DRAFT
Revision 2 - 07 Apr 00

Summary of Revisions:
Revision 1: Add Appendix A - Figures for Small Arms Range Design. Correlate Figures and Tables with Document.
Revision 2: Incorporate clarifications and comments provided by select reviewer groups and organizations. Add reference to Tech Man NEHC-TM6290.99-10.

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SUBJECT: **Engineering Technical Letter (ETL) 00-04: Small Arms Range Design and Construction**

1. Purpose. This Engineer Technical Letter (ETL) provides information and guidance for the design and construction of new or the rehabilitation of Air Force small arms ranges. This ETL supersedes AFMAN 36-2227, Volume 1, Combat Arms Training and Maintenance (CATM) Training Management and Range Operations, 1 Jun 96, Chapter 3.

2. Application. All U.S. Air Force installations. This document provides guidance, criteria, and standards for the purpose of planning, programming, design, and construction of combat arms facilities.

2.1. Authority. Air Force Policy Directive (AFPD) 32-10, Installations and Facilities, 27 Mar 95.

2.2. Effective date: Immediately. Expires five years from date of issue.

3. Referenced Publications.

3.1. AFOSH Standard 161-2, Industrial Ventilation, 26 Aug 77.

3.2. AFH 32-1084, Facility Requirements, 1 Sep 96.

3.3. MIL-HDBK-1027/3B, Range Facilities and Miscellaneous Training Facilities Other Than Buildings, 30 Nov 1992.

3.4. National Rifle Association of America, The NRA Source Book: A Guide to Planning and Construction, Nov 1999.

3.5. Naval Environmental Health Center, NEHC-TM6290.99-10: Indoor Firing Ranges Industrial Hygiene Technical Guide, Dec 1999.

4. Definitions.

4.1. *Small Arms Range.* A facility that is used in training those people that require certification in the use of handguns, shotguns, rifles up to 7.62mm, and machine guns up to 50 caliber. It includes special ranges for 40mm grenade launcher, Light Anti-Tank weapons, 81mm Mortar, and the 10 meter machine gun range.

4.2. *Surface Danger Zone (SDZ).* The SDZ is the landing area for fired rounds that escape the range. The SDZ may include a weapon back blast area when required. The SDZ includes the target line, an impact area, a ricochet trajectory area, and a secondary danger area.

4.3. *Vertical Danger Zone (VDZ).* The vertical danger zone is the area above the SDZ. This zone consists of projectile maximum altitude from a specified launch angle plus a safety factor. The vertical danger zone extends vertically above the outer limits of the SDZ to the total maximum vertical distance of the specified ammunition.

5. Requirements. This document includes criteria that apply to all the types of small arms ranges. Respective MAJCOM's may publish criteria exceeding the minimums specified in this document. Existing ranges and support facilities do not have to meet the criteria in this document, but when rehabilitation is accomplished these standards and criteria will be applied.

5.1. Range Types, Geometry, Standards, Site Selection and Development.
5.1.1. Range Types. There are three range types; Impact, Baffled, and Fully Contained.
5.1.1.1. Impact Range. An outdoor range where the discharge of weapons is controlled and supervised. The trajectory of the bullet is along the line of fire (orientation of the range) and the impact of the bullet is expected to be within the constructed limits of the range. There are no overhead baffles and the sides of the range are usually not contained. An impact range is the most desirable type because weapon and ammunition choice is only limited by the real estate available for accommodation of both the Surface Danger Zone (SDZ) and the Vertical Danger Zone (VDZ). The ammunition that will be used on the range controls the length of the SDZ and the height of the VDZ. The SDZ length will be 100 percent of the longest distance for the ammunition to be used based upon the values in Table 1. The VDZ will be150 meters in height unless higher elevations are required to support the weapon being fired and the training scenario.
5.1.1.2. Baffled Range. A baffled range may be either an outside or an indoor facility. For the purpose of definition, an indoor range is not designed with a roof or sidewalls to preclude bullet penetration. The baffled range is designed and constructed with overhead baffles, sidewalls (earth berms or cementious materials), and a backstop. The intent of the design and construction is to capture direct-fired bullets or low-angled ricochets and to minimize the opportunity for other ricochets to leave the constructed limits of the impact area. The firing line must be covered to preclude the weapon from seeing “blue sky” from any firing position. The SDZ length for a baffled range will be 50 percent of the longest distance based upon the intended use of the range using the values given in Table 1. The VDZ is 150 meters in height.

5.1.1.3. Fully Contained Range. When an SDZ of the minimum dimensions cannot be established because compatible use land area is not available, the small arms range will be relocated; or, as an alternative, site specific criteria will be developed for the range complex. A fully contained range is considered to be a fully enclosed range that includes a roof structure. The structure elements and materials used for the roof may vary depending upon the type and configuration of interior overhead baffles, type of backstop, and method used to trap bullets. The criteria that are developed will be critical with the intent being to preclude the escape of both a direct-fired bullet and a ricochet round. The respective MAJCOM Combat Arms, Civil Engineer, and Safety will jointly approve site specific design criteria for fully contained ranges. Criteria and designs for fully contained ranges will be submitted to HQ AFSFC/SFW and HQ AFCESA/CESC for review and approval prior to programming and budgeting.

Weapon/Caliber	Ammunition	Minimum SDZ Length (Meters)
Handgun, 9 mm Pistol Submachine Gun, 9 mm	M882	1840
Handgun, 44 Magnum	Commercial Local Purchase	2290
Shotgun, 12 gauge	00 Buckshot	600
Rifle, 5.56 mm	Ball, M193;Tracer M16	3100
Rifle, 5.56 mm	Ball, M855;Tracer, M856	3200
Rifle, 5.56 mm	M862	250
Rifle/Machine gun, 7.62 mm	Ball, M80	4300
Rifle/Machine gun, 7.62 mm	Match, M118	4800
Machine gun, Cal. 50	Ball, M2 and M33	6700
M79, M203, 40 mm Low Velocity	M781/M407A1/M406/ M433/M381/M386/M441	600 (100m Safety Factor)*
Mk-19, 40 mm High Velocity	MK19, M430	2650 (350m Safety Factor)
M72 LAW, 35 mm Subcaliber		1300 (100m Safety Factor)
M72 LAW, 66 mm RKT HEAT	M72, 66mm RKT Heat	1250 (250m Safety Factor)
AT4, 84 mm RKT HEAT	M136	2600 (200m Safety Factor)
M29 Mortar, 81 mm	M301/M374A3/M375	5400 (400m Safety Factor)
M252 Mortar, 81 mm	M819/M821/M853/M889	6400 (400m Safety Factor)

*****The safety factor is included in the minimum SDZ length given.

Table 1. Minimum SDZ Distance Requirements for Small Arms Ammunition

5.1.2. Range Type Combinations. The two range types can be integrated to form other configurations. The types of weapons used and the sequence determine the different combinations.

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

5.1.2.2. Superimposed Ranges. A superimposed range is either of the two types. The range will accommodate different types of weapons but only one weapon type can be fired at one time. The superimposed range allows for the maximum use of real estate and is usually the least expensive since there are no sidewalls between firing positions.

5.1.2.3. Special Ranges. Special ranges are usually impact ranges designed and constructed to accommodate multiple target lines or arrays. They are usually set up for special types of weapons or unique courses of fire.

5.1.2.4. Range Type Selection. The base Combat Arms (CA) unit will determine the type and the size of the range. The range type, size, and configuration is determined based upon the installation mission, real estate availability, Air Force and MAJCOM policy, the base population, annual training requirements, and weapon specific training requirements.

5.1.3. Roles and Responsibilities, Site Selection, Safety, Firing Line and Danger Zone Geometry, and Real Estate. The Base Civil Engineer will identify the real estate that can be used for the siting of the small arms range facilities. The range location, orientation, SDZ, and VDZ will be identified on the base master plan.

5.1.3.1. Planning. Combat Arms, a land use planner, a civil engineer, and ground safety representative should collectively review the proposed range usage and siting for land use compatibility. The Base Civil Engineer is responsible for plotting the SDZ and the VDZ on the base master plan. Any conflicts of land use or airspace operations with the SDZ or the VDZ shall be mitigated as a part of the planning, programming, and budgeting process. The Federal Aviation Administration (FAA) has jurisdiction when the vertical danger zone exceeds a height of 150 meters above ground level.

5.1.3.2. Safety. Safety is the primary concern in the siting of a small arms range. The location of the SDZ and the VDZ must be selected to positively minimize the impact of the range location and orientation on populated areas, aircraft ground and air operations, and land uses within the travel distance of the ammunition used on the range. It is not to be assumed that rounds will not escape from the range complex unless bullet resistant enclosures are constructed. It is the intent that the open and the baffled range construction will capture the direct fired round but it will not be assumed as fact that a ricochet will not land outside of the impact area.

5.1.3.3. Range Geometry. The layout and the dimensions of the facility must satisfy the user needs. The following are to be considered as facility minimums.

a) Firing Line Positions. The number of firing positions establishes the length of the firing line. All small arms (rifle, pistol, shotgun) ranges shall have a minimum of seven (7) positions on the firing line. The width of firing positions shall be at least 1.5 meters. The firing line will be on a concrete platform that is at least 4 meters wide, clear distance, for the length of the firing line. The Combat Arms unit will specify the number of firing positions and the widths of each position based upon training requirements and for ranges that are used for special weapon types.

b) Firing Line. A red line, 100mm wide, will be painted at a distance of 300mm from the target side edge of the firing platform. The line will be continuous for the length of the firing platform. The firing line side of the platform will be the front of the firing platform. This line is designated the *firing line*.

c) Ready Line. A yellow line, 100mm wide, will be painted on the firing line platform 2 meters behind the red line (towards the rear of the firing platform). The line will be continuous for the length of the firing platform. This line is designated the *ready line*.

d) Target Line. A line parallel to the firing line along which targets are placed. Targets are placed coincident with each firing position.

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

5.1.3.4. Danger Zone Geometry. The range danger zone includes the impact area, the SDZ, and a VDZ. Refer to Attachment A, Figures 1 through 4 for the typical geometry of the SDZ. The VDZ reflects the geometry of the SDZ extended to the VDZ height of 150 meters or higher if required to support for the ammunition being used on the range.

a) Impact Area or Impact Danger Zone. The impact area is bounded by the left and right limits of fire, the firing line, and the minimum SDZ arc length for the ammunition being used. The SDZ length is extracted from Table 1 and is based upon the ammunition used on the range that has the longest minimum SDZ length. When the target line is the same width as the firing line the impact area forms a rectangle (Figure 1). When the target line is wider than the firing line, the impact area includes a rectangular area the width of the firing line and pie shaped areas formed by the limits of fire and the arc of the minimum SDZ length (Figure 2). The intersection of the firing line and the limits of fire form the SDZ arc radius center.

b) Ricochet danger area. The ricochet danger area is that area between the impact area and the secondary danger area. The ricochet area is determined by extending a line drawn at a 10-degree angle off the left and right limits of fire beginning at the firing line and extended to the minimum SDZ arc length.

c) Secondary danger areas are provided to catch fragments from exploding ammunition or ricochet 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 and extending outward for 1,000 meters. From the 1,000-meter point extend a second line to a point on the minimum SDZ arc length 100 meters beyond the ricochet area limits.

5.1.3.5. Real Estate Acquisition. The Base Civil Engineer will allocate government owned property on the base master plan for use as a combat arms training facility for those installations authorized to maintain a range training facility. When suitable government owned property is not available, and where land acquisition is feasible, the Base Civil Engineer shall prepare those documents that are required to execute a real estate acquisition process.

5.2. Criteria Applicable to All Ranges.

5.2.1. Geography and Climatic Impacts.

5.2.1.1. When possible the outdoor range should have an orientation that puts the rising sun at either the right or left of the shooting positions. It is preferred that the sun be at the rear of the shooting position with the light on the target.

5.2.1.2. Ranges located in regimes subject to snow accumulation and periods of continuous sub-freezing temperatures (usually 90-days or more) should be designed as

indoor ranges. When this is not possible the range should be sited to minimize the impact of drifting snow, ice build-up, excess water accumulation inside the range periphery, and the prevailing wind direction with respect to firing positions.

5.2.2. Materials Used in Construction. The materials used in range construction must be selected to attain the longest life cycle possible for the environment. Materials used where a bullet could impact will be resilient to the impact but not directly cause a ricochet. Those areas of the range where ricochet is expected will be designed to assure that the ricochet proceeds downrange and is not reflected back to the firing position. These considerations must be included when determining how the locations of brackets used for baffles are positioned, position of bolt heads, and selection of protective construction.

5.2.3. Geometry and Facility Requirements.

5.2.3.1. Firing Line Configuration. The firing platform will be a minimum of 4 meters wide, clear distance, for the length of the firing positions. The platform will be concrete and the surface will be sloped from the target edge of the platform to the rear (away from the target line) at a grade of 2 percent.

a) Firing Line Positions. There shall be a minimum of seven (7) positions across the firing line on ranges used for rifle, shotgun, and pistol type weapons. The left edge of the first and the right edge of the last firing positions will be at least one (1) meter from sidewalls that run perpendicular to the firing line.

b) Position Barricades. A barricade will be installed at the center of each firing position. The barricade will be constructed of wood in the form of a "+". The material should be wood of 50mm x 150mm nominal dimension. The horizontal member will be located with the top surface at 120 cm above the platform. The barricades will be anchored with mechanical systems. Barricades will not be designed to insert into sub-platform sockets.

c) Firing Position Identification. Each firing position will be numbered beginning from the left as you face the target line. The numbers will be a minimum of 20cm in height. The numbers will be on rectangular backgrounds and attached to the position barricade. Odd numbered positions will be white numbers on a black background. Even numbered positions will be black numbers on a white background.

5.2.3.2. Target Line Configuration. The distance from the firing line to the target line will be maintained constant. Along the target line, targets may be placed on turning mechanisms, pop-up mechanisms, or stationary mechanisms. Mounting mechanisms for targets will be located below the grade of the impact area between the target line and the firing line. The line of sight from the firing line to the target line will be clear and the cross section uniform. Each target location will be numbered the same as the firing positions.

5.2.3.3. Horizontal and Vertical Control. Vertical Control is based on the firing line elevation being equal to 0.0 meters. The firing line will be the baseline used for horizontal control.

a) The center of the target shall be at an elevation between the upper limit of fire, or the standing position, which is +185 cm above the firing line and the lower limit of fire, or prone position, which is +15 cm above the firing line. The entire target face shall be fully displayed to the firing position.

b) The distance between the firing platform and the range floor immediately in front of the firing platform shall not be higher in elevation than 100 mm below the firing line elevation.

c) On outdoor ranges, positive grading will be used to direct water away from the firing line and towards the target line. When the length of the slope or the natural terrain necessitates the use of drains between the target and the firing line, the grade breaks will be constructed to preclude a vertical surface exposed towards the firing line.

d) The distance from the line of fire to side containment (base of an earth berm, foundation edge, or containment wall) will be at least 2 meters.

5.2.3.4. Site Development Considerations for Outdoor Ranges.

a) The design should allow for vehicle access to all of the range areas. Equipment access should include the backstop, side earth berm areas, and impact areas.

b) The site should take advantage of natural drainage. Flowing watercourses in the impact area or near a berm are not permitted. Avoid establishing range impact areas in locations subject to frequent flooding.

c) Plant grass on impact areas. Pea gravel will not be used to surface or edge the impact area of the range. The impact area will be surfaced with natural soils that are free of rocks and debris. Use a minimum depth of 150mm of clayey sands, sands, and silty-sands with no more than 5 percent of the material gradation being retained on the 9mm sieve.

d) Use natural barriers and/or signs that identify restricted areas to minimize incidental entrance onto range danger areas by people.

e) Take advantage of natural occurring geologic formations that can be used for backstops. Trees are allowed downrange.

f) Locate impact areas so to minimize the amount of fired projectiles and projectile residue that will land in waterways, wetlands, etc.

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

h) Direct the line of fire away from residential areas.

5.2.3.5. Range Design Considerations and Intent.

a) The desired life expectancy of permanent construction is 20 years. Permanent construction is not intended to include protective construction, baffles, or sacrificial materials intended to capture bullets.

b) When possible use earth berms or concrete walls to separate the line of fire from the ricochet zone to protect areas outside the impact area from inadvertent direct fired shots.

c) On impact ranges, the target line may be fixed and several firing lines constructed to permit firing at different distances. When this option is used only the rear most firing line will incorporate a firing platform.

5.2.4. Small Arms Range Infrastructure Requirements.

5.2.4.1. Impact Range Control Tower. The control tower is an elevated control center on from which the range officer can observe and control all range. The following criteria apply to the design and construction of control towers.

a) Locate the tower centered and at least 3 meters behind the firing line. The tower will be located so that there is an unrestricted view of all firing positions from the tower.

b) The floor of the control tower will be at least 2 meters above the firing platform. The tower must be high enough to permit an unrestricted view of the impact area including all entry points.

c) Provide a worktable or counter where reference materials may be placed. Provide at least one electrical outlet in the worktable area.

d) Include provisions for a public address system.

e) Minimum size for the control tower platform is 1.5 meters by 3 meters. Align the long side parallel to the firing line.

5.2.4.2. Baffle Range and Indoor Range Control Booth. The control booth is a fixed elevated platform under a shelter structure built on the firing platform from where the operator controls range operations. The control booth may also be used on impact ranges with a covered firing line. Use the design criteria in section **5.2.4.1** and incorporate the following provisions.

a) For ranges with 14 or less firing points the booth is located on the right end of the firing platform when facing the target area. Center the booth on the rear of the firing platform for ranges with more that 14 firing points.

b) The elevation of the control booth should be high enough to permit the range control officer an unrestricted view of the firing line, target, and impact area. The control booth should not be enclosed unless an unrestricted view can be provided.

c) Do not position the forward edge of the booth closer than 3 meters to the firing line.

d) Provide a worktable or counter where reference materials may be placed. Provide at least one electrical outlet in the worktable area and lighting for night/limited visibility operations.

5.2.4.3. Range Communication Systems. The range communications system must include communications between the control tower (or control booth) and the range support buildings. A public address system is required. There should be a communication capability between individual ranges on a multiple range complex. If it is not practical to install landlines, or if a break-in landline service occurs, radio or cellular communications may be used.

5.2.4.4. Barriers, Fences, and Signs. The range areas will be secured for safety reasons by preventing unauthorized people, animals, and vehicles from entering the range and the danger zones. Use barriers to block roads, walkways, or paths. The intent is to keep people out of the surface danger area.

a) Indoor ranges seldom require barriers. Baffled and side-berm ranges usually require only barriers for the access road coming into the range area.

b) Outdoor ranges that use a backstop and no baffles or that have an impact area in place of a backstop may require a number of barriers and signs to make the range safe.

c) Use fencing to prevent vehicles and people from entering the impact area. Block paths with gates. Attach a reflective sign to the barrier to warn people of the danger within. The number of barriers required depends on the number of roads, walkways and paths that lead into the danger zone.

d) Ranges or range complexes may require fences to prevent people, animals and vehicles from entering the danger zone of the ranges. A chain link fence around the complete range complex, including the SDZ, is desired. On baffled ranges

with earth side berms and earth/metal backstop, as a minimum, install a 2-meter chain link fence around the sides and down range side of the impact area incorporating the berms. Locate the fence no closer than 5 meters to the berms and backstop. For baffled ranges with concrete containment walls and an earth/metal backstop, as a minimum, install the fence from one wall around the backstop and closing on the opposite wall. Provide an access gate for maintenance equipment.

e) Typical range signs are shown in Figure 7. The signs, and flashing red lights for night operations, should be provided on the approaches to the range and the perimeter of the SDZ, if access is not otherwise restricted. Red flags and/or rotating, flashing red lights shall be provided at appropriate locations to signal when the range is in use. Place signs along the normal boundaries of the range. Post the signs no further than 150 meters apart along range perimeters parallel to the roads or paths. Based on local topography, place signs close enough to give reasonable warning along other areas of the SDZ. Signs will be bilingual where English is not the national language, or multilingual where needed. Post bilingual signs on CONUS ranges located near foreign borders. Consult the base legal office on local policy to determine these requirements.

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

5.2.4.5. Utilities. Install utilities so they will not be damaged from normal firing. Do not place any above ground utilities in the impact zone or the ricochet zone. When utilities are placed directly behind backstops or berms, provide access room for a maintenance vehicle. Under-ground utilities with proper cover may be placed anywhere on the range complex provided maintenance and repair easements are provided.

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

b) Electrical Power. Electricity is required to light offices, operate power equipment for maintenance, and provide power to public address systems and target-turning mechanisms.

5.2.4.6. Heat and Air Conditioning. Heat and air conditioning with positive ventilation is required for all indoor ranges. Some outdoor ranges will require radiant heat or a heated air curtain on the firing line depending upon geographic location.

5.2.4.7. Roads and Parking. Passenger vehicles and light or medium trucks generally use range-access roads. Surfaced all weather roads should be provided for connector roads from public roads to range the range complex.

a) Locate range access roads so vehicles approach and park at the rear of the firing line. The range access road will approach the range complex from behind the firing line but not within the cone formed by a line drawn from the line of fire at an angle downrange of more than 40 degrees. Locate parking areas at least 15m

to the rear of the firing platform. Normally, one parking space per firing point plus an allowance for range personnel is sufficient.

b) On indoor and baffled ranges using side berms or walls, the parking area may be on either or both sides of the range but not within the SDZ. Ranges with heavy training loads occasionally require two spaces per firing point. When feasible, surface parking lots for all-weather operation.

5.3. The Baffle Range, Design and Construction Criteria. The information included herein is applicable to indoor or outdoor construction. The criteria herein are supplemental to criteria of previous paragraphs. An outdoor baffle range is not considered to be a fully contained range. The intent of using baffles is to stop errant direct-fired rounds. Baffles are not placed with the intent to collect ricochet or to cause or direct a ricochet.

5.3.1. Intent. Baffles will be designed and maintained so they stop direct-fired bullets. Baffles may be constructed as earth berms, earth backstops, concrete walls, or laminated materials. A ricochet can occur and ricochet bullets may still fall outside the range even with a bullet deflector or catch at the impact zone of the backstop.

5.3.2. Baffle Types.

5.3.2.1. Canopy Baffles. A canopy baffle is an angled or horizontal baffle attached directly over the firing platform. The canopy extends downrange from the firing line and is intended to prevent bullets from escaping the range at locations between the first overhead baffle and the canopy. The baffle must prevent direct-fired rounds from exiting the range. The bottom of the canopy baffle must be at least 225 mm above the level of the firing line. The canopy will begin at least 1 meter behind the firing line and extend forward of the firing line a minimum distance of 4 meters. The actual forward extension will be determined based upon the position of the first downrange overhead baffle. The canopy extension must not permit line of sight daylight between the extension and the first overhead baffle. A canopy baffle may be used to provide a covered firing line position. The incorporation of a canopy baffle on an outdoor range does not dictate the need for overhead baffles or side containment.

5.3.2.2. Overhead Baffles. Overhead baffles are angled or vertical baffles installed downrange and are intended to capture direct-fired rounds. Overhead baffles must extend beyond the firing platform and must not permit line of sight daylight when sighting downrange from 80 degrees to the right to 80 degrees to the left from any firing position at either the standing or the prone heights. The bottom of overhead baffles must be at least 225 cm above the level of the firing line. Downrange overhead baffles mounted at an angle must have the bottom edge further downrange than the top. Overhead baffles are installed parallel to the firing line. Reference Figure 8 for a typical configuration.

a) The first downrange baffle is positioned so that a line drawn from the firing line, at the firing platform elevation, under and touching the bottom downrange edge of the canopy baffle intersects the first downrange baffle 100mm from the top of the overhead baffle.

b) To position the next downrange baffle, line of sight is taken from the firing line across the bottom of each overhead baffle to a point 100mm below the top of the succeeding baffle. The line drawn under the last downrange baffle must intersect the backstop no less than 2 meters from the top. When there is a deflector plate

mechanism the line drawn below the last overhead baffle must fall at least 600mm below the front edge of the deflector plate.

5.3.2.3. Wing Walls. Wing walls (side baffles) are similar to overhead baffles except that they are mounted outside the line of fire for the length of the line of fire. Wing walls provide an advantage over continuous walls where cross range ventilation is required. Wing walls are not used with continuous sidewalls. The distance from the nearest edge of a wing wall and the line of fire should not be less than 2 meters. Wing walls are discontinuous side protection set at 45^{o} to the line of fire. Wing walls are located so that the inside edge of a wing wall will overlap a successive wall by 1500mm based on any line of fire from the firing line that may strike the wall. Construct wing walls using the same materials that are required for overhead baffles.

5.3.2.4. Ground Baffles. Ground baffles are **not** permitted on Air Force ranges.

5.3.2.5. Vertical Element Protective Construction. Vertical construction within the range will be protected with baffles. Baffles should be mounted on the vertical elements at an angle of 45 degrees to the line of fire.

5.3.3. Baffle Materials and Construction. Canopy and overhead baffles shall be constructed of the materials specified in Table 2. The specified materials can also be used for protective construction. When acoustic reduction materials are being used they will be installed over the specified materials.

Weapons	Ammunition	Construction*
Handguns	22 LR, Cal. 38, Cal. 45	4 layers of 19mm OSB or particleboard backed with one layer of 9.5mm exterior grade plywood
Handguns	Cal. 357, 9mm, Cal. 44,	6.35mm steel plate with a 440 BHN set at 90, 42, or 30 degrees covered with one sheet of 19mm and one sheet of 11mm plywood
Rifle, Carbine, Machine gun	5.56 mm, 7.62mm, Cal. 30	9.5mm steel plate with a 500+ BHN set at 90, 42, or 30 degrees covered with one sheet of 19mm and one sheet of 11mm plywood

*Note: When steel plate is used the plywood is installed facing the firing line. The 19mm sheathing is attached to the steel using flat head countersunk screws. The 11mm plywood is attached to the 19mm sheathing using #8 flathead screws at 300mm spacing.

Table 2 – Construction Materials for Canopy and Overhead Baffles

5.3.4. Side Containment Design and Construction. Sidewalls (earth berms or continuous walls) shall have a finish elevation that is above the top edge of the highest overhead baffles. The height and placement will be such that sidewalls are high enough to preclude direct fire from exiting the range. Side containment will extend at least one (1) meter to the rear of the firing line. Locate the nearest element of the side containment construction at least two (2) meters from the outside firing position limits of fire. Construction of side containment may be of earth, masonry block, or reinforced concrete.

5.3.4.1. Earth (Outdoor Ranges Only). Construct to a side slope not to exceed 2 vertical to 3 horizontal unless stabilization is used. If native soil characteristics will not produce a stable slope at this angle, provide fabric reinforcement in the fill. Clay, or soils with more than 40% clay size particles, will not be used for the outside surface of the earth berm. Clay may be used for the core of the berm. Typical angles of repose for natural soils in loose or least dense state are given in Table 3. Table 3 should be used as a guide only

since mechanical stabilization may increase the angle of repose. The top width of an earth-berm shall be 3 meters, minimum. Soil side slopes of earth-berms for a minimum depth of one (1) meter shall be sands, silty sands, or clayey sands with a maximum particle size not exceeding 9mm. A vegetative cover for erosion control will be placed on the faces and tops of earth-berms. Access locations for maintenance vehicles will be provided on earth-berm construction. Irrigation devices may be placed on the faces and the tops of berms that are not subject to direct fire.

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

Table 3 - Natural Angle of Repose (Internal Friction) for Naturally Occurring Soil

5.3.4.2. Continuous Walls. Vertical smooth faced walls constructed of lightly reinforced concrete or grout filled lightly reinforced masonry block (CMU) may be used for sidewalls. The minimum wall thickness is specified in Table 4. The walls will be designed for all dead and live loads including lateral. When continuous walls are used, protective construction will be provided at the firing platform. The protective construction will be 19mm plywood with a 19mm air gap. The air gap should be filled with commercially available reprocessed rubber products. Any acoustic materials should be applied on the outside surface of the plywood. The protective construction will extend downrange and to the rear of the firing line to match the canopy baffle extensions.

Material/Caliber	.45/9mm	5.56mm	7.62mm	.50
3600psi Concrete	150mm	150mm	200mm	300mm
Grout-filled CMU	200mm	300mm	300mm	600mm

Table 4 – Minimum Sidewall Thickness

5.3.4.3. End Walls. May be constructed at the firing line edge in lieu of the side containment extending behind the firing line. The walls will be long enough to close off line of sight between the side containment and one (1) meter to the rear of the firing line. The end wall must have protective construction cladding extending from the canopy baffle to the firing line platform.

5.3.5. Backstop Design and Construction. A backstop is used behind the target line. It must stop a direct fire bullet by media capture or deflect the bullet to an angle greater than 45 degrees from the line of fire and into a trap. The criteria for a metal backstop is applicable to either indoor or outdoor baffled ranges.

5.3.5.1. Earth (Outdoor Ranges Only). Earth backstops are the most common type, see Figure 8. The backstop must be located so that the centerline of the berm is at least 50 meters distance from the firing line. The toe of the slope must be located at least 9

meters 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 below the top of the backstop. The impact face of the earth backstop must be soil (100% passing the 9mm. sieve size) for a depth of 2 meters. The slopes of the earth backstop should be stabilized with grass vegetation and access locations provided for maintenance and repair. Incorporate a steel deflector plate into the backstop if a higher degree of confidence is required for the prevention of direct fired rounds from leaving the impact area of the backstop. Soil with more than 40% clay size particles is not acceptable for use in the impact area face of the backstop.

5.3.5.2. Metal Backstops. Metal backstops should be used only for indoor ranges. They can be used on outdoor ranges when corrosion protection is incorporated into the construction. Painting is not considered as a form of corrosion protection. **CAUTION: On ranges that incorporate metal backstops do not use steel, steel penetrating, armor-piercing, or incendiary munitions. Do not fire ammunition with a bullet weight greater than 500 grains or ammunition with a muzzle velocity greater that 980 meters per second. If commercially designed range materials are used, ensure products exceed standards for 5.56mm and 7.62mm ball ammunition.**

5.3.5.3. Materials for Backstops (Deflector Plates and Traps).

a) Materials **Not** Used. Steel or carbon steel plate conforming to ASTM A36, Standard Specification for Structural Steel does not have adequate pitting resistance and deteriorates rapidly when used on small arms ranges. Steel that conforms to the designation ASTM A36 will not be used on small arms ranges. For similar reasons, steel that conforms to designations ASTM A242/A242M, Standard Specification for High Strength Low Alloy Structural Steel, or A572/A572M, Standard Specification for High Strength Low-Alloy Columbium Vanadium Structural Steel should not be used.

b) Materials that should be **used**. The design/specification shall reference the applicable ASTM designation or MIL reference number, the grade of steel required, and the hardness. To ensure that the correct grade of steel is procured and installed insist on a certificate of compliance. All steel plate looks the same.

- 'Armor plate" steel. ARMOR 46, normally used by commercial manufacturers (refer to MIL-A-12560, Armor Plate, Steel, Wrought, Homogeneous (For Use in Combat Vehicles and for Ammunition Testing)), that has been heat-treated.
- Steel that conforms to ASTM A514/A514M, Specification for High Yield Strength, Quenched and Tempered Alloy Steel Plate, Suitable for Welding. This is probably the best for use with Cal. 22 rim-fire ammunition (not magnums). The surface hardness will vary from 235 to 293 BHN.
- Steel with trade names such as Joalloy AR-320 (Jones and Laughlin Steel Co.), X-A-R-15 (LTV), T-1 type 321 (USX), SS-321 (ARMCO), or RQ-321A (Bethlehem Steel) should be used where center fire pistol ammunition will be used. The steel should be abrasion resistant and have a BHN 320, 360, or 400.

5.3.5.4. Construction Minimums for Deflector Plates. Suspend the backstop deflector plate at an angle of either 30 degrees or 42 degrees from horizontal for the most effective

angle of deflection. The highest edge of the deflector plate is set nearest the firing line. The shallow angle deflects bullets with greater ease and there is less metal fatigue and denting in the surface of the plate. Steel plates supported by concrete or masonry should be anchored using expansion bolts or toggle bolts with flush countersunk heads. Steel plates shall have milled edges at all joints. Joints shall be butted flush and smooth. Plates shall be free from buckle or wave. Exposed edges shall be chamfered to a 45-degree angle to a fillet approximately 4mm wide. There shall be no horizontal joints in any steel plate work. There will be no exposed vertical supporting structures. Welding shall be according to the American Welding Society Code for Welding in Building Construction. Position steel plates so welds are no closer than 450mm to the center of a target position. Any steel plate jointed at and supported on structural steel supports will be spot welded.

5.3.5.5. Steel Plate Thickness for Backstops, Deflector Plates, and Traps. A 6mm steel plate treated to 440BHN when set at an angle of 42 degrees is sufficient for all handgun cartridges not including Cal. 44 Magnum. A 10mm steel plate treated to 500+ BHN when set at 30 degrees will accommodate Cal. 30 (30-06), 7.62mm, and 5.56mm ball, and all handgun ammunition. Reference to Table 5.

Angle	Ammunition	Armor Plate	440 BHN	500+ BHN
42	22 LR Rimfire	6mm	6mm	6mm
42	Cal. 38 Ball	10mm	6mm	6mm
42	Cal. 45/ Cal. 357	10mm	6mm	6mm
42	9mm Pistol	10mm	6mm	6mm
42	Cal. 44 Magnum	12mm	10mm	10mm
30	5.56mm, 7.62mm	12mm	NR	10mm
30	Cal. 30 Carbine	12mm	NR	10mm

Table 5 - Minimum Steel Plate Thickness for Metal Backstops

5.3.5.6. Bullet Traps. The bullet trap must cover the entire area under the backstop deflector plate. The trap must be mined of accumulated deposits of bullets and fragments on a regular basis. Lead removal must be done only after consulting with bio-environmental personnel and only when using personnel protection. The space directly behind the bullet trap must be accessible for maintenance and repair of the backstop.

a) Sand Traps. Use dry sand to absorb the bullets deflected downward from the deflector plate and backstop. Make the sand trap the same size as the deflector plate and locate it directly under the plate. The trap is filled with fine sand that is free of rocks and debris. The maximum particle size will be less than the #40 ASTM Standard Sieve size. The sand must be at least 200mm deep. **CAUTION: Do not use silica sand. Silica is a crystalline compound that can be in the form of sand. When used as sand, silica may become solid and cause ricochets and/or silica dust may be generated.**

b) Water Traps. A water trap must be 300mm deep. This trap is considered an alternative design. A water tap requires a water supply, a drain, a circulation pump, and a filtration system. Cleaning a water trap is easier than mining a sand trap, and it creates no dust, thereby reducing health hazards. Depending on

national, state, and local environmental regulations, a water trap may require a disinfectant system in the water trap circulation system.

5.4. Outdoor Ranges.

5.4.1. Drainage. Designs must include provisions for proper drainage. Poor drainage may cause baffle bases, targets, sign emplacements, and roads to deteriorate or shift position. On outdoor ranges, where feasible, slope the range floor so the range drains from the firing platform towards the backstop. However, terrain features may make it desirable to provide drainage towards and to the sides of the firing platform. Use dirt to fill any low spots that develop. Make sure the ditches and other drainage facilities are large enough to carry normal runoff. If smooth concrete is used to surface an outdoor range, provide for proper drainage.

5.4.2. Lead Hazards Management. Lead is a hazardous heavy metal that could adversely affect humans when finely divided dust is taken into the body or lead particulate is transported into a drinking water supply. The local bio-environmental office should be asked about other considerations that would be based upon local laws and or environmental regulations. The minimum procedures to keep lead on the range are set forth following.

5.4.2.1. Soil Amendments. Soils within the impact areas should be tested for pH levels every 2 years by Base Civil Engineering environmental management. The desired pH level is in the basic range of 7 to 8. When soil additives are used to adjust soil pH there should be sufficient testing and research to assure that the chemical additives will not cause cementing or hardening of the soil surface. Lime will not be used as an additive or soil conditioner when the natural soil gradation includes more than 30% passing the 200 ASTM Standard Sieve and/or the natural Plasticity Index is higher than 12.

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

5.4.2.3. Engineering Controls. Design storm water control structures to preclude storm water from contributing to the erosion of impact berms. A drainage structure should be located on top of berms that precludes storm water accumulation from running down the sloped face of earth berms. Divert surface water runoff within the range (including the SDZ) to a vegetated detention or retention basin.

5.4.2.4. Contaminant Monitoring. The monitoring program is intended to provide early indications of lead movement. Sample the surface soil, surface water, and the ground water for soluble lead, dissolved lead, total lead, and nitrates. The sampling cycle should be based on the frequency of the range usage and site hydrological conditions.

5.4.2.5. Reclamation and Recycling. Remove lead from the impact face of earth berm backstops when there is evidence of lead mass build up. Personnel certified in lead reclamation operations can sift the lead from the soil by screening on the site. Collected lead must e disposed of in accordance with local laws and regulations. Consult base Civil Engineering Environmental Management, Bio-environmental Management, and the Defense Reutilization Management Office (DRMO) prior to initiating any reclamation and recycling operation.

5.4.3. Range Lighting. Provide downrange lighting for safety and cleanup purposes as well as general range illumination. Light intensity at the target face should be 85 to 100 foot-candles measured 120cm above the range surface at the target face. Controls should be provided so the variance of the lighting intensity may be changed to satisfy subdued light training requirements.

5.5. Ranges with Sidewalls and Baffles, Fully Contained, and Indoor Ranges. It is recommended that the criteria contained in the Navy Environmental Health Center TM-6290.99-10 be reviewed and when necessary coordinated with the local safety and environmental health officials prior to starting a design for ranges that require ventilation systems. Noise reduction construction should also be incorporated.

5.5.1. Housekeeping and Floor Surfaces. The desired covering for indoor range floors is smooth concrete protected with a waterproof sealant. Floor drains should be provided to allow for frequent flushing and capture of water to eliminate lead contamination and unburned powder build-up. Soil floors in indoor ranges are discouraged because they accumulate powder and lead debris and are impossible to maintain.

5.5.2. Openings. There will not be any doors or windows forward of the firing line. Openings for heating, ventilation, and air conditioning (HVAC) must be located behind baffles. When an existing building is converted, all such openings must be brick or masonry filled. In new buildings, all pipes and conduits will be concealed in the walls, behind ceiling, under floors, or behind protective baffles. Exposed pipes in converted buildings must be relocated or protective construction provided. In some situations fire doors may be required downrange. When fire doors are required, they must be equipped with hardware to allow opening only from the range side and those doors will be protected with baffles.

5.5.3. Ventilation. A ventilation system will be designed and constructed that will assure control of exposure to lead to meet requirements of 29CFR 1910.1025. The supply and exhaust air system is critical to the operation of an indoor range and the health of building inhabitants. A positive exhaust system for the removal of airborne lead must be provided. A slight negative air pressure should be maintained on the range. This can be accomplished by exhausting three to seven percent more air than is supplied.

5.5.3.1. Airflow. The airflow across the firing line (toward the target line) should be about 25 meters/minute (mpm). The minimum acceptable airflow across the firing line is 15 mpm. At a point approximately halfway between the firing line and the bullet trap, the airflow should be maintained between 1 and 10 mpm.

5.5.3.2. Air Distribution. A perforated rear wall or plenum will be constructed that provides uniform laminar air distribution across the firing line and continuing downrange to sweep contaminants away from the firing line. A minimum distance of 5 meters from the firing line to the perforated rear wall or plenum should be provided. Additional supply air, directed toward the target, is to be provided at the firing line between shooting positions.

5.5.3.3. Exhaust Openings. Exhaust openings are not permitted near the firing line. The exhaust openings will generally be located in the vicinity of the apex of the bullet trap.

5.5.3.4. Cross-Contamination. The exhaust discharge from the range must be separated from the supply air intake to prevent cross-contamination of lead fumes unless the

exhaust air is filtered prior to discharge. If range is a part of a larger building, exhaust air discharge will not be located where cross contamination of general building air can occur.

5.5.3.5. Filtration to Remove Airborne Lead. Filtration of exhaust air to the outside will be designed in accordance with OSHA and local regulatory requirements. Re-circulation of range air is permitted only if it is properly filtered for airborne range contaminants and includes dirty filter indication. HEPA filters may be used.

5.5.3.6. Lead Dust at Ranges Without Ventilation. A clean, hazard free, air environment is an essential design requirement for an indoor shooting range. Lead is a toxicant, which will cause lead poisoning in humans exposed to excessive amounts over a period of time. OSHA has established limits of exposure to lead dust at 50 micrograms/cu m/hr average for an 8 hour day (total daily exposure may not exceed 400 micrograms). The use of special training ammunition may be considered to reduce the cost of rehabilitation of an existing ventilation system. Use of special ammunition must be approved at the respective MAJCOM and provided that all users of the range will use the approved type of ammunition. An existing indoor range with a lead dust level in excess of normal exposure limits may be operated following the restricted criteria found in Table 6.

Table 6

Maximum Allowable Exposure Limits for Intermittent Atmospheric Lead

Airborne Lead Contamination (micrograms/cu m)			Maximum Hours of Allowable Exposure			
			Firing 30 or more days/year		Firing Less than 30 days/year	
			Hours/Week	Hours/Day	Hours/Week	Hours/Day
0.00	-	0.03	40	8	40	8
0.03	-	0.05	24	8	32	8
0.05	-	0.10	12	6	18	6
0.10	-	0.15	8	4	12	4
0.15	-	0.20	6	3	9	3
0.20	-	0.25	4.5	2.5	7.5	2.5
0.25	-	0.30	4	2	6	2
0.30	-	0.40	3	2.5	4.5	1.5
0.40	-	0.50	2.5	1	3	1
0.50	-	0.70	1.5	0.5	1.5	0.5
0.70	-	1.00	1	0.5	1	0.5
1.00	-	2.00	0.25	0.25	0.5	0.25
2.00	-	4.00	0.25	0.25	0.25	0.25
4.00			0	0	0	0

5.5.4. Sound Reflection Reduction. Noise reduction in the range and noise transmission out of the range is two different design considerations. Mass and limpness are two desirable attributes for a sound transmission barrier. Heavy masonry walls provide mass. Absorptive acoustical surfacing will reduce the noise level in the range but will have little effect on the transmission outside the range. Blown on acoustical material is not permitted. Conventional acoustical treatment should be used on surfaces behind

the firing line. Do not paint downrange block walls or acoustic tile; this significantly degrades the sound absorbing qualities of the materials. Existing ranges may continue use of painted surfaces. Wall treatments should be installed in panels not larger than 120cm wide panels to facilitate replacement. Floor areas behind the firing line may be covered with acoustic material provided it will withstand the process selected for lead dust removal. Carpet is not to be used for floor or wall surfaces.

5.6. Range Support Facilities. A weapons training range requires several facilities to support its operation. The support facilities include the Combat Arms Training and Maintenance (CATM) building (Cat Code 171-476), a building for the storage of range supplies and equipment (Cat Code 171-472), and a building for target storage and repair (Cat Code 171-473).

5.6.1. Combat Arms Building. This building provides humidity and temperature controlled environments and is used to shelter activities of the Combat Arms group. Space is provided in the building for classrooms, administration functions, weapons maintenance, space for the cleaning and degreasing of weapons, an alarmed weapons and munitions storage room, sanitary facilities, and miscellaneous activities. The Combat Arms building is a separate structure from the range. A typical floor plan is Figure 9. A facility supporting a small arms range system of more than 21 firing points requires proportionately larger facilities than provided below. Likewise, one supporting more than one range system or type of range requires a larger weapons and ammunition storage space.

5.6.1.1. Classrooms. The function is a demonstration/performance classroom. It must contain sufficient space to provide each student attending handgun, rifle, shotgun, or submachine gun training a chair and a table work surface of at least 600 x 900 mm. Provide space for each student receiving machine gun, mortar, or recoilless rifle training a work surface of at least 900 x 1200 mm. The classroom will include a raised instructor's platform, aisle space for instructor access to individual tables, and provisions for connecting video cassette equipment, 16mm movie projections, slide tape presentations, and overhead projection.

5.6.1.2. Administrative Space. The administrative space is used for program administrators and combat arms personnel. The administrative office requires about 13 m^2 net area for the CATM Superintendent or NCOIC and an office for the instructors.

5.6.1.3. Weapons Maintenance Shop. There must be space for workbenches, handtools, power tools, equipment, and spare parts storage. An average base will support between 4,000 to 5,000 weapons and will requires about 28 m^2; a base that supports over 5,000 weapons will require 37 m^2. Provide a lavatory with potable water in the immediate area.

5.6.1.4. Weapons Cleaning/Degreasing Room. The room accommodates workbenches, degreasing tanks, and spray hoods. There will be at least two workers when the room is being used. Special design requirements include forced ventilation, vapor-proof electrical fixtures, compressed air service, and solvent resistant wall and ceiling finishes. The space requirement is typically about 12 m^2. A lavatory with potable water should be in the immediate area. The base safety office and bio-environmental engineering may have further design requirements.

5.6.1.5. Alarmed Weapons and Ammunition Storage. The vault provides secure storage for all weapons for which the Combat Arms section is responsible and a 30-day supply of

each type of ammunition used on the range. A gross floor area of 14 m^2 is usually adequate. Room construction must satisfy the requirements of AFI 31-209, *The Air Force Resource Protection Program*, and AFMAN 32-1071, *Security Engineering*, for construction materials and specifications. The facility must be located to comply with explosive safety standards. Storage of explosives must comply with AFMAN 91-210.
5.6.1.6. Latrines (Sanitary Facilities). Provide facilities for both men and women. The size of each depends upon the class size at that particular installation. Usually, the women's latrine need only accommodate about one-fourth the number of people as the men's latrine.
5.6.1.7. Miscellaneous Storage. A room for the storage of administrative supplies, training aids, tools, and other miscellaneous items is required. The size of this area is directly related to the type and quantity of training the Combat Arms section performs.
5.6.1.8. Student Weapons Cleaning Area/Room. Students must clean their weapons after completion of firing. This area may be outside, if it is a covered, or in cold climates, a room large enough to accommodate cleaning tables/benches and cleaning materials. When it is enclosed the room must be well ventilated.
5.6.2. Range Supplies and Equipment Storage. This facility provides space for secure storage for miscellaneous range supplies, tools, and equipment used at combat ranges. Prefabricated metal, concrete or wooden buildings are used to store range supplies and equipment. Depending on location, type, and value of items stored consideration should be given to combining this facility with the target storage and repair building.
5.6.3. Range Target Storage and Repair Building.
This facility provides space for the secure storage and repair of targets. Items stored include target mechanisms, targets, and target construction and repair material. Repair space contains tables and workbenches. An electrical power source for operating power tools is required. Prefabricated metal, concrete or wooden buildings are used. Special weapons ranges for the M-60 machine gun, 40mm grenade launchers, shot guns or other special weapons require separate storage/repair facilities.

5.7. Criteria and SDZ for Specialty Weapons. Special weapons or facilities include the 40 mm Grenade Launcher, Light Antitank Weapon, 81mm Mortar, and 10 meter Machine Gun Range.
5.7.1. 40mm Grenade Launcher. (See Figure 3). The range permits firing of 40mm low velocity grenades fired from M79, M203, and XM148 grenade launchers. The entire surface of the impact area should be cleared of vegetation or clipped extremely close during mowing operations so the grenades will readily detonate on impact and so explosive ordnance disposal personnel can easily locate dud high explosive rounds for disposal. Construct targets in the target area using lumber, steel, or concrete. Terrain features, course of fire, and weather conditions will determine if a spotting tower is required for observation of the impact area. Observation is needed 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 visual observation of the entire range may be needed.
5.7.2. Light Antitank Weapons. (See Figure 4). The range is setup for firing of the M72 66mm rocket, the M73 35mm subcaliber training device, and the AT-4. The danger

zone to the rear of the launcher must be clear of personnel, material, and vegetation. Layout firing points so individual back blast areas do not overlap.

5.7.3. 81mm Mortar. This range permits firing of the 81mm mortar. Range design criteria will be set by AFSFC on a case by case basis.

5.7.4. Ten (10) meter Machine Gun Range.

5.7.4.1. M60 Machine Gun Tubes. Ten-meter machine gun range tubes must measure 6 feet inside diameter by 24 feet in length. They are to be reinforced concrete and must meet ASTM C76, Class III RCP requirements. For drainage, slope the tubes approximately 150mm toward the target line. Firing positions will be at least 4 m apart-measured center to center. The end of the tube toward the shooter should touch the firing line. When firing is conducted, the muzzle of the machine gun must be inside the tube. (See Figures 5 and 6).

5.7.4.2. Firing Platform. Ensure that the firing tube placement and the firing platform height are such that the muzzle of the machine gun is at the approximate center of the tube diameter. A recess in the platform of about 75mm deep and large enough to accept a tripod may be needed.

5.7.4.3. Backstop. Locate the backstop at least 50 meters from the firing line to the centerline of the backstop. The minimum height of the backstop is established by determining where a line, drawn from the firing line to the backstop, and intersecting the highest point the bullet could exit the target end of the tube, intersects the backstop. This line must intersect the backstop not less than 2 meters from the top. When a deflector plate is used the line will intersect the deflector plate and at least 600 mm below the front edge of the catch.

5.8. Construction Certifications, Test Firing and Trial Operation

5.8.1. Prior to 100% Design Approval. The design agent will submit a set of drawings and project specifications to the respective MAJCOM representative of the Combat Arms (CA) and Civil Engineer (CE). The MAJCOM is encouraged to use the Range Design Criteria Review Checklist to validate that the proposed project meets the minimum requirements for design as given in this document. The MAJCOM Civil Engineer must forward the drawings and specifications with completed checklist to HQ AFCESA/CESC and HQ AFSFC/SFW.

5.8.2. Subsequent to Construction. The Base Civil Engineer will validate that the proper materials have been used and that the construction satisfies the intent of the specifications and drawings. The range and range support facilities, when completed, must meet the requirements of this document and the approved contract documents. 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 baffled ranges, visually check both overhead and ground baffles to make sure they overlap so that a shooter from any firing position can not see "daylight." Overhead baffles must not permit line of sight daylight when looking downrange from any shooting position on any firing point between 80 degrees to the right and 80 degrees to the left.

5.8.3. Test Fire Requirements. After construction, or rehabilitation, and before operation for training and qualification, a controlled test-fire will be accomplished. The Combat Arms people will perform the test-fire. Representatives of ground safety and

civil engineering will act as observers. The most experienced shooter available will use the most powerful ammunition authorized for use on the range for the test. Make sure all fire hazards are removed from the range and areas surrounding the range. Make sure firefighting equipment is immediately available when conducting range tests using tracer ammunition.

5.8.3.1. Impact Ranges. A test-fire is not required for an impact range. After the specification check is completed, proceed to trial operations.

5.8.3.2. Baffled Ranges. The shooter will first fire into the baffles to determine if they will contain direct-fired rounds. Next, from the prone position, fire into the backstop at the highest point possible. A test screen (witness) may be used to test ricochet potential of the range floor. A test screen is constructed by building a 120cm x 120cm, four-sided cube from Celotex or cardboard material. Place the test screen at different areas on the range floor and fire into the range floor in front of the test screen at various angles from the firing line. To determine if ricochets would have left the range, sight along a small diameter dowel placed through ricochet holes in the screen material. If the angle of departure is less than 45 degrees and the sighting verifies that the bullet left the range, corrective measures must be taken. Conduct tracer tests using the same caliber of ammunition to be used on the range to determine patterns of ricochets. The use of tracer ammunition is the fastest and most efficient method of determining ricochet patterns and hazard potential.

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

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

6. Point of Contact. Mr. Jim Lafrenz, P.E., HQ AFCESA/CESC, DSN 523-6332, Commercial (850) 283-6332.

7. Appendices.

Appendix A - Figures for Small Arms Ranges
Appendix B - Small Arms Range Design and Construction Checklist

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