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

19 APR 2011

FROM: HQ AFCESA/CEO
139 Barnes Drive, Suite 1
Tyndall AFB, FL 32403-5319

SUBJECT: **Engineering Technical Letter (ETL) 11-18: Small Arms Range Design and Construction**

1. Purpose.

1.1. This ETL provides criteria for the design and construction of Air Force small arms ranges and applies to both new construction and major renovations. Additionally, this ETL should be used as a guide for any ranges purchased as equipment items. The intent of this ETL is to provide the minimum design criteria necessary for achieving a safe range design. This ETL assumes users have a formal engineering education and background or access to local engineering expertise. This ETL does not establish the number of firing points, target distance, targetry, or type of range. A planning team composed of major command (MAJCOM) and installation-level combat arms (CA), civil engineering (CE), bioenvironmental engineer (BEE) and safety (SE) personnel will jointly establish the number of firing points, the target distance, and the type of range based on mission, training requirements, and available real estate.

1.2. This ETL is directive in accordance with Air Force instruction (AFI) 32-1023, *Designing and Constructing Military Construction Projects*, and AFI 36-2226, *Combat Arms Program*, and must be used by the range designer when designing a new range or renovating an existing range. The range designer has the responsibility to ensure the minimum criteria presented in this ETL are used to provide a safe range design. This ETL may not cover all site-specific concerns and it is the designer's responsibility to adapt the intent of the ETL criteria to ensure the range is operationally safe. This ETL is not a specification or a prescriptive checklist and is not intended to replace professional judgment by a competent licensed professional engineer, after coordination with the end-user or installation CA section. Additionally, nothing in this ETL should preclude consideration and use of emerging technologies and commercially available products if these can be proven to result in a safe and satisfactory range design.

1.3. This ETL supersedes ETL 08-11, *Small Arms Range Design and Construction*.

Note: The use of the name or mark of any specific manufacturer, commercial product, commodity, or service in this ETL does not imply endorsement by the Air Force.

APPROVED FOR PUBLIC RELEASE: DISTRIBUTION UNLIMITED

2. Summary of Revisions. This ETL is revised as a result of a 2010 air ventilation survey. The primary change to this ETL eliminates the design of new, fully contained outdoor ranges. The reason for eliminating this option is because controlling air flow within the range is virtually impossible with an open roof over the baffles. With this new ETL only two options remain: fully contained indoor range or non-contained range, for design and major renovation of small arms ranges. Range ventilation performance will also need to be validated prior to final inspection to ensure that proper ventilation is provided within the range. This ETL also allows for expanded use of noise-reduction material to improve occupational exposure to high noise levels.

3. Application: All Air Force installations.

- The criteria in this ETL shall apply to all small arms ranges where the design phase is 35 percent complete or less on the effective date of this ETL.
- New partially contained ranges or fully contained outdoor ranges will not be designed or constructed. If planned major range or component repairs of an existing range will cost more than 50 percent of the estimated range replacement cost (plant replacement value), the entire facility must be upgraded to comply with this ETL.
- The salient safety, health, and environmental features of permanent ranges shall apply to expeditionary or portable ranges; therefore, these ETL standards shall apply to portable ranges purchased as equipment.
- The requirements in this ETL are applicable in OCONUS locations. When conflicts exist between this ETL and host nation requirements, the strictest requirement shall apply.
- After MAJCOM approval, HQ AFSFC/SFXW may approve deviations from the criteria in this ETL. MAJCOMs will submit requests for deviation to HQ AFSFC/SFXW, who will coordinate with HQ AFCESA and AFMSA for review.

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

3.2. Effective date: Immediately.

3.3. Intended Users: MAJCOM functional managers; CE; BEE; CA, and range designers for the Air Force.

3.4. Coordination: MAJCOM functional managers and HQ AFSFC/SFXW.

4. Referenced Publications. In some instances, the references listed in paragraphs 4.1 through 4.7 may advocate procedures that seem to contradict those in this ETL. In these cases, the information in this ETL supersedes any other design and construction source. Likewise, policy guidance on range operation and maintenance contained in AFI 36-2226 takes precedence over other sources.

4.1. Public Law:

- Title 29 Code of Federal Regulations (CFR) 1910.1000, *Air contaminants*, http://www.access.gpo.gov/nara/cfr/waisidx_10/29cfr1910a_10.html
- 29 CFR 1910.1025, *Lead*, http://www.access.gpo.gov/nara/cfr/waisidx_10/29cfr1910a_10.html

4.2. Department of Defense (DOD):

- DOD Directive (DODD) 5100.76-M, *Physical Security of Sensitive Conventional Arms, Ammunition, and Explosives*, http://www.dtic.mil/whs/directives/corres/pdf/510076m.pdf
- DOD Instruction (DODI) 6055.12, *Hearing Conservation Program (HCP)*, http://www.dtic.mil/whs/directives/corres/pdf/605512p.pdf
- Unified Facilities Criteria (UFC) 1-200-01, *General Building Requirements*, http://www.wbdg.org/ccb/browse_cat.php?o=29&c=4
- UFC 3-120-01, *Air Force Sign Standard*, http://www.wbdg.org/ccb/browse_cat.php?o=29&c=4
- UFC 4-010-01, *DoD Minimum Antiterrorism Standards for Buildings,* http://www.wbdg.org/ccb/browse_cat.php?o=29&c=4
- UFC 4-020-01, *DoD Security Engineering Facilities Planning Manual*, http://www.wbdg.org/ccb/browse_cat.php?o=29&c=4

4.3. Air Force (available at http://www.e-publishing.af.mil):

- AFI 31-101, *Integrated Defense* (FOUO)
- AFPD 32-10, *Installations and Facilities*
- AFI 32-1023, *Designing and Constructing Military Construction Projects*
- AFI 36-2226, *Combat Arms Program*
- AFI 90-901, *Operational Risk Management*
- Air Force pamphlet (AFPAM) 90-902, *Operational Risk Management (ORM) Guidelines and Tools*
- Air Force Occupational Safety and Health (AFOSH) Standard 48-20, *Occupational Noise and Hearing Conservation Program*
- Air Force manual (AFMAN) 48-155, *Occupational and Environmental Health Exposure Controls*

4.4. Navy:

- Navy and Marine Corps Public Health Center Technical Manual (NMCPHC-TM) IH 6290.10, *Indoor Firing Ranges Industrial Hygiene Technical Guide*, http://www-nehc.med.navy.mil/Publications_Reports/techmanuals.aspx
- Navy Environmental Health Center, Technical Manual (NEHC-TM) 6290.99-10 Rev. 1, *Indoor Firing Ranges Industrial Hygiene Technical Guide*, http://www-nehc.med.navy.mil/downloads/ih/indoor_firing_range.pdf

4.5. Army:

- Army Pamphlet (PAM) 385-63, *Range Safety*, http://www.apd.army.mil/jw2/xmldemo/p385_63/cover.asp

- Training Circular (TC) 25-8, *Training Ranges*, http://armypubs.army.mil/doctrine/tc_1.html
- National Guard Bureau Regulation (NGR) 385-15, *Policy and Responsibilities for Inspection, Evaluation and Operation of Army National Guard Indoor Firing Ranges*, http://www.ngbpdc.ngb.army.mil/pubs/ARNG%20Series/arngseries.htm

4.6. Environmental Protection Agency (EPA):

- *Best Management Practices for Lead at Outdoor Shooting Ranges*, http://www.epa.gov/region02/waste/leadshot/

4.7. Industry:

- American Welding Society (AWS) D1.1, *Structural Welding Code – Steel*, https://www.awspubs.com
- ASTM A514/A514M, *Standard Specification for High-Yield-Strength, Quenched and Tempered Alloy Steel Plate, Suitable for Welding*, http://www.astm.org
- ASTM C76, *Standard Specification for Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe*, http://www.astm.org
- ASTM C136, *Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates*, http://www.astm.org
- Illuminating Engineering Society of North America (IESNA) Lighting Handbook, http://www.iesna.org/
- American Conference of Governmental Industrial Hygienists (ACGIH), *Industrial Ventilation: A Manual of Recommended Practice*, 27th Edition, http://www.acgih.org/store/ProductDetail.cfm?id=1913

5. Acronyms and Symbols.

AFCESA	- Air Force Civil Engineer Support Agency
AFMAN	- Air Force manual
AFH	- Air Force handbook
AFI	- Air Force instruction
AFMSA/SG3PB	– Air Force Medical Support Agency, Bioenvironmental Engineering Division
AFOSH	- Air Force Occupational Safety & Health
AFPAM	- Air Force pamphlet
AFPD	- Air Force policy directive
AR	- abrasion resistant (e.g., AR500 plate)
AWS	- American Welding Society
BCE	- base civil engineer
BE	- bioenvironmental engineering (office)
BEE	- bioenvironmental engineer
BHN	- Brinnell Hardness Number
BMP	- best management practices
CA	- combat arms

cal.	- caliber
CE	- civil engineering
CFR	- Code of Federal Regulations
CMU	- concrete masonry unit
dBA	- decibels (“A” scale)
DOD	- Department of Defense
DODD	- Department of Defense Directive
DODI	- Department of Defense Instruction
EOD	- explosive ordnance disposal
EPA	- Environmental Protection Agency
ETL	- Engineering Technical Letter
FOUO	- For Official Use Only
fpm	- feet per minute
FRT	- fire resistant treated
ft	- foot
HEPA	- high-efficiency particulate air (filter)
HMMWV	- high-mobility multi-purpose wheeled vehicle
HQ AFCESA/CEOA	- Headquarters Air Force Civil Engineer Support Agency, Engineer and Programs Support Division, Engineer Support Branch
HQ AFSFC/SFXW	- Headquarters, Air Force Security Forces Center, Combat Arms
HVAC	- heating, ventilation, and air conditioning
IESNA	- Illuminating Engineering Society of North America
in.	- inch
LAW	- light anti-tank weapon
LR	- long rifle
m	- meter
MAJCOM	- major command
MIL-HDBK	- military handbook
mm	- millimeter
mpm	- meters per minute
NCOIC	- noncommissioned officer in charge
NEHC	- Navy Environmental Health Center
NMCPHC	- Navy and Marine Corps Public Health Center
OCONUS	- outside continental United States
ORM	- operational risk management
PEL	- permissible exposure limit
pH	- symbol for logarithm of reciprocal of hydrogen ion concentration in gram atoms per liter
PPBE	- planning, programming, budgeting, and execution
psi	- pound per square inch
RH	- relative humidity
RKT HEAT	- rocket high-explosive anti-tank
SDZ	- surface danger zone
SE	- safety

TACOM-ARDEC	- U.S. Army Tank-Automotive and Armaments Command – Armament Research Development and Engineering Center
TBD	- to be determined
TC	- Training Circular
UFC	- Unified Facilities Criteria
VDZ	- vertical danger zone

6. Definitions.

6.1. *Small arms range*: A live-fire training facility for training and certifying personnel in the use of handguns, shotguns, rifles up to 7.62mm, rifles or machine guns up to .50 caliber, and the MK-19 40mm machine gun. A small arms range may include special ranges for 40mm grenade launchers, light anti-tank weapons (LAW), and 81mm mortars. Equipment items such as fully (self-) contained portable or expeditionary ranges fall into this category.

6.2. *Surface danger zone (SDZ)*: The portions of the range in the horizontal plane that are endangered by firing a particular weapon. 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 also include a weapon back-blast area. The SDZ must be located completely within the boundaries of U.S. government-owned or -leased properties. A fully contained range which is incapable of allowing a fired projectile to escape its limits does not have an exterior SDZ.

6.3. *Vertical danger zone (VDZ)*: For non-contained and partially contained ranges, the VDZ 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 1). For fully contained ranges, the VDZ is the area between the SDZ and the upper limits of containment.

6.4. *Non-contained range (impact range)*: A non-contained 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. The non-contained range requires an 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.

6.5. *Partially contained range*: This range has a covered firing line, side containment, overhead baffles, and a bullet backstop. Direct fire is totally contained by the firing line canopy, side containment, baffles, and bullet trap (no “blue sky” observed from firing positions). Ricochets are not totally contained, but reduced by the baffles and side containment. A partially contained range requires an SDZ length equal to 50 percent of the maximum range of the most powerful round to be used on the range. A partially contained range will not permit lateral movement along the firing line or movement toward the target line unless the range has the additional baffles required to stop direct fire at the downrange firing lines.

6.6. *Fully contained range*: Range in which direct fire and ricochets are totally contained within the limits of the range. There is no SDZ requirement outside the limits of the containment.

7. Design Criteria. Range design is based on providing facilities that meet the needs of the training courses of fire specified by HQ AFSFC/SFXW and MAJCOMs based on mission needs. Future range designs must consider courses of fire that may differ from traditional "line-up-and-shoot" courses of fire: certain courses of fire may require the shooter to advance downrange toward the target; other scenarios may include driving a vehicle (HMMWV ["Hummvee"] without pedestal-mounted weapon) into the range to practice vehicle dismount, cover techniques, and target engagement. It is imperative that a range designer fully understand what types of training and courses of fire will take place on the range and design the range accordingly. The designer should also consider design flexibility that allows for changing courses of fire in the future. Facility design and construction must comply with UFC 1-200-01, *General Building Requirements*.

Air Force ranges will not be designed or constructed to only accommodate frangible ammunition. To ensure operational range safety is not compromised, existing ranges that do not have the required SDZ may restrict the range to frangible ammunition only. However, this must be a temporary work-around and the owning organization must program corrective action to permit firing of ball ammunition.

The goal of the new Air Force small arms training philosophy is to increase the current 25-meter standard target distance and expand the diversity of training that can be accomplished on the range. Ranges should be designed to allow the greatest target distance possible within the available land at the site (e.g., 50 meters, 100 meters, 300 meters, 1000 meters). The desired target distance is at or as close as possible to the sight zero distance for the weapon.

Base and MAJCOM CA, CE, BE, and SE offices will jointly develop site-specific designs using the minimum criteria outlined in this ETL. MAJCOMs may submit designs that deviate from the requirements of this ETL to HQ AFSFC/SFXW for review. HQ AFSFC/SFXW will coordinate with HQ AFCESA/CEOA, Engineer Support Branch, and AFMSA/SG3PB, Bioenvironmental Engineering Division, for review. Submit designs to HQ AFSFC only after MAJCOM approval. Individual MAJCOMs may establish design criteria exceeding the minimums specified in this ETL.

7.1. Range Types, Combination Ranges, Range Configuration, Site Selection, and Range Geometric Design.

7.1.1. Range Types.

7.1.1.1. Non-contained Range (Impact Range). The non-contained range accommodates the controlled and supervised discharge of weapons and has

sufficient land area to ensure the discharged projectile does not exit the SDZ. The trajectory of the projectile is along the line of fire (orientation of the range) and the impact of the projectile is designed to be within the limits of the impact area. The firing line may be covered or uncovered. Typically, there are no overhead baffles, but surface barriers or sidewalls may be provided to partially limit projectile trajectory. A non-contained range must have the land area to accommodate both the full SDZ and the full VDZ. Ammunition used on the range will establish 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 used on the range. The required SDZ must equal or exceed the minimum SDZ lengths listed in Table 1. For minimum VDZ height requirements, see Attachment 1.

Table 1. Minimum SDZ Distance Requirements for Small Arms Ammunition — Non-contained Range

Weapon/Caliber	Ammunition	Minimum SDZ Length Meters (Feet)
Handgun, 9mm pistol Submachine gun, 9mm	M882	1840 (6036)
Handgun, 9mm pistol	Frangible, lead-free, Winchester AA16	1584 (5196)
Handgun, .44 magnum	Commercial local purchase	2290 (7513)
Shotgun, 12 gauge	00 buckshot	600 (1968)
Rifle, 5.56mm	Ball M193; tracer M196	3100 (10,170)
Rifle, 5.56mm	Ball M855; tracer M856	3600 (11,811)
Rifle, 5.56mm	M862 (plastic)	250 (820)
Rifle, 5.56mm	Frangible, lead-free, Federal Cartridge BC556NT1, PSPCL and Winchester AA40	2750 (9022)
Rifle/machine gun, 7.62mm	Ball M80; tracer M81	4300 (14,107)
Rifle/machine gun, 7.62mm	Match M118	4800 (15,748)
Machine gun, .50 caliber	Ball M2 and M33/tracer M17/M8 API/M20 APIT	6700 (21,981)
M79, M203, 40mm low-velocity	M781/M407A1/M406/ M433/M381/M386/M441	500 (1640) 100* (328*)
MK-19, 40mm high-velocity	M918/M383/M430	2650 (8694) 350* (1148*)
M72 LAW, 35mm sub-caliber	M73	1300 (4265) 100* (328*)

Weapon/Caliber	Ammunition	Minimum SDZ Length Meters (Feet)
M72 LAW, 66mm RKT HEAT	M72	1250 (4101) 250* (820*)
AT-4, 84mm RKT HEAT	M136	2600 (8530) 200* (656*)

*Additional standoff distance that must be added to minimum SDZ length to allow for explosive ordnance disposal (EOD) make-safe procedure.

7.1.1.2. Fully Contained Range. A fully contained range is designed to prevent 100 percent of the direct-fired rounds and 100 percent of the ricochets from leaving the limits of the range. This type of range is used when the required minimum SDZ or VDZ requirements are not available because of lack of land area or compatible land use. These ranges have an overhead containment structure (ballistic safety baffles) and sidewalls. The building envelope is typically not designed to prevent projectile 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. The fully contained range design must preclude the escape of both direct-fired projectiles and ricochets. Construct the overhead baffles with a minimum of 150 millimeters (6 inches) of horizontal overlap between the trailing edge of any baffle and the leading edge of the next baffle downrange (see Figure 8). The range design must include engineering controls to mitigate hazardous noise and other occupational and environmental hazards resulting from the use of both lead and non-lead frangible ammunition. For example, ammunition residue may contain unburned propellant. Excess build-up of this residue has caused flammable hazards within ranges. This flammability hazard may be controlled using a combination of facility and operational procedures to eliminate the risk of fire. Range personnel must work with local agencies to determine the required frequencies and procedures for removing unburned propellant from the range.

7.1.1.2.1. Fully Contained Indoor Range. A fully contained indoor range has a firing platform, bullet trap, and baffle system (or other ballistic containment system) enclosed within a complete building envelope. The complete building envelope is required to prevent influences from the exterior environment and to allow a slight negative pressure to be maintained within the range.

7.1.1.2.2. Fully Contained Outdoor Range. A fully contained outdoor range has baffle systems exposed to the environment and does not have a complete building envelope enclosing the entire range. Fully contained outdoor ranges are not permitted for new construction unless specifically approved by HQ AFSFC, HQ AFCESA, and AFMSA. All existing fully contained outdoor ranges designed in accordance with previously

published criteria may continue to operate if range safety can be verified. If an existing fully contained outdoor range does not meet the mechanical air flow requirement of paragraph 7.2.8.1, at the firing platform only, the installation shall program a project to provide the required airflow.

7.1.1.3. Partially Contained Range.

7.1.1.3.1. Partially contained ranges are not permitted for new construction unless specifically approved by HQ AFSFC, HQ AFCESA, and AFMSA**.** There are many existing partially contained ranges in the Air Force inventory.

7.1.1.3.2. All existing partially contained ranges that do not have the required SDZ must be programmed for upgrade or replacement to meet either full-distance, non-contained range criteria, fully contained range criteria, or the footprint of the existing deficient SDZ must be increased to meet the 50 percent SDZ requirement for a partially contained range. Existing partially contained ranges and other facilities designed in accordance with previously published criteria may continue to operate if range safety can be verified. Existing partially contained ranges that have an enclosed firing platform with sidewalls and back wall shall remove the sidewalls and back wall to improve natural ventilation.

- Verify range safety using the operational risk management (ORM) analysis in accordance with AFI 90-901, *Operational Risk Management*. See Attachment 2 for an ORM example.
- Range computer modeling and simulation is a proven technique for analyzing range safety and identifying necessary improvements.

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

7.1.2. Combination Ranges. Range designs may be configured to accommodate a variety of weapons and courses of fire. The appropriate configuration must be determined by the types and sequence of weapons used.

7.1.2.1. Multi-purpose Ranges. The multi-purpose range provides for simultaneously firing 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.

7.1.2.2. Superimposed Ranges. A superimposed range accommodates different types of weapons and may be either a non-contained (impact) range or a fully contained (baffled) range; however, only one type of weapon may be fired at one time. The superimposed range allows for the maximum use of

land area and is usually the least expensive since there are no sidewalls between firing positions.

7.1.2.3. Special Ranges. Typically, special ranges are non-contained ranges designed to accommodate multiple target lines or arrays and set up for special types of weapons or unique courses of fire. Certain special ranges may exceed the scope of this ETL. Contact HQ AFSFC and HQ AFCESA for additional guidance.

7.1.3. Range Configuration. The range type, size, and configuration are based upon the installation mission, land availability, Air Force and MAJCOM policy, installation population, annual training requirements, and weapon-specific training requirements. Base CA personnel will submit their requirements for ranges through their chain of command to the MAJCOM functional manager. After the MAJCOM has validated the need, the BCE will begin a feasibility study for the proposed range. Programming and budgeting for range construction must occur within the framework of the normal planning, programming, budgeting and execution (PPBE) process.

7.1.4. Site Selection.

7.1.4.1. BCE. The BCE will identify the available real estate for the site of a small arms range facility that is consistent with the installation's master plan. The installation master plan will indicate the range location, orientation, SDZ, and VDZ.

7.1.4.2. Planning. A project team composed of the CA non-commissioned officer in charge (NCOIC), a land use planner, CE, SE, and BE representatives should collectively review the proposed range usage and location for land use compatibility. Safety is the primary concern when determining the site for a small arms range. Orient the SDZ and VDZ to minimize the effect of range operations on populated areas, aircraft ground and air operations, and land uses within the travel distance of the ammunition. Where full-containment enclosures have not been provided, the project team should assume that ricochets would land in all portions of the SDZ. The BCE is responsible for plotting the SDZ and the VDZ on the base master plan. Mitigate any conflicts of land use or airspace operations with the SDZ or the VDZ as part of the PPBE process.

7.1.4.3. 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.

7.1.4.4. Geographical, Environmental, and Climatic Effects.

7.1.4.4.1. If possible, the outdoor non-contained range should be oriented north-to-south to minimize glare. To minimize residue being blown back towards the shooter, site the non-contained range with the prevailing wind blowing from the shooter's back toward the target line. For existing outdoor non-contained and outdoor partially contained ranges, supplemental ventilation may be required if natural air flow is not adequate to remove contaminated air from the firing line area. Seek assistance from the local BEE when assessing the air quality at existing firing platform areas. Avoid locating the range upwind of residential or populated areas. Site non-contained ranges and their impact areas to minimize projectiles and projectile residue falling in wetlands or waterways.

7.1.4.4.2. Regions subject to snow accumulation and extended periods of continuous sub-freezing temperatures should have fully contained indoor ranges. When this is not possible, the non-contained range should be sited to minimize drifting snow, ice buildup, and excess water, and to facilitate snow removal inside the range periphery.

7.1.4.4.3. 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.

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

7.1.5.1. SDZ Geometry. The range danger zone includes the projectile impact area, the SDZ, and the VDZ. Refer to Figures 1 through 6 for the typical geometry of the SDZ. The VDZ reflects the geometry of the SDZ extended to the VDZ height.

7.1.5.2. Limits of Fire. The limits of fire are imaginary lines drawn from the outermost edges of the endmost firing positions, 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's configuration and use determines the departure angle of the limits of fire.

7.1.5.3. Projectile Impact Area or Direct Fire Zone. The projectile 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 becomes a pie-shaped area formed by the limits of fire and the arc of the minimum SDZ length (Figure 2).

7.1.5.4. Ricochet Danger Area. The ricochet danger area is the area between the impact area and the secondary danger area. The ricochet area is typically 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, and 3). For a LAW range (Figure 4), the ricochet area is drawn at a 13 degree angle.

7.1.5.5. 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.

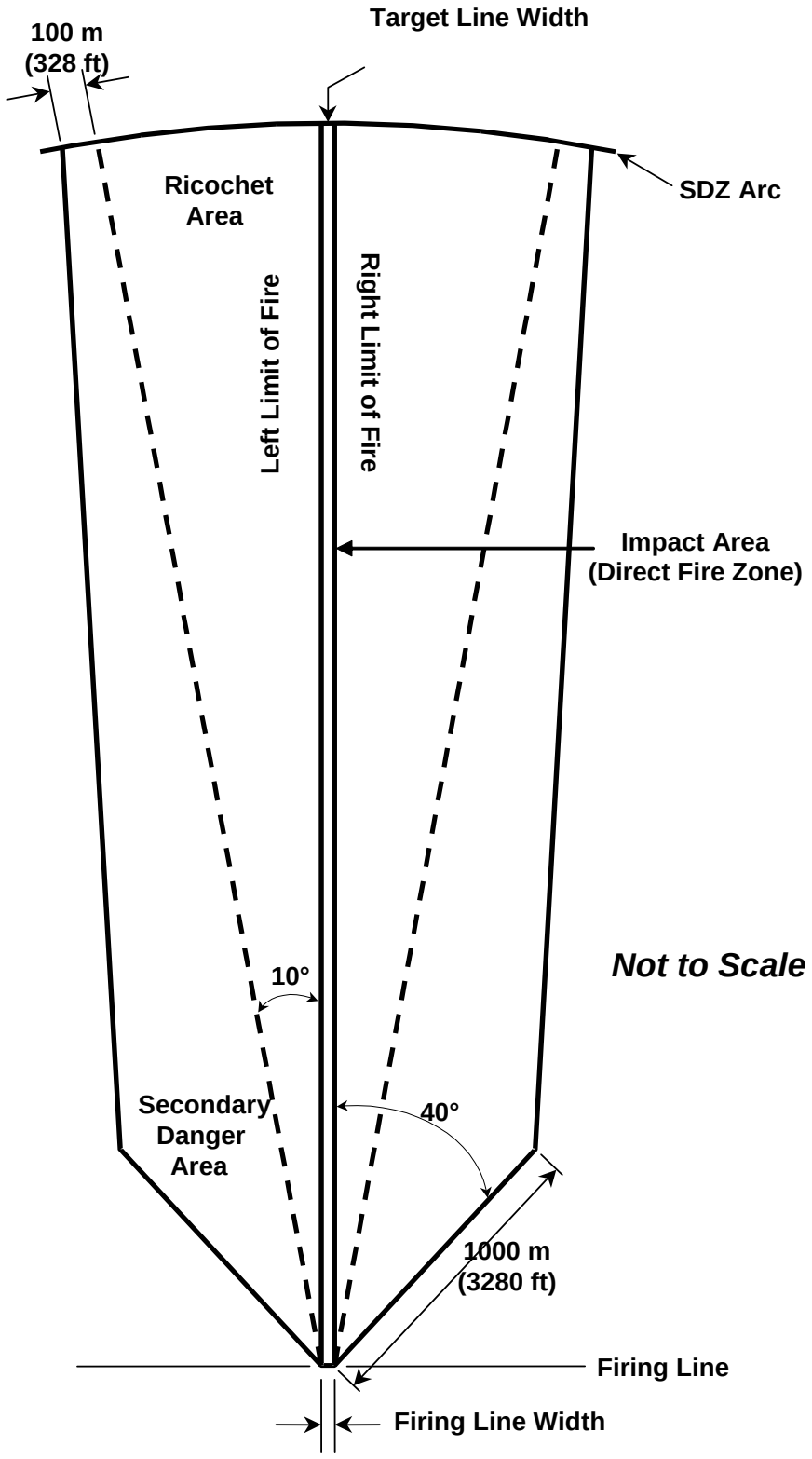


Figure 1. SDZ Configuration — Firing Line Width Equal to Target Line Width

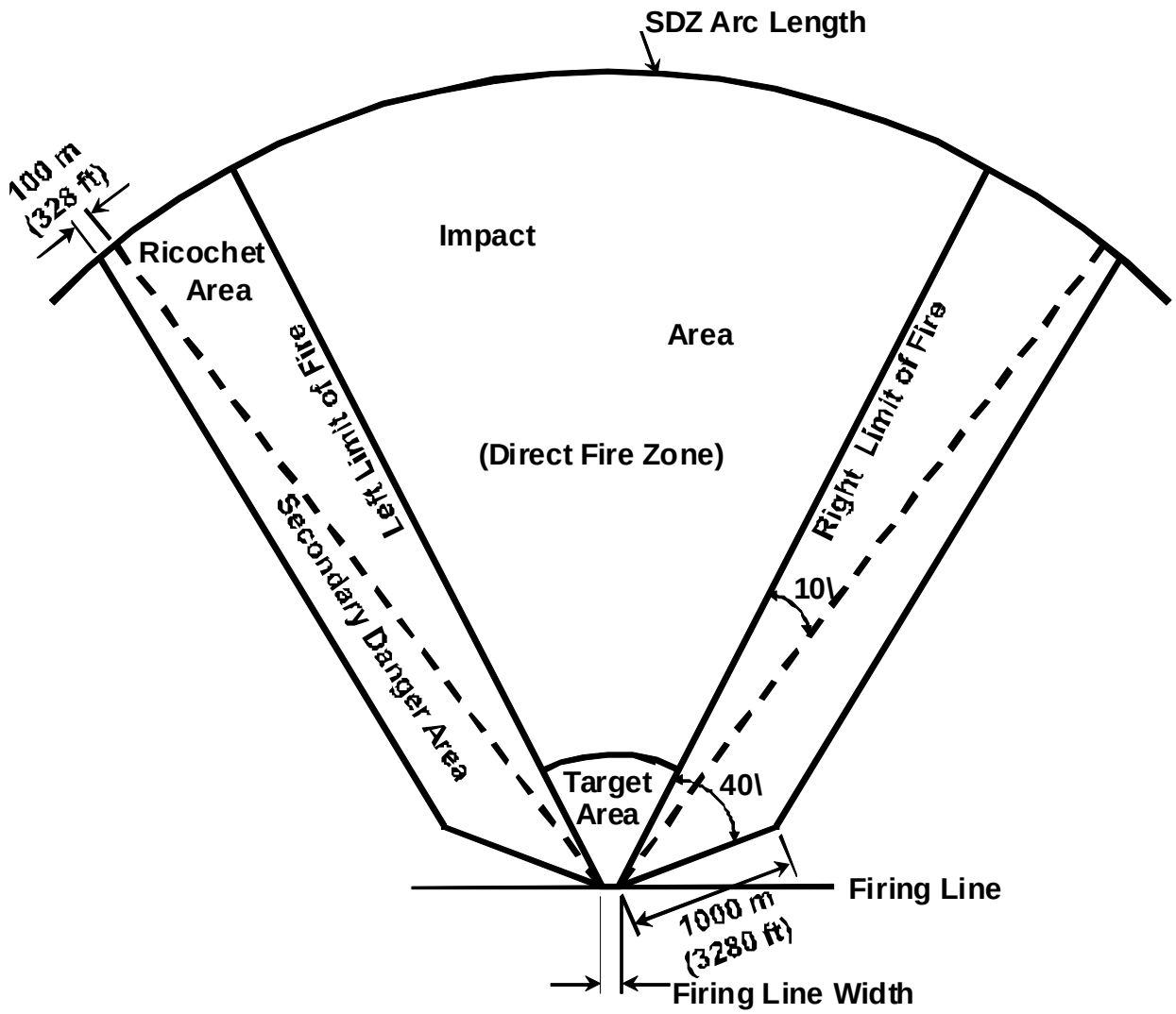
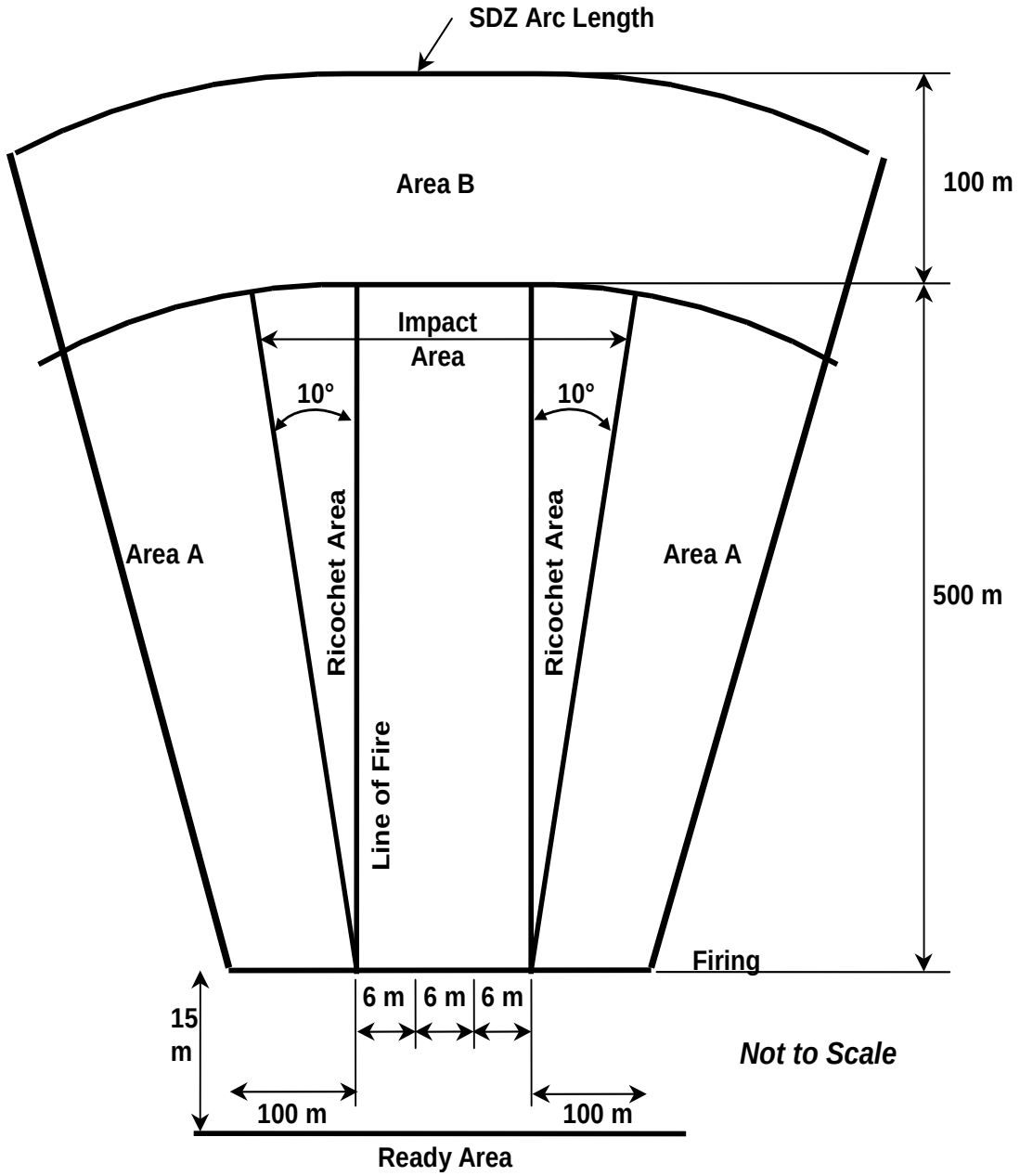


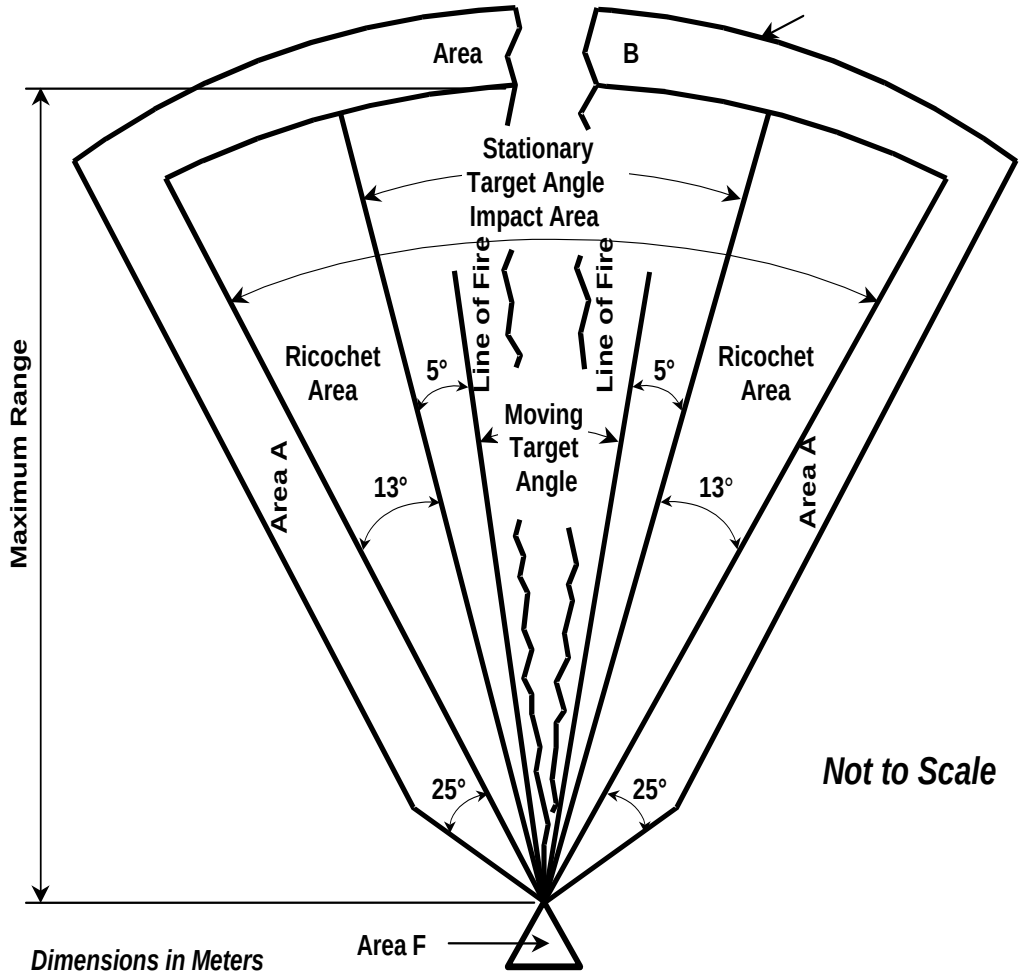
Figure 2. SDZ Configuration — Target Line Wider Than Firing Line



NOTES

1. Additional firing positions may be added provided minimum of 6 m (19 ft) is maintained.
2. Provide a 100-m (328-ft) 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 the 100-m (328-ft) space (Area A) to the left and right of the firing positions.

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



	Area		Minimum Range to Impact	Maximum Range	Area F	
	A	B			Depth	Base
66mm HEAT Rocket, M72	250	250	75	1250	40	25
35mm Subcaliber, M73	100	100	50	1300	40	25
84mm HEAT Rocket, M136	227	200	50	2600	95	190

Figure 4. SDZ Configuration — Light Anti-Tank Weapon (LAW) Range

7.1.5.6. SDZ for Frangible Ammunition. On existing ranges that do not have the required SDZ, the use of frangible ammunition may mitigate the lack of SDZ and allow the ranges to continue to operate safely. This may only be used as a temporary measure and the owning unit must program for corrective action to allow firing of full-power ball ammunition. The SDZs depicted in Figures 5 and 6 are based on firing from the firing line only; down-range firing training operations shall not be used unless a projectile trajectory analysis is performed.

7.1.5.6.1. For an existing 25-meter (82-foot) partially contained range with earth side berms and an earth backstop, the required SDZ when using frangible ammunition is 300 yards (274 meters). See Figure 5.

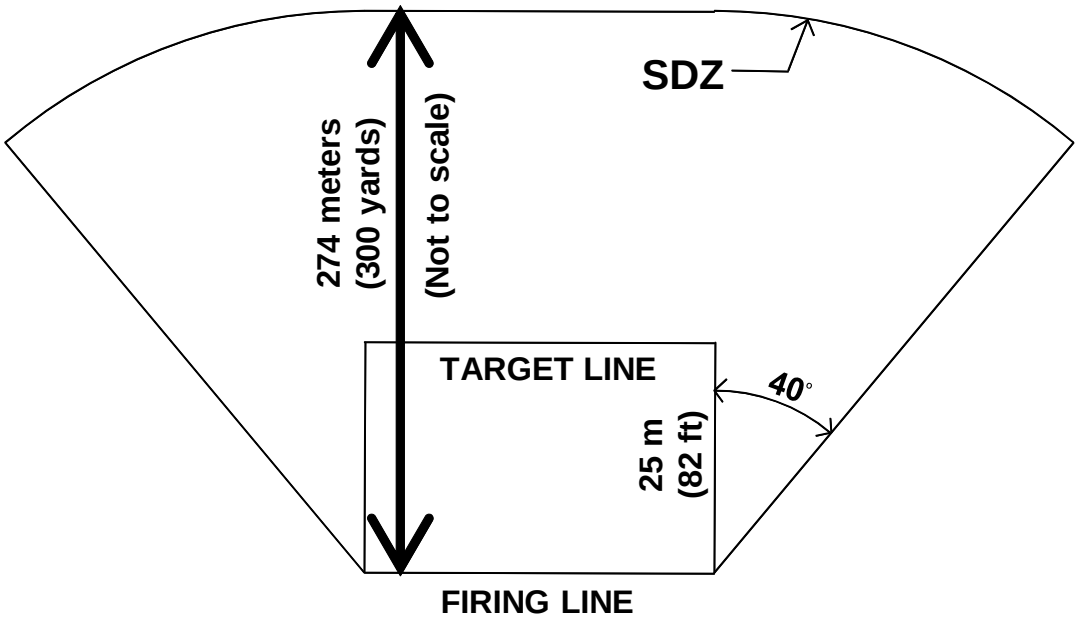


Figure 5. SDZ Requirement for Frangible Ammunition on a 25-Meter (82-Foot) Partially Contained Range with Earth Side Berms and Earth Backstop

7.1.5.6.2. For an existing 25-meter (82-foot) partially contained range with sidewalls of concrete or concrete block, overhead ballistic baffles (angled or vertical), and a bullet trap, the required SDZ when using frangible ammunition is 100 meters (328 feet). See Figure 6.

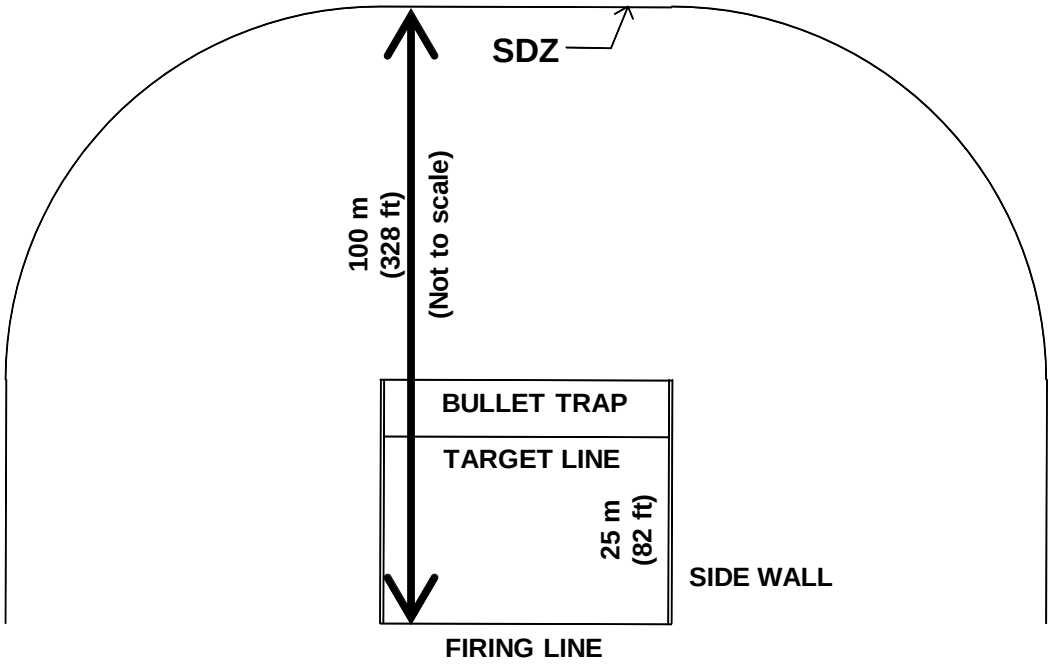


Figure 6. SDZ Requirements for Frangible Ammunition on a 25-Meter (82-Foot) Partially Contained Range with Sidewalls and Bullet Trap

7.1.5.7. Firing Line Positions/Platforms. 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 fourteen positions on the firing line. Add additional positions in increments of seven firing positions. The width of the firing positions must be at least 1.52 meters (5 feet) center-to-center. The firing line must be located on a stable horizontal surface that is at least 4.3 meters (14 feet) wide, clear distance, for the length of the firing line. For most ranges, the firing platform is a concrete slab on grade. For non-contained ranges that have fighting positions dug in the ground, sandbags, or other definite structures to identify the firing line, the firing platform can be an earth surface. For special weapons, CA personnel will specify the number of firing positions and the widths of each position based upon training requirements.

7.1.5.7.1. Position Numbering. Each firing position will be numbered beginning from the left when facing 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 clearly 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.

7.1.5.7.2. Position Barricades. A wooden barricade in the form of a cross (+) must be installed at the left edge of each firing position. The minimum 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.

7.1.5.7.3. Firing Line. Paint a red line a minimum of 100 millimeters (4 inches) wide on the leading edge of the firing platform on the target side. For non-contained ranges without concrete firing line platforms, a firing line will be marked definitively in red on the downrange side of the firing positions; examples include treated timber embedded along the firing line and painted red, or a line of safety cones. This is the stationary firing line and must be continuous for the full length of all the firing positions. For move-and-shoot courses of fire, the firing line is relocated down range as appropriate for the training scenario.

7.1.5.8. Ready Line. Paint a yellow line 100 millimeters (4 inches) wide on the firing line platform at least 2.4 meters (8 feet) behind the firing line (towards the rear of the firing platform). The line must be continuous for the length of the firing platform.

7.1.5.9. 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.

7.1.5.10. Target Line Configuration.

7.1.5.10.1. The distance from the firing line to the target line must be the same for all firing positions. Targets may be placed on turning, pop-up, or stationary mechanisms, or target-retrieval systems along the target line. Ensure that the line of sight from the firing line to the target line is clear and structural members, baffles, walls, or improper lighting do not obstruct the shooter's sight picture from any firing position the shooters will use (e.g., prone, kneeling, left barricade, right barricade). Number each target location the same as its corresponding firing position. On non-contained ranges, the target line may be fixed and several firing lines constructed to permit firing at reduced distances. When this option is used, only the rear-most firing line will incorporate a firing platform. If the range has an earthen backstop, ensure there is sufficient distance between the closest firing line and the earthen backstop to eliminate the possibility of backspatter and ricochets affecting the shooter. For manufactured bullet traps, ensure there is 15 meters (49 feet) between the closest firing line and the bullet trap.

7.1.5.10.2. The center of the target must be located between the upper limit of fire (standing position), which is 1500 millimeters (60 inches) above

the firing line, and the lower limit of fire (prone position), which is 150 millimeters (6 inches) above the firing platform. The entire target face must be fully displayed to the firing position when exposed to the shooter for engagement.

7.2. Criteria Applicable to All Ranges. Design all range components (including ballistic safety structures and deflector plates) to satisfy the requirements for the weapon and ball ammunition used on the range. Except for non-contained ranges, ballistic safety structures are required for firing ranges. Ballistic safety structures include baffles, side containment, and backstops. Baffles are safety structures classified as canopy baffles or overhead baffles. Side containment is provided by sidewalls, berms, or discontinuous side baffles. A backstop is an impact berm or bullet trap designed to stop direct-fired rounds. See paragraph 7.5 for more detailed descriptions of ballistic safety structures.

7.2.1. 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 small arms range construction is 20 years. Permanent construction does not include protective construction, baffles, or sacrificial materials intended to capture projectiles. Evaluate alternative range design options using a life-cycle cost composed of the initial costs plus all operation and maintenance (O&M) costs for the first five years of range operation. Using the proper materials for sidewalls, baffles, overhead containment, bullet traps, and other areas where a projectile 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, locating bolt heads, and selecting protective construction.

7.2.2. Horizontal and Vertical Control. Establish vertical control by assuming the firing platform surface is equal to elevation 0.0 meter. The firing line is the baseline for horizontal control.

7.2.3. Drains. On outdoor ranges, use positive grading to direct water away from the firing line and toward the target line. When the length of the slope or the natural terrain requires using drains between the target and the firing line, a trench drain should be located at the forward edge of the bullet trap. If a trench drain is installed, the bullet trap should extend into the trench drain to eliminate any exposed edges that may cause unpredictable ricochets. Use grade breaks to prevent exposing vertical surfaces to the firing line. Do not route storm water runoff from any range floor to a stream, pond, or other body of surface water. In some circumstances, if the range is located near a surface water body, it may be necessary to incorporate detention basins or flow-through sand or peat filters to prevent particulate heavy metals that may be present in storm water runoff from reaching surface water bodies. Indoor ranges will not have floor drains downrange of the firing line. See the EPA's *Best Management Practices for Lead at Outdoor Shooting Ranges* for additional guidance.

7.2.4. Range Occupational Health Standards. Design the range to control contaminants produced at the muzzle and ejection port of the weapon, bullet trap, and from the ventilation exhaust to ensure compliance with local, state, and federal regulations. Review NMCPHC-TM IH 6290.10, *Indoor Firing Ranges Industrial Hygiene Technical Guide*, and the EPA's *Best Management Practices for Lead at Outdoor Shooting Ranges*. Additionally, the designer must coordinate with SE and BEE for additional requirements to ensure compliance with current policy.

7.2.5. Floor Surfaces. Fully contained indoor ranges must have a smooth, steel-trowel-finished concrete floor extending from the firing line to the bullet trap. Concrete used in floor construction shall have a minimum compressive strength of 3500 pounds per square inch (psi). The concrete floor should not be painted and must be protected with a waterproof sealant. In special circumstances, hardened steel plate of a thickness sufficient to prevent penetration of the projectile may be used for the range floor if the designer provides design criteria, supporting data, and supporting calculations for approval. No protrusions from the floor that could be struck by bullets are permissible. Fully contained range floors should be cleaned using approved methods, such as HEPA-filtered vacuuming or damp mopping. Water wash-down or dry sweeping is not permitted. Design the range floor as a pavement to support anticipated vehicular loads (training or service vehicles). Design and locate floor slab joints to minimize the potential for unpredictable ricochets. Sawed control joints no more than 6 millimeters (0.25 inch) wide are permitted. Locate longitudinal floor joints between firing lanes. Traditional chamfered construction joints are not permitted.

7.2.6. Wall Surfaces. Construct wall surfaces for fully contained ranges of reinforced concrete, fully grouted reinforced masonry, or hardened steel plate of a thickness sufficient to prevent penetration by any projectiles fired on the range. If hardened steel plate walls are used, submit data and supporting calculations to the MAJCOM for approval. Steel plate wall designs must address noise abatement and must not have exposed bolts or anchors. If concrete or masonry walls are used, they must remain unpainted to preserve their inherent sound-absorbing properties. Walls should have a continuous smooth surface, with no projections above the wall surface from bolt or rivet heads or the leading edge of deflector plates. Wall expansion/contraction joints should be designed with care to ensure a smooth wall surface is maintained. The typical 19-millimeter (0.75-inch) chamfered wall joint detail is not permitted unless baffle/deflector plates are incorporated in the joint design to span the chamfer. To eliminate erratic ricochets, install baffle/deflector plates to protect any range features attached to the wall. The deflector plates should be recessed into the wall surface to eliminate exposed edges.

7.2.7. Openings. If an existing building is converted for use as a range, all openings downrange of the firing line must be filled in with ballistic safety

structures. All heating, ventilation, and air conditioning (HVAC) equipment downrange 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 baffles, or behind protective baffles. In converted buildings, relocate exposed pipes or provide protective construction. When doors are required downrange, they must be constructed of ballistic-resistant materials and equipped with hardware to allow opening only from the range side. Protect downrange doors with baffles and provide them with a visual and audible alarm.

7.2.8. Ventilation. The ventilation system must control exposure to lead in accordance with 29 CFR 1910.1025, *Lead*. The supply and exhaust air system is critical to the safe operation of fully contained ranges and for the health of range users.

7.2.8.1. Airflow. The ventilation system should provide laminar airflow across the range toward the bullet trap. At the firing line, the air velocity must be 23 meters per minute (mpm) (75 feet per minute [fpm]), ±4.6 mpm (15 fpm). Airflow should be evenly distributed across the firing line ±4.6 mpm (15 fpm). Noise from the ventilation system will not exceed 85 decibels (dBA) behind the firing line.

7.2.8.2. Air Distribution. To ensure contaminants are removed from the firing line, install a perforated air distribution plenum, radial plenum, or other distribution fixture along the rear wall to provide unidirectional airflow across the firing line and continuing downrange. The air-distribution fixture should be installed to ensure prescribed air velocities at every shooter location. The distance from the firing line to the perforated rear wall, radial plenum, or other distribution fixture will be a minimum of 5 meters (16.4 feet). The air distribution plenum openings must be sized to provide no more than 610 mpm (2000 fpm) velocity through the openings, with a recommended velocity between 122 mpm to 183 mpm (400 fpm to 600 fpm).

7.2.8.3. For a fully contained indoor range, the ventilation design must include a positive exhaust system for effectively capturing and removing airborne contaminants. Maintain slightly negative air pressure on the range, 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. All doors into the negative-pressure area must have air locks. Re-circulation of range air is not permitted.

7.2.8.4. Exhaust Intakes. To ensure proper airflow, locate exhaust intakes at or behind the bullet trap.

7.2.8.5. Exhaust Air Discharge. Exhaust air discharged from the range and bullet traps must meet local, state, and federal requirements and be separated from the supply air intake to prevent cross-contamination of heavy-

metal-laden air. If the range is part of a larger building, do not discharge exhaust air at locations which could cause cross-contamination of overall building air.

7.2.8.6. Supply Air. Because re-circulated air within a range is prohibited, range supply air should not be heated or cooled. Therefore, the range shall be designed as an unconditioned environment. Fully contained ranges in colder climates may require radiant heat on the firing line.

7.2.8.7. Personnel should not be exposed to airborne contaminants above permissible limits at firing ranges. The Occupational Safety and Health Administration (OSHA) has established the permissible exposure limit (PEL) for airborne lead as 50 micrograms per cubic meter (8-hour time-weighted average). The PEL for other heavy metals can be found at 29 CFR 1910.1000, *Air contaminants*, Table Z-1, “Limits for Air Contaminants,” and Table Z-2, “Toxic and Hazardous Substances.” Fully contained ranges (indoor and outdoor) must have ventilation systems designed to control exposure to airborne contaminants. BE will evaluate potential exposure to airborne contaminants to determine if the ventilation system is adequately controlling the hazard. Lead-free ammunition (LFA) may be used to eliminate the lead contamination concern with older existing ventilation systems.

7.2.9. Noise Reduction. Engineering controls to reduce noise levels and dampen reverberation shall be implemented. Noise reduction in the range and noise transmission out of the range are different design considerations. Mass and limpness are two desirable attributes for sound absorption. Unpainted heavy masonry walls provide mass. Absorptive acoustical surfacing will reduce the noise level in the range but have little effect on transmission outside the range. Ambient noise levels at the firing line shall not exceed 85 dBA. Short-duration noise such as gunfire will exceed the 85 dBA level and may be as high as 160 dBA. Reflective surfaces in a range will reverberate noise during firing, extending the decay rate of the noise. Long decay rates (>1 second) will require the engineer to treat the noise not only as impulse (peak pressure considerations) but also as continuous noise. Therefore, sound-absorbing materials should be used to reduce the reverberation rate to below 1.5 seconds.

7.2.9.1. Use acoustical treatment on surfaces behind the firing line and on the wall and baffle surfaces of the up-range half of the range. Acoustical material shall be nonflammable and will not impede heavy metal dust removal using a vacuum process. Floor areas behind the firing line may be covered with acoustic material (rubber mats) if it will not impede heavy metal dust removal.

7.2.9.2. Do not paint downrange walls or acoustic tile, since paint significantly degrades the sound-absorbing qualities of the materials. Existing ranges may continue using painted surfaces. Special sound-absorbing concrete blocks are available that reduce noise in the range.

7.2.9.3. Acoustic panels no larger than 1200 millimeters (47 inches) wide may be installed on walls, ceilings, and baffles. Blown-on acoustic material and carpeting are not permitted due to the difficulty of cleaning accumulated heavy metal dust.

7.2.9.4. Operational controls. Appropriately identified and properly fitted hearing protection will help reduce noise exposure for personnel below 85 dBA. BE will evaluate noise exposures and make recommendations for proper hearing protection to reduce noise levels for shooters and range personnel.

7.2.10. Fire Protection. Burnt propellant, muzzle flash, freezing temperatures, and bullet damage all conflict with the operation of standard fire protection design. To resolve these conflicts, the Air Force only requires sprinklers when the range is constructed integral with range support facilities like training rooms and cleaning rooms. Sprinklers are required in the range support facilities and on the firing platform area, but are not needed in the downrange area or at the target area. Smoke and infrared detectors are also problematic and impractical in the downrange area or at the target area because of the amount of smoke and periodic muzzle flashes from the weapons. No detection is required in the downrange area and none in the range support facilities or firing platform area since these areas are protected by sprinklers. Assume metal bullet traps—rubber, foam, and other materials used for bullet traps may require dedicated additional fire protection features per the manufacturer's recommendation. Egress paths shall not require travel downrange from the primary firing line. Downrange space shall not be included in calculating minimum egress capacity requirements. Egress marking, emergency lighting, and egress door hardware shall not be required downrange of the primary firing line.

7.2.11. Infrastructure.

7.2.11.1. Range Control Booth. The control booth is a control center from where the chief range officer can observe and control the entire range. All range types should have a control booth. The following criteria apply to the design and construction of control booths.

7.2.11.1.1. Locate the control booth behind the ready line. Place the booth to permit an unrestricted view of all firing positions. The booth location and design must not impede ventilation airflow.

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

7.2.11.1.3. The booth must be high enough (0.6 meter [2 feet] minimum above the floor) to permit the range official an unrestricted view of the

entire firing line and the projectile impact area, including all range entry points. Also, windows and doors within the booth must not restrict or distort the range official's view. Closed-circuit television monitors may be used to enhance, but will not replace, this requirement.

7.2.11.1.4. Provide a work table or counter at least 0.8 meter by 1.2 meters (2.5 feet by 4 feet) to accommodate reference materials, and provide at least one duplex electrical outlet in the worktable/counter area. Provide lighting for night/limited-visibility operations.

7.2.11.1.5. The range control booth should have positive pressure relative to the rest of the range or be sealed/isolated so that fumes and dust from firing do not enter and contaminate the booth.

7.2.11.2. Communication System. The range communication system must support communications between the control booth, the firing line, range control, range support buildings, and emergency response personnel. A permanent, hard-wired public address system is required. On a multiple-range complex, the system must also 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. The control booth should be wired with connections to the base local area computer network.

7.2.11.3. Lighting. Design downrange lighting in accordance with the IESNA *Lighting Handbook* to provide for safety and housekeeping operations as well as general range illumination. Light intensity at the target face should be 914 to 1076 lux (85 to 100 foot-candles) measured 1200 millimeters (47 inches) above the range surface at the target face. Provide approximately 322 lux (30 foot-candles) for white light general range illumination. An optional 107 lux (10 foot-candles) for red general lighting may be installed if night training scenarios are required. Provide controls to vary lighting intensity throughout the range to accommodate subdued-light training requirements. Controls for all lighting will be operated from the control booth. Optional flashing red and blue lights may be installed at the firing line and downrange to simulate emergency situations.

7.2.12. Barriers, Fences, and Signs. Secure the range and SDZ areas to prevent unauthorized entry. Use barriers to block roads, walkways, or paths.

7.2.12.1. Fully contained ranges require barriers in the form of key-operated, locked doors or electrically locked doors to prevent entry while firing is in progress.

7.2.12.2. Non-contained (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 SDZ. Attach reflective warning signs to barriers.

7.2.12.3. Use fencing to prevent people, animals, and vehicles from entering range SDZs. A chain-link fence around the complete range complex, including the SDZ, is preferred. Use barriers or gates to block access paths. On existing partially contained baffled ranges with earth side berms and an earth/metal backstop, as a minimum, install a 1.82-meter (6-foot) chain-link fence along the sides of the SDZ and on the downrange side of the impact area, incorporating the berms. Install the fence no closer than 5 meters (16 feet) from the toe of the berms and backstop. For 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 when range components are exposed. For example, if the back side of the bullet trap and spent round-retrieval system is exposed, erect a fence to restrict access by unauthorized personnel. Provide a locked access gate for maintenance equipment.

7.2.12.4. Typical range signs are shown in Figure 7. Warning signs, and flashing red warning lights for night operations, should be positioned on the approaches to the range and along the perimeter of the SDZ if access is not otherwise restricted. Place red flags and/or rotating/flashing red lights at appropriate locations to signal when the range is in use. Place signs along the normal boundaries of the range. Post the signs no more than 100 meters (328 feet) apart along the range perimeter, parallel to 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 installation legal office for local policy on bilingual signs. Construct warning signs in compliance with UFC 3-120-01, *Air Force Sign Standard*. The warning signs should have standard red letters on a white background.

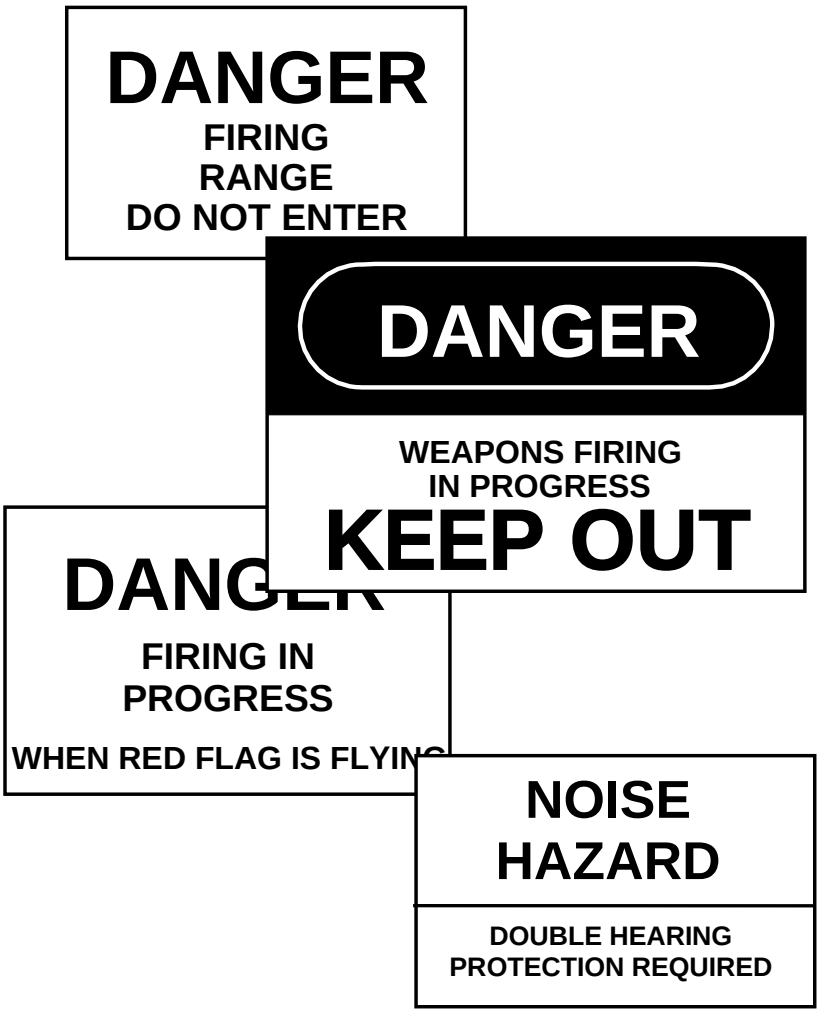


Figure 7. Typical Range Signs

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 every 100m (328 ft)
Danger Weapons Firing in Progress Keep Out	Entry road
Noise Hazard Double Hearing Protection Required	Firing line

7.2.13. 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 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.

7.2.13.1. Water and Sanitation. Water must be available for drinking, sanitation, hand-washing stations, and safety equipment. Drinking water and a latrine may be provided by adjacent range support facilities. The required latrine size will be determined using conventional planning criteria and based on the number of people (instructors and trainees) supported.

7.2.13.2. Electrical Power. Provide electrical power for lighting, maintenance equipment, public address systems, ventilation, bullet trap dust collection system, and target-turning mechanisms.

7.2.14. 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. Parking and roadway standoff must comply with UFC 4-010-01, *DoD Minimum Antiterrorism Standards for Buildings*.

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

7.2.14.2. Locate parking areas to the rear of the firing platform. On fully contained ranges, the parking area may be beside the range-side containment walls. Typically, 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.

7.2.15. Storm Water Runoff and Drainage. Design storm water control structures to prevent storm water erosion of impact berms. Divert surface water runoff within the range (including the SDZ) using best management practices (BMP) for heavy metal management that may include filtration, vegetated detention or retention basin, or other engineered structure to prevent direct discharge to a surface water body. Discharge of effluent to water bodies must meet all requirements of federal, state, and local laws.

7.2.16. Environmental Contaminant Monitoring. An environmental contaminant monitoring program may provide early indications of contaminant movement within and/or between environmental matrices, e.g., soil, groundwater. A comprehensive monitoring program includes sampling soil, surface water, and ground water. The frequency of sampling is dependent on many factors including, but not limited to, how often the range is used and unique site conditions. Consult with the installation CE and BE personnel to determine if a contaminant-monitoring program is required.

7.3. Additional Criteria for Non-contained Ranges.

7.3.1. Siting Considerations. 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. Take advantage of natural drainage. Where terrain permits, slope the range floor toward the backstop. Flowing watercourses (streams, ditches) in the impact area or near a berm should be avoided. Avoid establishing range impact areas in wetlands or in locations subject to frequent flooding. The non-contained range line of fire should not be in the direction of residential areas or upwind of residential areas.

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

7.3.3. 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 may be used between the firing line and the target line. Typically these will be clays, clayey sands, sands, silts, and silty

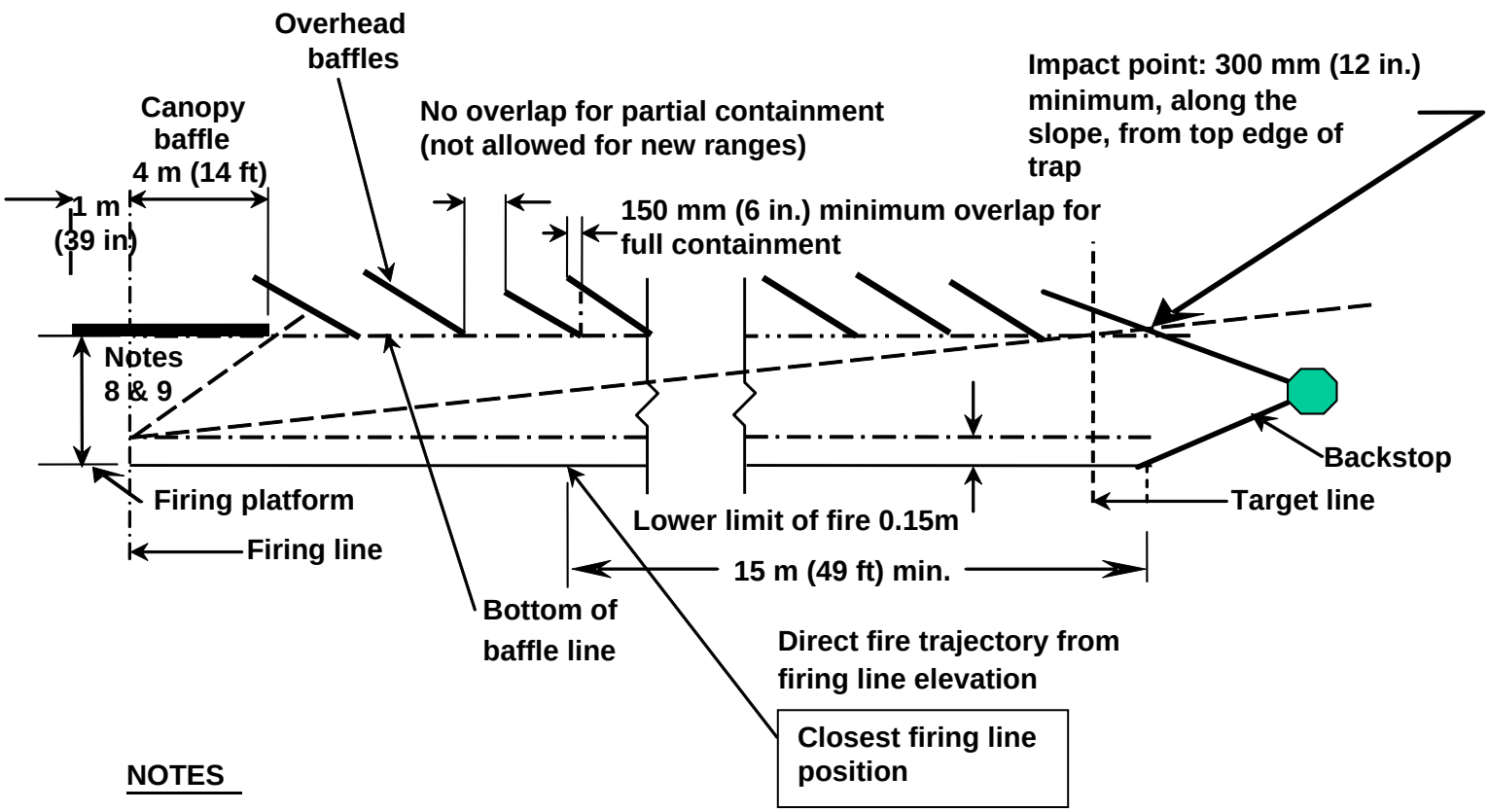
sands that are mostly free of rocks and debris, with no more than 15 percent of the material gradation retained on a 24-millimeter (1-inch) sieve.

7.3.3.1. Soil Amendments. BCE environmental management must test soils within the impact areas for pH levels every two years. The 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 sieve, ASTM C136, *Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates*, and/or the natural soil Plasticity Index is higher than 12.

7.3.3.2. Vegetation. Maintain vegetation on berms and drainage-ways when possible. Plant grass on impact areas. Turf grasses do an especially good job of retaining water and sediment onsite. Choose a grass variety that is native to the area and will require minimal water and fertilizer.

7.3.3.3. Reclamation and Recycling. Remove lead from the impact face of earth berm backstops when there is evidence of lead mass buildup. This will typically require that soil be excavated to a depth of 0.6 to 0.9 meter (2 to 3 feet) and screened using a 4-millimeter (#5) wire screen. Personnel certified in lead reclamation and wearing proper personal protection may sift the lead from the soil by screening onsite after consulting with BE personnel and satisfying all environmental requirements. Reclaimed lead must be disposed of or recycled in accordance with federal, state, and local laws and regulations. Consult CE environmental management, BE, and the Defense Reutilization Management Office (DRMO) about reclaiming, recycling, or disposing of lead. Lead removed from bullet traps and earth berms is not considered a hazardous waste if recycled for metal recovery.

7.4. Additional Criteria for Fully Contained Ranges. Construct fully contained ranges to preclude any bullets from leaving the containment limits. This requires additional attention to detail so no gaps, openings, or other paths for bullet escape are present. Use ballistic safety structures to provide the containment. For fully contained ranges, construct overhead baffles with a minimum of 150 millimeters (6 inches) of horizontal overlap between the trailing edge of any baffle and the leading edge of the next baffle downrange. Figure 8 shows a baffle arrangement for full containment.



NOTES

1. This profile is based on a level range and a fixed firing line.
2. The target distance is established by CA to satisfy the intended training or courses of fire.
3. A tactical, fully contained range will allow shooters to move laterally along the firing line and downrange.
4. Overhead baffles must be angled from 12° to 32° from the horizontal.
5. Fully contained ranges require a 150-mm (6-in.) minimum baffle overlap.
6. For existing partially contained ranges, baffles are spaced as required to bring the bullet into the baffle at a point not less than 300 mm (12 in.) below the top of the following baffle as measured along its slope.
7. The bullet impact point on the bullet trap is not less than 300 mm (12 in.) below the top edge of the trap as measured along the slope.
8. If vehicle access is not required, locate the bottom of the baffles at least 2.45 m (8 ft) above the firing platform.
9. If vehicle access (without machine gun pedestal) is required, locate the bottom of the baffles at least 3.68 m (12 ft) above the platform.
10. The canopy baffle may be sloped up to 30 degrees from the horizontal. If sloped, the high point of the canopy is closest to the target line.

Figure 8. Typical Overhead Baffle Configuration

7.5. Ballistic Safety Structures.

7.5.1. Canopy Baffles. A canopy baffle is an angled or horizontal baffle attached to and directly above the firing platform, extending downrange from the firing line. It prevents direct-fired rounds from escaping the range between the firing line and the first overhead baffle. The bottom of the canopy baffle must be at least 2.45 meters (8 feet) above the level of the firing platform if vehicle access is not required. The canopy will begin at least 1 meter (3.2 feet) behind the firing line and extend at least 4 meters (14 feet) forward of the firing line toward the target line. A canopy baffle may be used to provide a covered firing line position on a non-contained range without either overhead baffles or side containment. Face the portion of the canopy baffle directly over the firing positions with plywood, lumber or other approved material (par. 8.2) of sufficient thickness to capture the ricochet from a round fired directly over the shooters.

7.5.2. Overhead Baffles. An overhead baffle is an angled baffle (vertical baffles are not authorized for new range projects) installed downrange to deflect and contain direct-fired rounds. Install overhead baffles downrange between the overhead canopy and the backstop. A shallow angle deflects bullets more easily and there is less metal fatigue and denting in the surface of the plate. A fully contained range requires a 150-millimeter (6-inch) minimum overlap of baffles. The overlapping baffles will allow shooter movement throughout the range and will prevent projectiles from leaving the range even if the weapon is accidentally fired straight up. Line-of-sight analysis shall consider rounds fired from any angle and any training position forward of the firing line. Angled overhead baffles redirect projectiles downrange. Install angled overhead baffles with the bottom edge further downrange than the top edge. Install overhead baffles parallel to the firing line. Refer to Figure 8 for a typical configuration. Install angled overhead baffles for new ranges and baffle replacement projects.

7.5.3. Additional Criteria for Vehicle Access. New training scenarios will use vehicles for practicing vehicle dismount, cover, and engaging targets from the vehicle. The design vehicle for range design purposes is a HMMWV (“Humvee”) without a pedestal-mounted weapon. Vehicle access requires consideration of higher clearance from range floor to baffles and vehicle paths into the range. See Figure 8, note 9.

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

7.5.5. Baffle Construction.

7.5.5.1. Construct ballistic safety structures for fully contained ranges with attention to the quality of the fabricated parts. Baffle plates with butt joints must fit together closely to prevent any gaps more than 1.6 millimeters (0.0625 inch) wide. Modern plate-cutting techniques can provide precise dimensions, but particular care must be taken in erecting the baffles to ensure

a precision fit of parts. The development of construction/erection details that use overlapping joints and joint-closure plates may provide a better, more economical solution than precise fabrication and also may simplify the erection procedures.

7.5.5.2. 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 (16.4 feet) of the expected position of the shooter. If shooters move downrange and fire, splash-back protection will be required for baffles at the downrange locations as well. Plywood shall be fire resistant treated (FRT) plywood in accordance with International Building Code (IBC) section 803 class A flames spread 0-25 and smoke development 0-450. **Note:** The Brinnell Hardness Number (BHN) measures steel hardness. The higher the BHN, the harder the steel.

Table 3. Construction Materials for Canopy and Overhead Baffles

Weapons	Ammunition	Construction*
Handguns	.22 LR, .38 cal., .45 cal., .357 cal., 9mm, .44 cal.	6 mm (0.25 in) steel plate with a nominal 440 BHN or higher, covered with one sheet of 19 mm (0.75 in) and one sheet of 11 mm (0.4375 in) plywood
Rifle, carbine, machine gun	5.56mm, 7.62mm, .30 cal.	10 mm (0.375 in) steel plate with a nominal 500 BHN, covered with one sheet of 19 mm (0.75 in) and one sheet of 11 mm (0.4375 in) plywood

***Notes:**

1. On steel plate baffles, install FRT plywood facing on overhead baffles located within 5 meters (16.4 feet) of the shooter to mitigate the risk of “splash-back” ricochets. Attach the 19-millimeter (0.75-inch) sheathing to the steel using flathead countersunk screws. Attach the 11-millimeter (0.4375-inch) FRT plywood to the 19-millimeter (0.75-inch) sheathing using #8 flathead screws at 300-millimeter (11.8-inch) spacing.

2. Nominal AR500 ballistic plate manufactured to BHN 500 may have BHN values ranging from 480 to 530.

7.5.6. Side Containment or Sidewalls. Sidewalls 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 (5 feet) from the outside edge of the firing position limits of fire and extend at least 1 meter (3.2 feet) to the rear of the firing line. Sidewalls may be made of earth, fully grouted reinforced masonry block (CMU), reinforced concrete, or hardened steel.

7.5.6.1. Continuous Walls. Vertical smooth-faced walls constructed of reinforced concrete, CMU with fully filled cores, or hardened steel may be used for sidewalls. Table 4 lists minimum wall thicknesses. Design these walls for all dead and live loads, including lateral forces. See paragraph 7.2.9 for noise-reduction requirements. Walls will extend 1 meter (3.2 feet) behind the firing line to prevent a bullet fired parallel to the firing line from leaving the range.

Table 4. Sidewall Minimum Thickness

Material	Caliber			
	.45/9mm	5.56mm	7.62mm	.50
3500 psi concrete	150 mm (6 in.)	150 mm (6 in.)	200 mm (8 in.)	300 mm (12 in.)
Grout-filled CMU	200 mm (8 in.)	300 mm (12 in.)	300 mm (12 in.)	600 mm (24 in)

7.5.6.2. Discontinuous Sidewall 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.

.

7.5.6.3. Earth Berms. The 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. 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 5. Use Table 5 only as a guide, since mechanical stabilization may increase the angle of repose. The width of the top of the berm must be at least 3 meters (9.8 feet). Construct the outer layer (2 meters [6.5 feet] thick) of the impact face with sands, silty sands, or clayey sands, free of rocks, and with 100 percent passing the #4 sieve, ASTM C136. Soil with more than 40 percent clay-size particles passing the #200 sieve is not acceptable for the outer 2-meter (6.5-foot) layer of the impact face. Clay may be used for the core. 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 5. 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

7.5.7. 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.

7.5.7.1. Earth Backstops. Earth backstops are the most common backstop for non-contained ranges. As an example, for a 25-meter (82-foot) non-contained range, locate the backstop so the longitudinal centerline of the berm (backstop) is at least 50 meters (164 feet) 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 with 100 percent passing the #4 sieve, ASTM C136, for a depth of 2 meters (6.5 feet). The slopes should be stabilized with grass vegetation and access 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 7.3.3.1.

7.5.7.2. Metal Backstops. Metal backstops are large plates installed behind the target line to stop direct fire and ricochets. Metal backstops are not approved for new construction. They are typically found on older existing partially contained or fully contained ranges but may be found on non-contained ranges. A metal backstop is not a bullet trap. See paragraph 7.5.7.4 for bullet trap requirements. The metal backstop should be located a minimum of 15 meters (49 feet) beyond the target line to allow target and backstop maintenance and to minimize the possibility of splashback ricochets or lead exposure to the shooters executing a downrange course of fire. Additionally, provide sufficient vehicle access to maintain the backstop. The required direct fire and ricochet containment must not be compromised when providing vehicle access. On outdoor ranges, provide corrosion protection for

a metal backstop. Painting does not provide adequate protection. Consider adding an overhead cover to provide protection.

CAUTION

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

7.5.7.3. Backstop Deflector Plates (Eyebrows). A deflector plate is not a bullet trap. See paragraph 7.5.7.4 for bullet trap requirements. A backstop deflector is typically installed on top of an earth backstop to provided added containment safety. Install the backstop deflector plate at an angle between 30 and 42 degrees from horizontal (see Figure 11). Angles other than these are permissible if 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. Eliminate exposed edges which may produce erratic ricochets. 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 structural members supporting deflector plates are not permitted. Welding must conform to AWS D1.1, *Structural Welding Code – Steel*, latest edition. 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.

7.5.7.4. Bullet Traps. Only commercially designed and constructed bullet traps are permitted. Sand, media, or water traps (recycled lubricating water excepted) are not permitted in new construction. Bullet traps are typically used on contained ranges and placed 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 or other dust-management systems to capture projectile particles. Bullet traps installed at indoor ranges must have a dust-management system installed to provide heavy metal particle removal from the range environment. The bullet trap must be designed to accommodate the ammunition/weapon to be fired as well as the expected quantity of ammunition fired (annual rate of fire). The bullet trap should extend the entire width of the firing line. The trap shall not present any blunt surface exposure that would create a ricochet hazard internal to the equipment or at the connection to the sidewalls and floor. All future purchases

of bullet traps must incorporate trap designs with a continuous, non-partitioned, and unbroken slot or bullet path into the deceleration chamber. In the past, typical design fabrication details have had vertical bulkhead plates in the deceleration chambers. These plates create vertical blunt edges that cause back-splash-type ricochets of the steel penetrator tips of the M855 5.56mm round. There have been documented cases of the steel penetrator tips ricocheting back to the firing line and endangering the shooters. The trap must have the capability to be cleaned of accumulated deposits of bullets and fragments while minimizing lead exposure to the maintainer.

Note: Only trained personnel wearing proper personal protection will remove lead, and only after consulting with BE personnel and following the trap manufacturer's recommended procedures.

The space directly behind the bullet trap must be easily accessible for maintenance and repair of the bullet trap and backstop. The bullet trap's metal thickness and hardness must meet the minimums listed in Table 6 for each type of ammunition to be fired on the range. 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. Design all traps for tracer rounds if a tracer round can be used in the weapon operated on the range.

7.5.7.4.1. Qualifications for Commercial Trap Manufacturers. Commercial bullet trap and range component manufacturers must demonstrate at least five years of continuous component manufacturing and submit a minimum of five examples, with customer references, of similar range components installed by the manufacturer.

Table 6. Minimum Steel Plate Thickness for Metal Backstops, Deflector Plates, and Bullet Traps

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

Note: 0.25-inch and 0.375-inch plate may be substituted for 6-mm and 10-mm plate, respectively.

7.5.8. Metal Backstop, Deflector Plates, and Bullet Trap Material.

7.5.8.1. Construct metal backstops, deflector plates, and bullet traps with the minimum metal thickness and hardness listed in Table 6. Small variations of BHN (less than 5 percent lower than the nominal number) are acceptable.

The design/specification must reference the applicable ASTM standard (ASTM A514/A514M) or military specification, 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. Plate thickness tests were conducted for the plate angles listed; however, a flatter plate angle is desired (the flatter the angle of the plate, the better). A shallow angle deflects bullets more easily, and there is less metal fatigue and denting on the surface of the plate.

7.5.8.2. Do not use mild structural steel, carbon steel plate, or low-alloy steel conforming to ASTM A36/A36M, *Standard Specification for Carbon Structural Steel*, ASTM A242/A242M, *Standard Specification for High-Strength, Low-Alloy Structural Steel*, or ASTM 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.

7.6. Range Support Facilities. Range support facilities include the CA building and munitions storage room/building (Category Code 171-476), a building for storing range supplies and equipment (Category Code 171-472), and a building for target storage and repair (Category Code 171-473).

7.6.1. CA Building. The CA building provides a temperature-controlled environment for the CA section. The building houses classrooms, administrative

offices, weapons maintenance areas, space for cleaning and degreasing weapons, an alarmed weapons and munitions storage room, sanitary facilities, a student weapons cleaning room, and miscellaneous storage. Figure 9 presents an example of 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. Give consideration for space to accommodate weapons simulator training as mission needs dictate.

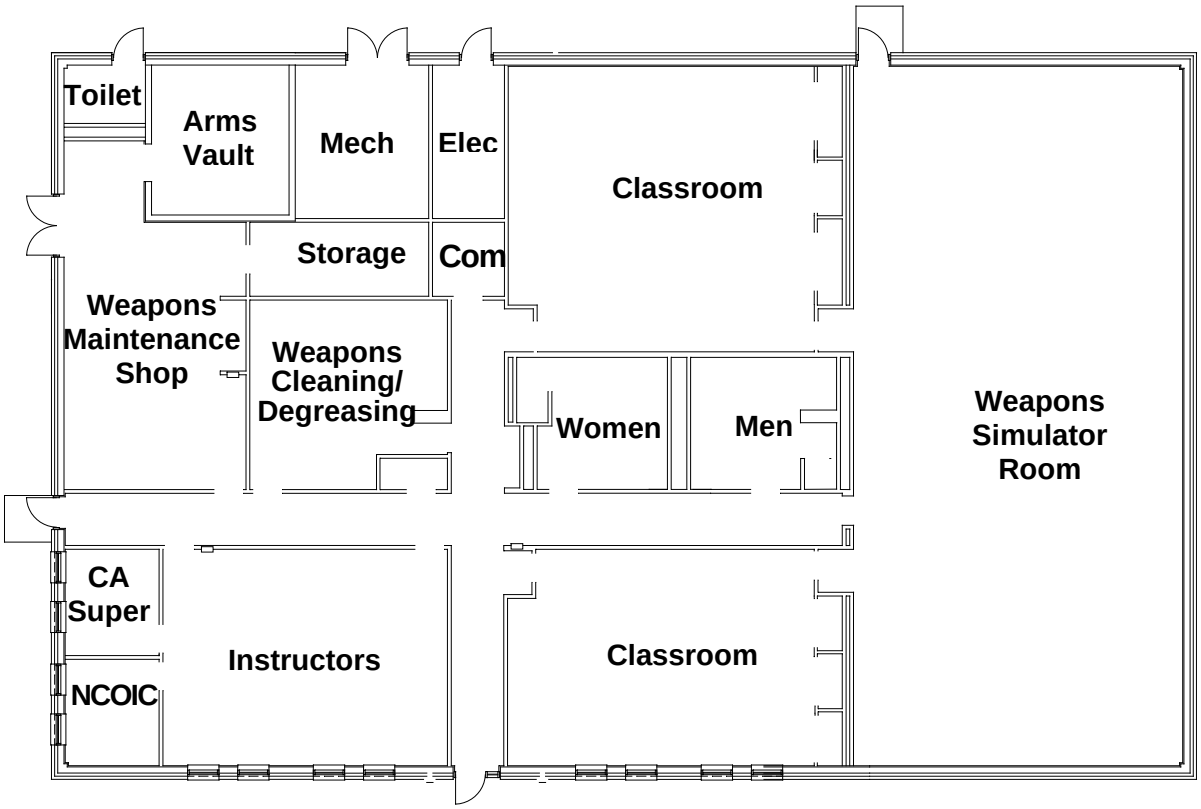


Figure 9. A Typical CA Building Configuration

7.6.1.1. 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 or LAW 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 audio-visual equipment and computers.

7.6.1.2. Administrative Space. This area (typically about 13 square meters [140 square feet]) contains offices for program administrators and CA personnel such as the NCOIC and several instructors.

7.6.1.3. Weapons Simulator Room. This room is specifically designed for commercially purchased projection-based weapons simulators. A five-lane system requires a room approximately 10.7 meters by 5.3 meters (35 feet by 17.5 feet). A ten-lane system requires approximately 10.7 meters by 10.7 meters (35 feet by 35 feet). The room should have at least a 2.7-meter (9-foot) ceiling height and no windows. The room must have dimmable lighting, HVAC, and a minimum of four 110-volt and/or 220-volt dedicated power outlets to operate air compressors, projectors, and computers. Two dedicated telephone lines are required for operating the system and for remote diagnostic support.

7.6.1.4. 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. An installation 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. Provide additional ventilation as required. Maintain relative humidity (RH) below 65 percent.

7.6.1.5. Weapons Cleaning/Degreasing Room. This room accommodates workbenches, degreasing tanks, and spray hoods. Special design requirements include exhaust ventilation, vapor-proof electrical fixtures, compressed air service, and solvent-resistant wall and ceiling finishes. The minimum 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 installation SE office and BE may have additional design requirements. Exhaust make-up air can be transferred from the administrative and classroom areas as long as sufficient ventilation air is provided in those areas to prevent negative air pressure in relation to the outside.

7.6.1.6. Weapons and Ammunition Storage. The arms vault provides secure storage for all weapons for which the CA 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, *Integrated Defense*, and UFC 4-020-01, *DoD Security Engineering Facilities Planning Manual*, for construction materials and specifications. Additionally, requirements of DOD 5100.76-M, *Physical Security of Sensitive Conventional Arms, Ammunition, and Explosives*, must be satisfied. In general, vault construction must provide a minimum ten 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. Maintain RH below 65 percent.

7.6.1.7. Latrines (Sanitary Facilities). Provide facilities for both men and women. Provide additional cold-water hand-washing stations at the entrance to the CA building and at the firing range. The size of sanitary facilities depends upon the class size at that particular installation. Typically, 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, hand-washing stations, warm-water showers, changing areas, laundry facilities, and lockers should be provided for instructors to remove lead contamination. Use of these facilities at the end of each shift will prevent recurring casual contamination and potential health concerns, and prevent accidental inhalation or ingestion from residual lead.

7.6.1.8. 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 the room is well ventilated and contains an emergency eye wash station.

7.6.1.9. 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 provided by the CA section.

7.6.2. 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 construction. Depending on location, type, and value of items stored, this facility may be combined with the target storage and repair building.

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

7.7. Specialty Weapons Ranges.

7.7.1. 40mm Grenade Launcher Range (Figure 3). The range supports firing of 40mm low-velocity grenades from M79 and M203 grenade launchers. The entire surface of the impact area must be cleared of vegetation or clipped extremely close during mowing so grenades will readily detonate on impact and EOD 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. The range must have electrical power and lighting for the night-fire course.

7.7.2. LAW Range (Figure 4). The LAW range is set up for firing the M72 66mm rocket, the M73 35mm sub-caliber training device, and the 84mm 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.

7.7.3. Ten-Meter Machine Gun Range. If a non-contained machine gun range is not available, the machine gun must be fired on either a 10-meter tube range or on a fully contained range designed to accommodate the firing of the automatic weapon. Ten-meter tube machine gun ranges must incorporate range tubes as described in paragraphs 7.7.3.1 through 7.7.3.3. Range tubes function as baffles, thereby reducing the SDZ requirements. When the machine gun tube range is constructed in accordance with Figures 10 and 11, the SDZ length requirement is 700 meters measured downrange from the firing line. Range tubes are not required on a fully contained range designed for firing automatic weapons which has ballistic safety structures (baffles, traps, berms) designed to prevent penetration of the containment based on the ammunition being fired. Range tubes are also not required for a non-contained range with sufficient real estate to accommodate the full SDZ. The machine gun tube range is acceptable for M60/M240B/M249 machine guns.

7.7.3.1. Machine Gun Tubes.

7.7.3.1.1. If a non-contained machine gun range is not available, the 10-meter machine gun range tubes must measure at least 1.52 meters (5 feet) inside diameter by 7.3 meters (24 feet) in length. The tubes may be constructed of sectional pieces if the spigot end of the bell-spigot joint is pointed downrange. Tubes may be made of reinforced concrete pipe and must meet ASTM C76, *Standard Specification for Reinforced Concrete Culvert, Storm Drain and Sewer Pipe*, Class V reinforced concrete pipe (RCP) requirements, or may be steel pipe of suitable thickness fabricated from rolled plates. The interior of the tubes must have a smooth continuous surface. Repair any lifting lugs or holes so the tube interior is smooth and does not produce erratic ricochets.

7.7.3.1.2. For drainage, slope the tubes approximately 150 millimeters (6 inches) 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 10 and 11).

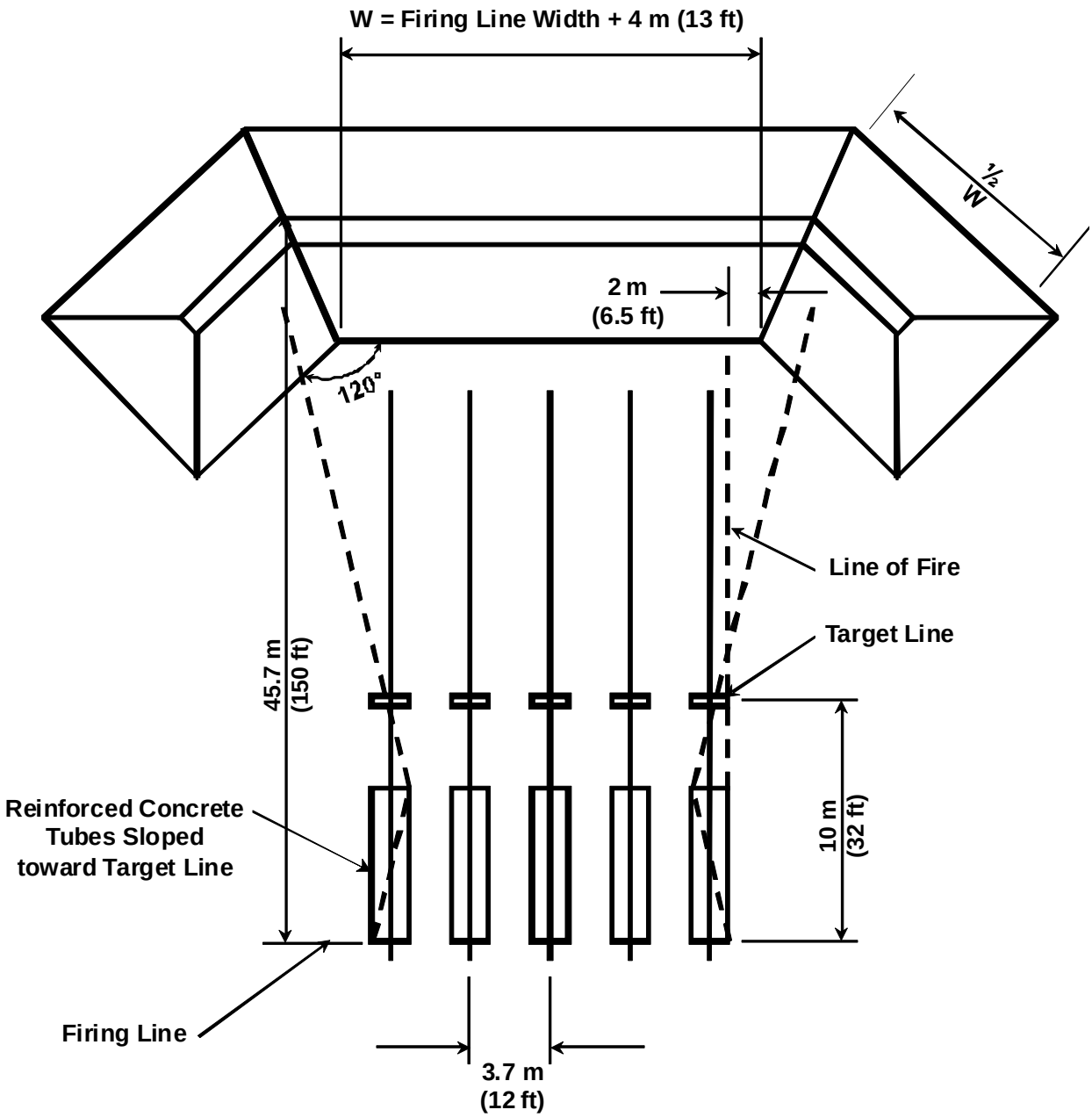


Figure 10. Machine Gun, 10-Meter Tube Range Typical Range Configuration

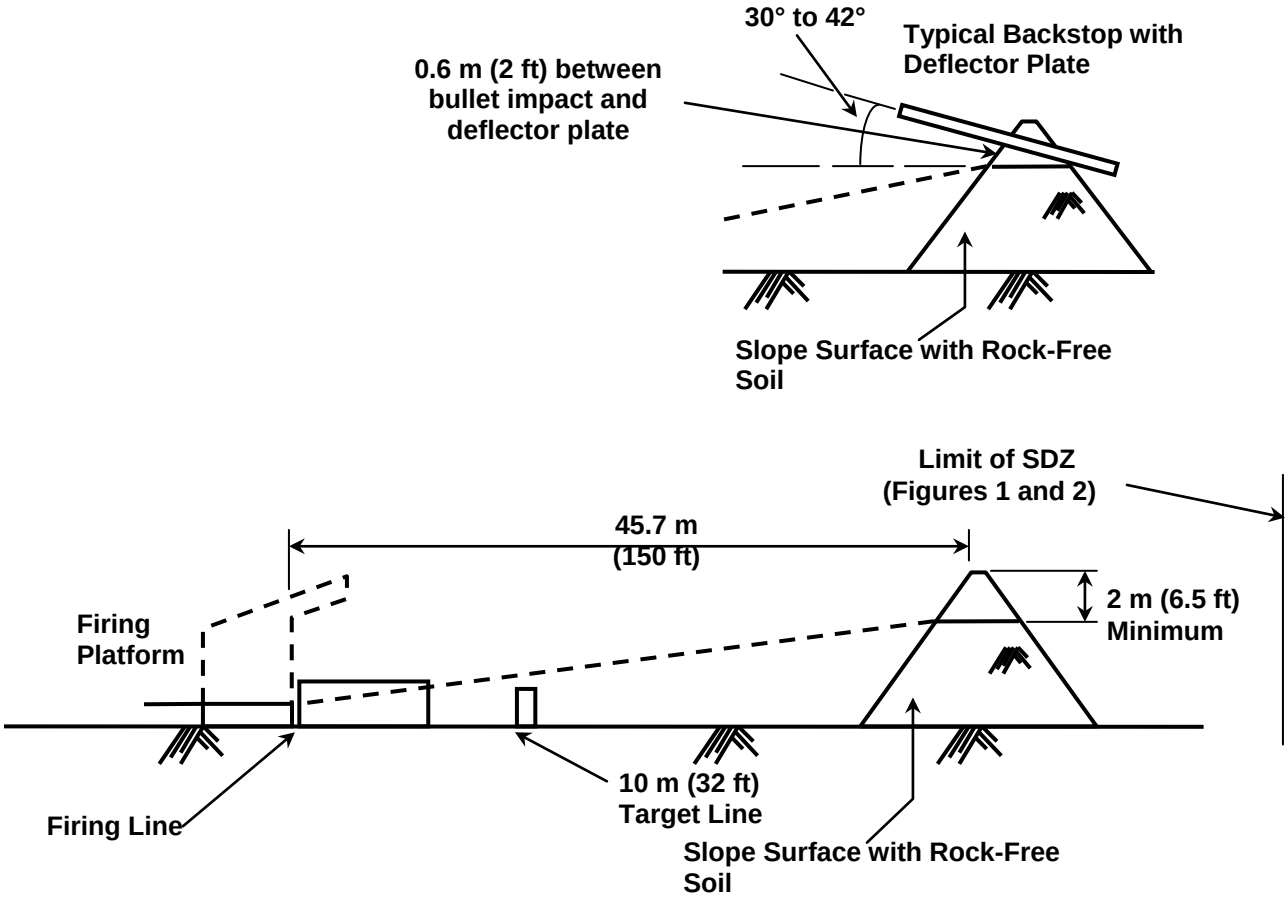


Figure 11. Machine Gun, 10-Meter Tube Range Typical Cross-Section

7.7.3.2. 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 (6 inches) inside the tube. A recess in the platform may be needed, about 76 millimeters (3 inches) deep and large enough to accept a tripod.

7.7.3.3. Backstop/Deflector Plate/Bullet Trap. For berm backstops, locate the berm no more than 45.7 meters (150 feet) from the firing line to the centerline of the berm. 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 berm. This line must intersect the berm not less than 2 meters (6.5 feet) 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 berm. For metal trap backstops, locate the trap at least 25 meters (82 feet) away from the firing point. The line drawn from the firing point to trap shall intersect the top plate of the trap not less than 300 millimeters (12 inches) from the top, measured along the slope of the trap.

7.7.3.4. Engineering solutions to reduce noise levels from tube ranges are limited and may consist only of sand bags along the bottom of the tube.

Appropriately operational mitigation must be established to reduce noise exposure in accordance with paragraph 7.2.9. The impact of hazardous noise levels for tube ranges must be evaluated by local SE and BE. BE will evaluate noise exposures and make recommendations for proper hearing protection to reduce noise levels for shooters and range personnel.

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

8.1. Design Approval.

8.1.1. The design agent will submit a set of prefinal drawings and project specifications to the respective MAJCOM representatives of CA, CE, SE, and BE for review to ensure compliance with this ETL.

8.1.2. After MAJCOM approval is complete, HQ AFSFC/SFXW must approve all new range designs, major renovations, and changes to the type or function of the range. This approval also applies to portable or trailer type ranges. HQ AFSFC/SFXW is the approval authority for deviations or waivers from design criteria and will coordinate requests with HQ AFCESA/CEOA and AFMSA/SG3PB.

8.2. Baffle Test Before Construction. For baffles which differ from the weapons and construction mandated in Table 3**,** construct baffle test blocks/cells using the baffle materials and construction details specified in the design documents. Completion of this test is required before construction and installation of the overhead baffles. From a protected position, a shooter will engage the test block/cell with direct fire from the most powerful round 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. Machine gun range tubes do not have to be tested if they meet the material requirements listed in paragraph 7.7.3.1.1.

8.3. 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 fully contained ranges, visually check baffles to make sure they overlap the required 150 millimeters (6 inches), validate lighting levels, range supply, and exhaust system testing and commissioning.

8.3.1. The contractor shall provide, prior to final inspection, a full testing and balancing report for all supply and exhaust equipment. From the results of those

tests, determination will be made on airflow compliance set forth in the contract specification and this ETL. The balancing and testing shall be performed by a qualified testing agent in accordance with design criteria. Design criteria may include ACGIH *Industrial Ventilation: A Manual of Recommended Practice*, and NEHC-TM) 6290.99-10 Rev. 1, *Indoor Firing Ranges Industrial Hygiene Technical Guide*.

8.3.2. When the project includes additions and/or modifications to the sound-absorbing materials within the range, the contractor shall accomplish a hazardous noise survey. The initial hazardous-noise survey shall be conducted within five days of final acceptance of the range. The contractor shall coordinate with the government in advance to ensure personnel are scheduled and present to perform necessary weapons firing while the hazardous noise survey is being accomplished. Alternatively, the initial hazardous noise survey may be conducted in conjunction with the trial operations test. The initial hazardous noise survey shall be performed in accordance with requirements of DODI 6055.12, *Hearing Conservation Program (HCP)*, Air Force manual (AFMAN) 48-155, *Occupational and Environmental Health Exposure Controls* and AFOSH Standard 48-20, *Occupational Noise and Hearing Conservation Program*.

8.4. Test Fire Requirements. After construction or rehabilitation, and before conducting training and qualification operations, CA personnel must accomplish controlled test-firing using tracer ammunition. If tracer ammunition cannot be safely fired on the range, CA personnel will fire ball ammunition with witness screens to conduct the test fire. Representatives of SE and CE will act as observers. The CA instructor will use the most powerful ammunition authorized for use on the range for the test. Remove all fire hazards from the range and areas surrounding the range. Make sure firefighting equipment is immediately available when conducting range tests using tracer ammunition. Provide sandbags or other protection for the shooter during test firing. Hang witness screens of paper when firing non-tracer rounds to see if splash-back ricochets are occurring at the bullet trap when using the M855 round.

8.4.1. Non-contained Ranges. A test-fire is not required for a non-contained range. After the construction inspection confirms that the full SDZ land area is available and all barriers, fences, and signs are erected, proceed to trial operations.

8.4.2. Fully Contained Ranges. Do not test baffles with direct fire. Test baffles for direct-fired round containment before construction, as described in paragraph 8.2. To test for ricochet containment, the shooter must first fire service ammunition (non-tracer) from the prone position into the backstop and then at the floor. A test screen (witness) may be used to test the 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 (3.9-foot by 3.9-foot) four-sided cube. Place the test

screen at different locations on the range floor. 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. Take corrective measures if the angle of departure and the sighting verifies that the bullet left the range. To determine ricochet patterns, conduct tracer tests using the same caliber of ammunition to be used on the range. Using tracer ammunition is the fastest and most efficient method of determining ricochet patterns and hazard potential.

8.5. Trial Operations. Trial operation of a new or rehabilitated range is mandatory. The CA NCOIC and installation SE 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 CA 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
- Initial hazardous noise survey report

9. Point of Contact. Recommendations for improvements to this ETL are encouraged and should be furnished to the Small Arms Range Program Manager, HQ AFCESA/CEOA, DSN 523-6119, commercial (850) 283-6119, e-mail AFCESAReachbackCenter@tyndall.af.mil

CLIFFORD C. FETTER, GS-15, P.E., DAF
Acting Chief, Operations & Programs Supt Div

3 Atchs
1. Minimum VDZ Height Requirements for Small Arms Ammunition at Non-contained Ranges
2. Operational Risk Management (ORM) Evaluation of Existing Range Facilities
3. Distribution List

MINIMUM VDZ HEIGHT REQUIREMENTS FOR SMALL ARMS AMMUNITION AT NON-CONTAINED RANGES

Weapon/Caliber	Ammunition	Maximum Ordinate of Ammunition at 30° VDZ Meters (Feet)	Safety Factor Meters (Feet)	VDZ Height in Meters (Feet)
.22 long rifle		500 (1640)	175 (575)	675 (2215)
Handgun, .38 cal.	Ball M41, PGU-12/B	500 (1640)	175 (575)	675 (2215)
Handgun, .45 cal. pistol Submachine gun, .45 cal.		400 (1312)	160 (525)	560 (1837)
Handgun, 9mm pistol Submachine gun, 9mm		500 (1640)	175 (575)	675 (2215)
Handgun, .44 magnum		TBD	TBD	TBD
Shotgun, 12 gauge	00 buckshot	200 (656)	130 (427)	330 (1083)
Rifle, 5.56mm	Ball M193; tracer M196	800 (2625)	220 (722)	1020 (3347)
Rifle, 5.56mm	Ball M855; tracer M856	900 (2953)	220 (722)	1120 (3345)
Rifle, 5.56mm	M862 (plastic)	TBD	TBD	TBD
Rifle/machine gun, 7.62mm	Ball, M80; tracer M81	1100 (3609)	265 (869)	1365 (4478P
Rifle/machine gun, 7.62mm	Match M118	1200 (3937)	280 (919)	1480 (4856)

Weapon/Caliber	Ammunition	Maximum Ordinate of Ammunition at 30° VDZ Meters (Feet)	Safety Factor Meters (Feet)	VDZ Height in Meters (Feet)
Machine gun, .50 cal.	Ball M2 and M33/Tracer M17/M8 API/M20 APIT	1600 (5248)	340 (1115)	1940 (6365)
M79 and M203, 40mm low-velocity	M781/M407A1/M406/ M433/M381/M386/ M441	100 (328)	115 (377)	215 (705)
MK-19, 40mm high-velocity	M918/M383/M430	500 (1640)	175 (575)	675 (2215)
M72 LAW, 35mm subcaliber	M73	300 (984)	145 (475)	445 (1460)
M72 Law, 66mm RKT HEAT	M72	200 (656)	280 (919)	480 (1575)
AT-4, 84mm RKT HEAT	M136	TBD	TBD	TBD

Notes:

1. VDZ in excess of 61 meters (200 feet) in height requires coordination with the local airfield manager.
2. Use a VDZ of 500 meters (1640 feet) for partially contained (baffled) ranges.

OPERATIONAL RISK MANAGEMENT (ORM) EVALUATION OF EXISTING RANGE FACILITIES

A2.1. Overview. Operational Risk Management (ORM) is a tool used to assess the risks associated with continued use of existing firing ranges that do not satisfy the minimum criteria outlined in this ETL. For further information on ORM, refer to AFI 90-901, *Operational Risk Management*, and AFPAM 90-902, *Operational Risk Management (ORM) Guidelines and Tools*. This attachment gives an example of how the ORM process can be applied to a safety evaluation 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

A2.2. Action Items. The six steps of the process can be broken down into several sub-steps called "actions." A discussion of each action follows.

A2.2.1. Identify the Hazard. This step has 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 found to not satisfy the ETL criteria. A tabular method for recording these actions and steps is presented in the following paragraphs.

A2.2.2. Assess the Risk. This step has three actions:

A2.2.2.1. 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, injury, or system damage)

A2.2.2.2. 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, six months, will occur, 10^{-3} to 10^{-5}
- D – Seldom, five years, could occur, 10^{-4} to 10^{-6}
- E – Unlikely, past five years has not occurred, rarely, 10^{-5} to 10^{-7}

A2.2.2.3. Assign a numerical rating based on the combination of steps A2.2.2.1 and A2.2.2.2. See Table A2.1 for the numerical value to assign to the risk.

Table A2.1. 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 higher risk.

A2.2.3. Analyze Risk-Control Measures. This step has three actions:

A2.2.3.1. Identify risk control options: Measures taken to mitigate the risk.

A2.2.3.2. Determine control effects: Select the control options desired for consideration.

A2.2.3.3. Determine the residual risk: Prioritize the control measures and re-score the risk based on the implemented control measures using the same procedures in paragraph A2.2.2.3.

A2.2.4. Make Control Decisions. This step has two actions:

A2.2.4.1. Select the risk control measures to implement.

A2.2.4.2. Decide whether the residual risk level is acceptable or not.

A2.2.5. Implement Risk Controls. This step has three actions:

A2.2.5.1. Make the implementation clear to all parties.

A2.2.5.2. Establish accountability and responsibility for implementing risk-control measures.

A2.2.5.3. Provide support to those tasked to implement the control measures.

A2.2.6. Supervise and Review. There are two actions in this step:

A2.2.6.1. Supervise the implementation of the control measures.

A2.2.6.2. Review the effectiveness of the control measures.

A2.3. Example. The following example shows a tabular method for performing the operational risk assessment for existing firing ranges. The example shows discrepancies taken from a real-world assessment at an Air Force base.

BASE "X" FIRING RANGE
OPERATIONAL RISK EVALUATION

Discrepancy	ORM STEP 1	ORM STEP 2			ORM STEP 3		ORM STEP 4	ORM STEP 5	ORM STEP 6
	Hazard	Severity	Probability	Risk	Control Options	Residual 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 an 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 an 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

DISTRIBUTION LIST

SPECIAL INTEREST ORGANIZATIONS

Information Handling Services 15 Inverness Way East Englewood, CO 80150	(1)	Construction Criteria Base National Institute of Bldg Sciences Washington, DC 20005	(1)