DEPARTMENT OF THE AIR FORCE
HEADQUARTERS AIR FORCE CIVIL ENGINEER SUPPORT AGENCY

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FROM: HQ AFCESA/CES
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SUBJECT: Engineering Technical Letter (ETL) 02-11: Small Arms Range Design and Construction

1. Purpose. This ETL provides guidance for design and construction of Air Force small arms ranges, and applies to both new construction and major renovations. It replaces Chapter 3 of Air Force Manual (AFMAN) 36-2227V1, *Combat Arms Training and Maintenance (CATM) Training Management and Range Operations*. The intent of this ETL is to be a performance-based document that provides basic minimum guidance on the considerations necessary for achieving a safe range design. The intended audiences for this ETL are functional managers at major commands (MAJCOMs), base civil engineers (BCE), bioenvironmental engineers, security forces, and private industry sources that provide range designs to the Air Force. This document assumes that readers have an engineering background or access to local engineering expertise.

This document should be used as an aid to guide a range designer in the design of a new range. The range designer ultimately has the responsibility to provide a safe range design. This ETL may not cover all site-specific concerns, but it is a good starting point to begin the design process. This document is not a specification. The ETL should not be followed without considering the site-specific situations that may invalidate these guidelines or require more stringent procedures. Additionally, nothing in this ETL should preclude consideration of emerging technologies and commercially available products if these can be proven to result in a safe range design.

2. Summary of Revisions. This ETL supersedes ETL 01-13, *Small Arms Range Design and Construction*. It updates requirements and standards consistent with current technology.

Note: This ETL substantially revises ETL 01-13 and should be completely reviewed.

3. Application: All Air Force installations.

- New Facilities: The criteria in this ETL apply to all small arms ranges where the design is 30 percent complete or less on the effective date of the ETL. All new small arms range projects at 30 percent design phase or less on the effective date of this ETL must consider the criteria herein in the design process. Alternate designs are acceptable, provided range safety can be validated prior to construction. This may be done by modeling and simulation or other methods.

- Existing Facilities: Ranges and other facilities designed in accordance with previously published criteria may continue to operate if range safety can be verified under the following conditions:
  - Range safety must be verified using ORM analysis on existing ranges that do not meet new criteria. At wing level, the safety office (SE) provides guidance on how to conduct ORM in accordance with Air Force Instruction (AFI) 91-213, *The Operational Risk Management (ORM) Program*. Additionally, Attachment 4 provides an example of using ORM analysis to evaluate existing ranges that do not meet the criteria outlined in this ETL.
  - Unsafe conditions must be corrected with appropriate modifications, repairs, or replacements (e.g., additional baffles, increased backstop height, deflector plates).

    Note: Range modeling and simulation is a proven technique for analyzing range safety and identifying necessary improvements.
  - Components repaired or replaced must satisfy the intent of this ETL. This document provides minimum standards for certain components.
  - If range or component repairs cost more than 50 percent of the range replacement cost, the entire facility must be upgraded to comply with this ETL.
  - Design changes to range components must comply with the intent of this ETL to achieve a safe range.

Safety violations and unsafe operating conditions must be addressed and corrected as soon as they are identified.

3.1. Authority: Air Force Policy Directive (AFPD) 32-10, *Installations and Facilities*.

3.2. Effective date: Immediately.

3.3. Ultimate Recipients: MAJCOM civil engineers and BCEs.

3.4. Coordination: MAJCOMs and HQ AFSFC/SW.

4. Referenced Publications.

4.1. Public Law:
- 29 Code of Federal Regulations (CFR) 1910, *Lead Exposure*

4.2. Air Force:
- AFI 31-101, *The Air Force Installation Security Program*, For Official Use Only (FOUO)
- AFI 91-213, *The Operational Risk Management (ORM) Program*
- AFMAN 32-1071, *Security Engineering Project Development* (FOUO)

- AFMAN 36-2227V1, *Combat Arms Training and Maintenance (CATM) Training Management and Range Operations*
- AFPD 32-10, *Installations and Facilities*
- ETL 01-13, *Small Arms Range Design and Construction*

4.3. Navy:

- Naval Environmental Health Center (NEHC) Technical Manual NEHC-TM6290.99-10, *Indoor Firing Ranges Industrial Hygiene Technical Guide*

4.4. Industry:

- American Welding Society (AWS) D1.1:2000, *Structural Welding Code – Steel*
- American Society for Testing and Materials (ASTM) A242/A242M*, Standard Specification for High Strength Low Alloy Structural Steel*
- ASTM A514/A514M, *Specification for High Yield Strength, Quenched and Tempered Alloy Steel Plate*
- ASTM A572/A572M, *Standard Specification for High Strength Low-Alloy Columbium Vanadium Structural Steel*
- ASTM C76, *Reinforced Concrete Culvert, Storm Drain and Sewer Pipe*

4.5. Other Federal Agencies:

Department of Defense

- DOD 5100.76M, *Physical Security of Conventional Arms, Ammunitions, and Explosives*

Environmental Protection Agency

- *Best Management Practices for Lead at Outdoor Shooting Ranges*

In some instances, the references listed in paragraphs 4.1 through 4.5 and 5.1 through 5.5 may advocate procedures that seem to contradict those in this ETL. In these cases, the information in this ETL supersedes any other source.

5. Additional References.

5.1. Air Force:

- AFH 32-1084, *Facility Requirements*
- AFOSH Standard 161-2, *Industrial Ventilation*

5.2. Navy:

- Military Handbook (MIL-HDBK) 1027/3B, *Range Facilities and Miscellaneous Training Facilities Other Than Buildings*

5.3. Army:

- Army Regulation (AR) 385-63, *Policies and Procedures for Firing Ammunition for Training, Target Practice, and Combat*
- Training Circular (TC) 25-8, *Training Ranges*

- NGB-AVS-SG, *Policy and Responsibilities for Inspection, Evaluation and Operation of Army National Guard Indoor Firing Ranges*

5.4. Other Federal Agencies:

Department of Justice

- Immigration and Naturalization Service/National Firearms Unit, *Firing Range Design Standard*

5.5. Organizations:

- National Rifle Association (NRA) of America, *The NRA Range Source Book*, latest edition

6. Acronyms.

AFCESA	Air Force Civil Engineer Support Agency
AFMAN	Air Force Manual
AFOSH	Air Force Occupational Safety and Health
AFPD	Air Force Policy Directive
AR	Army Regulation
ASTM	American Society for Testing and Materials
AWS	American Welding Society
BCE	base civil engineer
BHN	Brinnell Hardness Number
CATM	Combat Arms Training and Maintenance
CFR	Code of Federal Regulations
CMU	concrete masonry unit
CONUS	continental United States
Cwt	hundredweight
dBA	adjusted decibel
DRMO	Defense Reutilization Management Office
EOD	explosive ordnance disposal
EPA	Environmental Protection Agency
ETL	Engineering Technical Letter
FOB	freight on board
FOUO	For Official Use Only
HEAT	high-explosive anti-tank
HQ AFCESA/CESC	Headquarters Air Force Civil Engineer Support Agency Technical Support Directorate
HQ AFSFC/SW	Headquarters, Air Force Security Forces Center Training & Combat Arms Division
HVAC	air conditioning
LAW	light assault weapon
LR	long rifle
MAJCOM	major command

MIL-HDBK	military handbook
MIL SPEC	military specification
mpm	meters per minute
NCOIC	non commissioned officer in charge
NEHC	Naval Environmental Health Center
NRA	National Rifle Association
NSN	National Stock Number
ORM	Operational Risk Management
OSB	oriented strand board
OSHA	Occupational Safety and Health Administration
PEL	permissible exposure limit
POC	point of contact
psi	pounds per square inch
RKT	rocket
SDZ	Surface Danger Zone
SGPB	bioenvironmental engineer
TBD	to be determined
TC	Training Circular
VDZ	Vertical Danger Zone

7. Definitions.

7.1. *Small Arms Range:* A live-fire training facility for certifying personnel in the use of handguns, shotguns, rifles up to 7.62 mm, rifles or machine guns up to .50 caliber, and the MK-19, 40 mm machine gun. It includes special ranges for 40 mm grenade launcher, light anti-tank weapons, 81 mm mortars, and the 10-meter machine gun range.

7.2. *Surface Danger Zone (SDZ):* The portions of the range in the horizontal plane that are endangered by a particular weapon firing. The SDZ includes the area between the firing line and the target line, an impact area, a ricochet trajectory area, and a secondary danger area. The SDZ may include a weapon backblast area. The SDZ must be located completely within the boundaries of U.S. government-owned or -leased properties. Fully contained ranges incapable of allowing a fired round to escape its limits do not have an exterior SDZ, but do have an interior SDZ within the limits of the horizontal containment.

7.3. *Vertical Danger Zone (VDZ):* For noncontained and partially contained ranges, this is the volume of airspace above the SDZ between the ground surface and the maximum ordinate of a direct-fired or ricochet round. The height of the VDZ varies with the weapon and ammunition fired. (See Attachment 2.) For fully contained ranges, the VDZ is the area between the SDZ and the upper limits of containment.

7.4. *Noncontained Range*: A noncontained range is an outdoor/open range. The firing line may be covered or uncovered. Direct-fire rounds and ricochets are unimpeded and may fall anywhere within the SDZ (safety fan). The noncontained range requires a safety fan (SDZ) equal to 100 percent of the maximum range of the most powerful

round to be used on the range. This type of range requires the largest amount of real estate to satisfy the SDZ requirements.

7.5. *Partially Contained Range*: This range has a covered firing line, side containment, overhead baffles, and a bullet trap. Direct fire is totally contained by the firing line canopy, side containment, baffles and bullet trap. Ricochets are not totally contained, but reduced by the baffles and side containment. A partially contained range requires a safety fan (SDZ) equal to 50 percent of the maximum range of the most powerful round to be used on the range.

7.6. *Fully Contained Range*: Range in which direct fire and ricochets are totally contained within the limits of the range.

8. Background. Firing range design continues to be a sensitive issue with no easy solution. There are many Air Force ranges worldwide that were constructed using then-acceptable design criteria which has since been proven to be unsuitable to meet the needs of the Air Force.

In 1999, the Air Force Inspection Agency conducted an Eagle Look review of the entire Air Force small arms range program. This review found numerous shortcomings with the program. The small arms ranges were degraded and not capable of meeting mission needs without extensive workarounds by Combat Arms personnel. The review specifically pointed out that Air force range design criteria guidance was outdated and vague. The design criteria for ranges that were in use at that time are now over 30 years old and do not reflect the numerous changes that have occurred in safety, environmental standards, and weapons and ammunition capabilities. The review found that the Air Force had not kept abreast of these changes or maintained contemporary standards. Consequently, the review directed that new and updated range design criteria be developed.

Many, if not most, of the existing ranges will not satisfy all aspects of the design criteria outlined in this ETL. Existing ranges were designed using the best available information at that time. Our knowledge has greatly increased since then, and the Air Force must recognize that many of our current ranges are substandard. The degree at which the ranges are substandard must be considered on a case-by-case basis. Some of the substandard ranges should be closed and programmed for replacement. Others may continue to operate with procedural modifications that mitigate the risks associated with their use. Attachment 4 outlines a method for evaluating existing ranges using the Operational Risk Management (ORM) approach.

It is not possible to correct all the known discrepancies without adversely impacting the mission requirements; however, this does not mean that substandard conditions should be accepted on a long-term basis. The substandard ranges should be phased out of use at the earliest possible opportunity.

9. Design Criteria. MAJCOM security forces, civil engineering, and safety offices will jointly develop site-specific, performance-based design criteria using the guidance outlined in this ETL as a minimum. Designs may also be submitted to Headquarters Air Force Security Forces Center Training & Combat Arms Division (HQ AFSFC/SFW) and Headquarters Air Force Civil Engineer Support Agency Technical Support Directorate (HQ AFCESA/CESC) for review; however, reviews will be limited by the availability of personnel and funding. Designs should be submitted to HQ AFSFC and HQ AFCESA only after MAJCOM approval. Individual MAJCOMs may establish criteria exceeding the minimums specified in this ETL.

9.1. Range Types, Multiple Use Ranges, Configuration, Site Selection, and Geometry.

9.1.1. Range Types.

9.1.1.1. Noncontained Range (Impact). A noncontained range is an outdoor range where the discharge of weapons is controlled and supervised. The trajectory of the bullet is along the line of fire (orientation of the range) and the impact of the bullet is designed to be within the limits of the impact area. There are no overhead baffles, but surface barriers or sidewalls may be provided to partially limit bullet trajectory. A noncontained range is limited only by the real estate available for accommodation of both the SDZ and the VDZ. Ammunition used on the range establishes the required length of the SDZ and the required height of the VDZ. SDZ length must be equal to the longest distance equal to 100 percent of the extreme range for the types of ammunition authorized to be used, based upon the values in Table 1. For minimum VDZ height requirements, refer to Attachment 2.

Table 1. Minimum SDZ Distance Requirements for Small Arms Ammunition — Noncontained Range

Weapon/Caliber	Ammunition	Minimum SDZ Length (Meters)
Handgun, 9 mm pistol Submachine gun, 9 mm	M882	1840
Handgun, .44 magnum	Commercial local purchase	2290
Shotgun, 12 gauge	00 buckshot	600
Rifle, 5.56 mm	Ball, M193; tracer M196	3100
Rifle, 5.56 mm	Ball, M855; tracer, M856	3600
Rifle, 5.56 mm	M862 (plastic)	250
Rifle/machine gun, 7.62 mm	Ball, M80; tracer M81	4300
Rifle/machine gun, 7.62 mm	Match, M118	4800
Machine gun, .50 caliber	Ball, M2 and M33	6700
M79, M203, 40 mm low velocity	M781/M407A1/M406/ M433/M381/M386/M441	600 (100)*
Mk-19, 40 mm high velocity	M918/M383/M430	2650 (350)*
M72 LAW, 35 mm subcaliber	M73	1300 (100)*
M72 LAW, 66 mm RKT HEAT	M72	1250 (250)*
AT4, 84 mm RKT HEAT	M136	2600 (200)*
M29 mortar, 81 mm	M301/M374A3/M375	5400 (400)*
M252 mortar, 81 mm	M819/M821/M853/M889	6400 (400)*

***** These amounts are included in the minimum SDZ to provide a standoff distance for explosive ordnance disposal (EOD) make-safe procedures for unexploded ordinance beyond the maximum range of the ammunition.

9.1.1.2. Partially Contained Range (Baffled). A partially contained range is designed with overhead baffles, sidewalls (earth berms, masonry, or concrete), and a backstop. The objective of this design is to capture direct-fired bullets or low-angled ricochets and minimize the opportunity for other ricochets to leave the constructed limits of the impact area. The firing line must be covered and overhead baffles properly positioned to preclude the weapon from seeing "blue sky" from any firing position. In the absence of

site-specific analysis and modeling of ricochet patterns, the SDZ length for a partially contained range must be 50 percent of the values listed in Table 1. Since a properly designed partially contained range stops direct-fire rounds, only ricochets are assumed to exit the range. Computer modeling and simulation results for the typical 25-meter baffled range indicate that ricochets may travel vertically as much as 300 meters. For planning and design purposes, assume a VDZ of 500 meters for the partially contained range. Coordinate range location, orientation, and operation with the local airfield manager to ensure safe airspace.

9.1.1.3. Fully Contained Range (Indoor or Outdoor). A fully contained range is one that is designed to prevent 100 percent of the fired rounds and ricochets from leaving the limits of the range. This type of range is used when the required minimum SDZ dimensions cannot be met because of insufficient compatible-use land area. These ranges typically have an overhead containment structure and sidewalls. If the range is located in a building, the building envelope is not necessarily designed to preclude bullet penetration unless it is part of the containment. The structure elements and materials used for the building roof may vary depending upon the type and configuration of interior overhead containment, type of backstop, and method used to trap bullets. Site-specific design criteria must be established for fully contained ranges. The criteria developed must preclude escape of both a direct-fired bullet and a ricochet round. The criteria must also address noise control and environmental hazards from the use of ammunition containing lead.

9.1.2. Range Type Combinations. Range types may be combined. The appropriate configuration must be dictated by the types and sequence of weapons used.

9.1.2.1. Multipurpose Ranges. The multipurpose range provides for the simultaneous firing of more than one type of weapon. The complex consists of adjacent baffled and/or impact bays. A sidewall separates the two range types to prevent bullets from one range from entering the adjacent range.

9.1.2.2. Superimposed Ranges. A superimposed range accommodates different types of weapons and may be either a noncontained (impact) range or a partially contained (baffled) range; however, only one type of weapon may be fired at one time. The superimposed range allows for the maximum use of real estate and is usually the least expensive since there are no sidewalls between firing positions.

9.1.2.3. Special Ranges. Typically, special ranges are noncontained (impact) ranges designed to accommodate multiple target lines or arrays, and set up for special types of weapons or unique courses of fire.

9.1.3. Range Configuration. The range type, size, and configuration is based upon the installation mission, real estate availability, Air Force and MAJCOM policy, the base population, annual training requirements, and weapon-specific training requirements. Base Combat Arms personnel will submit their requirements for ranges through the

chain of command to the MAJCOM functional manager. Once the need has been validated by the MAJCOM, the BCE will begin a feasibility study for the proposed range.

9.1.4. Site Selection.

9.1.4.1. BCE. The BCE will identify the real estate for siting a small arms range facility. The range location, orientation, SDZ, and VDZ will be indicated on the base master plan.

9.1.4.2. Planning. A project team comprised of Combat Arms, a land use planner, a BCE, and a ground safety representative should collectively review the proposed range usage and siting for land use compatibility. The BCE is responsible for plotting the SDZ and the VDZ on the base master plan. For a noncontained range, use the VDZ values in Attachment 2. For a partially contained range, use a 500-meter VDZ. Any conflicts of land use or airspace operations with the SDZ or the VDZ must be mitigated as a part of the planning, programming, and budgeting process.

9.1.4.3. Real Estate Acquisition. When government-owned property suitable for a small arms range is not available, and where land acquisition is feasible, the BCE will prepare the documents required for purchase or lease. Safety is the primary concern when determining the site for a small arms range. The SDZ and VDZ must be oriented to minimize the effect of range operations on populated areas, aircraft ground and air operations, and land uses within travel distance of the ammunition. Where full containment enclosures have not been provided, the project team should assume that ricochets will land in all portions of the SDZ.

9.1.4.4. Geography, Environmental, and Climatic Effects.

9.1.4.4.1. If possible, an outdoor range should be oriented north-to-south to minimize glare. Do not site an outdoor range with the prevailing wind blowing toward the face of the shooter.

9.1.4.4.2. Regions subject to snow accumulation and periods of continuous sub-freezing temperatures (90 days or more) should employ indoor ranges. When this is not possible, the outdoor range should be sited to minimize drifting snow, ice buildup, excess water accumulation inside the range periphery, and the effects of prevailing winds on firing positions.

9.1.4.4.3. Range sites must consider environmental concerns such as storm water management, protection of wetlands, ground and surface waters, historical or archaeological features, previously contaminated sites, and other concerns as may be determined by federal, state, and local environmental laws.

9.1.5. Range Geometric Design. The layout and dimensions of the facility must satisfy safety requirements and user needs. The following are minimums:

9.1.5.1. Firing Line Positions. The number of firing positions establishes the width of the firing line. All small arms (rifle, pistol, and shotgun) ranges must have a minimum of 14 positions on the firing line. Additional positions shall be added in increments of 7 firing positions. The width of the firing positions must be at least 1.52 meters (5 feet). The firing line must be on a concrete platform that is at least 4 meters (13.1 feet) deep, clear distance, for the length of the firing line. The concrete platform requirement will be waived for noncontained ranges that have fighting positions dug in the ground, sandbags, or other definite structures to specifically identify the firing line. This will still be identified as the firing platform, even if the platform is the earth surface itself. For special weapons, the Combat Arms personnel will specify the number of firing positions and the widths of each position based upon training requirements.

9.1.5.1.1. Each firing position will be numbered beginning from the left as you face the target line. The numbers must be at least 200 millimeters (8 inches) tall, and displayed on rectangular backgrounds attached to the position barricade or other location that is totally visible to all shooters and range officials. Odd-numbered positions will be marked with white numbers on a black background; even-numbered positions will be marked with black numbers on a white background.

9.1.5.1.2. Position Barricades. A wooden barricade in the form of a cross (+) must be installed at the left edge of each firing position. The nominal dimensions of the wood must be 50 millimeters (2 inches) by 150 millimeters (6 inches). The top surface of the horizontal member must be 1220 millimeters (48 inches) above the platform.

9.1.5.1.3. Firing Line. A red line, a minimum of 102 millimeters (4 inches) wide, must be painted on the leading edge of the firing platform on the target side. For noncontained ranges without concrete firing line platforms, a red line will be painted on a concrete sidewalk on the downrange side of the firing positions. The line must be continuous for the full length of all the firing positions. This line is designated as the firing line.

9.1.5.2. Ready Line. A yellow line, 102 millimeters wide, must be painted on the firing line platform at least 2.4 meters (8 feet) behind the red line (towards the rear of the firing platform). The line must be continuous for the length of the firing platform. This line is designated the ready line.

9.1.5.3. Target Line. Targets are placed along the target line, which runs parallel to the firing line. Targets are placed opposite and aligned with each firing position.

9.1.5.4. Target Line Configuration.

9.1.5.4.1. The distance from the firing line to the target line must be the same for all firing positions. Along the target line, targets may be placed on turning, pop-up, or stationary mechanisms, or target retrieval systems. Ensure that the line of sight from the firing line to the target line is clear and the cross-section uniform. Number each target location the same as its corresponding firing position. On noncontained ranges, the target line may be fixed and several firing lines constructed to permit firing at different

distances. When this option is used, only the rear-most firing line will incorporate a firing platform.

9.1.5.4.2. The center of the target must be at an elevation between the upper limit of fire (standing position), which is 1850 millimeters (73 inches) above the firing line, and the lower limit of fire (prone position), which is 150 millimeters (6 inches) above the firing line. The entire target face must be fully displayed to the firing position when exposed to the shooter for engagement.

9.1.6. Danger Zone Geometry. The range danger zone includes the impact area, the SDZ, and a VDZ. Refer to Figures 1 and 2 for the typical geometry of the SDZ. The VDZ reflects the geometry of the SDZ extended to the VDZ height.

9.1.6.1. Limits of Fire. The limits of fire are imaginary lines drawn from the outer edge of the last firing position, extended downrange through the target line and terminating at the SDZ limit. The limits of fire may be perpendicular to the firing line or they may depart the firing line at a designated angle. The range configuration and use determines the departure angle of the limits of fire.

9.1.6.2. Impact Area or Direct Fire Zone. The impact area is bounded by the left and right limits of fire, the firing line, and extends to the minimum SDZ arc length for the ammunition and range type (Table 1). When the target line and the firing line are the same width, the impact area forms a rectangle (Figure 1). When the target line is wider than the firing line, the impact area includes a rectangular area the width of the firing line and pie-shaped areas formed by the limits of fire and the arc of the minimum SDZ length (Figure 2).

9.1.6.3. Ricochet Danger Area. The ricochet danger area is that area between the impact area and the secondary danger area. The ricochet area typically is determined by extending a line drawn at a 10-degree angle off the left and right limits of fire, beginning at the firing line and extending to the minimum SDZ arc (Figures 1, 2, 3, and 4).

9.1.6.4. Secondary Danger Areas. Secondary danger areas are provided to catch fragments from exploding ammunition or ricochets from rounds that impact at the outer edge of the ricochet danger area. A line beginning at the intersection of the firing line and the firing limits is drawn departing from the line of fire at an angle of 40 degrees, extending outward for 1,000 meters (3,280 feet). From the 1,000-meter point, a second line extends to a point on the minimum SDZ arc 100 meters (328 feet) outside the ricochet area limits.

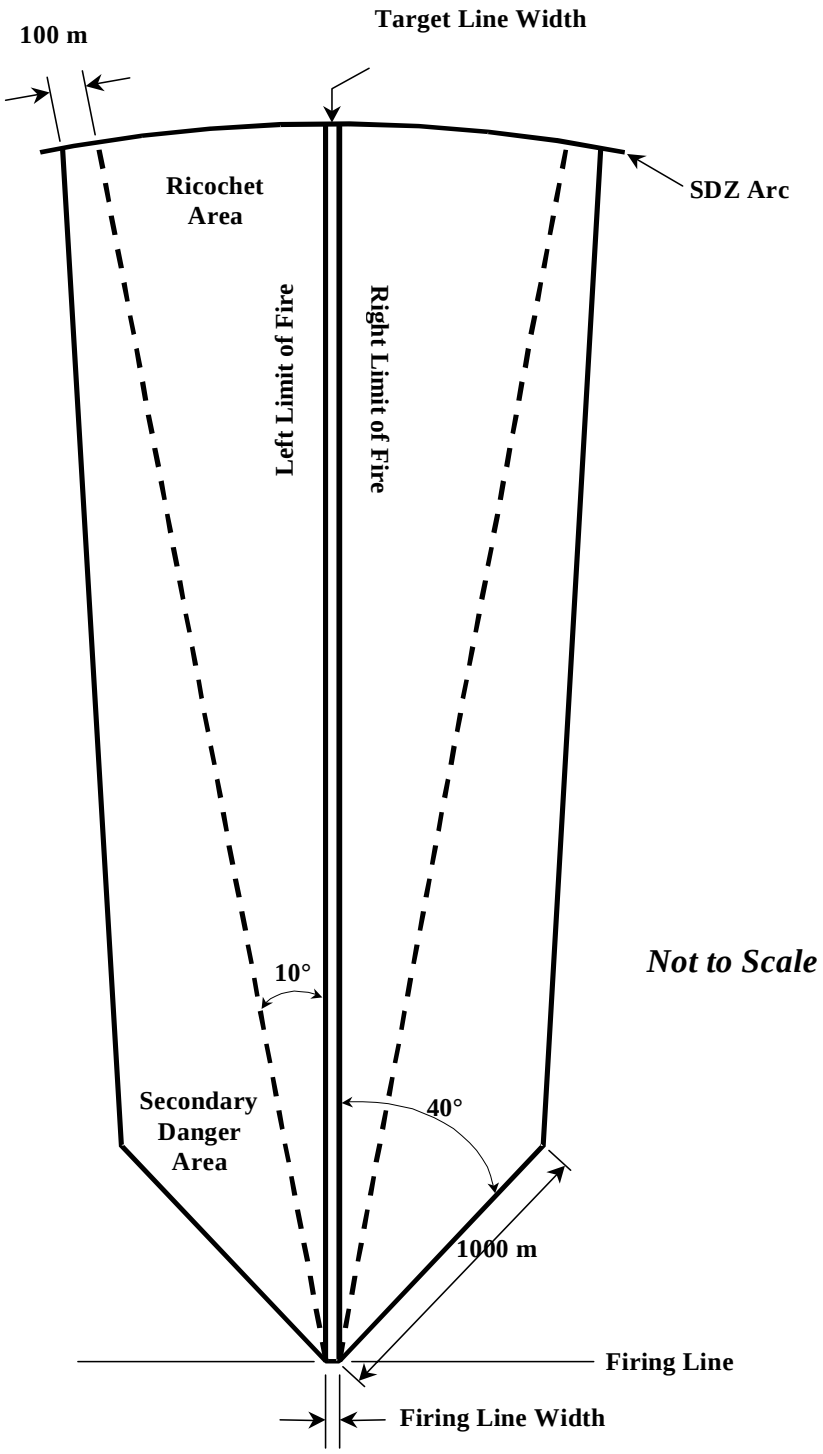


Figure 1. SDZ Configuration — Firing Line Width Equal to Target Line Width

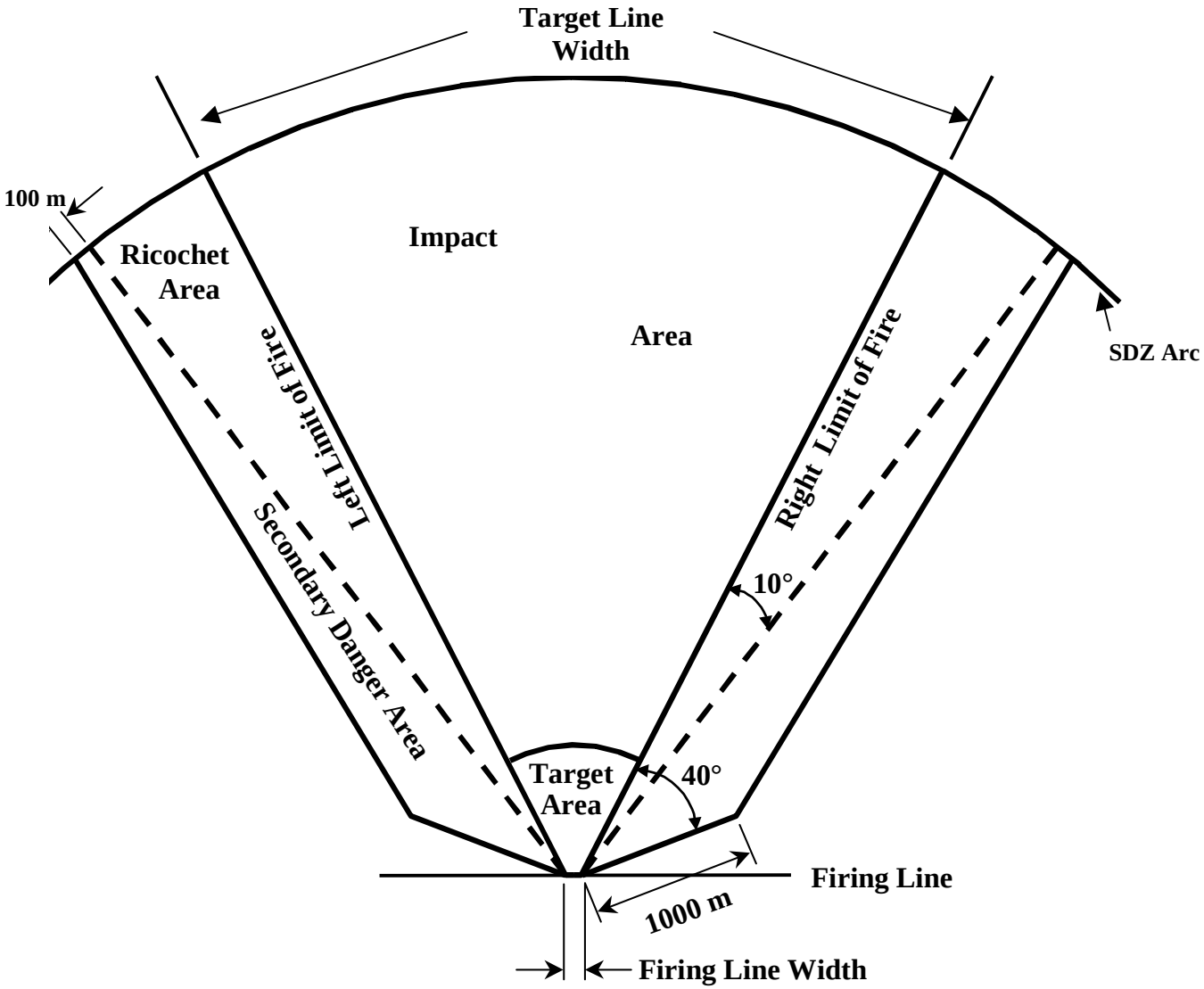
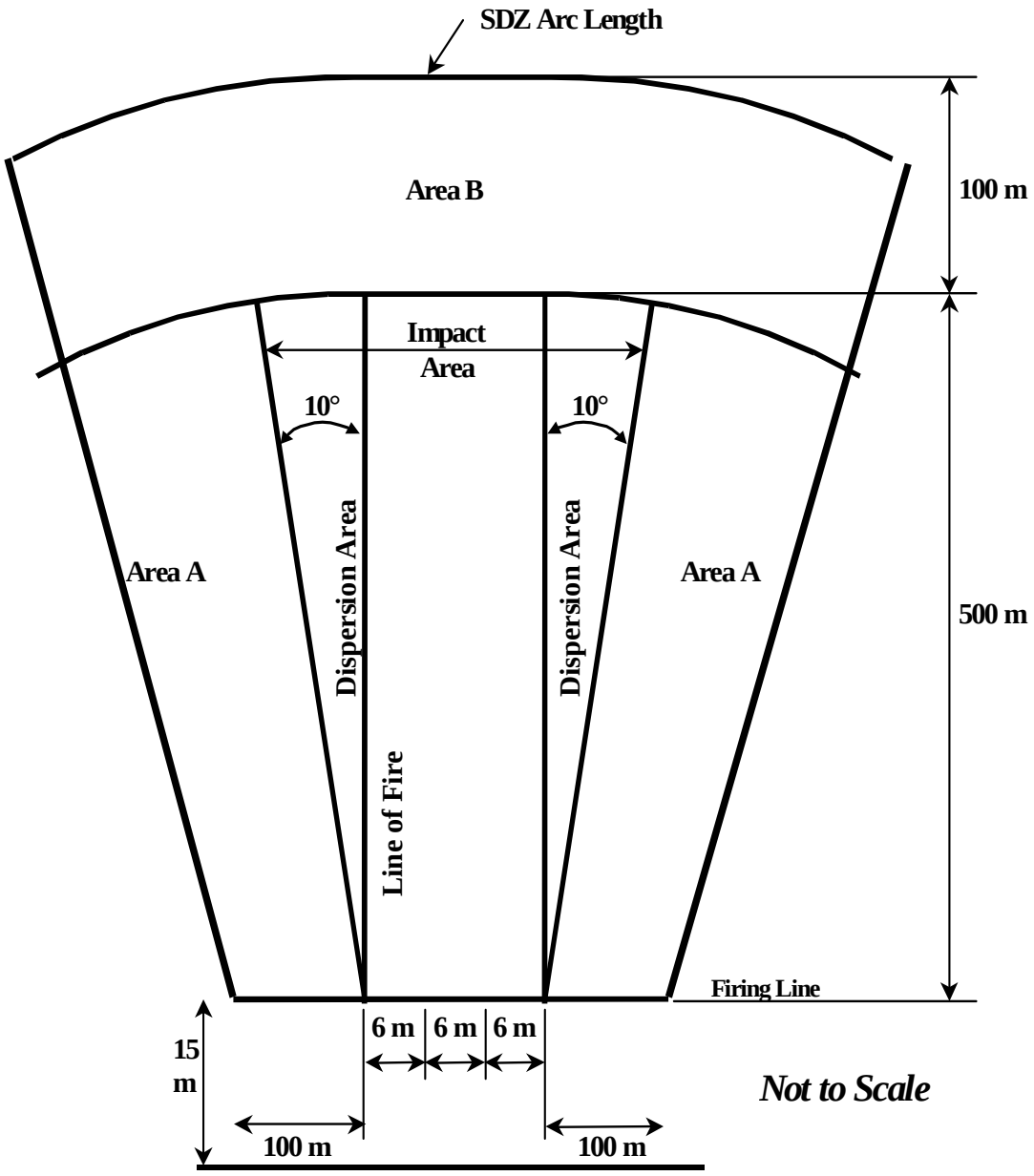


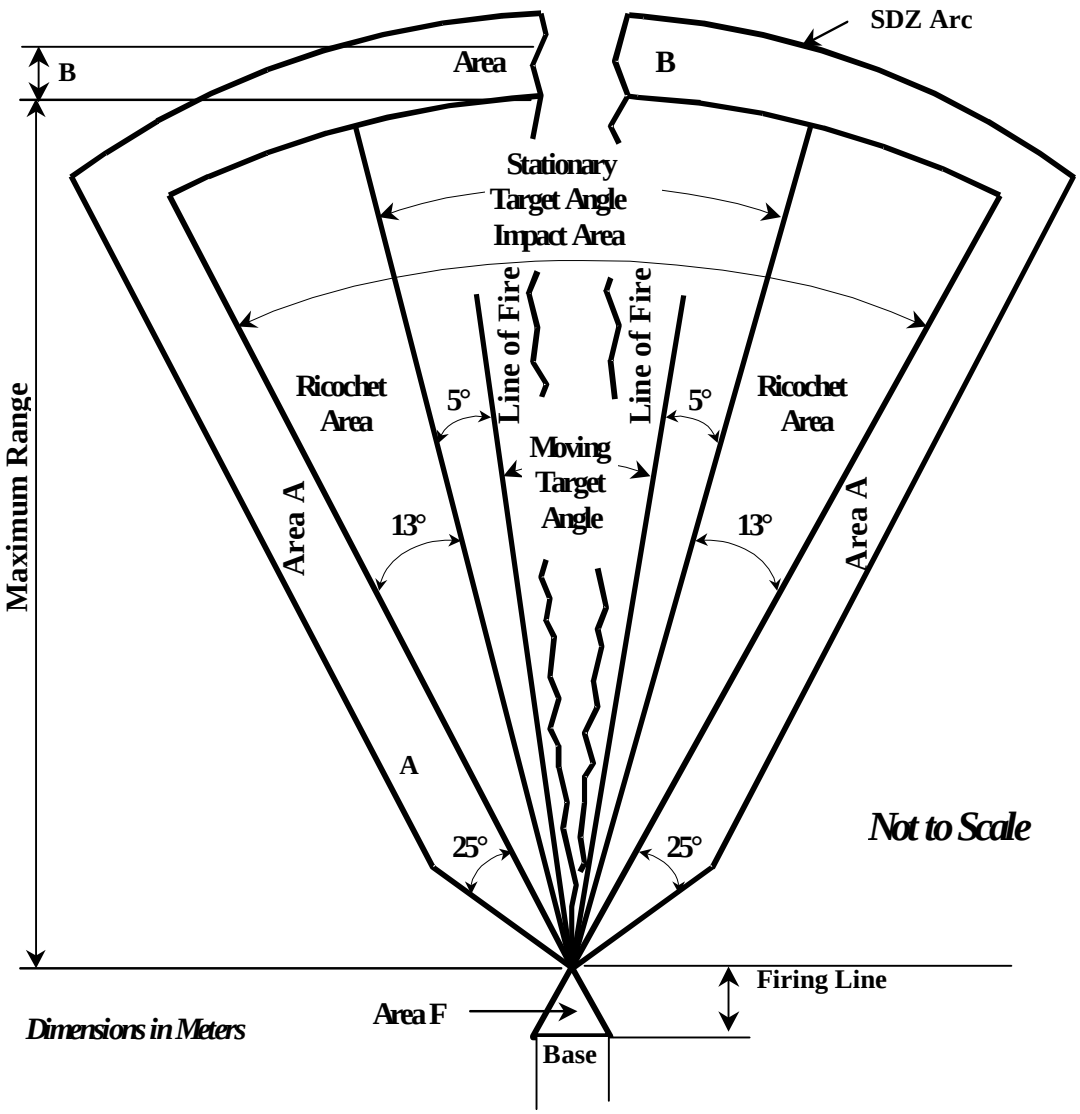
Figure 2. SDZ Configuration — Target Line Wider Than Firing Line



NOTES

1. **Additional firing positions may be added provided minimum of 6 meters is maintained.**
2. **Provide a 100-meter clear zone (Areas A and B) around the perimeter of the range for EOD disposal of dud rounds with explosive type projectiles.**
3. **Ranges only certified for use of M781 or other inert projectile rounds are not required. to include Areas A and B.**

Figure 3. SDZ Configuration — M79 and M203 Grenade Launcher Range



	Area		Minimum Range		Area F	
	A	B	to Impact	Maximum Range	Depth	Base
66mm HEAT Rocket, M72	250	250	75	1250	40	25
35mm Subcaliber , M72	100	100	50	1300	40	25

Figure 4. SDZ Configuration — Light Anti-Tank Weapons Range

9.2. Criteria Applicable to All Ranges. The design of all components (including baffles and deflector plates) is based on the worst-case requirements for the weapon and ammunition used on the range.

9.2.1. Except for noncontained ranges, ballistic safety structures are required for firing ranges. Ballistic safety structures consist of baffles, side containment, and backstops. Partially contained and fully contained ranges will require structures to contain direct fire and ricochets as appropriate for the type of range. Baffles are safety structures and can be classified as canopy baffles or overhead baffles. Side containment is sidewalls, berms, or discontinuous side baffles. Backstops are impact berms or bullet traps to stop direct-fired rounds. See paragraph 9.6 for more detailed description of ballistic safety structures.

9.2.2. Construction Materials. The materials selected for range construction must achieve the longest life cycle possible considering frequency of use, budget constraints, or other concerns. The desired life expectancy of permanent construction is 20 years. Permanent construction does not include protective construction, baffles, or sacrificial materials intended to capture bullets. Materials used for sidewalls, baffles, overhead containment, bullet traps, and other areas where a bullet could impact will ensure that the bullet is deflected downrange and not towards the firing line. Ricochet control must be considered when positioning brackets used for baffles, positioning bolt heads, and selecting protective construction.

9.2.3. Horizontal and Vertical Control. Vertical control is based on the firing line elevation being equal to 0.0 meter. The firing line is the baseline for horizontal control.

9.2.4. Drains. On outdoor ranges, use positive grading to direct water away from the firing line and towards the target line. When the length of the slope or the natural terrain requires using drains between the target and the firing line, locate a trench drain at the forward edge of the bullet trap, and construct the grade breaks to preclude exposing a vertical surface to the firing line.

9.2.5. Range Occupational Health Standards. Review NEHC TM-6290.99-10, *Indoor Firing Ranges Industrial Hygiene Technical Guide,* and *Best Management Practices for Lead at Outdoor Shooting Ranges*, available from the Environmental Protection Agency (EPA) Web site (http://www.epa.gov/region2/waste/leadshot). Additionally, the designer should coordinate with the local safety and bioenvironmental health officials for additional requirements. Refer to Air Force Occupational Safety and Health (AFOSH) standards to develop design criteria.

9.2.6. Floor Surfaces. The only flooring permitted for fully contained ranges is smooth concrete, protected with a waterproof sealant and sloped away from the firing line. Additionally, hardened steel floors of a thickness sufficient to prevent penetration of the bullet may be used if the designer provides design criteria, supporting data, and supporting calculations for approval. The concrete floor should not be swept, but should be vacuumed

with a vacuum cleaner designed to control lead dust exposure. Noncontained ranges will have turf or soil floors. Partially contained ranges will have smooth concrete floors for target distances of 50 meters (164 feet) or less, and may use soil or sand floors for the remaining distance beyond 50 meters. Pea gravel should not be used on ranges constructed after the effective date of this ETL.

Provide a means to capture water, lead contamination, and unburned powder buildup. Soil floors in partially contained ranges are discouraged because they accumulate powder and lead debris and are difficult to maintain. Water runoff from floors must be diverted to an approved collection system.

9.2.7. Wall Surfaces. Wall surfaces for partially contained ranges will be constructed of earth berms, fully grouted reinforced masonry, or reinforced concrete. To maintain the sound reduction properties of the wall materials, vertical masonry or concrete surfaces should not be sealed or painted. Wall surfaces for fully contained ranges will have wall surfaces of reinforced concrete, reinforced masonry, or hardened steel plate of a thickness sufficient to prevent penetration of the bullet through the wall. If hardened steel plate walls are used, data and supporting calculations will be submitted for approval to HQ AFCESA. Steel plate wall designs must address noise abatement in the design.

9.2.8. Openings. If an existing building is converted for use as a range, all openings forward of the firing line must be brick or masonry filled. All heating, ventilation, and air conditioning (HVAC) equipment forward of the firing line must be located behind baffles or the backstop. In new buildings, conceal pipes and conduits in the walls, above the ceiling, under floors, or behind protective baffles. In converted buildings, relocate exposed pipes or provide protective construction. When fire doors are required downrange, they must be equipped with hardware to allow opening only from the range side. Downrange fire doors must be protected with baffles and provided with a visual and audible alarm.

9.2.9. Ventilation. The ventilation system must control exposure to lead in accordance with 29 CFR 1910.1025, *Lead Exposure*. The supply and exhaust air system is critical to the operation of an indoor range and the health of building inhabitants. The design must include a positive exhaust system for removal of airborne lead. A slight negative air pressure must be maintained on the range, which can be achieved by exhausting 3 to 7 percent more air than is supplied. Supply and exhaust fan systems must have control interlocks to ensure simultaneous operation. On an indoor range, all doors into the negative pressure area must have air locks.

9.2.9.1. Airflow. The ventilation system should provide laminar airflow across the firing line toward the bullet trap. At the firing line, the air velocity should be 22.9 meters per minute (mpm) (75 feet per minute), plus or minus 5 percent. Airflow should be evenly distributed across the firing line. Noise from the ventilation system will not exceed 85 adjusted decibels (dBA).

9.2.9.2. Air Distribution. To ensure that contaminants are swept from the firing line, install a perforated air distribution plenum or other distribution fixture along the rear wall

to provide unidirectional airflow across the firing line and continuing downrange. The distance from the firing line to the perforated rear wall or plenum will be a minimum of 5 meters (16.4 feet).

9.2.9.3. Exhaust Openings. Exhaust openings are not permitted near the firing line. Locate exhaust openings at or behind the bullet trap.

9.2.9.4. Cross-Contamination. Exhaust discharge from the range must be separated from the supply air intake to prevent cross-contamination of lead-laden air. If the range is part of a larger building, exhaust air must not be discharged where cross-contamination of overall building air can occur.

9.2.9.5. Filtration to Remove Airborne Lead. Design exhaust air filtration systems in accordance with Occupational Safety and Health Administration (OSHA) and local regulatory requirements. Re-circulation of range air is not permitted.

9.2.9.6. Lead Dust at Ranges. Clean, hazard-free air is essential for a firing range. OSHA has established the permissible exposure limit (PEL) for airborne lead dust at 50 micrograms per cubic meter per hour average for an 8-hour day (total daily exposure may not exceed 400 micrograms). Special non-toxic training ammunition may be used to reduce the cost of rehabilitation of an existing ventilation system. Use of special ammunition must be approved by the MAJCOM, and all users of the range must use the approved type of ammunition.

WARNING

Exposure to lead dust is a severe health hazard associated with the operation of a small arms range.

9.2.10. Noise Reduction. Noise reduction in the range and noise transmission out of the range are different design considerations. Mass and limpness are two desirable attributes for a sound transmission barrier. Unpainted heavy masonry walls provide mass. Absorptive acoustical surfacing will reduce the noise level in the range but will have little effect on the transmission outside the range. Noise levels in the range should not exceed 85 decibels, and should be considerably less to improve communication between shooters and the range official.

9.2.10.1. Use conventional acoustical treatment on surfaces behind the firing line. Floor areas behind the firing line may be covered with acoustic material if it will withstand the lead dust removal process.

9.2.10.2. Do not paint downrange block walls or acoustic tile; this significantly degrades the sound-absorbing qualities of the materials. Existing ranges may continue using painted surfaces.

9.2.10.3. Install wall treatments in panels not larger than 1200 millimeters (48 inches) wide to facilitate replacement.

Note: Do not use blown-on acoustical material. Do not use carpet for floor or wall surfaces.

9.2.11. Infrastructure.

9.2.11.1. Range Control Tower. The control tower is an elevated control center from which the range officer can observe and control the entire range. Partially (baffled) and fully contained (indoor) ranges should have an elevated control booth. The following criteria apply to the design and construction of control towers.

9.2.11.1.1. Center the tower behind the firing line. The tower must be placed to permit an unrestricted view of all firing positions. For noncontained (impact) ranges, locate the tower at least 2.5 meters (8 feet) behind the firing line. The tower design shall not impede ventilation airflow.

9.2.11.1.2. The minimum size for the control tower platform is 1.5 meters by 3 meters (5 feet by 10 feet). Align the long side parallel to the firing line.

9.2.11.1.3. The tower must be high enough to permit an unrestricted view of the impact area, including all range entry points. The floor of the tower must be at least 1.83 meters (6 feet) above the firing platform.

9.2.11.1.4. Provide a worktable or counter sized 0.8 meters by 1.2 meters (2.5 feet by 4 feet) to accommodate reference materials, and provide at least one electrical outlet in the worktable/counter area. Provide red and white lighting for night/limited visibility operations.

9.2.11.2. Communication Systems. The range communication system must support communications between the control tower, range support buildings, and emergency response personnel. A permanent, hard-wired public address system is required. On a multiple range complex, the system must support communications between individual ranges. If it is not practical to install landlines, or if a break in landline service occurs, radio or cellular communications may be used. If practical, add connections for the base local area network.

9.2.11.3. Lighting. Provide downrange incandescent lighting (both red and white light) for safety and cleanup operations, as well as general range illumination. Light intensity at the target face should be 85 to 100 foot-candles measured 1200 millimeters above the range surface at the target face. Provide controls to vary lighting intensity

throughout the range to accommodate subdued light training requirements. Also provide flashing blue lights at the firing line and downrange to simulate emergency situations.

9.2.12. Barriers, Fences, and Signs. The range and danger zone areas must be secured to prevent unauthorized entry. Use barriers to block roads, walkways, or paths.

9.2.12.1. Fully contained (indoor) ranges require barriers in the form of key-operated, normally locked doors or electric locked doors to prevent entry while firing is in progress. Partially contained (baffled) ranges usually require barriers only for the access road leading into the range area.

9.2.12.2 Noncontained (impact) ranges require a number of barriers and signs to make the range safe. The number of barriers required depends on the number of roads, walkways, and paths that lead into the danger zone. Attach reflective warning signs to barriers.

9.2.12.3. Use fencing to prevent people, animals, and vehicles from entering range danger zones. A chain link fence around the complete range complex, including the SDZ, is preferred. Use barriers or gates to block access paths. On baffled ranges with earth side berms and an earth/metal backstop, as a minimum, install a 1.82-meter (6-foot) chain link fence around the sides and downrange side of the impact area incorporating the berms. Install the fence no closer than 5 meters from the berms and backstop. For partially or fully contained ranges with concrete containment walls and an earth/metal backstop, as a minimum, install the fence from one wall, around the backstop, to the opposite wall. Provide a locked access gate for maintenance equipment.

9.2.12.4. Typical range signs are shown in Figure 5. The signs, and flashing red warning lights for night operations, should be positioned on the approaches to the range and the perimeter of the SDZ, if access is not otherwise restricted. Red flags and/or rotating/flashing red lights must be placed at appropriate locations to signal when the range is in use. Place signs along the normal boundaries of the range. Post the signs no further apart than 150 meters along the range perimeter, parallel to the roads or paths. Based on local topography, place signs close enough to give reasonable warning along other areas of the SDZ. Refer to Table 2 for proper location of warning signs. Signs must be bilingual where English is not the national language, or multilingual where needed. Post bilingual signs on continental United States (CONUS) ranges located near foreign borders. Consult the base legal office for local policy on bilingual signs.

Figure 5. Typical Range Signs

Table 2. Locations of Warning Signs

Warning Sign	Location
Danger Firing in Progress When Red Flag is Flying	Approach Roads
Danger Firing Range Do Not Enter	Fencing and Barriers
Danger Weapons Firing in Progress Keep Out	Entry road

9.2.13. Utilities. Install utilities to prevent damage from normal firing range operations. Do not place any aboveground utilities in the impact zone or the ricochet zone. When utilities are placed directly behind backstops or berms, provide access for a maintenance vehicle. Underground utilities with proper cover may be placed anywhere on the range complex if maintenance and repair easements are provided.

9.2.13.1. Water and Sanitation. Water must be available for drinking, sanitation, and safety equipment. Base the latrine size on the number of people (instructors and trainees) supported using conventional planning criteria.

9.2.13.2. Electrical Power. Provide electrical power for lighting, maintenance equipment, public address systems, HVAC, and target-turning mechanisms.

9.2.13.3. Heat/Air Conditioning/Ventilation. Heat and/or air conditioning are at the discretion of the local commander. Negative pressure is required for all indoor ranges. Some outdoor ranges in colder climates will require radiant heat or a heated air curtain on the firing line. Outdoor ranges must be oriented so the prevailing wind is at the shooters' backs.

9.2.14. Roads and Parking. Design roads and parking for access by passenger vehicles and light or medium trucks. Provide surfaced all-weather roads for connector roads from public roads to the range complex.

9.2.14.1. Range access roads must approach the range complex from behind the firing line and outside the SDZ footprint.

9.2.14.2. Locate parking areas at least 15 meters (49 feet) to the rear of the firing platform. On partially and fully contained ranges using side berms or walls, the parking area may be on either or both sides of the range, but not within the SDZ. Normally, one parking space per firing position, plus an allowance for range personnel, is sufficient. Ranges with heavy training loads occasionally require two spaces per firing position. When feasible, surface parking lots for all-weather operation.

9.2.15. Storm Water Runoff and Drainage. Design storm water control structures to preclude storm water erosion of impact berms. A drainage structure should be located on top of berms to prevent storm water accumulation from running down the sloped face of earth berms. Divert surface water runoff within the range (including the SDZ) to a vegetated detention or retention basin. Discharge from detention basins must meet all requirements of federal, state, and local laws.

9.2.16. Contaminant Monitoring. A monitoring program provides early indications of lead movement. Sample the surface soil, surface water, and the ground water for soluble lead, dissolved lead, total lead, and nitrates. Frequency of sampling should be based on how often the range is used and site hydrological conditions.

9.3. Additional Criteria for Noncontained Ranges.

9.3.1. Siting Considerations.

9.3.1.1. Provide maintenance vehicle access to all of the range areas, including the backstop, side earth berm areas, and impact areas.

9.3.1.2. Use natural barriers and/or warning signs to minimize incidental entrance onto range danger areas.

9.3.1.3. Take advantage of natural geologic formations for use as backstops. Trees are allowed downrange of the impact berm, but not between the firing line and the target line.

9.3.1.4. Take advantage of natural drainage. Where terrain permits, slope the range floor toward the backstop. Flowing watercourses in the impact area or near a berm are not permitted. Avoid establishing range impact areas in locations subject to frequent flooding.

9.3.1.5. Locate impact areas to minimize fired projectiles and projectile residue falling in waterways or wetlands.

9.3.1.6. Avoid locating a range upwind (prevailing winds) of residential areas.

9.3.1.7. Ensure that the line of fire is directed away from residential areas.

9.3.2. Soils. Do not use pea gravel to surface or edge the impact area of the range, or the area between the firing line and the target line. Naturally occurring soils that are not excessively rocky can used between the firing line and the target line. Typically these will be clays, clayey sands, sands, silts, and silty sands that are mostly free of rocks and debris, with no more than 15 percent of the material gradation retained on the 24-millimeter sieve. Surfaces for impact berms should be natural or transported soils that are rock free for a minimum depth of 150 millimeters. These soils will be the same soil types indicated above; however, no more than 5 percent of the material should be retained on the 12-millimeter sieve.

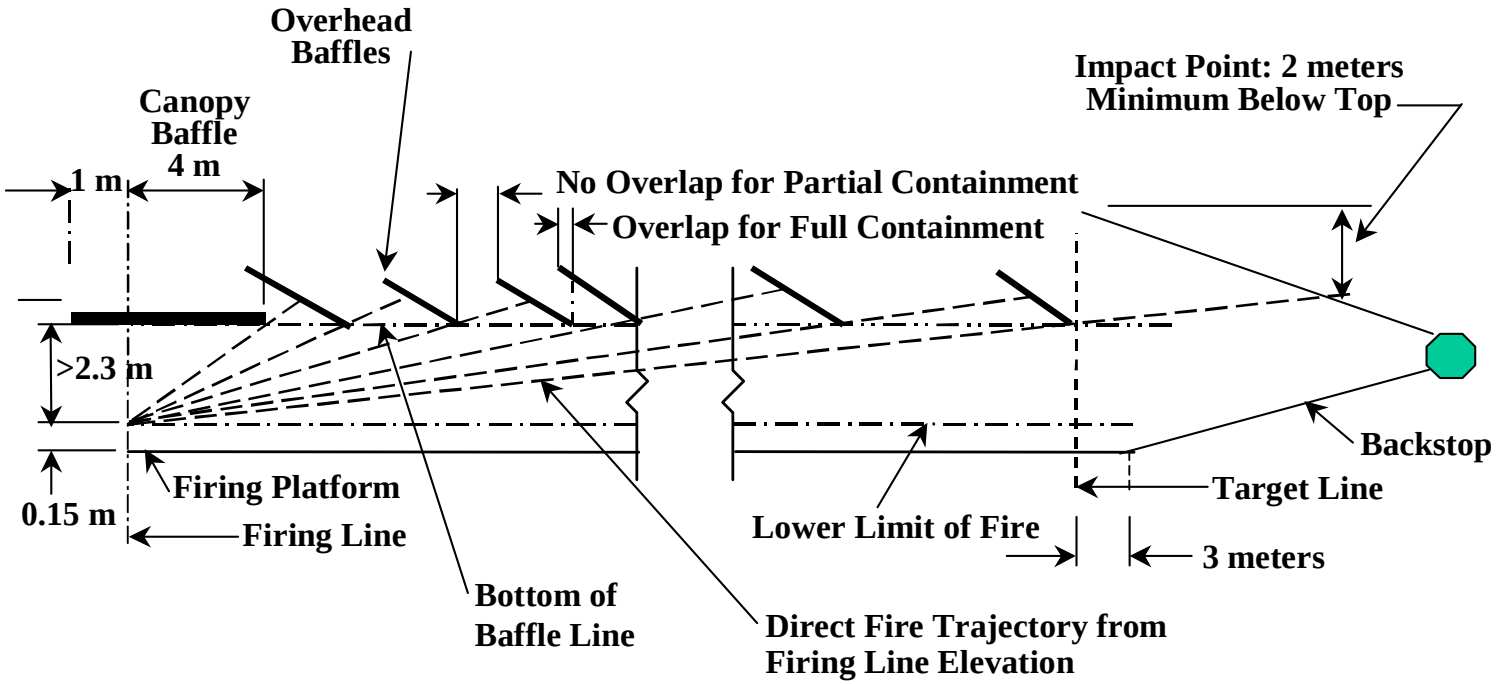
9.3.2.1. Soil Amendments. BCE environmental management must test soils within the impact areas for pH levels every 2 years. Desired pH ranges from 7 to 8. Test soil additives to ensure that they will not cause cementing or hardening of the soil surface. Do not use lime as an additive or soil conditioner when the natural soil gradation includes more than 30 percent passing the 200 American Society for Testing and Materials (ASTM) standard sieve, and/or the natural Plasticity Index is higher than 12.

9.3.2.2. Vegetation. Maintain vegetation on berms and drainage ways. Plant grass on impact areas. Turf grasses do an especially good job of retaining water and sediment on site. Choose a grass variety that will require minimal watering and fertilizer.

9.3.2.3. Reclamation and Recycling. Remove lead from the impact face of earth berm backstops when there is evidence of lead mass buildup. Personnel certified in lead reclamation can sift the lead from the soil by screening on the site. Collected lead must be disposed of or recycled in accordance with federal, state, and local laws and regulations. Consult BCE environmental management, bioenvironmental management, and the Defense Reutilization Management Office (DRMO) about disposing of, reclaiming, or recycling lead.

9.4. Additional Criteria for Partially Contained Ranges. A partially contained (baffled) range does not absolutely prevent 100 percent of the fired rounds from leaving the impact area of the range. Ballistic safety structures are used to stop errant direct-fired rounds and reduce ricochets. Even with a bullet deflector or catch at the backstop, ricochet rounds may fall outside the impact area. Baffles may be constructed as earth berms, earth backstops, concrete, masonry, or steel walls, or laminated materials. Vertical structural members within the range must be protected with baffles, mounted at an angle of 45 degrees to the line of fire, or clad with bullet-resistant materials.

9.5. Additional Criteria for Fully Contained Ranges. Fully contained ranges must be constructed to preclude any bullets from leaving the limits of containment. This will require additional attention to detail to be sure no gaps, openings, or other paths of bullet escape are present. Ballistic safety structures must be used to provide the containment. For fully contained ranges, overhead baffles must be constructed with a minimum of 150 millimeters (6 inches) of overlap between the leading edge of any baffle and the trailing edge of the next baffle downrange. This arrangement will provide containment such that a vertical line perpendicular to the range floor and projected upwards does not encounter any “blue sky” space. Figure 6 shows a baffle arrangement for full containment.



NOTES

1. **Profile based on a level range.**
2. **Horizontal baffle spacing as required to bring bullet into baffle at point not less than 450 millimeters below top of the following baffle.**
3. **Baffles must be angled 12 to 42 degrees from horizontal.**
4. **Bottom of Baffles must be at least 2.45 meters above the firing platform.**
5. **Canopy baffle may be sloped from 0 to 30 degrees from the horizontal. The high point of the sloped canopy baffle is towards the target line.**

Figure 6. Typical Overhead Baffle Location and Configuration

9.5.1. Ballistic safety structures for fully contained ranges must be constructed with attention to the quality of the fabricated parts. Baffle plates with butt joints must fit together closely to prevent any gaps more than 0.0625 inch wide. Modern plate cutting techniques can provide precise dimensions, but particular care must be taken in the erection of the baffles to ensure the precision fit of parts.

9.5.2. A good example of a fully contained range can be found at the Federal Law Enforcement Training Center in Glynco, Georgia. These ranges are considered fully contained and have a track record of millions of rounds fired without a documented case of a bullet leaving the containment limits.

9.6. Ballistic Safety Structures.

9.6.1. Canopy Baffles. A canopy baffle is an angled or horizontal baffle attached to and directly above the firing platform, and extending downrange from the firing line. It prevents direct-fired rounds from escaping the range between the first overhead baffle and the firing platform. The bottom of the canopy baffle must be at least 2.45 meters (8 feet) above the level of the firing platform. It will begin at least 1 meter behind the firing line and extend at least 4 meters (13.1 feet) toward the target line to block line-of-sight daylight from any possible firing position. A canopy baffle may be used to provide a covered firing line position. A canopy baffle may be used on a noncontained range without either overhead baffles or side containment.

9.6.2. Overhead Baffles. An overhead baffle is an angled or vertical baffle installed downrange to capture direct-fired rounds. Install overhead baffles downrange beyond the firing platform to prevent penetration of line-of-sight daylight when sighting downrange from 80 degrees to the right or left of any firing position, at either the standing or the prone positions. Angled overhead baffles redirect rounds downrange. The bottom of the overhead baffle must be at least 2.45 meters above the lower limit of fire. Install angled overhead baffles with the bottom edge further downrange than the top edge. Install overhead baffles parallel to the firing line. Under no circumstances may any “blue sky” be visible forward of the firing line from any firing position. Refer to Figure 6 for a typical configuration. Install angled overhead baffles for new ranges and baffle replacement projects.

9.6.3. Ground Baffles. Ground baffles are not permitted on Air Force ranges.

9.6.4. Baffle Construction. As a minimum, use materials specified in Table 3. These materials may also be used for protective construction. For angled steel plate baffles, install plywood facing to prevent “splash-back” ricochets on baffles located within 5 meters of the firing line. **Note:** Also install acoustic materials to canopy baffles to reduce noise.

Table 3. Construction Materials for Canopy and Overhead Baffles

Weapons	Ammunition	Construction*
Hand guns	22 LR, cal. .38, cal. .45	4 layers of 19 mm Oriented Strand Board (OSB) or particle board backed with one layer of 9.5 mm ($^{3}/_{8}$-inch) exterior grade plywood
Hand guns	Cal. .357, 9 mm, cal. .44,	6.35 mm steel plate with a 440 Brinnell Hardness Number (BHN), covered with one sheet of 19 mm (¾-inch) and one sheet of 11 mm ($^{7}/_{16}$-inch) plywood
Rifle, carbine, machine gun	5.56 mm, 7.62 mm, cal. .30	10 mm steel plate with a 500+ BHN, covered with one sheet of 19 mm (¾-inch) and one sheet of 11 mm ($^{7}/_{16}$-inch) plywood

***Note:** On steel plate baffles, install plywood facing the firing line. Attach the 19-millimeter sheathing to the steel using flathead countersunk screws. Attach the 11-millimeter plywood to the 19-millimeter sheathing using #8 flathead screws at 300-millimeter (11.8-inch) spacing. Plywood facing is to be used only on those overhead baffles located within 5 meters of the firing line to mitigate the risk of "splash-back" ricochets of bullet fragments.

9.6.5. Side Containment (Sidewalls). Sidewalls (earth berms, or continuous or wing wall baffles) are required to prevent direct fire from exiting the range. Finished elevation of a sidewall must be above the top edge of the highest overhead baffles. Each sidewall must be at least 1.52 meters from the outside firing position limits of fire and extend at least 1 meter to the rear of the firing line. Sidewalls may be made of earth, fully grouted reinforced masonry block, reinforced concrete, or hardened steel.

9.6.6. Earth Berms. Side slope of earth berms must not exceed a 2:3 vertical-to-horizontal ratio, unless materials are stabilized. If native soil characteristics will not produce a stable slope at this angle, use fabric reinforcement in the fill. Do not use clay or soils with more than 40 percent clay-size particles for the outside surface of the berm. Clay may be used for the core. The soil may require conditioning to achieve satisfactory soil pH levels to prevent lead decomposition. Typical angles of repose for natural soils in loose or least-dense state are shown in Table 4. Use Table 4 only as a guide, since mechanical stabilization may increase the angle of repose. The width of the top of the berm must be 3 meters (9.8 feet) minimum. Construct the top 1 meter of an earth berm with sands, silty sands, or clayey sands having a maximum particle size passing the #4 sieve and retained on the #200 sieve. For erosion control, plant a vegetative cover on the faces and tops of berms. Irrigation devices may be used on the faces and tops of berms not subject to direct fire. Ensure access for maintenance vehicles.

Table 4. Natural Angles of Repose (Internal Friction) for Naturally-Occurring Soils

Soil Types	Angle of Repose/ (Internal Friction)
Silty sand/fine sand/clayey sand	30
Coarse sand	35
Silts	25
Gravel/sandy gravel/gravelly sand	34

9.6.7. Continuous Walls. Vertical smooth-faced walls constructed of reinforced concrete, fully grouted reinforced masonry block (CMU), or hardened steel may be used for sidewalls. Table 5 lists minimum wall thickness. These walls must be designed for all dead and live loads, including lateral forces. See paragraph 9.2.10 for noise reduction requirements. Walls will extend beyond the rear of the firing platform to prevent a round fired parallel to the firing line from leaving the range.

9.6.8. Discontinuous Side (Wing Wall) Baffles. Side baffles are similar to overhead baffles, except they provide discontinuous protection to each side of the range outside the entire length of the line of fire. They are set between 15 and 45 degrees relative to the line of fire and provide an advantage over continuous walls whenever cross-range ventilation is needed.

Note: Discontinuous side baffles (wing walls) are not used with continuous sidewalls. The distance from the nearest edge of a wing wall and the line of fire should not be less than 2 meters (6.5 feet). Each wing wall must be positioned so that its inside edge will overlap the following wall by 1.5 meters, based on any line of fire from the firing line that may strike the wall. Wing walls should be built of the same materials required for continuous walls.

Table 5. Sidewall Minimum Thickness

	Caliber			
Material	.45/9 mm	5.56 mm	7.62 mm	.50
3500 psi concrete	150 mm	150 mm	200 mm	300 mm
Grout-filled CMU	200 mm	300 mm	300 mm	600 mm

9.6.9. Backstops. A backstop is used behind the target line. It must stop a direct-fire bullet by media capture, or deflect the bullet into a trap.

9.6.9.1. Earth Backstops. Earth backstops are the most common type for outdoor ranges. For a 25-meter range, locate the backstop so the longitudinal centerline of the berm (backstop) is at least 50 meters from the firing line. The toe of the slope must be located at least 9 meters (29.5 feet) from the target line nearest the backstop. The top of

the backstop must be high enough so that a line drawn from the firing line and under the last overhead baffle will intersect the backstop at least 2 meters (6.5 feet) below its top. The impact face of the earth backstop must be soil (100 percent passing the #4 sieve) for a depth of 2 meters. The slopes should be stabilized with grass vegetation with access locations provided for maintenance and repair equipment. Incorporate a steel deflector plate (eyebrow) into the backstop if a higher degree of confidence is required to prevent direct-fired rounds from leaving the impact area of the backstop. Soil with more than 40 percent clay-size particles passing the #200 sieve is not acceptable for use in the impact area face of the backstop. If required, soil should be conditioned to achieve suitable pH levels as indicated in paragraph 9.3.2.1.

9.6.9.2. Metal Backstops. These typically are used for partially contained or fully contained ranges but may be used for noncontained ranges. Locate a metal backstop a minimum of 4 meters beyond the target line to minimize lead exposure to shooters. Additionally, provide sufficient vehicle access to maintain the backstop. In any event, the required amount of containment must be provided regardless of the provision for vehicle access.

CAUTION

Do not use armor-piercing or incendiary rounds with metal backstops unless the backstops have been designed to accommodate these rounds. If commercially designed range materials are used, ensure that the products satisfy the design requirements for the ammunition used on the range.

Note: Metal backstops may be used on outdoor ranges when corrosion protection is incorporated into the construction. Painting does not provide adequate corrosion protection.

9.6.9.3. Backstop Deflector Plates. (Not applicable to commercial metal bullet trap systems.) Install the backstop deflector plate at an angle between 12 and 42 degrees from horizontal. Angles other than these are permissible provided test data and calculations support the design. Set the highest edge of the deflector plate nearest the firing line. The shallow angle deflects bullets more easily, and there is less metal fatigue and denting in the surface of the plate. Anchor steel plates supported by concrete or masonry with flush countersunk heads. Ensure edges of steel plates are milled at all joints, and joints are butted flush and smooth. Plates must be free from buckle or wave. Exposed edges must be chamfered to a 45-degree angle to a fillet approximately 4 millimeters (0.16 inch) wide. Exposed vertical support structures are not permitted. Welding must conform to AWS D1.1, latest edition, *Structural Welding Code — Steel*. Position steel plates so welds are no closer than 450 millimeters (17.7 inches) from the center of a target position. Steel plate jointed at and supported on structural steel supports must be spot-welded.

9.6.9.4. Bullet Traps. Only commercially designed and constructed bullet traps are permitted. The bullet trap must be designed for the ammunition/weapon used on the range and cover the entire area under the backstop deflector plate. The trap must be mined of accumulated deposits of bullets and fragments on a regular basis. Only trained personnel wearing proper personal protection must accomplish lead removal, and only after consulting with bioenvironmental personnel. The space directly behind the bullet trap must be accessible for maintenance and repair of the backstop. Sand and water traps are not permitted in new construction.

9.6.10. Metal Backstop Material (Deflector Plates and Traps).

9.6.10.1. Construct metal backstops, plates, and traps from the following materials:

- MIL-A-12560, *Armor Plate, Steel, Wrought, Homogeneous (For Use in Combat Vehicles and for Ammunition Testing*), that has been heat-treated.
- Steel that conforms to ASTM A514/A514M, *Specification for High Yield Strength, Quenched and Tempered Alloy Steel Plate*, and/or a surface hardness which varies from 235 to 293 BHN; best used with caliber .22 rimfire ammunition (not magnums).
- A BHN of 320 or greater where center-fire pistol ammunition will be used.

The design/specification must reference the applicable ASTM standard or MIL SPEC, the grade of steel required, and the hardness. To ensure that the correct grade of steel is installed (all steel plate looks the same), require a certificate of compliance. Refer to Attachment 1 for steel plate information and Table 6 for required thickness and hardness.

Note: The BHN measures steel hardness. The higher the BHN number, the harder the steel.

9.6.10.2. Do not use steel, carbon steel plate, or low alloy steel conforming to ASTM A242/A242M*, Standard Specification for High Strength Low Alloy Structural Steel*, or A572/A572M, *Standard Specification for High Strength Low-Alloy Columbium Vanadium Structural Steel*. They lack adequate pitting resistance and deteriorate rapidly on small arms ranges.

9.6.10.3. A 6-millimeter (0.25-inch) steel plate treated to 440 BHN when set at an angle of 42 degrees is sufficient for all handgun cartridges except caliber .44 magnum. A 10-millimeter (0.4-inch) steel plate treated to 500+ BHN when set at 30 degrees will accommodate cal. .30 (.30-06), 7.62 mm, and 5.56 mm ball, and all handgun ammunition. Refer to Table 6.

Table 6. Minimum Steel Plate Thickness for Metal Backstops

Min. Angle	Ammunition	Armor Plate/ 300 BHN	440 BHN	500+ BHN
42	.22 LR rim fire	6 mm	6 mm	6 mm
42	Cal. .38 ball	10 mm	6 mm	6 mm
42	Cal. .45/ cal. .357	10 mm	6 mm	6 mm
42	9 mm pistol	10 mm	6 mm	6 mm
42	Cal. .44 magnum	12 mm	10 mm	10 mm
30	5.56 mm, 7.62 mm	12 mm	Not recommended	10 mm
30	Cal. .30 carbine	12 mm	Not recommended	10 mm

9.6.11. Commercially Manufactured Metal Bullet/Total Containment Traps. These traps are installed/placed on partially contained and fully contained ranges in front of the backstop or rear wall of the range. They are total systems that deflect, stop, trap and contain direct-fired rounds, and may incorporate vacuum systems to capture lead particles. Metal thickness and hardness must meet the minimums listed in Table 6 for ammunition the range is licensed to handle. If lesser thicknesses are proposed, the range component designer must provide test data and calculations supporting a lesser thickness. Angles of the metal plates must conform to those directed by the manufacturer to handle the munitions fired from varying shooter positions, target distances, and target positions. All traps must be designed for tracer rounds if a tracer round can be used in this type of weapon.

9.7. Range Support Facilities. These include the Combat Arms building and munitions storage room/building (Category Code 171-476), a building for the storage of range supplies and equipment (Category Code 171-472), and a building for target storage and repair (Category Code 171-473).

9.7.1. Combat Arms Building. This building provides a humidity- and temperature-controlled environment for the Combat Arms section. The building houses classrooms, administrative offices, weapons maintenance areas, space for the cleaning and degreasing of weapons, an alarmed weapons and munitions storage room, sanitary facilities, a student weapons cleaning room, and miscellaneous storage. Figure 7 presents a typical floor plan. A small arms range with more than 21 firing points, or an installation with more than one range or type of range, requires proportionately larger facilities. Consideration should be given for space to accommodate weapons simulator training as mission needs dictate.

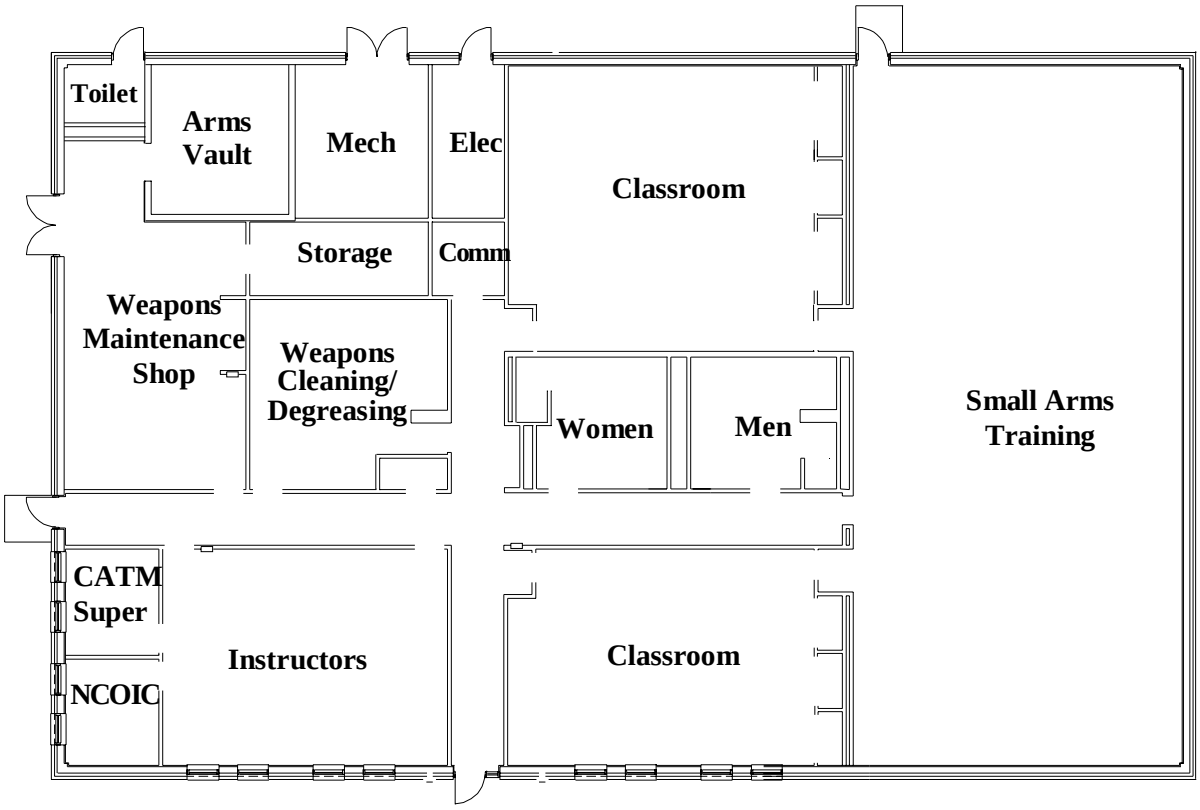


Figure 7. Typical Combat Arms Building Configuration

9.7.1.1. Classrooms. Classrooms must be large enough to provide each student receiving handgun, rifle, shotgun, or submachine gun training a chair and a table work surface of at least 610 by 915 millimeters (24 by 36 inches). Provide space for each student receiving machine gun, mortar, or recoilless rifle training to accommodate a work surface of at least 865 by 1145 millimeters (34 by 45 inches). The classroom will include a raised instructor's platform, aisle space for instructor access to individual tables, and sufficient space and connections for audiovisual equipment such as videocassette recorders, movie projectors, audio tape recorders, slide projectors, overhead projectors, and computers.

9.7.1.2. Administrative Space. This area (typically about 13 square meters [140 square feet]) contains offices for program administrators and Combat Arms personnel such as the CATM superintendent or non commissioned officer in charge (NCOIC) and several instructors.

9.7.1.3. Weapons Maintenance Shop. The weapons maintenance shop must have space for workbenches, hand tools, power tools, equipment, and spare parts storage. A range that supports less than 5,000 weapons requires a 28-square-meter (300-square-foot) shop. A base that supports over 5,000 weapons will require 37 square meters (400

square feet). Provide a lavatory with potable water in the immediate area. An emergency eyewash station is also required.

9.7.1.4. Weapons Cleaning/Degreasing Room. This room accommodates workbenches, degreasing tanks, and spray hoods. Special design requirements include forced ventilation, vapor-proof electrical fixtures, compressed air service, and solvent-resistant wall and ceiling finishes. The space requirement is typically about 12 square meters (130 square feet). A lavatory with potable water should be in the immediate area. An emergency eyewash station is also required. The base safety office and bioenvironmental engineering may have additional design requirements.

9.7.1.5. Weapons and Ammunition Storage. The vault provides secure storage for all weapons for which the Combat Arms section is responsible and a less-than-30-day supply of each type of ammunition used on the range. A gross floor area of 14 square meters (151 square feet) is usually adequate. Room construction must satisfy the requirements of AFI 31-101, *The AF Installation Security Program (For Official Use Only [FOUO])*, and AFMAN 32-1071, *Security Engineering Project Development (FOUO)*, for construction materials and specifications. Additionally, requirements of DOD 5100.76M, *Physical Security of Conventional Arms, Ammunitions, and Explosives,* must be satisfied. In general, vault construction must provide a minimum 10 minutes of forced entry delay. Typical vault construction features walls, floors, and roof of 200-millimeter (7.9-inch) concrete reinforced with two layers of number 4 rebar on 225-millimeter (9-inch) centers, fitted with a class V door.

9.7.1.6. Latrines (Sanitary Facilities). Provide facilities for both men and women. The size of each depends upon the class size at that particular installation. Usually, the women's latrine need only accommodate about one-fourth the number of people as the men's latrine. Because instructors have daily contact with lead/heavy metals and may transfer these contaminants by casual contact, showers, changing areas, laundry facilities, and lockers should be provided for instructors to remove contamination. Use of these facilities will prevent recurring casual contamination and potential health concerns away from the range facilities. Cold water should be used for body washing to prevent lead absorption. Hot water opens the pores of the skin and permits easier absorption through the skin.

9.7.1.7. Student Weapons Cleaning Area/Room. Students must clean their weapons after completing firing. The cleaning area may be outside as long as it is covered; in cold climates, provide a room large enough to accommodate cleaning tables/benches and cleaning materials. Ensure that the room is well ventilated.

9.7.1.8. Miscellaneous Storage. A storage area is required for administrative supplies, training aids, tools, and miscellaneous items. The size of this area is directly related to the type and quantity of training accomplished by the Combat Arms section.

9.7.2. Range Supplies and Equipment Storage. This building provides secure storage for miscellaneous range supplies, tools, and equipment. Use prefabricated metal,

reinforced concrete, reinforced masonry, or wooden buildings. Depending on location, type, and value of items stored, this facility may be combined with the target storage and repair building.

9.7.3. Range Target Storage and Repair Building. This facility provides space for repair and storage of targets and related equipment items, including target mechanisms and construction and repair material. Use prefabricated metal, reinforced concrete, masonry, or wooden construction. Repair space contains tables and workbenches. An electrical power source for operating power tools is required.

9.8. Specialty Weapons Ranges.

9.8.1. 40 mm Grenade Launcher Range (Figure 3). The range supports firing of 40 mm low velocity grenades fired from M79, M203, and XM148 grenade launchers. The entire surface of the impact area must be cleared of vegetation or clipped extremely close during mowing operations so the grenades will readily detonate on impact and explosive ordnance disposal personnel can easily locate dud high-explosive rounds for disposal. Construct targets using lumber, steel, or concrete. Terrain features, course of fire, and weather conditions determine if a spotting tower may be needed for observing the impact area (to note point of impact for adjustment of fire and for safety). Range personnel must be able to spot and mark dud rounds as they occur. A central tower high enough to permit observation of the entire range may be required.

9.8.2. Light Antitank Weapons Range (Figure 4). The range is set up for firing of the M72 66 mm rocket, the M73 35 mm sub-caliber training device, and the AT-4. The danger zone to the rear of the launcher (Area F) must be clear of personnel, material, and vegetation. Arrange firing points so individual back-blast areas do not overlap.

9.8.3. 81 mm Mortar Range. Design criteria are established by AFSFC, on a case-by-case basis.

9.8.4. Ten-Meter Machine Gun Range. Machine gun ranges must incorporate range tubes as described in paragraphs 9.8.4.1 through 9.8.4.3. Range tubes function as baffles, thereby reducing the SDZ requirements. When the M60 tube range is constructed in accordance with Figures 8 and 9, the SDZ requirement is 700 meters measured downrange from the firing line. Range tubes are not required on a totally contained range designed for firing automatic weapons, or on a noncontained range with sufficient real estate to accommodate the full SDZ.

9.8.4.1. M60 Machine Gun Tubes. Ten-meter machine gun range tubes must measure at least 1.52 meters inside diameter by 7.3 meters (24 feet) in length. The tubes may be constructed of sectional pieces as long as the spigot end of the bell-spigot joint is pointed downrange. Tubes may be made of reinforced concrete pipe and must meet ASTM C76, *Reinforced Concrete Culvert, Storm Drain and Sewer Pipe,* Class V RCP requirements, or may be steel pipe of suitable thickness fabricated from rolled plates. For drainage, slope the tubes approximately 150 millimeters toward the target line.

Firing positions must be at least 3.7 meters (12 feet) apart, measured center-to-center. The end of the tube toward the shooter should touch the firing line. When firing, the muzzle of the machine gun will be at least 150 millimeters (6 inches) inside the tube (see Figures 8 and 9).

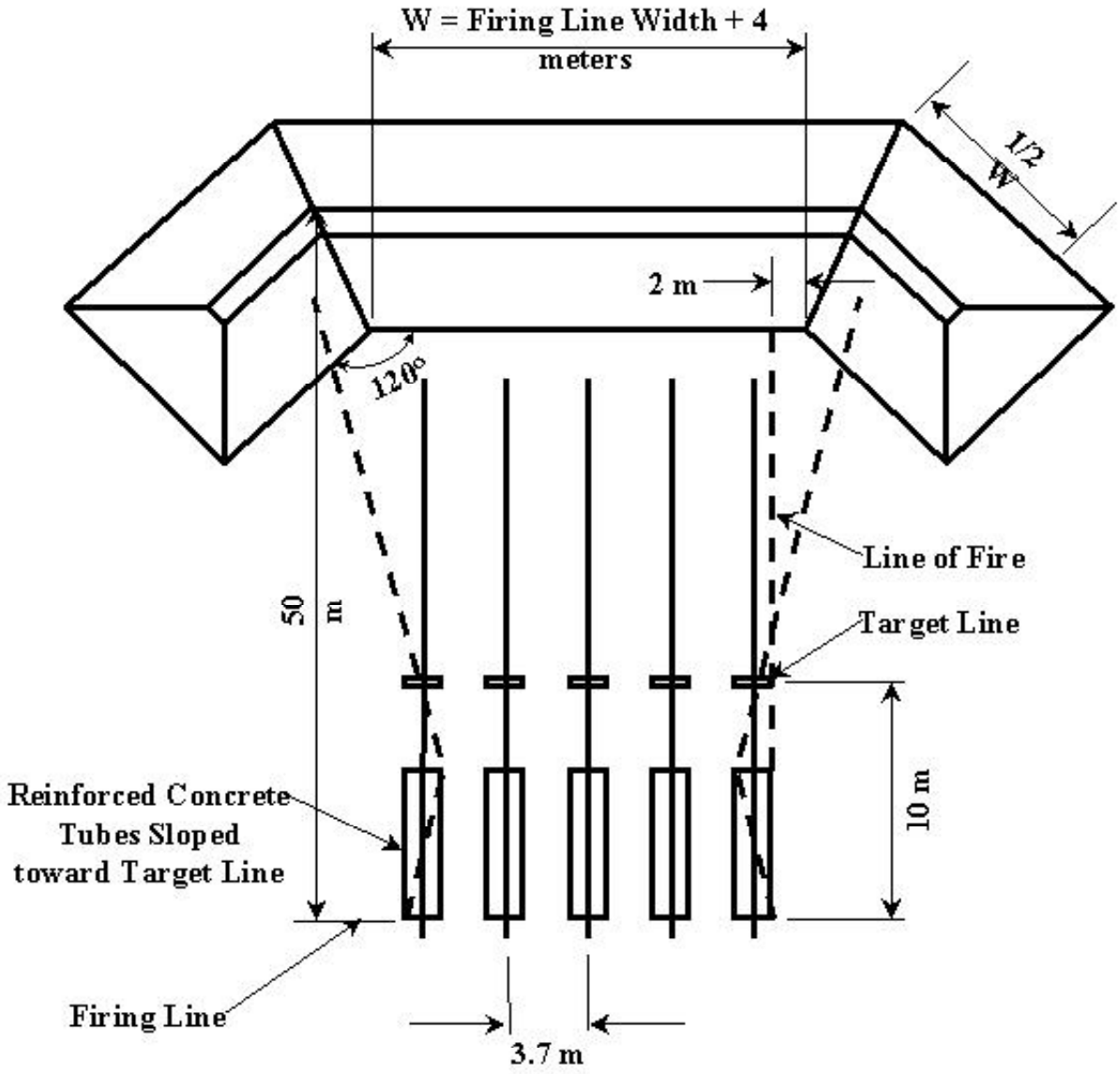


Figure 8. M60 Machine Gun, 10-Meter Tube Range Typical Range Configuration

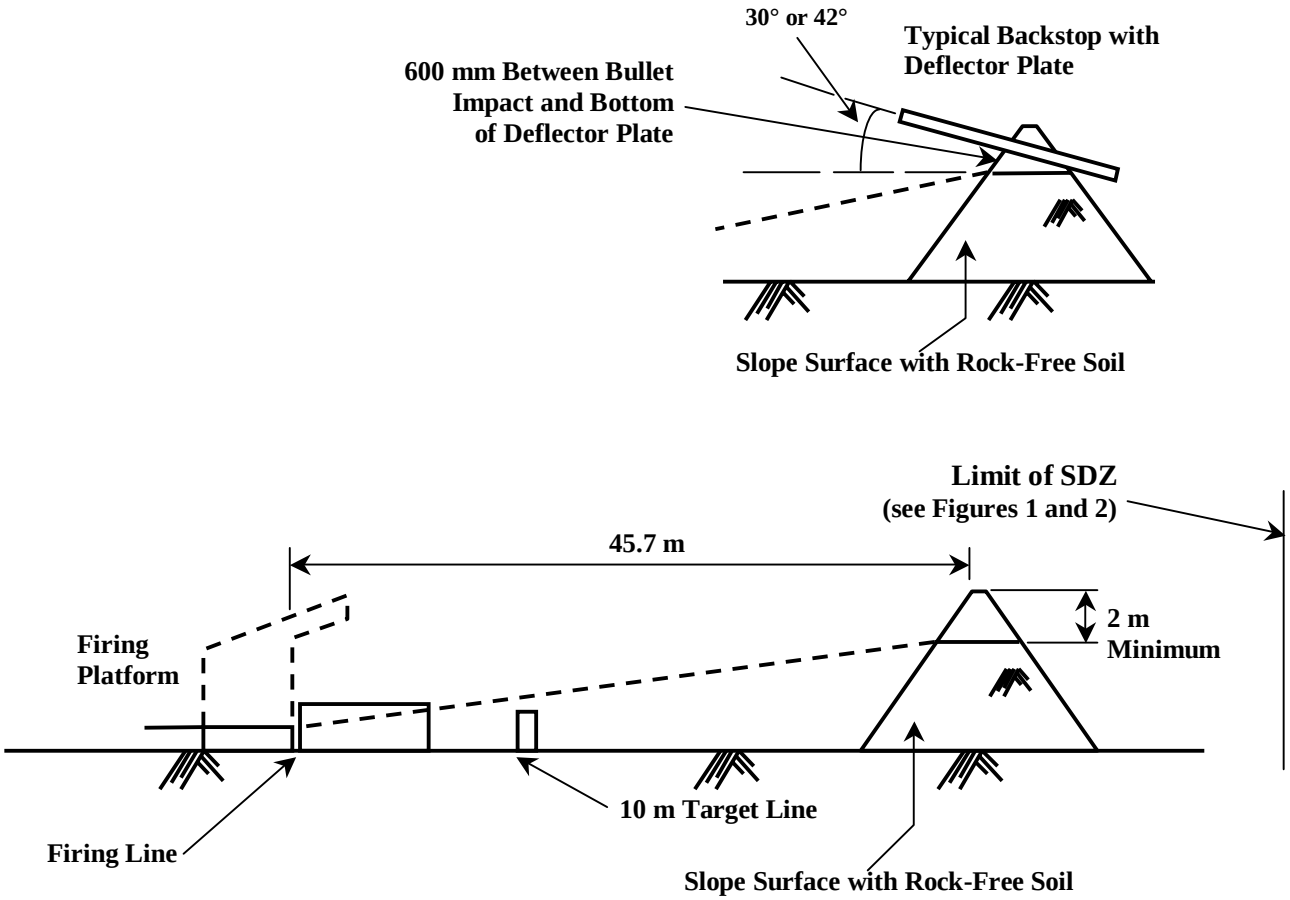


Figure 9. M60 Machine Gun, 10-Meter Tube Range Typical Cross-Section

9.8.4.2. Firing Platform. Ensure that the firing tube placement and the firing platform height will place the muzzle of the machine gun at the approximate center of the tube diameter and at least 150 millimeters inside the tube. A recess in the platform may be needed, about 76 millimeters (3 inches) deep and large enough to accept a tripod.

9.8.4.3. Backstop/Deflector Plate/Bullet Trap. Locate the backstop no more than 45.7 meters (150 feet) from the firing line to the centerline of the backstop. The minimum height of the backstop is established by determining where a line drawn from the firing line to the backstop, and intersecting the highest point that a bullet could exit the target end of the tube, intersects the backstop. This line must intersect the backstop not less than 2 meters from the top. When a deflector plate is used, locate the deflector plate at least 0.6 meter (2 feet) above the bullet impact point on the backstop.

9.9. Design Review, Construction Inspection, Test Firing, and Trial Operation.

9.9.1. Design Approval. The design agent will submit a set of percent drawings and project specifications to the respective MAJCOM representatives of Security Forces, Combat Arms, CE, Safety (SE), and Bioenvironmental Engineering (SGPB) for review to ensure compliance with this ETL. For range designs that do not satisfy this ETL, the

installation can prove the validity and range safety by conducting a computer modeling and simulation safety analysis. Coordinate with the Fire Control and Software Engineering Division at Picatinny Arsenal (TACOM-ARDEC, ARMSTA-AR-FSF-T) to conduct a Safety Analysis Modeling and Simulation as early in the design process as feasible to minimize lost design effort and to ensure a safe range facility. The installation will review the Safety Analysis Modeling and Simulation results for proper risk management decisions or recommended changes and forward the results to the installation MAJCOM for approval before proceeding to final design.

9.9.2. Baffle Test Prior to Construction. Prior to final construction and installation of baffles, construct baffle test blocks/cells using baffle materials and construction details specified in the design documents. From a protected position, a shooter will engage the test block/cell with direct fire from the most powerful round that will be authorized for the range. The baffle test should have secondary containment to stop the round if it penetrates the test baffle. Do not test the baffle blocks/cells using tracers. Do not test baffles after they are installed in their overhead position. Conducting direct-fire tests following construction could be very unsafe and costly if the baffles fail to stop the round.

9.9.3. Construction Inspection. The BCE will validate that the proper materials have been used and construction complies with the specifications and drawings. The range and its support facilities, when completed, must satisfy or exceed the requirements of this ETL. The materials, distances, and angles are critical to safety. Distances from the firing lines to target lines are critical and must be measured during construction and on completion of the range. On partially contained and fully contained ranges, visually check baffles to make sure they overlap so that a shooter from any firing position cannot see "blue sky." Overhead baffles must not permit line-of-sight blue sky when looking downrange from any shooting position on any firing point.

9.9.4. Test Fire Requirements. After construction or rehabilitation, and before conducting training and qualification operations, Combat Arms personnel must accomplish a controlled test-fire. Representatives of ground safety and civil engineering will act as observers. The most experienced shooter available will use the most powerful ammunition authorized for use on the range for the test. Make sure all fire hazards are removed from the range and areas surrounding the range. Make sure firefighting equipment is immediately available when conducting range tests using tracer ammunition.

9.9.4.1. Noncontained Ranges. A test-fire is not required for a noncontained range. After the construction inspection is completed, proceed to trial operations.

9.9.4.2. Partially Contained. Do not test baffles with direct fire. Test baffles for direct-fired-round containment prior to construction, as described in paragraph 9.9.2. To test for ricochet containment, the shooter first must fire from the prone position into the backstop at the highest point possible. A test screen (witness) may be used to test ricochet potential of the range floor. A test screen may be constructed from Celotex

(National Stock Number [NSN] 5640-00-073-2803) or cardboard material, fashioned into a 1.2-meter by 1.2-meter, four-sided cube. Place the test screen at different locations on the range floor, and fire into the range floor in front of the test screen at various angles from the firing line. To determine if ricochets would have left the range, sight along a small diameter dowel placed through ricochet holes in the screen material. If the angle of departure is less than 45 degrees and the sighting verifies that the bullet left the range, corrective measures must be taken. Conduct tracer tests using the same caliber of ammunition to be used on the range to determine patterns of ricochets. Use of tracer ammunition is the fastest and most efficient method of determining ricochet patterns and hazard potential.

9.9.5. Trial Operations. Trial operation of a new or rehabilitated range is mandatory. The Combat Arms NCOIC and base ground safety representative will be present during trial operations. Document the results of the trial operations in a range trial operation report. One copy of the trial operations report must be included in the construction acceptance documentation. The Combat Arms section will retain an additional copy on file for the life of the range. Include the following items in the report:

- Date of construction completion.
- Date of trial operation.
- Course of fire.
- Type of weapon, caliber, and ammunition used for the trial. (This must be the most powerful ammunition intended for use on the range.)
- Target system functioning (may be mechanical or fixed).
- Number of shooters who fired.
- Firing points used.
- Damage incurred or improperly functioning items.

10. Point of Contact: Recommendations for improvements to this ETL are encouraged and should be furnished to Mr. Jim Caulder, P.E., HQ AFCESA/CESC, DSN 523-6332, commercial (850) 283-6332, e-mail mailto:jim.caulder@tyndall.af.mil.

MICHAEL J. COOK, Colonel, USAF

4 Atch
1. Steel Plate Sources and Costs
2. Minimum VDZ Height Requirements for Small Arms Ammunition — Noncontained Ranges
3. Operational Risk Management Evaluation of Existing Range Facilities
4. Distribution List

STEEL PLATE SOURCES AND COSTS

Manufacturer	Description	ASTM	Grade	BHN	Costs* ($/Cwt.)	Lead Time (Months)	POC
Bethlehem	MIL-A-46100	N/A		300	69.00 to 76.80		Steve Painter Bethlehem Steel Coatesville, PA 19320 Ph: 800-638-6169
	T-1A	N/A		360	37.75 to 44.25	4	
	Hardwear 400	N/A		400	46.25 to 52.75	4	
	Hardwear 500	N/A		500	46.25 to 52.75	4	
Oregon Steel	Formalloy 400	N/A		363/ 444	32.25 to 36.75	1 to 2	Bruce Iredale Oregon Steel 1440 N. River-gate Blvd. Portland, OR 97203 Ph: 503-240-5791
	Formalloy 500	N/A		477/ 534	37.25 to 41.75	1 to 2	
	AR 350	N/A		321/ 363	31.25 to 35.75	1 to 2	
	AR 400	N/A		363/ 444	31.25 to 35.75	1 to 2	
	AR 425	N/A		301/ 461	35.25 to 39.75	1 to 2	
	AR 500	N/A		477/ 534	36.25 to 40.75	1 to 2	
USX	T1 Type A	A514	B	321	45.00 to 54.00	3	Karen Davidcock US Steel Gary Works Plate Mill Sales Office Gary IN 46402 Ph: 800-219-7450
	Shield 400	N/A		360/ 444	45.00 to 4.00	3	
	Shield 500	N/A		400/ 480	45.00 to 54.00	3	

*Pricing varies based on thickness (6-millimeter [0.25-inch] plate is the most expensive).

Note: All pricing is FOB mill.

MINIMUM VDZ HEIGHT REQUIREMENTS FOR SMALL ARMS AMMUNITION — NONCONTAINED RANGES

Weapon/Caliber	Ammunition	Maximum Ordinate of Ammunition at 30°VDZ	Safety Factor	VDZ Height (Meters)
.22 long rifle		500	175	675
Handgun, cal. .38	Ball, M41, PGU-12/B	500	175	675
Handgun, cal. .45 pistol		400	160	560
Submachine gun, cal. .45		400	160	560
Handgun, .357 magnum		TBD	TBD	TBD
Handgun, 9 mm pistol		500	175	675
Submachine gun, 9 mm		TBD	TBD	TBD
Handgun, .44 magnum		TBD	TBD	TBD
Shotgun, 12 gauge	00 buckshot	200	130	330
Rifle/machine gun, cal. .30	Ball and M21	TBD	TBD	TBD
Carbine, cal. .30		TBD	TBD	TBD
Rifle, 5.56 mm	Ball, M193; Tracer, M196	800	220	1020
Rifle, 5.56 mm	Ball M855; Tracer, M856	900	220	1120
Rifle, 5.56 mm	M862	TBD	TBD	TBD
Rifle/machine gun, 7.62 mm	Ball, M80	1100	265	1365
Rifle/machine gun, 7.62 mm	Match, M118	1200	260	1480
Machine gun, cal. .50	Ball, M2 and M33	1600	340	1940
M79, M203, XM148, 40 mm low velocity	M781/M407A1/M406/ M433/M381/M386/ M441	100	115	215
Mk-19, 40 mm high velocity	M918/280M383/M430	500	175	675
M72 LAW, 35 mm subcaliber	M73	300	145	445
M72 Law, 66 mm RKT HEAT	M72, 66 mm RKT HEAT	200	280	480
AT4, 84 mm RKT HEAT	M136	TBD	TBD	TBD
M29 or M252 mortar, 81 mm	M301/M374A3/M375	2100	TBD	TBD
M252 mortar, 81 mm	M819/M821/M853/ M889	TBD	TBD	TBD

Note:

1. VDZ in excess of 61 meters (200 feet) height require coordination with the local airfield manager.
1. 2. For partially contained (baffled) ranges use a VDZ of 500 meters.

OPERATIONAL RISK MANAGEMENT EVALUATION OF EXISTING RANGE FACILITIES

A4.1. Overview. Operational Risk Management (ORM) is a tool that can be used to assess the risks associated with continued use of existing firing ranges that do not satisfy the minimum criteria outlined in this ETL. This attachment does not go into detail concerning ORM since it is covered in AFI 91-213. This narrative shows an example of how the ORM process can be applied to an evaluation of the safety of an existing range. Briefly, the ORM process can be considered to be a six-step process:

1. Identify the hazard
2. Assess the risk
3. Analyze risk control measures
4. Make control decisions
5. Implement risk controls
6. Supervise and review

A4.2. Action Items. The six steps of the process can be broken down into several sub-steps called "actions." A discussion of each action follows.

A4.2.1. Hazard Identification. This step is broken down in three actions:

- Mission/task analysis (e.g., Training personnel to fire weapons)
- Listing the hazards (e.g., fired rounds leaving the range)
- Listing the causes (e.g., baffles are of insufficient thickness)

Listing the causes of the hazards is the action where deficiencies or discrepancies are items that are found to not satisfy the ETL criteria. A tabular method for recording these actions and steps is presented in the following paragraphs.

A4.2.2. Assess the Risk. This step is broken down into three actions:

A4.2.2.1. Assess hazard severity category:

- I Catastrophic (i.e., mission failure, death, system loss)
- II Critical (i.e., major mission impact, severe injury, or major system loss)
- III Moderate (i.e., minor mission impact, injury, or system damage)
- IV Negligible (i.e., little mission impact, minor injury, or damage)

A4.2.2.2. Assess the mishap probability:

- A – Frequent, Daily, often, 10^-1 to 10^-4
- B – Likely, three weeks, occurs several times, 10^-2 to 10^-4
- C – Occasional, 6 months, will occur, 10^-3 to 10^-5
- D – Seldom, 5 years, could occur, 10^-4 to 10^-6
- E – Unlikely, Past five years has not occurred, rarely, 10^-5 to 10^-7

A4.2.2.3. Assign a numerical rating based on the combination of steps A4.2.2.1 and A4.2.2.2. See the table below for the numerical value to assign to the risk:

Table A1.1. Mishap Probability

		MISHAP PROBABILITY				
SEVERITY		Frequent A	Likely B	Occasional C	Seldom D	Unlikely E
Catastrophic	I	1	2	6	8	12
Critical	II	3	4	7	11	15
Moderate	III	5	9	10	14	16
Negligible	IV	13	17	18	19	20

Note: Lower numbers indicate the highest risk.

A4.2.3. Analyze Risk Control Measures. This step is broken down into three actions:

A4.2.3.1. Identify risk control options: Measures taken to mitigate the risk.

A4.2.3.2. Determine control effects: Select the control options desired for consideration.

A4.2.3.3. Determine the residual risk: Prioritize the control measures and re-score the risk based on the implemented control measures using the same procedures as in paragraph A4.2.2.3.

A4.2.4. Make Control Decisions. This step is broken down into two actions:

A4.2.4.1. Select the risk control measures to implement.

A4.2.4.2. Decide whether the residual risk level is acceptable or not.

A4.2.5. Implement the Risk Controls. Break this step into three actions:

A4.2.5.1. Make the implementation clear to all parties.

A4.2.5.2. Establish accountability and responsibility for the implementing the risk control measures.

A4.2.5.3. Provide support to those tasked to implement the control measures

A4.2.6. Supervise and Review. There are two actions in this step:

A4.2.6.1. Supervise the implementation of the control measures.

A4.2.6.2. Review the effectiveness of the control measures.

The following example shows a tabular method for performing the operational risk assessment for existing firing ranges. The example shows discrepancies taken from an actual assessment made at a real-world Air Force base.

BASE "X" FIRING RANGE
OPERATIONAL RISK EVALUATION

	ORM STEP 1	ORM STEP 2			ORM STEP 3		ORM STEP 4	ORM STEP 5	ORM STEP 6
					Control	Residual			
Discrepancy	Hazard	Severity	Probability	Risk	Options	Risk	Decision	Implementation	Results
Baffle materials do not meet ETL guidelines	Shoot through the baffle and bullets leave the range containment	I	C	6	Add additional thickness to baffles, or replace with correct material	repair or replace will yield I,E=12	12	Make repairs	Compare as-built repairs with ETL guidelines
Baffle materials or slopes do not meet ETL guidelines	Ricochet	II	C	7	Install plywood facing on two baffles nearest the shooter, frangible ammunition	Install plywood facing is II,D=11. Frangible ammunition is III,E=16	16	Buy frangible ammunition	Verify ammunition performs as advertised
Baffle materials or slopes do not meet ETL guidelines	Lead pollution, outside of containment	II	C	7	Lead-Free Ammunition, Frangible Ammunition	Lead Free is IV,E=20. Frangible ammo is III, D= 14	20	Buy lead-free ammunition	Verify that lead ammunition is no longer being used
Side wall berm has a opening that is visible to some firing positions	Bullets leave the range containment	I	A	1	Fill in the opening, or establish a procedure to not use those firing positions	Fill opening is IV,D=19. Procedure is II,E=15	19	Fill in opening	Re-inspect to verify opening has been closed
Side wall berm has a opening that is visible to some firing positions	Lead pollution, outside of containment	II	A	3	Fill in the opening, or establish a procedure to not use those firing positions, lead monitoring program, lead-free ammunition	Fill opening is IV,D=19. Procedure is II,E=15. Lead Monitoring is II,E=15, Lead Free Ammo is IV,E=20	19	Fill in opening	Re-inspect to verify opening has been closed
Surface Water runoff can leave the range	Lead pollution, outside of containment	II	C	7	Water monitoring program, including surface water samples and groundwater monitoring wells	Monitoring program is II,E=15	15	Install monitoring wells and hire environmental testing firm	Regular reports documenting monitoring results

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