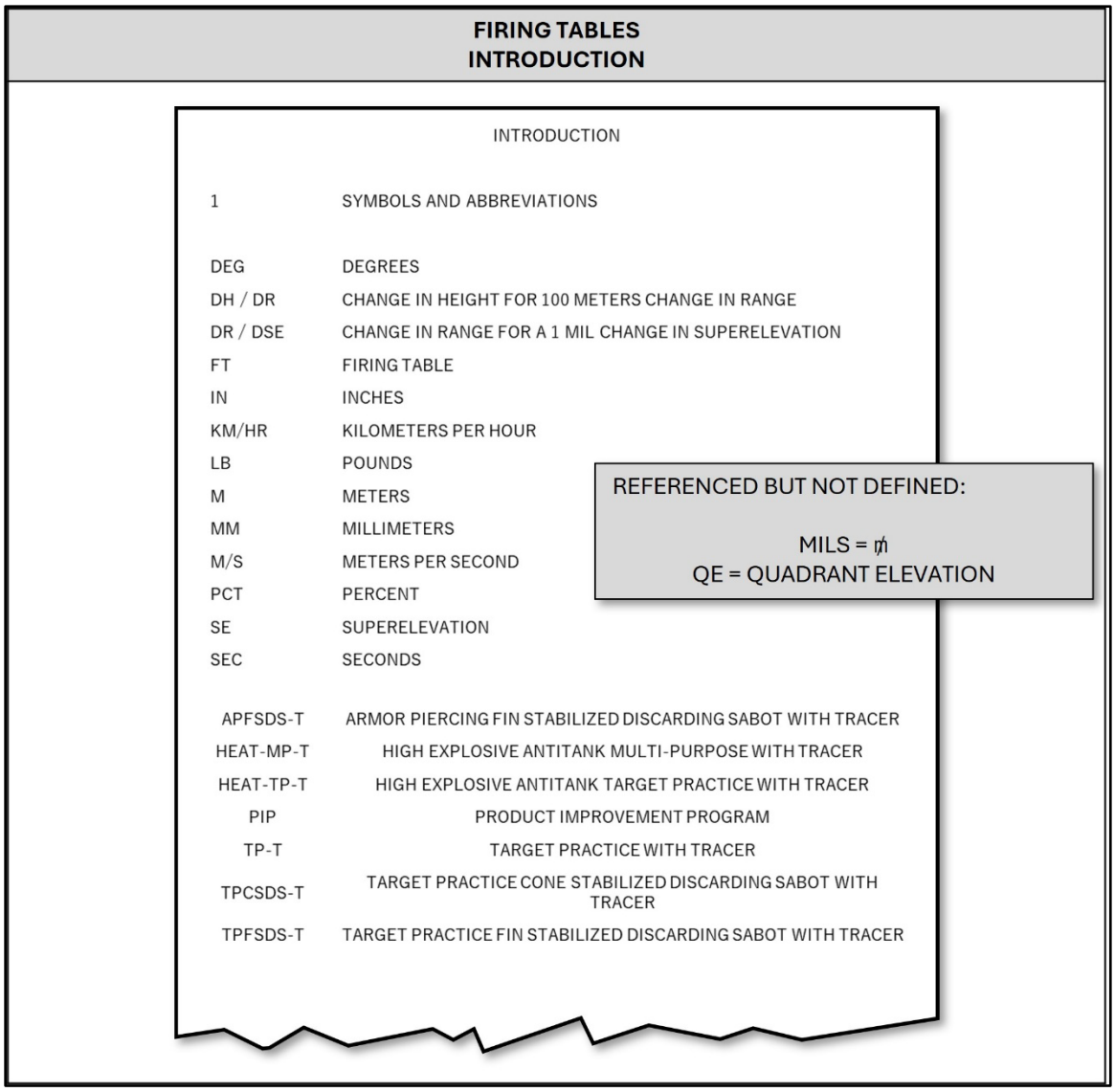


Figure 3-3. Firing tables introduction

CONVERSION FACTORS

3-7. Firing tables calculations require unit conversion. It is a simple process that involves multiplication or division by a numerical factor and rounding. Figure 3-4 shows conversion factors for calculations conducted during use of firing tables publications.

FIRING TABLES
CONVERSION FACTORS

2 CONVERSION FACTORS

MULTIPLY	BY	TO OBTAIN
METERS	1.0936	YARDS
YARDS	0.9144	METERS
FEET	0.3048	METERS
MILES	1.6093	KILOMETERS
KILOMETERS	0.6214	MILES
KNOTS	0.1508	MPH
MPH	0.8690	KNOTS
DEGREES	17.7778	MILS
MILS	0.05625	DEGREES
MINUTES	0.2963	MILS
MILS	3.375	MINUTES

Legend:
mph—Miles per Hour

Figure 3-4. Conversion factors chart

USING CONVERSION FACTORS

3-8. Unit conversion is a simple process that involves multiplication or division by a numerical factor and rounding. Use the following steps to construct a unit conversion problem so that the initial unit of measurement cancels and the desired unit remains:

- Identify the starting unit (meters, yards, feet, for example).
- Identify the desired unit.
- Identify the appropriate unit conversion factor(s) (see chapter 2, figure 2-4) and use exact conversion factors whenever available.
- Cancel units and perform the calculation (multiply, divide, for example) and double check by repeating the calculation.
- Evaluate the result to ensure the answer makes sense.

3-9. There are best practices to keep in mind when converting units of measurement. First, do not attempt to round any of the quantities/numbers during execution of the calculation. If necessary, only round the final calculated solution. Many unit conversion problems require only a single unit conversion factor; however, multiple conversion factors may be required to solve a problem. Ensure the correct conversion factor is used to solve your problem. If an incorrect (or approximate) conversion factor is used, a correct solution is not achieved. Figure 3-5 lists standard conversions.

CONVERSION FACTORS		
MULTIPLY	**BY**	**TO OBTAIN**
What I have ✖	*Factor* =	*What I need*
METERS (m)	*1.0936*	YARDS (yd)
YARDS (yd)	*0.9144*	METERS (m)
FEET (ft)	*0.3048*	METERS (m)
MILES (mi)	*1.6093*	KILOMETERS (km)
KILOMETERS (km)	*0.6214*	MILES (m)
KNOTS (kn)	*1.1508*	MILES PER HOUR (mph)
MILES PER HOUR (mph)	*0.8690*	KNOTS (kn)
MILES PER HOUR (mph)	*1.6093*	KILOMETERS PER HOUR (kmph)
KILOMETERS PER HOUR (kmph)	*0.6214*	MILES PER HOUR (mph)
DEGREES (deg or °)	*17.7778*	MILS (‰)
MILS (‰)	*0.05625*	DEGREES (deg or °)

Figure 3-5. Using conversion factors

GENERAL INFORMATION

3-10. The general information section of the firing tables provides basic data for and characteristics of a round type. This includes where test firing was conducted and the report numbers for ammunition listed in the firing table (see figure 3-6).

FIRING TABLES
GENERAL INFORMATION

Explains where firing was conducted and the report numbers for ammunition listed in the firing table.

3 GENERAL INFORMATION

A THE ICAO STANDARD ATMOSPHERE AND A MODIFIED POINT MASS TRAJECTORY MODEL, AS DESCRIBED IN BALLISTIC RESEARCH LABORATORY MEMORANDUM REPORT NO. 1314, WERE USED IN THE COMPUTATION OF THE TRAJECTORIES FROM WHICH THE TABLES WERE DERIVED. THE TRAJECTORY MODEL WAS ADJUSTED TO ALLOW COMPUTATION RELATIVE TO A LINE OF SIGHT RATHER THAN A CURVED EARTH SURFACE FOR THE BASIC TABLES (TABLE A) WHILE TABLE B OF THE RANGE SAFETY TABLES WAS COMPUTED USING A TRAJECTORY MODEL BASED ON A CURVED, NONROTATING EARTH.

B THE EXTERIOR BALLISTIC PARAMETERS USED TO GENERATE THE TABLES HEREIN FOR THE M829, M829A1, M829A2, M827, DM13, M830, M830A1, DM12, M865, M865 PIP, M866, DM28, M831, M831A2, AND DM18 ARE BASED ON FIRINGS CONDUCTED AT ABERDEEN PROVING GROUND, MARYLAND. THE VERTICAL TARGET TEST RESULTS FOR THE M829, M866, M865, M830, AND M831 ARE DESCRIBED IN TEST AGENCY FIRING RECORD NO. P-82998, WHILE THE M827 AND DM28 TEST RESULTS ARE PUBLISHED IN FIRING RECORD NO. P-82908. THE M865 PIP VERTICAL TARGET TEST RESULTS ARE PROVIDED IN FIRING RECORD NO. P-83123 AND THE DM13, DM 12, AND DM18 TEST RESULTS ARE PUBLISHED IN FIRING RECORD NO. P-82866. THE TABLES FOR THE M829A1, M829A2, M830A1, AND M831A1 ARE BASED ON RANGE FIRINGS CONDUCTED AT YUMA PROVING GROUND, ARIZONA, ABERDEEN PROVING GROUND, MARYLAND, AND CHINA LAKE, CALIFORNIA, AND OTHER UNPUBLISHED FIRING RESULTS.

CARTRIDGE	VERTICAL TARGET TEST RESULTS FIRING RECORD
M829	NO. P–82998
M829A1	
M829A2	
M827	NO. P–82908
DM13	NO. P–82866
M830	NO. P–82998
M830A1	
DM12	NO. P–82866
M865	NO. P–82998
M865 PIP	NO. P–83123
M866	NO. P–82998
DM28	NO. P–82908
M831	NO. P–82998
M831A1	
DM18	

Legend: *ICAO—International Civil Aviation Organization; mph—Miles per Hour*

Figure 3-6. General information example

EXPLANATION OF TABLES

3-11. The explanation of tables (see figure 3-7) section defines the table itself, tabulated information available, and its calculable functions.

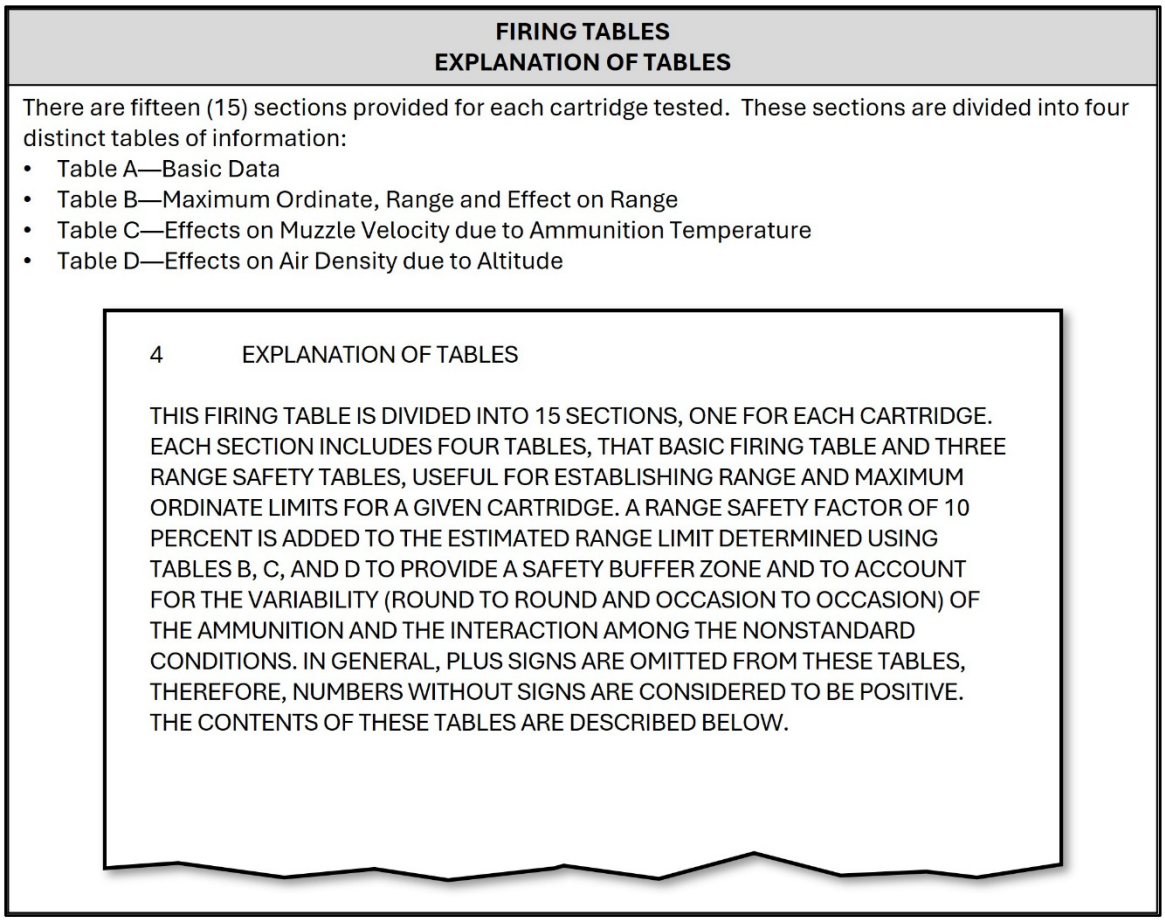


Figure 3-7. Explanation of tables

SAMPLE PROBLEMS

3-12. For each cartridge listed in the firing tables, two sample problems are provided (see figure 3-8). These are used to explain how to utilize the firing tables with notional data. They help to explain the computation steps for basic ballistic changes.

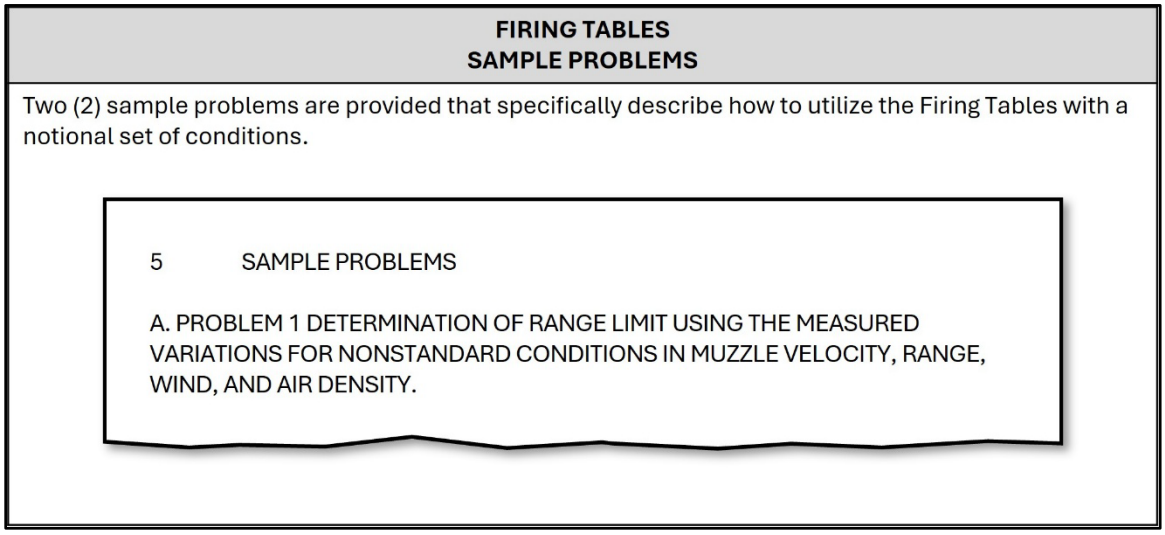


Figure 3-8. Sample problems

AMMUNITION CARTRIDGE COVER SHEET

3-13. To find the appropriate tables for your ammunition, the ammunition type must be located by nomenclature. Every set of firing tables is preceded by an ammunition cover sheet that defines the ammunition type, MV, projectile weight, aerodynamics package, ballistic coefficient, or other important data for a given round. For the purposes of this section, the M865 performance improvement package (PIP) target practice cone stabilized discarding sabot with tracer (TPCSDS-T) is used. Figure 3-9 displays the ammunition cover sheet for the M865 PIP TPCSDS-T.

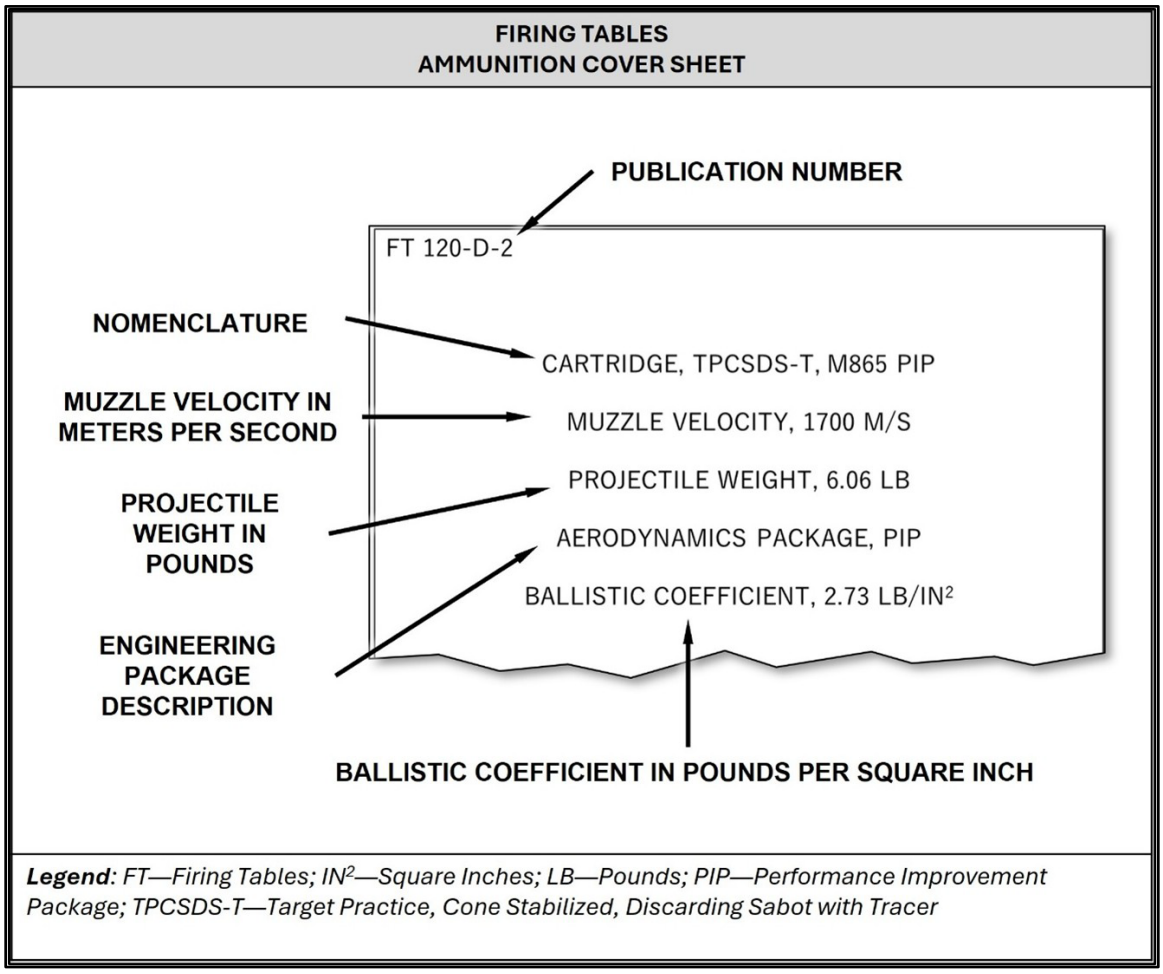


Figure 3-9. M865 PIP TPCSDS-T ammunition cover sheet

Chapter 4

Table A, Basic Data

This chapter provides an overview of Table A, Basic Data. Each column, the differences between rifled and smoothbore barrel information, and general examples using each column are described. When appropriate, a description of how the column's data impacts trajectory of a projectile is described.

OVERVIEW

4-1. Table A consists of 11 total columns. A 12th column may be introduced on the far right of Table A to reflect the range value given in column 1; however, it is simply a duplication of the first column for ease of reading when a table continues to a second page. Figure 4-1 shows what column numbers are used to display each data point for each ammunition category.

FIRING TABLES
TABLE A, BASIC DATA
COLUMN DATA BY AMMUNITION TYPE

	RANGE	SUPER ELEVATION	DR / DSE	DH /DR	DRIFT	TIME OF FLIGHT	X WIND DEFLECTION	MAX ORD	RANGE TO MAX ORD	ANGLE OF FALL	REMAINING VELOCITY
SMALL CALIBER	1	2	3	4	5	6	7	8	9	10	11
MEDIUM CALIBER	1	2	3	4	5	6	7	8	9	10	11
LARGE CALIBER, RIFLED BORE	1	2	3	4	5	6	7	8	9	10	11
LARGE CALIBER, SMOOTH BORE	1	2	3	4		5	6	7	8	9	10

Notes: Large caliber, smooth bore cannon munitions do not include DRIFT information. That column is not displayed. DRIFT is only listed for rifled guns and cannons (105mm, for example).

Some Firing Tables may include an additional RANGE column on the far right to assist when tabular information covers multiple pages or to provide RANGE information closer to the column being used.

Legend:
DH—Change in Height; DR—Change in Range; DSE—Change in Superelevation; MAX—Maximum; mm—Millimeter; ORD—Ordinate

Figure 4-1. Table A columns

Note. For large-caliber smoothbore munitions, the drift column is not required and is excluded from Table A. Drift is considered for rifled munitions only.

BASIC DATA CALCULATIONS

4-2. When determining information in firing tables, the ammunition, range, and column required must be known. This is referred to as the ammunition, range, column (ARC) process. This information is used to select the appropriate row to determine the ballistic outcome. ARC answers these three basic questions:

- A—What is the type of ammunition?
- R—What is the range to target under scrutiny?
- C—What information is needed, and which column is needed?

4-3. Figure 4-2 provides a simple example of the ARC process. The example question is, what is the MAX ORD when firing an M865 PIP round at a target at 2,200 meters?

FIRING TABLES
BASIC DATA CALCULATIONS
AMMUNITION, RANGE, COLUMN (ARC) PROCESS

Example: What is the MAXIMUM ORDINATE of the M865PIP at 2,200 meters?

When looking up information, ask the following three questions:

A—Type of ammunition? (Table of Contents of available cartridge type information).
R—Range—the range to target under scrutiny.
C—Column—What information is needed from the columns available?

DETERMINE MAXIMUM ORDINATE EXAMPLE

You're firing CARTRIDGE, 120MM, TPCSDS-T, M865 PIP.

Engaging a target at 2,200m, how high does the bullet travel above the gun-target line?

A—AMMUNITION	M865 PIP
R—RANGE	2,200m
C—COLUMN	MAXIMUM ORDINATE
ANSWER:	3.6m

TABLE A
BASIC DATA

1	2	3	4	5	6	7	8	9	10	11
RANGE	SUPER-ELEVATION	DR / DSE	DH / DR	TIME OF FLIGHT	10 KM/HR CROSSWIND DEFLECTION	MAXIMUM ORDINATE	RANGE TO MAXIMUM ORDINATE	ANGLE OF FALL	REMAINING VELOCITY	RANGE
METERS	MILS	M/MIL	M/100M	SEC	MILS	METERS	METERS	MILS	M/SEC	METERS
2000	4.82	277	0.7	1.51	0.5	2.8	1086	7	1013	2000
2100	5.17	265	0.7	1.61	0.5	3.2	1146	7	980	2100
2200	5.53	253	0.9	1.71	0.5	3.6	1207	8	946	2200
2300	5.91	242	0.9	1.82	0.6	4.0	1269	9	913	2300
2400	6.31	231	1.0	1.93	0.6	4.6	1331	10	880	2400
	6.73		1.1	2.05	0.7	5.1	1395	11	847	2500

Legend:
DH—Change in Height; DR—Change in Range; DSE—Change in Super Elevation; KM/HR—Kilometers per Hour; m—Meters; M/MIL—Meters per Mils; M/SEC—Meters per Second; PIP—Performance Improvement Package; sec—Second; TPCSDS-T—Target Practice, Cone Stabilized, Discarding Sabot with Tracer

Figure 4-2. ARC process

RANGE

4-4. Finding a known range is done by locating it in the first column of the firing table. This is the starting point and identifies what row must be used. Figure 4-3 demonstrates finding information for a target at 2,200 meters.

FIRING TABLES
TABLE A, BASIC DATA
RANGE

The RANGE column determines the ROW needed to answer the BASIC DATA question.

Use either column 1 on the far left or column 11 on the far right to find the RANGE to target in the ballistic question.

TABLE A
BASIC DATA

1	2	3	4	5
RANGE	SUPER-ELEVATION	DR / DSE	DH / DR	TIME OF FLIGHT
METERS	MILS	M/MIL	M/100M	SEC
0	0.00	536	0.0	0.00
100	0.18	522	0.0	0.06
200	0.36	508	0.0	0.12
300	0.54	494	0.1	0.18
400	0.73	480	0.1	0.25
500	0.93	466	0.1	0.31
600	1.13	453	0.1	0.38
700	1.34	439	0.1	0.44
800	1.56	426	0.2	0.51
900	1.78	413	0.2	0.59
1000	2.01	400	0.2	0.66
1100	2.25	387	0.3	0.73
1200	2.49	374	0.3	0.81
1300	2.75	361	0.3	0.89
1400	3.01	349	0.4	0.97
1500	3.28	337	0.4	1.05
1600	3.57	324	0.5	1.14
1700	3.86	312	0.5	1.23
1800	4.17	300	0.6	1.32
1900	4.49	288	0.6	1.41
2000	4.82	277	0.7	1.51
2100	5.17	265	0.7	1.61
2200	5.53	253	0.9	1.71
2300	5.91	242	0.9	1.82
2400	6.31	231	1.0	1.93
2500	6.73	220	1.1	2.05

FT 120-D-2, *FIRING TABLES FOR CANNON, 120MM, M256.* **M865 PIP**

TABLE A
BASIC DATA

6	7	8	9	10	11
10 KM/HR CROSSWIND DEFLECTION	MAXIMUM ORDINATE	RANGE TO MAXIMUM ORDINATE	ANGLE OF FALL	REMAINING VELOCITY	RANGE
MILS	METERS	METERS	MILS	M/SEC	METERS
0.0	0.0	0	0	1700	0
0.0	0.0	50	0	1665	100
0.0	0.0	101	0	1630	200
0.1	0.0	152	1	1595	300
0.1	0.1	203	1	1561	400
0.1	0.1	255	1	1526	500
0.1	0.2	307	1	1491	600
0.1	0.2	359	1	1457	700
0.2	0.3	412	2	1423	800
0.2	0.4	465	2	1388	900
0.2	0.5	519	2	1354	1000
0.2	0.7	573	3	1320	1100
0.2	0.8	628	3	1286	1200
0.3	1.0	683	3	1252	1300
0.3	1.2	739	4	1218	1400
0.3	1.4	795	4	1184	1500
0.3	1.6	852	5	1149	1600
0.4	1.8	909	5	1115	1700
0.4	2.1	968	6	1081	1800
0.4	2.4	1026	6	1047	1900
0.5	2.8	1086	7	1013	2000
0.5	3.2	1146	7	980	2100
0.5	3.6	1207	8	946	2200
0.6	4.0	1269	9	913	2300
0.6	4.6	1331	10	880	2400
0.7	5.1	1395	11	847	2500

FT 120-D-2, *FIRING TABLES FOR CANNON, 120MM, M256.* **M865 PIP**

Legend:
DH—Change in Height; DR—Change in Range; DSE—Change in Super Elevation; KM/HR—Kilometers per Hour; m—Meters; M/100M—Meters per 100 Meters; M/MIL—Meters per Mils; M/SEC—Meters per Second; mm—Millimeters; PIP—Performance Improvement Package; sec—Second

Figure 4-3. Locate the range and row

4-5. With the 2,200-meter range row identified, the subsequent columns indicate projectile performance data at that range. Read from left to right across the row to collect data.

SUPERELEVATION

4-6. The gun angle in the vertical plane above the LOS to reach and hit a target at a given range is the SE. SE, measured in ṁ, is found in column 2. Using the example M865 PIP at 2,200 meters, continue the ARC process with column 2. Figure 4-4 on shows how to determine the ṁ of SE required to hit a target at 2,200 meters with the M865 PIP.

FIRING TABLES
TABLE A, BASIC DATA
SUPER ELEVATION

The SUPERELEVATION column determines the angular measurement of superelevation required to hit the point of aim at the RANGE for the AMMUNITION TYPE. Column 2 is used to determine the mils (ṁ) of SUPERELEVATION.

TABLE A
BASIC DATA

1	2	3	4	5
RANGE	SUPER-ELEVATION	DR / DSE	DH / DR	TIME OF FLIGHT
METERS	MILS	M/MIL	M/100M	SEC
1500	3.28	337	0.4	1.05
1600	3.57	324	0.5	1.14
1700	3.86	312	0.5	1.23
1800	4.17	300	0.6	1.32
1900	4.49	288	0.6	1.41
2000	4.82	277	0.7	1.51
2100	5.17	265	0.7	1.61
2200	5.53	253	0.9	1.71
2300	5.91	242	0.9	1.82
2400	6.31	231	1.0	1.93
2500	6.73	220	1.1	2.05

FT 120-D-2, *FIRING TABLES FOR CANNON, 120MM, M256.* **M865 PIP**

TABLE A
BASIC DATA

6	7	8	9	10	11
10 KM/HR CROSSWIND DEFLECTION	MAXIMUM ORDINATE	RANGE TO MAXIMUM ORDINATE	ANGLE OF FALL	REMAINING VELOCITY	RANGE
MILS	METERS	METERS	MILS	M/SEC	METERS
0.3	1.4	795	4	1184	1500
0.3	1.6	852	5	1149	1600
0.4	1.8	909	5	1115	1700
0.4	2.1	968	6	1081	1800
0.4	2.4	1026	6	1047	1900
0.5	2.8	1086	7	1013	2000
0.5	3.2	1146	7	980	2100
0.5	3.6	1207	8	946	2200
0.6	4.0	1269	9	913	2300
0.6	4.6	1331	10	880	2400
0.7	5.1	1395	11	847	2500

FT 120-D-2, *FIRING TABLES FOR CANNON, 120MM, M256.* **M865 PIP**

A—Ammunition Type—M865 PIP.
R—Range—2,200 meters.
C—Column—SUPERELEVATION

DETERMINE SUPER ELEVATION EXAMPLE

You're firing CARTRIDGE, 120MM, TPCSDS-T, M865 PIP.

Engaging a target at 2,200m, how much SUPERELEVATION is required?

A—AMMUNITION	M865 PIP
R—RANGE	2,200m
C—COLUMN	SUPERELEVATION
ANSWER:	5.53 mils

Legend:
DH—Change in Height; DR—Change in Range; DSE—Change in Super Elevation; KM/HR—Kilometers per Hour; m—Meters; M/100M—Meters per 100 Meters; M/MIL—Meters per Mils; M/SEC—Meters per Second; mm—Millimeters; PIP—Performance Improvement Package; sec—Second; TPCSDS-T—Target Practice, Cone Stabilized, Discarding Sabot with Tracer

Figure 4-4. Locating superelevation

4-7. Because column 2 is read in m, the SE that must be applied to the gun to strike a target at 2,200 meters using M865 PIP is 5.53m. Figure 4-5 depicts the SE applied to the target at 2,200 meters.

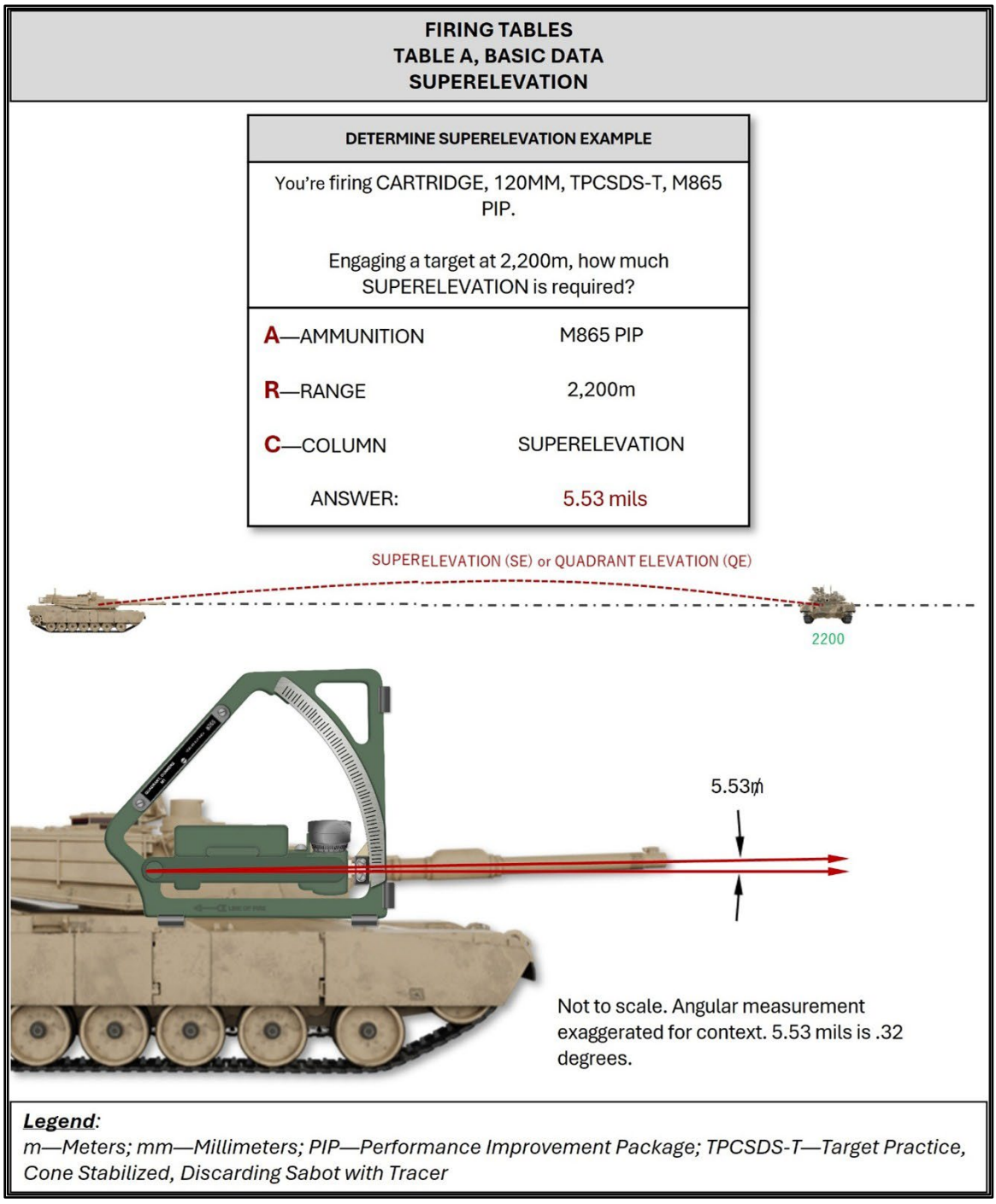


Figure 4-5. Superelevation as it applies to the main gun

CHANGE IN RANGE FOR A 1-MIL CHANGE IN SUPERELEVATION

4-8. Column 3 describes the distance over or under the target where a projectile strikes when 1m̀ is applied or subtracted from the SE. Figure 4-6 illustrates the process to determine how far past the target the projectile strikes given this new SE.

FIRING TABLES
TABLE A, BASIC DATA
DR / DSE

The DR / DSE listed in column 3 answers the question "what is the CHANGE IN RANGE (DR) for a 1 mil CHANGE IN SUPERELEVATION (DSE)?"

TABLE A
BASIC DATA

1	2	3	4	5
RANGE	SUPER-ELEVATION	DR / DSE	DH / DR	TIME OF FLIGHT
METERS	MILS	M/MIL	M/100M	SEC
1500	3.28	337	0.4	1.05
1600	3.57	324	0.5	1.14
1700	3.86	312	0.5	1.23
1800	4.17	300	0.6	1.32
1900	4.49	288	0.6	1.41
2000	4.82	277	0.7	1.51
2100	5.17	265	0.7	1.61
2200	5.53	253	0.9	1.71
2300	5.91	242	0.9	1.82
2400	6.31	231	1.0	1.93
2500	6.73	220	1.1	2.05

FT 120-D-2, *FIRING TABLES FOR CANNON, 120MM, M256.* **M865 PIP**

TABLE A
BASIC DATA

6	7	8	9	10	11
10 KM/HR CROSSWIND DEFLECTION	MAXIMUM ORDINATE	RANGE TO MAXIMUM ORDINATE	ANGLE OF FALL	REMAINING VELOCITY	RANGE
MILS	METERS	METERS	MILS	M/SEC	METERS
0.3	1.4	795	4	1184	1500
0.3	1.6	852	5	1149	1600
0.4	1.8	909	5	1115	1700
0.4	2.1	968	6	1081	1800
0.4	2.4	1026	6	1047	1900
0.5	2.8	1086	7	1013	2000
0.5	3.2	1146	7	980	2100
0.5	3.6	1207	8	946	2200
0.6	4.0	1269	9	913	2300
0.6	4.6	1331	10	880	2400
0.7	5.1	1395	11	847	2500

FT 120-D-2, *FIRING TABLES FOR CANNON, 120MM, M256.* **M865 PIP**

A—Ammunition Type—M865 PIP.
R—Range—2,200 meters.
C—Column—DR / DSE

DETERMINE CHANGE IN RANGE EXAMPLE

You're firing CARTRIDGE, 120MM, TPCSDS-T, M865 PIP.

Engaging a target at 2,200m, if you apply an additional 1mil of SUPERELEVATION, how far beyond the target will the projectile travel?

A—AMMUNITION	M865 PIP
R—RANGE	2,200m
C—COLUMN	DR / DSE
ANSWER:	+253 meters

Legend:
DH—Change in Height; KM/HR—Kilometers per Hour; m—Meters; M/100M—Meters per 100 Meters; M/MIL—Meters per Mils; M/SEC—Meters per Second; mm—Millimeters; PIP—Performance Improvement Package; TPCSDS-T—Target Practice, Cone Stabilized, Discarding Sabot with Tracer

Figure 4-6. Locating change in range for a 1-mil change in superelevation

4-9. In the previous SE example, 5.53 ṁ of SE are applied to the M865 PIP round to strike a target at 2,200 meters. Figure 4-7 shows the gunner adding 1ṁ of SE above the target. Because of the adjustment, the change in range (DR) for a 1-mil change in SE (DSE) adds 253 meters to the original 2,200-meters range to target. The projectile strikes the ground at 2,453 meters.

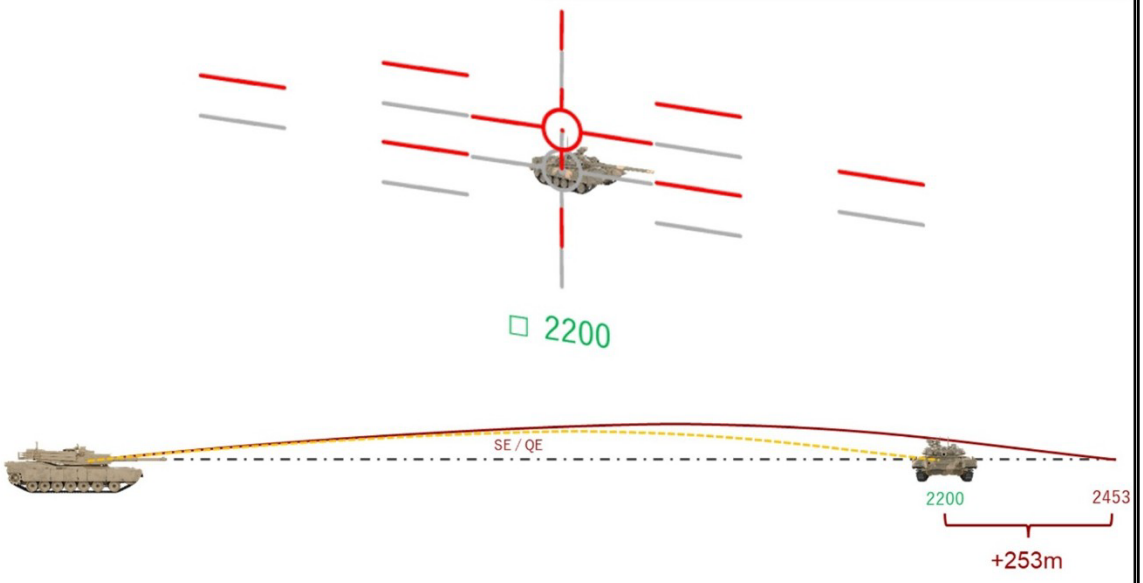
FIRING TABLES
TABLE A, BASIC DATA
DR / DSE

GUNNER'S PRIMARY SIGHT

Gunner ADDS 1ṁ superelevation from the aim point above the target. This is a standard adjustment (ADD 1ṁ) if the round strikes short of the target.

Adding 1ṁ to a ballistic solution using M865 PIP against a target at 2,200 meters ADDS 253 meters to the trajectory.

DETERMINE CHANGE IN RANGE EXAMPLE	
You're firing CARTRIDGE, 120MM, TPCSDS-T, M865 PIP.	
Engaging a target at 2,200m, if you ADD 1mil of SUPERELEVATION, how far beyond the target will the projectile travel?	
A—AMMUNITION	M865 PIP
R—RANGE	2,200m
C—COLUMN	DR / DSE
ANSWER:	+253 meters



Legend:
ṁ– Mils; DR—Change in Range; DSE—Change in Super Elevation; m—Meters; mm—Millimeters; PIP—Performance Improvement Package; TPCSDS-T—Target Practice, Cone Stabilized, Discarding Sabot with Tracer

Figure 4-7. Change in range based on change in superelevation

4-10. The same process can be applied if your gun is lowered by 1m̸, in which case the projectile would hit 253 meters short of the target. This is shown in figure 4-8.

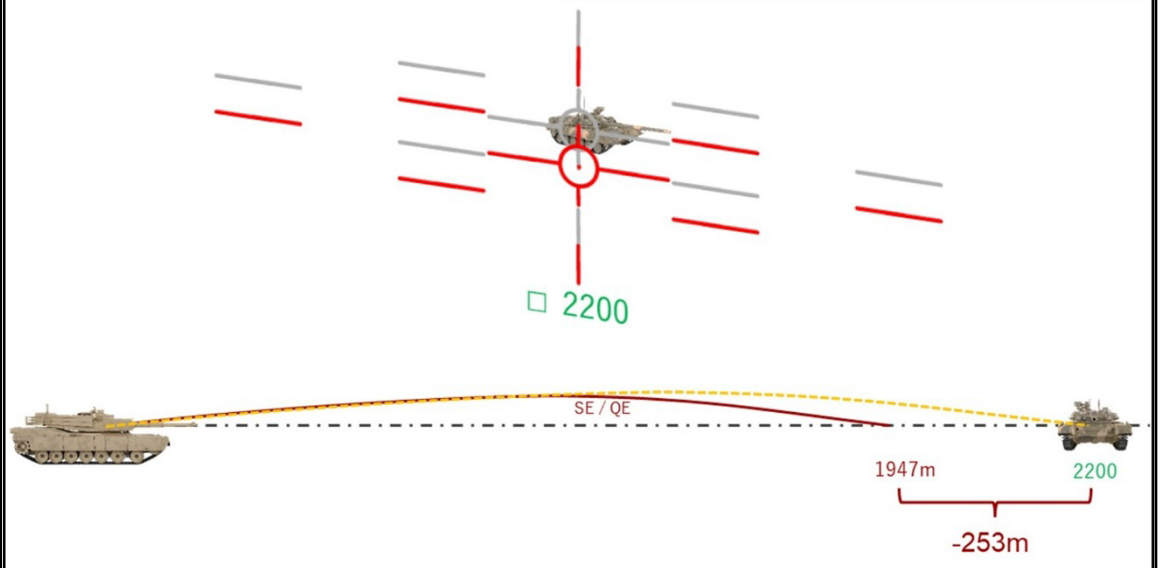
FIRING TABLES
TABLE A, BASIC DATA
DR / DSE

GUNNER'S PRIMARY SIGHT

Gunner DROPS 1m̸ superelevation from the aim point on the target. This is a standard adjustment (DROP 1m̸) if the round strikes OVER the target.

Subtracting 1m̸ to a ballistic solution using M865 PIP against a target at 2,200 meters subtracts 253 meters from the trajectory.

DETERMINE CHANGE IN RANGE EXAMPLE	
You're firing CARTRIDGE, 120MM, TPCSDS-T, M865 PIP.	
Engaging a target at 2,200m, if you DROP 1mil of SUPERELEVATION from the point of aim, how far will the projectile travel?	
A—AMMUNITION	M865 PIP
R—RANGE	2,200m
C—COLUMN	DR / DSE
ANSWER:	–253 meters



Legend:
m̸– Mils; DR—Change in Range; DSE—Change in Super Elevation; m—Meters; mm—Millimeters; PIP—Performance Improvement Package; TPCSDS-T—Target Practice, Cone Stabilized, Discarding Sabot with Tracer

Figure 4-8. Drop superelevation results in change in range

4-11. The change in range for a 1-mil change in superelevation (DR/DSE) column only provides distances relating to a 1m̸ increase or decrease in SE. When adding half values (2.5m̸ of SE, for example), the DR/DSE value is multiplied by that number and added to the range. Figure 4-9 illustrates this process.

FIRING TABLES
TABLE A, BASIC DATA
CHANGE IN RANGE for CHANGE IN SUPERELEVATION RULES OF THUMB

ADD

Adding 1m̸ adds to the range.

Adding 1.5m̸ adds 1.5 × DR to the range.

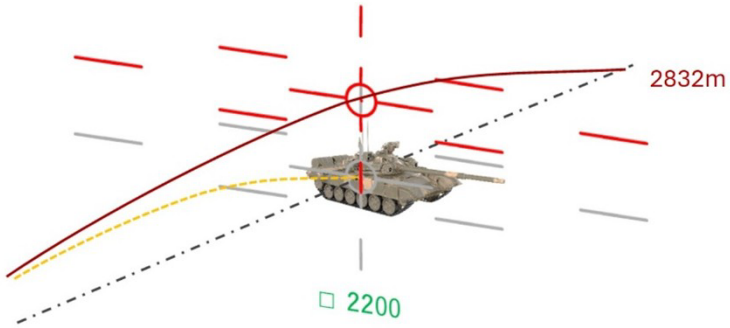
Adding 2m̸ adds 2 × DR to the range

DROP

Dropping 1m̸ subtracts from the range.

Dropping 1.5m̸ subtracts 1.5 × DR from the range.

Dropping 2m̸ subtracts 2 × DR from the range



DETERMINE DR / DSE HALF VALUES

You're firing CARTRIDGE, 120MM, TPCSDS-T, M865 PIP.
If you added **2.5m̸** of superelevation to a ballistic solution for 2,200m,
how far beyond the target will the impact of the round strike?

A—AMMUNITION			M865 PIP		
R—RANGE			2,200m		2,200m
C—COLUMN			DR / DSE		253m
MAKE ADJUSTMENTS BASED ON RULES OF THUMB					
M—MULTIPLY	253m	×	2.5	=	632m
A—ADD RANGE	TOTAL DR	+	2,200m	=	2,832m

Legend:
m̸– Mils; DR—Change in Range; DSE—Change in Super Elevation; m—Meters; PIP—Performance Improvement Package; TPCSDS-T—Target Practice, Cone Stabilized, Discarding Sabot with Tracer

Figure 4-9. Change in range for change in superelevation rules of thumb

CHANGE IN HEIGHT FOR 100-METERS CHANGE IN RANGE

4-12. Column 4 describes a change in height corresponding with an increase or decrease of 100 meters in range. Using the 2,200-meter target example and assuming a weapon system operator has estimated the range to target at 2,300 meters (100 meters greater than the actual range), calculate the change in height (also called DH/DR). Figure 4-10 illustrates this process.

FIRING TABLES
TABLE A, BASIC DATA
DH / DR

The DH / DR listed in column 4 answers the question "what is the CHANGE IN HEIGHT (DH) for a 100 METER CHANGE IN RANGE (DR)?"

TABLE A
BASIC DATA

1	2	3	4	5
RANGE	SUPER-ELEVATION	DR / DSE	DH / DR	TIME OF FLIGHT
METERS	MILS	M/MIL	M/100M	SEC
1500	3.28	337	0.4	1.05
1600	3.57	324	0.5	1.14
1700	3.86	312	0.5	1.23
1800	4.17	300	0.6	1.32
1900	4.49	288	0.6	1.41
2000	4.82	277	0.7	1.51
2100	5.17	265	0.7	1.61
2200	5.53	253	0.9	1.71
2300	5.91	242	0.9	1.82
2400	6.31	231	1.0	1.93
2500	6.73	220	1.1	2.05

FT 120-D-2, *FIRING TABLES FOR CANNON, 120MM, M256.* **M865 PIP**

TABLE A
BASIC DATA

6	7	8	9	10	11
10 KM/HR CROSSWIND DEFLECTION	MAXIMUM ORDINATE	RANGE TO MAXIMUM ORDINATE	ANGLE OF FALL	REMAINING VELOCITY	RANGE
MILS	METERS	METERS	MILS	M/SEC	METERS
0.3	1.4	795	4	1184	1500
0.3	1.6	852	5	1149	1600
0.4	1.8	909	5	1115	1700
0.4	2.1	968	6	1081	1800
0.4	2.4	1026	6	1047	1900
0.5	2.8	1086	7	1013	2000
0.5	3.2	1146	7	980	2100
0.5	3.6	1207	8	946	2200
0.6	4.0	1269	9	913	2300
0.6	4.6	1331	10	880	2400
0.7	5.1	1395	11	847	2500

FT 120-D-2, *FIRING TABLES FOR CANNON, 120MM, M256.* **M865 PIP**

A—Ammunition Type—M865 PIP.
R—Range—2,200 meters.
C—Column—DH / DR.

DETERMINE CHANGE IN HEIGHT EXAMPLE

You're firing CARTRIDGE, 120MM, TPCSDS-T, M865 PIP.

Engaging a target at 2,200m, if you manually index an additional 100 meters of RANGE, how far above the target will the projectile travel?

A—AMMUNITION	M865 PIP
R—RANGE	2,200m
C—COLUMN	DH / DR
ANSWER:	+0.9 meters

Legend:
DH—Change in Height; DR—Change in Range; DSE—Change in Super Elevation; KM/HR—Kilometers per Hour; m—Meters; M/100M—Meters per 100 Meters; M/MIL—Meters per Mils; M/SEC—Meters per Second; mm—Millimeters; PIP—Performance Improvement Package; sec—Second; TPCSDS-T—Target Practice, Cone Stabilized, Discarding Sabot with Tracer

Figure 4-10. Change in height for a change in range

4-13. Aiming center mass at the 2,200-meter target while having 2,300-meter input to the ballistic solution causes the strike of the M865 PIP to rise on target by 0.9 meters. Remember that the change in height for 100-meters change in range, or DH/DR, column only provides data based on 100-meter increments. The rules of thumb shown in figure 4-11 provide examples of how to adjust for half-value increments like 50 meters, 150 meters, and so on.

FIRING TABLES
TABLE A, BASIC DATA
CHANGE IN HEIGHT for CHANGE IN RANGE RULES OF THUMB

ADD

Adding 100 meters adds to the height.

Adding 150 meters adds 1.5 × DH to the height.

Adding 200 meters adds 2 × DH to the height

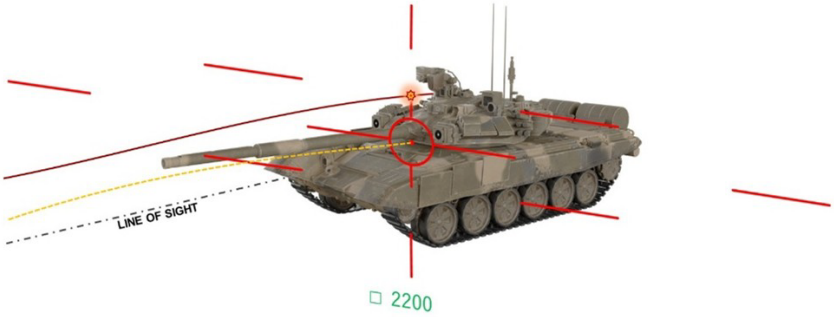
DROP

Dropping 100 meters subtracts from the height.

Dropping 150 meters subtracts 1.5 × DH from the height.

Dropping 200 meters subtracts 2 × DH from the height

Adding 250m to the range moves the strike of the round 2.25m higher on the target. At 2,200 meters, the strike of the round is 2.25 meters higher, or approximately 1 mil in the gunner's reticle.



DETERMINE DH / DR HALF VALUES

You're firing CARTRIDGE, 120MM, TPCSDS-T, M865 PIP.
If you added **250 meters** to the range of a ballistic solution for 2,200m, how far above the target will the impact of the round strike?

A—AMMUNITION			M865 PIP		
R—RANGE			2,200m		2,200m
C—COLUMN			DH / DR		0.9m
MAKE ADJUSTMENTS BASED ON RULES OF THUMB					
M—MULTIPLY	0.9m	×	2.5	=	2.25m

Legend:
DH—Change in Height; DR—Change in Range; m—Meters; mm—Millimeters; PIP—Performance Improvement Package; TPCSDS-T—Target Practice, Cone Stabilized, Discarding Sabot with Tracer

Figure 4-11. Change in range for change in height rules of thumb

TIME OF FLIGHT

4-14. Column 5 lists the time a projectile travels under standard conditions from the muzzle to the level point on target. Figure 4-12 shows where to locate the time of flight.

FIRING TABLES
TABLE A, BASIC DATA
TIME OF FLIGHT

The TIME–OF–FLIGHT column provides how long the selected projectile will take to reach the RANGE selected.

TABLE A
BASIC DATA

1	2	3	4	5
RANGE	SUPER-ELEVATION	DR / DSE	DH / DR	TIME OF FLIGHT
METERS	MILS	M/MIL	M/100M	SEC
1500	3.28	337	0.4	1.05
1600	3.57	324	0.5	1.14
1700	3.86	312	0.5	1.23
1800	4.17	300	0.6	1.32
1900	4.49	288	0.6	1.41
2000	4.82	277	0.7	1.51
2100	5.17	265	0.7	1.61
2200	5.53	253	0.9	1.71
2300	5.91	242	0.9	1.82
2400	6.31	231	1.0	1.93
2500	6.73	220	1.1	2.05

FT 120-D-2, *FIRING TABLES FOR CANNON, 120MM, M256.* **M865 PIP**

TABLE A
BASIC DATA

6	7	8	9	10	11
10 KM/HR CROSSWIND DEFLECTION	MAXIMUM ORDINATE	RANGE TO MAXIMUM ORDINATE	ANGLE OF FALL	REMAINING VELOCITY	RANGE
MILS	METERS	METERS	MILS	M/SEC	METERS
0.3	1.4	795	4	1184	1500
0.3	1.6	852	5	1149	1600
0.4	1.8	909	5	1115	1700
0.4	2.1	968	6	1081	1800
0.4	2.4	1026	6	1047	1900
0.5	2.8	1086	7	1013	2000
0.5	3.2	1146	7	980	2100
0.5	3.6	1207	8	946	2200
0.6	4.0	1269	9	913	2300
0.6	4.6	1331	10	880	2400
0.7	5.1	1395	11	847	2500

FT 120-D-2, *FIRING TABLES FOR CANNON, 120MM, M256.* **M865 PIP**

A—Ammunition Type—M865 PIP.
R—Range—2,200 meters.
C—Column—TIME OF FLIGHT.

DETERMINE TIME OF FLIGHT EXAMPLE

You're firing CARTRIDGE, 120MM, TPCSDS-T, M865 PIP.

Engaging a target at 2,200m, how long will the projectile take to reach the target aiming point?

A—AMMUNITION	M865 PIP
R—RANGE	2,200m
C—COLUMN	TIME OF FLIGHT
ANSWER:	1.71 seconds

Legend:
DH—Change in Height; DR—Change in Range; DSE—Change in Super Elevation; KM/HR—Kilometers per Hour; m—Meters; M/100M—Meters per 100 Meters; M/MIL—Meters per Mils; M/SEC—Meters per Second; mm—Millimeters; PIP—Performance Improvement Package; sec—Second; TPCSDS-T—Target Practice, Cone Stabilized, Discarding Sabot with Tracer

Figure 4-12. Locating time of flight

4-15. The answer in column 5, time of flight, is provided in seconds. The example in figure 4-12 shows an M865 PIP round fired at 2,200 meters has a 1.71 second time of flight.

DRIFT

4-16. Drift is the angular displacement a projectile incurs when it is spun. The drift column is only used when using firing tables for rifled guns and cannons. This column accounts for the movement of a projectile to the right side of the vertical plane when spin-stabilized projectiles are fired. The training sabot round for the 105-mm cannon is used in the drift example illustrated in figure 4-13.

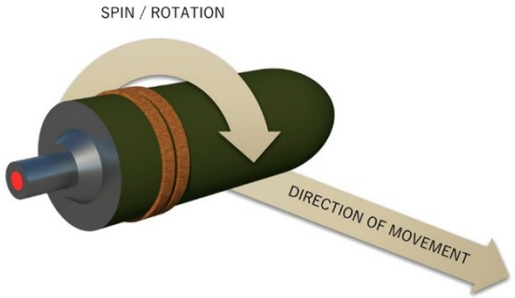
FIRING TABLES
TABLE A, BASIC DATA
DRIFT

The DRIFT column provides the ballistic drift of a spin stabilized projectile fired through a rifled gun or cannon. It is listed in mils (m). It is applied to the right following the direction of the rifling in the bore.

DRIFT is the lateral deviation of spin–stabilized projectiles from the line of trajectory. The uniform right hand twist of the rifling (M68) causes all spin–stabilized rounds to drift in the same direction.

1	2	3	4	5	6	7	8	9	10	11
RANGE	SUPER-ELEVATION	DR / DSE	DH / DR	DRIFT	TIME OF FLIGHT	10 KM/HR CROSSWIND DEFLECTION	MAXIMUM ORDINATE	RANGE TO MAXIMUM ORDINATE	ANGLE OF FALL	REMAINING VELOCITY
METERS	MILS	M/MIL	M/100M	MILS	SEC	MILS	METERS	METERS	MILS	M/SEC
2000	21.71	39	5.2	0.8	3.56	2.5	16.0	1216	51	315
2100	24.37	35	6.0	0.9	3.89	2.7	19.3	1287	58	302
2200	27.27	32	6.8	1.0	4.22	2.9	23.1	1358	67	292
2300	30.44	30	7.7	1.2	4.57	3.1	27.4	1428	76	283
2400	33.86	28	8.7	1.3	4.93	3.2	32.3	1496	85	275

A—Ammunition Type—M724A2.
R—Range—2,200 meters.
C—Column—DRIFT.



DETERMINE DRIFTEXAMPLE

You're firing CARTRIDGE, 105MM, TPCSDS-T, M724A2.

Engaging a target at 2,200m, what is the induced amount of DRIFT applied in the ballistic solution?

A—AMMUNITION	M724A2
R—RANGE	2,200m
C—COLUMN	DRIFT
ANSWER:	1.0 mils

Legend:
m—Mils; DH—Change in Height; DR—Change in Range; DSE—Change in Super Elevation; KM/HR—Kilometers per Hour; m—Meters; M/100M—Meters per 100 Meters; M/MIL—Meters per Mils; M/SEC—Meters per Second; mm—Millimeters; PIP—Performance Improvement Package; sec—Second; TPCSDS-T—Target Practice, Cone Stabilized, Discarding Sabot with Tracer

Figure 4-13. Determining drift applied to the ballistic solution

10 KILOMETERS PER HOUR CROSSWIND DEFLECTION

4-17. Column 6 is used to determine the change (in m) of the firing angle needed to correct for deflection created by a 10 kilometers per hour (km/hr) crosswind. Crosswind is the lateral movement of wind between the firing platform and target that has a lateral effect on projectile travel. When the ballistic computer calculates crosswind deflection, it offsets the gun from the target aiming point to compensate for the crosswind. Figure 4-14 illustrates the use of the ARC model for an M865 PIP experiencing crosswind when fired at a 2,200-meter target.

FIRING TABLES
TABLE A, BASIC DATA
10 KM/HR CROSSWIND DEFLECTION

The 10 KM/HR CROSSWIND DEFLECTION column describes the amount of gun/sight offset is applied to the ballistic solution based on the known CROSSWIND speed. The CROSSWIND DEFLECTION is provided in mils per 10 kilometer per hour wind speed.

TABLE A
BASIC DATA

1	2	3	4	5
RANGE	SUPER-ELEVATION	DR / DSE	DH / DR	TIME OF FLIGHT
METERS	MILS	M/MIL	M/100M	SEC
1500	3.28	337	0.4	1.05
1600	3.57	324	0.5	1.14
1700	3.86	312	0.5	1.23
1800	4.17	300	0.6	1.32
1900	4.49	288	0.6	1.41
2000	4.82	277	0.7	1.51
2100	5.17	265	0.7	1.61
2200	5.53	253	0.9	1.71
2300	5.91	242	0.9	1.82
2400	6.31	231	1.0	1.93
2500	6.73	220	1.1	2.05

FT 120-D-2, *FIRING TABLES FOR CANNON, 120MM, M256*. **M865 PIP**

TABLE A
BASIC DATA

6	7	8	9	10	11
10 KM/HR CROSSWIND DEFLECTION	MAXIMUM ORDINATE	RANGE TO MAXIMUM ORDINATE	ANGLE OF FALL	REMAINING VELOCITY	RANGE
MILS	METERS	METERS	MILS	M/SEC	METERS
0.3	1.4	795	4	1184	1500
0.3	1.6	852	5	1149	1600
0.4	1.8	909	5	1115	1700
0.4	2.1	968	6	1081	1800
0.4	2.4	1026	6	1047	1900
0.5	2.8	1086	7	1013	2000
0.5	3.2	1146	7	980	2100
0.5	3.6	1207	8	946	2200
0.6	4.0	1269	9	913	2300
0.6	4.6	1331	10	880	2400
0.7	5.1	1395	11	847	2500

FT 120-D-2, *FIRING TABLES FOR CANNON, 120MM, M256*. **M865 PIP**

A—Ammunition Type—M865 PIP.
R—Range—2,200 meters.
C—Column—CROSSWIND DEFLECTION.

DETERMINE 10 KM/HR CROSSWIND DEFLECTION EXAMPLE

You're firing CARTRIDGE, 120MM, TPCSDS-T, M865 PIP.

Engaging a target at 2,200m, how much lead is applied to offset 10km/h crosswind?

A—AMMUNITION	M865 PIP
R—RANGE	2,200m
C—COLUMN	CROSSWIND DEFLECTION
ANSWER:	0.5 mils

Legend:
m—Mils; DH—Change in Height; DR—Change in Range; DSE—Change in Super Elevation; KM/HR—Kilometers per Hour; m—Meters; M/100M—Meters per 100 Meters; M/MIL—Meters per Mils; M/SEC—Meters per Second; mm—Millimeters; PIP—Performance Improvement Package; sec—Second; TPCSDS-T—Target Practice, Cone Stabilized, Discarding Sabot with Tracer

Figure 4-14. Locating 10 kilometers per hour crosswind deflection

4-18. In the example from figure 4-14, the M865 PIP fired at a target 2,200 meters away requires the fire control system to apply a 0.5mil deflection into the 10 km/hr crosswind to strike the intended aiming point. When fire control systems are fully operational, the ballistic computer would account for this change automatically. The basics of this applied lead angle to the ballistic solution is shown in figure 4-15.

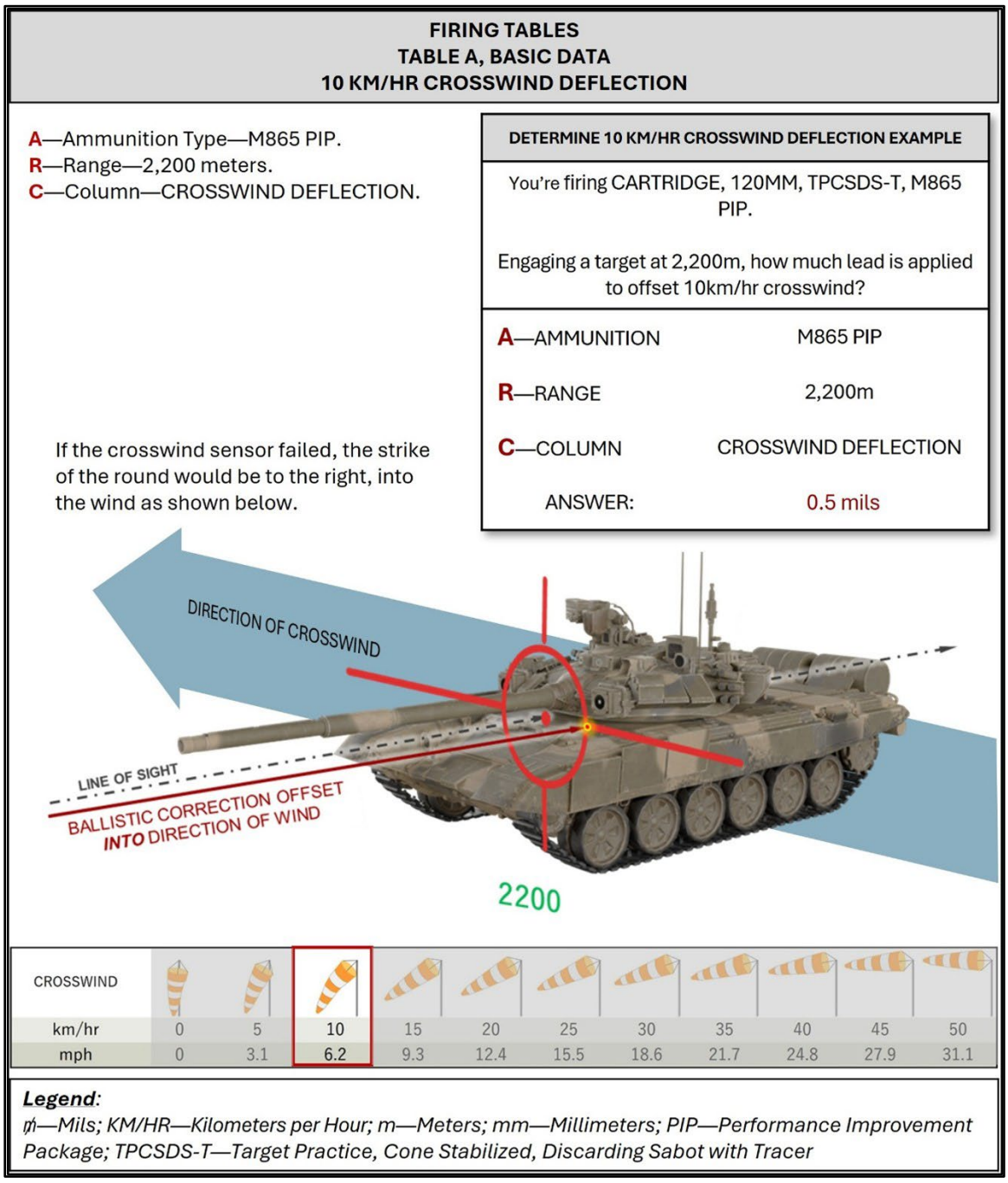


Figure 4-15. Crosswind with applied lead into wind

4-19. Column 6 can also be used to calculate the deflection for crosswind speeds less or greater than 10 km/hr. Determining true crosswind deflection requires determining a speed factor and then multiplying the (column 6 value) by the speed factor. Figure 4-16 illustrates this process.

FIRING TABLES
TABLE A, BASIC DATA
10 KM/HR CROSSWIND DEFLECTION

The SPEED FACTOR is 1/10th the CROSSWIND DEFLECTION listed in Table A for the RANGE to target.

The SPEED FACTOR converts the known CROSSWIND speed to a variable that represents "how many 10 km/h are there in the known windspeed?"

In this example, the crosswind is 25 km/hr.

A—Ammunition Type—M865 PIP.
R—Range—2,200 meters.
C—Column—CROSSWIND DEFLECTION.

TABLE A

BASIC DATA

6	7	8	9	10	11
10 KM/HR CROSSWIND DEFLECTION	MAXIMUM ORDINATE	RANGE TO MAXIMUM ORDINATE	ANGLE OF FALL	REMAINING VELOCITY	RANGE
MILS	METERS	METERS	MILS	M/SEC	METERS
0.3	1.4	795	4	1184	1500
0.3	1.6	852	5	1149	1600
0.4	1.8	909	5	1115	1700
0.4	2.1	968	6	1081	1800
0.4	2.4	1026	6	1047	1900
0.5	2.8	1086	7	1013	2000
0.5	3.2	1146	7	980	2100
0.5	3.6	1207	8	946	2200
0.6	4.0	1269	9	913	2300
0.6	4.6	1331	10	880	2400
0.7	5.1	1395	11	847	2500

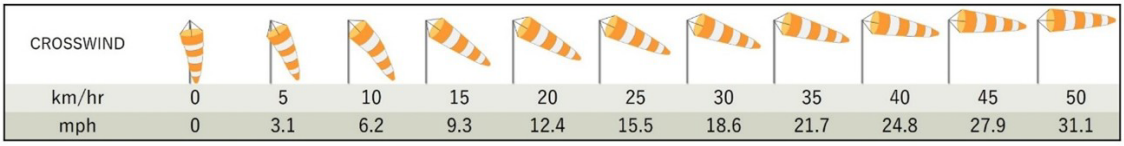
FT 120-D-2, *FIRING TABLES FOR CANNON, 120MM, M256.* **M865 PIP**

Divide CROSSWIND DEFLECTION by 10

CROSSWIND				SPEED FACTOR
25 km/hr	÷	10	=	2.5

Calculate the TRUE CROSSWIND DEFLECTION by multiplying CROSSWIND DEFLECTION value by the SPEED FACTOR

CROSSWIND DEFLECTION		SPEED FACTOR		LEAD REQUIRED
0.5 mils	×	2.5	=	1.25 mils



Legend:
m—Mils; KM/HR—Kilometers per Hour; m—Meters; mph—Miles per Hour, M/SEC—Meters per Second

Figure 4-16. Determining deflection in crosswind speeds greater than 10 kilometers per hour

MAXIMUM ORDINATE

4-20. Column 7 indicates the maximum height of a projectile's trajectory when firing in standard conditions. This height is the MAX ORD. Figure 4-17 shows where to locate MAX ORD.

FIRING TABLES
TABLE A, BASIC DATA
MAXIMUM ORDINATE

The MAXIMUM ORDINATE column provides the maximum height of the trajectory above the gun / target line, under normal conditions. This is the highest point of the trajectory of the projectile on its path to the target at distance.

TABLE A
BASIC DATA

1	2	3	4	5	6	7	8	9	10	11
RANGE	SUPER-ELEVATION	DR / DSE	DH / DR	TIME OF FLIGHT	10 KM/HR CROSSWIND DEFLECTION	MAXIMUM ORDINATE	RANGE TO MAXIMUM ORDINATE	ANGLE OF FALL	REMAINING VELOCITY	RANGE
METERS	MILS	M/MIL	M/100M	SEC	MILS	METERS	METERS	MILS	M/SEC	METERS
1500	3.28	337	0.4	1.05	0.3	1.4	795	4	1184	1500
1600	3.57	324	0.5	1.14	0.3	1.6	852	5	1149	1600
1700	3.86	312	0.5	1.23	0.4	1.8	909	5	1115	1700
1800	4.17	300	0.6	1.32	0.4	2.1	968	6	1081	1800
1900	4.49	288	0.6	1.41	0.4	2.4	1026	6	1047	1900
2000	4.82	277	0.7	1.51	0.5	2.8	1086	7	1013	2000
2100	5.17	265	0.7	1.61	0.5	3.2	1146	7	980	2100
2200	5.53	253	0.9	1.71	0.5	3.6	1207	8	946	2200
2300	5.91	242	0.9	1.82	0.6	4.0	1269	9	913	2300
2400	6.31	231	1.0	1.93	0.6	4.6	1331	10	880	2400
2500	6.73	220	1.1	2.05	0.7	5.1	1395	11	847	2500

FT 120-D-2, *FIRING TABLES FOR CANNON, 120MM, M256.* **M865 PIP**

FT 120-D-2, *FIRING TABLES FOR CANNON, 120MM, M256.* **M865 PIP**

A—Ammunition Type—M865 PIP.
R—Range—2,200 meters.
C—Column—MAXIMUM ORDINATE.

DETERMINE MAXIMUM ORDINATE EXAMPLE

You're firing CARTRIDGE, 120MM, TPCSDS-T, M865 PIP.

Engaging a target at 2,200m, what is the MAXIMUM ORDINATE?

A—AMMUNITION	M865 PIP
R—RANGE	2,200m
C—COLUMN	MAXIMUM ORDINATE
ANSWER:	3.6 meters

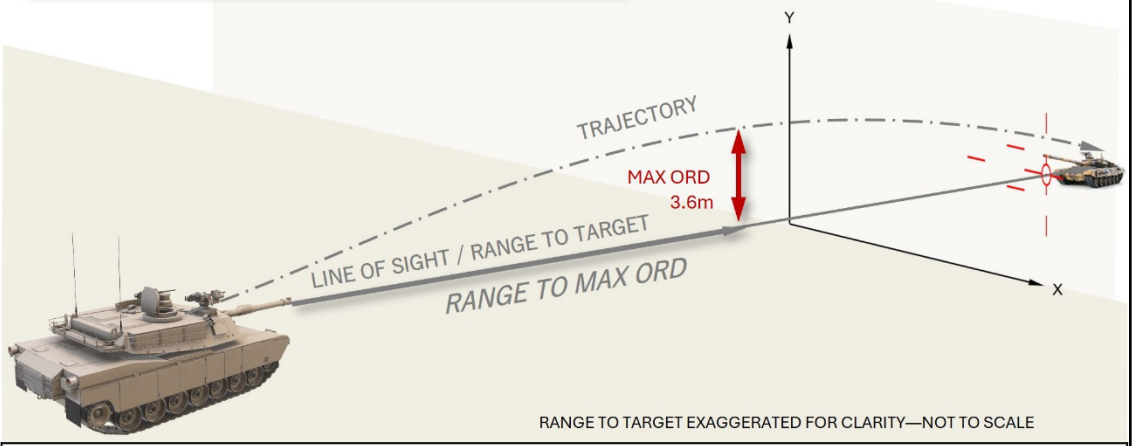
Legend:
m—Mils; DH—Change in Height; DR—Change in Range; DSE—Change in Super Elevation; KM/HR—Kilometers per Hour; m—Meters; M/100M—Meters per 100 Meters; M/MIL—Meters per Mils; M/SEC—Meters per Second; mm—Millimeters; PIP—Performance Improvement Package; sec—Second; TPCSDS-T—Target Practice, Cone Stabilized, Discarding Sabot with Tracer

Figure 4-17. Locating maximum ordinate

4-21. The MAX ORD is measured in meters above the gun-target line. Figure 4-18 illustrates the 3.6-meter MAX ORD from the last example.

FIRING TABLES
TABLE A, BASIC DATA
MAXIMUM ORDINATE

DETERMINE MAXIMUM ORDINATE EXAMPLE	
You're firing CARTRIDGE, 120MM, TPCSDS-T, M865 PIP. Engaging a target at 2,200m, what is the MAXIMUM ORDINATE?	
A—AMMUNITION	M865 PIP
R—RANGE	2,200m
C—COLUMN	MAXIMUM ORDINATE
ANSWER:	3.6 meters



***Legend**:*
m—Meters; MAX ORD—Maximum Ordinate; mm—Millimeter; PIP—Performance Improvement Package; TPCSDS-T—Target Practice, Cone Stabilized, Discarding Sabot with Tracer

Figure 4-18. Maximum ordinate, example

RANGE TO MAXIMUM ORDINATE

4-22. Column 8 lists the range from the muzzle to the point in the horizontal plane perpendicular to the MAX ORD from column 7. Figure 4-19 shows how to determine the range to MAX ORD using Table A.

FIRING TABLES
TABLE A, BASIC DATA
RANGE TO MAXIMUM ORDINATE

The RANGE TO MAXIMUM ORDINATE column provides the distance in the horizontal plane measured from the gun muzzle to the point perpendicular to the MAXIMUM ORDINATE.

TABLE A
BASIC DATA

1	2	3	4	5
RANGE	SUPER-ELEVATION	DR / DSE	DH / DR	TIME OF FLIGHT
METERS	MILS	M/MIL	M/100M	SEC
1500	3.28	337	0.4	1.05
1600	3.57	324	0.5	1.14
1700	3.86	312	0.5	1.23
1800	4.17	300	0.6	1.32
1900	4.49	288	0.6	1.41
2000	4.82	277	0.7	1.51
2100	5.17	265	0.7	1.61
2200	5.53	253	0.9	1.71
2300	5.91	242	0.9	1.82
2400	6.31	231	1.0	1.93
2500	6.73	220	1.1	2.05

FT 120-D-2, *FIRING TABLES FOR CANNON, 120MM, M256.* **M865 PIP**

TABLE A
BASIC DATA

6	7	8	9	10	11
10 KM/HR CROSSWIND DEFLECTION	MAXIMUM ORDINATE	RANGE TO MAXIMUM ORDINATE	ANGLE OF FALL	REMAINING VELOCITY	RANGE
MILS	METERS	METERS	MILS	M/SEC	METERS
0.3	1.4	795	4	1184	1500
0.3	1.6	852	5	1149	1600
0.4	1.8	909	5	1115	1700
0.4	2.1	968	6	1081	1800
0.4	2.4	1026	6	1047	1900
0.5	2.8	1086	7	1013	2000
0.5	3.2	1146	7	980	2100
0.5	3.6	1207	8	946	2200
0.6	4.0	1269	9	913	2300
0.6	4.6	1331	10	880	2400
0.7	5.1	1395	11	847	2500

FT 120-D-2, *FIRING TABLES FOR CANNON, 120MM, M256.* **M865 PIP**

A—Ammunition Type—M865 PIP.
R—Range—2,200 meters.
C—Column—RANGE TO MAXIMUM ORDINATE.

DETERMINE RANGE TO MAXIMUM ORDINATE EXAMPLE

You're firing CARTRIDGE, 120MM, TPCSDS-T, M865 PIP.

Engaging a target at 2,200m, what is the RANGE TO MAXIMUM ORDINATE?

A—AMMUNITION	M865 PIP
R—RANGE	2,200m
C—COLUMN	RANGE TO MAXIMUM ORDINATE
ANSWER:	1,207 meters

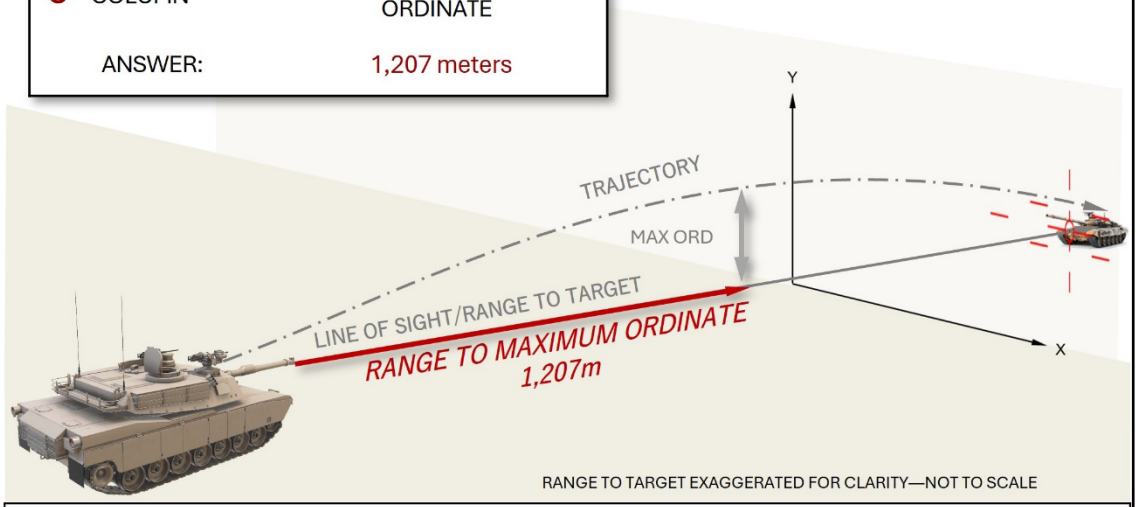
Legend:
DH—Change in Height; DR—Change in Range; DSE—Change in Super Elevation; KM/HR—Kilometers per Hour; m—Meters; M/100M—Meters per 100 Meters; M/MIL—Meters per Mils; M/SEC—Meters per Second; mm—Millimeters; PIP—Performance Improvement Package; sec—Second; TPCSDS-T—Target Practice, Cone Stabilized, Discarding Sabot with Tracer

Figure 4-19. Determining the range to maximum ordinate, example

4-23. The range to MAX ORD is measured in meters. Figure 4-20 shows the 1,207-meter range to MAX ORD (determined in the figure 4-19, page 59 example).

FIRING TABLES
TABLE A, BASIC DATA
RANGE TO MAXIMUM ORDINATE

DETERMINE RANGE TO MAXIMUM ORDINATE EXAMPLE	
You're firing CARTRIDGE, 120MM, TPCSDS-T, M865 PIP. Engaging a target at 2,200m, what is the RANGE TO MAXIMUM ORDINATE?	
A—AMMUNITION	M865 PIP
R—RANGE	2,200m
C—COLUMN	RANGE TO MAXIMUM ORDINATE
ANSWER:	1,207 meters



Legend:
m—Meters; MAX ORD—Maximum Ordinate; mm—Millimeters; PIP—Performance Improvement Package; TPCSDS-T—Target Practice, Cone Stabilized, Discarding Sabot with Tracer

Figure 4-20. Range to maximum ordinate, example

ANGLE OF FALL

4-24. Column 9 lists the least angle (in m) measured clockwise from the LOS to a line tangent to the trajectory at the level point. The level point can be visualized as the very end of the LOS—the point of impact on target. When a projectile reaches that point, it is not level to the LOS but angled. This is because the projectile's trajectory is an arc, not a straight line. Figure 4-21 illustrates where to locate the angle of fall measurement.

FIRING TABLES
TABLE A, BASIC DATA
ANGLE OF FALL

The ANGLE OF FALL column provides the angle of the projectile in mils expected at the point of impact.

TABLE A
BASIC DATA

1	2	3	4	5
RANGE	SUPER-ELEVATION	DR / DSE	DH / DR	TIME OF FLIGHT
METERS	MILS	M/MIL	M/100M	SEC
1500	3.28	337	0.4	1.05
1600	3.57	324	0.5	1.14
1700	3.86	312	0.5	1.23
1800	4.17	300	0.6	1.32
1900	4.49	288	0.6	1.41
2000	4.82	277	0.7	1.51
2100	5.17	265	0.7	1.61
2200	5.53	253	0.9	1.71
2300	5.91	242	0.9	1.82
2400	6.31	231	1.0	1.93
2500	6.73	220	1.1	2.05

FT 120-D-2, *FIRING TABLES FOR CANNON, 120MM, M256.* **M865 PIP**

TABLE A
BASIC DATA

6	7	8	9	10	11
10 KM/HR CROSSWIND DEFLECTION	MAXIMUM ORDINATE	RANGE TO MAXIMUM ORDINATE	ANGLE OF FALL	REMAINING VELOCITY	RANGE
MILS	METERS	METERS	MILS	M/SEC	METERS
0.3	1.4	795	4	1184	1500
0.3	1.6	852	5	1149	1600
0.4	1.8	909	5	1115	1700
0.4	2.1	968	6	1081	1800
0.4	2.4	1026	6	1047	1900
0.5	2.8	1086	7	1013	2000
0.5	3.2	1146	7	980	2100
0.5	3.6	1207	8	946	2200
0.6	4.0	1269	9	913	2300
0.6	4.6	1331	10	880	2400
0.7	5.1	1395	11	847	2500

FT 120-D-2, *FIRING TABLES FOR CANNON, 120MM, M256.* **M865 PIP**

A—Ammunition Type—M865 PIP.
R—Range—2,200 meters.
C—Column—ANGLE OF FALL.

DETERMINE ANGLE OF FALL EXAMPLE

You're firing CARTRIDGE, 120MM, TPCSDS-T, M865 PIP.

Engaging a target at 2,200m, what is the ANGLE OF FALL of the projectile?

A—AMMUNITION	M865 PIP
R—RANGE	2,200m
C—COLUMN	ANGLE OF FALL
ANSWER:	8 mils

Legend:
DH—Change in Height; DR—Change in Range; DSE—Change in Super Elevation; KM/HR—Kilometers per Hour; m—Meters; M/100M—Meters per 100 Meters; M/MIL—Meters per Mils; M/SEC—Meters per Second; mm—Millimeters; PIP—Performance Improvement Package; sec—Second; TPCSDS-T—Target Practice, Cone Stabilized, Discarding Sabot with Tracer

Figure 4-21. Angle of fall

4-25. In the figure 4-21, page 61 example, the M865 PIP fired at a 2,200-meter target has an angle of fall of 8m̀. Figure 4-22 illustrates this angle as it relates to the LOS and trajectory.

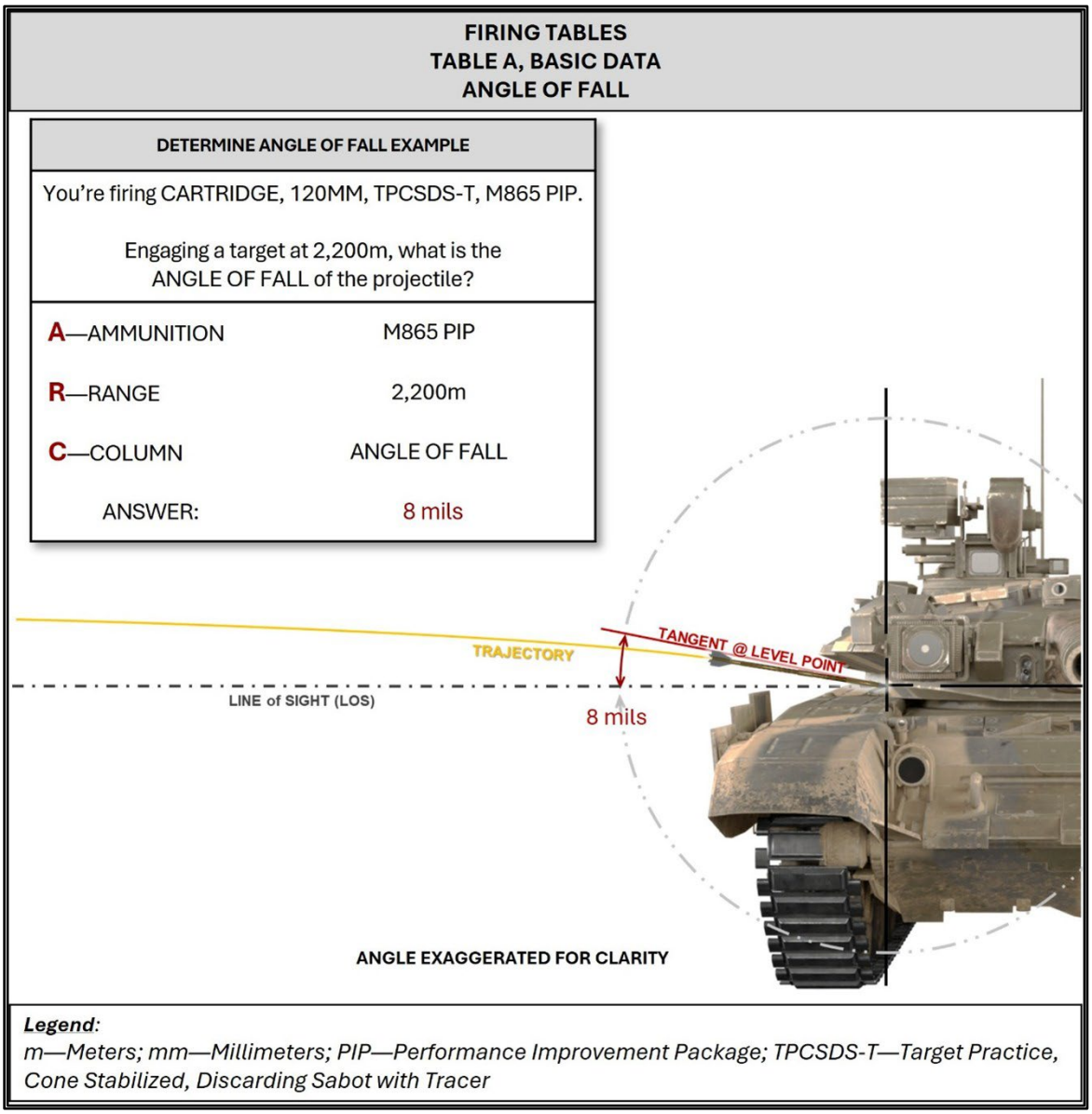


Figure 4-22. Visualizing angle of fall

REMAINING VELOCITY

4-26. Column 10 lists the velocity (in m/s) of a projectile at the level point. The level point can be visualized as the very end of the LOS—the point of impact on target. Figure 4-23 shows where to locate the remaining velocity in Table A.

FIRING TABLES
TABLE A, BASIC DATA
REMAINING VELOCITY

The REMAINING VELOCITY is the speed in meters per second (m/sec) of the projectile at the level point of impact at the range selected.

TABLE A
BASIC DATA

1	2	3	4	5
RANGE	SUPER-ELEVATION	DR / DSE	DH / DR	TIME OF FLIGHT
METERS	MILS	M/MIL	M/100M	SEC
1500	3.28	337	0.4	1.05
1600	3.57	324	0.5	1.14
1700	3.86	312	0.5	1.23
1800	4.17	300	0.6	1.32
1900	4.49	288	0.6	1.41
2000	4.82	277	0.7	1.51
2100	5.17	265	0.7	1.61
2200	5.53	253	0.9	1.71
2300	5.91	242	0.9	1.82
2400	6.31	231	1.0	1.93
2500	6.73	220	1.1	2.05

FT 120-D-2, *FIRING TABLES FOR CANNON, 120MM, M256.* **M865 PIP**

TABLE A
BASIC DATA

6	7	8	9	10	11
10 KM/HR CROSSWIND DEFLECTION	MAXIMUM ORDINATE	RANGE TO MAXIMUM ORDINATE	ANGLE OF FALL	REMAINING VELOCITY	RANGE
MILS	METERS	METERS	MILS	M/SEC	METERS
0.3	1.4	795	4	1184	1500
0.3	1.6	852	5	1149	1600
0.4	1.8	909	5	1115	1700
0.4	2.1	968	6	1081	1800
0.4	2.4	1026	6	1047	1900
0.5	2.8	1086	7	1013	2000
0.5	3.2	1146	7	980	2100
0.5	3.6	1207	8	946	2200
0.6	4.0	1269	9	913	2300
0.6	4.6	1331	10	880	2400
0.7	5.1	1395	11	847	2500

FT 120-D-2, *FIRING TABLES FOR CANNON, 120MM, M256.* **M865 PIP**

A—Ammunition Type—M865 PIP.
R—Range—2,200 meters.
C—Column—REMAINING VELOCITY.

DETERMINE REMAINING VELOCITY EXAMPLE

You're firing CARTRIDGE, 120MM, TPCSDS-T, M865 PIP.

Engaging a target at 2,200m, what is the REMAINING VELOCITY of the projectile?

A—AMMUNITION	M865 PIP
R—RANGE	2,200m
C—COLUMN	REMAINING VELOCITY
ANSWER:	946 m/sec

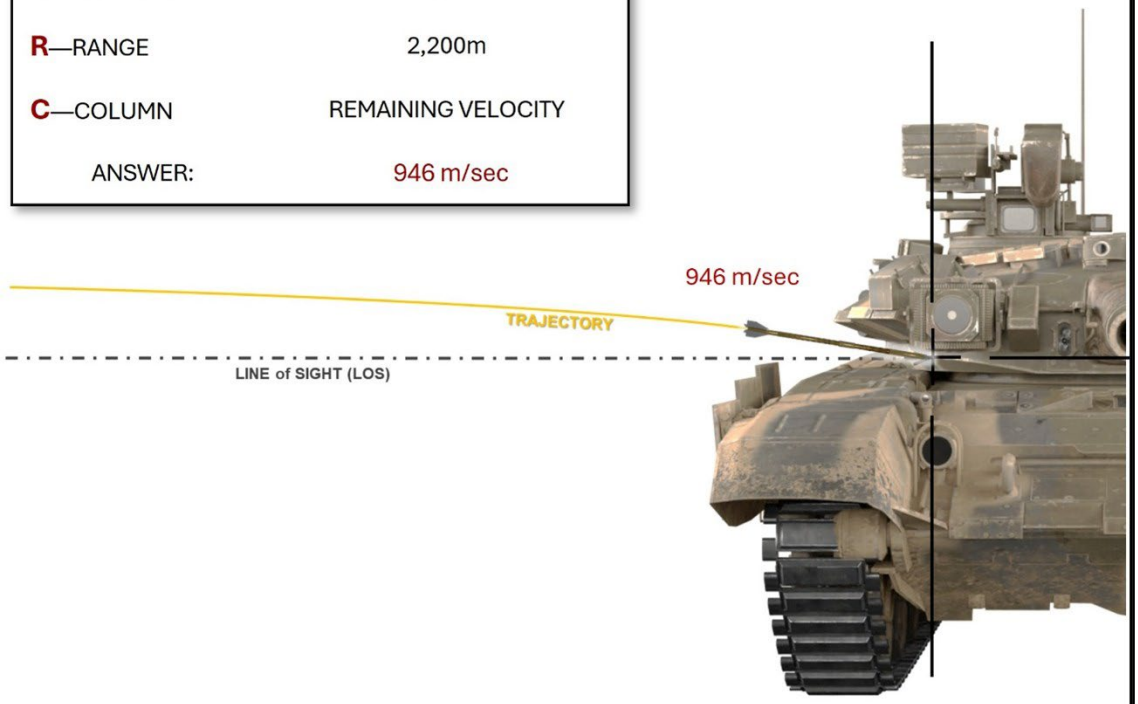
Legend:
DH—Change in Height; DR—Change in Range; DSE—Change in Super Elevation; KM/HR—Kilometers per Hour; m—Meters; M/100M—Meters per 100 Meters; M/MIL—Meters per Mils; M/SEC—Meters per Second; mm—Millimeters; PIP—Performance Improvement Package; sec—Second; TPCSDS-T—Target Practice, Cone Stabilized, Discarding Sabot with Tracer

Figure 4-23. Remaining velocity

4-27. In the figure 4-23, page 63 example, the M865 PIP fired at a 2,200-meter target has a remaining velocity of 946m/s. Figure 4-24 illustrates the location of measurement for remaining velocity.

FIRING TABLES
TABLE A, BASIC DATA
REMAINING VELOCITY

DETERMINE REMAINING VELOCITY EXAMPLE	
You're firing CARTRIDGE, 120MM, TPCSDS-T, M865 PIP. Engaging a target at 2,200m, what is the REMAINING VELOCITY of the projectile?	
A—AMMUNITION	M865 PIP
R—RANGE	2,200m
C—COLUMN	REMAINING VELOCITY
ANSWER:	946 m/sec



Legend:
m—Meters; mm—Millimeters; PIP—Performance Improvement Package; TPCSDS-T—Target Practice, Cone Stabilized, Discarding Sabot with Tracer

Figure 4-24. Visualizing remaining velocity

Chapter 5

Table B, Maximum Ordinate, Range and Effect on Range

This chapter provides an overview of Table B and each column is described with supporting computation examples. When appropriate, a description of how the column's data impacts trajectory of a projectile is also described.

OVERVIEW

5-1. Table B, (MAX ORD, Range, and Effects on Range) are used to determine range effects for the nonstandard conditions of MV, range wind, and air density. It is divided into nine columns comprised of six primary segments (see figure 5-1, page 66):

- EL, in degrees (not mil).
- MAX ORD, in meters.
- Range, in meters.
- Range effects for MV, 1m/s:
  - Decrease in MV.
  - Increase in MV.
- Range effects for range wind, 1km/hr:
  - Headwind.
  - Tailwind.
- Range effects for air density, 1 percent:
  - Decrease in air density.
  - Increase in air density.

FIRING TABLES
TABLE B, MAXIMUM ORDINATE, RANGE AND EFFECTS ON RANGE
OVERVIEW

TABLE B—MAXIMUM ORDINATE, RANGE, AND EFFECTS ON RANGE—Used to determine range effects for the nonstandard conditions of muzzle velocity, range wind and air density.

Commonly used to determine the approximate location of a round fired out of an impact area.

TABLE B
MAXIMUM ORDINATE, RANGE AND EFFECTS ON RANGE

1	2	3	4	5	6	7	8	9
QUADRANT ELEVATION	MAXIMUM ORDINATE	RANGE	RANGE EFFECTS FOR					
			MUZZLE VELOCITY 1 M/S		RANGE WIND 1 KM/HR		AIR DENSITY 1 PCT	
			DEC	INC	HEAD	TAIL	DEC	INC
DEG	M	M	M	M	M	M	M	M
5	289	6228	–3.4	3.4	–3.2	3.2	54.4	–45.5
10	711	7239	–3.6	3.6	–5.3	5.4	66.1	–55.1
15	1188	7855	–3.7	3.7	–7.1	7.1	74.4	–61.7
20	1707	8271	–3.8	3.8	–8.7	8.7	81.3	–67.1
25	2257	8544	–3.9	4.0	–10.2	10.2	87.2	–71.5
30	2833	8697	–4.1	4.1	–11.6	11.6	92.1	–75.1
34	3326	8737	–4.1	4.1	–12.7	12.8	95.6	–77.5

FT 120–D–2–1, M865 PIP

***Legend**:*
DEC—Decrease; DEG—Degrees; FT—Firing Table; INC—Increase; KM/HR—Kilometers per Hour; m—Meters; m/s—Meters per Second; PCT—Percent; PIP—Performance Improvement Package

Figure 5-1. Table B overview

COLUMN 1—QUADRANT ELEVATION

5-2. Column 1, quantified in degrees, indicates the QE required to reach the range in column 3. The last (bottom) box in this QE column is the angle that produces the projectile's maximum range under standard conditions, rounded to the nearest whole degree. Figure 5-2 outlines these rounded QE values in column 1.

FIRING TABLES
TABLE B, MAXIMUM ORDINATE, RANGE AND EFFECTS ON RANGE
QUADRANT ELEVATION

QUADRANT ELEVATION —the angle of the gun in the vertical plane required to reach the range tabulated in column 3.

The final entry in this column is the elevation angle which produces the MAXIMUM RANGE under standard conditions rounded to the nearest whole degree.

TABLE B
MAXIMUM ORDINATE, RANGE AND EFFECTS ON RANGE

1	2	3	4	5	6	7	8	9
QUADRANT ELEVATION	MAXIMUM ORDINATE	RANGE	RANGE EFFECTS FOR					
			MUZZLE VELOCITY 1 M/S		RANGE WIND 1 KM/HR		AIR DENSITY 1 PCT	
			DEC	INC	HEAD	TAIL	DEC	INC
DEG	M	M	M	M	M	M	M	M
5	289	6228	–3.4	3.4	–3.2	3.2	54.4	–45.5
10	711	7239	–3.6	3.6	–5.3	5.4	66.1	–55.1
15	1188	7855	–3.7	3.7	–7.1	7.1	74.4	–61.7
20	1707	8271	–3.8	3.8	–8.7	8.7	81.3	–67.1
25	2257	8544	–3.9	4.0	–10.2	10.2	87.2	–71.5
30	2833	8697	–4.1	4.1	–11.6	11.6	92.1	–75.1
34	3326	8737	–4.1	4.1	–12.7	12.8	95.6	–77.5

FT 120–D–2–1, M865 PIP

Legend:
DEC—Decrease; DEG—Degrees; FT—Firing Table; INC—Increase; KM/HR—Kilometers per Hour; m—Meters; m/s—Meters per Second; PCT—Percent; PIP—Performance Improvement Package

Figure 5-2. Column 1

COLUMN 2—MAXIMUM ORDINATE

5-3. Column 2, quantified in meters, displays the MAX ORD of a projectile fired in standard conditions at the QE listed in column 1. Figure 5-3 outlines column 2.

FIRING TABLES
TABLE B, MAXIMUM ORDINATE, RANGE AND EFFECTS ON RANGE
MAXIMUM ORDINATE

MAXIMUM ORDINATE—The maximum height for the trajectory above the gun, under standard conditions, based on the QUADRANT ELEVATION in Column 1, with a corresponding RANGE in Column 3.

TABLE B
MAXIMUM ORDINATE, RANGE AND EFFECTS ON RANGE

1	2	3	4	5	6	7	8	9
QUADRANT ELEVATION	MAXIMUM ORDINATE	RANGE	RANGE EFFECTS FOR					
			MUZZLE VELOCITY 1 M/S		RANGE WIND 1 KM/HR		AIR DENSITY 1 PCT	
			DEC	INC	HEAD	TAIL	DEC	INC
DEG	M	M	M	M	M	M	M	M
5	289	6228	–3.4	3.4	–3.2	3.2	54.4	–45.5
10	711	7239	–3.6	3.6	–5.3	5.4	66.1	–55.1
15	1188	7855	–3.7	3.7	–7.1	7.1	74.4	–61.7
20	1707	8271	–3.8	3.8	–8.7	8.7	81.3	–67.1
25	2257	8544	–3.9	4.0	–10.2	10.2	87.2	–71.5
30	2833	8697	–4.1	4.1	–11.6	11.6	92.1	–75.1
34	3326	8737	–4.1	4.1	–12.7	12.8	95.6	–77.5

FT 120–D–2–1, M865 PIP

Legend:
DEC—Decrease; DEG—Degrees; FT—Firing Table; INC—Increase; KM/HR—Kilometers per Hour; m—Meters; m/s—Meters per Second; PCT—Percent; PIP—Performance Improvement Package

Figure 5-3. Column 2

COLUMN 3—RANGE

5-4. Column 3, quantified in meters, indicates the distance measured from the muzzle to a target at the level point when a projectile is fired under standard conditions. Figure 5-4 outlines column 3.

FIRING TABLES
TABLE B, MAXIMUM ORDINATE, RANGE AND EFFECTS ON RANGE
RANGE

RANGE—The distance measured from the muzzle to the expected impact at the level point under standard conditions.

The ranges listed are based on standard firing conditions using the QUADRANT ELEVATION from Column 1.

TABLE B
MAXIMUM ORDINATE, RANGE AND EFFECTS ON RANGE

1	2	3	4	5	6	7	8	9
QUADRANT ELEVATION	MAXIMUM ORDINATE	RANGE	RANGE EFFECTS FOR					
			MUZZLE VELOCITY 1 M/S		RANGE WIND 1 KM/HR		AIR DENSITY 1 PCT	
			DEC	INC	HEAD	TAIL	DEC	INC
DEG	M	M	M	M	M	M	M	M
5	289	6228	–3.4	3.4	–3.2	3.2	54.4	–45.5
10	711	7239	–3.6	3.6	–5.3	5.4	66.1	–55.1
15	1188	7855	–3.7	3.7	–7.1	7.1	74.4	–61.7
20	1707	8271	–3.8	3.8	–8.7	8.7	81.3	–67.1
25	2257	8544	–3.9	4.0	–10.2	10.2	87.2	–71.5
30	2833	8697	–4.1	4.1	–11.6	11.6	92.1	–75.1
34	3326	8737	–4.1	4.1	–12.7	12.8	95.6	–77.5

FT 120–D–2–1, M865 PIP

Legend:
DEC—Decrease; DEG—Degrees; FT—Firing Table; INC—Increase; KM/HR—Kilometers per Hour; m—Meters; m/s—Meters per Second; PCT—Percent; PIP—Performance Improvement Package

Figure 5-4. Column 3

DETERMINE MAXIMUM ORDINATE AND RANGE

5-5. Figure 5-5 provides an example of MAX ORD and range calculation for a M865 PIP firing at 15° QE. The maximum range is 7,855 meters with a MAX ORD of 1,188 meters.

FIRING TABLES
TABLE B, MAXIMUM ORDINATE, RANGE AND EFFECTS ON RANGE
QUADRANT ELEVATION, MAXIMUM ORDINATE, AND RANGE

DETERMINE MAX ORD AND MAX RANGE

You're firing CARTRIDGE, 120MM, TPCSDS-T, M865 PIP.
A round was fired out of impact.
The round was fired at 15 degrees.
What was the MAX ORDINATE and maximum RANGE for the bullet fired?

1—AMMUNITION	M865 PIP
2—QUADRANT ELEVATION	15°
3—MAXIMUM ORDINATE	1,188m
4—RANGE	7,855m

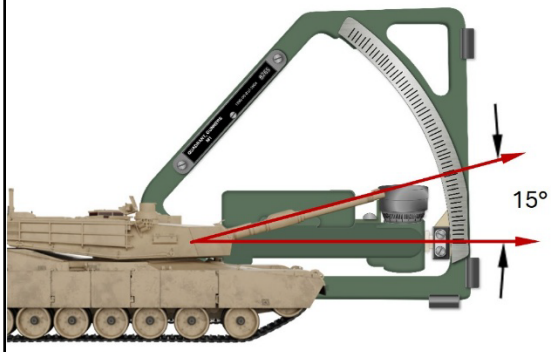


TABLE B
MAXIMUM ORDINATE, RANGE AND EFFECT

1	2	3	4	5	6	
QUADRANT ELEVATION	MAXIMUM ORDINATE	RANGE	RANGE EFFECT			
			MUZZLE VELOCITY 1 M/S		RANGE WIND 1 KM/HR	
			DEC	INC	HEAD	T
DEG	M	M	M	M	M	M
5	289	6228	-3.4	3.4	-3.2	3
10	711	7239	-3.6	3.6	-5.3	
15	1188	7855	-3.7	3.7	-7.1	
20	1707	8271	-3.8	3.8	-8.7	8.
25	2257	8544	-3.9	4.0	-10.2	10.
30	2833	8697	-4.1	4.1	-11.6	1
34	3326	8737	-4.1	4.1	-12.7	12

FT 120-D-2-1, M865 PIP

Not to scale. Angular measurement exaggerated for context.

Legend:
°—Degrees; DEC—Decrease; DEG—Degrees; FT—Firing Table; INC—Increase; KM/HR—Kilometers per Hour; m—Meters; m/s—Meters per Second; PCT—Percent; PIP—Performance Improvement Package

Figure 5-5. Quadrant elevation for M865 PIP determining maximum ordinate and range

COLUMNS 4 AND 5—MUZZLE VELOCITY

5-6. Columns 4 and 5, quantified in meters, indicate the effect on range for a decrease or increase of 1 m/s in MV. The effects on range are caused by a change from standard MV, provided on the ammunition cartridge firing tables cover sheet. Figure 5-6 highlights column 4, showing the decreased range for a known MV decrease.

> ***Note.*** This column shows that for each m/s decrease in MV from the round's standard, the round will travel x-meters less.

FIRING TABLES
TABLE B, MAXIMUM ORDINATE, RANGE AND EFFECTS ON RANGE
RANGE EFFECTS FOR MUZZLE VELOCITY DECREASE

MUZZLE VELOCITY—Range effects for a change of one meter per second in MUZZLE VELOCITY—effects on range caused by variations from the STANDARD MUZZLE VELOCITY.

Column 4 provides the DECREASE in meters based on 1 meter per second changes to the MUZZLE VELOCITY

⚠

Note: Use of RANGE EFFECTS FOR MUZZLE VELOCITY is in conjunction with Table C, EFFECTS ON MUZZLE VELOCITY DUE TO AMMUNITION TEMPERATURE.

TABLE B
MAXIMUM ORDINATE, RANGE AND EFFECTS ON RANGE

1	2	3	4	5	6	7	8	9
QUADRANT ELEVATION	MAXIMUM ORDINATE	RANGE	RANGE EFFECTS FOR					
			MUZZLE VELOCITY 1 M/S		RANGE WIND 1 KM/HR		AIR DENSITY 1 PCT	
			DEC	INC	HEAD	TAIL	DEC	INC
DEG	M	M	M	M	M	M	M	M
5	289	6228	–3.4	3.4	–3.2	3.2	54.4	–45.5
10	711	7239	–3.6	3.6	–5.3	5.4	66.1	–55.1
15	1188	7855	–3.7	3.7	–7.1	7.1	74.4	–61.7
20	1707	8271	–3.8	3.8	–8.7	8.7	81.3	–67.1
25	2257	8544	–3.9	4.0	–10.2	10.2	87.2	–71.5
30	2833	8697	–4.1	4.1	–11.6	11.6	92.1	–75.1
34	3326	8737	–4.1	4.1	–12.7	12.8	95.6	–77.5

FT 120–D–2–1, M865 PIP

Legend:
DEC—Decrease; DEG—Degrees; FT—Firing Table; INC—Increase; KM/HR—Kilometers per Hour; m—Meters; m/s—Meters per Second; PCT—Percent; PIP—Performance Improvement Package

Figure 5-6. Range effects for decrease in muzzle velocity

5-7. Column 5, quantified in meters, indicates the effect on range for an increase of 1m/s in MV. The effects on range are caused by change from the standard MV, provided on the ammunition cartridge firing tables cover sheet. Figure 5-7 highlights column 5.

Note. This column shows that for each m/s increase in MV from the round's standard, the round will travel x-meters farther.

FIRING TABLES
TABLE B, MAXIMUM ORDINATE, RANGE AND EFFECTS ON RANGE
RANGE EFFECTS FOR MUZZLE VELOCITY INCREASE

MUZZLE VELOCITY—Range effects for a change of one meter per second in MUZZLE VELOCITY—effects on range caused by variations from the STANDARD MUZZLE VELOCITY.

Column 5 provides the INCREASE in meters based on 1 meter per second changes to the MUZZLE VELOCITY

⚠

Note: Use of RANGE EFFECTS FOR MUZZLE VELOCITY is in conjunction with Table C, EFFECTS ON MUZZLE VELOCITY DUE TO AMMUNITION TEMPERATURE.

TABLE B
MAXIMUM ORDINATE, RANGE AND EFFECTS ON RANGE

1	2	3	4	5	6	7	8	9
QUADRANT ELEVATION	MAXIMUM ORDINATE	RANGE	RANGE EFFECTS FOR					
			MUZZLE VELOCITY 1 M/S		RANGE WIND 1 KM/HR		AIR DENSITY 1 PCT	
			DEC	INC	HEAD	TAIL	DEC	INC
DEG	M	M	M	M	M	M	M	M
5	289	6228	–3.4	3.4	–3.2	3.2	54.4	–45.5
10	711	7239	–3.6	3.6	–5.3	5.4	66.1	–55.1
15	1188	7855	–3.7	3.7	–7.1	7.1	74.4	–61.7
20	1707	8271	–3.8	3.8	–8.7	8.7	81.3	–67.1
25	2257	8544	–3.9	4.0	–10.2	10.2	87.2	–71.5
30	2833	8697	–4.1	4.1	–11.6	11.6	92.1	–75.1
34	3326	8737	–4.1	4.1	–12.7	12.8	95.6	–77.5

FT 120–D–2–1, M865 PIP

Legend:
DEC—Decrease; DEG—Degrees; FT—Firing Table; INC—Increase; KM/HR—Kilometers per Hour; m—Meters; m/s—Meters per Second; PCT—Percent; PIP—Performance Improvement Package

Figure 5-7. Range effects for increase in muzzle velocity

CHANGES TO MUZZLE VELOCITY

5-8. Units operating in austere environments, particularly those with extreme hot or cold conditions, can experience changes in MV. Although MV changes can be minor, they can have a comparable effect on a projectile's flight. Figure 5-8 illustrates an example where MV has increased 150 m/s due to extremely high ammunition propellant temperature. The hot ammunition temperature in this example increases the rate of propellant burn, increasing the MV and range of projectile travel.

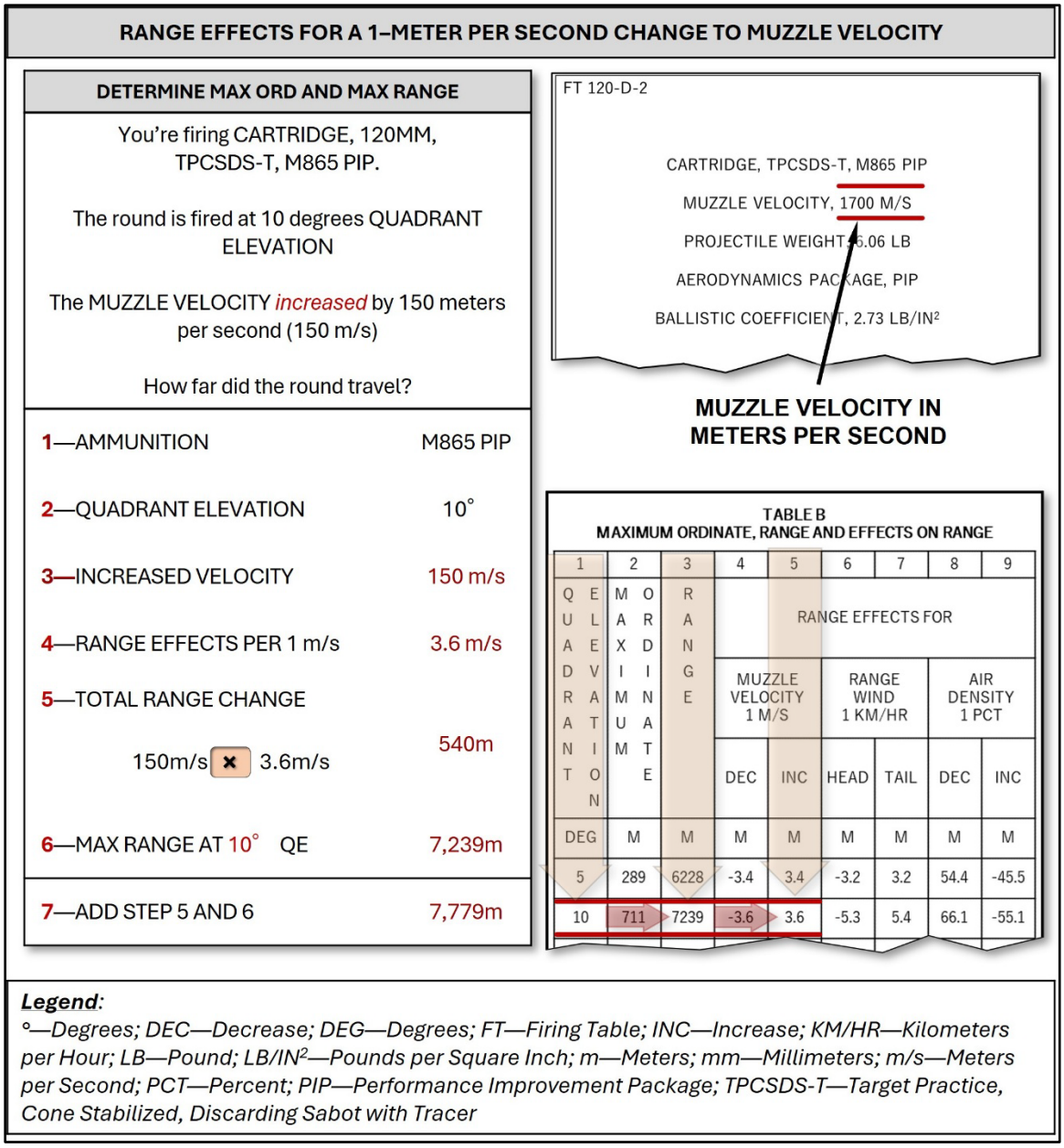


Figure 5-8. Range effects for an increase in muzzle velocity, example

COLUMNS 6 AND 7—RANGE WIND

5-9. Column 6, quantified in meters, indicates the effect on range caused by a headwind of 1 km/hr. The range effects are caused by wind blowing against the front of the projectile. This column is not to be confused with the crosswind column in Table A, Basic Data. Figure 5-9 shows an example using column 6 to calculate a decrease in range due to headwind.

Note. This column shows that for each kilometer-per-hour headwind affecting the projectile, the round will travel x-meters less.

FIRING TABLES
TABLE B, MAXIMUM ORDINATE, RANGE AND EFFECTS ON RANGE
RANGE EFFECTS FOR RANGE WIND 1 KM/HR HEADWIND

RANGE WIND—Range effects for a change of 1 kilometer per hour RANGE WIND (not CROSSWIND)

Column 6—Effects on range caused by a wind blowing against (HEAD) the projectile or sub–projectile.

TABLE B
MAXIMUM ORDINATE, RANGE AND EFFECTS ON RANGE

1	2	3	4	5	6	7	8	9
QUADRANT ELEVATION	MAXIMUM ORDINATE	RANGE	RANGE EFFECTS FOR					
			MUZZLE VELOCITY 1 M/S		RANGE WIND 1 KM/HR		AIR DENSITY 1 PCT	
			DEC	INC	HEAD	TAIL	DEC	INC
DEG	M	M	M	M	M	M	M	M
5	289	6228	–3.4	3.4	–3.2	3.2	54.4	–45.5
10	711	7239	–3.6	3.6	–5.3	5.4	66.1	–55.1
15	1188	7855	–3.7	3.7	–7.1	7.1	74.4	–61.7
20	1707	8271	–3.8	3.8	–8.7	8.7	81.3	–67.1
25	2257	8544	–3.9	4.0	–10.2	10.2	87.2	–71.5
30	2833	8697	–4.1	4.1	–11.6	11.6	92.1	–75.1
34	3326	8737	–4.1	4.1	–12.7	12.8	95.6	–77.5

FT 120–D–2–1, M865 PIP

Legend:
DEC—Decrease; DEG—Degrees; FT—Firing Table; INC—Increase; KM/HR—Kilometers per Hour; m—Meters; m/s—Meters per Second; PCT—Percent; PIP—Performance Improvement Package

Figure 5-9. Range effects for headwind against a projectile

5-10. Column 7, quantified in meters, indicates the effect on range caused by a tailwind of 1km/hr. The range effects are caused by a wind blowing with (against the rear of) the projectile. This column is not to be confused with the crosswind column in Table A, Basic Data, which considers lateral projectile deviation. Figure 5-10 shows an example using column 7 to calculate an increase in range due to tailwind.

Note. This column shows that for each kilometer-per-hour tailwind affecting the projectile, the round will travel x-meters farther.

FIRING TABLES
TABLE B, MAXIMUM ORDINATE, RANGE AND EFFECTS ON RANGE
RANGE EFFECTS FOR RANGE WIND 1 KM/HR TAILWIND

RANGE WIND—Range effects for a change of 1 kilometer per hour RANGE WIND (not CROSSWIND)

Column 7—Effects on range caused by a wind blowing with (TAIL) the projectile or sub–projectile.

TABLE B
MAXIMUM ORDINATE, RANGE AND EFFECTS ON RANGE

1	2	3	4	5	6	7	8	9
QUADRANT ELEVATION	MAXIMUM ORDINATE	RANGE	RANGE EFFECTS FOR					
			MUZZLE VELOCITY 1 M/S		RANGE WIND 1 KM/HR		AIR DENSITY 1 PCT	
			DEC	INC	HEAD	TAIL	DEC	INC
DEG	M	M	M	M	M	M	M	M
5	289	6228	–3.4	3.4	–3.2	3.2	54.4	–45.5
10	711	7239	–3.6	3.6	–5.3	5.4	66.1	–55.1
15	1188	7855	–3.7	3.7	–7.1	7.1	74.4	–61.7
20	1707	8271	–3.8	3.8	–8.7	8.7	81.3	–67.1
25	2257	8544	–3.9	4.0	–10.2	10.2	87.2	–71.5
30	2833	8697	–4.1	4.1	–11.6	11.6	92.1	–75.1
34	3326	8737	–4.1	4.1	–12.7	12.8	95.6	–77.5

FT 120–D–2–1, M865 PIP

Legend:
DEC—Decrease; DEG—Degrees; FT—Firing Table; INC—Increase; KM/HR—Kilometers per Hour; m—Meters; m/s—Meters per Second; PCT—Percent; PIP—Performance Improvement Package

Figure 5-10. Range effects for tailwind

CHANGES IN RANGE WIND

5-11. Range effects for range wind are the only columns in Table B that do not also utilize Table C for calculations. The next chapter describes Table C in detail and incorporates more complex ballistic calculations using it with Table B.

5-12. Using the M865 PIP, figure 5-11 shows an example of how to compute further range effects for a tailwind. For this example, the QE is 15° and tailwind is 10 km/hr.

RANGE EFFECTS FOR A 10KM/HR RANGE TAILWIND

DETERMINE RANGE WITH WIND EFFECTS

You're firing CARTRIDGE, 120MM, TPCSDS-T, M865 PIP.
A *tailwind* of 10km/hr exists.
The round was fired at 15 degrees.

What is the range?

	AMMUNITION	M865 PIP
QE	QUADRANT ELEVATION	15°
RW	RANGE WIND (TAIL)	10km/hr
	RANGE EFFECTS FOR RANGE WIND ×	7.1m
	MAXIMUM RANGE AT 15° QE	7,855m
	MULTIPLIED RW RANGE EFFECTS	71m
+	ADD TO MAXIMUM RANGE AT 15° QE	7,926m

FT 120-D-2

CARTRIDGE, TPCSDS-T, M865 PIP
MUZZLE VELOCITY, 1700 M/S
PROJECTILE WEIGHT, 6.06 LB
AERODYNAMICS PACKAGE, PIP
BALLISTIC COEFFICIENT, 2.73 LB/IN²

TABLE B
MAXIMUM ORDINATE, RANGE AND EFFECTS ON RANGE

1	2	3	4	5	6	7	8	9
QUADRANT ELEVATION	MAXIMUM ORDINATE	RANGE	RANGE EFFECTS FOR					
			MUZZLE VELOCITY 1 M/S		RANGE WIND 1 KM/HR		AIR DENSITY 1 PCT	
			DEC	INC	HEAD	TAIL	DEC	INC
DEG	M	M	M	M	M	M	M	M
5	289	6228	-3.4	3.4	-3.2	3.2	54.4	-45.5
10	711	7239	-3.6	3.6	-5.3	5.4	66.1	-55.1
15	1188	7855	-3.7	3.7	-7.1	7.1	74.4	-61.7
20	1707	8271	-3.8	3.8	-8.7	8.7	81.3	-67.1

Legend:
°—Degrees; DEC—Decrease; DEG—Degrees; FT—Firing Table; INC—Increase; KM/HR—Kilometers per Hour; LB—Pound; LB/IN²—Pounds per Square Inch; m—Meters; mm—Millimeters; m/s—Meters per Second; PCT—Percent; PIP—Performance Improvement Package; TPCSDS-T—Target Practice, Cone Stabilized, Discarding Sabot with Tracer

Figure 5-11. Range effects for a 10 kilometers per hour tailwind

5-13. Calculating a change in range for headwind is performed in the same manner as the example in figure 5-11, but this time by subtracting the effects on range due to range wind. Figure 5-12 illustrates this computation using the M865 PIP, fired at 15° QE, and with a headwind of 10 km/hr.

RANGE EFFECTS FOR A 10KM/HR RANGE HEADWIND

DETERMINE RANGE WITH WIND EFFECTS

You're firing CARTRIDGE, 120MM, TPCSDS-T, M865 PIP.
A *headwind* of 10km/hr exists.
The round was fired at 15 degrees.

What is the range?

	AMMUNITION	M865 PIP
QE	QUADRANT ELEVATION	15°
RW	RANGE WIND (HEAD)	10km/hr
×	RANGE EFFECTS FOR RANGE WIND	–7.1m
	MAXIMUM RANGE AT 15° QE	7,855m
	MULTIPLIED RW RANGE EFFECTS	–71m
-	SUBTRACT FROM MAXIMUM RANGE AT 15° QE	7,784m

FT 120-D-2

CARTRIDGE, TPCSDS-T, M865 PIP

MUZZLE VELOCITY, 1700 M/S

PROJECTILE WEIGHT, 6.06 LB

AERODYNAMICS PACKAGE, PIP

BALLISTIC COEFFICIENT, 2.73 LB/IN²

TABLE B
MAXIMUM ORDINATE, RANGE AND EFFECTS ON RANGE

1	2	3	4	5	6	7	8	9
QUADRANT ELEVATION	MAXIMUM ORDINATE	RANGE	RANGE EFFECTS FOR					
			MUZZLE VELOCITY 1 M/S		RANGE WIND 1 KM/HR		AIR DENSITY 1 PCT	
			DEC	INC	HEAD	TAIL	DEC	INC
DEG	M	M	M	M	M	M	M	M
5	289	6228	-3.4	3.4	-3.2	3.2	54.4	-45.5
10	711	7239	-3.6	3.6	-5.3	5.4	66.1	-55.1
15	1188	7855	-3.7	3.7	-7.1	7.1	74.4	-61.7
20	1707	8271	-3.8	3.8	-8.7	8.7	81.3	-67.1

Legend:
°—Degrees; DEC—Decrease; DEG—Degrees; FT—Firing Table; INC—Increase; KM/HR—Kilometers per Hour; LB—Pound; LB/IN²—Pounds per Square Inch; m—Meters; mm—Millimeters; m/s—Meters per Second; PCT—Percent; PIP—Performance Improvement Package; TPCSDS-T—Target Practice, Cone Stabilized, Discarding Sabot with Tracer

Figure 5-12. Range effects for a 10 kilometers per hour headwind

5-14. Column 8 quantified in meters, displays the effect on range for a decrease of 1 percent in air density from the standard. The effects on range are caused by change from standard air density (1,225 grams per cubic meter) as measured at sea level. (Figure 5-13 highlights column 8 for an increase in range due to air density.)

Note. This column shows that for each 1-percent decrease in air density from standard, the round will travel x-meters farther. Positive values indicate an increase to the maximum range due to less drag on the projectile.

FIRING TABLES
TABLE B, MAXIMUM ORDINATE, RANGE AND EFFECTS ON RANGE
RANGE EFFECTS FOR RANGE AIR DENSITY 1 PERCENT DECREASE

AIR DENSITY 1 PERCENT CHANGE—Range effects for a change of 1 percent in AIR DENSITY.

The changes to range based on the effects caused by variations from STANDARD AIR DENSITY

- 1,225 grams per cubic meter at sea level

Column 8—Effects on range based on DECREASES to AIR DENSITY.

TABLE B
MAXIMUM ORDINATE, RANGE AND EFFECTS ON RANGE

1	2	3	4	5	6	7	8	9
QUADRANT ELEVATION	MAXIMUM ORDINATE	RANGE	RANGE EFFECTS FOR					
			MUZZLE VELOCITY 1 M/S		RANGE WIND 1 KM/HR		AIR DENSITY 1 PCT	
			DEC	INC	HEAD	TAIL	DEC	INC
DEG	M	M	M	M	M	M	M	M
5	289	6228	–3.4	3.4	–3.2	3.2	54.4	–45.5
10	711	7239	–3.6	3.6	–5.3	5.4	66.1	–55.1
15	1188	7855	–3.7	3.7	–7.1	7.1	74.4	–61.7
20	1707	8271	–3.8	3.8	–8.7	8.7	81.3	–67.1
25	2257	8544	–3.9	4.0	–10.2	10.2	87.2	–71.5
30	2833	8697	–4.1	4.1	–11.6	11.6	92.1	–75.1
34	3326	8737	–4.1	4.1	–12.7	12.8	95.6	–77.5

FT 120–D–2–1, M865 PIP

Legend:
DEC—Decrease; DEG—Degrees; FT—Firing Table; INC—Increase; KM/HR—Kilometers per Hour; m—Meters; m/s—Meters per Second; PCT—Percent; PIP—Performance Improvement Package

Figure 5-13. Range effects for air density decreases

5-15. Column 9, quantified in meters, indicates the effect on range for an increase of 1 percent in air density from the standard. The effects on range are caused by change from standard air density (1,225 grams per cubic meter) as measured at sea level. (Figure 5-14 highlights column 9 for a decrease in range due to air density.)

Note. This column determines for each 1-percent increase in air density from standard affecting the projectile, the round will travel x-meters less. Negative values represent a decrease to the maximum range in meters, indicating more drag on the projectile.

FIRING TABLES
TABLE B, MAXIMUM ORDINATE, RANGE AND EFFECTS ON RANGE
RANGE EFFECTS FOR RANGE AIR DENSITY 1 PERCENT INCREASE

AIR DENSITY 1 PERCENT CHANGE—Range effects for a change of 1 percent in AIR DENSITY.

The changes to range based on the effects caused by variations from STANDARD AIR DENSITY

- 1,225 grams per cubic meter at sea level

Column 9—Effects on range based on INCREASES to AIR DENSITY.

TABLE B
MAXIMUM ORDINATE, RANGE AND EFFECTS ON RANGE

1	2	3	4	5	6	7	8	9
QUADRANT ELEVATION	MAXIMUM ORDINATE	RANGE	RANGE EFFECTS FOR					
			MUZZLE VELOCITY 1 M/S		RANGE WIND 1 KM/HR		AIR DENSITY 1 PCT	
			DEC	INC	HEAD	TAIL	DEC	INC
DEG	M	M	M	M	M	M	M	M
5	289	6228	–3.4	3.4	–3.2	3.2	54.4	–45.5
10	711	7239	–3.6	3.6	–5.3	5.4	66.1	–55.1
15	1188	7855	–3.7	3.7	–7.1	7.1	74.4	–61.7
20	1707	8271	–3.8	3.8	–8.7	8.7	81.3	–67.1
25	2257	8544	–3.9	4.0	–10.2	10.2	87.2	–71.5
30	2833	8697	–4.1	4.1	–11.6	11.6	92.1	–75.1
34	3326	8737	–4.1	4.1	–12.7	12.8	95.6	–77.5

FT 120–D–2–1, M865 PIP

Legend:
DEC—Decrease; DEG—Degrees; FT—Firing Table; INC—Increase; KM/HR—Kilometers per Hour; m—Meters; m/s—Meters per Second; PCT—Percent; PIP—Performance Improvement Package

Figure 5-14. Range effects for air density increases

CHANGES TO AIR DENSITY

5-16. Air density changes from standard sea level density affect how much drag is imposed on a projectile in flight. Because higher density imposes more drag, a projectile encountering more resistance flies a shorter distance. The opposite is true for lower densities.

5-17. Using the M865 PIP as an example, figure 5-15 illustrates how to compute range effects for an increased air density. For this example, the QE is 15° and air density has increased by 3 percent.

RANGE EFFECTS FOR A 3 PERCENT INCREASE IN AIR DENSITY

DETERMINE RANGE WITH AIR DENSITY EFFECTS

You're firing CARTRIDGE, 120MM, TPCSDS-T, M865 PIP.
Air density has increased 3 PCT from the standard 1,225 grams per cubic meter.
The round was fired at 15 degrees.

What is the range?

	AMMUNITION	M865 PIP
QE	QUADRANT ELEVATION	15 Degrees
AD	AIR DENSITY (INC)	3 PCT
	RANGE EFFECTS FOR AIR DENSITY	× –61.7m
	MAXIMUM RANGE AT 15° QE	7,855m
	MULTIPLIED AD RANGE EFFECTS	–185.1m
-	SUBTRACT FROM MAXIMUM RANGE AT 15° QE	7,669.9m

FT 120-D-2

CARTRIDGE, TPCSDS-T, M865 PIP
MUZZLE VELOCITY, 1700 M/S
PROJECTILE WEIGHT, 6.06 LB
AERODYNAMICS PACKAGE, PIP
BALLISTIC COEFFICIENT, 2.73 LB/IN²

TABLE B
MAXIMUM ORDINATE, RANGE AND EFFECTS ON RANGE

1	2	3	4	5	6	7	8	9
QUADRANT ELEVATION	MAXIMUM ORDINATE	RANGE	RANGE EFFECTS FOR					
			MUZZLE VELOCITY 1 M/S		RANGE WIND 1 KM/HR		AIR DENSITY 1 PCT	
			DEC	INC	HEAD	TAIL	DEC	INC
DEG	M	M	M	M	M	M	M	M
5	289	6228	-3.4	3.4	-3.2	3.2	54.4	-45.5
10	711	7239	-3.6	3.6	-5.3	5.4	66.1	-55.1
15	1188	7855	-3.7	3.7	-7.1	7.1	74.4	-61.7
20	1707	8271	-3.8	3.8	-8.7	8.7	81.3	-67.1

Legend:
°—Degrees; DEC—Decrease; DEG—Degrees; FT—Firing Table; INC—Increase; KM/HR—Kilometers per Hour; LB—Pound; LB/IN²—Pounds per Square Inch; m—Meters; mm—Millimeters; m/s—Meters per Second; PCT—Percent; PIP—Performance Improvement Package; TPCSDS-T—Target Practice, Cone Stabilized, Discarding Sabot with Tracer

Figure 5-15. Range effects for a 3-percent increase in air density

5-18. Calculating a change in range for decreased air density is performed the same manner as the example in figure 5-15, but this time by adding the effects on range instead of subtracting. Figure 5-16 illustrates this computation using the M865 PIP, fired at 15° QE, and with a 3-percent decrease in air density.

RANGE EFFECTS FOR A 3 PERCENT DECREASE IN AIR DENSITY

DETERMINE RANGE WITH AIR DENSITY EFFECTS

You're firing CARTRIDGE, 120MM, TPCSDS-T, M865 PIP.
Air density has decreased 3 PCT from the standard 1,225 grams per cubic meter.
The round was fired at 15 degrees.

What is the range?

	AMMUNITION	M865 PIP
QE	QUADRANT ELEVATION	15°
AD	AIR DENSITY (DEC)	3 PCT
	RANGE EFFECTS FOR AIR DENSITY (×)	74.4m
	MAXIMUM RANGE AT 15° QE	7,855m
	MULTIPLIED AD RANGE EFFECTS	223.2m
	ADD TO MAXIMUM RANGE AT 15° QE (+)	8,078.2m

FT 120-D-2

CARTRIDGE, TPCSDS-T, M865 PIP
MUZZLE VELOCITY, 1700 M/S
PROJECTILE WEIGHT, 6.06 LB
AERODYNAMICS PACKAGE, PIP
BALLISTIC COEFFICIENT, 2.73 LB/IN²

TABLE B
MAXIMUM ORDINATE, RANGE AND EFFECTS ON RANGE

1	2	3	4	5	6	7	8	9
QUADRANT ELEVATION	MAXIMUM ORDINATE	RANGE	RANGE EFFECTS FOR					
			MUZZLE VELOCITY 1 M/S		RANGE WIND 1 KM/HR		AIR DENSITY 1 PCT	
			DEC	INC	HEAD	TAIL	DEC	INC
DEG	M	M	M	M	M	M	M	M
5	289	6228	-3.4	3.4	-3.2	3.2	54.4	-45.5
10	711	7239	-3.6	3.6	-5.3	5.4	66.1	-55.1
15	1188	7855	-3.7	3.7	-7.1	7.1	74.4	-61.7
20	1707	8271	-3.8	3.8	-8.7	8.7	81.3	-67.1

Legend:
°—Degrees; DEC—Decrease; DEG—Degrees; FT—Firing Table; INC—Increase; KM/HR—Kilometers per Hour; LB—Pound; LB/IN²—Pounds per Square Inch; m—Meters; mm—Millimeters; m/s—Meters per Second; PCT—Percent; PIP—Performance Improvement Package; TPCSDS-T—Target Practice, Cone Stabilized, Discarding Sabot with Tracer

Figure 5-16. Range effects for a 3-percent decrease in air density

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Chapter 6

Effects on Muzzle Velocity Due to Ammunition Temperature

This chapter provides an overview of Table C and each column is described with supporting computation examples. When appropriate, a description of how the column's data impacts trajectory of a projectile is also described.

OVERVIEW

6-1. Table C describes the effects on MV due to ammunition temperature. This table is important because ammunition temperature directly impacts how, and how fast, ammunition propellant burns. Cold ammunition propellant burns more slowly, causing reduced MV. Hot ammunition propellant burns faster, causing increased MV. Table C is used in conjunction with Table B to determine range effects for MV. It is divided into three columns (see figure 6-1, page 84):

- Temperature of ammunition, in degrees Fahrenheit (F).
- Effects on velocity, in m/s.
- Temperature of ammunition, in degrees Celsius (C).

FIRING TABLES
TABLE C, EFFECTS ON MUZZLE VELOCITY DUE TO AMMUNITION TEMPERATURE
OVERVIEW

TABLE C—EFFECTS ON MUZZLE VELOCITY DUE TO AMMUNITION TEMPERATURE
– Used to determine effects on velocity due to temperature of the ammunition propellant.

Commonly used in conjunction with Table B to determine range effects for muzzle velocity.

TABLE C
EFFECTS ON MUZZLE VELOCITY
DUE TO AMMUNITION TEMPERATURE

TEMPERATURE OF AMMUNITION	EFFECTS ON VELOCITY	TEMPERATURE OF AMMUNITION
DEGREES F	M/S	DEGREES C
–40.0	–123.4	–40.0
–30.0	–111.2	–34.4
–20.0	–99.3	–28.9
–10.0	–87.5	–23.3
0.0	–75.9	–17.8
10.0	–64.5	–12.2
20.0	–53.3	–6.7
30.0	–42.2	–1.1
40.0	–31.4	4.4
50.0	–20.7	10.0
60.0	–10.3	15.6
70.0	0.0	21.1
80.0	10.1	26.7
90.0	20.0	32.2
100.0	29.7	37.8
110.0	39.2	43.3
120.0	48.5	48.9
130.0	57.7	54.4

FT 120–D–2–1, M865 PIP

Legend:
C—Celsius; F—Fahrenheit; FT—Firing Table; m/s—Meters per Second; PIP—Performance Improvement Package

Figure 6-1. Table C overview

COLUMN 1—TEMPERATURE OF AMMUNITION (IN DEGREES FAHRENHEIT)

6-2. Column 1, quantified in degrees F, shows ammunition temperature (the temperature of its propellant). Real-world temperature of ammunition should be accurately measured before consulting Table C, as estimations based on air temperature can result in inaccurate readings. Figure 6-2 highlights column 1.

FIRING TABLES
TABLE C, EFFECTS ON MUZZLE VELOCITY DUE TO AMMUNITION TEMPERATURE
TEMPERATURE OF AMMUNITION (DEGREES F)

TEMPERATURE OF AMMUNITION (DEGREES F)—the temperature of the ammunition propellant (in Degrees F) that will determine how quickly or slowly propellant burn will occur.

TABLE C
EFFECTS ON MUZZLE VELOCITY
DUE TO AMMUNITION TEMPERATURE

TEMPERATURE OF AMMUNITION	EFFECTS ON VELOCITY	TEMPERATURE OF AMMUNITION
DEGREES F	M/S	DEGREES C
–40.0	-123.4	-40.0
–30.0	-111.2	-34.4
–20.0	-99.3	-28.9
–10.0	-87.5	-23.3
0.0	-75.9	-17.8
10.0	-64.5	-12.2
20.0	-53.3	-6.7
30.0	-42.2	-1.1
40.0	-31.4	4.4
50.0	-20.7	10.0
60.0	-10.3	15.6
70.0	0.0	21.1
80.0	10.1	26.7
90.0	20.0	32.2
100.0	29.7	37.8
110.0	39.2	43.3
120.0	48.5	48.9
130.0	57.7	54.4

FT 120–D–2–1, M865 PIP

Legend:
C—Celsius; F—Fahrenheit; FT—Firing Table; m/s—Meters per Second; PIP—Performance Improvement Package

Figure 6-2. Column 1

COLUMN 2—EFFECTS ON VELOCITY

6-3. Column 2 (see figure 6-3), quantified in m/s, shows the effects on velocity caused by ammunition temperatures listed in columns 1 and 3. A decrease in MV is indicated with a negative number, while an increase is indicated with a positive.

FIRING TABLES
TABLE C, EFFECTS ON MUZZLE VELOCITY DUE TO AMMUNITION TEMPERATURE
EFFECTS ON VELOCITY

EFFECTS ON VELOCITY—the effects on velocity caused by an increase or decrease of ammunition propellant temperature.

Hot ammunition propellant burns at a faster rate than cool ammunition, causing increased muzzle velocity. Cold ammunition propellant burns more slowly, causing reduced muzzle velocity.

TABLE C
EFFECTS ON MUZZLE VELOCITY
DUE TO AMMUNITION TEMPERATURE

TEMPERATURE OF AMMUNITION	EFFECTS ON VELOCITY	TEMPERATURE OF AMMUNITION
DEGREES F	M/S	DEGREES C
-40.0	–123.4	-40.0
-30.0	–111.2	-34.4
-20.0	–99.3	-28.9
-10.0	–87.5	-23.3
0.0	–75.9	-17.8
10.0	–64.5	-12.2
20.0	–53.3	-6.7
30.0	–42.2	-1.1
40.0	–31.4	4.4
50.0	–20.7	10.0
60.0	–10.3	15.6
70.0	0.0	21.1
80.0	10.1	26.7
90.0	20.0	32.2
100.0	29.7	37.8
110.0	39.2	43.3
120.0	48.5	48.9
130.0	57.7	54.4

FT 120–D–2–1, M865 PIP

Legend:
C—Celsius; F—Fahrenheit; FT—Firing Table; m/s—Meters per Second; PIP—Performance Improvement Package

Figure 6-3. Column 2

COLUMN 3—TEMPERATURE OF AMMUNITION (IN DEGREES CELSIUS)

6-4. Column 3 (see figure 6-4), quantified in degrees C, shows ammunition temperature (the temperature of its propellant). Real-world temperature of ammunition should be accurately measured before consulting Table C, as estimations based on air temperature can result in inaccurate readings.

FIRING TABLES
TABLE C, EFFECTS ON MUZZLE VELOCITY DUE TO AMMUNITION TEMPERATURE
TEMPERATURE OF AMMUNITION (DEGREES C)

TEMPERATURE OF AMMUNITION (DEGREES C)—the temperature of the ammunition propellant (in Degrees C) that will determine how quickly or slowly propellant burn will occur.

TABLE C
EFFECTS ON MUZZLE VELOCITY
DUE TO AMMUNITION TEMPERATURE

TEMPERATURE OF AMMUNITION	EFFECTS ON VELOCITY	TEMPERATURE OF AMMUNITION
DEGREES F	M/S	DEGREES C
-40.0	-123.4	–40.0
-30.0	-111.2	–34.4
-20.0	-99.3	–28.9
-10.0	-87.5	–23.3
0.0	-75.9	–17.8
10.0	-64.5	–12.2
20.0	-53.3	–6.7
30.0	-42.2	–1.1
40.0	-31.4	4.4
50.0	-20.7	10.0
60.0	-10.3	15.6
70.0	0.0	21.1
80.0	10.1	26.7
90.0	20.0	32.2
100.0	29.7	37.8
110.0	39.2	43.3
120.0	48.5	48.9
130.0	57.7	54.4

FT 120–D–2–1, M865 PIP

Legend:
C—Celsius; F—Fahrenheit; FT—Firing Table; m/s—Meters per Second; PIP—Performance Improvement Package

Figure 6-4. Column 3

CHANGES TO AMMUNITION TEMPERATURE

6-5. To determine the effects on velocity due to ammunition temperature, know the following:

- Ammunition type.
- Ammunition temperature.
- Standard MV.

6-6. Using the M865 PIP, figure 6-5 illustrates how to compute effects on MV for an increased ammunition temperature. In this example, the ammunition temperature is 30°F.

EFFECTS ON MUZZLE VELOCITY FOR AMMUNITION TEMPERATURE

DETERMINE EFFECT ON MUZZLE VELOCITY FOR AMMUNITION TEMPERATURE

You're firing CARTRIDGE, 120MM, TPCSDS-T, M865 PIP.
The ammunition temperature is 30 Degrees F.

What is the effect on muzzle velocity?

	AMMUNITION	M865 PIP
AT	AMMUNITION TEMPERATURE	30 Degrees F
MV	MUZZLE VELOCITY (STANDARD)	1,700m/s
	EFFECTS ON VELOCITY -	–42.2m/s
	SUBTRACT THE EFFECTS ON VELOCITY FROM STANDARD MV	1,657.8m/s

FT 120-D-2

CARTRIDGE, TPCSDS-T, M865 PIP
MUZZLE VELOCITY, 1700 M/S
PROJECTILE WEIGHT, 6.06 LB
AERODYNAMICS PACKAGE, PIP
BALLISTIC COEFFICIENT, 2.73 LB/IN²

MUZZLE VELOCITY IN METERS PER SECOND

TABLE C
EFFECTS ON MUZZLE VELOCITY
DUE TO AMMUNITION TEMPERATURE

TEMPERATURE OF AMMUNITION	EFFECTS ON VELOCITY	TEMPERATURE OF AMMUNITION
DEGREES F	M/S	DEGREES C
-40.0	-123.4	-40.0
-30.0	-111.2	-34.4
-20.0	-99.3	-28.9
-10.0	-87.5	-23.3
0.0	-75.9	-17.8
10.0	-64.5	-12.2
20.0	-53.3	-6.7
30.0	-42.2	-1.1
	-31.4	4.4

Legend:
C—Celsius; F—Fahrenheit; FT—Firing Table; LB—Pound; LB/IN²—Pounds per Square Inch; m—Meters; mm—Millimeters; PIP—Performance Improvement Package; TPCSDS-T—Target Practice, Cone Stabilized, Discarding Sabot with Tracer

Figure 6-5. Effects on muzzle velocity for ammunition temperature

Chapter 7

Effects on Air Density Due to Altitude

This chapter provides an overview of Table D, and each column is described with supporting computation examples. When appropriate, a description of how the column's data impacts the trajectory of the projectile is also described.

OVERVIEW

7-1. Table D describes the effects on air density because of altitude. Standard air density at sea level is 1,225 grams per cubic meter (considered 100-percent density). Whenever possible, actual air density and its difference from standard air density should be used instead of the values in this table. However, Table D allows firing tables users to understand generally accepted air density variations at different ELs. Air density and barometric pressure are related in fire control systems such as Abrams. EL changes to air density are equivalent to EL changes to standard barometric pressure. It is important to ensure that a correct measurement is always taken. Unadjusted barometric pressure readings cause fire control systems to calculate inaccurate ballistic solutions.

7-2. Table D is divided into 2 columns, altitude and decrease in air density. (Figure 7-1, page 90 shows Table D.)

FIRING TABLES
TABLE D, EFFECTS ON AIR DENSITY DUE TO ALTITUDE
OVERVIEW

TABLE D—EFFECTS ON AIR DENSITY DUE TO ALTITUDE
– Used to determine effects on air density due to altitude. For every increase in altitude above sea level (where the air density is 1,225 grams per cubic meter and considered 100 percent density) there is a corresponding decrease in air density.

TABLE D

EFFECTS ON AIR DENSITY DUE TO ALTITUDE

ALTITUDE	DECREASE IN AIR DENSITY
METERS	PERCENT
0	0.0
100	1.0
200	1.9
300	2.8
400	3.8
500	4.7
600	5.6
700	6.5
800	7.5
900	8.4
1000	9.3
1100	10.1
1200	11.0
1300	11.9
1400	12.8
1500	13.6
1600	14.5
1700	15.3
1800	16.2
1900	17.0
2000	17.8

FT 120–D–1, M865 PIP

Legend:
FT—Firing Table; PIP—Performance Improvement Package

Figure 7-1. Table D overview

COLUMN 1—ALTITUDE

7-3. Column 1 of Table D (see figure 7-2) lists altitude in meters. It refers to the altitude of the firing platform during firing.

FIRING TABLES
TABLE D, EFFECTS ON AIR DENSITY DUE TO ALTITUDE
ALTITUDE

ALTITUDE—the height in meters above sea level of the vehicle platform when firing.

TABLE D

EFFECTS ON AIR DENSITY DUE TO ALTITUDE

ALTITUDE	DECREASE IN AIR DENSITY
METERS	PERCENT
0	0.0
100	1.0
200	1.9
300	2.8
400	3.8
500	4.7
600	5.6
700	6.5
800	7.5
900	8.4
1000	9.3
1100	10.1
1200	11.0
1300	11.9
1400	12.8
1500	13.6
1600	14.5
1700	15.3
1800	16.2
1900	17.0
2000	17.8

FT 120–D–1, M865 PIP

Legend:
FT—Firing Table; PIP—Performance Improvement Package

Figure 7-2. Column 1

COLUMN 2—DECREASE IN AIR DENSITY

7-4. Column 2 (see figure 7-3), quantified in percent, lists a decrease in air density for every increase in altitude above sea level. Air becomes less dense, or thins, as EL increases. Changes in air density are important to include in ballistic calculations because projectile velocities are impacted by air density fluctuations.

FIRING TABLES
TABLE D, EFFECTS ON AIR DENSITY DUE TO ALTITUDE
DECREASE IN AIR DENSITY

DECREASE IN AIR DENSITY—For every increase in altitude above sea level (where the air density is 1,225 grams per cubic meter and considered 100 percent density) there is a corresponding decrease in air density.

TABLE D

EFFECTS ON AIR DENSITY DUE TO ALTITUDE

ALTITUDE	DECREASE IN AIR DENSITY
METERS	PERCENT
0	0.0
100	1.0
200	1.9
300	2.8
400	3.8
500	4.7
600	5.6
700	6.5
800	7.5
900	8.4
1000	9.3
1100	10.1
1200	11.0
1300	11.9
1400	12.8
1500	13.6
1600	14.5
1700	15.3
1800	16.2
1900	17.0
2000	17.8

FT 120–D–1, M865 PIP

Legend:
FT—Firing Table; PIP—Performance Improvement Package

Figure 7-3. Column 2

CHANGES TO ALTITUDE

7-5. Change of firing position is usually accompanied by a minor but noticeable change of altitude. Figure 7-4 illustrates how to determine the effects on air density due to altitude for a firing EL of 1,100 meters.

EFFECTS ON AIR DENSITY DUE TO ALTITUDE

DETERMINE EFFECT ON AIR DENSITY DUE TO ALTITUDE

You're firing CARTRIDGE, 120MM,
TPCSDS-T, M865 PIP.
The elevation is 1,100m.

What is the effect on air density?

	AMMUNITION	M865 PIP
ALT	ALTITUDE	1,100m
	EFFECT ON AIR DENSITY	DECREASE of 10.1 percent

TABLE D

EFFECTS ON AIR DENSITY DUE TO ALTITUDE

ALTITUDE	DECREASE IN AIR DENSITY
METERS	PERCENT
0	0.0
100	1.0
200	1.9
300	2.8
400	3.8
500	4.7
600	5.6
700	6.5
800	7.5
900	8.4
1000	9.3
1100	10.1
1200	11.0

***Legend**:*
ALT—Altitude; m—Meters; mm—Millimeters; PIP—Performance Improvement Package; TPCSDS-T—Target Practice, Cone Stabilized, Discarding Sabot with Tracer

Figure 7-4. Effects on air density due to altitude

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Chapter 8
Complex Application

This chapter provides some of the most common practical applications for firing tables. The examples provided are not all-encompassing to what a unit may require but provide general examples for context and real-world use cases.

OVERVIEW

8-1. Detailed processes are provided to build a better understanding of the use of firing tables. They reinforce the previous chapter's information, procedures, and processes, and clearly demonstrate firing table applicability for unit training or combat operations.

8-2. The following use cases are described in this chapter:

- Complex calculations using multiple tables.
- Determine battlesight range for an ammunition type.
- Interpolation.
- Round out of impact (ROI) area during live fire training:
  - Wrong ammunition indexed.
  - Wrong range-to-target induced.
- Incorrect environmental data:
  - Ammunition temperature.
  - Barometric pressure.
  - Crosswind sensor.

8-3. These examples are for training purposes only. They present a problem, application of the firing tables, and a solution. All information necessary to determine the solution is provided in the conditions statement for each problem.

COMPLEX CALCULATIONS USING MULTIPLE TABLES

8-4. The operational environment has all elements of the firing tables occurring simultaneously. Range wind, altitude, air/ammunition temperatures, and air densities are continuously changing and must be included in a complex firing table calculation. This means using multiples of or the full spectrum of Firing Tables A through D to calculate a solution.

Note. Complex calculations in this chapter are examples and do not illustrate all combinations of calculations that may be necessary during application.

COMPLEX CALCULATION 1—TABLES B AND C

8-5. For this example, Tables B and C determine the effects on range due to ammunition temperature. This is a more complex process than simply determining its effect on velocity. For this example, an M865 PIP round with an ammunition temperature of 40°F is fired at 20° QE. Figures 8-1 and 8-2, pages 96 and 97, respectively, illustrate the calculation process.

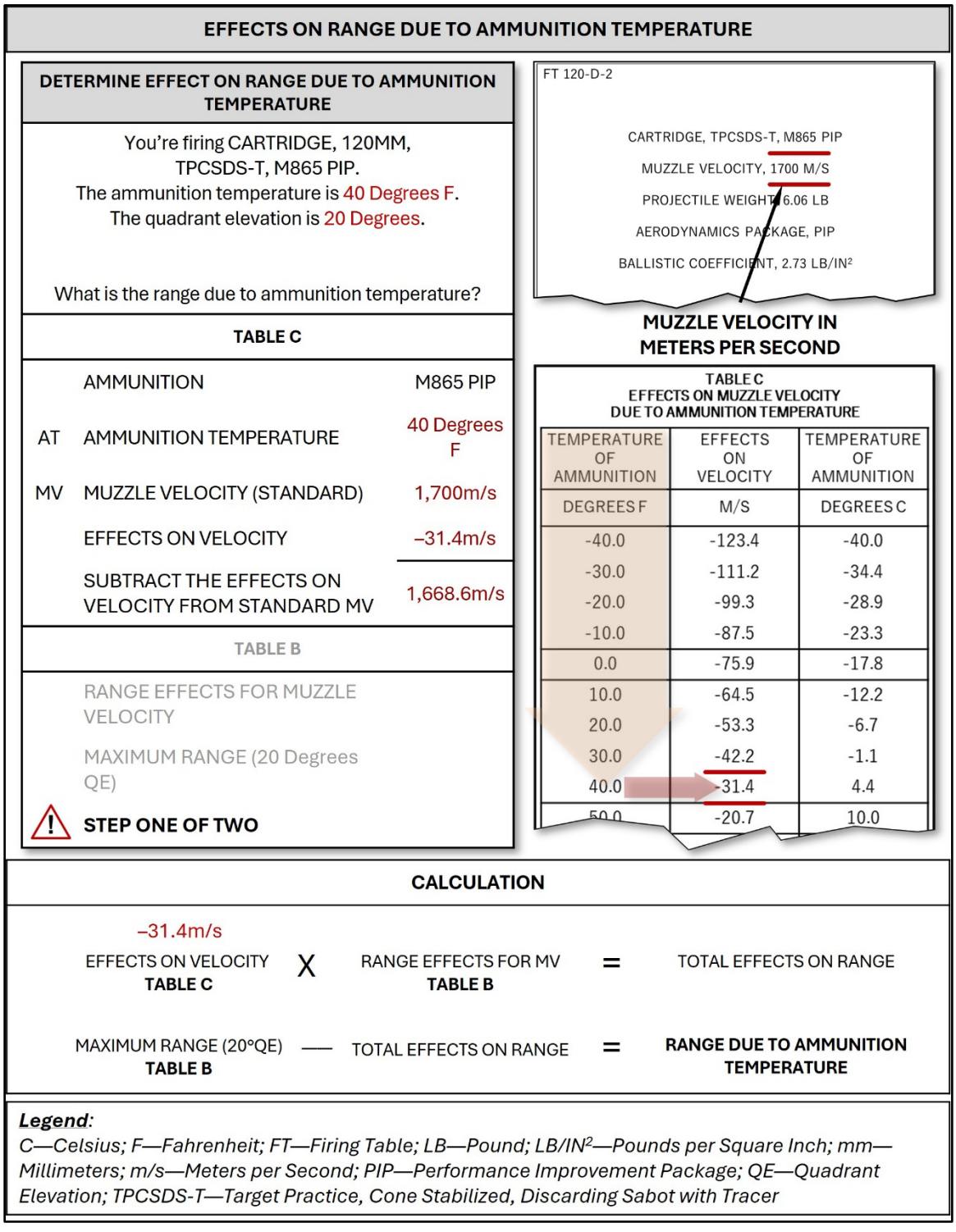


Figure 8-1. Effects on range due to ammunition temperature Table C

EFFECTS ON RANGE DUE TO AMMUNITION TEMPERATURE

DETERMINE EFFECT ON RANGE DUE TO AMMUNITION TEMPERATURE

You're firing CARTRIDGE, 120MM, TPCSDS-T, M865 PIP.
The ammunition temperature is 40 Degrees F.
The quadrant elevation is 20 Degrees.

What is the range due to ammunition temperature?

TABLE C

	AMMUNITION	M865 PIP
AT	AMMUNITION TEMPERATURE	40 Degrees F
MV	MUZZLE VELOCITY (STANDARD)	1,700m/s
	EFFECTS ON VELOCITY	–31.4m/s
	SUBTRACT THE EFFECTS ON VELOCITY FROM STANDARD MV	1,668.6m/s

TABLE B

RANGE EFFECTS FOR MUZZLE VELOCITY	–3.8m/s
MAXIMUM RANGE (20 Degrees QE)	8,271m

⚠ **STEP TWO OF TWO**

TABLE B
MAXIMUM ORDINATE, RANGE AND EFFE

1	2	3	4	5	6
QUADRANT ELEVATION	MAXIMUM ORDINATE	RANGE	RANGE E		
			MUZZLE VELOCITY 1 M/S		RANGE WIND 1 KM/HR
			DEC	INC	HEAD
DEG	M	M	M	M	M
5	289	6228	-3.4	3.4	-3.2
10	711	7239	-3.6	3.6	-5.3
15	1188	7855	-3.7	3.7	-7.1
20	1707	8271	-3.8	3.8	-8.7
25	2257	8544	-3.9	4.0	-10.2
30	2833	8697	-4.1	4.1	-11.6
34	3326	8737	-4.1	4.1	-12.7

FT 120-D-2-1, M865 PIP

CALCULATION

–31.4m/s EFFECTS ON VELOCITY **TABLE C**	X	–3.8m RANGE EFFECTS FOR MV **TABLE B**	=	–119.32m TOTAL EFFECTS ON RANGE
8,271m MAXIMUM RANGE (20°QE) **TABLE B**	—	119.32m TOTAL EFFECTS ON RANGE	=	8,151.68m **RANGE DUE TO AMMUNITION TEMPERATURE**

Legend:
F—Fahrenheit; FT—Firing Table; LB—Pound; LB/IN²—Pounds per Square Inch; mm—Millimeters; m/s—Meters per Second; PIP—Performance Improvement Package; QE—Quadrant Elevation; TPCSDS-T—Target Practice, Cone Stabilized, Discarding Sabot with Tracer

Figure 8-2. Effects on range due to ammunition temperature Table B

COMPLEX CALCULATION 2—TABLES B AND C

8-6. For this example, Tables B and C are used to determine the effects on range due to ammunition temperature and a tailwind. An M865 PIP round with an ammunition temperature of 20°F is fired at 15° QE. The existing tailwind is 30 km/hr. Figures 8-3 and 8-4 illustrate the determination process.

EFFECTS ON RANGE DUE TO AMMUNITION TEMPERATURE AND TAILWIND

DETERMINE EFFECT ON RANGE DUE TO AMMUNITION TEMPERATURE AND TAILWIND

You're firing CARTRIDGE, 120MM, TPCSDS-T, M865 PIP.
The ammunition temperature is 20 Degrees F.
The quadrant elevation is 15 Degrees.
A range wind (tail) speed of 30km/hr exists.

What is the effect range due to ammunition temperature and range wind?

TABLE C

	AMMUNITION	M865 PIP
AT	AMMUNITION TEMPERATURE	20 Degrees F
RW	RANGE WIND (TAIL)	30km/hr
MV	MUZZLE VELOCITY (STANDARD)	1,700m/s
	EFFECTS ON VELOCITY	–53.3m/s
	SUBTRACT THE EFFECTS ON VELOCITY FROM STANDARD MV	1,646.7m/s

TABLE B

RANGE EFFECTS FOR MUZZLE VELOCITY

RANGE EFFECTS FOR RANGE WIND

MAXIMUM RANGE (15 Degrees QE)

STEP ONE OF TWO

FT 120-D-2

CARTRIDGE, TPCSDS-T, M865 PIP
MUZZLE VELOCITY, 1700 M/S
PROJECTILE WEIGHT, 6.06 LB
AERODYNAMICS PACKAGE, PIP
BALLISTIC COEFFICIENT, 2.73 LB/IN²

MUZZLE VELOCITY IN METERS PER SECOND

TABLE C
EFFECTS ON MUZZLE VELOCITY DUE TO AMMUNITION TEMPERATURE

TEMPERATURE OF AMMUNITION	EFFECTS ON VELOCITY	TEMPERATURE OF AMMUNITION
DEGREES F	M/S	DEGREES C
-40.0	-123.4	-40.0
-30.0	-111.2	-34.4
-20.0	-99.3	-28.9
-10.0	-87.5	-23.3
0.0	-75.9	-17.8
10.0	-64.5	-12.2
20.0	-53.3	-6.7
30.0	-42.2	-1.1
40.0	-31.4	4.4
50.0	-20.7	10.0

CALCULATION

RANGE EFFECTS FOR RANGE WIND (TABLE B) X 30km/hr RANGE WIND (TAIL) = CHANGE IN RANGE FOR RANGE WIND

–53.3m/s EFFECTS ON VELOCITY (TABLE C) X RANGE EFFECTS FOR MV (TABLE B) = CHANGE IN RANGE FOR AMMO TEMP

MAXIMUM RANGE (15°QE) (TABLE B) — CHANGE IN RANGE FOR AMMO TEMP + CHANGE IN RANGE FOR RANGE WIND = **RANGE DUE TO AMMUNITION TEMPERATURE AND RANGE WIND**

Legend:
C—Celsius; F—Fahrenheit; FT—Firing Table; km/hr—Kilometers per Hour; LB—Pound; LB/IN²—Pounds per Square Inch; mm—Millimeters; m/s—Meters per Second; PIP—Performance Improvement Package; QE—Quadrant Elevation; TPCSDS-T—Target Practice, Cone Stabilized, Discarding Sabot with Tracer

Figure 8-3. Effects on range due to ammunition temperature and tailwind Table C

EFFECTS ON RANGE DUE TO AMMUNITION TEMPERATURE AND TAILWIND

DETERMINE EFFECT ON RANGE DUE TO AMMUNITION TEMPERATURE AND TAILWIND

You're firing CARTRIDGE, 120MM, TPCSDS-T, M865 PIP.
The ammunition temperature is 20 Degrees F.
The quadrant elevation is 15 Degrees.
A range wind (tail) speed of 30km/hr exists.

What is the effect range due to ammunition temperature and range wind?

TABLE C

	AMMUNITION	M865 PIP
AT	AMMUNITION TEMPERATURE	20 Degrees F
RW	RANGE WIND (TAIL)	30km/hr
MV	MUZZLE VELOCITY (STANDARD)	1,700m/s
	EFFECTS ON VELOCITY	–53.3m/s
	SUBTRACT THE EFFECTS ON VELOCITY FROM STANDARD MV	1,646.7m/s

TABLE B

RANGE EFFECTS FOR MUZZLE VELOCITY	–3.7m/s
RANGE EFFECTS FOR RANGE WIND	7.1m
MAXIMUM RANGE (15 Degrees QE)	7,855m

⚠ **STEP TWO OF TWO**

TABLE B
MAXIMUM ORDINATE, RANGE AND EFFECT

1	2	3	4	5	6	7
QUADRANT ELEVATION	MAXIMUM ORDINATE	RANGE	RANGE EFFECTS			
			MUZZLE VELOCITY 1 M/S		RANGE WIND 1 KM/HR	
			DEC	INC	HEAD	TAIL
DEG	M	M	M	M	M	M
5	289	6228	-3.4	3.4	-3.2	3.2
10	711	7239	-3.6	3.6	-5.3	5.4
15	1188	7855	-3.7	3.7	-7.1	7.1
20	1707	8271	-3.8	3.8	-8.7	8.7
25	2257	8544	-3.9	4.0	-10.2	1
30	2833	8697	-4.1	4.1	-11.6	11.6
34	3326	8737	-4.1	4.1	-12.7	1

FT 120-D-2-1, M865 PIP

CALCULATION

7.1m RANGE EFFECTS FOR RANGE WIND **TABLE B**	X	30km/hr RANGE WIND (TAIL)	=	213m CHANGE IN RANGE FOR RANGE WIND			
–53.3m/s EFFECTS ON VELOCITY **TABLE C**	X	–3.7m/s RANGE EFFECTS FOR MV **TABLE B**	=	–197.21m CHANGE IN RANGE FOR AMMO TEMP			
7,855m MAXIMUM RANGE (15°QE) **TABLE B**	—	197.21m CHANGE IN RANGE FOR AMMO TEMP	+	213m CHANGE IN RANGE FOR RANGE WIND	=	7,870.79m **RANGE DUE TO AMMUNITION TEMPERATURE AND RANGE WIND**	

Legend:
DEC—Decrease; DEG—Degrees; F—Fahrenheit; FT—Firing Table; INC—Increase; KM/HR—Kilometers per Hour; m—Meters; mm—Millimeters; m/s—Meters per Second; PCT—Percent; PIP—Performance Improvement Package; QE—Quadrant Elevation; TPCSDS-T—Target Practice, Cone Stabilized, Discarding Sabot with Tracer

Figure 8-4. Effects on range due to ammunition temperature and tailwind Table B

COMPLEX CALCULATION 3—TABLES B AND D

8-7. For this example, Tables B and D are used to determine the effects on range due to an increase in altitude. An M865 PIP round is fired at 15° QE at an altitude of 1,800m. Figures 8-5 and 8-6 illustrate the calculation process.

EFFECTS ON RANGE DUE TO INCREASED ALTITUDE

DETERMINE EFFECT ON RANGE DUE TO AMMUNITION TEMPERATURE

You're firing CARTRIDGE, 120MM, TPCSDS-T, M865 PIP.
The altitude is 1,800m.
The quadrant elevation is 15 Degrees.

What is the range due to increased altitude?

TABLE D

	AMMUNITION	M865 PIP
ALT	ALTITUDE	40 Degrees F
	EFFECT ON AIR DENSITY	1,700m/s
	EFFECTS ON VELOCITY	DECREASE of 16.2 PCT

TABLE B

RANGE EFFECTS FOR AIR DENSITY

MAXIMUM RANGE (15 Degrees QE)

STEP ONE OF TWO

FT 120-D-2

CARTRIDGE, TPCSDS-T, M865 PIP
MUZZLE VELOCITY, 1700 M/S
PROJECTILE WEIGHT, 6.06 LB
AERODYNAMICS PACKAGE, PIP
BALLISTIC COEFFICIENT, 2.73 LB/IN²

TABLE D

EFFECTS ON AIR DENSITY DUE TO ALTITUDE

1300	11.9
1400	12.8
1500	13.6
1600	14.5
1700	15.3
1800	16.2
1900	17.0
2000	17.8

FT 120-D-1, M865 PIP

CALCULATION

16.2 PCT (DECREASE IN AIR DENSITY DUE TO ALTITUDE, **TABLE D**) X (RANGE EFFECTS FOR AIR DENSITY, **TABLE B**) = TOTAL EFFECTS ON RANGE

\+ (MAXIMUM RANGE (15°QE), **TABLE B**) + (TOTAL EFFECTS ON RANGE) = **RANGE DUE TO INCREASED ALTITUDE**

Legend:
F—Fahrenheit; FT—Firing Table; LB—Pound; LB/IN²—Pounds per Square Inch; m—Meters; mm—Millimeters; m/s—Meters per Second; PCT—Percent; PIP—Performance Improvement Package; QE—Quadrant Elevation; TPCSDS-T—Target Practice, Cone Stabilized, Discarding Sabot with Tracer

Figure 8-5. Effects on range due to increased altitude Table D

EFFECTS ON RANGE DUE TO INCREASED ALTITUDE

DETERMINE EFFECT ON RANGE DUE TO AMMUNITION TEMPERATURE

You're firing CARTRIDGE, 120MM,
TPCSDS-T, M865 PIP.
The altitude is 1,800m.
The quadrant elevation is 15 Degrees.

What is the range due to increased altitude?

TABLE D

	AMMUNITION	M865 PIP
ALT	ALTITUDE	40 Degrees F
	EFFECT ON AIR DENSITY	1,700m/s
	EFFECTS ON VELOCITY	DECREASE of 16.2 PCT

TABLE B

RANGE EFFECTS FOR AIR DENSITY (DEC)	74.4m
MAXIMUM RANGE (15° QE)	7,855m

⚠ **STEP TWO OF TWO**

TABLE B
MAXIMUM ORDINATE, RANGE AND EFFECTS ON RANGE

1	2	3	4	5	6	7	8	9
QUADRANT ELEVATION	MAXIMUM ORDINATE	RANGE	RANGE EFFECTS FOR					
			MUZZLE VELOCITY 1 M/S		RANGE WIND 1 KM/HR		AIR DENSITY 1 PCT	
			DEC	INC	HEAD	TAIL	DEC	INC
DEG	M	M	M	M	M	M	M	M
5	289	6228	-3.4	3.4	-3.2	3.2	54.4	-45.5
10	711	7239	-3.6	3.6	-5.3	5.4	66.1	-55.1
15	1188	7855	-3.7	3.7	-7.1	7.1	74.4	-61.7
20	1707	8271	-3.8	3.8	-8.7	8.7	81.3	-67.1
25	2257	8544	-3.9	4.0	-10.2	10.2	87.2	-71.5
30	2833	8697	-4.1	4.1	-11.6	11.6	92.1	-75.1
34	3326	8737	-4.1	4.1	-12.7	12.8	95.6	-77.5

FT 120-D-2-1, M865 PIP

CALCULATION

16.2 PCT DECREASE IN AIR DENSITY DUE TO ALTITUDE **TABLE D**	X	74.4m RANGE EFFECTS FOR AIR DENSITY **TABLE B**	=	1,205.28m TOTAL EFFECTS ON RANGE
7,855m MAXIMUM RANGE (15°QE) **TABLE B**	+	1,205.28m TOTAL EFFECTS ON RANGE	=	9,060.28m **RANGE DUE TO INCREASED ALTITUDE**

Legend:
DEC—Decrease; DEG—Degrees; F—Fahrenheit; FT—Firing Table; INC—Increase; KM/HR—Kilometers per Hour; LB—Pound; LB/IN²—Pounds per Square Inch; m—Meters; mm—Millimeters; m/s—Meters per Second; PCT—Percent; PIP—Performance Improvement Package; QE—Quadrant Elevation; TPCSDS-T—Target Practice, Cone Stabilized, Discarding Sabot with Tracer

Figure 8-6. Effects on range due to increased altitude Table B

BATTLESIGHT RANGE

8-8. Battle carry ammunition and battlesight range are used when an accurate target range cannot be determined or when fire control computers are inoperable. Battlesight range is used on crew platforms to set a default range value when the laser range finder is inoperative, multiple returns are frequent, or when fighting the platform while degraded.

8-9. Unit standard operating procedures (also called SOPs) determine battlesight ranges based on the commander's analysis of METT-TC (I) which stands for mission, enemy, terrain and weather, troops and support available, time available, civil considerations, and informational considerations. Master gunners are responsible for maximizing lethality under any conditions; properly establishing battle carry ammunition and battlesight range enables units to maintain overmatch when equipment does not operate as intended.

8-10. Firing tables are required to establish effective battle carry ammunition and battlesight ranges. Given a commander's assessment and the master gunner's ability to take advantage of the relatively flat trajectories of armor-defeating ammunition, table data is used to determine the best option for a high probability of first-round strikes on target.

8-11. Master gunners take the information from the commander and determine battle carry ammunition and battlesight range based on two main factors: height of the anticipated target and MAX ORD of the ammunition type. The MAX ORD and range to MAX ORD for ammunition provides necessary information to determine a battlesight range.

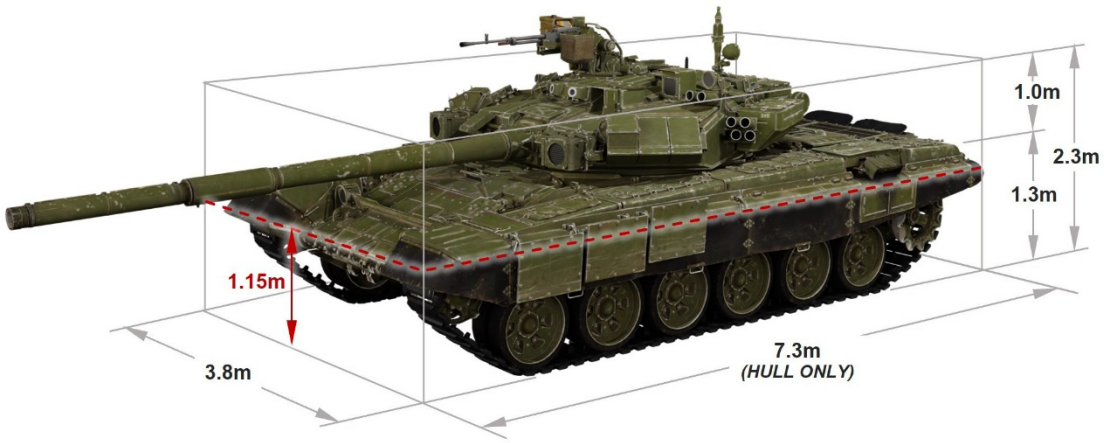
8-12. In this example (see figure 8-7), the unit determines a battlesight range for an M865 PIP. The battlesight range creates a default range value for the ballistic solution. The battlesight range should provide the highest probability of hit while minimizing the potential for the round to fly over the target.

DETERMINE BATTLESIGHT RANGE EXAMPLE

You're firing CARTRIDGE, 120MM, TPCSDS-T, M865 PIP.

Aiming the Center of Visible Mass (CoVM), what is the farthest BATTLESIGHT RANGE where the MAXIMUM ORDINATE does not exceed the height of the target?

A—AMMUNITION	M865 PIP
H—MAXIMUM HEIGHT from CENTER OF VISIBLE MASS	1.15m
C—COLUMN	MAXIMUM ORDINATE



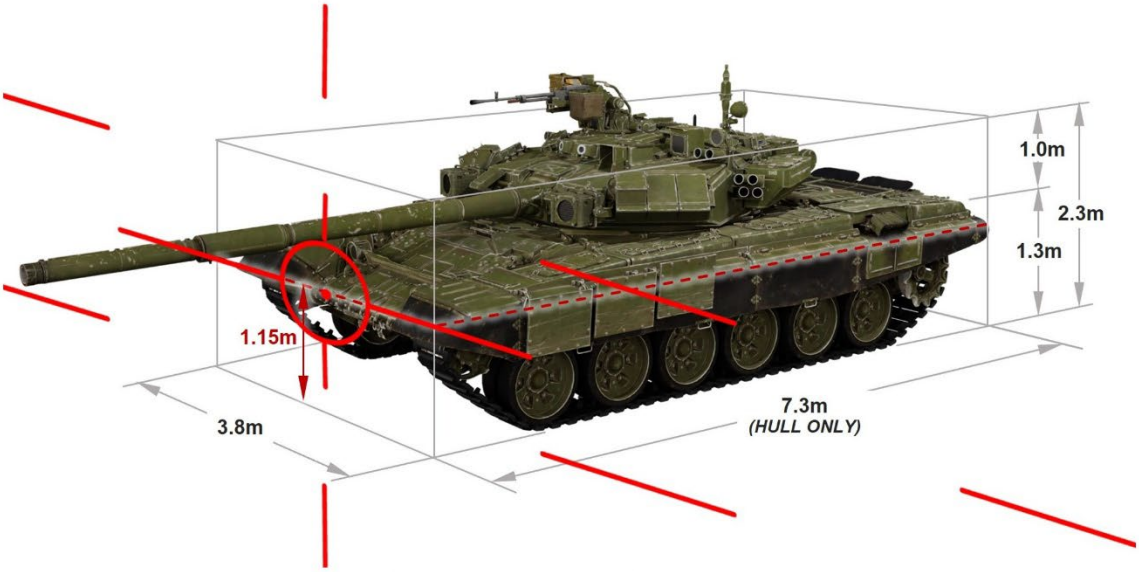
Height of the T–90S is approximately *2.3m*
Point of Aim (PoA) is center of visible mass ≈ *1.15m*
Find the NEAREST MAXIMUM ORDINATE listed to the PoA (rounded) *1.2m*

Legend:
≈—Approximately; *m—Meters; mm—Millimeters; PIP—Performance Improvement Package; TPCSDS-T—Target Practice, Cone Stabilized, Discarding Sabot with Tracer*

Figure 8-7. Identify center of visible mass to determine maximum ordinate

8-13. Figure 8-8 depicts a T90S's center of visible mass, where gunners should aim. If the T90 is fully visible, the center of visible mass is half its height. In this example, 1.15 meters is the center of the visible mass. Determining the appropriate battlesight range uses that value, rounded to the nearest match in firing tables, to find the MAX ORD for the round. This ensures that the target can be struck at all distances out to at least the battlesight range.

DETERMINE BATTLESIGHT RANGE EXAMPLE



Height of the T–90S is approximately *2.3m*
Point of Aim (PoA) is center of visible mass ≈ *1.15m*
Find the NEAREST MAXIMUM ORDINATE listed to the PoA (rounded) *1.2m*

TABLE A
BASIC DATA

1	2	3	4	5	6	7	8	9	10	11
RANGE	SUPER-ELEVATION	DR / DSE	DH / DR	TIME OF FLIGHT	10 KM/HR CROSSWIND DEFLECTION	MAXIMUM ORDINATE	RANGE TO MAXIMUM ORDINATE	ANGLE OF FALL	REMAINING VELOCITY	RANGE
METERS	MILS	M/MIL	M/100M	SEC	MILS	METERS	METERS	MILS	M/SEC	METERS
1000	2.01	400	0.2	0.66	0.2	0.5	519	2	1354	1000
1100	2.25	387	0.3	0.73	0.2	0.7	573	3	1320	1100
1200	2.49	374	0.3	0.81	0.2	0.8	628	3	1286	1200
1300	2.75	361	0.3	0.89	0.3	1.0	683	3	1252	1300
1400	3.01	349	0.4	0.97	0.3	1.2	739	4	1218	1400
1500	3.28	337	0.4	1.05	0.3	1.4	795	4	1184	1500
1600	3.57	324	0.5	1.14	0.3	1.6	852	5	1149	1600

BATTLESIGHT RANGE = *1,400m*

Legend:
≈—Approximately; *DH—Change in Height; DR—Change in Range; DSE—Change in Super Elevation; KM/HR—Kilometers per Hour; m—Meters; M/100M—Meters per 100 Meters; M/MIL—Meters per Mils; M/SEC—Meters per Second; sec—Second*

Figure 8-8. Identify battlesight range from maximum ordinate and center of visible mass

8-14. In the figure 8-8 example on page 103, 1.2 meters is the rounded value to find in the MAX ORD column (column 7). The range (column 1) at which the MAX ORD occurs is 1,400 meters. This is the determined battlesight range for the M865 PIP for this unit.

DISTANCE X

8-15. When constructing a range in austere conditions, ammunition surface danger zones (SDZs) are drawn to ensure the range is safe for use. When planning ranges with various SDZs, the maximum planned superelevation for a weapon system is typically 10° of QE. The rule of thumb is to plan for a maximum of 10° and build scenarios that require no more than 5°. Figure 8-9 shows how to determine distance X to support the SDZ development.

FIRING TABLES
TABLE B, MAXIMUM ORDINATE, RANGE AND EFFECTS ON RANGE
DETERMINE DISTANCE X

DETERMINE MAX ORD AND MAX RANGE	
You're firing CARTRIDGE, 120MM, TPCSDS-T, M865 PIP. Determine Distance X of 10 Degrees to accurately draw the Surface Danger Zone (SDZ).	
1—AMMUNITION	M865 PIP
2—QUADRANT ELEVATION	10 Degrees
3—RANGE	7,239m

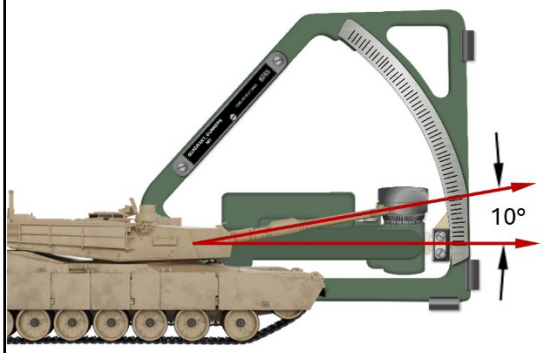


TABLE B
MAXIMUM ORDINATE, RANGE AND EFFEC

1	2	3	4	5	6	
QUADRANT ELEVATION	MAXIMUM ORDINATE	RANGE	RANGE EFFECT			
			MUZZLE VELOCITY 1 M/S		RANGE WIND 1 KM/HR	
			DEC	INC	HEAD	T
DEG	M	M	M	M	M	M
5	289	6228	-3.4	3.4	-3.2	3
10	711	7239	-3.6	3.6	-5.3	
15	1188	7855	-3.7	3.7	-7.1	
20	1707	8271	-3.8	3.8	-8.7	8.
25	2257	8544	-3.9	4.0	-10.2	10.
30	2833	8697	-4.1	4.1	-11.6	1
34	3326	8737	-4.1	4.1	-12.7	12

FT 120-D-2-1, M865 PIP

Not to scale. Angular measurement exaggerated for context.

Legend:
DEC—Decrease; DEG—Degrees; FT—Firing Table; INC—Increase; KM/HR—Kilometers per Hour; m—Meters; mm—Millimeters; m/s—Meters per Second; PIP—Performance Improvement Package; TPCSDS-T—Target Practice, Cone Stabilized, Discarding Sabot with Tracer

Figure 8-9. Determine distance x

LOCATE LOST ROUND

8-16. Figure 8-10 provides a use case example determining the general location of a round fired out of impact. Firing out of impact voids any SDZ waiver for the training facility and may halt unit training. In this example, a tank was maneuvering out of a steep ravine when the gun fired. The QE during firing was 30°. Table B is used to determine the maximum range the round traveled when fired under these conditions.

FIRING TABLES
TABLE B, MAXIMUM ORDINATE, RANGE AND EFFECTS ON RANGE
DETERMINE MAXIMUM RANGE

DETERMINE MAXIMUM RANGE

You're firing CARTRIDGE, 120MM, TPCSDS-T, M865 PIP.

A crew fired a round out of impact during collective training. They were maneuvering cross country and were exiting a ravine when the round was fired. The gun was measured at 30 Degrees quadrant elevation.

How far did the round travel?

1—AMMUNITION	M865 PIP
2—QUADRANT ELEVATION	30 Degrees
3—RANGE	8,697m

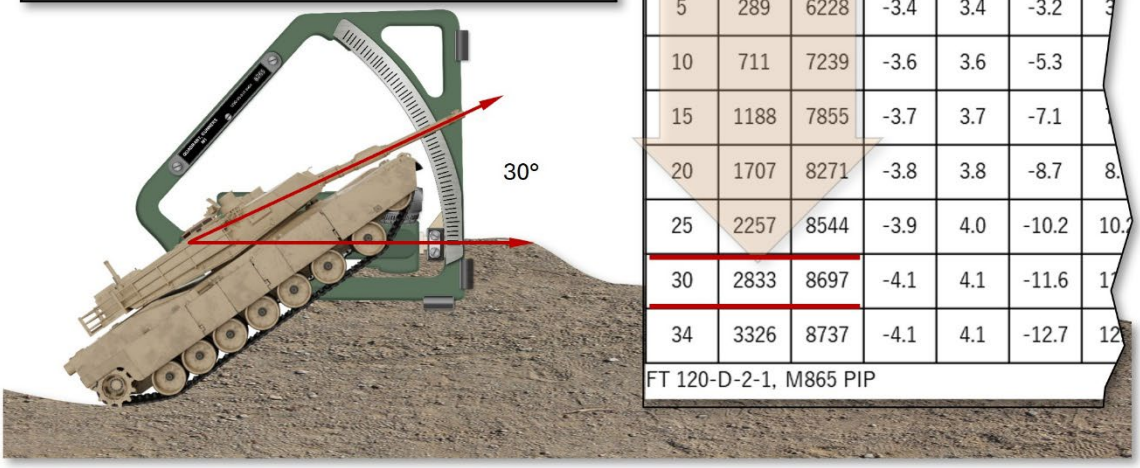


TABLE B
MAXIMUM ORDINATE, RANGE AND EFFEC

1	2	3	4	5	6	
QUADRANT ELEVATION	MAXIMUM ORDINATE	RANGE	RANGE EFFECT			
			MUZZLE VELOCITY 1 M/S		RANGE WIND 1 KM/HR	
			DEC	INC	HEAD	T
DEG	M	M	M	M	M	M
5	289	6228	-3.4	3.4	-3.2	3
10	711	7239	-3.6	3.6	-5.3	
15	1188	7855	-3.7	3.7	-7.1	
20	1707	8271	-3.8	3.8	-8.7	8.
25	2257	8544	-3.9	4.0	-10.2	10.
30	2833	8697	-4.1	4.1	-11.6	1
34	3326	8737	-4.1	4.1	-12.7	12

FT 120-D-2-1, M865 PIP

Not to scale. Angular measurement exaggerated for context.

Legend:
DEC—Decrease; DEG—Degrees; FT—Firing Table; INC—Increase; KM/HR—Kilometers per Hour; m—Meters; mm—Millimeters; m/s—Meters per Second; PIP—Performance Improvement Package; TPCSDS-T—Target Practice, Cone Stabilized, Discarding Sabot with Tracer

Figure 8-10. Determining maximum range use case

INTERPOLATION

8-17. This section focuses on the first three columns of Table B: QE, MAX ORD, and range. To illustrate the process of interpolation (the estimation of a value between two known values), example prompts are provided followed by illustrations of the calculation methods. Interpolation can be performed using multiple columns. An example is provided for interpolating with an unlisted QE for the following:

- Maximum range.
- MAX ORD.
- Change in MV, 1m/s.
- Range wind effects, 1 km/hr.
- Air density effects, 1 percent change.

INTERPOLATION FOR UNLISTED QUADRANT ELEVATION—MAXIMUM RANGE

8-18. When a range determination is required for a QE listed between the 5-degree increments listed, use interpolation. Interpolation is the estimation of a value between two known (listed) values.

8-19. Because Table B only lists QE data in increments of 5°, the situation arises where firing tables are needed to compute a MAX ORD or range for unlisted QEs that fall between those increments. For example, a cartridge, 120MM, TPCSDS-T M865 PIP has been fired and landed out of impact. The round was fired at 13° QE, which is unlisted in Table B. What is the MAX ORD and maximum range of the fired round?

8-20. Figures 8-11 through 8-16 through page 111 illustrate an example of QE interpolation to estimate maximum range for the M865 PIP fired at 13° QE. There are six steps to determining the estimated range.

FIRING TABLES
TABLE B, MAXIMUM ORDINATE, RANGE AND EFFECTS ON RANGE
RANGE INTERPOLATION FOR UNLISTED QUADRANT ELEVATION

Determine the QUADRANT ELEVATION needed.

DETERMINE INTERPOLATION FOR RANGE

You're firing CARTRIDGE, 120MM,
TPCSDS-T, M865 PIP.
A round was fired out of impact.
The round was fired at 13 Degrees.

What is maximum RANGE for the bullet fired?

	AMMUNITION	M865 PIP
QE	QUADRANT ELEVATION	13 Degrees

Legend:
mm—Millimeters; PIP—Performance Improvement Package; TPCSDS-T—Target Practice, Cone Stabilized, Discarding Sabot with Tracer

Figure 8-11. Determining range using interpolation of the quadrant elevation, example, step 1

FIRING TABLES
TABLE B, MAXIMUM ORDINATE, RANGE AND EFFECTS ON RANGE
RANGE INTERPOLATION FOR UNLISTED QUADRANT ELEVATION

Identify the HIGHER and LOWER values listed in Table B.

DETERMINE INTERPOLATION FOR RANGE		
You're firing CARTRIDGE, 120MM, TPCSDS-T, M865 PIP. A round was fired out of impact. The round was fired at 13 Degrees. What is maximum RANGE for the bullet fired?		
	AMMUNITION	M865 PIP
QE	QUADRANT ELEVATION	13 Degrees
H	HIGHEST RANGE—15°	7,855m
L	LOWEST RANGE—10°	7,239m

13 Degrees

TABLE B
MAXIMUM ORDINATE, RANGE AND EFFEC

1	2	3	4	5	6	
QUADRANT ELEVATION	MAXIMUM ORDINATE	RANGE	RANGE EFFECT			
			MUZZLE VELOCITY 1 M/S		RANGE WIND 1 KM/HR	
			DEC	INC	HEAD	T
DEG	M	M	M	M	M	M
5	289	6228	-3.4	3.4	-3.2	3
10	711	7239	-3.6	3.6	-5.3	
15	1188	7855	-3.7	3.7	-7.1	
20	1707	8271	-3.8	3.8	-8.7	8.
25	2257	8544	-3.9	4.0	-10.2	10.
30	2833	8697	-4.1	4.1	-11.6	1
34	3326	8737	-4.1	4.1	-12.7	12

FT 120-D-2-1, M865 PIP

Legend:
°—Degrees; DEC—Decrease; DEG—Degrees; FT—Firing Table; INC—Increase; KM/HR—Kilometers per Hour; m—Meters; mm—Millimeters; m/s—Meters per Second; PIP—Performance Improvement Package; TPCSDS-T—Target Practice, Cone Stabilized, Discarding Sabot with Tracer

Figure 8-12. Determining range using interpolation of the quadrant elevation, example, step 2

FIRING TABLES
TABLE B, MAXIMUM ORDINATE, RANGE AND EFFECTS ON RANGE
RANGE INTERPOLATION FOR UNLISTED QUADRANT ELEVATION

Subtract the LOWER RANGE from the HIGHER RANGE.

DETERMINE INTERPOLATION FOR RANGE		
You're firing CARTRIDGE, 120MM, TPCSDS-T, M865 PIP. A round was fired out of impact. The round was fired at 13 Degrees. What is maximum RANGE for the bullet fired?		
	AMMUNITION	M865 PIP
QE	QUADRANT ELEVATION	13 Degrees
H	HIGHEST RANGE—15°	7,855m
L	LOWEST RANGE—10°	- 7,239m
	SUBTRACT LOW from HIGH	616m

TABLE B
MAXIMUM ORDINATE, RANGE AND EFFEC

1	2	3	4	5	6	
QUADRANT ELEVATION	MAXIMUM ORDINATE	RANGE	RANGE EFFECT			
			MUZZLE VELOCITY 1 M/S		RANGE WIND 1 KM/HR	
			DEC	INC	HEAD	T
DEG	M	M	M	M	M	M
5	289	6228	-3.4	3.4	-3.2	3
10	711	7239	-3.6	3.6	-5.3	
15	1188	7855	-3.7	3.7	-7.1	
20	1707	8271	-3.8	3.8	-8.7	8.
25	2257	8544	-3.9	4.0	-10.2	10.
30	2833	8697	-4.1	4.1	-11.6	1
34	3326	8737	-4.1	4.1	-12.7	12

FT 120-D-2-1, M865 PIP

Legend:
°—Degrees; DEC—Decrease; DEG—Degrees; FT—Firing Table; INC—Increase; KM/HR—Kilometers per Hour; m—Meters; mm—Millimeters; m/s—Meters per Second; PIP—Performance Improvement Package; TPCSDS-T—Target Practice, Cone Stabilized, Discarding Sabot with Tracer

Figure 8-13. Determining range using interpolation of the quadrant elevation, example, step 3

FIRING TABLES
TABLE B, MAXIMUM ORDINATE, RANGE AND EFFECTS ON RANGE
RANGE INTERPOLATION FOR UNLISTED QUADRANT ELEVATION

Divide the SUBTRACTED RANGE by 5 (answer is WHOLE number only—drop the remainder). This will give you the RANGE value for 1 increment (degree) of quadrant elevation.

DETERMINE INTERPOLATION FOR RANGE

You're firing CARTRIDGE, 120MM,
TPCSDS-T, M865 PIP.
A round was fired out of impact.
The round was fired at 13 Degrees.

What is maximum RANGE for the bullet fired?

	AMMUNITION	M865 PIP
QE	QUADRANT ELEVATION	13 Degrees
H	HIGHEST RANGE—15°	7,855m
L	LOWEST RANGE—10°	7,239m
	SUBTRACT LOW from HIGH	616m
÷	DIVIDE BY 5, *(ANSWER IS WHOLE NUMBER ONLY, DROP REMAINDER)*	123m

TABLE B
MAXIMUM ORDINATE, RANGE AND EFFEC

1	2	3	4	5	6	
QUADRANT ELEVATION	MAXIMUM ORDINATE	RANGE	RANGE EFFECT			
			MUZZLE VELOCITY 1 M/S		RANGE WIND 1 KM/HR	
			DEC	INC	HEAD	T
DEG	M	M	M	M	M	M
5	289	6228	-3.4	3.4	-3.2	3
10	711	7239	-3.6	3.6	-5.3	
15	1188	7855	-3.7	3.7	-7.1	
20	1707	8271	-3.8	3.8	-8.7	8.
25	2257	8544	-3.9	4.0	-10.2	10.
30	2833	8697	-4.1	4.1	-11.6	1
34	3326	8737	-4.1	4.1	-12.7	12

FT 120-D-2-1, M865 PIP

Legend:
°—Degrees; DEC—Decrease; DEG—Degrees; FT—Firing Table; INC—Increase; KM/HR—Kilometers per Hour; m—Meters; mm—Millimeters; m/s—Meters per Second; PIP—Performance Improvement Package; TPCSDS-T—Target Practice, Cone Stabilized, Discarding Sabot with Tracer

Figure 8-14. Determining range using interpolation of the quadrant elevation, example, step 4

FIRING TABLES
TABLE B, MAXIMUM ORDINATE, RANGE AND EFFECTS ON RANGE
RANGE INTERPOLATION FOR UNLISTED QUADRANT ELEVATION

Multiply the SINGLE INCREMENT VALUE (123m) by the ***right digit*** of the desired quadrant elevation. Because the quadrant elevation is 13 degrees, the right digit is **3**.

DETERMINE INTERPOLATION FOR RANGE

You're firing CARTRIDGE, 120MM, TPCSDS-T, M865 PIP.
A round was fired out of impact.
The round was fired at 13 Degrees.

What is maximum RANGE for the bullet fired?

	AMMUNITION	M865 PIP
QE	QUADRANT ELEVATION	13 Degrees
H	HIGHEST RANGE—15°	7,855m
L	LOWEST RANGE—10°	7,239m
	SUBTRACT LOW from HIGH	616m
	DIVIDE BY 5, *(WHOLE NUMBER ONLY, DROP REMAINDER)*	123m
✖	MULTIPLY BY QE ***RIGHT DIGIT*** (**3**)	369m

TABLE B
MAXIMUM ORDINATE, RANGE AND EFFEC

1	2	3	4	5	6	
QUADRANT ELEVATION	MAXIMUM ORDINATE	RANGE	RANGE EFFECT			
			MUZZLE VELOCITY 1 M/S		RANGE WIND 1 KM/HR	
			DEC	INC	HEAD	T
DEG	M	M	M	M	M	M
5	289	6228	-3.4	3.4	-3.2	3
10	711	7239	-3.6	3.6	-5.3	
15	1188	7855	-3.7	3.7	-7.1	
20	1707	8271	-3.8	3.8	-8.7	8.
25	2257	8544	-3.9	4.0	-10.2	10.
30	2833	8697	-4.1	4.1	-11.6	1
34	3326	8737	-4.1	4.1	-12.7	12

FT 120-D-2-1, M865 PIP

Legend:
°—Degrees; DEC—Decrease; DEG—Degrees; FT—Firing Table; INC—Increase; KM/HR—Kilometers per Hour; m—Meters; mm—Millimeters; m/s—Meters per Second; PIP—Performance Improvement Package; TPCSDS-T—Target Practice, Cone Stabilized, Discarding Sabot with Tracer

Figure 8-15. Determining range using interpolation of the quadrant elevation, example, step 5

FIRING TABLES
TABLE B, MAXIMUM ORDINATE, RANGE AND EFFECTS ON RANGE
RANGE INTERPOLATION FOR UNLISTED QUADRANT ELEVATION

Add the MULTIPLIED VALUE to the LOWEST RANGE (value of the 10 degrees quadrant elevation range).

DETERMINE INTERPOLATION FOR RANGE

You're firing CARTRIDGE, 120MM,
TPCSDS-T, M865 PIP.
A round was fired out of impact.
The round was fired at 13 Degrees.

What is maximum RANGE for the bullet fired?

	AMMUNITION	M865 PIP
QE	QUADRANT ELEVATION	13 Degrees
H	HIGHEST RANGE—15°	7,855m
L	LOWEST RANGE—10°	7,239m
	SUBTRACT LOW from HIGH	616m
	DIVIDE BY 5, *(WHOLE NUMBER ONLY, DROP REMAINDER)*	123m
	MULTIPLY BY QE ***RIGHT DIGIT*** (**3**)	369m
+	ADD LOWER RANGE *(7,239m)* AND INTERPOLATION RANGE *(369m)*	7,608m

⚠ If the solution is NOT BETWEEN the LOWEST and HIGHEST RANGE values, an error was made.

TABLE B
MAXIMUM ORDINATE, RANGE AND EFFEC

1	2	3	4	5	6	
QUADRANT ELEVATION	MAXIMUM ORDINATE	RANGE	RANGE EFFECT			
			MUZZLE VELOCITY 1 M/S		RANGE WIND 1 KM/HR	
			DEC	INC	HEAD	T
DEG	M	M	M	M	M	M
5	289	6228	-3.4	3.4	-3.2	3
10	711	7239	-3.6	3.6	-5.3	
15	1188	7855	-3.7	3.7	-7.1	
20	1707	8271	-3.8	3.8	-8.7	8.
25	2257	8544	-3.9	4.0	-10.2	10.
30	2833	8697	-4.1	4.1	-11.6	1
34	3326	8737	-4.1	4.1	-12.7	12

FT 120-D-2-1, M865 PIP

Legend:
°—Degrees; DEC—Decrease; DEG—Degrees; FT—Firing Table; INC—Increase; KM/HR—Kilometers per Hour; m—Meters; mm—Millimeters; m/s—Meters per Second; PIP—Performance Improvement Package; TPCSDS-T—Target Practice, Cone Stabilized, Discarding Sabot with Tracer

Figure 8-16. Determining range using interpolation of the quadrant elevation, example, final

INTERPOLATION FOR UNLISTED QUADRANT ELEVATION—MAXIMUM ORDINATE

8-21. When determining the MAX ORD for a QE between the listed 5-degree values in a firing table, interpolation helps approximate a value. Interpolation is the estimate between two known values. Although not exactly precise, the solution provides an approximation that can be used for clearance of fires and that the trajectory ensures a path clear of physical barriers.

8-22. Figures 8-17 through 8-22 through page 117 provide an example of QE interpolation to estimate MAX ORD. In this example, the M865 PIP round is fired at 134° QE. There are six steps to determining the MAX ORD.

FIRING TABLES
TABLE B, MAXIMUM ORDINATE, RANGE AND EFFECTS ON RANGE
MAXIMUM ORDINATE INTERPOLATION FOR UNLISTED QUADRANT ELEVATION

Determine the QUADRANT ELEVATION needed.

DETERMINE INTERPOLATION FOR RANGE		
You're firing CARTRIDGE, 120MM, TPCSDS-T, M865 PIP. A round was fired out of impact. The round was fired at 13 Degrees. What is the maximum ordinate of the bullet fired?		
	AMMUNITION	M865 PIP
QE	QUADRANT ELEVATION	13 Degrees

Legend:
mm—Millimeters; PIP—Performance Improvement Package; TPCSDS-T—Target Practice, Cone Stabilized, Discarding Sabot with Tracer

Figure 8-17. Determining maximum ordinate using interpolation of the quadrant elevation, example, step 1

FIRING TABLES
TABLE B, MAXIMUM ORDINATE, RANGE AND EFFECTS ON RANGE
MAXIMUM ORDINATE INTERPOLATION FOR UNLISTED QUADRANT ELEVATION

Identify the HIGHER and LOWER values listed in Table B.

DETERMINE INTERPOLATION FOR RANGE		
You're firing CARTRIDGE, 120MM, TPCSDS-T, M865 PIP. A round was fired out of impact. The round was fired at 13 Degrees. What is the maximum ordinate of the bullet fired?		
	AMMUNITION	M865 PIP
QE	QUADRANT ELEVATION	13 Degrees
H	HIGHEST MAX ORD—15°	1,188m
L	LOWEST MAX ORD—10°	711m

TABLE B
MAXIMUM ORDINATE, RANGE AND EFFEC

1	2	3	4	5	6	
QUADRANT ELEVATION	MAX ORD MAXIMUM ORDINATE	RANGE	RANGE EFFECT			
			MUZZLE VELOCITY 1 M/S		RANGE WIND 1 KM/HR	
			DEC	INC	HEAD	T
DEG	M	M	M	M	M	M
5	289	6228	-3.4	3.4	-3.2	3
10	711	7239	-3.6	3.6	-5.3	
15	1188	7855	-3.7	3.7	-7.1	
20	1707	8271	-3.8	3.8	-8.7	8.
25	2257	8544	-3.9	4.0	-10.2	10.
30	2833	8697	-4.1	4.1	-11.6	1
34	3326	8737	-4.1	4.1	-12.7	12

FT 120-D-2-1, M865 PIP

13 Degrees

Legend:
°—Degrees; DEC—Decrease; DEG—Degrees; FT—Firing Table; INC—Increase; KM/HR—Kilometers per Hour; MAX ORD—Maximum Ordinate; m—Meters; mm—Millimeters; m/s—Meters per Second; PIP—Performance Improvement Package; TPCSDS-T—Target Practice, Cone Stabilized, Discarding Sabot with Tracer

Figure 8-18. Determining maximum ordinate using interpolation of the quadrant elevation, example, step 2

FIRING TABLES
TABLE B, MAXIMUM ORDINATE, RANGE AND EFFECTS ON RANGE
MAXIMUM ORDINATE INTERPOLATION FOR UNLISTED QUADRANT ELEVATION

Subtract the LOWER MAX ORD from the HIGHER MAX ORD.

DETERMINE INTERPOLATION FOR RANGE		
You're firing CARTRIDGE, 120MM, TPCSDS-T, M865 PIP. A round was fired out of impact. The round was fired at 13 Degrees. What is the maximum ordinate of the bullet fired?		
	AMMUNITION	M865 PIP
QE	QUADRANT ELEVATION	13 Degrees
H	HIGHEST MAX ORD—15°	1,188m
L	LOWEST MAX ORD—10°	- 711m
	SUBTRACT LOW from HIGH	477m

TABLE B
MAXIMUM ORDINATE, RANGE AND EFFEC

1	2	3	4	5	6	
QUADRANT ELEVATION	MAXIMUM ORDINATE	RANGE	RANGE EFFECT			
			MUZZLE VELOCITY 1 M/S		RANGE WIND 1 KM/HR	
			DEC	INC	HEAD	T
DEG	M	M	M	M	M	M
5	289	6228	-3.4	3.4	-3.2	3
10	711	7239	-3.6	3.6	-5.3	
15	1188	7855	-3.7	3.7	-7.1	
20	1707	8271	-3.8	3.8	-8.7	8.
25	2257	8544	-3.9	4.0	-10.2	10.
30	2833	8697	-4.1	4.1	-11.6	1
34	3326	8737	-4.1	4.1	-12.7	12

FT 120-D-2-1, M865 PIP

Legend:
°—Degrees; DEC—Decrease; DEG—Degrees; FT—Firing Table; INC—Increase; KM/HR—Kilometers per Hour; MAX ORD—Maximum Ordinate; m—Meters; mm—Millimeters; m/s—Meters per Second; PIP—Performance Improvement Package; TPCSDS-T—Target Practice, Cone Stabilized, Discarding Sabot with Tracer

Figure 8-19. Determining maximum ordinate using interpolation of the quadrant elevation, example, step 3

FIRING TABLES
TABLE B, MAXIMUM ORDINATE, RANGE AND EFFECTS ON RANGE
MAXIMUM ORDINATE INTERPOLATION FOR UNLISTED QUADRANT ELEVATION

Divide the SUBTRACTED MAX ORD by 5 (answer is WHOLE number only—drop the remainder). This will give you the MAX ORD value for 1 increment (degree) of quadrant elevation.

DETERMINE INTERPOLATION FOR RANGE

You're firing CARTRIDGE, 120MM,
TPCSDS-T, M865 PIP.
A round was fired out of impact.
The round was fired at 13 Degrees.

What is the maximum ordinate of the bullet fired?

	AMMUNITION	M865 PIP
QE	QUADRANT ELEVATION	13 Degrees
H	HIGHEST MAX ORD—15°	1,188m
L	LOWEST MAX ORD—10°	711m
	SUBTRACT LOW from HIGH	477m
÷	DIVIDE BY 5, *(ANSWER IS WHOLE NUMBER ONLY, DROP REMAINDER)*	95m

TABLE B
MAXIMUM ORDINATE, RANGE AND EFFEC

1	2	3	4	5	6	
QUADRANT ELEVATION	MAXIMUM ORDINATE	RANGE	RANGE EFFECT			
			MUZZLE VELOCITY 1 M/S		RANGE WIND 1 KM/HR	
			DEC	INC	HEAD	T
DEG	M	M	M	M	M	M
5	289	6228	-3.4	3.4	-3.2	3
10	711	7239	-3.6	3.6	-5.3	
15	1188	7855	-3.7	3.7	-7.1	
20	1707	8271	-3.8	3.8	-8.7	8.
25	2257	8544	-3.9	4.0	-10.2	10.
30	2833	8697	-4.1	4.1	-11.6	1
34	3326	8737	-4.1	4.1	-12.7	12

FT 120-D-2-1, M865 PIP

Legend:
°—Degrees; DEC—Decrease; DEG—Degrees; FT—Firing Table; INC—Increase; KM/HR—Kilometers per Hour; MAX ORD—Maximum Ordinate; m—Meters; mm—Millimeters; m/s—Meters per Second; PIP—Performance Improvement Package; TPCSDS-T—Target Practice, Cone Stabilized, Discarding Sabot with Tracer

Figure 8-20. Determining maximum ordinate using interpolation of the quadrant elevation, example, step 4

FIRING TABLES
TABLE B, MAXIMUM ORDINATE, RANGE AND EFFECTS ON RANGE
MAXIMUM ORDINATE INTERPOLATION FOR UNLISTED QUADRANT ELEVATION

Multiply the SINGLE INCREMENT VALUE (95m) by the ***right digit*** of the quadrant elevation. Because the quadrant elevation is 13 degrees, the right digit is **3**.

DETERMINE INTERPOLATION FOR RANGE

You're firing CARTRIDGE, 120MM,
TPCSDS-T, M865 PIP.
A round was fired out of impact.
The round was fired at 13 Degrees.

What is the maximum ordinate of the bullet fired?

	AMMUNITION	M865 PIP
QE	QUADRANT ELEVATION	13 Degrees
H	HIGHEST MAX ORD—15°	1,188m
L	LOWEST MAX ORD—10°	711m
	SUBTRACT LOW from HIGH	477m
	DIVIDE BY 5, *(WHOLE NUMBER ONLY, DROP REMAINDER)*	95m
✖	MULTIPLY BY QE ***RIGHT DIGIT*** (**3**)	285m

TABLE B
MAXIMUM ORDINATE, RANGE AND EFFEC

1	2	3	4	5	6	
QUADRANT ELEVATION	MAXIMUM ORDINATE	RANGE	RANGE EFFECT			
			MUZZLE VELOCITY 1 M/S		RANGE WIND 1 KM/HR	
			DEC	INC	HEAD	T
DEG	M	M	M	M	M	M
5	289	6228	-3.4	3.4	-3.2	3
10	711	7239	-3.6	3.6	-5.3	
15	1188	7855	-3.7	3.7	-7.1	
20	1707	8271	-3.8	3.8	-8.7	8.
25	2257	8544	-3.9	4.0	-10.2	10.
30	2833	8697	-4.1	4.1	-11.6	1
34	3326	8737	-4.1	4.1	-12.7	12

FT 120-D-2-1, M865 PIP

Legend:
°—Degrees; DEC—Decrease; DEG—Degrees; FT—Firing Table; INC—Increase; KM/HR—Kilometers per Hour; MAX ORD—Maximum Ordinate; m—Meters; mm—Millimeters; m/s—Meters per Second; PIP—Performance Improvement Package; TPCSDS-T—Target Practice, Cone Stabilized, Discarding Sabot with Tracer

Figure 8-21. Determining maximum ordinate using interpolation of the quadrant elevation, example, step 5

FIRING TABLES
TABLE B, MAXIMUM ORDINATE, RANGE AND EFFECTS ON RANGE
MAXIMUM ORDINATE INTERPOLATION FOR UNLISTED QUADRANT ELEVATION

Add the MULTIPLIED VALUE to the LOWEST MAX ORD (value of the 10 degrees quadrant elevation MAX ORD).

DETERMINE INTERPOLATION FOR MAX ORD

You're firing CARTRIDGE, 120MM,
TPCSDS-T, M865 PIP.
A round was fired out of impact.
The round was fired at 13 degrees.

What is the maximum ordinate of the bullet fired?

	AMMUNITION	M865 PIP
QE	QUADRANT ELEVATION	13 Degrees
H	HIGHEST MAX ORD—15°	1,188m
L	LOWEST MAX ORD—10°	711m
	SUBTRACT LOW from HIGH	477m
	DIVIDE BY 5, *(WHOLE NUMBER ONLY, DROP REMAINDER)*	95m
	MULTIPLY BY QE ***RIGHT DIGIT*** (**3**)	285m
+	ADD LOWER MAX ORD *(711m)* AND INTERPOLATION MAX ORD *(285m)*	996m

⚠ If the solution is NOT BETWEEN the LOWEST and HIGHEST MAX ORD values, an error was made.

TABLE B
MAXIMUM ORDINATE, RANGE AND EFFEC

1	2	3	4	5	6	
QUADRANT ELEVATION	MAXIMUM ORDINATE	RANGE	RANGE EFFECT			
			MUZZLE VELOCITY 1 M/S		RANGE WIND 1 KM/HR	
			DEC	INC	HEAD	T
DEG	M	M	M	M	M	M
5	289	6228	-3.4	3.4	-3.2	3
10	711	7239	-3.6	3.6	-5.3	
15	1188	7855	-3.7	3.7	-7.1	
20	1707	8271	-3.8	3.8	-8.7	8.
25	2257	8544	-3.9	4.0	-10.2	10.
30	2833	8697	-4.1	4.1	-11.6	1
34	3326	8737	-4.1	4.1	-12.7	12

FT 120-D-2-1, M865 PIP

Legend:
°—Degrees; DEC—Decrease; DEG—Degrees; FT—Firing Table; INC—Increase; KM/HR—Kilometers per Hour; MAX ORD—Maximum Ordinate; m—Meters; mm—Millimeters; m/s—Meters per Second; PIP—Performance Improvement Package; TPCSDS-T—Target Practice, Cone Stabilized, Discarding Sabot with Tracer

Figure 8-22. Determining maximum ordinate using interpolation of the quadrant elevation, example, final

INTERPOLATION FOR UNLISTED QUADRANT ELEVATION—EFFECTS OF MUZZLE VELOCITY

8-23. When determining the effects of MV for a QE between the listed 5-degree values in the firing table, interpolation helps approximate a value. Interpolation is the estimate between two known values. Although not exactly precise, the solution provides an approximation that can be used for estimating the effects of MV.

8-24. Figures 8-23 through 8-28 through page 123 provide an example of QE interpolation to estimate a change in MV. In this example, the M865 PIP round is fired at 13° QE. There are six steps to determining the effects of MV.

FIRING TABLES
TABLE B, MAXIMUM ORDINATE, RANGE AND EFFECTS ON RANGE
MUZZLE VELOCITY EFFECTS INTERPOLATION FOR UNLISTED QUADRANT ELEVATION

Determine the QUADRANT ELEVATION needed.

DETERMINE INTERPOLATION FOR RANGE		
You're firing CARTRIDGE, 120MM, TPCSDS-T, M865 PIP. A round was fired out of impact. The round was fired at 13 Degrees. What are the muzzle velocity effects for the bullet fired?		
	AMMUNITION	M865 PIP
QE	QUADRANT ELEVATION	13 Degrees

Legend:
mm—Millimeters; PIP—Performance Improvement Package; TPCSDS-T—Target Practice, Cone Stabilized, Discarding Sabot with Tracer

Figure 8-23. Determining effects of muzzle velocity using interpolation of the quadrant elevation, example, step 1

FIRING TABLES
TABLE B, MAXIMUM ORDINATE, RANGE AND EFFECTS ON RANGE
MUZZLE VELOCITY EFFECTS INTERPOLATION FOR UNLISTED QUADRANT ELEVATION

Identify the HIGHER and LOWER values listed in Table B.

DETERMINE INTERPOLATION FOR RANGE

You're firing CARTRIDGE, 120MM,
TPCSDS-T, M865 PIP.
A round was fired out of impact.
The round was fired at 13 Degrees.

What are the muzzle velocity effects for the bullet fired?

	AMMUNITION	M865 PIP
QE	QUADRANT ELEVATION	13 Degrees
H	HIGHEST EFFECT OF MUZZLE VELOCITY—15°	–3.7m
L	LOWEST EFFECT OF MUZZLE VELOCITY—10°	–3.6m

13 Degrees

TABLE B
MAXIMUM ORDINATE, RANGE AND EFFEC

1	2	3	4	5	6	
QUADRANT ELEVATION	MAXIMUM ORDINATE	RANGE	RANGE EFFECT			
			MUZZLE VELOCITY 1 M/S		RANGE WIND 1 KM/HR	
			DEC	INC	HEAD	T
DEG	M	M	M	M	M	M
5	289	6228	-3.4	3.4	-3.2	3
10	711	7239	-3.6	3.6	-5.3	
15	1188	7855	-3.7	3.7	-7.1	
20	1707	8271	-3.8	3.8	-8.7	8.
25	2257	8544	-3.9	4.0	-10.2	10.
30	2833	8697	-4.1	4.1	-11.6	1
34	3326	8737	-4.1	4.1	-12.7	12

FT 120-D-2-1, M865 PIP

Legend:
°—Degrees; DEC—Decrease; DEG—Degrees; FT—Firing Table; INC—Increase; KM/HR—Kilometers per Hour; m—Meters; mm—Millimeters; m/s—Meters per Second; PIP—Performance Improvement Package; TPCSDS-T—Target Practice, Cone Stabilized, Discarding Sabot with Tracer

Figure 8-24. Determining effects of muzzle velocity using interpolation of the quadrant elevation, example, step 2

FIRING TABLES
TABLE B, MAXIMUM ORDINATE, RANGE AND EFFECTS ON RANGE
MUZZLE VELOCITY EFFECTS INTERPOLATION FOR UNLISTED QUADRANT ELEVATION

Subtract the LOWER EFFECT OF MUZZLE VELOCITY from the HIGHER EFFECT OF MUZZLE VELOCITY.

DETERMINE INTERPOLATION FOR RANGE

You're firing CARTRIDGE, 120MM,
TPCSDS-T, M865 PIP.
A round was fired out of impact.
The round was fired at 13 Degrees.

What are the muzzle velocity effects for the bullet fired?

	AMMUNITION	M865 PIP
QE	QUADRANT ELEVATION	13 Degrees
H	HIGHEST EFFECT OF MUZZLE VELOCITY—15°	–3.7m
L	LOWEST EFFECT OF MUZZLE VELOCITY—10°	–3.6m
	SUBTRACT LOW from HIGH	–0.1m

TABLE B
MAXIMUM ORDINATE, RANGE AND EFFEC

1	2	3	4	5	6	
QUADRANT ELEVATION	MAXIMUM ORDINATE	RANGE	RANGE EFFECT			
			MUZZLE VELOCITY 1 M/S		RANGE WIND 1 KM/HR	
			DEC	INC	HEAD	T
DEG	M	M	M	M	M	M
5	289	6228	-3.4	3.4	-3.2	3
10	711	7239	-3.6	3.6	-5.3	
15	1188	7855	-3.7	3.7	-7.1	
20	1707	8271	-3.8	3.8	-8.7	8.
25	2257	8544	-3.9	4.0	-10.2	10.
30	2833	8697	-4.1	4.1	-11.6	1
34	3326	8737	-4.1	4.1	-12.7	12

FT 120-D-2-1, M865 PIP

Legend:
°—Degrees; DEC—Decrease; DEG—Degrees; FT—Firing Table; INC—Increase; KM/HR—Kilometers per Hour; m—Meters; mm—Millimeters; m/s—Meters per Second; PIP—Performance Improvement Package; TPCSDS-T—Target Practice, Cone Stabilized, Discarding Sabot with Tracer

Figure 8-25. Determining effects of muzzle velocity using interpolation of the quadrant elevation, example, step 3

FIRING TABLES
TABLE B, MAXIMUM ORDINATE, RANGE AND EFFECTS ON RANGE
MUZZLE VELOCITY EFFECTS INTERPOLATION FOR UNLISTED QUADRANT ELEVATION

Divide the SUBTRACTED EFFECT OF MUZZLE VELOCITY by 5. This will give you the EFFECT OF MUZZLE VELOCITY value for 1 increment (degree) of quadrant elevation.

DETERMINE INTERPOLATION FOR RANGE

You're firing CARTRIDGE, 120MM, TPCSDS-T, M865 PIP.
A round was fired out of impact.
The round was fired at 13 Degrees.

What are the muzzle velocity effects for the bullet fired?

	AMMUNITION	M865 PIP
QE	QUADRANT ELEVATION	13 Degrees
H	HIGHEST EFFECT OF MUZZLE VELOCITY—15°	–3.7m
L	LOWEST EFFECT OF MUZZLE VELOCITY—10°	–3.6m
	SUBTRACT LOW from HIGH	–0.1m
÷	DIVIDE BY 5	–0.02m

TABLE B
MAXIMUM ORDINATE, RANGE AND EFFEC

1	2	3	4	5	6	
QUADRANT ELEVATION	MAXIMUM ORDINATE	RANGE	RANGE EFFECT			
			MUZZLE VELOCITY 1 M/S		RANGE WIND 1 KM/HR	
			DEC	INC	HEAD	T
DEG	M	M	M	M	M	M
5	289	6228	-3.4	3.4	-3.2	3
10	711	7239	-3.6	3.6	-5.3	
15	1188	7855	-3.7	3.7	-7.1	
20	1707	8271	-3.8	3.8	-8.7	8.
25	2257	8544	-3.9	4.0	-10.2	10.
30	2833	8697	-4.1	4.1	-11.6	1
34	3326	8737	-4.1	4.1	-12.7	12

FT 120-D-2-1, M865 PIP

Legend:
°—Degrees; DEC—Decrease; DEG—Degrees; FT—Firing Table; INC—Increase; KM/HR—Kilometers per Hour; m—Meters; mm—Millimeters; m/s—Meters per Second; PIP—Performance Improvement Package; TPCSDS-T—Target Practice, Cone Stabilized, Discarding Sabot with Tracer

Figure 8-26. Determining effects of muzzle velocity using interpolation of the quadrant elevation, example, step 4

FIRING TABLES
TABLE B, MAXIMUM ORDINATE, RANGE AND EFFECTS ON RANGE
MUZZLE VELOCITY EFFECTS INTERPOLATION FOR UNLISTED QUADRANT ELEVATION

Multiply the SINGLE INCREMENT VALUE (-0.02m) by the ***right digit*** of the quadrant elevation. Because the quadrant elevation is 13 degrees, the right digit is **3**.

DETERMINE INTERPOLATION FOR RANGE

You're firing CARTRIDGE, 120MM, TPCSDS-T, M865 PIP.
A round was fired out of impact.
The round was fired at 13 Degrees.

What are the muzzle velocity effects for the bullet fired?

	AMMUNITION	M865 PIP
QE	QUADRANT ELEVATION	13 Degrees
H	HIGHEST EFFECT OF MUZZLE VELOCITY—15°	–3.7m
L	LOWEST EFFECT OF MUZZLE VELOCITY—10°	–3.6m
	SUBTRACT LOW from HIGH	–0.1m
	DIVIDE BY 5	–0.02m
✖	MULTIPLY BY QE ***RIGHT DIGIT*** (**3**)	–0.06m

TABLE B
MAXIMUM ORDINATE, RANGE AND EFFEC

1	2	3	4	5	6	
QUADRANT ELEVATION	MAXIMUM ORDINATE	RANGE	RANGE EFFECT			
			MUZZLE VELOCITY 1 M/S		RANGE WIND 1 KM/HR	
			DEC	INC	HEAD	T
DEG	M	M	M	M	M	M
5	289	6228	-3.4	3.4	-3.2	3
10	711	7239	-3.6	3.6	-5.3	
15	1188	7855	-3.7	3.7	-7.1	
20	1707	8271	-3.8	3.8	-8.7	8.
25	2257	8544	-3.9	4.0	-10.2	10.
30	2833	8697	-4.1	4.1	-11.6	1
34	3326	8737	-4.1	4.1	-12.7	12

FT 120-D-2-1, M865 PIP

Legend:
°—Degrees; DEC—Decrease; DEG—Degrees; FT—Firing Table; INC—Increase; KM/HR—Kilometers per Hour; m—Meters; mm—Millimeters; m/s—Meters per Second; PIP—Performance Improvement Package; TPCSDS-T—Target Practice, Cone Stabilized, Discarding Sabot with Tracer

Figure 8-27. Determining effects of muzzle velocity using interpolation of the quadrant elevation, example, step 5

FIRING TABLES
TABLE B, MAXIMUM ORDINATE, RANGE AND EFFECTS ON RANGE
MUZZLE VELOCITY EFFECTS INTERPOLATION FOR UNLISTED QUADRANT ELEVATION

Add the MULTIPLIED VALUE to the LOWEST EFFECT OF MUZZLE VELOCITY (value of the 10 degrees quadrant elevation effect on muzzle velocity).

DETERMINE INTERPOLATION FOR MUZZLE VELOCITY EFFECTS

You're firing CARTRIDGE, 120MM,
TPCSDS-T, M865 PIP.
A round was fired out of impact.
The round was fired at 13 Degrees.

What are the muzzle velocity effects for the bullet fired?

	AMMUNITION	M865 PIP
QE	QUADRANT ELEVATION	13 Degrees
H	HIGHEST EFFECT OF MUZZLE VELOCITY—15°	–3.7m
L	LOWEST EFFECT OF MUZZLE VELOCITY—10°	–3.6m
	SUBTRACT LOW from HIGH	–0.1m
	DIVIDE BY 5	–0.02m
	MULTIPLY BY QE ***RIGHT DIGIT*** (3)	–0.06m
+	ADD LOWER MUZZLE VELOCITY EFFECT *(-3.6m)* AND INTERPOLATION MUZZLE VELOCITY EFFECT *(-0.06m)*	–3.66m

⚠ If the solution is NOT BETWEEN the LOWEST and HIGHEST muzzle velocity effect values, an error was made.

TABLE B
MAXIMUM ORDINATE, RANGE AND EFFEC

1	2	3	4	5	6	
QUADRANT ELEVATION	MAXIMUM ORDINATE	RANGE	RANGE EFFECT			
			MUZZLE VELOCITY 1 M/S		RANGE WIND 1 KM/HR	
			DEC	INC	HEAD	T
DEG	M	M	M	M	M	M
5	289	6228	-3.4	3.4	-3.2	3
10	711	7239	-3.6	3.6	-5.3	
15	1188	7855	-3.7	3.7	-7.1	
20	1707	8271	-3.8	3.8	-8.7	8.
25	2257	8544	-3.9	4.0	-10.2	10.
30	2833	8697	-4.1	4.1	-11.6	1
34	3326	8737	-4.1	4.1	-12.7	12

FT 120-D-2-1, M865 PIP

Legend:
°—Degrees; DEC—Decrease; DEG—Degrees; FT—Firing Table; INC—Increase; KM/HR—Kilometers per Hour; m—Meters; mm—Millimeters; m/s—Meters per Second; PIP—Performance Improvement Package; TPCSDS-T—Target Practice, Cone Stabilized, Discarding Sabot with Tracer

Figure 8-28. Determining effects of muzzle velocity using interpolation of the quadrant elevation, example, final

INTERPOLATION FOR UNLISTED QUADRANT ELEVATION—RANGE WIND EFFECTS

8-25. When determining the effects of range wind for a QE between the listed 5-degree values in the firing table, interpolation helps approximate a value. Although not exactly precise, the solution provides an approximation that can be used for estimating how the effects of range wind impact the range travel of the projectile.

8-26. Figures 8-29 through 8-34 through page 129 provide an example of QE interpolation to estimate range wind effects on range. In this example, the M865 PIP round is fired at 13° QE. There are six steps to determining the effects of range wind.

FIRING TABLES
TABLE B, MAXIMUM ORDINATE, RANGE AND EFFECTS ON RANGE
RANGE WIND EFFECTS INTERPOLATION FOR UNLISTED QUADRANT ELEVATION

Determine the QUADRANT ELEVATION needed.

DETERMINE INTERPOLATION FOR RANGE

You're firing CARTRIDGE, 120MM,
TPCSDS-T, M865 PIP.
A round was fired out of impact.
The round was fired at 13 Degrees.

What are the range wind effects for the bullet fired?

	AMMUNITION	M865 PIP
QE	QUADRANT ELEVATION	13 Degrees

Legend:
mm—Millimeters; PIP—Performance Improvement Package; TPCSDS-T—Target Practice, Cone Stabilized, Discarding Sabot with Tracer

Figure 8-29. Determining effects of range wind using interpolation of the quadrant elevation, example, step 1

FIRING TABLES
TABLE B, MAXIMUM ORDINATE, RANGE AND EFFECTS ON RANGE
RANGE WIND EFFECTS INTERPOLATION FOR UNLISTED QUADRANT ELEVATION

Identify the HIGHER and LOWER values listed in Table B.

DETERMINE INTERPOLATION FOR RANGE WIND EFFECTS

You're firing CARTRIDGE, 120MM, TPCSDS-T, M865 PIP.
A round was fired out of impact.
The round was fired at 13 Degrees.

What are the range wind effects for the bullet fired?

	AMMUNITION	M865 PIP
QE	QUADRANT ELEVATION	13 Degrees
H	HIGHEST EFFECT OF RANGE WIND—15°	–7.1m
L	LOWEST EFFECT OF RANGE WIND—10°	–5.3m

13 Degrees

TABLE B
MAXIMUM ORDINATE, RANGE AND EFFECTS ON RAN

1	2	3	4	5	6	7	
QUADRANT ELEVATION	MAXIMUM ORDINATE	RANGE	RANGE EFFECTS FOR				
			MUZZLE VELOCITY 1 M/S		RANGE WIND 1 KM/HR		
			DEC	INC	HEAD	TAIL	DE
DEG	M	M	M	M	M	M	
5	289	6228	-3.4	3.4	-3.2	3.2	54
10	711	7239	-3.6	3.6	-5.3	5.4	6
15	1188	7855	-3.7	3.7	-7.1	7.1	74
20	1707	8271	-3.8	3.8	-8.7	8.7	8
25	2257	8544	-3.9	4.0	-10.2	10.2	87.
30	2833	8697	-4.1	4.1	-11.6	11.6	9
34	3326	8737	-4.1	4.1	-12.7	12.8	

FT 120-D-2-1, M865 PIP

Legend:
°—Degrees; DEC—Decrease; DEG—Degrees; FT—Firing Table; INC—Increase; KM/HR—Kilometers per Hour; m—Meters; mm—Millimeters; m/s—Meters per Second; PIP—Performance Improvement Package; TPCSDS-T—Target Practice, Cone Stabilized, Discarding Sabot with Tracer

Figure 8-30. Determining effects of range wind using interpolation of the quadrant elevation, example, step 2

FIRING TABLES
TABLE B, MAXIMUM ORDINATE, RANGE AND EFFECTS ON RANGE
RANGE WIND EFFECTS INTERPOLATION FOR UNLISTED QUADRANT ELEVATION

Subtract the LOWER EFFECT OF RANGE WIND from the HIGHER EFFECT OF RANGE WIND.

DETERMINE INTERPOLATION FOR RANGE WIND EFFECTS		
You're firing CARTRIDGE, 120MM, TPCSDS-T, M865 PIP. A round was fired out of impact. The round was fired at 13 Degrees. What are the range wind effects for the bullet fired?		
	AMMUNITION	M865 PIP
QE	QUADRANT ELEVATION	13 Degrees
H	HIGHEST EFFECT OF RANGE WIND—15°	–7.1m
L	LOWEST EFFECT OF RANGE WIND—10°	–5.3m
	SUBTRACT LOW from HIGH	–1.8m

TABLE B
MAXIMUM ORDINATE, RANGE AND EFFECTS ON RAN

1	2	3	4	5	6	7	
QUADRANT ELEVATION	MAXIMUM ORDINATE	RANGE	RANGE EFFECTS FOR				
			MUZZLE VELOCITY 1 M/S		RANGE WIND 1 KM/HR		
			DEC	INC	HEAD	TAIL	DE
DEG	M	M	M	M	M	M	
5	289	6228	-3.4	3.4	-3.2	3.2	54
10	711	7239	-3.6	3.6	-5.3	5.4	6
15	1188	7855	-3.7	3.7	-7.1	7.1	74
20	1707	8271	-3.8	3.8	-8.7	8.7	8
25	2257	8544	-3.9	4.0	-10.2	10.2	87.
30	2833	8697	-4.1	4.1	-11.6	11.6	9
34	3326	8737	-4.1	4.1	-12.7	12.8	

FT 120-D-2-1, M865 PIP

Legend:
°—Degrees; DEC—Decrease; DEG—Degrees; FT—Firing Table; INC—Increase; KM/HR—Kilometers per Hour; m—Meters; mm—Millimeters; m/s—Meters per Second; PIP—Performance Improvement Package; TPCSDS-T—Target Practice, Cone Stabilized, Discarding Sabot with Tracer

Figure 8-31. Determining effects of range wind using interpolation of the quadrant elevation, example, step 3

FIRING TABLES
TABLE B, MAXIMUM ORDINATE, RANGE AND EFFECTS ON RANGE
RANGE WIND EFFECTS INTERPOLATION FOR UNLISTED QUADRANT ELEVATION

Divide the SUBTRACTED EFFECT OF RANGE WIND by 5. This will give you the EFFECT OF RANGE WIND value for 1 increment (degree) of quadrant elevation.

DETERMINE INTERPOLATION FOR RANGE WIND EFFECTS

You're firing CARTRIDGE, 120MM, TPCSDS-T, M865 PIP.
A round was fired out of impact.
The round was fired at 13 Degrees.

What are the range wind effects for the bullet fired?

	AMMUNITION	M865 PIP
QE	QUADRANT ELEVATION	13 Degrees
H	HIGHEST EFFECT OF RANGE WIND—15°	–7.1m
L	LOWEST EFFECT OF RANGE WIND—10°	–5.3m
	SUBTRACT LOW from HIGH	–1.8m
÷	DIVIDE BY 5	–0.36m

TABLE B
MAXIMUM ORDINATE, RANGE AND EFFECTS ON RAN

1	2	3	4	5	6	7	
QUADRANT ELEVATION	MAXIMUM ORDINATE	RANGE	RANGE EFFECTS FOR				
			MUZZLE VELOCITY 1 M/S		RANGE WIND 1 KM/HR		
			DEC	INC	HEAD	TAIL	DE
DEG	M	M	M	M	M	M	
5	289	6228	-3.4	3.4	-3.2	3.2	54
10	711	7239	-3.6	3.6	-5.3	5.4	6
15	1188	7855	-3.7	3.7	-7.1	7.1	74
20	1707	8271	-3.8	3.8	-8.7	8.7	8
25	2257	8544	-3.9	4.0	-10.2	10.2	87.
30	2833	8697	-4.1	4.1	-11.6	11.6	9
34	3326	8737	-4.1	4.1	-12.7	12.8	

FT 120-D-2-1, M865 PIP

Legend:
°—Degrees; DEC—Decrease; DEG—Degrees; FT—Firing Table; INC—Increase; KM/HR—Kilometers per Hour; m—Meters; mm—Millimeters; m/s—Meters per Second; PIP—Performance Improvement Package; TPCSDS-T—Target Practice, Cone Stabilized, Discarding Sabot with Tracer

Figure 8-32. Determining effects of range wind using interpolation of the quadrant elevation, example, step 4

FIRING TABLES
TABLE B, MAXIMUM ORDINATE, RANGE AND EFFECTS ON RANGE
RANGE WIND EFFECTS INTERPOLATION FOR UNLISTED QUADRANT ELEVATION

Multiply the SINGLE INCREMENT VALUE (-0.36m) by the ***right digit*** of the quadrant elevation. Because the quadrant elevation is 13 degrees, the right digit is **3**.

DETERMINE INTERPOLATION FOR RANGE WIND EFFECTS

You're firing CARTRIDGE, 120MM, TPCSDS-T, M865 PIP.
A round was fired out of impact.
The round was fired at 13 Degrees.

What are the range wind effects for the bullet fired?

	AMMUNITION	M865 PIP
QE	QUADRANT ELEVATION	13 Degrees
H	HIGHEST EFFECT OF RANGE WIND—15°	–7.1m
L	LOWEST EFFECT OF RANGE WIND—10°	–5.3m
	SUBTRACT LOW from HIGH	–1.8m
	DIVIDE BY 5	–0.36m
×	MULTIPLY BY QE ***RIGHT DIGIT*** (3)	–1.08m

TABLE B
MAXIMUM ORDINATE, RANGE AND EFFECTS ON RAN

1	2	3	4	5	6	7	
QUADRANT ELEVATION	MAXIMUM ORDINATE	RANGE	RANGE EFFECTS FOR				
			MUZZLE VELOCITY 1 M/S		RANGE WIND 1 KM/HR		
			DEC	INC	HEAD	TAIL	DE
DEG	M	M	M	M	M	M	
5	289	6228	-3.4	3.4	-3.2	3.2	54
10	711	7239	-3.6	3.6	-5.3	5.4	6
15	1188	7855	-3.7	3.7	-7.1	7.1	74
20	1707	8271	-3.8	3.8	-8.7	8.7	8
25	2257	8544	-3.9	4.0	-10.2	10.2	87.
30	2833	8697	-4.1	4.1	-11.6	11.6	9
34	3326	8737	-4.1	4.1	-12.7	12.8	

FT 120-D-2-1, M865 PIP

Legend:
°—Degrees; DEC—Decrease; DEG—Degrees; FT—Firing Table; INC—Increase; KM/HR—Kilometers per Hour; m—Meters; mm—Millimeters; m/s—Meters per Second; PIP—Performance Improvement Package; TPCSDS-T—Target Practice, Cone Stabilized, Discarding Sabot with Tracer

Figure 8-33. Determining effects of range wind using interpolation of the quadrant elevation, example, step 5

FIRING TABLES
TABLE B, MAXIMUM ORDINATE, RANGE AND EFFECTS ON RANGE
RANGE WIND EFFECTS INTERPOLATION FOR UNLISTED QUADRANT ELEVATION

Add the MULTIPLIED VALUE to the LOWEST EFFECT OF RANGE WIND (value of the 10 degrees quadrant elevation range wind effect).

DETERMINE INTERPOLATION FOR RANGE WIND EFFECTS

You're firing CARTRIDGE, 120MM, TPCSDS-T, M865 PIP.
A round was fired out of impact.
The round was fired at 13 Degrees.

What are the range wind effects for the bullet fired?

	AMMUNITION	M865 PIP
QE	QUADRANT ELEVATION	13 Degrees
H	HIGHEST EFFECT OF RANGE WIND—15°	–7.1m
L	LOWEST EFFECT OF RANGE WIND—10°	–5.3m
	SUBTRACT LOW from HIGH	–1.8m
	DIVIDE BY 5	–0.36m
	MULTIPLY BY QE ***RIGHT DIGIT*** (3)	–1.08m
+	ADD LOWER RANGE WIND EFFECT (*-5.3m*) AND INTERPOLATION RANGE WIND EFFECT (*-1.08m*)	–6.38m

⚠ If the solution is NOT BETWEEN the LOWEST and HIGHEST range wind effect values, an error was made.

TABLE B
MAXIMUM ORDINATE, RANGE AND EFFECTS ON RAN

1	2	3	4	5	6	7	
QUADRANT ELEVATION	MAXIMUM ORDINATE	RANGE	RANGE EFFECTS FOR				
			MUZZLE VELOCITY 1 M/S		RANGE WIND 1 KM/HR		
			DEC	INC	HEAD	TAIL	DE
DEG	M	M	M	M	M	M	
5	289	6228	-3.4	3.4	-3.2	3.2	54
10	711	7239	-3.6	3.6	-5.3	5.4	6
15	1188	7855	-3.7	3.7	-7.1	7.1	7
20	1707	8271	-3.8	3.8	-8.7	8.7	8
25	2257	8544	-3.9	4.0	-10.2	10.2	87.
30	2833	8697	-4.1	4.1	-11.6	11.6	9
34	3326	8737	-4.1	4.1	-12.7	12.8	

FT 120-D-2-1, M865 PIP

Legend:
°—Degrees; DEC—Decrease; DEG—Degrees; FT—Firing Table; INC—Increase; KM/HR—Kilometers per Hour; m—Meters; mm—Millimeters; m/s—Meters per Second; PIP—Performance Improvement Package; TPCSDS-T—Target Practice, Cone Stabilized, Discarding Sabot with Tracer

Figure 8-34. Determining effects of range wind using interpolation of the quadrant elevation, example final

INTERPOLATION FOR UNLISTED QUADRANT ELEVATION—AIR DENSITY EFFECTS

8-27. When determining the effects of air density for a QE between the listed 5-degree values in the firing table, interpolation helps approximate a value. Although not exactly precise, the solution provides an approximation that can be used for estimating how the effects of air density on range impact the range travel of the projectile.

8-28. Figures 8-35 through 8-40 through page 135 provide an example of QE interpolation to estimate air density effects on range. In this example, the M865 PIP round is fired at 13° QE. There are six steps to determine the effects of air density.

FIRING TABLES
TABLE B, MAXIMUM ORDINATE, RANGE AND EFFECTS ON RANGE
AIR DENSITY EFFECTS INTERPOLATION FOR UNLISTED QUADRANT ELEVATION

Determine the QUADRANT ELEVATION needed.

DETERMINE INTERPOLATION FOR RANGE		
You're firing CARTRIDGE, 120MM, TPCSDS-T, M865 PIP. A round was fired out of impact. The round was fired at 13 Degrees. What are the air density effects for the bullet fired?		
	AMMUNITION	M865 PIP
QE	QUADRANT ELEVATION	13 Degrees

***Legend**:*
mm—Millimeters; PIP—Performance Improvement Package; TPCSDS-T—Target Practice, Cone Stabilized, Discarding Sabot with Tracer

Figure 8-35. Determining effects of air density using interpolation of the quadrant elevation, example, step 1

FIRING TABLES
TABLE B, MAXIMUM ORDINATE, RANGE AND EFFECTS ON RANGE
AIR DENSITY EFFECTS INTERPOLATION FOR UNLISTED QUADRANT ELEVATION

Identify the HIGHER and LOWER values listed in Table B.

DETERMINE INTERPOLATION FOR AIR DENSITY EFFECTS

You're firing CARTRIDGE, 120MM, TPCSDS-T, M865 PIP.
A round was fired out of impact.
The round was fired at 13 Degrees.

What are the air density effects for the bullet fired?

	AMMUNITION	M865 PIP
QE	QUADRANT ELEVATION	13 Degrees
H	HIGHEST EFFECT OF AIR DENSITY—15°	74.4m
L	LOWEST EFFECT OF AIR DENSITY—10°	66.1m

TABLE B
MAXIMUM ORDINATE, RANGE AND EFFECTS ON RANGE

1	2	3	4	5	6	7	8	9
QUADRANT ELEVATION	MAXIMUM ORDINATE	RANGE	RANGE EFFECTS FOR					
			MUZZLE VELOCITY 1 M/S		RANGE WIND 1 KM/HR		AIR DENSITY 1 PCT	
			DEC	INC	HEAD	TAIL	DEC	INC
DEG	M	M	M	M	M	M	M	M
5	289	6228	-3.4	3.4	-3.2	3.2	54.4	-45.5
10	711	7239	-3.6	3.6	-5.3	5.4	66.1	-55.1
15	1188	7855	-3.7	3.7	-7.1	7.1	74.4	-61.7
20	1707	8271	-3.8	3.8	-8.7	8.7	81.3	-67.1
25	2257	8544	-3.9	4.0	-10.2	10.2	87.2	-71.5
30	2833	8697	-4.1	4.1	-11.6	11.6	92.1	-75.1
34	3326	8737	-4.1	4.1	-12.7	12.8	95.6	-77.5

FT 120-D-2-1, M865 PIP

Legend:
°—Degrees; DEC—Decrease; DEG—Degrees; FT—Firing Table; INC—Increase; KM/HR—Kilometers per Hour; m—Meters; mm—Millimeters; m/s—Meters per Second; PIP—Performance Improvement Package; TPCSDS-T—Target Practice, Cone Stabilized, Discarding Sabot with Tracer

Figure 8-36. Determining effects of air density using interpolation of the quadrant elevation, example, step 2

FIRING TABLES
TABLE B, MAXIMUM ORDINATE, RANGE AND EFFECTS ON RANGE
AIR DENSITY EFFECTS INTERPOLATION FOR UNLISTED QUADRANT ELEVATION

Subtract the LOWER EFFECT OF AIR DENSITY from the HIGHER EFFECT OF AIR DENSITY.

DETERMINE INTERPOLATION FOR AIR DENSITY EFFECTS

You're firing CARTRIDGE, 120MM, TPCSDS-T, M865 PIP.
A round was fired out of impact.
The round was fired at 13 Degrees.

What are the air density effects for the bullet fired?

	AMMUNITION	M865 PIP
QE	QUADRANT ELEVATION	13 Degrees
H	HIGHEST EFFECT OF AIR DENSITY—15°	74.4m
L	LOWEST EFFECT OF AIR DENSITY—10°	- 66.1m
	SUBTRACT LOW from HIGH	8.3m

TABLE B
MAXIMUM ORDINATE, RANGE AND EFFECTS ON RANGE

1	2	3	4	5	6	7	8	9
QUADRANT ELEVATION	MAXIMUM ORDINATE	RANGE	RANGE EFFECTS FOR					
			MUZZLE VELOCITY 1 M/S		RANGE WIND 1 KM/HR		AIR DENSITY 1 PCT	
			DEC	INC	HEAD	TAIL	DEC	INC
DEG	M	M	M	M	M	M	M	M
5	289	6228	-3.4	3.4	-3.2	3.2	54.4	-45.5
10	711	7239	-3.6	3.6	-5.3	5.4	66.1	-55.1
15	1188	7855	-3.7	3.7	-7.1	7.1	74.4	-61.7
20	1707	8271	-3.8	3.8	-8.7	8.7	81.3	-67.1
25	2257	8544	-3.9	4.0	-10.2	10.2	87.2	-71.5
30	2833	8697	-4.1	4.1	-11.6	11.6	92.1	-75.1
34	3326	8737	-4.1	4.1	-12.7	12.8	95.6	-77.5

FT 120-D-2-1, M865 PIP

Legend:
°—Degrees; DEC—Decrease; DEG—Degrees; FT—Firing Table; INC—Increase; KM/HR—Kilometers per Hour; m—Meters; mm—Millimeters; m/s—Meters per Second; PIP—Performance Improvement Package; TPCSDS-T—Target Practice, Cone Stabilized, Discarding Sabot with Tracer

Figure 8-37. Determining effects of air density using interpolation of the quadrant elevation, example, step 3

FIRING TABLES
TABLE B, MAXIMUM ORDINATE, RANGE AND EFFECTS ON RANGE
AIR DENSITY EFFECTS INTERPOLATION FOR UNLISTED QUADRANT ELEVATION

Divide the SUBTRACTED EFFECT OF AIR DENSITY by 5. This will give you the EFFECT OF AIR DENSITY value for 1 increment (degree) of quadrant elevation.

DETERMINE INTERPOLATION FOR AIR DENSITY EFFECTS

You're firing CARTRIDGE, 120MM, TPCSDS-T, M865 PIP.
A round was fired out of impact.
The round was fired at 13 Degrees.

What are the air density effects for the bullet fired?

	AMMUNITION	M865 PIP
QE	QUADRANT ELEVATION	13 Degrees
H	HIGHEST EFFECT OF AIR DENSITY—15°	74.4m
L	LOWEST EFFECT OF AIR DENSITY—10°	66.1m
	SUBTRACT LOW from HIGH	8.3m
÷	DIVIDE BY 5	1.66m

TABLE B
MAXIMUM ORDINATE, RANGE AND EFFECTS ON RANGE

1	2	3	4	5	6	7	8	9
QUADRANT ELEVATION	MAXIMUM ORDINATE	RANGE	RANGE EFFECTS FOR					
			MUZZLE VELOCITY 1 M/S		RANGE WIND 1 KM/HR		AIR DENSITY 1 PCT	
			DEC	INC	HEAD	TAIL	DEC	INC
DEG	M	M	M	M	M	M	M	M
5	289	6228	-3.4	3.4	-3.2	3.2	54.4	-45.5
10	711	7239	-3.6	3.6	-5.3	5.4	66.1	-55.1
15	1188	7855	-3.7	3.7	-7.1	7.1	74.4	-61.7
20	1707	8271	-3.8	3.8	-8.7	8.7	81.3	-67.1
25	2257	8544	-3.9	4.0	-10.2	10.2	87.2	-71.5
30	2833	8697	-4.1	4.1	-11.6	11.6	92.1	-75.1
34	3326	8737	-4.1	4.1	-12.7	12.8	95.6	-77.5

FT 120-D-2-1, M865 PIP

Legend:
°—Degrees; DEC—Decrease; DEG—Degrees; FT—Firing Table; INC—Increase; KM/HR—Kilometers per Hour; m—Meters; mm—Millimeters; m/s—Meters per Second; PIP—Performance Improvement Package; TPCSDS-T—Target Practice, Cone Stabilized, Discarding Sabot with Tracer

Figure 8-38. Determining effects of air density using interpolation of the quadrant elevation, example, step 4

FIRING TABLES
TABLE B, MAXIMUM ORDINATE, RANGE AND EFFECTS ON RANGE
AIR DENSITY EFFECTS INTERPOLATION FOR UNLISTED QUADRANT ELEVATION

Multiply the SINGLE INCREMENT VALUE (1.66m) by the ***right digit*** of the quadrant elevation. Because the quadrant elevation is 13 degrees, the right digit is **3**.

DETERMINE INTERPOLATION FOR AIR DENSITY EFFECTS

You're firing CARTRIDGE, 120MM, TPCSDS-T, M865 PIP.
A round was fired out of impact.
The round was fired at 13 Degrees.

What are the air density effects for the bullet fired?

	AMMUNITION	M865 PIP
QE	QUADRANT ELEVATION	13 Degrees
H	HIGHEST EFFECT OF AIR DENSITY—15°	74.4m
L	LOWEST EFFECT OF AIR DENSITY—10°	66.1m
	SUBTRACT LOW from HIGH	8.3m
	DIVIDE BY 5	1.66m
✖	MULTIPLY BY QE ***RIGHT DIGIT*** (**3**)	4.98m

TABLE B
MAXIMUM ORDINATE, RANGE AND EFFECTS ON RANGE

1	2	3	4	5	6	7	8	9
QUADRANT ELEVATION	MAXIMUM ORDINATE	RANGE	RANGE EFFECTS FOR					
			MUZZLE VELOCITY 1 M/S		RANGE WIND 1 KM/HR		AIR DENSITY 1 PCT	
			DEC	INC	HEAD	TAIL	DEC	INC
DEG	M	M	M	M	M	M	M	M
5	289	6228	-3.4	3.4	-3.2	3.2	54.4	-45.5
10	711	7239	-3.6	3.6	-5.3	5.4	66.1	-55.1
15	1188	7855	-3.7	3.7	-7.1	7.1	74.4	-61.7
20	1707	8271	-3.8	3.8	-8.7	8.7	81.3	-67.1
25	2257	8544	-3.9	4.0	-10.2	10.2	87.2	-71.5
30	2833	8697	-4.1	4.1	-11.6	11.6	92.1	-75.1
34	3326	8737	-4.1	4.1	-12.7	12.8	95.6	-77.5

FT 120-D-2-1, M865 PIP

Legend:
°—Degrees; DEC—Decrease; DEG—Degrees; FT—Firing Table; INC—Increase; KM/HR—Kilometers per Hour; m—Meters; mm—Millimeters; m/s—Meters per Second; PIP—Performance Improvement Package; TPCSDS-T—Target Practice, Cone Stabilized, Discarding Sabot with Tracer

Figure 8-39. Determining effects of air density using interpolation of the quadrant elevation, example step 5

FIRING TABLES
TABLE B, MAXIMUM ORDINATE, RANGE AND EFFECTS ON RANGE
AIR DENSITY EFFECTS INTERPOLATION FOR UNLISTED QUADRANT ELEVATION

Add the MULTIPLIED VALUE to the LOWEST EFFECT OF AIR DENSITY (value of the 10 degrees quadrant elevation air density effect).

DETERMINE INTERPOLATION FOR AIR DENSITY EFFECTS

You're firing CARTRIDGE, 120MM, TPCSDS-T, M865 PIP.
A round was fired out of impact.
The round was fired at 13 Degrees.

What are the air density effects for the bullet fired?

	AMMUNITION	M865 PIP
QE	QUADRANT ELEVATION	13 Degrees
H	HIGHEST EFFECT OF AIR DENSITY—15°	74.4m
L	LOWEST EFFECT OF AIR DENSITY—10°	66.1m
	SUBTRACT LOW from HIGH	8.3m
	DIVIDE BY 5	1.66m
	MULTIPLY BY QE ***RIGHT DIGIT*** (3)	4.98m
+	ADD LOWER AIR DENSITY EFFECT (*66.1m*) AND INTERPOLATION AIR DENSITY EFFECT (*4.98m*)	71.08m
⚠	If the solution is NOT BETWEEN the LOWEST and HIGHEST air density effect values, an error was made.	

TABLE B
MAXIMUM ORDINATE, RANGE AND EFFECTS ON RANGE

1	2	3	4	5	6	7	8	9
QUADRANT ELEVATION	MAXIMUM ORDINATE	RANGE	RANGE EFFECTS FOR					
			MUZZLE VELOCITY 1 M/S		RANGE WIND 1 KM/HR		AIR DENSITY 1 PCT	
			DEC	INC	HEAD	TAIL	DEC	INC
DEG	M	M	M	M	M	M	M	M
5	289	6228	-3.4	3.4	-3.2	3.2	54.4	-45.5
10	711	7239	-3.6	3.6	-5.3	5.4	66.1	-55.1
15	1188	7855	-3.7	3.7	-7.1	7.1	74.4	-61.7
20	1707	8271	-3.8	3.8	-8.7	8.7	81.3	-67.1
25	2257	8544	-3.9	4.0	-10.2	10.2	87.2	-71.5
30	2833	8697	-4.1	4.1	-11.6	11.6	92.1	-75.1
34	3326	8737	-4.1	4.1	-12.7	12.8	95.6	-77.5

FT 120-D-2-1, M865 PIP

Legend:
°—Degrees; DEC—Decrease; DEG—Degrees; FT—Firing Table; INC—Increase; KM/HR—Kilometers per Hour; m—Meters; mm—Millimeters; m/s—Meters per Second; PIP—Performance Improvement Package; TPCSDS-T—Target Practice, Cone Stabilized, Discarding Sabot with Tracer

Figure 8-40. Determining effects of air density using interpolation of the quadrant elevation, example, final

QUADRANT ELEVATION, MAXIMUM ORDINATE, AND RANGE USE CASE

8-29. There are several firing occasions where the use of Table B's first three columns is necessary. Some use cases include the following:

- Determining distance variable X for an SDZ (An SDZ is typically measured based on range at 10° QE for the ammunition type).
- Determining the general location of an ROI.
- Employing indirect fire applications using the main gun.
- Designing and constructing ranges.

8-30. Examples are provided for determining distance X and maximum range based on QE. These examples use Table B.

Round Out of Impact—Sabot Fired with Coax Indexed

8-31. A tank fires an ROI causing a cease-fire freeze. When the crew is asked what was fired and how, they say they fired sabot with the master blaster after a misfire. The master gunner must analyze what led to the misfire and why the projectile left the SDZ.

8-32. Upon analysis, it is discovered that the prior engagement consisted of a tank and troop presentation. The crew successfully engaged the tank target with sabot indexed and proceeded to index coax to service the troops. The most common cause of ROI, having high-explosive antitank (HEAT) indexed when firing sabot, is ruled out as there were no HEAT engagements immediately prior to firing the ROI. All HEAT rounds allocated to the run were still in the ready ammunition compartment.

8-33. Ruling out HEAT index, the master gunner evaluates the actions taken immediately prior to the ROI. Having serviced troops last, the coaxial-ready ammunition box is inspected. No rounds remain after the prior engagement. When the crew is confronted, the gunner does not remember running out of coax ammunition. At this point, the master gunner identifies that coax is still selected on the gunner's primary sight lower panel and the gun tube SE is far higher than it would be if MAIN was selected. The correct range to target was input before firing.

8-34. In this example, the master gunner determines that after expending all 7.62-mm coax ammunition, the gunner did not index main gun before proceeding to the next engagement, which presented a single stationary tank. When the target lifted, the gunner indexed sabot while coax was still selected and attempted to fire at a 1,720-meter tank target. The fire control system induced the required SE for 7.62-mm M80 ammunition to hit the target. Because the main gun was not selected and the coaxial was out of ammunition, the gunner attempted to fire, but no ignition occurred. The gunner then announced MISFIRE using the "master blaster" to manually fire the main gun. The fired main gun round missed the target and landed out of impact due to excessive SE. Now, the traveled distance of the projectile must be determined.

8-35. Figure 8-41 illustrates the 1,720-meter tank target at 90-meters EL, which is 53.25m above the firing position. Because coax was indexed and 7.62-mm M80 ammunition was used, the firing table for M80 is used to determine the SE.

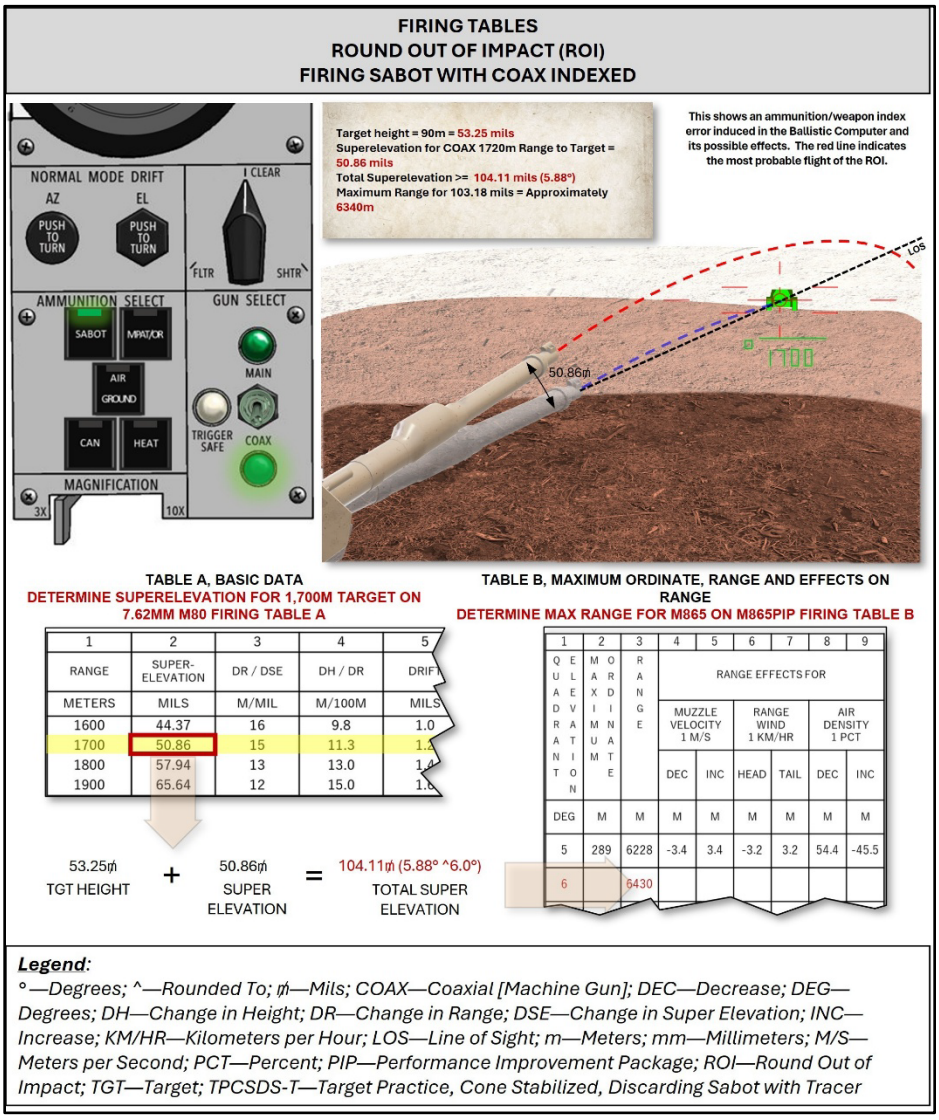


Figure 8-41. Round out of impact sabot with coax indexed, example

Note. The location of impact varies greatly depending on equipment and environmental conditions like barometric pressure, air temperature, ammunition temperature, range winds, wind speeds, impact mediums, and terrain. All influences must be considered when estimating the impact location of ROI.

Round Out of Impact—Incorrect Lase to Target

8-36. A tank fired an ROI. The gunner placed the Eye-safe Laser Range Finder (also called ELRF) to last return and induced a 3,500-meter range for a target at 1,200 meters. How far did the round travel?

8-37. Figure 8-42 illustrates the 1,200-meter tank target at 50-meters EL, which is 42.42m, above the firing position. The M865 PIP firing tables are the only ones used for this example.

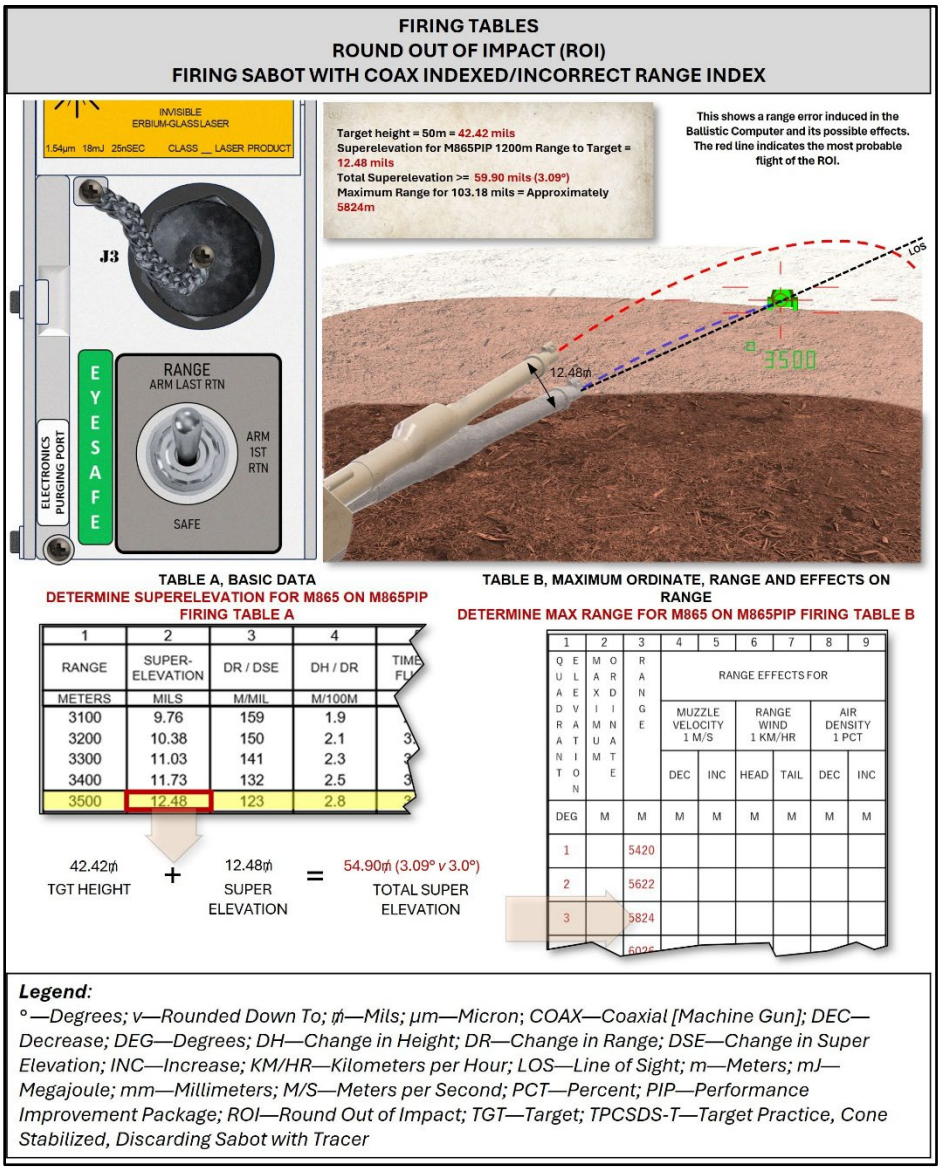


Figure 8-42. Round out of impact sabot with incorrect lase to target, example

Note. The location of impact varies greatly depending on equipment and environmental conditions like barometric pressure, air temperature, ammunition temperature, range winds, wind speeds, impact mediums, and terrain. All must be considered when estimating impact location of ROIs.

Distance X

8-38. In austere environments where a range must be built from scratch, SDZs are developed and cleared for each planned ammunition type. Typically, 10° of QE is used to determine distance X when developing SDZs. Figure 8-43 illustrates using Table B to determine distance X.

FIRING TABLES
TABLE B, MAXIMUM ORDINATE, RANGE AND EFFECTS ON RANGE
DETERMINE DISTANCE X

DETERMINE DISTANCE X	
You're firing CARTRIDGE, 120MM, TPCSDS-T, M865 PIP. The reference angle to determine distance X is 10 degrees quadrant elevation. What is distance X for the bullet fired?	
1—AMMUNITION	M865 PIP
2—QUADRANT ELEVATION	10 Degrees
4—RANGE (DISTANCE X)	7,239m

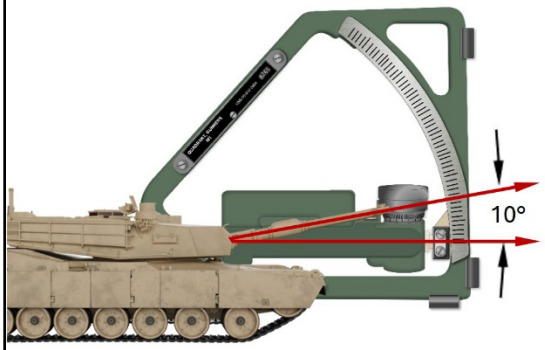


TABLE B
MAXIMUM ORDINATE, RANGE AND EFFEC

1	2	3	4	5	6	
QUADRANT ELEVATION	MAXIMUM ORDINATE	RANGE	RANGE EFFECT			
			MUZZLE VELOCITY 1 M/S		RANGE WIND 1 KM/HR	
			DEC	INC	HEAD	T
DEG	M	M	M	M	M	M
5	289	6228	-3.4	3.4	-3.2	3
10	711	7239	-3.6	3.6	-5.3	
15	1188	7855	-3.7	3.7	-7.1	1
20	1707	8271	-3.8	3.8	-8.7	8.
25	2257	8544	-3.9	4.0	-10.2	10.
30	2833	8697	-4.1	4.1	-11.6	1
34	3326	8737	-4.1	4.1	-12.7	12

FT 120-D-2-1, M865 PIP

Not to scale. Angular measurement exaggerated for context.

Legend:
° —Degrees; DEC—Decrease; DEG—Degrees; FT—Firing Table; INC—Increase; KM/HR—Kilometers per Hour; m—Meters; mm—Millimeters; m/s—Meters per Second; PIP—Performance Improvement Package; TPCSDS-T—Target Practice, Cone Stabilized, Discarding Sabot with Tracer

Figure 8-43. Determine distance x

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Appendix A

Accessing Digital Firing Tables

Obtaining firing tables requires a common access card (also called CAC) and submitting a publications management application (PMA) through Picatinny Arsenal's Joint Center of Excellence for Guns and Ammunition PMA managers. Once an account is approved, access to firing tables is granted on a need-to-use basis.

PUBLICATIONS MANAGEMENT APPLICATION

A-1. Firing tables are accessed by visiting the PMA homepage. Registration is required and navigating to the website prompts information fields to appear on-screen. Figure A-1 displays the PMA pages new users must complete.

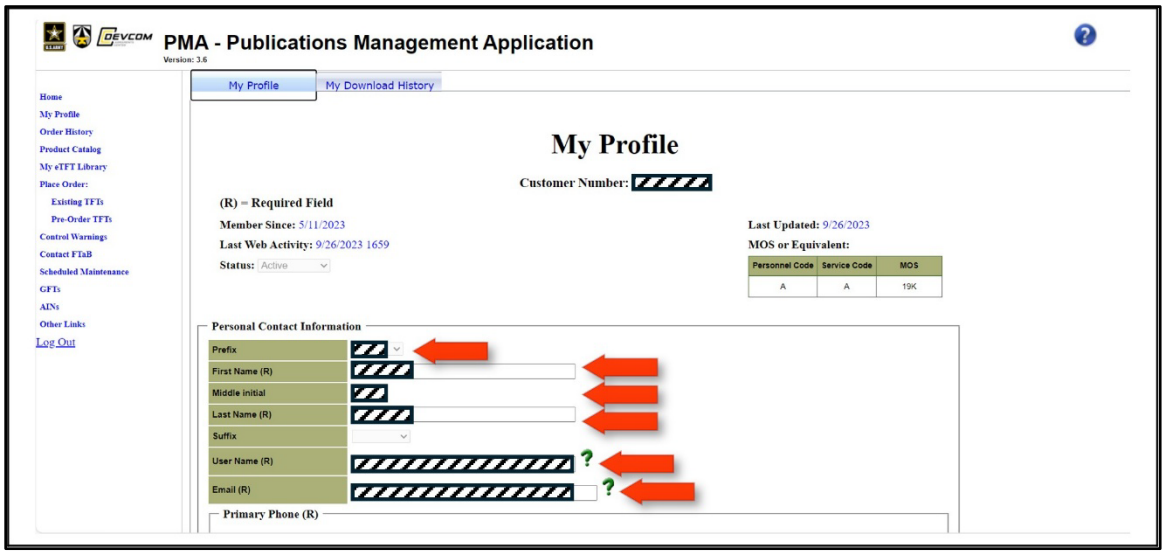


Figure A-1. Publications management application

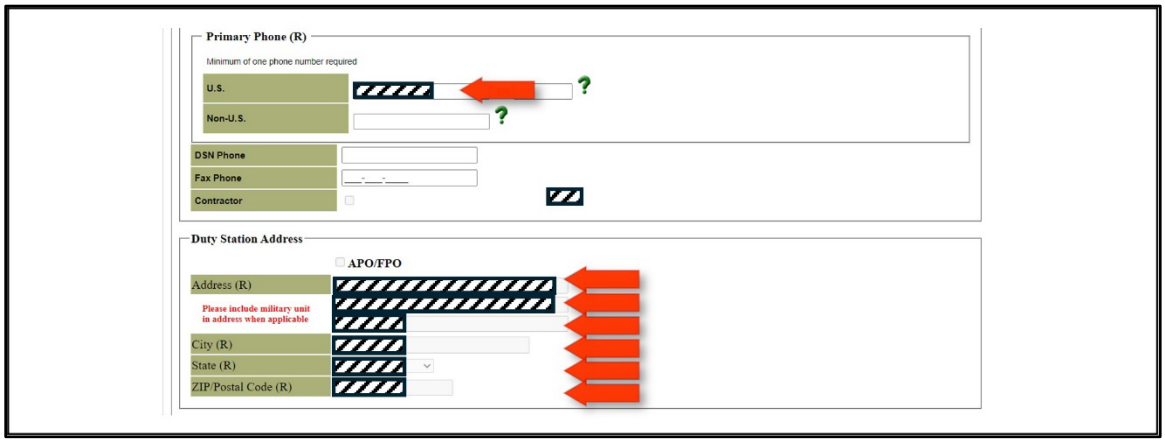


Figure A-1. Publications management application (continued)

A-2. Once granted access to the Picatinny Arsenal Joint Center of Excellence for Guns and Ammunition publications, firing tables are accessible by request to the PMA manager. The PMA manager must be contacted by email or phone to obtain the firing tables needed. Authorized firing tables are available in the My eTFT Library as PDF files. Figures A-2 and A-3 illustrate the menu selection to arrive at the eTFT library.

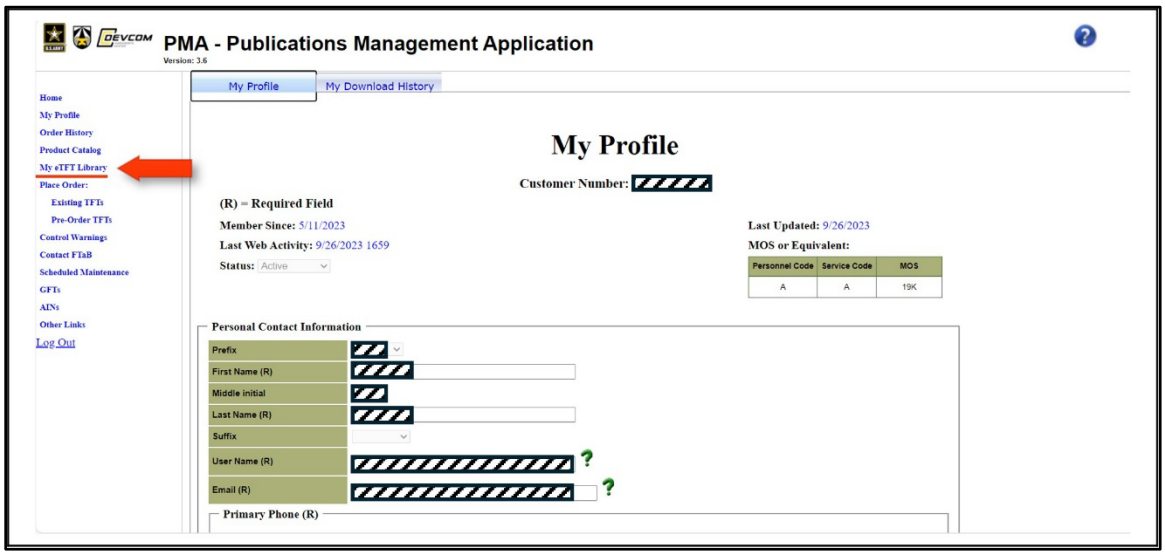


Figure A-2. Locating the My eTFT Library tab

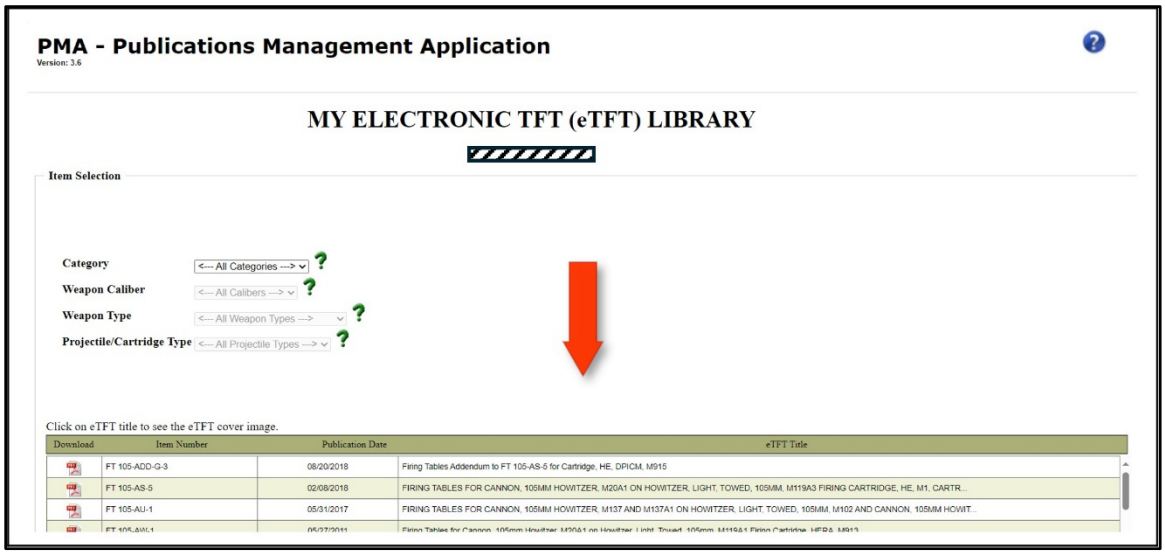


Figure A-3. My eTFT Library Firing Tables Access web page

Appendix B

Firing Tables

This appendix includes sample firing tables for various ammunition types. They are for training purposes only. These samples are used to reinforce the practical application examples provided in this manual.

120MM

B-1. The first example firing table describes the 120mm M865 PIP. Figures B-2 through B-5 through page 150 illustrate its data.

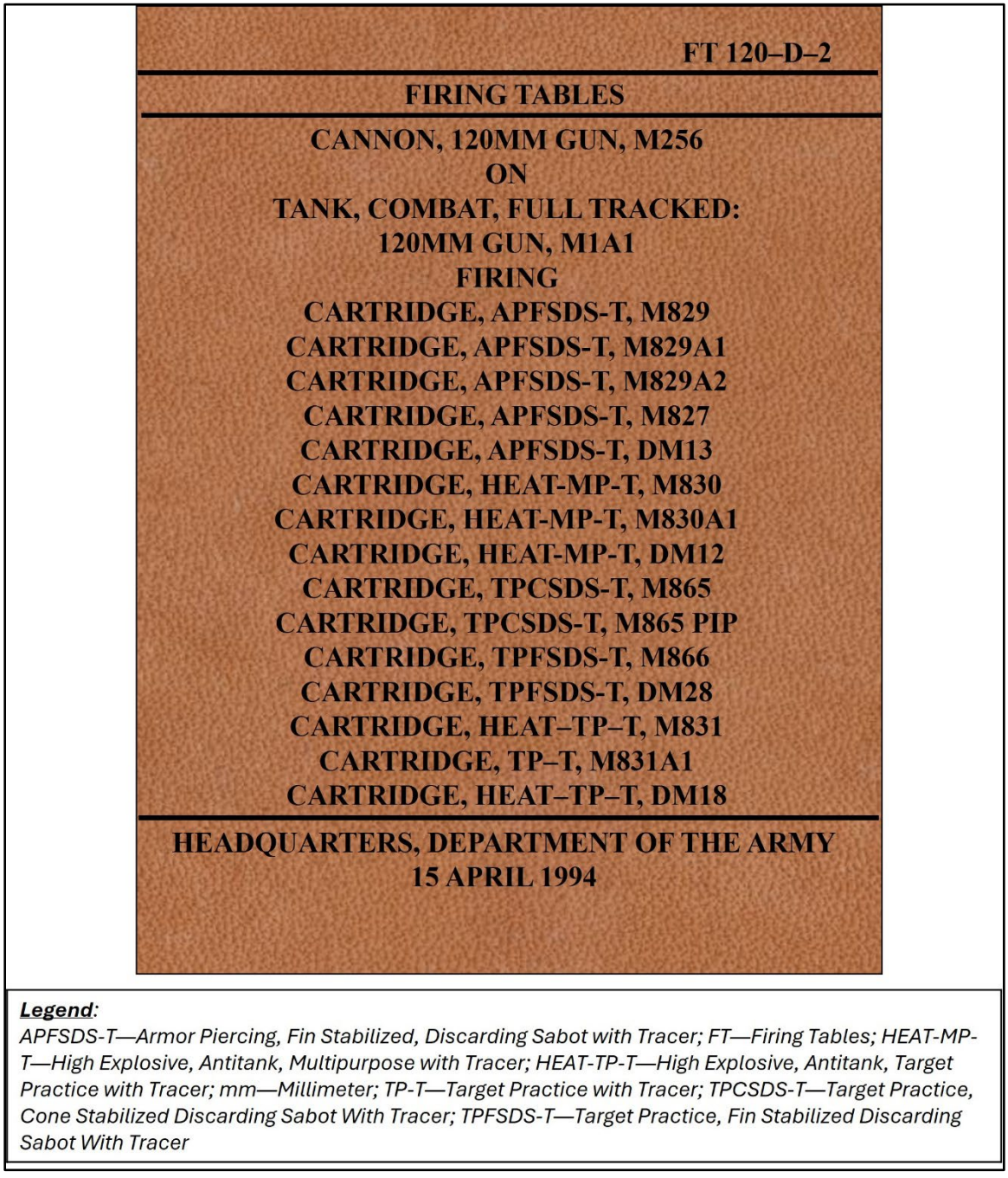


Figure B-1. 120mm M865 PIP Firing Tables Cover

EXPLANATION OF TABLES

THIS FIRING TABLE IS DIVIDED INTO 15 SECTIONS, ONE FOR EACH CARTRIDGE. EACH SECTION INCLUDES FOUR TABLES, THAT BASIC FIRING TABLE AND THREE RANGE SAFETY TABLES, USEFUL FOR ESTABLISHING RANGE AND MAXIMUM ORDINATE LIMITS FOR A GIVEN CARTRIDGE. A RANGE SAFETY FACTOR OF 10 PERCENT IS ADDED TO THE ESTIMATED RANGE LIMIT DETERMINED USING TABLES B, C, AND D TO PROVIDE A SAFETY BUFFER ZONE AND TO ACCOUNT FOR THE VARIABILITY (ROUND TO ROUND AND OCCASION TO OCCASION) OF THE AMMUNITION AND THE INTERACTION AMONG THE NONSTANDARD CONDITIONS. IN GENERAL, PLUS SIGNS ARE OMITTED FROM THESE TABLES, THEREFORE, NUMBERS WITHOUT SIGNS ARE CONSIDERED TO BE POSITIVE. THE CONTENTS OF THESE TABLES ARE DESCRIBED BELOW.

TABLE A

BASIC DATA—A COMPILATION FO THE BASIC DATA REQUIRED FOR THE TANK FIRE CONTROL SOLUTION.

COLUMN

1, 11	RANGE—THE DISTANCE MEASURED FROM THE MUZZLE TO A TARGET AT THE LEVEL POINT UNDER STANDARD CONDITIONS
2	SUPERELEVATION—THE GUN ANGLE IN THE VERTICAL PLANE ABOVE THE LINE OF SIGHT REQUIRED TO REACH THE RANGE LISTED IN COLUMN 1 OR 11.
3	DR / DSE—THE ADJUSTMENT IN RANGE FOR A 1 MIL CHANGE IN THE ANGLE OF SUPERELEVATION LISTED IN COLUMN 2.
4	DH / DR—CHANGE IN THE HEIGHT OF THE TRAJECTORY CORRESPONDING TO AN INCREASE OF 100 METERS TO THE RANGE LISTED IN COLUMN 1 OR 11 WITH THE APPROPRIATE CHANGE IN THE ANGLE OF SUPERELEVATION.
5	TIME OF FLIGHT—THE PROJECTILE TRAVEL TIME, UNDER STANDARD CONDITIONS, FROM THE MUZZLE TO THE LEVEL POINT AT THE RANGE LISTED IN COLUMN 1 OR 11.

Figure B-2. 120mm M865 PIP explanation of tables

COLUMN	
6	10 KM/HR CROSSWIND DEFLECTION—THE EFFECT TABULATED IN THIS COLUMN IS USED WHEN DETERMINING THE CHANGE IN TRAVERSE ANGLE NEEDED TO OFFSET THE CROSSWIND WHICH CREATES A DEFLECTION EFFECT. THE LISTED EFFECT OF WIND DEFLECTION ASSUMES A 10 KM/HR CROSSWIND; THE CORRECTION FOR WHICH IS APPLIED INTO THE WIND. THEREFORE, IF THE WIND IS BLOWING FROM LEFT TO RIGHT, CORRECT TO THE RIGHT. THE WIND EFFECT CAN BE DETERMINED FOR ANY CROSSWIND SPEED BY APPLYING THE APPROPRIATE FACTOR TO THE 10 KM/HR CROSSWIND COLUMN. FOR EXAMPLE, IF THE OBSERVED CROSSWIND IS 5 KM/HR, THE EFFECT IS HALVED OR IF THE CROSS WIND IS 20 KM/HR, THE EFFECT IS DOUBLED.
7	MAXIMUM ORDINATE—THE MAXIMUM HEIGHT OF THE TRAJECTORY ABOVE THE GUN, UNDER STANDARD CONDITIONS, TO THE RANGE IN COLUMN 1 OR 11.
8	RANGE TO MAXIMUM ORDINATE—THE DISTANCE IN THE HORIZONTAL PLANE MEASURED FROM THE GUN MUZZLE TO THE POINT PERPENDICULAR TO THE MAXIMUM ORDINATE LISTED IN COLUMN 7.
9	ANGLE OF FALL—THE LEAST ANGLE MEASURED CLOCKWISE FROM THE HORIZONTAL TO A LINE TANGENT TO THE TRAJECTORY AT THE LEVEL POINT.
10	REMAINING VELOCITY—THE SPEED OF THE PROJECTILE AT THE LEVEL POINT.

Figure B-2. 120mm M865 PIP explanation of tables (continued)

TABLE B

MAXIMUM ORDINATE, RANGE AND EFFECT ON RANGE—RANGE EFFECTS FOR THE NONSTANDARD CONDITIONS OF MUZZLE VELOCITY, RANGE WIND, AND AIR DENSITY

COLUMN

1	QUADRANT ELEVATION —THE ANGLE OF THE GUN IN THE VERTICAL PLANE REQUIRED TO RACH THE RANGE TABULATED IN COLUMN 3. THE FINAL ENTRY IN THIS COLUMN IS THE ELEVATION ANGLE WHICH PRODUCES THE MAXIMUM RANGE UNDER STANDARD CONDITIONS ROUNDED TO THE NEAREST WHOLE DEGREE.
2	MAXIMUM ORDINATE—THE MAXIMUM HEIGHT FOR THE TRAJECTORY ABOVE THE GUN, UNDER STANDARD CONDITIONS, TO THE RANGE IN COLUMN 3.
3	RANGE—THE DISTANCE MEASURED FROM THE MUZZLE TO A TARGET AT THE LEVEL POINT UNDER STANDARD CONDITIONS.
4—5	RANGE EFFECTS FOR A DECREASE (INCREASE) OF 1 METER PER SECOND IN MUZZLE VELOCITY—EFFECTS ON RANGE CAUSED BY VARIATIONS FROM THE STANDARD MUZZLE VELOCITY.
6—7	RANGE EFFECTS FOR A HEAD WIND (TAIL WIND) OF 1 KILOMETER PER HOUR—EFFECTS ON RANGE CAUSED BY A WIND BLOWING AGAINST (WITH) THE SHELL.
8—9	RANGE EFFECTS FOR A DECREASE (INCREASE) OF 1 PERCENT IN AIR DENSITY—EFFECTS ON RANGE CAUSED BY VARIATIONS FROM STANDARD AIR DENSITY (1,225 GRAMS PER CUBIC METER AT SEA LEVEL).

Figure B-2. 120mm M865 PIP explanation of tables (continued)

TABLE C

EFFECTS ON MUZZLE VELOCITY DUE TO AMMUNITION TEMPERATURE—THE CHANGES IN MUZZLE VELOCITY PRODUCED BY VARIATIONS IN AMMUNITION TEMPERATURE. COLUMNS 1 AND 3 LIST THE AMMUNITION TEMPERATURE IN DEGREES FAHRENHEIT AND DEGREES CELSIUS, RESPECTIVELY. COLUMN 2 LISTS THE EFFECT ON MUZZLE VELOCITY CAUSED BY THE CORRESPONDING AMMUNITION TEMPERATURE VARIATION. WHENEVER POSSIBLE, THE TEMPERATURE OF THE AMMUNITION ITSELF SHOULD BE MEASURED, RATHER THAN ASSUMING THAT IT IS THE SAME AS AIR TEMPERATURE. THE CHANGE IN MUZZLE VELOCITY IS CONVERTED TO A RANGE EFFECT USING COLUMNS 4 OR 5 OF TABLE B.

TABLE D

EFFECTS ON AIR DENSITY DUE TO ALTITUDE—CORRECTIONS TO THE STANDARD AIR DENSITY FOR THE ALTITUDE OF THE FIRING UNIT. COLUMN 1 LISTS THE ALTITUDE IN METERS AND COLUMN 2 LISTS THE CORRESPONDING PERCENTAGE DECREASE IN AIR DENSITY. THE STANDARD AIR DENSITY VALUE AT SEA LEVEL IS 1,225 GRAMS PER CUBIC METER (100 PERCENT). WHENEVER POSSIBLE, THE ACTUAL AIR DENSITY AND ITS VARIATION FROM THE STANDARD SHOULD BE COMPUTED AND USED INSTEAD OF THE STANDARD VARIATION WITH ALTITUDE SHOWN IN THIS TABLE. THE AIR DENSITY EFFECT IS CONVERTED TO A RANGE EFFECT USING COLUMN 8 OR 9 OF TABLE B.

Figure B-2. 120mm M865 PIP explanation of tables (continued)

TABLE A
BASIC DATA

1	2	3	4	5	6	7	8	9	10	11
RANGE	SUPER–ELEVATION	DR / DSE	DH / DR	TIME OF FLIGHT	10 KM/HR CROSSWIND DEFLECTION	MAXIMUM ORDINATE	RANGE TO MAXIMUM ORDINATE	ANGLE OF FALL	REMAINING VELOCITY	RANGE
METERS	MILS	M/MIL	M/100M	SEC	MILS	METERS	METERS	MILS	M/SEC	METERS
0	0.00	536	0.0	0.00	0.0	0.0	0	0	1700	0
100	0.18	522	0.0	0.06	0.0	0.0	50	0	1665	100
200	0.36	508	0.0	0.12	0.0	0.0	101	0	1630	200
300	0.54	494	0.1	0.18	0.1	0.0	152	1	1595	300
400	0.73	480	0.1	0.25	0.1	0.1	203	1	1561	400
500	0.93	466	0.1	0.31	0.1	0.1	255	1	1526	500
600	1.13	453	0.1	0.38	0.1	0.2	307	1	1491	600
700	1.34	439	0.1	0.44	0.1	0.2	359	1	1457	700
800	1.56	426	0.2	0.51	0.2	0.3	412	2	1423	800
900	1.78	413	0.2	0.59	0.2	0.4	465	2	1388	900
1000	2.01	400	0.2	0.66	0.2	0.5	519	2	1354	1000
1100	2.25	387	0.3	0.73	0.2	0.7	573	3	1320	1100
1200	2.49	374	0.3	0.81	0.2	0.8	628	3	1286	1200
1300	2.75	361	0.3	0.89	0.3	1.0	683	3	1252	1300
1400	3.01	349	0.4	0.97	0.3	1.2	739	4	1218	1400
1500	3.28	337	0.4	1.05	0.3	1.4	795	4	1184	1500
1600	3.57	324	0.5	1.14	0.3	1.6	852	5	1149	1600
1700	3.86	312	0.5	1.23	0.4	1.8	909	5	1115	1700
1800	4.17	300	0.6	1.32	0.4	2.1	968	6	1081	1800
1900	4.49	288	0.6	1.41	0.4	2.4	1026	6	1047	1900
2000	4.82	277	0.7	1.51	0.5	2.8	1086	7	1013	2000
2100	5.17	265	0.7	1.61	0.5	3.2	1146	7	980	2100
2200	5.53	253	0.9	1.71	0.5	3.6	1207	8	946	2200
2300	5.91	242	0.9	1.82	0.6	4.0	1269	9	913	2300
2400	6.31	231	1.0	1.93	0.6	4.6	1331	10	880	2400
2500	6.73	220	1.1	2.05	0.7	5.1	1395	11	847	2500
2600	7.17	210	1.2	2.17	0.7	5.7	1459	12	814	2600
2700	7.63	199	1.3	2.29	0.7	6.4	1524	13	782	2700
2800	8.12	189	1.4	2.42	0.8	7.2	1590	14	750	2800
2900	8.64	179	1.6	2.56	0.8	8.0	1658	15	718	2900
3000	9.18	169	1.7	2.70	0.9	8.9	1726	17	686	3000
3100	9.76	159	1.9	2.85	0.9	9.9	1795	19	655	3100
3200	10.38	150	2.1	3.01	1.0	11.0	1866	20	624	3200
3300	11.03	141	2.3	3.17	1.1	12.2	1938	22	594	3300
3400	11.73	132	2.5	3.34	1.1	13.6	2011	25	564	3400
3500	12.48	123	2.8	3.53	1.2	15.1	2086	27	536	3500
3600	13.29	115	3.1	3.72	1.3	16.8	2162	30	507	3600
3700	14.15	107	3.4	3.92	1.3	18.6	2240	33	480	3700
3800	15.08	99	3.8	4.13	1.4	20.7	2319	37	453	3800
3900	16.09	92	4.2	4.36	1.5	23.1	2400	41	427	3900
4000	17.19	85	4.7	4.60	1.6	25.7	2482	46	402	4000
4100	18.38	78	5.3	4.86	1.7	28.6	2566	51	377	4100
4200	19.68	71	5.9	5.13	1.8	32.0	2652	57	354	4200
4300	21.10	65	6.6	5.42	1.9	35.7	2740	64	333	4300
4400	22.66	60	7.4	5.73	2.0	40.0	2830	72	314	4400
4500	24.37	54	8.3	6.06	2.1	44.8	2920	81	299	4500
4600	26.25	50	9.3	6.40	2.3	50.3	3012	91	286	4600
4700	28.30	46	10.4	6.75	2.4	56.5	3105	101	274	4700
4800	30.53	42	11.6	7.12	2.5	63.4	3197	113	263	4800
4900	32.96	39	12.9	7.51	2.7	71.1	3289	125	253	4900
5000	35.60	220	14.2	7.91	2.8	79.8	3381	138	244	5000

FT 120–D–2–1, M865 PIP

***Legend**:*
DH—Change in Height; DR—Change in Range; DSE—Change in Super Elevation; FT—Firing Table; KM/HR—Kilometers per Hour; M/100M—Meters per 100 Meters; M/MIL—Meters per Mils; M/SEC—Meters per Second; PIP—Performance Improvement Package; SEC—Second

Figure B-3. 120mm M865 PIP Firing Table A

TABLE B
MAXIMUM ORDINATE, RANGE AND EFFECTS ON RANGE

1	2	3	4	5	6	7	8	9
QUADRANT ELEVATION	MAXIMUM ORDINATE	RANGE	RANGE EFFECTS FOR					
			MUZZLE VELOCITY 1 M/S		RANGE WIND 1 KM/HR		AIR DENSITY 1 PCT	
			DEC	INC	HEAD	TAIL	DEC	INC
DEG	M	M	M	M	M	M	M	M
5	289	6228	-3.4	3.4	-3.2	3.2	54.4	-45.5
10	711	7239	-3.6	3.6	-5.3	5.4	66.1	-55.1
15	1188	7855	-3.7	3.7	-7.1	7.1	74.4	-61.7
20	1707	8271	-3.8	3.8	-8.7	8.7	81.3	-67.1
25	2257	8544	-3.9	4.0	-10.2	10.2	87.2	-71.5
30	2833	8697	-4.1	4.1	-11.6	11.6	92.1	-75.1
34	3326	8737	-4.1	4.1	-12.7	12.8	95.6	-77.5

FT 120-D-2-1, M865 PIP

TABLE C
EFFECTS ON MUZZLE VELOCITY
DUE TO AMMUNITION TEMPERATURE

TEMPERATURE OF AMMUNITION	EFFECTS ON VELOCITY	TEMPERATURE OF AMMUNITION
DEGREES F	M/S	DEGREES C
-40.0	-123.4	-40.0
-30.0	-111.2	-34.4
-20.0	-99.3	-28.9
-10.0	-87.5	-23.3
0.0	-75.9	-17.8
10.0	-64.5	-12.2
20.0	-53.3	-6.7
30.0	-42.2	-1.1
40.0	-31.4	4.4
50.0	-20.7	10.0
60.0	-10.3	15.6
70.0	0.0	21.1
80.0	10.1	26.7
90.0	20.0	32.2
100.0	29.7	37.8
110.0	39.2	43.3
120.0	48.5	48.9
130.0	57.7	54.4

FT 120-D-2-1, M865 PIP

Legend:
C—Celsius; DEC—Decrease; DEG—Degrees; F—Fahrenheit; FT—Firing Table; INC—Increase; KM/HR—Kilometers per Hour; M—Meters; M/S—Meters per Second; PCT—Percent; PIP—Performance Improvement Package

Figure B-4. 120mm M865 PIP Firing Tables B and C

TABLE D

EFFECTS ON AIR DENSITY
DUE TO ALTITUDE

ALTITUDE	DECREASE IN AIR DENSITY
METERS	PERCENT
0	0.0
100	1.0
200	1.9
300	2.8
400	3.8
500	4.7
600	5.6
700	6.5
800	7.5
900	8.4
1000	9.3
1100	10.1
1200	11.0
1300	11.9
1400	12.8
1500	13.6
1600	14.5
1700	15.3
1800	16.2
1900	17.0
2000	17.8

FT 120-D-1, M865 PIP

***Legend**:*
FT—Firing Table; PIP—Performance Improvement Package

Figure B-5. 120mm M865 PIP Firing Table D

105MM

B-2. The next example firing table describes the 105mm cartridge white phosphorous with tracer (WP-T) M416. Figures B-6 through B-10 through page 159 illustrate its data.

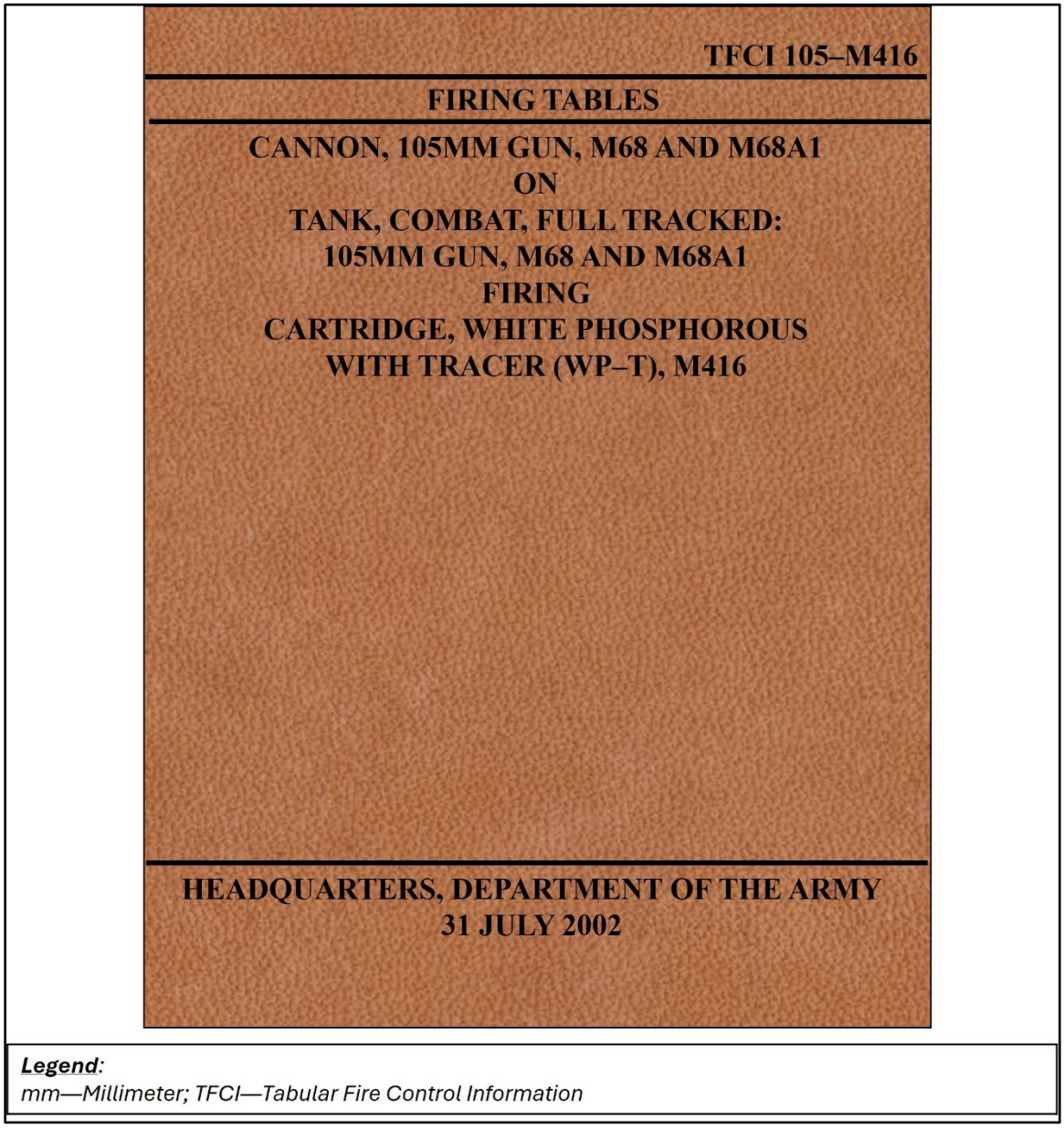


Figure B-6. 105mm WP-T M416 Firing Tables Cover

EXPLANATION OF TABLES

THIS FIRING TABLE IS DIVIDED INTO 15 SECTIONS, ONE FOR EACH CARTRIDGE. EACH SECTION INCLUDES FOUR TABLES, THAT BASIC FIRING TABLE AND THREE RANGE SAFETY TABLES, USEFUL FOR ESTABLISHING RANGE AND MAXIMUM ORDINATE LIMITS FOR A GIVEN CARTRIDGE. A RANGE SAFETY FACTOR OF 10 PERCENT IS ADDED TO THE ESTIMATED RANGE LIMIT DETERMINED USING TABLES B, C, AND D TO PROVIDE A SAFETY BUFFER ZONE AND TO ACCOUNT FOR THE VARIABILITY (ROUND TO ROUND AND OCCASION TO OCCASION) OF THE AMMUNITION AND THE INTERACTION AMONG THE NONSTANDARD CONDITIONS. IN GENERAL, PLUS SIGNS ARE OMITTED FROM THESE TABLES, THEREFORE, NUMBERS WITHOUT SIGNS ARE CONSIDERED TO BE POSITIVE. THE CONTENTS OF THESE TABLES ARE DESCRIBED BELOW.

TABLE A

BASIC DATA—A COMPILATION FOR THE BASIC DATA REQUIRED FOR THE TANK FIRE CONTROL SOLUTION.

COLUMN

1	RANGE—THE DISTANCE MEASURED FROM THE MUZZLE TO A TARGET AT THE LEVEL POINT UNDER STANDARD CONDITIONS
2	SUPERELEVATION—THE GUN ANGLE IN THE VERTICAL PLANE ABOVE THE LINE OF SIGHT REQUIRED TO REACH THE RANGE LISTED IN COLUMN 1.
3	DR / DSE—THE ADJUSTMENT IN RANGE FOR A 1 MIL CHANGE IN THE ANGLE OF SUPERELEVATION LISTED IN COLUMN 2.
4	DH / DR—CHANGE IN THE HEIGHT OF THE TRAJECTORY CORRESPONDING TO AN INCREASE OF 100 METERS TO THE RANGE LISTED IN COLUMN 1 WITH THE APPROPRIATE CHANGE IN THE ANGLE OF SUPERELEVATION.
5	DRIFT—WHEN PROJECTILES ARE SPUN FOR STABILIZATION PURPOSES BY GUN TUBES WITH A RIGHT–HANDED TWIST OF RIFLING, THE DRIFT OF THE PROJECTILE IS TO THE RIGHT OF THE VERTICAL PLANE OF FIRE. DRIFT IS THE ANGULAR DISPLACEMENT A PROJECTILE WILL INCUR WHEN IT IS SPUN.

Figure B-7. 105mm WP-T M416 explanation of tables

COLUMN	
6	TIME OF FLIGHT—THE PROJECTILE TRAVEL TIME, UNDER STANDARD CONDITIONS, FROM THE MUZZLE TO THE LEVEL POINT AT THE RANGE LISTED IN COLUMN 1.
7	10 KM/HR CROSSWIND DEFLECTION—THE EFFECT TABULATED IN THIS COLUMN IS USED WHEN DETERMINING THE CHANGE IN TRAVERSE ANGLE NEEDED TO OFFSET THE CROSSWIND WHICH CREATES A DEFLECTION EFFECT. THE LISTED EFFECT OF WIND DEFLECTION ASSUMES A 10 KM/HR CROSSWIND; THE CORRECTION FOR WHICH IS APPLIED INTO THE WIND. THEREFORE, IF THE WIND IS BLOWING FROM LEFT TO RIGHT, CORRECT TO THE RIGHT. THE WIND EFFECT CAN BE DETERMINED FOR ANY CROSSWIND SPEED BY APPLYING THE APPROPRIATE FACTOR TO THE 10 KM/HR CROSSWIND COLUMN. FOR EXAMPLE, IF THE OBSERVED CROSSWIND IS 5 KM/HR, THE EFFECT IS HALVED OR IF THE CROSSWIND IS 20 KM/HR, THE EFFECT IS DOUBLED.
8	MAXIMUM ORDINATE—THE MAXIMUM HEIGHT OF THE TRAJECTORY ABOVE THE GUN, UNDER STANDARD CONDITIONS, TO THE RANGE IN COLUMN 1.
9	RANGE TO MAXIMUM ORDINATE—THE DISTANCE IN THE HORIZONTAL PLANE MEASURED FROM THE GUN MUZZLE TO THE POINT PERPENDICULAR TO THE MAXIMUM ORDINATE LISTED IN COLUMN 8.
10	ANGLE OF FALL—THE LEAST ANGLE MEASURED CLOCKWISE FROM THE HORIZONTAL TO A LINE TANGENT TO THE TRAJECTORY AT THE LEVEL POINT.
11	REMAINING VELOCITY—THE SPEED OF THE PROJECTILE AT THE LEVEL POINT.

Legend:
KM/HR—Kilometers per Hour

Figure B-7. 105mm WP-T M416 explanation of tables (continued)

TABLE B

MAXIMUM ORDINATE, RANGE AND EFFECT ON RANGE—RANGE EFFECTS FOR THE NONSTANDARD CONDITIONS OF MUZZLE VELOCITY, RANGE WIND, AND AIR DENSITY

COLUMN

1	QUADRANT ELEVATION —THE ANGLE OF THE GUN IN THE VERTICAL PLANE REQUIRED TO REACH THE RANGE TABULATED IN COLUMN 3. THE FINAL ENTRY IN THIS COLUMN IS THE ELEVATION ANGLE WHICH PRODUCES THE MAXIMUM RANGE UNDER STANDARD CONDITIONS ROUNDED TO THE NEAREST WHOLE DEGREE.
2	MAXIMUM ORDINATE—THE MAXIMUM HEIGHT FOR THE TRAJECTORY ABOVE THE GUN, UNDER STANDARD CONDITIONS, TO THE RANGE IN COLUMN 3.
3	RANGE—THE DISTANCE MEASURED FROM THE MUZZLE TO A TARGET AT THE LEVEL POINT UNDER STANDARD CONDITIONS.
4—5	RANGE EFFECTS FOR A DECREASE (INCREASE) OF 1 METER PER SECOND IN MUZZLE VELOCITY—EFFECTS ON RANGE CAUSED BY VARIATIONS FROM THE STANDARD MUZZLE VELOCITY.
6—7	RANGE EFFECTS FOR A HEAD WIND (TAIL WIND) OF 1 KILOMETER PER HOUR—EFFECTS ON RANGE CAUSED BY A WIND BLOWING AGAINST (WITH) THE SHELL.
8—9	RANGE EFFECTS FOR A DECREASE (INCREASE) OF 1 PERCENT IN AIR DENSITY—EFFECTS ON RANGE CAUSED BY VARIATIONS FROM STANDARD AIR DENSITY (1,225 GRAMS PER CUBIC METER AT SEA LEVEL).

Figure B-7. 105mm WP-T M416 explanation of tables (continued)

TABLE C

EFFECTS ON MUZZLE VELOCITY DUE TO AMMUNITION TEMPERATURE—THE CHANGES IN MUZZLE VELOCITY PRODUCED BY VARIATIONS IN AMMUNITION TEMPERATURE. COLUMNS 1 AND 3 LIST THE AMMUNITION TEMPERATURE IN DEGREES FAHRENHEIT AND DEGREES CELSIUS, RESPECTIVELY. COLUMN 2 LISTS THE EFFECT ON MUZZLE VELOCITY CAUSED BY THE CORRESPONDING AMMUNITION TEMPERATURE VARIATION. WHENEVER POSSIBLE, THE TEMPERATURE OF THE AMMUNITION ITSELF SHOULD BE MEASURED, RATHER THAN ASSUMING THAT IT IS THE SAME AS AIR TEMPERATURE. THE CHANGE IN MUZZLE VELOCITY IS CONVERTED TO A RANGE EFFECT USING COLUMNS 4 OR 5 OF TABLE B.

TABLE D

EFFECTS ON AIR DENSITY DUE TO ALTITUDE—CORRECTIONS TO THE STANDARD AIR DENSITY FOR THE ALTITUDE OF THE FIRING UNIT. COLUMN 1 LISTS THE ALTITUDE IN METERS AND COLUMN 2 LISTS THE CORRESPONDING PERCENTAGE DECREASE IN AIR DENSITY. THE STANDARD AIR DENSITY VALUE AT SEA LEVEL IS 1,225 GRAMS PER CUBIC METER (100 PERCENT). WHENEVER POSSIBLE, THE ACTUAL AIR DENSITY AND ITS VARIATION FROM THE STANDARD SHOULD BE COMPUTED AND USED INSTEAD OF THE STANDARD VARIATION WITH ALTITUDE SHOWN IN THIS TABLE. THE AIR DENSITY EFFECT IS CONVERTED TO A RANGE EFFECT USING COLUMN 8 OR 9 OF TABLE B.

Figure B-7. 105mm WP-T M416 explanation of tables (continued)

TABLE A
BASIC DATA

1	2	3	4	5	6	7	8	9	10	11
RANGE	SUPER–ELEVATION	DR / DSE	DH / DR	DRIFT	TIME OF FLIGHT	10 KM/HR CROSSWIND DEFLECTION	MAXIMUM ORDINATE	RANGE TO MAXIMUM ORDINATE	ANGLE OF FALL	REMAINING VELOCITY
METERS	MILS	M/MIL	M/100M	MILS	SEC	MILS	METERS	METERS	MILS	M/SEC
0	0.00	105	0.0	0.0	0.00	0.0	0.0	0	0	732
100	0.95	101	0.1	0.0	0.14	0.1	0.0	50	1	709
200	1.95	97	0.2	0.1	0.28	0.1	0.1	101	2	688
300	2.98	93	0.3	0.1	0.43	0.2	0.2	152	3	667
400	4.06	89	0.4	0.2	0.58	0.2	0.4	204	4	646
500	5.18	86	0.6	0.2	0.74	0.3	0.7	257	6	626
600	6.35	82	0.7	0.3	0.90	0.4	1.0	309	7	607
700	7.58	79	0.9	0.3	1.07	0.5	1.4	363	9	588
800	8.86	75	1.1	0.3	1.24	0.5	1.9	417	10	570
900	10.19	72	1.2	0.4	1.42	0.6	2.5	471	12	552
1000	11.59	69	1.4	0.5	1.60	0.7	3.2	526	14	534
1100	13.05	66	1.7	0.5	1.79	0.7	4.0	582	16	517
1200	14.58	63	1.9	0.6	1.99	0.8	4.9	638	19	501
1300	16.18	60	2.1	0.6	2.19	0.9	5.9	695	21	485
1400	17.86	58	2.4	0.7	2.40	1.0	7.1	752	24	470
1500	19.61	55	2.7	0.8	2.62	1.1	8.4	809	27	455
1600	21.45	53	3.0	0.8	2.84	1.2	10.0	868	30	441
1700	23.37	50	3.4	0.9	3.07	1.2	11.6	926	33	428
1800	25.38	48	3.7	1.0	3.31	1.3	13.5	985	37	415
1900	27.48	46	4.1	1.1	3.56	1.4	15.6	1045	41	403
2000	29.68	44	4.5	1.1	3.81	1.5	18.0	1105	45	391
2100	31.99	42	5.0	1.2	4.07	1.6	20.5	1165	49	380
2200	34.40	40	5.4	1.3	4.34	1.7	23.4	1226	54	370
2300	36.91	39	5.9	1.4	4.61	1.8	26.5	1287	59	361
2400	39.54	37	6.5	1.5	4.89	1.9	29.9	1348	64	352
2500	42.28	35	7.0	1.7	5.18	2.0	33.6	1409	70	344
2600	45.14	34	7.6	1.8	5.47	2.1	37.6	1471	76	337
2700	48.11	33	8.2	1.9	5.77	2.2	42.0	1532	82	331
2800	51.19	32	8.8	2.0	6.08	2.3	46.7	1594	88	325
2900	54.39	31	9.4	2.2	6.39	2.4	51.8	1655	94	320
3000	57.71	29	10.1	2.3	6.71	2.5	57.3	1716	101	315
3100	61.14	29	10.8	2.5	7.03	2.5	63.2	1777	108	311
3200	64.68	28	11.5	2.7	7.36	2.6	69.5	1838	115	307
3300	68.34	27	12.2	2.8	7.69	2.7	76.2	1898	122	303
3400	72.10	26	12.9	3.0	8.02	2.8	83.3	1958	129	300
3500	75.97	25	13.6	3.2	8.36	2.9	90.9	2017	136	296
3600	79.94	25	14.4	3.5	8.71	3.0	98.9	2076	144	293
3700	84.03	24	15.2	3.7	9.05	3.0	107.3	2135	152	290
3800	88.21	24	16.0	3.9	9.41	3.1	116.2	2193	159	287
3900	92.50	23	16.8	4.2	9.76	3.2	125.6	2251	167	285
4000	96.89	22	17.6	4.4	10.12	3.3	135.5	2308	175	282
4100	101.39	22	18.4	4.7	10.48	3.3	145.8	2365	184	280
4200	105.99	21	19.3	4.9	10.85	3.4	156.6	2421	192	277
4300	110.69	21	20.2	5.2	11.22	3.5	167.9	2477	201	275
4400	115.49	21	21.1	5.5	11.60	3.6	179.8	2533	209	273
4500	120.39	20	22.0	5.8	11.98	3.6	192.1	2589	218	270
4600	125.39	20	22.9	6.2	12.36	3.7	205.0	2644	227	268
4700	130.49	19	23.9	6.5	12.75	3.8	218.5	2700	236	266
4800	135.70	19	24.8	6.8	13.14	3.8	232.4	2755	246	264
4900	141.01	19	25.8	7.2	13.54	3.9	247.0	2810	255	263
5000	146.42	18	26.8	7.5	13.94	4.0	262.1	2865	264	261

FT TFCI 105–M416

***Legend**:*
DH—Change in Height; DR—Change in Range; DSE—Change in Super Elevation; FT—Firing Table; KM/HR—Kilometers per Hour; M/100M—Meters per 100 Meters; M/MIL—Meters per Mils; M/SEC—Meters per Second; SEC—Second; TFCI—Tabular Fire Control Information

Figure B-8. 105mm WP-T M416 Firing Table A

TABLE A
BASIC DATA

1	2	3	4	5	6	7	8	9	10	11
RANGE	SUPER–ELEVATION	DR / DSE	DH / DR	DRIFT	TIME OF FLIGHT	10 KM/HR CROSSWIND DEFLECTION	MAXIMUM ORDINATE	RANGE TO MAXIMUM ORDINATE	ANGLE OF FALL	REMAINING VELOCITY
METERS	MILS	M/MIL	M/100M	MILS	SEC	MILS	METERS	METERS	MILS	M/SEC
5100	151.93	18	27.8	7.9	14.34	4.0	277.8	2920	274	259
5200	157.55	18	28.9	8.3	14.75	4.1	294.2	2974	284	257
5300	163.27	17	30.0	8.7	15.16	4.2	311.1	3029	294	256
5400	169.11	17	31.1	9.1	15.58	4.2	328.7	3084	304	254
5500	175.04	17	32.2	9.5	16.00	4.3	347.0	3139	314	253
5600	181.09	16	33.3	10.0	16.43	4.4	365.9	3194	325	251
5700	187.25	16	34.5	10.4	16.86	4.4	385.5	3249	335	250
5800	193.52	16	35.7	10.9	17.30	4.5	405.8	3304	346	248
5900	199.91	15	36.9	11.4	17.74	4.6	426.8	3359	357	247
6000	206.41	15	38.1	11.8	18.18	4.6	448.6	3414	368	246
6100	213.04	15	39.4	12.3	18.64	4.7	471.2	3469	379	244
6200	219.79	15	40.7	12.9	19.09	4.7	494.6	3525	390	243
6300	226.66	14	42.0	13.4	19.55	4.8	518.8	3580	402	242
6400	233.66	14	43.4	13.9	20.02	4.9	543.8	3635	413	241
6500	240.80	14	44.8	14.5	20.50	4.9	569.8	3691	425	240
6600	248.07	14	46.2	15.0	20.98	5.0	596.6	3746	437	239
6700	255.48	13	47.7	15.6	21.47	5.1	624.4	3802	449	238
6800	263.04	13	49.2	16.2	21.96	5.1	653.2	3858	462	237
6900	270.75	13	50.7	16.9	22.46	5.2	683.0	3913	474	236
7000	278.62	13	52.3	17.5	22.97	5.3	713.8	3969	487	235
7100	286.65	12	53.9	18.2	23.48	5.3	745.8	4025	499	234
7200	294.85	12	55.6	18.8	24.01	5.4	778.9	4081	512	234
7300	303.22	12	57.3	19.5	24.54	5.4	813.2	4137	526	233
7400	311.78	12	59.1	20.3	25.08	5.5	848.8	4193	539	233
7500	320.54	11	60.9	21.0	25.63	5.6	885.8	4249	552	232
7600	329.50	11	62.8	21.8	26.18	5.6	924.1	4306	566	231
7700	338.67	11	64.7	22.6	26.75	5.7	963.9	4362	580	231
7800	348.07	10	66.8	23.4	27.33	5.8	1005.3	4418	594	231
7900	357.72	10	68.8	24.3	27.92	5.9	1048.3	4475	608	230
8000	367.62	10	71.0	25.2	28.53	5.9	1093.1	4531	623	230
8100	377.80	10	73.2	26.1	29.14	6.0	1139.7	4587	638	230
8200	388.28	9	75.6	27.0	29.77	6.1	1188.4	4644	652	230
8300	399.08	9	78.0	28.0	30.42	6.2	1239.3	4701	668	230
8400	410.22	9	80.5	29.1	31.08	6.2	1292.4	4757	683	230
8500	421.75	9	83.1	30.2	31.76	6.3	1348.2	4814	699	230
8600	433.69	8	85.9	31.3	32.46	6.4	1406.7	4870	715	230
8700	446.10	8	88.8	32.6	33.18	6.5	1468.3	4927	731	230
8800	459.02	8	91.9	33.8	33.93	6.6	1533.3	4983	748	230
8900	472.53	7	95.2	35.2	34.70	6.7	1602.1	5040	765	231
9000	486.71	7	98.8	36.7	35.51	6.8	1675.3	5096	783	231
9100	501.70	6	102.6	38.2	36.36	6.9	1753.7	5153	801	232
9200	517.63	6	106.7	39.9	37.25	7.0	1838.1	5209	821	232
9300	534.71	6	111.3	41.8	38.20	7.1	1929.8	5265	841	233
9400	553.23	5	116.5	43.9	39.22	7.2	2030.6	5321	862	234
9500	573.65	5	122.5	46.3	40.33	7.3	2143.1	5377	885	235
9600	596.74	4	129.7	49.0	41.57	7.5	2272.1	5433	909	236
9700	623.99	3	139.6	52.4	43.01	7.7	2426.5	5488	938	238
9800	659.30	2	0.0	57.1	44.85	8.0	2629.4	5542	973	240

FT TFCI 105–M416

***Legend**:*
DH—Change in Height; DR—Change in Range; DSE—Change in Super Elevation; FT—Firing Table; KM/HR—Kilometers per Hour; M/100M—Meters per 100 Meters; M/MIL—Meters per Mils; M/SEC—Meters per Second; SEC—Second; TFCI—Tabular Fire Control Information

Figure B-8. 105mm WP-T M416 Firing Table A (continued)

TABLE B
MAXIMUM ORDINATE, RANGE AND EFFECTS ON RANGE

1	2	3	4	5	6	7	8	9
QUADRANT ELEVATION	MAXIMUM ORDINATE	RANGE	RANGE EFFECTS FOR					
			MUZZLE VELOCITY 1 M/S		RANGE WIND 1 KM/HR		AIR DENSITY 1 PCT	
			DEC	INC	HEAD	TAIL	DEC	INC
DEG	M	M	M	M	M	M	M	M
5	118	3823	-5.1	5.0	-2.0	2.1	18.6	-16.2
10	356	5553	-5.6	5.6	-4.0	4.2	27.7	-24.0
15	668	6855	-5.9	5.9	-5.8	6.0	34.9	-30.4
20	1040	7885	-6.1	6.1	-7.4	7.6	41.5	-36.1
25	1462	8694	-6.3	6.2	-8.8	9.1	47.4	-41.2
30	1925	9298	-6.3	6.3	-10.0	10.3	52.5	-45.8
35	2419	9700	-6.4	6.3	-11.1	11.4	56.8	-49.4
40	2934	9890	-6.3	6.2	-11.9	12.2	59.9	-51.9
42	3121	9904	-6.3	6.2	-12.1	12.4	60.6	-52.4

FT TFCI 105-M416

TABLE C
EFFECTS ON MUZZLE VELOCITY
DUE TO AMMUNITION TEMPERATURE

TEMPERATURE OF AMMUNITION	EFFECTS ON VELOCITY	TEMPERATURE OF AMMUNITION
DEGREES F	M/S	DEGREES C
-40.0	-26.4	-40.0
-30.0	-24.2	-34.4
-20.0	-22.0	-28.9
-10.0	-19.7	-23.3
0.0	-17.4	-17.8
10.0	-15.0	-12.2
20.0	-12.6	-6.7
30.0	-10.2	-1.1
40.0	-7.7	4.4
50.0	-5.2	10.0
60.0	-2.6	15.6
70.0	0.0	21.1
80.0	2.7	26.7
90.0	5.3	32.2
100.0	8.1	37.8
110.0	10.9	43.3
120.0	13.7	48.9
130.0	16.5	54.4

FT TFCI 105-M416

***Legend**:*
C—Celsius; DEC—Decrease; DEG—Degrees; F—Fahrenheit; FT—Firing Table; INC—Increase; KM/HR—Kilometers per Hour; M—Meters; M/S—Meters per Second; PCT—Percent; TFCI—Tabular Fire Control Information

Figure B-9. 105mm WP-T M416 Firing Tables B and C

TABLE D

EFFECTS ON AIR DENSITY
DUE TO ALTITUDE

ALTITUDE	DECREASE IN AIR DENSITY
METERS	PERCENT
0	0.0
100	1.0
200	1.9
300	2.8
400	3.8
500	4.7
600	5.6
700	6.5
800	7.5
900	8.4
1000	9.3
1100	10.1
1200	11.0
1300	11.9
1400	12.8
1500	13.6
1600	14.5
1700	15.3
1800	16.2
1900	17.0
2000	17.8

FT TFCI 105-M416

Legend:
FT—Firing Table; TFCI—Tabular Fire Control Information

Figure B-10. 105mm WP-T M416 Firing Table D

25MM

B-3. The next example firing table describes the 25mm M791. Figures B-11 through B-15 through page 167 illustrate its data.

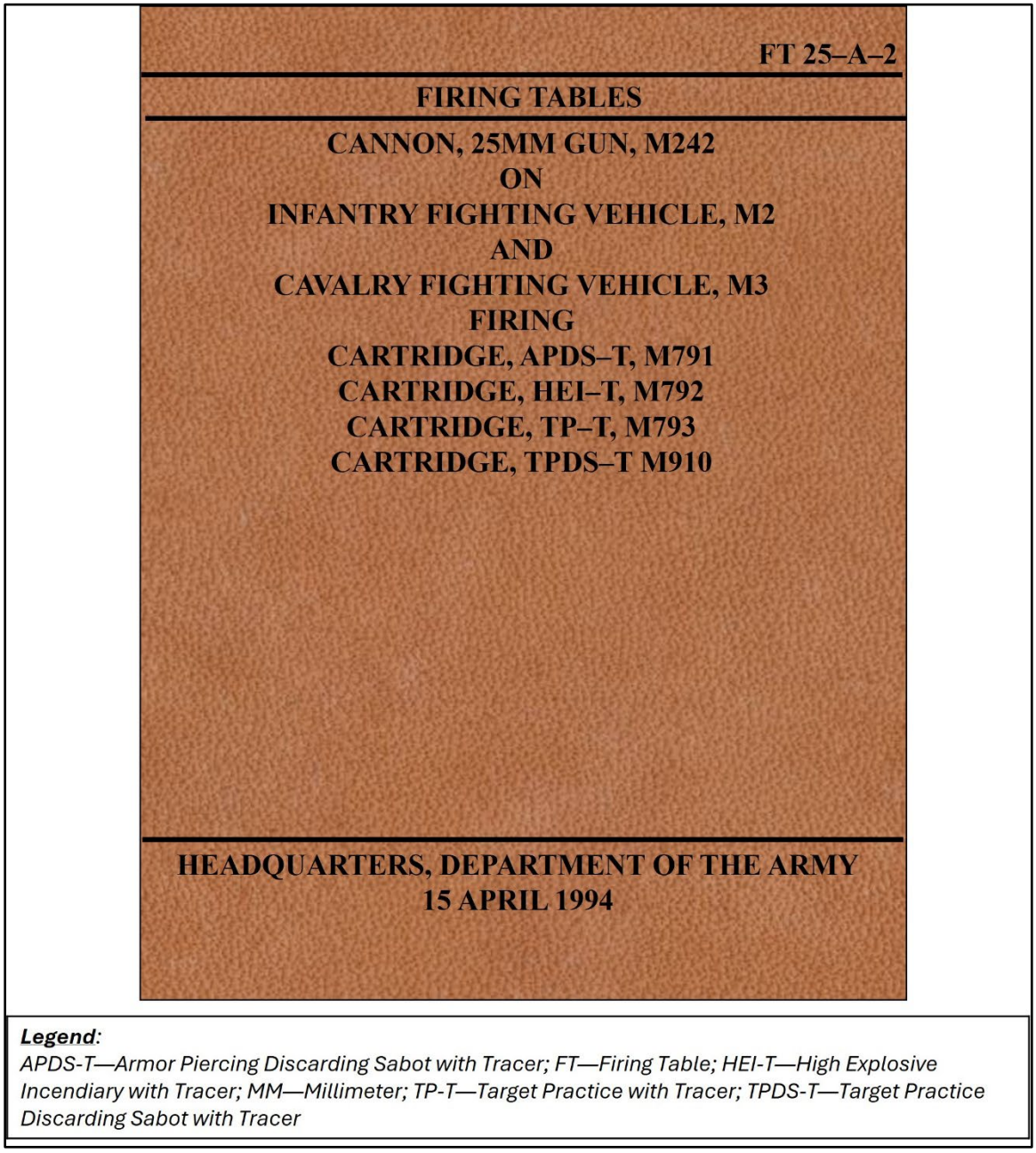


Figure B-11. 25mm M791 Firing Tables Cover

EXPLANATION OF TABLES

THIS FIRING TABLE IS DIVIDED INTO 15 SECTIONS, ONE FOR EACH CARTRIDGE. EACH SECTION INCLUDES FOUR TABLES, THAT BASIC FIRING TABLE AND THREE RANGE SAFETY TABLES, USEFUL FOR ESTABLISHING RANGE AND MAXIMUM ORDINATE LIMITS FOR A GIVEN CARTRIDGE. A RANGE SAFETY FACTOR OF 10 PERCENT IS ADDED TO THE ESTIMATED RANGE LIMIT DETERMINED USING TABLES B, C, AND D TO PROVIDE A SAFETY BUFFER ZONE AND TO ACCOUNT FOR THE VARIABILITY (ROUND TO ROUND AND OCCASION TO OCCASION) OF THE AMMUNITION AND THE INTERACTION AMONG THE NONSTANDARD CONDITIONS. IN GENERAL, PLUS SIGNS ARE OMITTED FROM THESE TABLES, THEREFORE, NUMBERS WITHOUT SIGNS ARE CONSIDERED TO BE POSITIVE. THE CONTENTS OF THESE TABLES ARE DESCRIBED BELOW.

TABLE A

BASIC DATA—A COMPILATION FOR THE BASIC DATA REQUIRED FOR THE TANK FIRE CONTROL SOLUTION.

COLUMN

1	RANGE—THE DISTANCE MEASURED FROM THE MUZZLE TO A TARGET AT THE LEVEL POINT UNDER STANDARD CONDITIONS
2	SUPERELEVATION—THE GUN ANGLE IN THE VERTICAL PLANE ABOVE THE LINE OF SIGHT REQUIRED TO REACH THE RANGE LISTED IN COLUMN 1.
3	DR / DSE—THE ADJUSTMENT IN RANGE FOR A 1 MIL CHANGE IN THE ANGLE OF SUPERELEVATION LISTED IN COLUMN 2.
4	DH / DR—CHANGE IN THE HEIGHT OF THE TRAJECTORY CORRESPONDING TO AN INCREASE OF 100 METERS TO THE RANGE LISTED IN COLUMN 1 WITH THE APPROPRIATE CHANGE IN THE ANGLE OF SUPERELEVATION.
5	DRIFT—WHEN PROJECTILES ARE SPUN FOR STABILIZATION PURPOSES BY GUN TUBES WITH A RIGHT–HANDED TWIST OF RIFLING, THE DRIFT OF THE PROJECTILE IS TO THE RIGHT OF THE VERTICAL PLANE OF FIRE. DRIFT IS THE ANGULAR DISPLACEMENT A PROJECTILE WILL INCUR WHEN IT IS SPUN.

Figure B-12. 25mm M791 explanation of tables

COLUMN	
6	TIME OF FLIGHT—THE PROJECTILE TRAVEL TIME, UNDER STANDARD CONDITIONS, FROM THE MUZZLE TO THE LEVEL POINT AT THE RANGE LISTED IN COLUMN 1.
7	10 KM/HR CROSSWIND DEFLECTION—THE EFFECT TABULATED IN THIS COLUMN IS USED WHEN DETERMINING THE CHANGE IN TRAVERSE ANGLE NEEDED TO OFFSET THE CROSSWIND WHICH CREATES A DEFLECTION EFFECT. THE LISTED EFFECT OF WIND DEFLECTION ASSUMES A 10 KM/HR CROSSWIND; THE CORRECTION FOR WHICH IS APPLIED INTO THE WIND. THEREFORE, IF THE WIND IS BLOWING FROM LEFT TO RIGHT, CORRECT TO THE RIGHT. THE WIND EFFECT CAN BE DETERMINED FOR ANY CROSSWIND SPEED BY APPLYING THE APPROPRIATE FACTOR TO THE 10 KM/HR CROSSWIND COLUMN. FOR EXAMPLE, IF THE OBSERVED CROSSWIND IS 5 KM/HR, THE EFFECT IS HALVED OR IF THE CROSSWIND IS 20 KM/HR, THE EFFECT IS DOUBLED.
8	MAXIMUM ORDINATE—THE MAXIMUM HEIGHT OF THE TRAJECTORY ABOVE THE GUN, UNDER STANDARD CONDITIONS, TO THE RANGE IN COLUMN 1.
9	RANGE TO MAXIMUM ORDINATE—THE DISTANCE IN THE HORIZONTAL PLANE MEASURED FROM THE GUN MUZZLE TO THE POINT PERPENDICULAR TO THE MAXIMUM ORDINATE LISTED IN COLUMN 8.
10	ANGLE OF FALL—THE LEAST ANGLE MEASURED CLOCKWISE FROM THE HORIZONTAL TO A LINE TANGENT TO THE TRAJECTORY AT THE LEVEL POINT.
11	REMAINING VELOCITY—THE SPEED OF THE PROJECTILE AT THE LEVEL POINT.

Legend:
KM/HR—Kilometers per Hour

Figure B-12. 25mm M791 explanation of tables (continued)

TABLE B

MAXIMUM ORDINATE, RANGE AND EFFECT ON RANGE—RANGE EFFECTS FOR THE NONSTANDARD CONDITIONS OF MUZZLE VELOCITY, RANGE WIND, AND AIR DENSITY

COLUMN

1	QUADRANT ELEVATION —THE ANGLE OF THE GUN IN THE VERTICAL PLANE REQUIRED TO REACH THE RANGE TABULATED IN COLUMN 3. THE FINAL ENTRY IN THIS COLUMN IS THE ELEVATION ANGLE WHICH PRODUCES THE MAXIMUM RANGE UNDER STANDARD CONDITIONS ROUNDED TO THE NEAREST WHOLE DEGREE.
2	MAXIMUM ORDINATE—THE MAXIMUM HEIGHT FOR THE TRAJECTORY ABOVE THE GUN, UNDER STANDARD CONDITIONS, TO THE RANGE IN COLUMN 3.
3	RANGE—THE DISTANCE MEASURED FROM THE MUZZLE TO A TARGET AT THE LEVEL POINT UNDER STANDARD CONDITIONS.
4—5	RANGE EFFECTS FOR A DECREASE (INCREASE) OF 1 METER PER SECOND IN MUZZLE VELOCITY—EFFECTS ON RANGE CAUSED BY VARIATIONS FROM THE STANDARD MUZZLE VELOCITY.
6—7	RANGE EFFECTS FOR A HEAD WIND (TAIL WIND) OF 1 KILOMETER PER HOUR—EFFECTS ON RANGE CAUSED BY A WIND BLOWING AGAINST (WITH) THE SHELL.
8—9	RANGE EFFECTS FOR A DECREASE (INCREASE) OF 1 PERCENT IN AIR DENSITY—EFFECTS ON RANGE CAUSED BY VARIATIONS FROM STANDARD AIR DENSITY (1,225 GRAMS PER CUBIC METER AT SEA LEVEL).

Figure B-12. 25mm M791 explanation of tables (continued)

TABLE C

EFFECTS ON MUZZLE VELOCITY DUE TO AMMUNITION TEMPERATURE—THE CHANGES IN MUZZLE VELOCITY PRODUCED BY VARIATIONS IN AMMUNITION TEMPERATURE. COLUMNS 1 AND 3 LIST THE AMMUNITION TEMPERATURE IN DEGREES FAHRENHEIT AND DEGREES CELSIUS, RESPECTIVELY. COLUMN 2 LISTS THE EFFECT ON MUZZLE VELOCITY CAUSED BY THE CORRESPONDING AMMUNITION TEMPERATURE VARIATION. WHENEVER POSSIBLE, THE TEMPERATURE OF THE AMMUNITION ITSELF SHOULD BE MEASURED, RATHER THAN ASSUMING THAT IT IS THE SAME AS AIR TEMPERATURE. THE CHANGE IN MUZZLE VELOCITY IS CONVERTED TO A RANGE EFFECT USING COLUMNS 4 OR 5 OF TABLE B.

TABLE D

EFFECTS ON AIR DENSITY DUE TO ALTITUDE—CORRECTIONS TO THE STANDARD AIR DENSITY FOR THE ALTITUDE OF THE FIRING UNIT. COLUMN 1 LISTS THE ALTITUDE IN METERS AND COLUMN 2 LISTS THE CORRESPONDING PERCENTAGE DECREASE IN AIR DENSITY. THE STANDARD AIR DENSITY VALUE AT SEA LEVEL IS 1,225 GRAMS PER CUBIC METER (100 PERCENT). WHENEVER POSSIBLE, THE ACTUAL AIR DENSITY AND ITS VARIATION FROM THE STANDARD SHOULD BE COMPUTED AND USED INSTEAD OF THE STANDARD VARIATION WITH ALTITUDE SHOWN IN THIS TABLE. THE AIR DENSITY EFFECT IS CONVERTED TO A RANGE EFFECT USING COLUMN 8 OR 9 OF TABLE B.

Figure B-12. 25mm M791 explanation of tables (continued)

TABLE A
BASIC DATA

1	2	3	4	5	6	7	8	9	10	11
RANGE	SUPER–ELEVATION	DR / DSE	DH / DR	DRIFT	TIME OF FLIGHT	10 KM/HR CROSSWIND DEFLECTION	MAXIMUM ORDINATE	RANGE TO MAXIMUM ORDINATE	ANGLE OF FALL	REMAINING VELOCITY
METERS	MILS	M/MIL	M/100M	MILS	SEC	MILS	METERS	METERS	MILS	M/SEC
0	0.00	352	0.00	0.00	0.00	0.00	0.0	0	0	1345
100	0.28	346	0.0	0.0	0.07	0.0	0.0	50	0	1328
200	0.56	340	0.1	0.0	0.15	0.0	0.0	101	1	1311
300	0.85	334	0.1	0.0	0.23	0.0	0.1	151	1	1294
400	1.14	329	0.1	0.0	0.31	0.1	0.1	202	1	1277
500	1.44	323	0.1	0.0	0.38	0.1	0.2	253	2	1260
600	1.75	317	0.2	0.0	0.46	0.1	0.3	304	2	1243
700	2.06	312	0.2	0.0	0.55	0.1	0.4	356	2	1226
800	2.37	306	0.3	0.0	0.63	0.1	0.5	407	3	1209
900	2.69	301	0.3	0.0	0.71	0.1	0.6	459	3	1193
1000	3.02	295	0.3	0.0	0.79	0.1	0.8	511	3	1176
1100	3.35	290	0.4	0.1	0.88	0.2	0.9	564	4	1159
1200	3.69	284	0.4	0.1	0.97	0.2	1.1	617	4	1143
1300	4.04	279	0.5	0.1	1.06	0.2	1.4	669	5	1126
1400	4.39	273	0.5	0.1	1.15	0.2	1.6	723	5	1109
1500	4.75	268	0.5	0.1	1.24	0.2	1.9	776	5	1092
1600	5.12	263	0.6	0.1	1.33	0.2	2.2	830	6	1075
1700	5.49	257	0.6	0.1	1.42	0.3	2.5	884	6	1058
1800	5.88	252	0.7	0.1	1.52	0.3	2.8	938	7	1041
1900	6.27	247	0.7	0.1	1.61	0.3	3.2	993	8	1025
2000	6.67	241	0.8	0.1	1.71	0.3	3.6	1048	8	1008
2100	7.08	236	0.9	0.1	1.81	0.3	4.0	1103	9	991
2200	7.49	231	0.9	0.1	1.91	0.4	4.5	1159	9	974
2300	7.92	226	1.0	0.1	2.02	0.4	5.0	1215	10	957
2400	8.36	221	1.1	0.1	2.12	0.4	5.5	1271	11	940
2500	8.80	216	1.1	0.1	2.23	0.4	6.1	1328	11	924
2600	9.26	211	1.2	0.1	2.34	0.4	6.7	1385	12	907
2700	9.73	206	1.3	0.2	2.45	0.5	7.3	1443	13	890
2800	10.21	201	1.4	0.2	2.56	0.5	8.0	1501	14	873
2900	10.70	196	1.4	0.2	2.68	0.5	8.8	1559	14	855
3000	11.21	191	1.5	0.2	2.80	0.5	9.6	1618	15	838
3100	11.73	186	1.6	0.2	2.92	0.6	10.4	1677	16	821
3200	12.26	181	1.7	0.2	3.04	0.6	11.3	1736	17	803
3300	12.80	176	1.8	0.2	3.17	0.6	12.2	1796	18	786
3400	13.37	171	1.9	0.2	3.30	0.6	13.3	1857	19	769
3500	13.94	167	2.0	0.2	3.43	0.7	14.3	1918	21	752
3600	14.54	162	2.2	0.2	3.56	0.7	15.5	1979	22	735
3700	15.15	157	2.3	0.2	3.70	0.7	16.7	2042	23	719
3800	15.78	152	2.4	0.3	3.84	0.8	18.0	2104	24	702
3900	16.43	148	2.6	0.3	3.98	0.8	19.3	2167	26	686
4000	17.11	143	2.7	0.3	4.13	0.8	20.8	2231	27	670
4100	17.80	139	2.9	0.3	4.28	0.9	22.3	2296	29	654
4200	18.51	135	3.0	0.3	4.44	0.9	23.9	2361	31	638
4300	19.25	130	3.2	0.3	4.60	0.9	25.7	2426	32	622
4400	20.02	126	3.4	0.3	4.76	1.0	27.5	2493	34	606
4500	20.81	122	3.6	0.3	4.93	1.0	29.5	2559	36	590
4600	21.62	118	3.8	0.4	5.10	1.0	31.6	2627	38	575
4700	22.47	114	4.1	0.4	5.27	1.1	33.8	2695	41	560
4800	23.35	110	4.3	0.4	5.46	1.1	36.1	2764	43	545
4900	24.26	106	4.6	0.4	5.64	1.2	38.6	2834	45	530
5000	25.20	102	4.8	0.4	5.83	1.2	41.3	2904	48	515

FT 25–A–2, M791

***Legend**:*
DH—Change in Height; DR—Change in Range; DSE—Change in Super Elevation; FT—Firing Table; KM/HR—Kilometers per Hour; M/100M—Meters per 100 Meters; M/MIL—Meters per Mils; M/SEC—Meters per Second; SEC—Second

Figure B-13. 25mm M791 Firing Table A

TABLE B
MAXIMUM ORDINATE, RANGE AND EFFECTS ON RANGE

1	2	3	4	5	6	7	8	9
QUADRANT ELEVATION	MAXIMUM ORDINATE	RANGE	RANGE EFFECTS FOR					
			MUZZLE VELOCITY 1 M/S		RANGE WIND 1 KM/HR		AIR DENSITY 1 PCT	
			DEC	INC	HEAD	TAIL	DEC	INC
DEG	M	M	M	M	M	M	M	M
5	319	8236	-7.0	6.9	-3.0	3.0	62.5	-53.1
10	863	10231	-7.4	7.6	-5.4	5.5	82.7	-69.7
15	1509	11561	-8.2	8.1	-7.6	7.6	98.0	-82.2
20	2233	12563	-8.6	8.6	-9.5	9.5	111.4	-92.9
25	3024	13339	-9.1	9.3	-11.2	11.3	124.3	-102.9
30	3873	13929	-9.9	9.6	-12.9	13.0	135.9	-112.2
35	4770	14333	-10.1	10.6	-14.4	14.6	147.7	-120.2
40	5704	14550	-11.1	10.9	-15.9	16.0	157.6	-127.9
42	6170	14578	-11.3	11.1	-16.5	16.6	162.2	-130.9

FT 25-A-2, M791

TABLE C
EFFECTS ON MUZZLE VELOCITY
DUE TO AMMUNITION TEMPERATURE

TEMPERATURE OF AMMUNITION	EFFECTS ON VELOCITY	TEMPERATURE OF AMMUNITION
DEGREES F	M/S	DEGREES C
-40.0	-59.9	-40.0
-30.0	-54.5	-34.4
-20.0	-49.0	-28.9
-10.0	-43.6	-23.3
0.0	-38.1	-17.8
10.0	-32.7	-12.2
20.0	-27.2	-6.7
30.0	-21.8	-1.1
40.0	-16.3	4.4
50.0	-10.9	10.0
60.0	-5.4	15.6
70.0	0.0	21.1
80.0	5.4	26.7
90.0	10.9	32.2
100.0	16.3	37.8
110.0	21.8	43.3
120.0	27.2	48.9
130.0	32.7	54.4

FT 25-A-2, M791

Legend:
C—Celsius; DEC—Decrease; DEG—Degrees; F—Fahrenheit; FT—Firing Table; INC—Increase; KM/HR—Kilometers per Hour; M—Meters; M/S—Meters per Second; PCT—Percent

Figure B-14. 25mm M791 Firing Tables B and C

TABLE D

EFFECTS ON AIR DENSITY
DUE TO ALTITUDE

ALTITUDE	DECREASE IN AIR DENSITY
METERS	PERCENT
0	0.0
100	1.0
200	1.9
300	2.8
400	3.8
500	4.7
600	5.6
700	6.5
800	7.5
900	8.4
1000	9.3
1100	10.1
1200	11.0
1300	11.9
1400	12.8
1500	13.6
1600	14.5
1700	15.3
1800	16.2
1900	17.0
2000	17.8

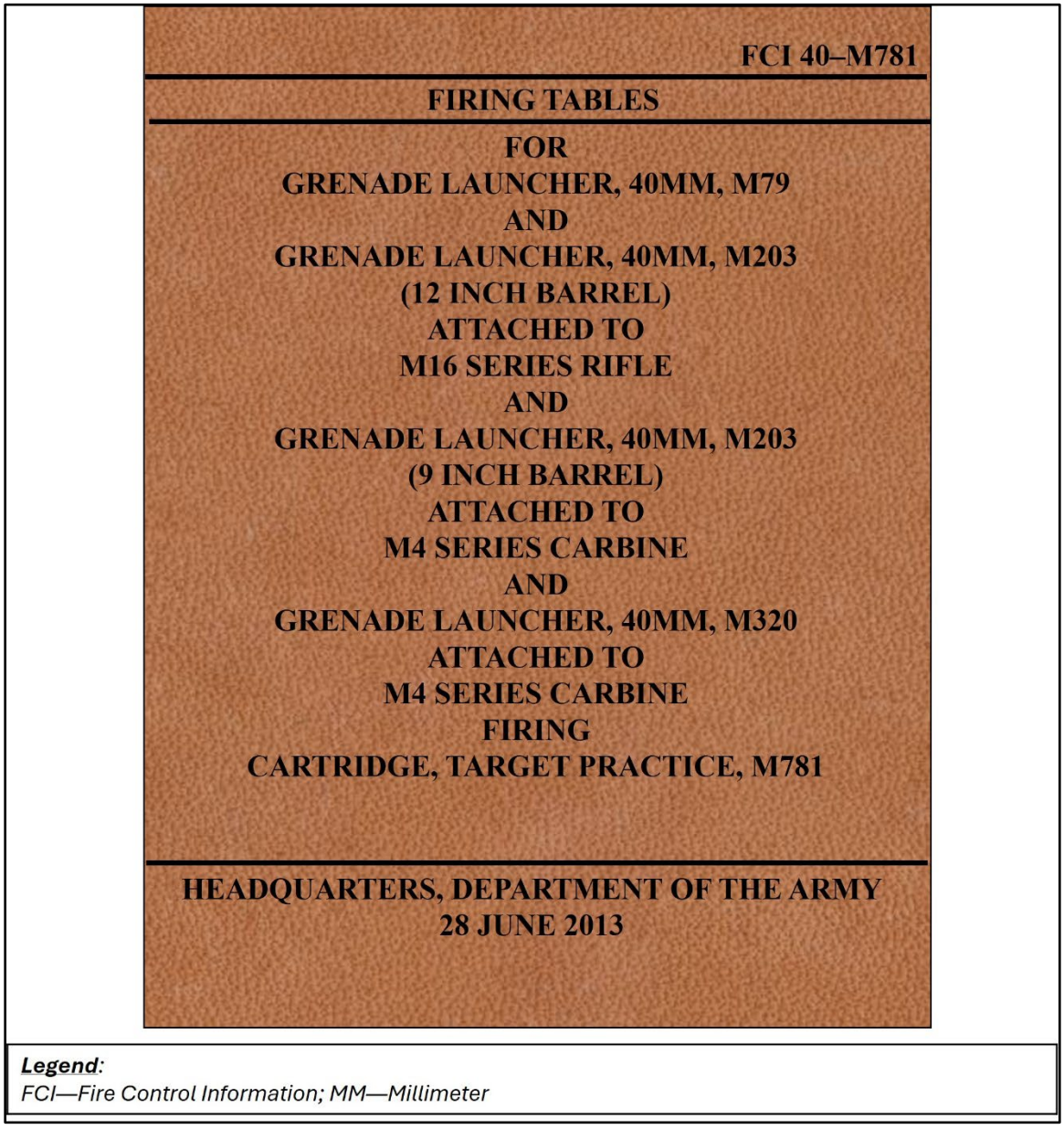
FT 25-A-2, M791

Legend:
FT—Firing Table

Figure B-15. 25mm M791 Firing Table D

40MM

B-4. The next example firing table describes the 40mm M781. Figures B-16 through B-20 through page 175 illustrate its data.



Legend:
FCI—Fire Control Information; MM—Millimeter

Figure B-16. 40mm M781 Firing Tables Cover

EXPLANATION OF TABLES

THIS FIRING TABLE IS DIVIDED INTO 15 SECTIONS, ONE FOR EACH CARTRIDGE. EACH SECTION INCLUDES FOUR TABLES, THAT BASIC FIRING TABLE AND THREE RANGE SAFETY TABLES, USEFUL FOR ESTABLISHING RANGE AND MAXIMUM ORDINATE LIMITS FOR A GIVEN CARTRIDGE. A RANGE SAFETY FACTOR OF 10 PERCENT IS ADDED TO THE ESTIMATED RANGE LIMIT DETERMINED USING TABLES B, C, AND D TO PROVIDE A SAFETY BUFFER ZONE AND TO ACCOUNT FOR THE VARIABILITY (ROUND TO ROUND AND OCCASION TO OCCASION) OF THE AMMUNITION AND THE INTERACTION AMONG THE NONSTANDARD CONDITIONS. IN GENERAL, PLUS SIGNS ARE OMITTED FROM THESE TABLES, THEREFORE, NUMBERS WITHOUT SIGNS ARE CONSIDERED TO BE POSITIVE. THE CONTENTS OF THESE TABLES ARE DESCRIBED BELOW.

TABLE A

BASIC DATA—A COMPILATION FOR THE BASIC DATA REQUIRED FOR THE TANK FIRE CONTROL SOLUTION.

COLUMN

1	RANGE—THE DISTANCE MEASURED FROM THE MUZZLE TO A TARGET AT THE LEVEL POINT UNDER STANDARD CONDITIONS
2	SUPERELEVATION—THE GUN ANGLE IN THE VERTICAL PLANE ABOVE THE LINE OF SIGHT REQUIRED TO REACH THE RANGE LISTED IN COLUMN 1.
3	DR / DSE—THE ADJUSTMENT IN RANGE FOR A 1 MIL CHANGE IN THE ANGLE OF SUPERELEVATION LISTED IN COLUMN 2.
4	DH / DR—CHANGE IN THE HEIGHT OF THE TRAJECTORY CORRESPONDING TO AN INCREASE OF 100 METERS TO THE RANGE LISTED IN COLUMN 1 WITH THE APPROPRIATE CHANGE IN THE ANGLE OF SUPERELEVATION.
5	DRIFT—WHEN PROJECTILES ARE SPUN FOR STABILIZATION PURPOSES BY GUN TUBES WITH A RIGHT–HANDED TWIST OF RIFLING, THE DRIFT OF THE PROJECTILE IS TO THE RIGHT OF THE VERTICAL PLANE OF FIRE. DRIFT IS THE ANGULAR DISPLACEMENT A PROJECTILE WILL INCUR WHEN IT IS SPUN.

Figure B-17. 40mm M781 explanation of tables

COLUMN	
6	TIME OF FLIGHT—THE PROJECTILE TRAVEL TIME, UNDER STANDARD CONDITIONS, FROM THE MUZZLE TO THE LEVEL POINT AT THE RANGE LISTED IN COLUMN 1.
7	10 KM/HR CROSSWIND DEFLECTION—THE EFFECT TABULATED IN THIS COLUMN IS USED WHEN DETERMINING THE CHANGE IN TRAVERSE ANGLE NEEDED TO OFFSET THE CROSSWIND WHICH CREATES A DEFLECTION EFFECT. THE LISTED EFFECT OF WIND DEFLECTION ASSUMES A 10 KM/HR CROSSWIND; THE CORRECTION FOR WHICH IS APPLIED INTO THE WIND. THEREFORE, IF THE WIND IS BLOWING FROM LEFT TO RIGHT, CORRECT TO THE RIGHT. THE WIND EFFECT CAN BE DETERMINED FOR ANY CROSSWIND SPEED BY APPLYING THE APPROPRIATE FACTOR TO THE 10 KM/HR CROSSWIND COLUMN. FOR EXAMPLE, IF THE OBSERVED CROSSWIND IS 5 KM/HR, THE EFFECT IS HALVED OR IF THE CROSSWIND IS 20 KM/HR, THE EFFECT IS DOUBLED.
8	MAXIMUM ORDINATE—THE MAXIMUM HEIGHT OF THE TRAJECTORY ABOVE THE GUN, UNDER STANDARD CONDITIONS, TO THE RANGE IN COLUMN 1.
9	RANGE TO MAXIMUM ORDINATE—THE DISTANCE IN THE HORIZONTAL PLANE MEASURED FROM THE GUN MUZZLE TO THE POINT PERPENDICULAR TO THE MAXIMUM ORDINATE LISTED IN COLUMN 8.
10	ANGLE OF FALL—THE LEAST ANGLE MEASURED CLOCKWISE FROM THE HORIZONTAL TO A LINE TANGENT TO THE TRAJECTORY AT THE LEVEL POINT.
11	REMAINING VELOCITY—THE SPEED OF THE PROJECTILE AT THE LEVEL POINT.

Legend:
KM/HR—Kilometers per Hour

Figure B-17. 40mm M781 explanation of tables (continued)

TABLE B

MAXIMUM ORDINATE, RANGE AND EFFECT ON RANGE—RANGE EFFECTS FOR THE NONSTANDARD CONDITIONS OF MUZZLE VELOCITY, RANGE WIND, AND AIR DENSITY

COLUMN

1	QUADRANT ELEVATION —THE ANGLE OF THE GUN IN THE VERTICAL PLANE REQUIRED TO REACH THE RANGE TABULATED IN COLUMN 3. THE FINAL ENTRY IN THIS COLUMN IS THE ELEVATION ANGLE WHICH PRODUCES THE MAXIMUM RANGE UNDER STANDARD CONDITIONS ROUNDED TO THE NEAREST WHOLE DEGREE.
2	MAXIMUM ORDINATE—THE MAXIMUM HEIGHT FOR THE TRAJECTORY ABOVE THE GUN, UNDER STANDARD CONDITIONS, TO THE RANGE IN COLUMN 3.
3	RANGE—THE DISTANCE MEASURED FROM THE MUZZLE TO A TARGET AT THE LEVEL POINT UNDER STANDARD CONDITIONS.
4—5	RANGE EFFECTS FOR A DECREASE (INCREASE) OF 1 METER PER SECOND IN MUZZLE VELOCITY—EFFECTS ON RANGE CAUSED BY VARIATIONS FROM THE STANDARD MUZZLE VELOCITY.
6—7	RANGE EFFECTS FOR A HEAD WIND (TAIL WIND) OF 1 KILOMETER PER HOUR—EFFECTS ON RANGE CAUSED BY A WIND BLOWING AGAINST (WITH) THE SHELL.
8—9	RANGE EFFECTS FOR A DECREASE (INCREASE) OF 1 PERCENT IN AIR DENSITY—EFFECTS ON RANGE CAUSED BY VARIATIONS FROM STANDARD AIR DENSITY (1,225 GRAMS PER CUBIC METER AT SEA LEVEL).

Figure B-17. 40mm M781 explanation of tables (continued)

TABLE C

EFFECTS ON MUZZLE VELOCITY DUE TO AMMUNITION TEMPERATURE—THE CHANGES IN MUZZLE VELOCITY PRODUCED BY VARIATIONS IN AMMUNITION TEMPERATURE. COLUMNS 1 AND 3 LIST THE AMMUNITION TEMPERATURE IN DEGREES FAHRENHEIT AND DEGREES CELSIUS, RESPECTIVELY. COLUMN 2 LISTS THE EFFECT ON MUZZLE VELOCITY CAUSED BY THE CORRESPONDING AMMUNITION TEMPERATURE VARIATION. WHENEVER POSSIBLE, THE TEMPERATURE OF THE AMMUNITION ITSELF SHOULD BE MEASURED, RATHER THAN ASSUMING THAT IT IS THE SAME AS AIR TEMPERATURE. THE CHANGE IN MUZZLE VELOCITY IS CONVERTED TO A RANGE EFFECT USING COLUMNS 4 OR 5 OF TABLE B.

TABLE D

EFFECTS ON AIR DENSITY DUE TO ALTITUDE—CORRECTIONS TO THE STANDARD AIR DENSITY FOR THE ALTITUDE OF THE FIRING UNIT. COLUMN 1 LISTS THE ALTITUDE IN METERS AND COLUMN 2 LISTS THE CORRESPONDING PERCENTAGE DECREASE IN AIR DENSITY. THE STANDARD AIR DENSITY VALUE AT SEA LEVEL IS 1,225 GRAMS PER CUBIC METER (100 PERCENT). WHENEVER POSSIBLE, THE ACTUAL AIR DENSITY AND ITS VARIATION FROM THE STANDARD SHOULD BE COMPUTED AND USED INSTEAD OF THE STANDARD VARIATION WITH ALTITUDE SHOWN IN THIS TABLE. THE AIR DENSITY EFFECT IS CONVERTED TO A RANGE EFFECT USING COLUMN 8 OR 9 OF TABLE B.

Figure B-17. 40mm M781 explanation of tables (continued)

TABLE A
BASIC DATA

1	2	3	4	5	6	7	8	9	10	11
RANGE	SUPER–ELEVATION	DR / DSE	DH / DR	DRIFT	TIME OF FLIGHT	10 KM/HR CROSSWIND DEFLECTION	MAXIMUM ORDINATE	RANGE TO MAXIMUM ORDINATE	ANGLE OF FALL	REMAINING VELOCITY
METERS	MILS	M/MIL	M/100M	MILS	SEC	MILS	METERS	METERS	MILS	M/SEC
0	0.00	1	0.0	0.0	0.00	0.0	0.0	0	0	75
10	8.93	1	0.9	0.2	0.13	0.5	0.0	5	9	74
20	17.92	1	1.8	0.5	0.27	1.0	0.1	10	18	74
30	27.02	1	2.7	0.7	0.40	1.5	0.2	15	27	73
40	36.21	1	3.6	1.0	0.54	2.0	0.4	20	37	73
50	45.51	1	4.6	1.3	0.68	2.6	0.6	25	47	72
60	54.91	1	5.6	1.5	0.82	3.1	0.8	30	57	72
70	64.43	1	6.6	1.8	0.96	3.6	1.1	35	67	71
80	74.07	1	7.6	2.1	1.10	4.1	1.5	40	77	71
90	83.83	1	8.6	2.3	1.25	4.7	1.9	46	88	70
100	93.73	1	9.7	2.6	1.39	5.2	2.4	51	98	70
110	103.76	1	10.8	2.9	1.54	5.7	2.9	56	109	69
120	113.94	1	11.9	3.2	1.68	6.3	3.5	61	121	69
130	124.26	1	13.1	3.5	1.83	6.8	4.1	66	132	68
140	134.75	1	14.3	3.8	1.99	7.4	4.8	71	144	68
150	145.41	1	15.5	4.1	2.14	8.0	5.6	76	156	67
160	156.24	1	16.7	4.5	2.29	8.5	6.4	82	169	67
170	167.26	1	18.0	4.8	2.45	9.1	7.3	87	182	66
180	178.48	1	19.4	5.1	2.61	9.7	8.3	92	195	66
190	189.92	1	20.7	5.5	2.77	10.3	9.4	97	208	65
200	201.58	1	22.1	5.8	2.93	10.9	10.5	102	222	65
210	213.48	1	23.6	6.2	3.10	11.5	11.8	108	236	64
220	225.63	1	25.1	6.6	3.27	12.1	13.1	113	251	64
230	238.07	1	26.7	7.0	3.44	12.7	14.5	118	266	64
240	250.80	1	28.3	7.4	3.62	13.4	16.0	124	281	63
250	263.85	1	30.0	7.8	3.79	14.0	17.6	129	297	63
260	277.25	1	31.8	8.3	3.98	14.7	19.4	134	313	62
270	291.02	1	33.6	8.7	4.16	15.4	21.2	140	330	62
280	305.21	1	35.5	9.2	4.35	16.1	23.2	145	348	62
290	319.85	1	37.6	9.7	4.55	16.8	25.3	150	366	61
300	334.99	1	39.7	10.3	4.75	17.5	27.6	156	385	61
310	350.69	1	41.9	10.8	4.95	18.3	30.0	161	404	60
320	367.02	1	44.3	11.4	5.16	19.1	32.7	166	424	60
330	384.05	1	46.8	12.1	5.38	19.9	35.5	172	446	60
340	401.90	1	49.5	12.7	5.61	20.7	38.6	177	468	59
350	420.69	1	52.3	13.5	5.85	21.6	41.9	183	491	59
360	440.58	0	55.4	14.3	6.10	22.6	45.5	188	515	59
370	461.81	0	58.8	15.1	6.36	23.6	49.5	194	542	59
380	484.69	0	62.6	16.1	6.64	24.7	53.9	199	569	58
390	509.66	0	66.8	17.2	6.93	25.9	58.9	205	600	58
400	537.45	0	71.7	18.4	7.26	27.2	64.6	210	633	58
410	569.28	0	77.4	19.9	7.63	28.7	71.3	216	671	58
420	607.71	0	84.7	21.9	8.06	30.5	79.5	221	715	58
430	660.14	0	95.3	24.7	8.63	33.0	91.2	227	775	58

FCI 40, M781

Legend:
DH—Change in Height; DR—Change in Range; DSE—Change in Super Elevation; FCI—Fire Control Information; KM/HR—Kilometers per Hour; M/100M—Meters per 100 Meters; M/MIL—Meters per Mils; M/SEC—Meters per Second; SEC—Second

Figure B-18. 40mm M781 Firing Table A

TABLE B
MAXIMUM ORDINATE, RANGE AND EFFECTS ON RANGE

1	2	3	4	5	6	7	8	9
QUADRANT ELEVATION	MAXIMUM ORDINATE	RANGE	RANGE EFFECTS FOR					
			MUZZLE VELOCITY 1 M/S		RANGE WIND 1 KM/HR		AIR DENSITY 1 PCT	
			DEC	INC	HEAD	TAIL	DEC	INC
DEG	M	M	M	M	M	M	M	M
5	2	95	-2.3	2.5	-0.1	0.1	0.0	0.0
10	8	179	-4.2	4.6	-0.4	0.3	0.2	-0.2
15	18	252	-5.7	6.1	-0.8	0.7	0.3	-0.3
20	31	313	-6.9	7.3	-1.3	1.0	0.5	-0.4
25	46	362	-7.8	8.2	-1.8	1.4	0.6	-0.6
30	64	399	-8.4	8.8	-2.3	1.8	0.8	-0.7
35	83	423	-8.8	9.1	-2.7	2.1	0.9	-0.8
40	103	436	-9.0	9.2	-3.1	2.2	1.0	-0.9
43	114	437	-9.0	9.2	-3.3	2.3	1.0	-0.9

FCI 40, M781

TABLE C
EFFECTS ON MUZZLE VELOCITY
DUE TO AMMUNITION TEMPERATURE

TEMPERATURE OF AMMUNITION	EFFECTS ON VELOCITY	TEMPERATURE OF AMMUNITION
DEGREES F	M/S	DEGREES C
-40.0	-1.0	-40.0
-30.0	-1.0	-34.4
-20.0	-0.9	-28.9
-10.0	-0.9	-23.3
0.0	-0.8	-17.8
10.0	-0.8	-12.2
20.0	-0.7	-6.7
30.0	-0.6	-1.1
40.0	-0.4	4.4
50.0	-0.3	10.0
60.0	-0.2	15.6
70.0	0.0	21.1
80.0	0.2	26.7
90.0	0.4	32.2
100.0	0.6	37.8
110.0	0.8	43.3
120.0	1.0	48.9
130.0	1.3	54.4

FCI 40, M781

Legend:
C—Celsius; DEC—Decrease; DEG—Degrees; F—Fahrenheit; FCI—Fire Control Information; INC—Increase; KM/HR—Kilometers per Hour; M—Meters; M/S—Meters per Second; PCT—Percent

Figure B-19. 40mm M781 Firing Tables B and C

TABLE D

EFFECTS ON AIR DENSITY
DUE TO ALTITUDE

ALTITUDE	DECREASE IN AIR DENSITY
METERS	PERCENT
0	0.0
100	1.0
200	1.9
300	2.8
400	3.8
500	4.7
600	5.6
700	6.5
800	7.5
900	8.4
1000	9.3
1100	10.1
1200	11.0
1300	11.9
1400	12.8
1500	13.6
1600	14.5
1700	15.3
1800	16.2
1900	17.0
2000	17.8

FCI 40, M781

Legend:
FCI—Fire Control Information

Figure B-20. 40mm M781 Firing Table D

.50 CAL

B-5. The next example firing table describes the .50 CAL M8. Figures B-21 through B-25 through page 183 illustrate its data.

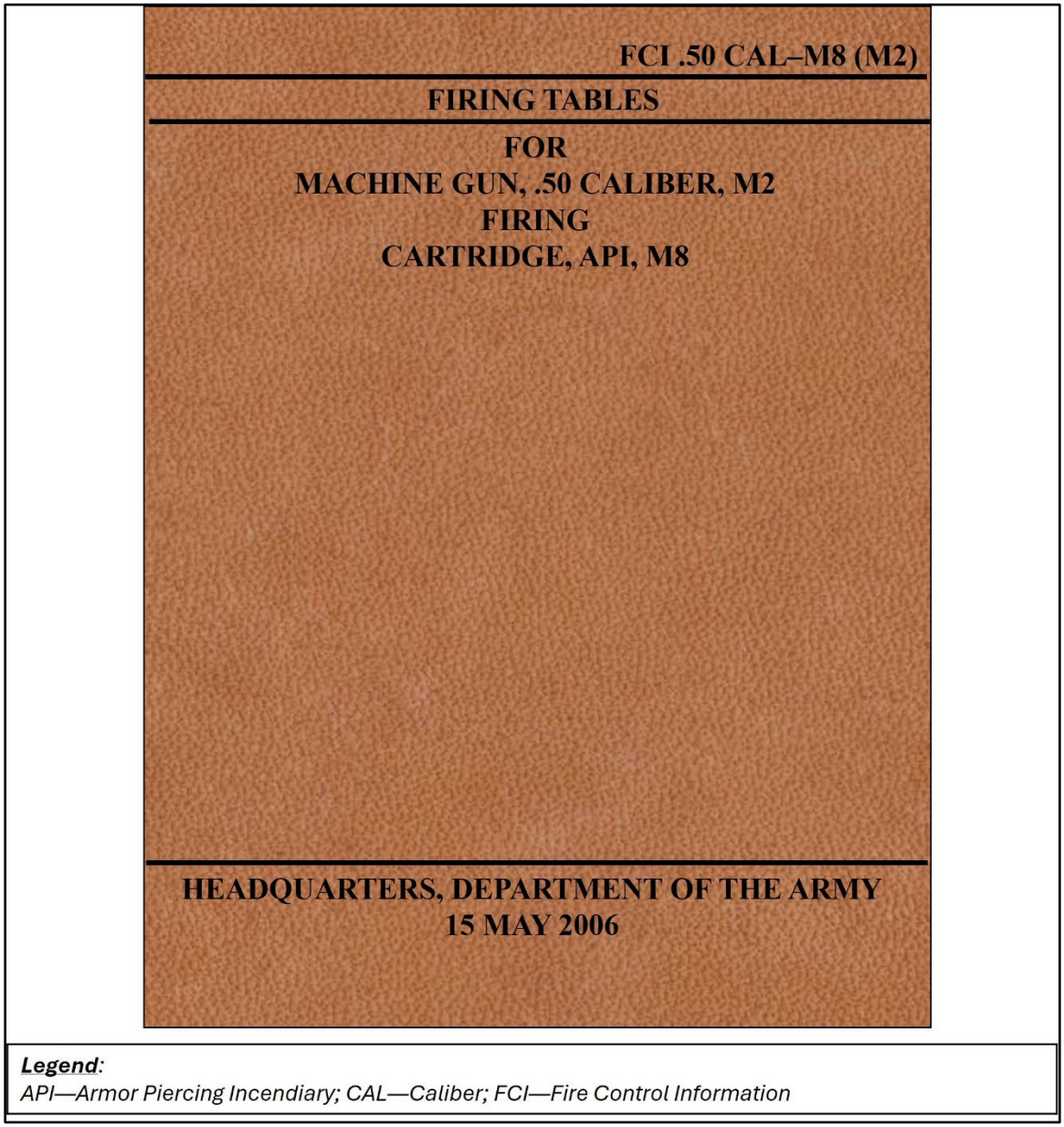


Figure B-21. .50 CAL M8 Firing Tables Cover

EXPLANATION OF TABLES

THIS FIRING TABLE IS DIVIDED INTO 15 SECTIONS, ONE FOR EACH CARTRIDGE. EACH SECTION INCLUDES FOUR TABLES, THAT BASIC FIRING TABLE AND THREE RANGE SAFETY TABLES, USEFUL FOR ESTABLISHING RANGE AND MAXIMUM ORDINATE LIMITS FOR A GIVEN CARTRIDGE. A RANGE SAFETY FACTOR OF 10 PERCENT IS ADDED TO THE ESTIMATED RANGE LIMIT DETERMINED USING TABLES B, C, AND D TO PROVIDE A SAFETY BUFFER ZONE AND TO ACCOUNT FOR THE VARIABILITY (ROUND TO ROUND AND OCCASION TO OCCASION) OF THE AMMUNITION AND THE INTERACTION AMONG THE NONSTANDARD CONDITIONS. IN GENERAL, PLUS SIGNS ARE OMITTED FROM THESE TABLES, THEREFORE, NUMBERS WITHOUT SIGNS ARE CONSIDERED TO BE POSITIVE. THE CONTENTS OF THESE TABLES ARE DESCRIBED BELOW.

TABLE A

BASIC DATA—A COMPILATION FOR THE BASIC DATA REQUIRED FOR THE TANK FIRE CONTROL SOLUTION.

COLUMN

1	RANGE—THE DISTANCE MEASURED FROM THE MUZZLE TO A TARGET AT THE LEVEL POINT UNDER STANDARD CONDITIONS
2	SUPERELEVATION—THE GUN ANGLE IN THE VERTICAL PLANE ABOVE THE LINE OF SIGHT REQUIRED TO REACH THE RANGE LISTED IN COLUMN 1.
3	DR / DSE—THE ADJUSTMENT IN RANGE FOR A 1 MIL CHANGE IN THE ANGLE OF SUPERELEVATION LISTED IN COLUMN 2.
4	DH / DR—CHANGE IN THE HEIGHT OF THE TRAJECTORY CORRESPONDING TO AN INCREASE OF 100 METERS TO THE RANGE LISTED IN COLUMN 1 WITH THE APPROPRIATE CHANGE IN THE ANGLE OF SUPERELEVATION.
5	DRIFT—WHEN PROJECTILES ARE SPUN FOR STABILIZATION PURPOSES BY GUN TUBES WITH A RIGHT–HANDED TWIST OF RIFLING, THE DRIFT OF THE PROJECTILE IS TO THE RIGHT OF THE VERTICAL PLANE OF FIRE. DRIFT IS THE ANGULAR DISPLACEMENT A PROJECTILE WILL INCUR WHEN IT IS SPUN.

Figure B-22. .50 CAL M8 explanation of tables

COLUMN	
6	TIME OF FLIGHT—THE PROJECTILE TRAVEL TIME, UNDER STANDARD CONDITIONS, FROM THE MUZZLE TO THE LEVEL POINT AT THE RANGE LISTED IN COLUMN 1.
7	10 KM/HR CROSSWIND DEFLECTION—THE EFFECT TABULATED IN THIS COLUMN IS USED WHEN DETERMINING THE CHANGE IN TRAVERSE ANGLE NEEDED TO OFFSET THE CROSSWIND WHICH CREATES A DEFLECTION EFFECT. THE LISTED EFFECT OF WIND DEFLECTION ASSUMES A 10 KM/HR CROSSWIND; THE CORRECTION FOR WHICH IS APPLIED INTO THE WIND. THEREFORE, IF THE WIND IS BLOWING FROM LEFT TO RIGHT, CORRECT TO THE RIGHT. THE WIND EFFECT CAN BE DETERMINED FOR ANY CROSSWIND SPEED BY APPLYING THE APPROPRIATE FACTOR TO THE 10 KM/HR CROSSWIND COLUMN. FOR EXAMPLE, IF THE OBSERVED CROSSWIND IS 5 KM/HR, THE EFFECT IS HALVED OR IF THE CROSSWIND IS 20 KM/HR, THE EFFECT IS DOUBLED.
8	MAXIMUM ORDINATE—THE MAXIMUM HEIGHT OF THE TRAJECTORY ABOVE THE GUN, UNDER STANDARD CONDITIONS, TO THE RANGE IN COLUMN 1.
9	RANGE TO MAXIMUM ORDINATE—THE DISTANCE IN THE HORIZONTAL PLANE MEASURED FROM THE GUN MUZZLE TO THE POINT PERPENDICULAR TO THE MAXIMUM ORDINATE LISTED IN COLUMN 8.
10	ANGLE OF FALL—THE LEAST ANGLE MEASURED CLOCKWISE FROM THE HORIZONTAL TO A LINE TANGENT TO THE TRAJECTORY AT THE LEVEL POINT.
11	REMAINING VELOCITY—THE SPEED OF THE PROJECTILE AT THE LEVEL POINT.

Legend:
KM/HR—Kilometers per Hour

Figure B-22. .50 CAL M8 explanation of tables (continued)

TABLE B

MAXIMUM ORDINATE, RANGE AND EFFECT ON RANGE—RANGE EFFECTS FOR THE NONSTANDARD CONDITIONS OF MUZZLE VELOCITY, RANGE WIND, AND AIR DENSITY

COLUMN

1	QUADRANT ELEVATION —THE ANGLE OF THE GUN IN THE VERTICAL PLANE REQUIRED TO REACH THE RANGE TABULATED IN COLUMN 3. THE FINAL ENTRY IN THIS COLUMN IS THE ELEVATION ANGLE WHICH PRODUCES THE MAXIMUM RANGE UNDER STANDARD CONDITIONS ROUNDED TO THE NEAREST WHOLE DEGREE.
2	MAXIMUM ORDINATE—THE MAXIMUM HEIGHT FOR THE TRAJECTORY ABOVE THE GUN, UNDER STANDARD CONDITIONS, TO THE RANGE IN COLUMN 3.
3	RANGE—THE DISTANCE MEASURED FROM THE MUZZLE TO A TARGET AT THE LEVEL POINT UNDER STANDARD CONDITIONS.
4—5	RANGE EFFECTS FOR A DECREASE (INCREASE) OF 1 METER PER SECOND IN MUZZLE VELOCITY—EFFECTS ON RANGE CAUSED BY VARIATIONS FROM THE STANDARD MUZZLE VELOCITY.
6—7	RANGE EFFECTS FOR A HEAD WIND (TAIL WIND) OF 1 KILOMETER PER HOUR—EFFECTS ON RANGE CAUSED BY A WIND BLOWING AGAINST (WITH) THE SHELL.
8—9	RANGE EFFECTS FOR A DECREASE (INCREASE) OF 1 PERCENT IN AIR DENSITY—EFFECTS ON RANGE CAUSED BY VARIATIONS FROM STANDARD AIR DENSITY (1,225 GRAMS PER CUBIC METER AT SEA LEVEL).

Figure B-22. .50 CAL M8 explanation of tables (continued)

TABLE C

EFFECTS ON MUZZLE VELOCITY DUE TO AMMUNITION TEMPERATURE—THE CHANGES IN MUZZLE VELOCITY PRODUCED BY VARIATIONS IN AMMUNITION TEMPERATURE. COLUMNS 1 AND 3 LIST THE AMMUNITION TEMPERATURE IN DEGREES FAHRENHEIT AND DEGREES CELSIUS, RESPECTIVELY. COLUMN 2 LISTS THE EFFECT ON MUZZLE VELOCITY CAUSED BY THE CORRESPONDING AMMUNITION TEMPERATURE VARIATION. WHENEVER POSSIBLE, THE TEMPERATURE OF THE AMMUNITION ITSELF SHOULD BE MEASURED, RATHER THAN ASSUMING THAT IT IS THE SAME AS AIR TEMPERATURE. THE CHANGE IN MUZZLE VELOCITY IS CONVERTED TO A RANGE EFFECT USING COLUMNS 4 OR 5 OF TABLE B.

TABLE D

EFFECTS ON AIR DENSITY DUE TO ALTITUDE—CORRECTIONS TO THE STANDARD AIR DENSITY FOR THE ALTITUDE OF THE FIRING UNIT. COLUMN 1 LISTS THE ALTITUDE IN METERS AND COLUMN 2 LISTS THE CORRESPONDING PERCENTAGE DECREASE IN AIR DENSITY. THE STANDARD AIR DENSITY VALUE AT SEA LEVEL IS 1,225 GRAMS PER CUBIC METER (100 PERCENT). WHENEVER POSSIBLE, THE ACTUAL AIR DENSITY AND ITS VARIATION FROM THE STANDARD SHOULD BE COMPUTED AND USED INSTEAD OF THE STANDARD VARIATION WITH ALTITUDE SHOWN IN THIS TABLE. THE AIR DENSITY EFFECT IS CONVERTED TO A RANGE EFFECT USING COLUMN 8 OR 9 OF TABLE B.

Figure B-22. .50 CAL M8 explanation of tables (continued)

TABLE A
BASIC DATA

1	2	3	4	5	6	7	8	9	10	11
RANGE	SUPER–ELEVATION	DR / DSE	DH / DR	DRIFT	TIME OF FLIGHT	10 KM/HR CROSSWIND DEFLECTION	MAXIMUM ORDINATE	RANGE TO MAXIMUM ORDINATE	ANGLE OF FALL	REMAINING VELOCITY
METERS	MILS	M/MIL	M/100M	MILS	SEC	MILS	METERS	METERS	MILS	M/SEC
0	0.00	152	0.0	0.0	0.00	0.0	0.0	0	0	899
100	0.64	142	0.1	0.0	0.11	0.1	0.0	51	1	850
200	1.33	132	0.1	0.0	0.24	0.2	0.1	103	1	803
300	2.08	123	0.2	0.0	0.36	0.3	0.2	156	2	758
400	2.89	113	0.3	0.1	0.50	0.4	0.3	210	3	714
500	3.77	105	0.4	0.1	0.64	0.5	0.5	265	5	672
600	4.72	97	0.6	0.1	0.80	0.6	0.8	320	6	632
700	5.76	89	0.7	0.1	0.96	0.7	1.1	377	8	594
800	6.90	82	0.9	0.1	1.13	0.9	1.6	435	9	558
900	8.13	75	1.1	0.2	1.32	1.0	2.1	494	12	523
1000	9.49	68	1.4	0.2	1.52	1.1	2.8	554	14	489
1100	10.98	62	1.7	0.2	1.73	1.3	3.7	615	17	458
1200	12.62	57	2.0	0.3	1.95	1.5	4.7	678	21	427
1300	14.43	51	2.4	0.3	2.20	1.6	6.0	741	25	398
1400	16.43	46	2.9	0.3	2.46	1.8	7.5	806	29	370
1500	18.65	42	3.4	0.4	2.74	2.0	9.3	872	35	346
1600	21.12	38	4.1	0.4	3.04	2.2	11.5	939	41	328
1700	23.84	35	4.7	0.5	3.35	2.4	14.1	1007	48	319
1800	26.81	32	5.5	0.5	3.66	2.6	17.1	1075	55	310
1900	30.01	30	6.2	0.6	3.99	2.8	20.6	1141	63	302
2000	33.43	28	7.0	0.6	4.33	3.0	24.5	1206	71	295
2100	37.08	26	7.8	0.7	4.67	3.1	29.0	1270	79	288
2200	40.95	25	8.6	0.8	5.02	3.3	33.9	1331	87	281
2300	45.04	24	9.5	0.8	5.39	3.5	39.3	1391	96	274
2400	49.35	23	10.4	0.9	5.76	3.6	45.3	1448	106	267
2500	53.88	21	11.4	1.0	6.14	3.8	51.9	1504	115	261
2600	58.63	20	12.4	1.1	6.53	4.0	59.0	1559	126	254
2700	63.61	20	13.5	1.1	6.93	4.1	66.8	1613	137	248
2800	68.83	19	14.7	1.2	7.34	4.3	75.2	1668	148	243
2900	74.28	18	15.9	1.3	7.77	4.4	84.3	1723	160	237
3000	79.99	17	17.1	1.4	8.20	4.6	94.1	1779	173	231
3100	85.95	16	18.5	1.5	8.65	4.7	104.6	1836	186	226
3200	92.17	16	19.9	1.7	9.11	4.9	116.0	1894	200	221
3300	98.67	15	21.4	1.8	9.58	5.0	128.3	1952	215	216
3400	105.46	14	23.0	1.9	10.06	5.2	141.5	2011	231	211
3500	112.54	14	24.7	2.0	10.55	5.4	155.7	2070	247	207
3600	119.93	13	26.5	2.2	11.06	5.5	171.0	2130	264	202
3700	127.65	13	28.4	2.3	11.59	5.7	187.4	2191	282	198
3800	135.71	12	30.4	2.5	12.13	5.9	205.1	2252	301	194
3900	144.13	12	32.5	2.6	12.68	6.0	224.0	2313	320	190
4000	152.93	11	34.8	2.8	13.25	6.2	244.3	2376	341	186
4100	162.13	11	37.2	3.0	13.84	6.4	266.1	2438	363	183
4200	171.75	10	39.7	3.2	14.45	6.5	289.6	2501	385	180
4300	181.81	10	42.4	3.4	15.07	6.7	314.7	2565	409	176
4400	192.36	9	45.3	3.6	15.71	6.9	341.8	2628	433	174
4500	203.41	9	48.3	3.8	16.38	7.1	370.9	2693	459	171
4600	215.01	8	51.6	4.1	17.07	7.3	402.2	2757	485	168
4700	227.21	8	55.1	4.3	17.78	7.5	435.8	2822	513	166
4800	240.05	8	58.8	4.6	18.52	7.7	472.2	2887	542	164
4900	253.59	7	62.8	4.9	19.28	7.9	511.4	2953	571	162
5000	267.91	7	67.1	5.2	20.08	8.1	553.9	3019	602	160

FCI .50 CAL–M8 (M2)

Legend:
CAL—Caliber; DH—Change in Height; DR—Change in Range; DSE—Change in Super Elevation; FCI—Fire Control Information; KM/HR—Kilometers per Hour; M/100M—Meters per 100 Meters; M/MIL—Meters per Mils; M/SEC—Meters per Second; SEC—Second

Figure B-23. .50 CAL M8 Firing Table A

TABLE B
MAXIMUM ORDINATE, RANGE AND EFFECTS ON RANGE

1	2	3	4	5	6	7	8	9
QUADRANT ELEVATION	MAXIMUM ORDINATE	RANGE	RANGE EFFECTS FOR					
			MUZZLE VELOCITY 1 M/S		RANGE WIND 1 KM/HR		AIR DENSITY 1 PCT	
			DEC	INC	HEAD	TAIL	DEC	INC
DEG	M	M	M	M	M	M	M	M
5	110	3152	-2.5	2.6	-2.2	2.2	18.7	-16.1
10	305	4264	-2.6	2.6	-3.9	4.0	26.9	-23.2
15	551	4994	-2.6	2.6	-5.3	5.5	33.3	-28.6
20	834	5506	-2.7	2.5	-6.6	6.8	38.4	-33.0
25	1145	5859	-2.8	2.5	-7.7	7.9	42.5	-36.3
30	1477	6082	-2.9	2.4	-8.8	9.0	45.5	-38.9
35	1822	6188	-2.9	2.4	-9.7	9.9	47.7	-40.6
37	1978	6199	-2.8	2.4	-10.1	10.3	48.3	-41.1

FCI .50 CAL-M8 (M2)

TABLE C
EFFECTS ON MUZZLE VELOCITY
DUE TO AMMUNITION TEMPERATURE

TEMPERATURE OF AMMUNITION	EFFECTS ON VELOCITY	TEMPERATURE OF AMMUNITION
DEGREES F	M/S	DEGREES C
-40.0	-40.4	-40.0
-30.0	-36.7	-34.4
-20.0	-33.0	-28.9
-10.0	-29.3	-23.3
0.0	-25.7	-17.8
10.0	-22.0	-12.2
20.0	-18.3	-6.7
30.0	-14.7	-1.1
40.0	-11.0	4.4
50.0	-7.3	10.0
60.0	-3.7	15.6
70.0	0.0	21.1
80.0	3.7	26.7
90.0	7.3	32.2
100.0	11.0	37.8
110.0	14.7	43.3
120.0	18.3	48.9
130.0	22.0	54.4

FCI .50 CAL-M8 (M2)

Legend:
C—Celsius; CAL—Caliber; DEC—Decrease; DEG—Degrees; F—Fahrenheit; FCI—Fire Control Information; INC—Increase; KM/HR—Kilometers per Hour; M—Meters; M/S—Meters per Second; PCT—Percent

Figure B-24. .50 CAL M8 Firing Tables B and C

TABLE D

EFFECTS ON AIR DENSITY
DUE TO ALTITUDE

ALTITUDE	DECREASE IN AIR DENSITY
METERS	PERCENT
0	0.0
100	1.0
200	1.9
300	2.8
400	3.8
500	4.7
600	5.6
700	6.5
800	7.5
900	8.4
1000	9.3
1100	10.1
1200	11.0
1300	11.9
1400	12.8
1500	13.6
1600	14.5
1700	15.3
1800	16.2
1900	17.0
2000	17.8

FCI .50 CAL-M8 (M2)

***Legend**:*
CAL—Caliber; FCI—Fire Control Information

Figure B-25. .50 CAL M8 Firing Table D

7.62MM

B-6. The next example firing table describes the 7.62mm M-80. Figures B-26 through B-30 through page 191 illustrate its data.

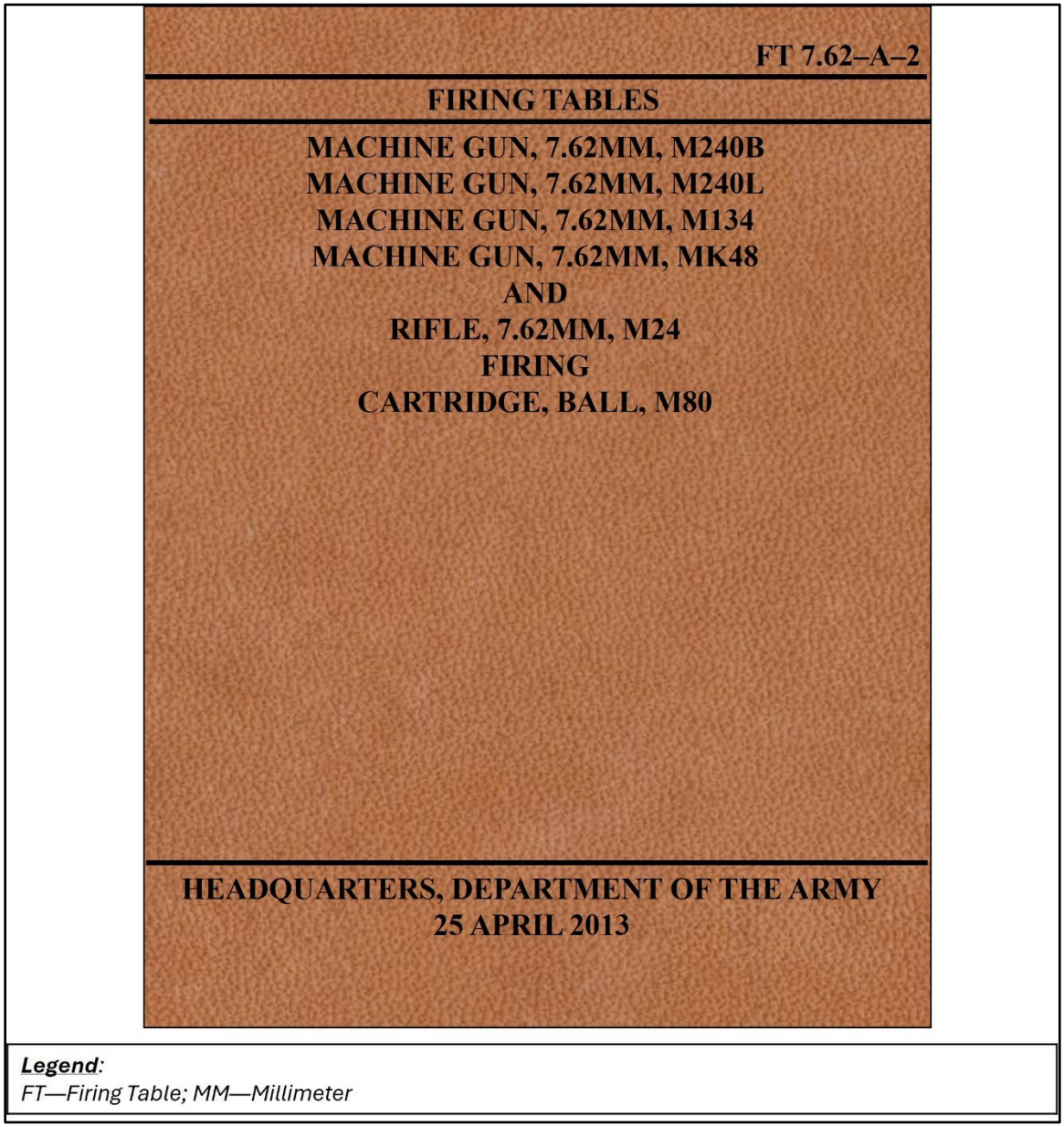


Figure B-26. 7.62mm M80 Firing Tables Cover

EXPLANATION OF TABLES

THIS FIRING TABLE IS DIVIDED INTO 15 SECTIONS, ONE FOR EACH CARTRIDGE. EACH SECTION INCLUDES FOUR TABLES, THAT BASIC FIRING TABLE AND THREE RANGE SAFETY TABLES, USEFUL FOR ESTABLISHING RANGE AND MAXIMUM ORDINATE LIMITS FOR A GIVEN CARTRIDGE. A RANGE SAFETY FACTOR OF 10 PERCENT IS ADDED TO THE ESTIMATED RANGE LIMIT DETERMINED USING TABLES B, C, AND D TO PROVIDE A SAFETY BUFFER ZONE AND TO ACCOUNT FOR THE VARIABILITY (ROUND TO ROUND AND OCCASION TO OCCASION) OF THE AMMUNITION AND THE INTERACTION AMONG THE NONSTANDARD CONDITIONS. IN GENERAL, PLUS SIGNS ARE OMITTED FROM THESE TABLES, THEREFORE, NUMBERS WITHOUT SIGNS ARE CONSIDERED TO BE POSITIVE. THE CONTENTS OF THESE TABLES ARE DESCRIBED BELOW.

TABLE A

BASIC DATA—A COMPILATION FOR THE BASIC DATA REQUIRED FOR THE TANK FIRE CONTROL SOLUTION.

COLUMN

1	RANGE—THE DISTANCE MEASURED FROM THE MUZZLE TO A TARGET AT THE LEVEL POINT UNDER STANDARD CONDITIONS
2	SUPERELEVATION—THE GUN ANGLE IN THE VERTICAL PLANE ABOVE THE LINE OF SIGHT REQUIRED TO REACH THE RANGE LISTED IN COLUMN 1.
3	DR / DSE—THE ADJUSTMENT IN RANGE FOR A 1 MIL CHANGE IN THE ANGLE OF SUPERELEVATION LISTED IN COLUMN 2.
4	DH / DR—CHANGE IN THE HEIGHT OF THE TRAJECTORY CORRESPONDING TO AN INCREASE OF 100 METERS TO THE RANGE LISTED IN COLUMN 1 WITH THE APPROPRIATE CHANGE IN THE ANGLE OF SUPERELEVATION.
5	DRIFT—WHEN PROJECTILES ARE SPUN FOR STABILIZATION PURPOSES BY GUN TUBES WITH A RIGHT–HANDED TWIST OF RIFLING, THE DRIFT OF THE PROJECTILE IS TO THE RIGHT OF THE VERTICAL PLANE OF FIRE. DRIFT IS THE ANGULAR DISPLACEMENT A PROJECTILE WILL INCUR WHEN IT IS SPUN.

Figure B-27. 7.62mm M80 explanation of tables

COLUMN	
6	TIME OF FLIGHT—THE PROJECTILE TRAVEL TIME, UNDER STANDARD CONDITIONS, FROM THE MUZZLE TO THE LEVEL POINT AT THE RANGE LISTED IN COLUMN 1.
7	10 KM/HR CROSSWIND DEFLECTION—THE EFFECT TABULATED IN THIS COLUMN IS USED WHEN DETERMINING THE CHANGE IN TRAVERSE ANGLE NEEDED TO OFFSET THE CROSSWIND WHICH CREATES A DEFLECTION EFFECT. THE LISTED EFFECT OF WIND DEFLECTION ASSUMES A 10 KM/HR CROSSWIND; THE CORRECTION FOR WHICH IS APPLIED INTO THE WIND. THEREFORE, IF THE WIND IS BLOWING FROM LEFT TO RIGHT, CORRECT TO THE RIGHT. THE WIND EFFECT CAN BE DETERMINED FOR ANY CROSSWIND SPEED BY APPLYING THE APPROPRIATE FACTOR TO THE 10 KM/HR CROSSWIND COLUMN. FOR EXAMPLE, IF THE OBSERVED CROSSWIND IS 5 KM/HR, THE EFFECT IS HALVED OR IF THE CROSSWIND IS 20 KM/HR, THE EFFECT IS DOUBLED.
8	MAXIMUM ORDINATE—THE MAXIMUM HEIGHT OF THE TRAJECTORY ABOVE THE GUN, UNDER STANDARD CONDITIONS, TO THE RANGE IN COLUMN 1.
9	RANGE TO MAXIMUM ORDINATE—THE DISTANCE IN THE HORIZONTAL PLANE MEASURED FROM THE GUN MUZZLE TO THE POINT PERPENDICULAR TO THE MAXIMUM ORDINATE LISTED IN COLUMN 8.
10	ANGLE OF FALL—THE LEAST ANGLE MEASURED CLOCKWISE FROM THE HORIZONTAL TO A LINE TANGENT TO THE TRAJECTORY AT THE LEVEL POINT.
11	REMAINING VELOCITY—THE SPEED OF THE PROJECTILE AT THE LEVEL POINT.

Legend:
KM/HR—Kilometers per Hour

Figure B-27. 7.62mm M80 explanation of tables (continued)

TABLE B

MAXIMUM ORDINATE, RANGE AND EFFECT ON RANGE—RANGE EFFECTS FOR THE NONSTANDARD CONDITIONS OF MUZZLE VELOCITY, RANGE WIND, AND AIR DENSITY

COLUMN

1	QUADRANT ELEVATION —THE ANGLE OF THE GUN IN THE VERTICAL PLANE REQUIRED TO REACH THE RANGE TABULATED IN COLUMN 3. THE FINAL ENTRY IN THIS COLUMN IS THE ELEVATION ANGLE WHICH PRODUCES THE MAXIMUM RANGE UNDER STANDARD CONDITIONS ROUNDED TO THE NEAREST WHOLE DEGREE.
2	MAXIMUM ORDINATE—THE MAXIMUM HEIGHT FOR THE TRAJECTORY ABOVE THE GUN, UNDER STANDARD CONDITIONS, TO THE RANGE IN COLUMN 3.
3	RANGE—THE DISTANCE MEASURED FROM THE MUZZLE TO A TARGET AT THE LEVEL POINT UNDER STANDARD CONDITIONS.
4—5	RANGE EFFECTS FOR A DECREASE (INCREASE) OF 1 METER PER SECOND IN MUZZLE VELOCITY—EFFECTS ON RANGE CAUSED BY VARIATIONS FROM THE STANDARD MUZZLE VELOCITY.
6—7	RANGE EFFECTS FOR A HEAD WIND (TAIL WIND) OF 1 KILOMETER PER HOUR—EFFECTS ON RANGE CAUSED BY A WIND BLOWING AGAINST (WITH) THE SHELL.
8—9	RANGE EFFECTS FOR A DECREASE (INCREASE) OF 1 PERCENT IN AIR DENSITY—EFFECTS ON RANGE CAUSED BY VARIATIONS FROM STANDARD AIR DENSITY (1,225 GRAMS PER CUBIC METER AT SEA LEVEL).

Figure B-27. 7.62mm M80 explanation of tables (continued)

TABLE C

EFFECTS ON MUZZLE VELOCITY DUE TO AMMUNITION TEMPERATURE—THE CHANGES IN MUZZLE VELOCITY PRODUCED BY VARIATIONS IN AMMUNITION TEMPERATURE. COLUMNS 1 AND 3 LIST THE AMMUNITION TEMPERATURE IN DEGREES FAHRENHEIT AND DEGREES CELSIUS, RESPECTIVELY. COLUMN 2 LISTS THE EFFECT ON MUZZLE VELOCITY CAUSED BY THE CORRESPONDING AMMUNITION TEMPERATURE VARIATION. WHENEVER POSSIBLE, THE TEMPERATURE OF THE AMMUNITION ITSELF SHOULD BE MEASURED, RATHER THAN ASSUMING THAT IT IS THE SAME AS AIR TEMPERATURE. THE CHANGE IN MUZZLE VELOCITY IS CONVERTED TO A RANGE EFFECT USING COLUMNS 4 OR 5 OF TABLE B.

TABLE D

EFFECTS ON AIR DENSITY DUE TO ALTITUDE—CORRECTIONS TO THE STANDARD AIR DENSITY FOR THE ALTITUDE OF THE FIRING UNIT. COLUMN 1 LISTS THE ALTITUDE IN METERS AND COLUMN 2 LISTS THE CORRESPONDING PERCENTAGE DECREASE IN AIR DENSITY. THE STANDARD AIR DENSITY VALUE AT SEA LEVEL IS 1,225 GRAMS PER CUBIC METER (100 PERCENT). WHENEVER POSSIBLE, THE ACTUAL AIR DENSITY AND ITS VARIATION FROM THE STANDARD SHOULD BE COMPUTED AND USED INSTEAD OF THE STANDARD VARIATION WITH ALTITUDE SHOWN IN THIS TABLE. THE AIR DENSITY EFFECT IS CONVERTED TO A RANGE EFFECT USING COLUMN 8 OR 9 OF TABLE B.

Figure B-27. 7.62mm M80 explanation of tables (continued)

TABLE A
BASIC DATA

1	2	3	4	5	6	7	8	9	10	11
RANGE	SUPER–ELEVATION	DR / DSE	DH / DR	DRIFT	TIME OF FLIGHT	10 KM/HR CROSSWIND DEFLECTION	MAXIMUM ORDINATE	RANGE TO MAXIMUM ORDINATE	ANGLE OF FALL	REMAINING VELOCITY
METERS	MILS	M/MIL	M/100M	MILS	SEC	MILS	METERS	METERS	MILS	M/SEC
0	0.00	135	0.0	0.0	0.00	0.0	0.0	0	0	858
100	0.72	121	0.1	0.0	0.12	0.6	0.0	51	1	783
200	1.54	107	0.2	0.0	0.26	1.2	0.1	103	2	711
300	2.47	93	0.3	0.0	0.40	1.9	0.2	157	3	642
400	3.55	81	0.5	0.1	0.57	2.6	0.4	213	5	576
500	4.80	70	0.7	0.1	0.75	3.5	0.7	271	7	513
600	6.27	59	0.9	0.1	0.96	4.4	1.1	332	10	453
700	8.02	50	1.3	0.2	1.20	5.5	1.8	395	1	396
800	10.13	41	1.8	0.2	1.47	6.8	2.6	461	19	343
900	12.71	34	2.5	0.3	1.77	8.2	3.9	529	26	311
1000	15.81	29	3.3	0.4	2.11	9.6	5.6	599	33	294
1100	19.39	26	4.1	0.4	2.46	10.9	7.8	667	42	279
1200	23.44	23	5.0	0.5	2.82	12.1	10.6	731	51	266
1300	27.96	21	6.1	0.6	3.21	13.3	14.0	790	62	254
1400	32.94	19	7.2	0.8	3.61	14.4	18.0	846	73	242
1500	38.40	17	8.4	0.9	4.04	15.5	22.7	901	85	231
1600	44.37	16	9.8	1.0	4.48	16.7	28.1	957	99	219
1700	50.86	15	11.3	1.2	4.96	17.8	34.4	1014	115	208
1800	57.94	13	13.0	1.4	5.45	19.0	41.7	1072	132	198
1900	65.64	12	15.0	1.6	5.98	20.1	50.0	1132	151	187
2000	74.05	11	17.2	1.8	6.54	21.4	59.6	1193	173	177
2100	83.24	10	19.7	2.0	7.13	22.7	70.7	1256	199	166
2200	93.34	9	22.7	2.3	7.77	24.0	83.5	1321	228	156
2300	104.50	8	26.3	2.6	8.47	25.5	98.4	1388	262	145
2400	116.94	8	30.6	2.9	9.23	27.2	115.8	1458	303	133
2500	130.98	7	36.1	3.3	10.07	29.0	136.5	1530	353	121
2600	147.14	6	43.3	3.7	11.03	31.2	161.5	1607	416	109
2700	166.23	5	53.2	4.3	12.15	33.7	192.5	1690	498	98
2800	189.50	4	66.9	5.0	13.46	36.8	232.3	1779	600	90
2900	219.00	3	86.4	6.0	15.04	40.5	285.7	1878	726	84
3000	258.67	2	116.1	7.3	17.03	45.2	361.8	1990	875	50
3100	319.26	1	168.7	9.4	19.82	52.1	485.6	2119	1054	79

FT 7.62–A–2, M80

***Legend**:*
DH—Change in Height; DR—Change in Range; DSE—Change in Super Elevation; FT—Firing Table; KM/HR—Kilometers per Hour; M/100M—Meters per 100 Meters; M/MIL—Meters per Mils; M/SEC—Meters per Second; SEC—Second

Figure B-28. 7.62mm M80 Firing Table A

TABLE B
MAXIMUM ORDINATE, RANGE AND EFFECTS ON RANGE

1	2	3	4	5	6	7	8	9
QUADRANT ELEVATION	MAXIMUM ORDINATE	RANGE	RANGE EFFECTS FOR					
			MUZZLE VELOCITY 1 M/S		RANGE WIND 1 KM/HR		AIR DENSITY 1 PCT	
			DEC	INC	HEAD	TAIL	DEC	INC
DEG	M	M	M	M	M	M	M	M
5	78	2159	-1.7	1.6	-6.8	6.9	13.8	-12.0
10	212	2753	-1.7	1.5	-12.0	12.3	21.2	-18.4
15	378	3017	-1.6	1.5	-16.4	16.7	26.1	-22.1
20	564	3138	-1.6	1.5	-20.1	20.6	28.6	-24.0
25	762	3179	-1.5	1.4	-23.4	24.0	29.9	-24.9
26	797	3180	-1.5	1.4	-24.0	24.6	30.0	-25.0

FT 7.62-A-2, M80

TABLE C
EFFECTS ON MUZZLE VELOCITY
DUE TO AMMUNITION TEMPERATURE

TEMPERATURE OF AMMUNITION	EFFECTS ON VELOCITY	TEMPERATURE OF AMMUNITION
DEGREES F	M/S	DEGREES C
-40.0	-38.5	-40.0
-30.0	-35.0	-34.4
-20.0	-31.5	-28.9
-10.0	-28.0	-23.3
0.0	-24.5	-17.8
10.0	-21.0	-12.2
20.0	-17.5	-6.7
30.0	-14.0	-1.1
40.0	-10.5	4.4
50.0	-7.0	10.0
60.0	-3.5	15.6
70.0	0.0	21.1
80.0	3.5	26.7
90.0	7.0	32.2
100.0	10.5	37.8
110.0	14.0	43.3
120.0	17.5	48.9
130.0	21.0	54.4

FT 7.62-A-2, M80

***Legend**:*
C—Celsius; CAL—Caliber; DEC—Decrease; DEG—Degrees; F—Fahrenheit; FCI—Fire Control Information; INC—Increase; KM/HR—Kilometers per Hour; M—Meters; M/S—Meters per Second; PCT—Percent

Figure B-29. 7.62mm M80 Firing Tables B and C

TABLE D

EFFECTS ON AIR DENSITY
DUE TO ALTITUDE

ALTITUDE	DECREASE IN AIR DENSITY
METERS	PERCENT
0	0.0
100	1.0
200	1.9
300	2.8
400	3.8
500	4.7
600	5.6
700	6.5
800	7.5
900	8.4
1000	9.3
1100	10.1
1200	11.0
1300	11.9
1400	12.8
1500	13.6
1600	14.5
1700	15.3
1800	16.2
1900	17.0
2000	17.8

FT 7.62-A-2, M80

Legend:
FT—Firing Tables

Figure B-30. 7.62mm M80 Firing Table D

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Glossary

The glossary lists acronyms and terms with Army definitions.

SECTION I – ACRONYMS AND ABBREVIATIONS

°	degrees
AoB	axis of the bore
ARC	ammunition, range, column
BK	ballistic kernel
BRL	Ballistic Research Laboratory
C	Celsius
DA	Department of the Army
DR/DSE	change in range for a 1-mil change in superelevation
EL	elevation
F	Fahrenheit
FFI	Forsvarets Forshningsinsitutt
FM	field manual
FTaB	firing tables and ballistics
HEAT	high-explosive antitank
IMBC	improved mortar ballistic computer
km/hr	kilometers per hour
LoD	line of departure
LoE	line of elevation
LOS	line of sight
m̓	mils
m/s	meters per second
MACH	mach number
MAX ORD	maximum ordinate
MCTP	Marine Corps tactical publication
mm	millimeters
MPM	modified point mass
MV	muzzle velocity
NABK	NATO Armament Ballistic Kernel
NATO	North Atlantic Treaty Organization
PIP	performance improvement package
PMA	publications management application
QE	quadrant elevation
ROI	round out of impact

SDZ	surface danger zone
SE	superelevation
TC	training circular
TE	tangent elevation
TFT	tabular firing tables
TPCSDS-T	target practice cone stabilized discarding sabot with tracer
U.S.	United States
WP-T	white phosphorous with tracer

SECTION II – TERMS

aeroballistics

The science of ballistics combined with that of aerodynamics, dealing primarily with the flight path of projectiles, rockets, guided missiles, and others, through the atmosphere.

aerodynamic characteristics

The branch of mechanics that deals with the motion of air and other gases and with the effects of such motion on objects in such a media.

axis of the bore

The line passing through the center of the bore.

azimuth

For fire control systems, azimuth is the rotation of a weapon about the pintle or turret ring (side to side) as opposed to elevation, which is up and down. Azimuth also indicates direction in degrees or mils. It can be measured using a compass, optic, or sensor to determine the angular relationship between two or more points.

ballistic drift

The lateral departure of spin-stabilized ammunition from the gun-target line. Only spin-stabilized rounds are affected.

ballistic trajectory

The path of a projectile when influenced only by external forces such as gravity and atmospheric friction.

ballistics

The science or study of the motion, propulsion, flight, and impact of projectiles. It is also the art or science of designing projectiles for maximum flight or terminal effects performance.

caliber

The measurement of the diameter of the bore of the gun. This measurement is also used as a relational distance, for example “the last 5 calibers of the gun.”

commencement of rifling

The point in a rifled gun tube at which the lands have attained full size.

distance x

The maximum distance a projectile (to include guided missiles and rockets) will travel when fired or launched at a given quadrant elevation with a given charge or propulsion system.

exterior/external ballistics

Encompasses the period from when the projectile has left the muzzle and any sabot pedal discard has occurred until impact with the target. It includes the projectile muzzle velocity, projectile dynamics and stability, the predicted flight path, time of flight, and the angle, velocity, and location of impact. It is the study of projectiles in flight.

fire control

The science of offsetting the direction of weapon fire from the line of sight to the target to hit the target.

jump

Vertical jump is the angle, measured in ṁ, between the line of departure and the line of elevation.

kinetic energy

Energy due to mass and velocity. It can be calculated by taking half the mass and multiplying it by the velocity squared ($1/2\ mv^2$).

line of departure

The center of axis as the projectile leaves the muzzle.

line of elevation

The center of the axis of the gun bore. Also known as the axis of the bore, the line of elevation describes the exact bore centerline from the chamber region, to the muzzle, and onward indefinitely.

line of sight

The straight line between the gun sight and the target.

Mach number

The speed (velocity) of the projectile in relation to the speed of sound (343m/s).

maximum ordinate

The maximum height the projectile will travel above the gun line of sight on its path to the point of impact.

muzzle velocity

The speed (velocity) of the projectile approximately 2 feet beyond the muzzle of the gun (after shot exit).

obscuration

The effects of firing which hinder observation.

prediction angle

The angle between the line of sight (the line from the weapon station to target at the instant the weapon fires) and the weapon line (the extension of the weapon axis).

superelevation/tangent elevation

The gun angle between the line of sight and axis of the bore measured in ṁ.

surface danger zone

The ground and airspace designated within the training complex, to include associated safety areas, for vertical and lateral containment of projectiles, fragments, debris, and components resulting from the firing, launching, or detonation of weapon systems to include explosives and demolitions.

time of flight

The time taken for a projectile to reach a given range after firing.

yaw

The rotation of the nose of a projectile away from the line of flight in the Y-axis.

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12 January 2026

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RANDY A. GEORGE
General, United States Army
Chief of Staff

Official:



MATTHEW L. SANNITO
Administrative Assistant
to the Secretary of the Army
2535700

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