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MILITARY HANDBOOK

RANGE FACILITIES AND MISCELLANEOUS TRAINING FACILITIES OTHER THAN BUILDINGS

AMSC N/A

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ABSTRACT

This handbook presents the design criteria for training facilities other than buildings, and is intended for use by design engineers for design of new facilities and major rehabilitation of existing ranges. Range facilities are for use in training personnel in weapons firing. Weapons include small arms, aircraft, and ground weapons systems used by Navy and Marine Corps. Criteria for support facilities, parade and drill fields, end training course structures are presented.

FOREWORD

This handbook has been developed from an evaluation of facilities in the shore establishment, from surveys *of* the availability of new materials end construction methods, end from selection *of* the best design practices of the Naval Facilities Engineering Command (NAVFACENGCOM), other Government agencies, and the private sector. This handbook was prepared using, to the maximum extent feasible, national professional society, association, and institute standards. Deviations from this criteria, in the planning, engineering, design, and construction *of* Naval shore facilities, cannot be made without prior approval of NAVFACENGCOM HQ Code 04.

Design cannot remain static any more than can the functions it serves or the technologies it uses. Accordingly, recommendations for improvement are encouraged and should be furnished to Commanding Officer, Southern Division, Naval Facilities Engineering Command, Code 04A3, P.O. Box 10068, Charleston, SC 29411-0068; telephone (803) 743-0458.

THIS HANDBOOK SHALL NOT BE USED AS A REFERENCE DOCUMENT FOR PROCUREMENT OF FACILITIES CONSTRUCTION. IT IS TO BE USED IN THE PURCHASE OF FACILITIES ENGINEERING STUDIES AND DESIGN (FINAL PLANS, SPECIFICATIONS, AND COST ESTIMATES). DO NOT REFERENCE IT IN MILITARY OR FEDERAL SPECIFICATIONS OR OTHER PROCUREMENT DOCUMENTS.

TRAINING FACILITY CRITERIA MANUALS

CRITERIA MANUAL	TITLE	PREPARING ACTIVITY
MIL-HDBK-1027/1	Fire Fighting School Facilities	LANTDIV
MIL-HDBK-1027/2	Training Facilities, Buildings (proposed)	SOUTHDIV
MIL-HDBK-1027/3A	Range Facilities and Miscellaneous Training Facilities, Other than Buildings	SOUTHDIV
MIL-HDBK-1027/4	Aviation Training Facilities (proposed)	SOUTHDIV

NOTICE OF
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MIL-HDBK-1027/3B
NOTICE 1
30 June 1995

MILITARY HANDBOOK

RANGE FACILITIES AND MISCELLANEOUS TRAINING FACILITIES
OTHER THAN BUILDINGS

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RANGE FACILITIES AND MISCELLANEOUS TRAINING FACILITIES, OTHER THAN BUILDINGS

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Section 1: DESIGN CRITERIA

1.1 Scope. This handbook provides guidance for design of small arms ranger, aircraft and gunnery ranges, range towers, parade and drill fields, training course structures, and support facilities. "Range" is used throughout the handbook to identify areas for weapons firing for personnel training (not ordnance test ranges).

1.2 Cancellation. This handbook cancels and supersedes MIL-HDBK-1027/3A, Range Facilities and Miscellaneous Training Facilities Other than Buildings, of 31 January 1989, and Notice 1, of 31 December 1989.

Section 2: SMALL ARMS RANGES

2.1 Indoor Small Arms Weapons Ranges

2.1.1 Planning Factors. Ranges and other facilities designed and constructed using previously published criteria need not necessarily meet the requirements of this handbook. When rehabilitation is accomplished, criteria in this handbook shall be applied. When full compliance cannot be accomplished, an operational plan can often be developed that will offset the non-compliance condition. Any such operational plan will be developed by the user and submitted to the Chief of Naval Operations (CNO) for approval.

2.1.1.1 Design Objectives. Small arms are defined as handguns, riotguns (12 gauge shotguns), rifles up to 7.62 mm, and machine guns to 50 cal. Although the basic training element is the outdoor range, severe weather or safety limitations in the locale may make an outdoor range unusable. The mission of the activity may dictate that an indoor range be provided. The range design must promote safe, efficient operation and yet be affordable to construct and maintain. Where the safety of personnel is in question, the designer shall take into account the safety value of range administrative controls to mitigate the need for overly stringent design parameter8 and thereby keep the project within budgetary limits. When considering size and selecting materiels, consider that a small arms range should be capable of providing training for all appropriate military weapons assigned to Host and Tenant commends. The indoor range could be an existing building, a new range in a separate building, or a new range as just one part of a larger new building.

2.1.1.2 Range Type and Size. Indoor ranges are designed for use of handguns firing both lead and ball ammunition up to and including .357 magnum, cal. 45 automatic and 9 mm. Rifle cartridges will normally be limited to lead cal. .22 rimfire. The use of any type of armor piercing ammunition shall be prohibited. Not every range will be designed for M-14 and M-16 firing service ammunition or shotgun. In locations where adequate outdoor facilities do not exist, the indoor facility may be upgraded to permit the use of 7.62 mm M-14, and 5.56 mm M-16 service rifles with ball ammunition. This requirement must, be identified during planning. The designer must secure design criteria for structural, equipment, and safety related requirements before designing a range for automatic weapons, H-14, H-16 using service ammunition, and shotgun. Capacity of ranges will be determined in accordance with NAVFAC P-80, Facility Planning Criteria for Navy and Marine Corps Shore Installations.

2.1.1.3 Local Operating Procedures. Safety of personnel and property cannot depend upon design features alone; proper operating procedures and discipline must be established and enforced at all times. Local standard operating procedures which allow a waiver of design manual criteria shall be approved by Chief of Naval Operations (CNO).

2.1.1.4 Lead and Its Effect Upon Range Users. A clean, hazard-free, air environment is an essential design requirement for an indoor shooting range. had is a toxicant which will cause lead poisoning in humans exposed to excessive amounts over a period of time. The Occupational Safety and Health Administration (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). For trainees and others who are exposed less than 240 hours per year, this total daily dosage may be absorbed at a rate of up to 200 micrograms/cu m/hr without the benefit of respiratory protection. Administrative controls should require the we of respiratory protection for full-time range personnel or limit their daily exposure to the hazard to not more than an B-hour Time Weighted Average (TWA) of 50 micrograms/cu m/hr. However, because range operation is intermittent, exposure to lead dust by shooters, instructors, and maintenance personnel is somewhat less than a full-time eight-hour day. Although design criteria could be based upon such anticipated range usage, the initial design goal for lead dust exposure is 3O-40 micrograms/cu m/hr TWA with an acceptable limit of 50 micrograms/cu m/hr TWA. Refer to Occupational Safety and Health Administration (OSHA), Department of Labor Handbook, CFR Title 29-1910.1025c.(1) and (2) and e. (1) (ii). If subsequent testing establishes that this design limit is not achievable, an adjustment of operating hours or individual exposures as shown in Table 2 should be considered. Design criteria should be based upon anticipated range usage end local operating procedures.

2.1.2 Physical Features. Indoor ranges shall be housed in a building furnished with heating, lighting, ventilating, air conditioning (if required by criteria for comfort control in the locale) and water, sewer. and electric services. Fire protection features shall be in accordance with MIL-HDBK-1008, Fire Protection for Facilities Engineering, Design and Construction. Portable water dispensers, portable toilets, or use of existing facilities will be acceptable when defined as a requirement during project planning stage. Refer to DM-3.03, Heating Ventilating, Air Conditioning and Dehumidifying Systems, for criteria pertaining to air conditioning. building material surfaces will be selected to facilitate housekeeping procedures for the removal of lead dust. As an example, a range floor should not be swept, but should be vacuumed with a vacuum cleaner designed for safe. collection of range materials, washed down, or damp mopped. Building ledges must be minimized to reduce surfaces where lead dust will collect. The floor shall slope to floor drains located approximately 20 ft (6.1 m) downrange from the firing line for range washdown purposes. Floor drain8 are desirable, but not required for existing structures or for new structures not identified during planning to have piped water. Floor drains shall be designed to minimize the possibility of ricochet. Drains must connect to the treatment/filtration system or to a "sediment trap" so as not to pollute lakes or rivers.

2.1.3 Construction Materials

2.1.3.1 Sheathing and Baffles. Wild shots that do not hit the backstop may occur on any range. It is necessary to sheath the walls, Ceiling, and possibly the floor to contain wild shots. The amount of protection is dependent on the type of building construction. A suggested sheathing material is two layers of 3/4-in. (19 mm) particleboard backed with one layer of 3/8-in. (9.5 mm) plywood when the range is intended for .22 LR cal. rimfire only. Four layers of 3/4-in. particleboard backed with one layer of 3/8-in. plywood is adequate if .45 ACP hardball is the cartridge used. All non-bulletproof walls, ceilings, and possibly floor8 downrange must be either sheathed with bullet-containing material or baffled to divert stray bullets beck into the range. Sheathing should be installed behind acoustic materiel.

Downrange projections such as pilasters or columns should be minimized, or protected with sheet metal baffles placed at 30 to the line of fire. Downrange electrical and mechanical installations such as lights, pipes, and ducts, shall be protected by sheet metal baffles which will divert a stray bullet beck into the downrange area where its energy can be expended toward or into the backstop.

Sheet metal baffles should be constructed of sheet metal covered with plywood. Wood covering tends to reduce ricochets and backsplatter. The gauge or hardness of the metal required is dependent on the caliber to be used and the angle at which the baffles are installed. Ten or twelve gauge hot rolled sheet metal is usually sufficient if the angle of fire is 30 degrees or less. Tests have shown that 10 gauge steel set at right angles to the firing line and covered with 2 in. (50.8 mm) of soft wood will stop bullets up to .45 cal. At 30 the stopping/deflecting effect would be greeter with less damage to the baffle. No metal should be placed at right angles to the line of fire without adequate wood covering.

2.1.3.2 Bulletproof Materials. Walls, floors, and roof construction must be bulletproof. Concrete masonry (gravel filled) or concrete walls, reinforced concrete floors, and flat concrete slab construction for ceilings is the preferred type of construction. Other construction materials, if used, which will not provide equivalent protection, and buildings of wood shall have protective steel plates or sandwich panels in walls, floor, and ceiling. When selecting materiels, consideration will be given to the requirements for acoustic treatment, ventilation, lighting, target carrier mechanisms, and lead dust clean up.

2.1.3.3 Ceilings. Ceilings above firing line will be covered with a protective shield suitable for the most powerful cartridge authorized for range use. Shield shall extend a minimum of 12 ft (3.66 m) in front of firing line for all ranges and 3 ft (0.914 m) behind the firing line when occupied rooms are above. On existing ranges, the openings in this shield for lighting, ventilation, and target carrier mechanism shall be kept to a minimum. The remainder of the ceiling from the and of the shield to the bullet trap may be treated in the following ways:

a) Continuous flat steel plates all the way to the trap;

b) Ceiling baffles to protect overhead projections and joists;

c) Continuous ceiling of sandwich construction; or

d) Combinations of theme treatments.

Final design should provide protection from stray bullets penetrating wood ceiling members and prevent ricochet from wood joists, steel bar joists, and concrete pen construction.

2.1.3.4 Floors. The preferred material is flat concrete slab or equivalent. Cover non-bulletproof floors of converted buildings with protective shield suitable for the most powerful cartridge authorized for range use. This coverage shall extend a minimum of 12 ft (3.66 m) in front of the firing line for all ranges, and 3 ft (0.914 m) behind the firing line when occupied rooms are below. The remainder of the floor from the end of this shield to the bullet trap may be covered with steel plating or suitable sandwich construction.

2.1.3.5 Walls. The preferred material is flat reinforced concrete or corefilled masonry. Cover non-bulletproof walls of converted buildings with a protective shield suitable for the most powerful cartridge authorized for range use. Shield shall extend a minimum of 12 ft forward of the firing line for all ranges and 3 ft behind the firing line when occupied rooms are adjacent. The remainder of the non-bulletproof wall extending to the bullet trap may be treated with a combination of flat steel plate, baffles, or sandwich construction. Cover the sidewalls at the bullet trap with steel plate of same thickness as the bullet trap for a distance of at least 2 ft (0.61 m) forward of the leading edge of the bullet trap.

2.1.3.6 Protective Steel Plate. Cover non-bulletproof floors and sidewalls of converted buildings with steel plate or bullet absorbing sandwich panels. Provide safety baffles set at 30 degrees to the line of fire across the range at intervals down the range ceiling to provide protection from stray bullets. penetrating wood ceiling members and to prevent ricochet from wood joists, steel joists, and concrete pan construction. Thickness of steel plate or sandwich panel shall be able to withstand the most powerful cartridge to be used on the range. Commercially available baffles may be used. The angle of impact upon the plate will be the determining factor in selecting plate thickness to prevent penetration. Use of range for 5.56 mm and 7.62 mm rifle service ammunition must be determined during pluming phase. Where there are rooms above, below, or beside the range, minimum plate thickness between the range and the rooms, in accordance with the angle of impact the bullet trajectory makes with the surface, shall be as shown in Table 1.

2.1.4 Environmental Factors. A range forming part of another building must provide for the following:

a) Separated heating and ventilating systems for range (and air conditioning, if required).

b) Effective noise reduction from pistol and rifle firing for other rooms in building and outside areas.

Locate range on outside wall of existing building. Design consideration shall be given to noise transmission and structural impact effect of bullets striking bullet traps and metal baffle plates. Consider incorporating dampening pads under supports for bullet traps if required by structural analysis. Refer to DM-3.10, Noise and Vibration Control for Mechanical Equipment; NAVFAC DM-1.03, Architectural Acoustics; and MIL-HDBK-1002/1, Structural Engineering General Requirements.

2.1.5 Bullet Traps. Ricochet end backsplatter are two products of bullet projectiles that must be controlled by utilizing a properly designed and constructed bullet trap.

In existing or converted facilities, bullet traps may be steel plate set at 30 degrees to the line of fire for 5.56 mm or 7.62 mm rifle ammunition and all pistol ammunition, or 42 degrees to the line of fire for pistol only, both types with a water/send pit. Commercially available "escalator" or "venetian blind" bullet traps will normally meet all requirements provided sufficient space is available for installation. Solid wood, stone, concrete, or brick bullet stops cause richocets and are prohibited. The range must be designed to withstand the most powerful cartridge authorized for use on the range. New indoor ranges will normally be designed to withstand use of .357 magnum and 9 mm ammunition.

The ventilation system must be designed to remove all contaminates In the bullet trap area including silica dust if a sand trap is provided. Two commercially available types of bullet traps are:

a) Reverse Escalator Plate Type. The commercially available, reverse "escalator" plate type bullet trap with dry lead catcher is preferred for military ranges. The bullet trap will be selected to accommodate the most powerful weapon and ammunition to be used at the range, but no Armor Piercing (AP) ammunition. The space behind the bullet trap shall be accessible for maintenance and repair of facilities.

Table 1
Materiel Specification Options for Baffles and
Non-Bulletproof Surface Protection (Note 1)

Caliber	Angle of Impact 90 degrees	42 degrees	30 degrees
	Notes	Notes	Notes
.22 LR Rimfire	2-12	2-12	2-12
.38 Ball or Wadcutter	3-11	3-11	3-12
.45 Ball or Wadcutter	3-11	3-11	3-12
.357 mag/9mm	4-7, 9-11	4-7, 9-11	3-7, 9-11
.44 mag	4,5,7,9-11	4,5,7,9-11	4-7, 9-11
5.56 mm Ball	4-7, 9-11	4-7,9-11	4-7,9-11
7.62 mm Ball	4,5,7	4,5,10,11	4,5,10,11
Cal.30 (30-06) Ball	4,5,7	4,5,10,11	4,5,10,11

NOTES:

1. Installed behind and in addition to desired acoustic materiel.

2. Two layers of 3/4-in. (19 mm) particleboard backed with one layer of 3/8-in. plywood.

3. Four layers of 3/4-in. (9.5 mm) particleboard backed with one layer of 3/8-in. plywood.

4. 12 in. (0.3 m) corefilled masonry.

5. 8 in. (203 mm) concrete slab.

6. Sandwich composed of 3/4-in. exterior grade plywood and 9 gauge, low-alloy ASTM A607 HS, Steel Sheet and Strip High-Strength Low-Alloy Columbium or Vanadium or Both Hot-Rolled and Cold-Rolled:steel, plywood, steel.

7. Sandwich composed of 3/4-in. exterior grade plywood and 9 gauge ASTM A 607 HS, low-alloy steel: steel, plywood, steel, plywood, steel.

8. 10 gauge steel covered with 2 in. nominal of soft wood.

9. l/4-in. (6.35 mm) steel plate with minimum 3/4-in. wood facing.

10. 3/8-in, steel plate with minimum 3/4-in. wood facing.

11. Steel plate appropriate for caliber from Table 1 with minimum 3/4-in. wood facing (a costly, conservative design).

12. 12 gauge steel covered with 2 in. (50.8) nominal of soft wood (while protection is adequate, Note 8 is preferred for ranger where use of .45 cal. ammunition is expected to be heavy).

b) Venetian Blind Type. Where space is limited, the commercially available, "venetian blind" type bullet trap may be used. If necessary to prevent backsplatter and reduce lead dust flow, provide commercially available target backing curtains of rubber or cloth, loose hung in front of the bullet trap. Types and caliber of ammunition which can be contained by backing curtains must be in accordance with recommendations of curtain manufacturer. Curtains also provide sound reduction of noises emanating from the bullet trap area.

2.1.5.1 Bullet Trap Steel Specifications. Different types of steel for use in bullet traps have been mentioned in various reports and manuals. The type of steel used in existing facilities in present backstops may be unknown. The use of "regular quality" steel plate or carbon steel plate conforming to American Society for Testing and Materials (ASTM) A36, Standard Specification for Structural Steel, is not recommended for backstops. Where this steel has been used, rapid deterioration (pitting with resultant backsplatter) has been experienced even with the use of only .22 cal. rimfire ammunition. Similarly, High-Strength Low-Alloy (HSIA) steels conforming to ASTM A242/A242M, Standard Specification for High Strength Low-Alloy Structural Steel, A441/A441M Specification for High Strength Low-Alloy Structural Magnesium Vanadium Steel, and A572/A572M, Standard Specification for High-Strength Low-Alloy Columbium-Vanadium Steels of Structural Quality do not have sufficient pitting resistance to provide an adequate backstop. Steel specifications shall conform to the following:

a) "Armor plate" steel conforming to MIL-S-16216 J(1) performs satisfactorily but is not readily available from ordinary commercial sources. Manufacturers of commercial backstops and bullet traps use an alloy steel known as ARMOR 46 (refer to MIL-A-12560 G(1) Armor Plate, Steel, Wrought, Homogeneous (For Use in Combat-Vehicles and Ammunition Testing)), that has been heat-treated to a range of 340 to 440 Brinell Hardness Number (HN).

b) Abrasion-resistant carbon steel rated at 225-285/BHN is suitable for backstops where firing is limited to .22 cal. rimfire ammunition. This steel requires special welding techniques, and might not be readily available in some areas.

c) Possibly the best steel for .22 cal. rimfire ammunition (not magnums) conforms to ASTM A514/A514M, Specification for High-Yield-Strength Quenched and Tempered Alloy Steel Plate. Suitable for Welding. Surface hardness will vary from 235 BHN to 293 BHN. This steel is readily available under various trade names from major steel manufacturers and has good weldability, when low hydrogen conditions are maintained, and recommended electrodes are kept dry. The "Stringer-bead technique" is preferred with heat input limited.

d) For center fire pistols the steel should be abrasion resistant conforming to BHN 320, BHN 360, and BHN 400, with such trade names as Joalloy AR-320 (Jones & Laughlin Steel Co.), X-A-R-15 (LTV), T-1 type A321 (USX), SS-AR-321 (ARMCO) and RQ-32lA (Bethlehem steel). Steels which have higher

degrees of hardness are available, such as Joalloy AR-360 or Joalloy AR-400. Other steels are available and other steel companies have equivalents. Such steels are normally stocked by jobbers supplying mining, heavy engineering, and highway construction trades. Welding requirements remain the same as for ASTM A514/A514M.

The design engineer should specify the ASTM or Mil-reference number, grade of steel and other qualities, and hardness for the specific application. To ensure that the grade of steel needed is obtained, the purchaser should deal only with a reputable supplier. While steel plates look alike, there are significant differences in backstop performance spending upon the hardness and quality of alloy.

A 3/8-in. (9.5 mm) steel plate treated to 440 BHN when set at an angle of 42 degrees is sufficient for all handgun cartridges including .44 magnum. A 3/8-in. steel plate treated to 500+BHN when set at 30 degrees will accommodate cal. 30 (30-06), 7.62 mm, and 5.56 mm ball ammunition, as well as all pistol calibers.

2.1.5.2 Bullet Trap Plate Thickness. Minimum plate thicknesses shall be as given in Table 2. Plate joints shall be flush and either buttwelded ground smooth or butted and bolted to a beck plate on the rear with countersunk heeds on the face. No joint should be horizontal or located directly behind a target.

Table 2

Minimum Bullet Trap Plate Thickness

ANGLE FROM (degrees)	AMMUNITION (caliber	STEELPLATE MIL-S-16216J	ARMORPLATE MIL-A-12560G	STEEL PLATE 440BHN	STEEL PLATE 550+BHN
42	.22 LR rimfire	1/4 (6 mm)	1/4	1/4	1/4
42	.38 Ball/Wadcutter	1/2 (13 mm)	3/8 (10 mm)	1/4	1/4
42	.45 ACP/Wadcutter	1/2	3/8	1/4	1/4
42	.357 mag/9 mm/.30 cal. Carbine	1/2	3/8	1/4	1/4
42	.44 mag	1/2	1/2	3/8	3/8
30	5.56 mm	NR	1/2	NR	3/8
30	7.62 mm	NR	1/2	NR	3/8
30	Cal .30 (30-06)	NR	1/2	NR	3/8

NR - not recommended.

2.1.5.3 Sand Pit. In an existing facility using an inclined plate bullet trap, a sand pit directly in front of the metal plate bullet stop may be used.

The pit should be 6 to 8 in. (152.4 to 203 mm) deep and approximately 8 ft (2.44 m) wide. The pit extends the full width of the range. If silica dust cannot be eliminated by the ventilation system or by the use of wetted send, the sand pit is prohibited.

2.1.5.4 Water Pit. A water pit may be constructed using the same dimensions as a sand pit except deep enough to hold 10 to 12 in. (254 to 304.8 mm) of water for pistol calibers and a minimum of 24 in. (609.6 mm) of water for centerfire rifle calibers. Water is safer from a lead and silica-dust pollution standpoint. Consideration should be given to the addition of common laundry bleach to the water to retard algae growth.

2.1.6 Equipment

2.1.6.1 Communication System. This system will communicate between range officer and shooters. A wireless system uses a standard two-way public address system in conjunction with headsets serving also as ear protection. Options include booth-mounted, wired, two-way speaker systems. A minimal system will be a two-way speaker system with one speaker serving every four or five firing stations.

2.1.6.2 Target Carrier Systems. Commercially available retractable target carrier systems eliminate the hazard of anyone going downrange during range operation and improve range operating efficiency. Carrier and target systems may be manual, of a type that can be converted to electric when funds become available.

2.1.6.3 Shooting Booths. Commercially available shooting booth partitions provide for safety of the shooter. Shooting booths shall not extend more then 18 in. (457.2 mm) behind the firing line to avoid restricting the view of the range officer.

2.1.6.4 Turning Targets. Automatic target turning mechanisms shall have provisions for programming any time limit for target exposure times including 3, 5, 10, 15, and 20 seconds. Manually controlled targets are acceptable for infrequently used ranges.

2.1.6.5 Additional Building Facilities. The following should be considered:

a) Toilet facilities when piped water and drains are available.

b) Drinking fountain.

c) Bulletin board.

d) Range control room or platform, control consoles, chairs, and benches.

e) Emergency eyewash, if weapons cleaning capability is included.

f) Storage closet for equipment.

2.1.7 Safety Standards. A safe range is defined to be a facility that will contain all bullets within its walls, ceiling, and floor when operated by a qualified range officer who follows a standard operating procedure specifically tailored for the range. Safety standers described in pares. 2.1.7.1 through 2.1.7.3 shall be observed.

2.1.7.1 Firing Points. Space firing points for pistol ranges and rifle or rifle-pistol range8 as follows.

a) Pistol Ranges. On ranges used exclusively for pistol firing, firing points shall be placed a minimum of 4 ft (1.22 m) (preferably 4.5 ft) (1.5 m), on center.

b) Rifle or Rifle-Pistol Ranges. On ranges used exclusively for rifle, or rifle end pistol firing, firing points shall be placed a minimum of 4 ft (1.22 a), preferably 5 ft (1.52 m) on center.

2.1.7.2 Openings. No door, window, or other opening, except any required for forced air ventilation, is allowed forward of the firing line. Where an existing building is converted, all such openings must be brick or masonry filled, and doors and windows securely bolted from the inside or protected by steel safety baffles. In new buildings, conceal all pipes and conduits in the walls, ceiling, and floors. Protect exposed pipes in converted buildings with steel plates to match design requirements for the most powerful cartridge to be used. Commercially available safety baffles may be used. In some situations fire doors may be required downrange. When fire doors are required, they may be opened only from the range side.

2.1.7.3 Protective Baffles. Downrange projections shall be minimized in new construction. All beams, columns, lights, or other projecting surfaces downrange of the firing line shall be protected. This protection can be a steel plate to match the most powerful cartridge used or a commercially available safety baffle providing comparable protection. Sheet metal baffles placed at 30 degrees to the line of fire to protect lighting fixtures my be constructed to thickness shown in Table 1 or may be commercially available safety baffles. Resign of baffle should not create a problem with vision lighting.

2.1.8 Ventilation. The supply and exhaust air system design is critical to the proper operation of an indoor range. Provide a positive exhaust ventilation system for removal of airborne lead dust (and silica dust in the case of an existing range using sand traps). A slight negative air pressure should be maintained in the range. This can be accomplished by exhausting three to seven percent more air than is supplied. Air inlets must have dampers or other volume control devices which can be adjusted to retain proper air balance. Consideration should be given to energy recovery systems because of the large volumes of air being exhausted.

2.1.8.1 Air Flow. Air flow of 75 ft per/min or 1.25 ft/sec (22.86 m/min or 0.38 m/sec) across the firing line is recommended, and a minimum acceptableair flow is 50 ft/min (15.2 m/min). At a point approximately halfway between the firing line and the bullet trap, the air flow should be maintained at 2 to 30 ft/min (6.1 to 9.14 m/min). The flow should be evenly distribute past the shooter. It Is important to have the required velocity without it being excessive at any shooting position. The design engineer should avoid excessive entrance air velocity and keep the sonic exposure from the ventilation system below 85 dBA. For initial design, the minimum quantity of total ventilation for a range shall be the greeter of the cross sectional area at the firing line times the maximum design velocity, 75 ft/min, or the average range cross-sectional area (downrange of the firing line) times the maximum downrange velocity of 30 ft/min. In calculating the cross sectional area at the firing line, it should be assumed that shooting booth doors are open.

2.1.8.2 Air Distribution. A perforated rear wall will provide uniform air distribution to ensure diffuse, nonturbulent airflow toward the firing line and laminar airflow downrange to sweep contaminants away from the firing line. A minimum distance of 15 ft (4.57 m) from the firing line to the perforated rear wall should be provided. Ceiling supply systems are permitted in existing facilities provided the minimum flow of 50 ft/min (15.2 m/min.) at the firing line is maintained; however, a beck wall supply is preferred. A minimum of 20 ft/min (6.1 m/min.) must be maintained downrange for satisfactory visibility. To maintain the downrange velocity economically where construction permits, an 8-ft high (2.44 m) cross section (under any protective baffles) is recommended. See Figure 1 for indoor range ventilation. If separate supply air and exhaust air fans are used, they shall be interlocked to prevent independent operation.

2.1.8.3 Exhaust Openings. An optional set of exhaust openings may be located approximately 15 ft (4.57 m) forward of the firing line (not over the firing line) to exhaust not more than 25 percent of the total airflow. The remainder of the exhaust openings will generally be located at the apex of the bullet trap area. Modification of existing ranges to this design is not required so long as a flow of 50 ft/min is maintained at the firing line.

2.1.8.4 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 pert of a larger building, exhaust air discharge will not be located where cross contamination of general building air can occur. Intake air should be located to avoid recirculation of exhaust air.

2.1.8.5 Ventilation Criteria. For design of the ventilation system, refer to DM-3.03 and American Conference of Governmental Industrial Hygienists, Industrial Ventilation Manual Refer to DM-3.03 for criteria for inside comfort conditions.

2.1.8.6 Filtration to Remove Airborne Lead. Filtration of exhaust air to the outside will be designed in accordance with current OSHA and local regulatory requirements. Recirculation of range air is permitted only if it is properly filtered for airborne range contaminants and includes dirty filter indication. If required by Government or local regulations, High Efficiency Particulate Air (HEPA) Filter shall be provided. Provisions should be made in the design for increasing fan horsepower and static pressure in the future for HEPA installation if not an initial design requirement.

2.1.8.7 Other Techniques/Controlling Airborne Lead. There are techniques for controlling airborne lead such as building a wall in front of the firing line and shooting through 18 in. diameter (457 mm) ports, thus separating the muzzle from the face of the shooter. Another technique is shooting through a cylinder which has an exhaust connection to remove airborne lead as it leaves the muzzle. Electronic lead dust collection plates will be considered for heavily used ranges where the savings generated by less frequent changes of the expensive HEPA filters will offset the cost and the equipment costs. Unique and unusual installations are outside the scope of this manual. Approval from the using activity must be obtained before using these techniques. Criteria may be obtained from the National Rifle Association or other expert authority.

2.1.8.8 Lead Dust in Existing Ranges. The use of special training ammunition may be considered to reduce the cost of rehabilitation of an existing ventilation system; only if commend assurance is provided that all users of the range will use this type ammunition. An existing indoor range with a lead dust level in excess of norms1 exposure limits may be operated following the restricted criteria found in Table 3. Table 3 is developed and used by the US Army and the National Guard. Any constraints on range use must be in writing end included in the Standard Operating Procedure for the range.

2.1.9 Sound Reflection Reduction. Noise reduction in the range and noise transmission out of the range are two different design considerations. Mass and limpness are the two desirable attributes for a sound transmission barrier. Heavy masonry walls are generally the most economical method for isolating the range. Other types of construction such as gravel or grout. filled concrete block will provide mass. Absorptive acoustical surfacing will reduce the noise level in the range but will have little effect on transmission outside the range. Blown-on acoustical material is not permitted. Conventional acoustical treatment is encouraged behind the firing line. Downrange acoustic treatment must be compatible with the planned lead dust removal process. Do not paint downrange block walls or acoustic tile sound absorbing walls; this significantly degrades the sound absorbing qualities of the materials. Existing ranges may continue use of painted surface.

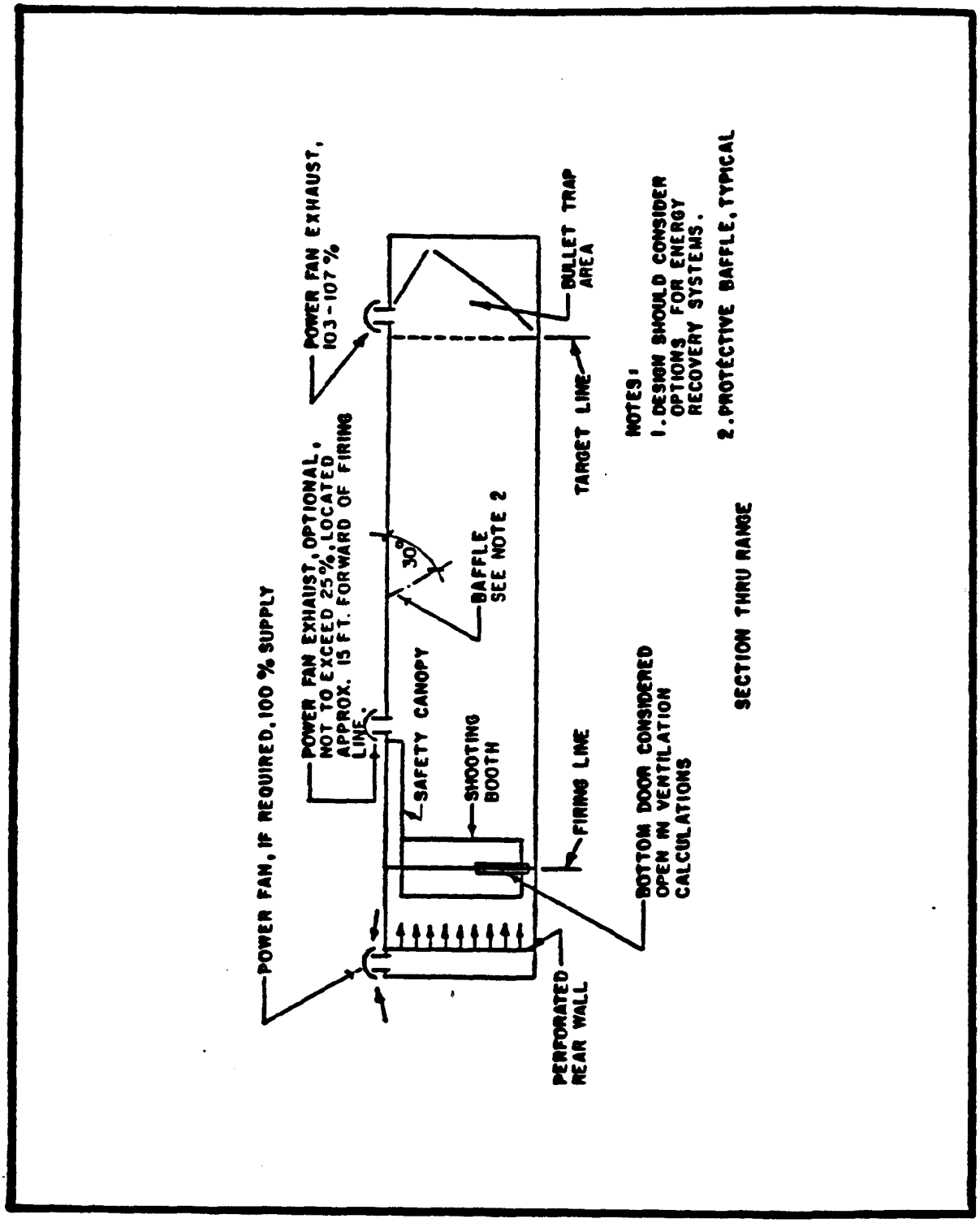


Figure 1
Indoor Range Ventilation

Table 3
Maximum Allowable Exposure Limits for Intermittent Atmospheric Lead

AIRBORNE LEAD CONCENTRATION (micrograms/cu m)	MAXIMUM HOURS OF ALLOWABLE EXPOSURE			
	FIRING 30 OR MORE DAYS/YEAR		FIRING LESS THAN 30 DAYS/YEAR	
	Hrs/Week	Hrs/Day	Hrs/Week	Hrs/Day
0 · 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 1/2	2 1/2	7 1/2	2 1/2
0.25 · 0.30	4	2	6	2
0.3 · 0.4	3	1 1/2	4 1/2	1 1/2
0.4 · 0.5	2 1/2	1	3	1
0.5 · 0.7	1 1/2	1/2	1 1/2	1/2
0.7 · 1.0	1	1/2	1	1/2
1.0 · 2.0	1/4	1/4	1/2	1/4
2.0 · 4.0	1/4	1/4	1/4	1/4
4.00	0	0	0	0

Wall treatment should be installed in not larger than four foot wide panels to facilitate replacement after damage. Install. acoustic wall treatment on furring strips spaced away from the wall. Ventilation duct openings should have noise traps to reduce noise transmission to outside or other occupied building areas. The floor area behind the firing line may be covered with acoustic material that can withstand the chosen lead removal process. While carpet is not recommended, it need not be removed from existing facilities. Airborne noise can be reduced by sealing off air leaks. Doors should be solid core, weather stripped. Provide double doors (air lock arrangement) when connecting directly with another pert of a larger building. Double glazing of windows into control rooms will reduce transmission.

2.1.10 Lighting;. Provide general downrange lighting for safety and cleanup purposes as well as for general range illumination. The preferred method is a continuous bank of fluorescent lights with supplemental halogen or a combination of lights running the full width of the range. Light intensity at target face should be between 85 to 100 footcandles measured 4 feet (1.22 m) above the floor at the target. The ideal light wavelength is 550 plus or minus 50 nanometers. Range should have dimmer or lighting to satisfy various training requirements of using activities.

2.1.11 Range Design Review. For weapons to be fired, weapons type, ammunition to be fired, and distances of firing line to targets must be determined during the planning phase. Other design considerations include: number of firing points; lighting possibilities; manual and automatic target carrier/turning mechanisms; offices or at least tables for administrative support; shooting benches; clocks and timers; ventilation; ease of lead dust cleanup; spectator safety; acoustics; lead dust control; lead removal from lead dust collectors and bullet traps. A range which adjoins a classroom requires soundproofing. Glass walls separating firing points from waiting areas may be used to reduce noise and lead dangers to spectators or waiting shooters.

During the planning phase, the weapons officer, range officer, range training officer, safety officer, industrial hygienist, and public works engineer should review the design requirement before construction drawings are started. When the station or design agent is unable to proceed with preparation of construction drawings in accordance with the criteria of this military handbook, requests for deviation must be addressed to Commander, Naval Facilities Engineering Command, Code 15C, 1510 Gilbert Street, Norfolk, VA 23511-2699. During the design phase, submittal reviews by the appropriate Naval Industrial Hygienist are required in accordance with NAVFAC Instruction 6260.2, Reviews for Health Hazards During Facility Design Process, and may be required by the appropriate Engineering Field Division (EFD) or Engineering Field Activity (EFA) in accordance with EFD or EFA published instructions.

2.2 Outdoor Small Arms Ranges

2.2.1 Planning Phase. The weapons officer, range safety officer, industrial hygienist, activity planner, and public works engineer (and others who may have interest) shall review the proposed range usage and resulting design requirements for compatibility before construction drawings are started. Plot the proposed Surface Danger Zone (SDZ) on the activity General Development Map (GDM) to confirm the lack of conflicts. Check aircraft operations. Note that the Federal Aviation Administration (FAA) has jurisdiction if there is a vertical weapon component that exceeds 500 feet. Consult NAVFAC publication P-80 for guidance on the number of personnel to be supported and the size of the range.

Note that rifles, pistols, and shotguns produce greatly varying amounts of projectile energy to be controlled by range structures. Design range components to accommodate the maximum energy anticipated.

If the following criteria can be met, request site approval under normal conditions through the cognizant EFD or EFA. Refer to NAVFAC Instruction 11010.44E, Shore Facilities Planning Manual: A System for the Planning of Shore Facilities. Deviations from this criteria cannot be made without prior approval of NAVFACENGCOM Code 15C. The point of contact is:

Commander
Naval Facilities Engineering Command
Attn: Code 15C
1510 Gilbert Street
Norfolk, VA 23511-2699
Telephone: Commercial (804) 322-4205
DSN 262-4205
Fax: (804) 322-4416

2.2.2 Application. These paragraphs (par. 2.2 inclusive) apply to new construction and any rehabilitation or repair of existing ranges.

2.2.3 Record of Compliance. After construction is complete, a Record of Compliance is required from NAVFACENGCOM Code 15C before the range is authorized to operate. Coordinate through the cognizant EFD or EFA.

2.2.4 Design Policy. Design the range such that the SDZ is unoccupied by any personnel, livestock, vehicles, facilities, etc., which may be damaged. The SDZ is any area that may reasonably expect projectile impact resulting from direct fire (DF), including misdirected and accidental discharges (MAD), and ricochets (RC). The SDZ is only in force when weapons are being fired. The U.S. Navy and Marine Corps through the Range Safety Officer (RSO) shall maintain complete control over the SDZ. The entire SDZ must be either U.S. Government owned or legally authorized for Government use as a small arms range (SAR). The maximum range of the most powerful cartridge to be fired shall be used in calculating the limits of the SDZ. Select the longer distance if potential weapons are close in maximum range (as 45 caliber; select 9 mm). Maximum ranges for various small arms ammunition are shown in Table 4. Required SDZ footprints (based on soil type and range improvements) are shown in Figures 2.2-l through 2.2-5. When two or more ranges are located contiguous and parallel, use the longest maximum distance to plot one composite symmetrical SDZ. If land area for a full SDZ is unavailable then various improvements (baffles) shall be constructed to contain the projectiles. Alternative designs producing smaller SDZ's are presented starting in par. 2.2.6. Note that the land available for the SDZ directs the design effort.

Table 4
Maximum Range of Small Arms Ammunition

Caliber	Cartridge	Max. Range in meters
.22 long rifle		1400
.38 revolver	Ball, M41	1600
.38 revolver	Ball, PGU-12/8	1900
.45 pistol		1500
.45 submachinegun		1600
.357 magnum		2160
9 mm pistol		1740
9 mm submachinegun		1840
.44 magnum		2290
shotgun, 12 ga	00 buckshot	600
.30 rifle/machinegun	Ball, M-33	3100
.30 rifle/machinegun	AP, M2	4400
.30 carbine		2300
5.56 mm rifle (M-16)	Ball, M19	3100
7.62 mm rifle/machinegun	Ball, M80	4100
7.62 mm riflelmachinegun	Match, M118	4800
.50 machinegun	Ball, M33	6500
.50 machinegun	AP, M2	6100

2.2.4.1 Other Publications. The joint Army Regulation (AR) 385-63 and MCO P3570.1A, Policies and Procedures for Firing Ammunition for Training, Target Practice, and Combat are coordinated with this military handbook.

2.2.4.2 Environmental Concerns. Environmental regulations will become more stringent. Design and site the range considering future cleanup efforts in the intended impact areas and other areas where MAD and RC may land. Avoid shooting over flowing water courses or into wetlands. Nearby communities will complain about noise.

2.2.5 Best Management Practices

2.2.5.1 Lead. Lead (and other associated projectile components) is a hazardous heavy metal that may adversely affect humans when finely divided dust is taken into the body or lead particulate is transported into a drinking water supply. The following procedures will keep the lead on the range, treat it to be chemically harmless, and recycle it when safety requires its removal. The procedures involve soil amendments, vegetation management, engineering controls, contaminant monitoring, reclaiming, and recycling.

2.2.5.2 Soil Amendments. Soils should be tested for pH levels every 2 years. Consult local agricultural extension agents. The desired pH levels is in the neutral range of 6 to 8. The pH level can be raised if necessary by adding hydrated, crushed, or pulverized limestone.

2.2.5.3 Vegetation. Maintain vegetation on berms and drainageways. Turf grasses do an especially good job of retaining water and sediment on site. Choose a grass with minimal watering and fertilizer needs. Rework the projectile pocket in the berm by adding soil and grass often. Use non-nitrate based fertilizer. Minimal amounts of nitrate based fertilizer may be used during the initial grow-in period. Remove any decaying wood or other plant life on the range, particularly on the berm face and in the SDZ in near proximity to the berm back.

2.2.5.4 Engineering Controls. Prevent stormwater runoff from impact berms from flowing directly into surface water environments. Divert surface water runoff within the range (including the SDZ) to a vegetated detention basin or infiltration area. Provide straw bales, geotextile fabrics or other erosion controls in drainage areas. Slow the runoff and provide sediment traps.

2.2.5.5 Contaminant Monitoring. The monitoring program is 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 range usage and site geohydrological conditions. Monitoring wells should be correlated with other existing wells on the activity. Monitoring wells are not required if the ground water table is 20 feet or greater below the range surface. On deep water tables note the tests derived from the other activity wells, Contact the activity Environmental Engineer for support.

2.2.5.6 Reclamation and Recycling. Remove lead in the berm face when there is a noticeable lead mass that is causing RC. The lead is to be sifted from the soil on site. Place the soil immediately back on the berm face. Send the sifted lead in containers to the, local recycling contractor or smelter.

a) Health and Safety Plan. Develop a site specific Health and Safety Plan in cooperation with the local industrial hygienist before excavating or removing any lead contaminated soil. OSHA regulations 29 CFR 1910.1025 and 29 CFR 1926.62 apply.

2.2.6 Surface Danger Zones Over Water. If the SDZ is to be oriented over navigable water, obtain prior approval of the plan from CNO (Code N-411E).

a) To obtain approval the following SDZ controls are required. The SDZ's shall be included in construction drawings and written into the range standard operating procedures (SOP):

(1) Limits of the water impact area shall be drafted so the limits can be transferred onto local navigation charts as a SDZ in the U.S. Army Corps of Engineers (COE) application. Refer to par. 2.2.6(2).

(2) At least two poles shall display "holiday" size red flags when the range is "live." Flags shall be visible from all points of entry into the SDZ. Provide either a red or white strobe light to call attention to the flag at night. Flags shall be placed wherever there is a conspicuous location. Oceanside requirements are different from swamp- and canal-side requirements.

(3) Provide marking buoys at the outer limits of the SDZ. Abnormal depths or extensive ship traffic may require other procedures. Submit alternate proposals for marking limits to NAVFACENGCOM Code 15C if buoys are impractical.

(4) A lookout having direct communication with the firing line (to stop the firing if the SDZ is entered) shall be maintained. A high observation tower could be provided for this lookout. High speed vessels may be required to police the SDZ if there is significant water traffic.

b) After receiving CNO's approval, file an application for a SDZ with the COE District Engineer having jurisdiction in accordance with 33 CFR Part 344. Verify that the COE has communicated with the U.S. Coast Guard to publish an announcement in the "Notice To Mariners" routinely to warn mariners to "stand clear" when the range is in operation.

2.2.7 Local Operating Procedures. Safety of personnel and property is paramount. Proper range operation procedures and discipline will be required for safe usage. The designer shall include in the general notes on the construction drawings the pertinent design parameters such as: weapons, ammunition, target types, SDZ's, property lines, and aircraft flight paths to assist the RSO in writing the SOP manual.

2.2.7.1 Warnings. Warning signs shall 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. Refer to the information listed in the following table and AR 385-30, Safety Color Code Markings and Signs for guidance. Fencing may be required when there are no other entry restrictions.

WARNINGS	LOCATIONS
Danger--Firing in Progress When Red Flag is Flying	Approach Roads
Danger--Firing Ranges Do Not Enter	Fencing and Barriers
Danger--Laser	Entry road and 100 feet (30.5 m) intervals on perimeter fencing

2.2.7.2 Wind Direction. On rifle ranges, provide flags on poles at each end of the impact berm or target line and at each firing line to indicate wind direction to the shooters. This could be the same flag called for in par. 2.2.6.a)(2).

2.2.8 Site Requirements. The site selection should address the following items.

2.2.8.1 Location. Sites should be remote from communities to avoid interaction with residents and allow for future development of the range. The SDZ shall be recorded on activity GDM's. The following items shall be addressed when selecting a location:

a) Site shall be accessible by road.

b) Site shall have natural drainage, but no flowing water courses near the range floor or impact berm.

c) Take advantage of any natural barriers or base restricted areas to prevent access by personnel and animals to the SDZ. Most activities have boundary conditions such as runways, magazine areas, and perimeter fences.

d) Take advantage of any natural backstops that may exist for both cost savings on berm construction and noise abatement.

e) Locate so as to minimize the amount of lead (MAD and RC) that will land in adjoining waterways, wetlands, etc. Use a minimum setback from these features of 30 meters on either side of the range and 60 meters behind the impact berm.

f) Avoid areas that are subject to flooding. Cleanup costs for berms that have been washed away by floods are becoming prohibitive.

g) Avoid locating the range upwind (prevailing) of residential areas, if possible.

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

2.2.8.2 Characteristics. The following criteria should be considered when locating a range on a site:

a) Range floor should require minimal grading to produce a smooth surface of homogeneous material. A rocky surface will increase RC and enlarge the SDZ (see Figure 2.2-2).

b) Trees are allowed downrange of the impact berm in the SDZ, on exterior faces of the impact berm and side berms, and in the side SDZ's.

c) Vehicle access inside the range is required to ease maintenance operations and grass mowing.

d) If possible (safety and site considerations holding priority), the range should be oriented to eliminate firing into the sun. Backlighting the target line may cause aiming problems. In the northern hemisphere, north to northeast direction is preferable. Overhead baffling may provide sufficient shading on the targets to remove the backlighting.

e) The following utilities should be provided in the area:

(1) Electricity - size service to accommodate power requirements for lighting, communication systems, target manipulation and control, etc. Locate wiring aboveground in conduit on any available structure or berm not exposed to DF. Many ranges are experiencing trouble with groundwater when new connections are made to upgrade systems.

(2) Telephone or radio communication - needed for communication if there is a range emergency or accident. User can supply handheld units.

(3) Water - if available provides service for fire protection, drinking, and sanitary uses. If not available, comment in design parameters so operators will provide required portable fire extinguishers and drinking and handwashing water. Handwashing water is required on the range.

f) There should be sufficient parking of appropriate surface to accommodate the anticipated vehicles.

g) If requested by the user, provide toilets and a storehouse to be used for ready ammunition storage, target storage and repair, first aid area, etc. User may prefer to provide portable toilets. On rifle ranges consider placing target storage and some toilets at the ends of the target butts.

h) Consider a built-in communication system so the RSO can communicate with all parts of the range. The user may prefer to furnish portable radios and battery operated loud hailers.

i) Provide a weapon clearing barrel at the exit from the firing line. See Figure 2.2-20 for details.

2.2.8.3 Vertical Clearance. On most weapons, DF could reach 1500 meters vertically. RC could reach 300 meters. Normal range clearance for planning (assuming proper range control) would be 500 meters.

2.2.9 Types of Ranges. The three basic types of outdoor SAR's are:

a) Open (0) has an uncovered firing line(s) and, highly recommended, but not required at this time, an impact structure to concentrate cleanup efforts. SDZ distance of 100 percent of the maximum range of the most powerful cartridge to be used; see Figure 2.2-1, 2.2-2, or 2.2-3. Note that "0" SAR's have wider fans and increased lateral spacing as opposed to baffled ranges. No effort is made to contain DF or RC. "0" SAR's are generally required for moving target systems; see Figure 2.2-3. There must be sufficient land available for a full sized SDZ.

b) Partially baffled (PB) has a covered firing line(s), side containment, overhead baffles (OB), and impact structure. SDZ distance of 50 percent of the maximum range of the most powerful round to be used; see Figure 2.2-4. Additional components are provided to prevent escape of DF. From whatever location a weapon may be expected to be discharged, "the weapon can see no blue sky." Available land area will not support a full sized SDZ. Placing a moving target system in a "PB" SAR creates numerous technical problems (SDZ fan and OB columns). Consult with NAVFACENGCOM Code 15C if moving targets are required.

c) Fully baffled (FB) has a covered firing line(s), side containment, OB, ricochet containment, a clean, smooth floor surface, and a covered impact structure or bullet trap. The SDZ is 45 meters; see Figure 2.2-5. Additional components are provided to prevent escape of RC as well as DF. Available land area is extremely limited. Type "FB" SAR's generally cannot be used for moving targets or rapid fire (machine guns) because of baffle columns and RC geometry.

2.2.10 Geometry. Vertical control is based on the firing line floor surface (FLFS) equals 0.00 meter, (refer to par. 2.2.11.1). Horizontal control is based on measurements taken from the rearmost firing line (FL). The various range components (par. 2.2.11) are located as follows:

a) The center of the target shall be at an elevation between the upper limit of fire (ULF) (standing: plus 1.85 meters above FLFS) and the lower limit of fire (LLF) (prone: plus 0.15 meter above FLFS). The entire target face shall be fully displayed to the shooter.

b) The range floor (RF) (par. 2.2.11.6) shall be a minimum of minus 0.03 meter below FLFS.

c) Transverse spacing for firing lanes for rifles shall be 2.75 meters center to center; see Figure 2.2-6. Firing lanes for pistols and shotguns shall be 1.50 meters center to center; see Figure 2.2-7.

d) The length of the range (distance between the farthest spaced firing and target lines) shall be as appropriate to the weapon being used and the desired training; from 3 meters to 550 meters. Normally there will be several different firing lines to target distances on the same range. Training requirements will dictate the distances.

e) Ranges may be located parallel to one another in compliance with Figure 2.2-8 for separation.

2.2.11 Range Components. Depending on the restrictions of the SDZ, selected items of the following component list will be combined to form the operating range.

2.2.11.1 Firing Line Items. Provide the following components:

a) Floor Surface. The FLFS elevation is the range controlling elevation. The surface shall be smooth, firm, and graded to drain away from the targets. Side to side grading should be minimal. Transverse firing line grading should match target line transverse grading. Fore and aft distance shall be sufficient to support the type of training conducted. Firing lanes shall be clearly marked on the surface to match the targets. Depending on the number of personnel to be supported (and their comfort) and the funds available, the following surfaces should be considered:

(1) Ground, firmly compacted with mown grasses. Railroad ties could be used for lane marking.

(2) Sand or fine gravel (prone firing could be uncomfortable).

(3) Wood decking of sufficient thickness and supporting members to avoid movement.

(4) Concrete topped with appropriate cushioning material.

b) Overhead Containment. For Types "PB" and "FB" ranges a ballistic canopy shall be provided over all locations where a weapon may be

expected to be discharged (firing line by definition). This canopy shall begin at least 1.0 meter behind the firing line. General structural requirements may dictate more distance. The canopy shall extend forward a distance (4 meters minimum) that will work geometrically with the first OB in preventing a weapon from firing directly out of the range. See Figure 2.2-9. Note the prone firing location (LLF). The canopy shall be constructed of ballistic material with sacrificial cladding as defined in par. 2.2.11.8. Sound reduction ceiling waffles should be considered. The minimum elevation of the lowest point is to be 0.60 meter above UFL (plus 2.45 meters FLFS). Weather roofing is required above the ballistic material. Slope roof to drain.

c) Benches. Continuous benches or individual trays may be provided to hold ammunition and weapons. Do not place the trays in a position to encourage unsafe weapon handling.

d) Partitions. Partitions between shooting positions may be provided if the user requests.

e) Shed Roof. On Type "0" ranges any structurally sound roof may be provided for weather protection if the user requests.

f) Visual Area. The RSO shall have unrestricted view of the entire firing line from his control position.

2.2.11.2 Side Containment. For range types "PB" and "FB" (Figures 2.2-4 and 2.2-5), the top elevation of the side containment shall geometrically mate with the overhead baffles to be high enough to prevent any direct fire from exiting the range. Full height side containment will extend 1.0 meter to the rear of the FL. Locate the side containment at least 3 meters outboard of the centerline of the outermost firing lane. Construction may be in the following forms:

a) Earth Berm. Construct to an inside side slope of 1.0v to 1.5h. If native soil characteristics will not produce a stable slope at this angle, provide geotechnical fabric reinforcement in the fill. Top width of berm shall be 3 meters. No rocks are permitted in the top 1 meter of the inside surface. Slopes on the outside may be whatever is consistent with the native soils. Vegetate appropriately for erosion control and maintenance. Generally, earth berms cannot be used on Type "FB" SAR's, however berms are permissible if the SAR is small and the overhead baffle and berm geometry intercept RC.

b) Continuous Walls. Construct of ballistic material (par. 2.2.11.6) and structurally capable of withstanding local weather and seismic conditions. Provide sacrificial cladding (par. 2.2.11.8) to 4 meters forward of the FL and 1 meter behind the FL. Continuous walls are preferred for Type "FB" ranges.

c) Wing Walls. Wing walls (side baffles) are discontinuous side protection set at 45 degrees to the line of fire. Locate the wing walls such that they are overlapped by 0.15 meter based on any line of fire that may strike the wing walls. Construct of ballistic material. Provide sacrificial cladding on wing walls closer than 10 meters to the FL. Wing walls assist cross range ventilation.

d) End Walls. May be constructed at the firing lane edge on the FL in lieu of side containment extending 1.0 meter behind the FL. Walls shall be long enough to close off any line of sight between the end of the side containment and the rear 1 meter mark. The end walls shall be constructed of ballistic material with sacrificial cladding extending from the canopy to the FLFS.

2.2.11.3 Overhead Baffles (OS). The lowest elevation of the bottom of an OB shall be plus 0.15 meter above the ULF (plus 2.0 meters, FLFS). The OB shall be located such that no direct fire can exit the range from any firing position (LLF usually is the controlling position). The first OB shall be geometrically coordinated with the firing line ballistic canopy (par. 2.2.11.1.b). The top elevation of the top of each following baffle shall be 0.15 meter higher than a line of fire that just clears beneath each preceding baffle. OB should be the same height; space them apart down range to achieve the required geometry. The last baffle shall be placed such that the line of fire will strike the impact structure (par. 2.2.11.4) no higher than 1.5 meters below the top elevation of the structure. See Figure 2.2-9 for profile guidance. On a Type "FB" range, the last OB shall be over the last target line.

a) The OB shall extend laterally to within 0.3 meter of the side containment (par. 2.2.11.2). On Type "FB" ranges the OB shall tie into the side containment.

b) The vertical dimension of a OB when it is vertical varies with the number and spacing of the baffles. Normally the height is between 1.25 and 2.5 meters when considering structural support size and costs.

c) The baffles shall be constructed of ballistic material (par. 2.2.11.7). Baffles within 10 meters of the FL shall be covered with sacrificial cladding. See Figure 2.2-10 for possible configurations.

d) Space the structural columns as far apart laterally as possible to open firing lanes. If possible do not construct columns within the range. Design columns or beams to withstand local wind and seismic loads. Provide protective steel plate on the faces of the columns exposed to the FL in accordance with Figure 2.2-10. Provide sacrificial cladding if the column is within 10 meters of the FL.

e) The OB may be placed on a flatter slope and overlapped to function as FL canopies if multiple FL's are to be used. See Figure 2.2-11. This arrangement is cost effective for baffled combat lanes.

2.2.11.4 Ricochet Containment. On Type "FB" ranges, construct non-ballistic panelling in accordance with Figure 2.2.12. Alternative materials and methods to prevent RC from leaving the range may be presented to NAVFACENGCOM Code 15C for prior approval.

2.2.11.5 Impact Structure. The structure varies depending on the type of range. Acceptable structures by range type are listed below. Alternative methods may be presented to NAVFACENGCOM Code 15C for prior approval.

a) Type "O" Ranges. The top elevation of the impact structure should be plus 8.0 meters FLFS for ranges 92 meters or greater in length and plus 5.0 meters above FLFS for ranges 50 meters or less in length. The impact structure should extend 45 meters beyond the target line ends for 92 meter ranges and 15 meters for 50 meter ranges, or until joining with the side containment, if provided. Locate the beginning of the structure as close to the last target line as possible.

(1) Earth Berm. The suggested elevation may be met by designing a combination of earth berm and vertical baffle (Figure 2.2-13). The earth berm portion should have a top elevation of plus 5.0 meters above FLFS. The vertical baffle shall be constructed of ballistic material (par. 2.2.11.7) and designed to withstand local seismic and wind loads. This combination arrangement would reduce the footprint and the amount of material in the earth berm. The slope of the impact face should be no lower than 1.0v to 1.5h. The top should be 3 meters wide. The impact slope should be constructed with a 1 meter layer of easily filtered soil (to reclaim the lead rounds) with no rocks, sticks, etc. The impact face of the berm will be periodically mined for spent lead, so consider maintenance when designing. The rear slope should be appropriate to the native soil and maintenance requirements. Vegetate appropriately to prevent erosion.

(2) Reprocessed Rubber Products. New products are coming to the market. Their use is encouraged if appropriate and cost effective. Contact NAVFACENGCOM Code 15C for prior approval.

b) Type "PB" and "FB" Ranges. The top elevation will vary depending upon the OB and impact structure arrangement. The impact structure for Type "PB" can be: standard berm, bullet trap, or hybrid. For Type "FB" the impact structure shall be a bullet trap. In all instances, the impact structure will connect to the side containment.

(1) The standard earth berm shall have slopes and width in accordance with par. 2.2.11.5.a)(1). Provide geotextiles as necessary to

achieve the slope. The top of the berm shall be at an elevation that is 1.5 meters above the point where the highest line of direct fire can strike the berm.

(2) Outdoor bullet traps can be constructed by placing the last vertical OB over the last target line and placing a sloped baffle to connect from the top of the earth berm to the back of the last vertical OB. The bottom of this lower sloped OB shall be 0.50 meter above the highest point on the berm where DF might strike. Vegetation will not grow on the berm so more frequent maintenance will be required. See Figure 2.2.14 for material and construction details. Address rainfall runoff from sloped baffle onto berm.

(3) Hybrids may be possible. Any means of providing slope stability, round and ricochet control, and surface screening may be presented to NAVFACENGCOM Code 15C at an early design stage for approval and comments.

Some methods are: (1) gabions to make the berm surface vertical faced with two overlapping rows of automobile tires stacked on top of each other to elevation plus 2.0 meters FLFS; or (2) constructing a "Venetian blind" bullet deflector made from steel supports with interchangeable steel slats set in a concrete floor slab; or (3) commercial available steel bullet traps or reprocessed rubber products.

2.2.11.6 Range Floor. The surface shall be graded smooth and sloped for storm drainage. The floor should be graded side to side at between 1 and 2 percent. Use very shallow swales in the surface area. Place culverts and pipes in protected locations with collection points where runoff can be monitored and controlled for lead contamination, if required. Consider subdrains. Provide erosion control vegetation that can be maintained at a low height. Refer to par. 2.2.5.3.

a) Types "0" and "PB" ranges may use a 100 mm thick pea gravel surface.

b) Concrete walks with edges exposed to the FL are discouraged.

c) Type "FB" ranges require a clean, smooth surface that minimizes deflected RC. The RC is intended to end up in the bullet trap. No large foreign objects are permitted. Entire surface may be 100 mm thick portland cement concrete.

2.2.11.7 Ballistic Material. The purpose of this material is to absorb, deflect, or fragment the rounds. Material for baffles on Types "PB" and "FB" ranges is shown in Figure 2.2.10. Wood that is used shall be of middle grade exterior timber or plywood. Timber in contact with the ground shall be pressure treated for the purpose. Avoid exposed connectors if possible. Alternative commercial products may be used, contact NAVFACENGCOM Code 15C. Refer to Table 5 for thickness of various materials.

2.2.11.8 Sacrificial Cladding. Provide 19 mm thick plywood in front of a 19 mm air gap on any surfaces (baffles, wing walls, metal connectors, etc.) that are within 10 meters of the FL to prevent backsplatter. Size panels for easy replacement of damaged areas.

a) Canopies shall have sacrificial cladding from 1 meter behind the FL to 4 meters forward of the FL.

b) Various reprocessed rubber products for sacrificial cladding use are commercially available. Contact NAVFACENGCOM Code 15C.

2.2.11.9 Target Line and Mechanisms. Components will be as follows:

a) Target line bases shall match grading with the FL. Mechanical target support bases shall be protected from the direct line of fire. They may be buried flush with the ground or placed behind a protective wall. Note that a small raised earth berm at this location generates significant RC. The complexity of the mechanism will dictate the protection requirement. See Figure 2.2-15 for wall or trench protection of high cost target line mechanisms.

b) Target supports can be made of steel angles and channels, PVC pipe or wood. Do not use metal parts within 10 meters of the FL where DF strikes are anticipated. Discharging weapons close to metal surfaces is extremely dangerous. Present the smallest surface area that is structurally sound to the line of fire to minimize RC. Design the target holders for easy and inexpensive replacement. This is one area to "keep it simple." Skidable, self-supporting 2 by 4 wood frames or 2 by 2's placed into buried PVC pipe work well on simple ranges. Note: the full face of the target shall be visible to the shooter. The target components are at the user's discretion, based on his training requirements. Consult with the RSO for his needs. Provide necessary components.

c) Turning targets and the display time are at the discretion of the user. Commercially available, electrically motorized target carrier and electronic scoring systems should be considered when the economics of training warrant.

d) See Figures 2.2-16, 2.2-17, 2.2-18, and 2.2-19 for rifle butts and targets. Rifle target frames shall be 1.2 meters by 1.8 meters high for use to 274 meters and 1.8 meters square at greater distances.

2.2.12 Multiple Firing Lines Versus Target Lines. On Type "PB" or "FB" ranges, in most instances, a single FL with multiple target lines will produce the most cost effective range because of the FL canopy. An extremely advanced target mechanism may be sufficiently more expensive than multiple canopies to shift the advantage. On Type "O" ranges the single target line with multiple FL's is preferred; especially on rifle ranges where butts are required.

2.2.13 Combat Ranges. Forward moving (run and shoot) courses can be constructed with the above criteria. On a Type "PB" or "FB" range, any location where a weapon is discharged shall have a ballistic canopy and the required geometry of baffles. See Figure 2.2-11. It is possible that lateral personnel movement with targets at varying distances on adjoining firing lanes will provide a cost effective alternative. However, the training procedure may encourage a two lane multi-canopied range alongside a conventional multi-lane single FL, multi-target line range. Required firing position barricades will be provided by the user.

2.2.14 Shooting Houses. Without overhead containment the SDZ is 360 degrees at the maximum range of the weapon being used. If DF and RC are contained by a ballistic canopy the SDZ would be 50 meters at 360 degrees. One method is to provide a ballistic canopy 3 meters above the "house" and construct an earth berm 0.5 meter higher than the canopy around the "house." Another method is to extend the roof below the top of the side walls. The roof end should be 1 meter below and 1 meter away from the side wall to allow for air movement. Houses are made of ballistic material. Enclosed rooms are considered as indoor ranges, refer to par. 2.1.

2.2.15 Skeet and Trap Ranges. Refer to MIL-HDBK-1037/3, Outdoor Snorts and Recreational Facilities. SDZ distance is 275 meters.

2.2.16 Existing Type "FB" Ranges With Ground Baffles. These ranges can continue to operate as is but the ground baffles should be removed as they require maintenance. Ground baffles are a major contributor of RC. Provide a concrete range floor. Note that Type "FB" ranges require overhead ricochet containment because of the RC caused by the surfaces of the column sides regardless of the presence of ground baffles.

2.2.17 Machine Gun Ranges. The standard distance between the FL and the target is 25 meters. The range is Type "0" with the SDZ shaped as Figure 2.2-1, 2.2-2, or 2.2-3. Targets are chosen and placed to satisfy local conditions and training requirements by the user. An impact structure 8 meters high is required.

2.3 Composite Ranges. Where site conditions permit, shotgun, pistol, rifle, and machine gun ranges should be located close to each other to better utilize supporting facilities. The SDZ's should be a common area.

2.4 Combat Villages. Combat villages may be designed using the individual paragraphs (par. 2.2 inclusive) that apply to the particular course of fire or training. The SDZ is based on the most powerful round and direction of fire.

Table 5
Ballistic Material Thickness

Material	Caliber			
	.45/9 mm	5.56 mm	7.62 mm	.50
Concrete (5000 psi)	100 mm	130 mm	160 mm	300 mm
Grout-filled CMU's	200 mm	300 mm	300 mm	600 mm
Broken Stone	350 mm	350 mm	500 mm	760 mm
Sand	600 mm	600 mm	900 mm	1200 mm
Clay	1100 mm	1100 mm	1650 mm	2540 mm
Earth	900 mm	900 mm	1300 mm	1700 mm
Oak Logs	700 mm	700 mm	1000 mm	1400 mm
AR-500 (BHN) Steel Plate	6.5 mm	10 mm	10 mm	none
Auto Tires/Earth Filled	1.5 dia	1.5 dia	1.5 dia	none

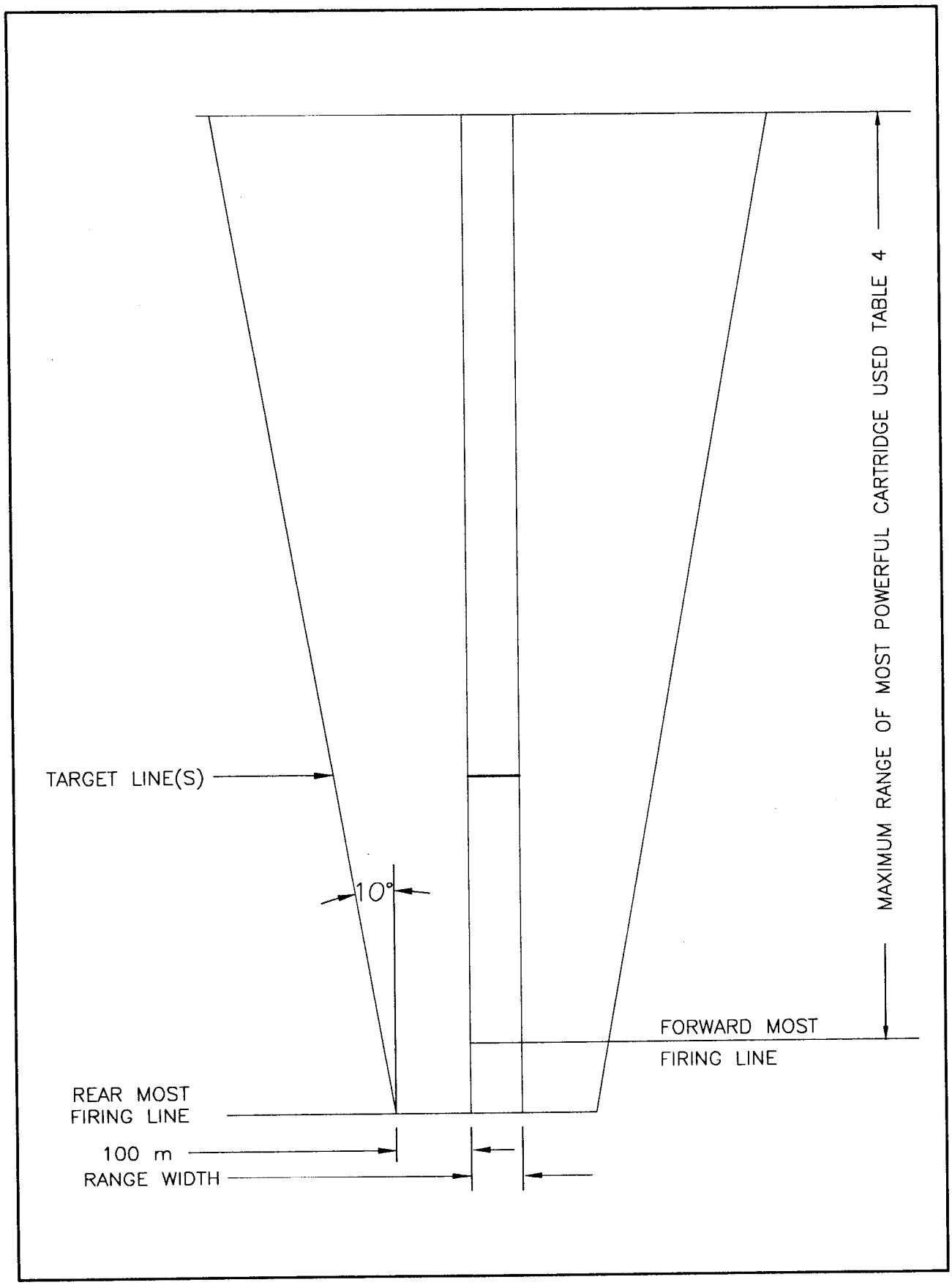


Figure 2.2-1

Surface Danger Zone for Small Arms Weapons Firing at Fixed Ground Targets - Open Range (Type "0")

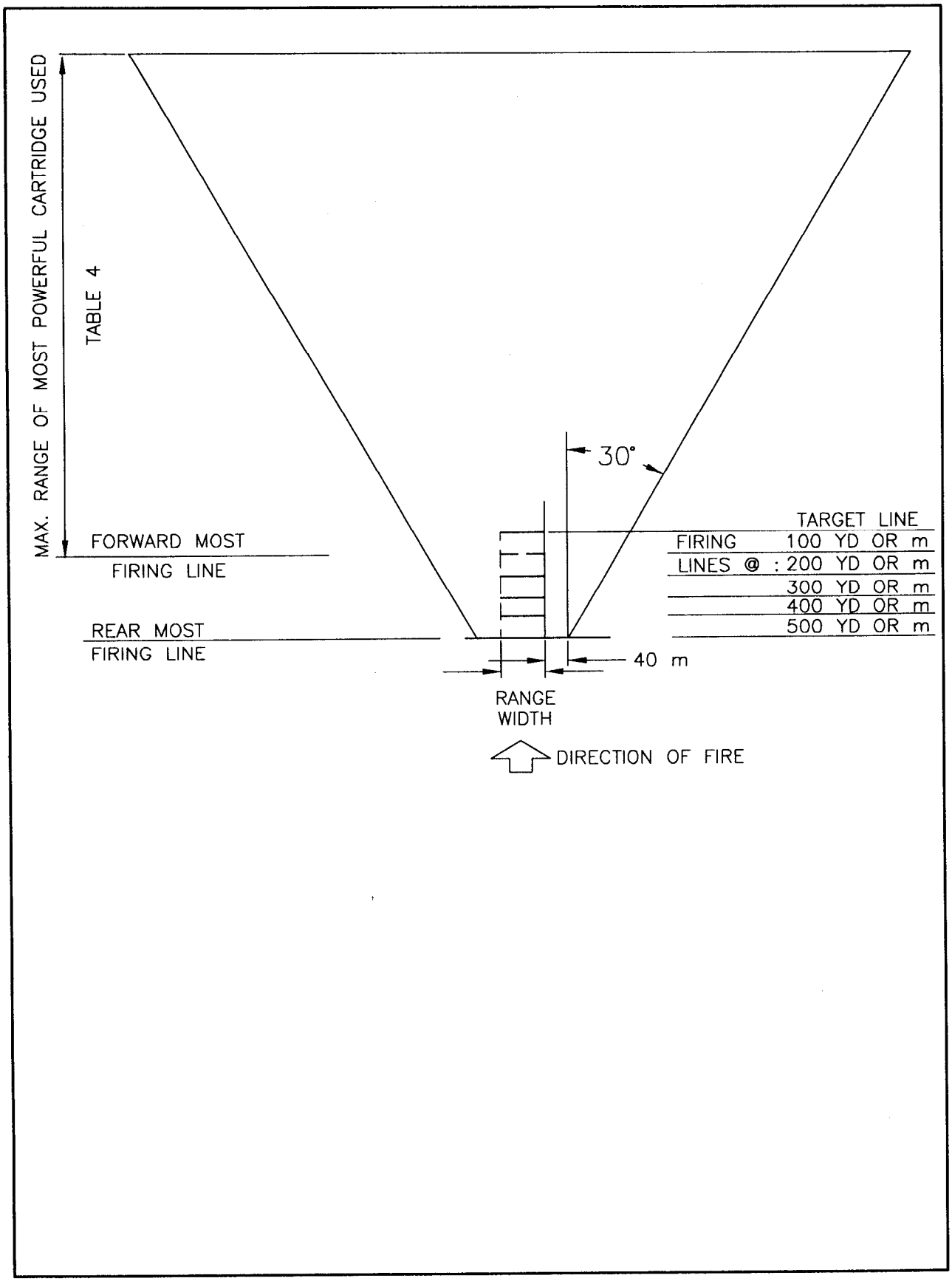


Figure 2.2-2
Surface Danger Zone for Small Arms Weapons Firing at Fixed Ground Targets - Open Range (Type "0") With Rocky Soil or Target Causing Ricochet

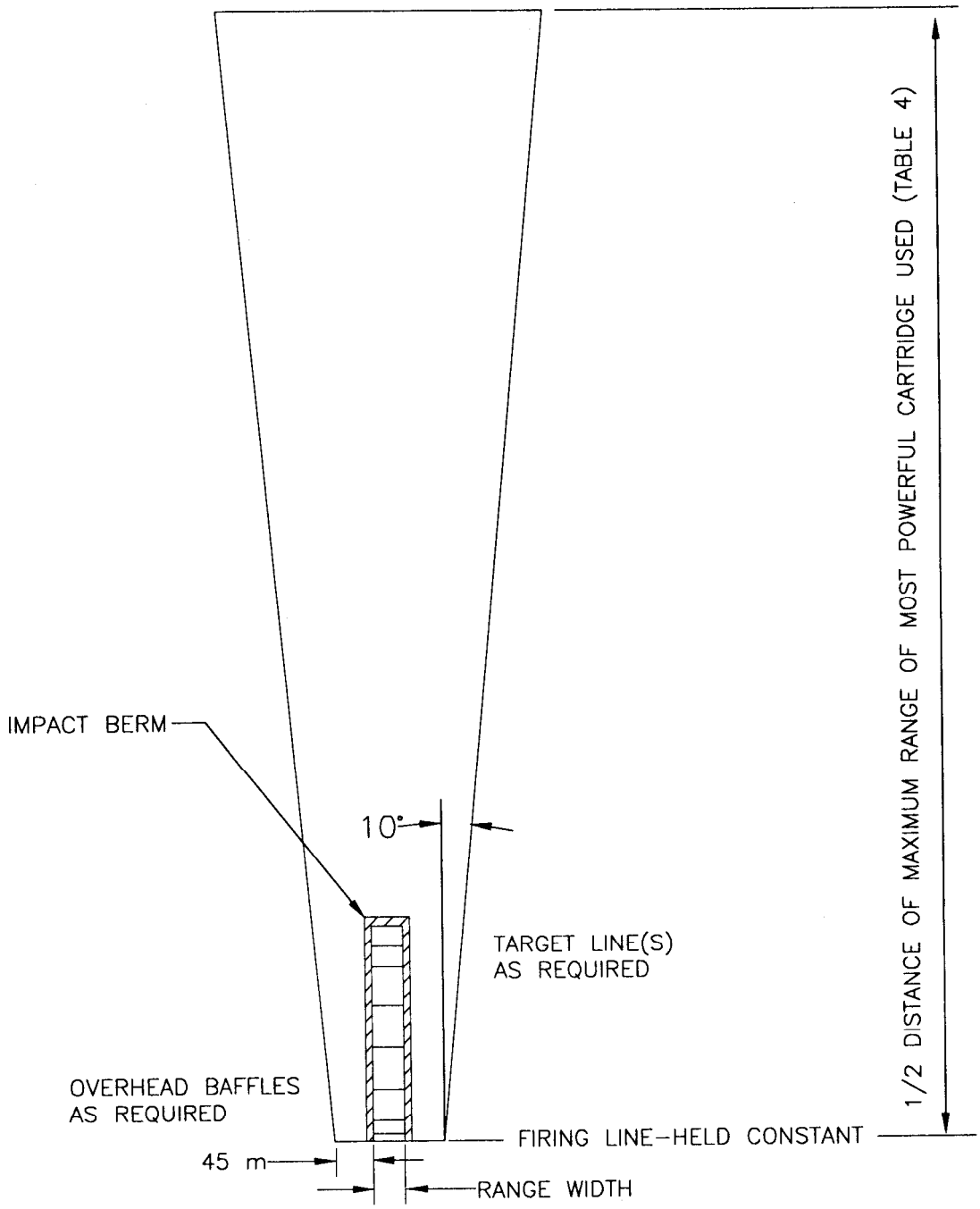


Figure 2.2-4
Surface Danger Zone for Small Arms Weapons Firing at Fixed Ground Targets - Partially Baffled Range (Type "PB")

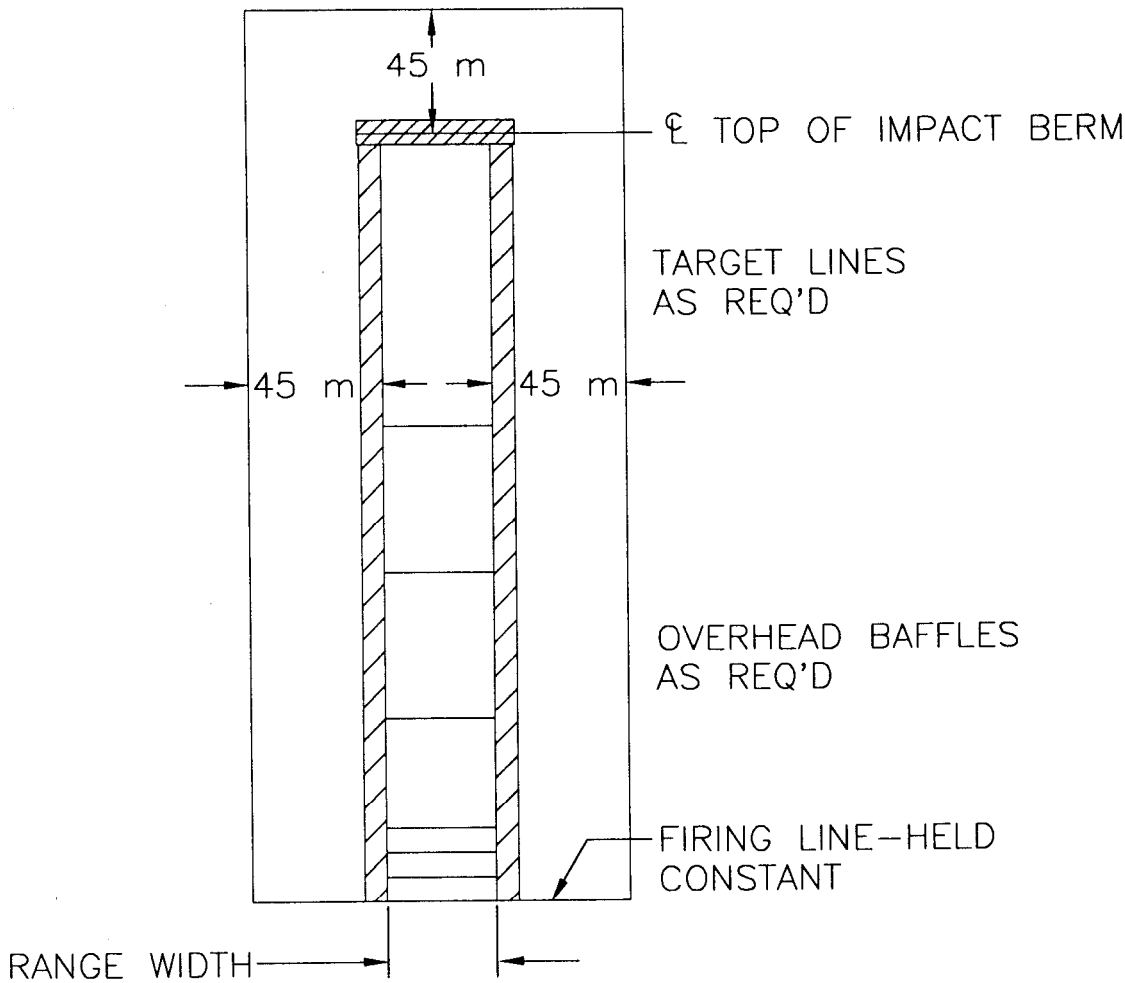


Figure 2.2-5

Surface Danger Zone for Small Arms Weapons Firing at Fixed Ground Targets - Fully Baffled Range (Type "FB")

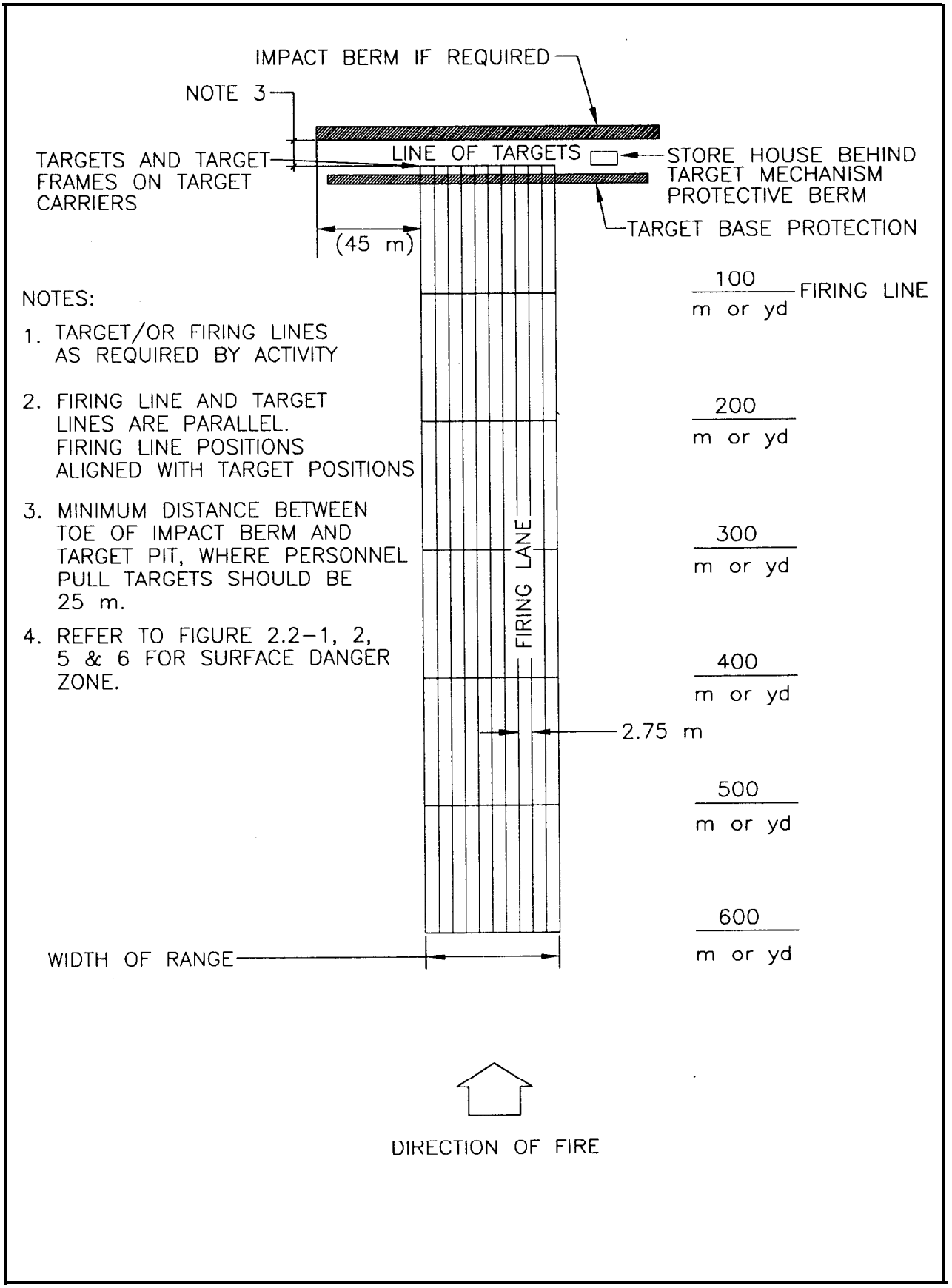


Figure 2.2-6
Outdoor Rifle Range Layout

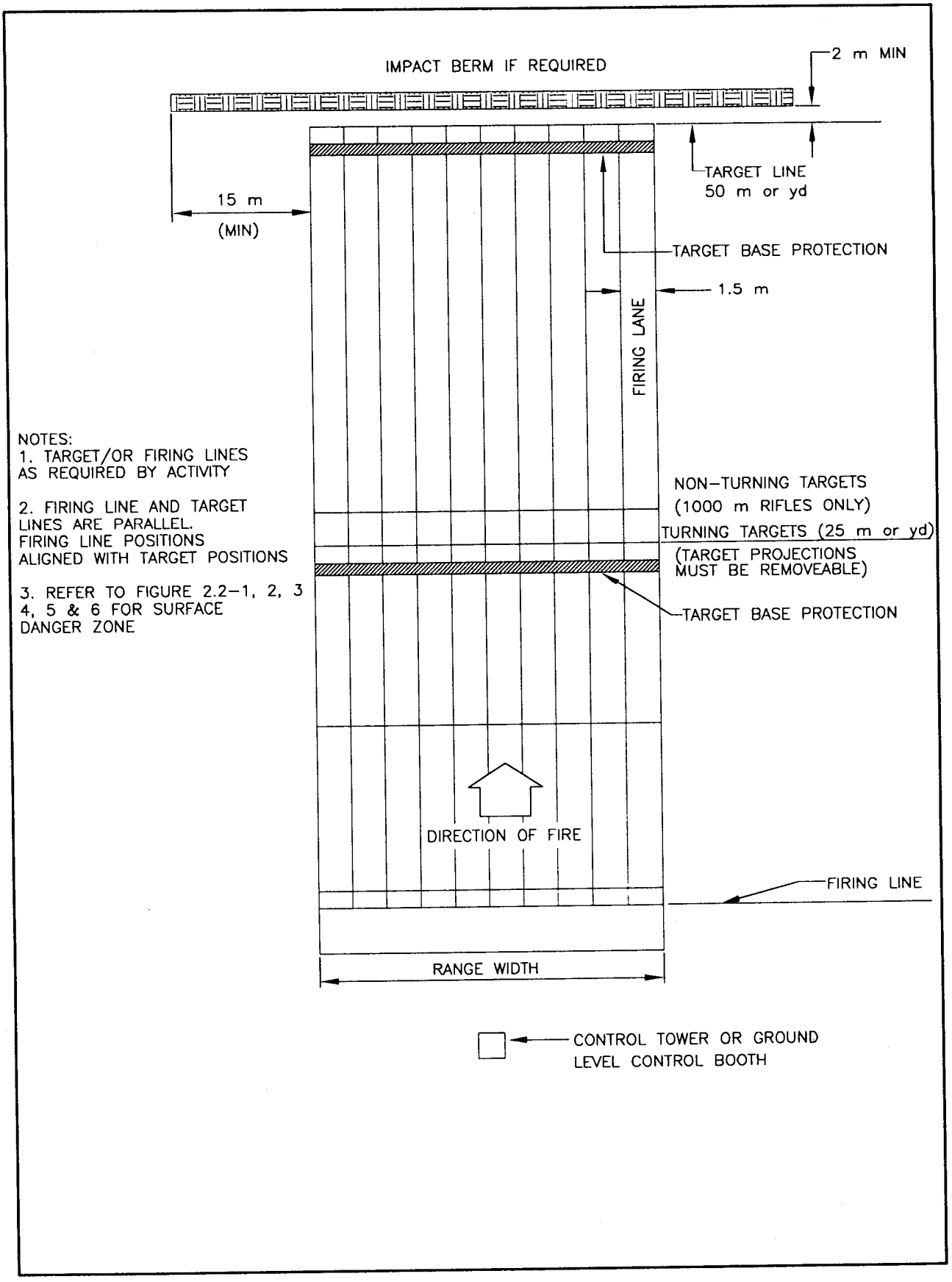
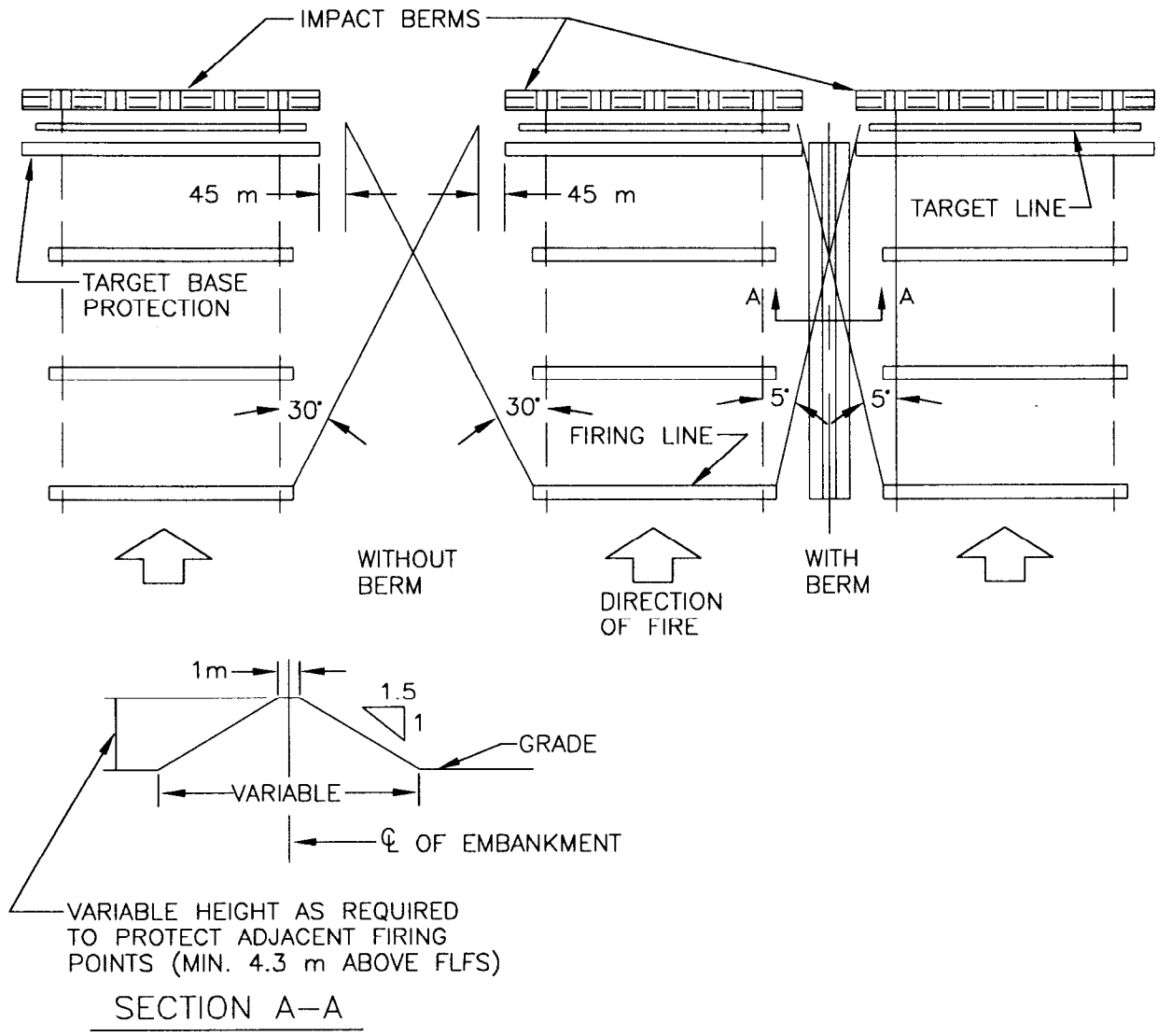


Figure 2.2-7
Outdoor Pistol Range Layout



NOTE: SAFETY ARCS FOR PARALLEL UNBERMED RANGES MAY OVERLAP AS, SHOWN, BUT NOT CLOSER THAN 45 m TO THE ENTRY POINT FOR THE TARGET PITS ON THE ADJACENT RANGE ANOTHER SPACE. WHEN THIS IS NOT POSSIBLE AND THE REQUIREMENT EXISTS FOR SIMULTANEOUS OPERATION OF ADJACENT RANGES, A SEPARATING WALL OR EMBANKMENT WILL BE REQUIRED. THE LENGTH OF THE WALL OR EMBANKMENT SHALL BE FROM THE MOST DISTANT FIRING LINE TO THE TARGET PITS. THE WALL MAY BE 200 mm THICK CONCRETE, 300 mm THICK CONCRETE MASONRY-GROUT FILLED OR EQUIVALENT.

Figure 2.2-8
Parallel Ranges

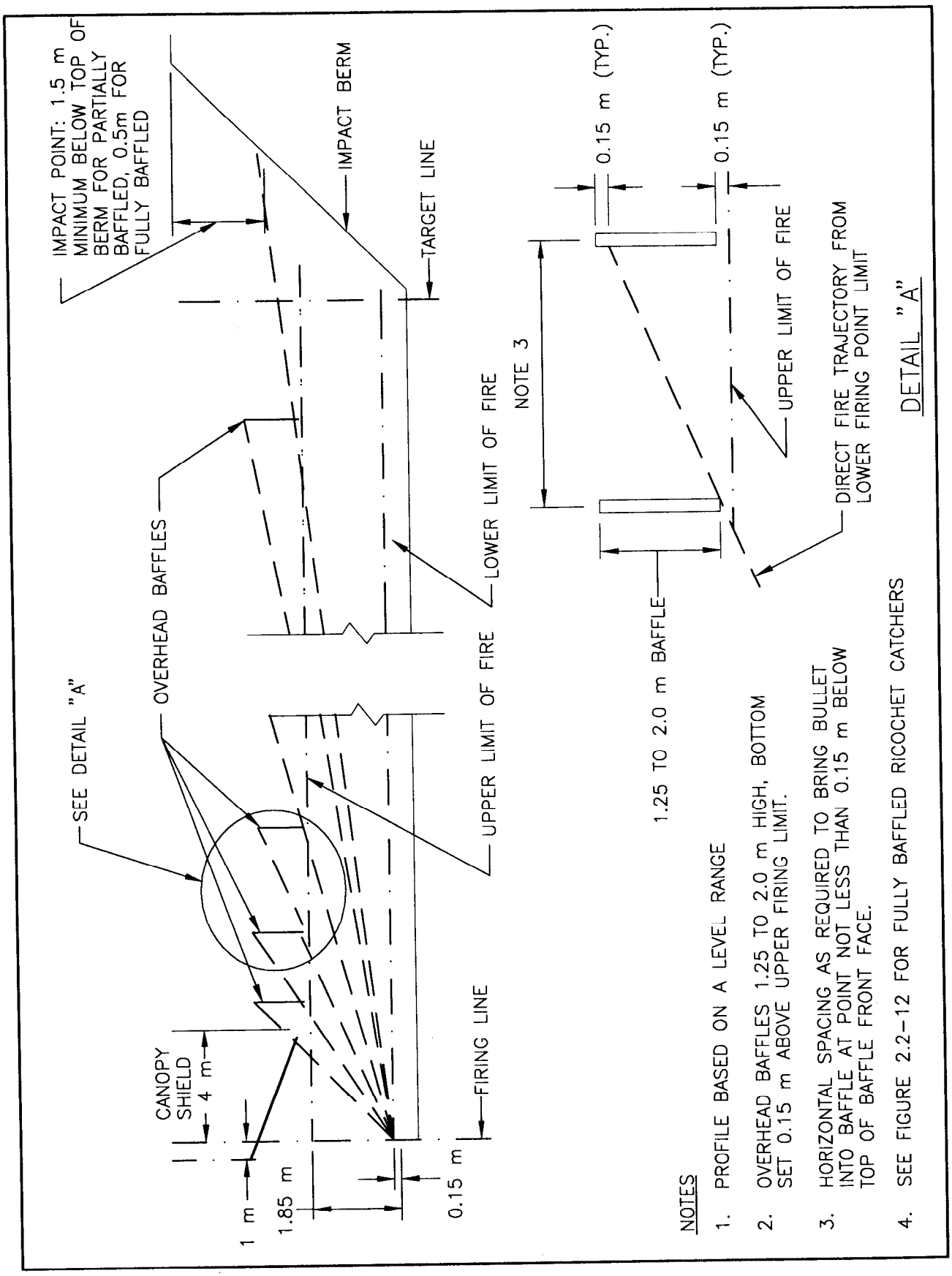


Figure 2.2-9
Baffled Range Profile

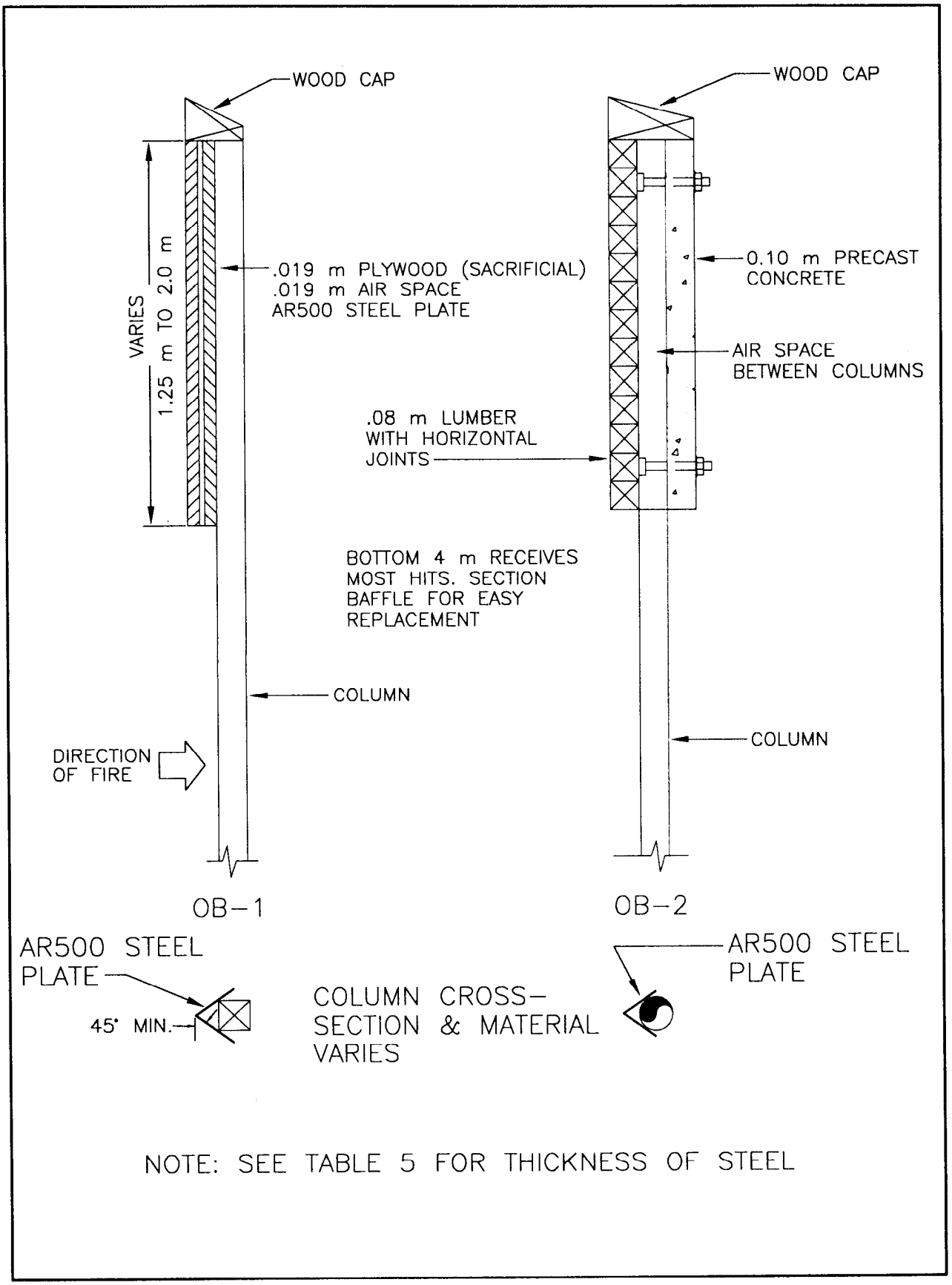


Figure 2.2-10
Overhead Baffle

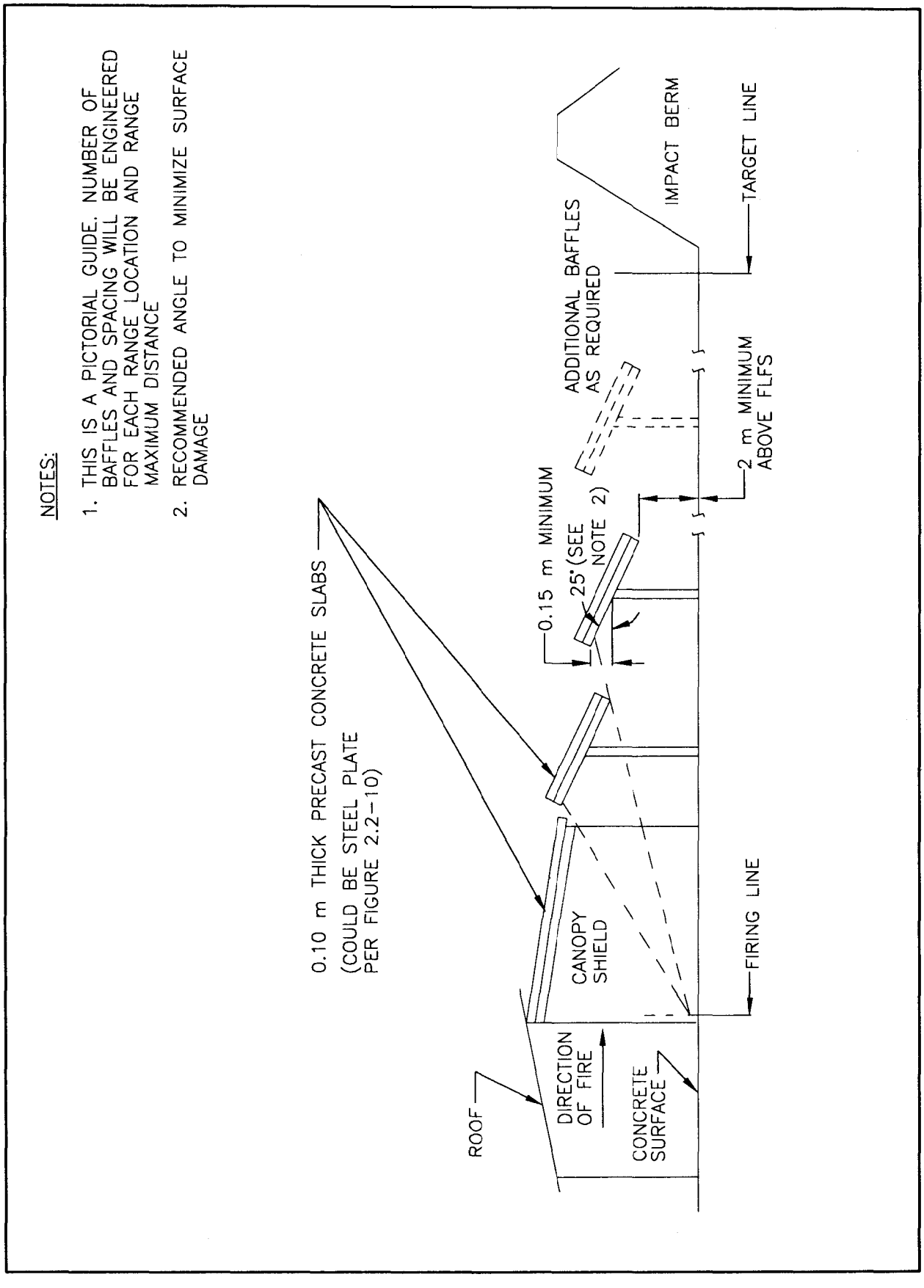


Figure 2.2-11
Alternate Overhead Baffle Arrangement

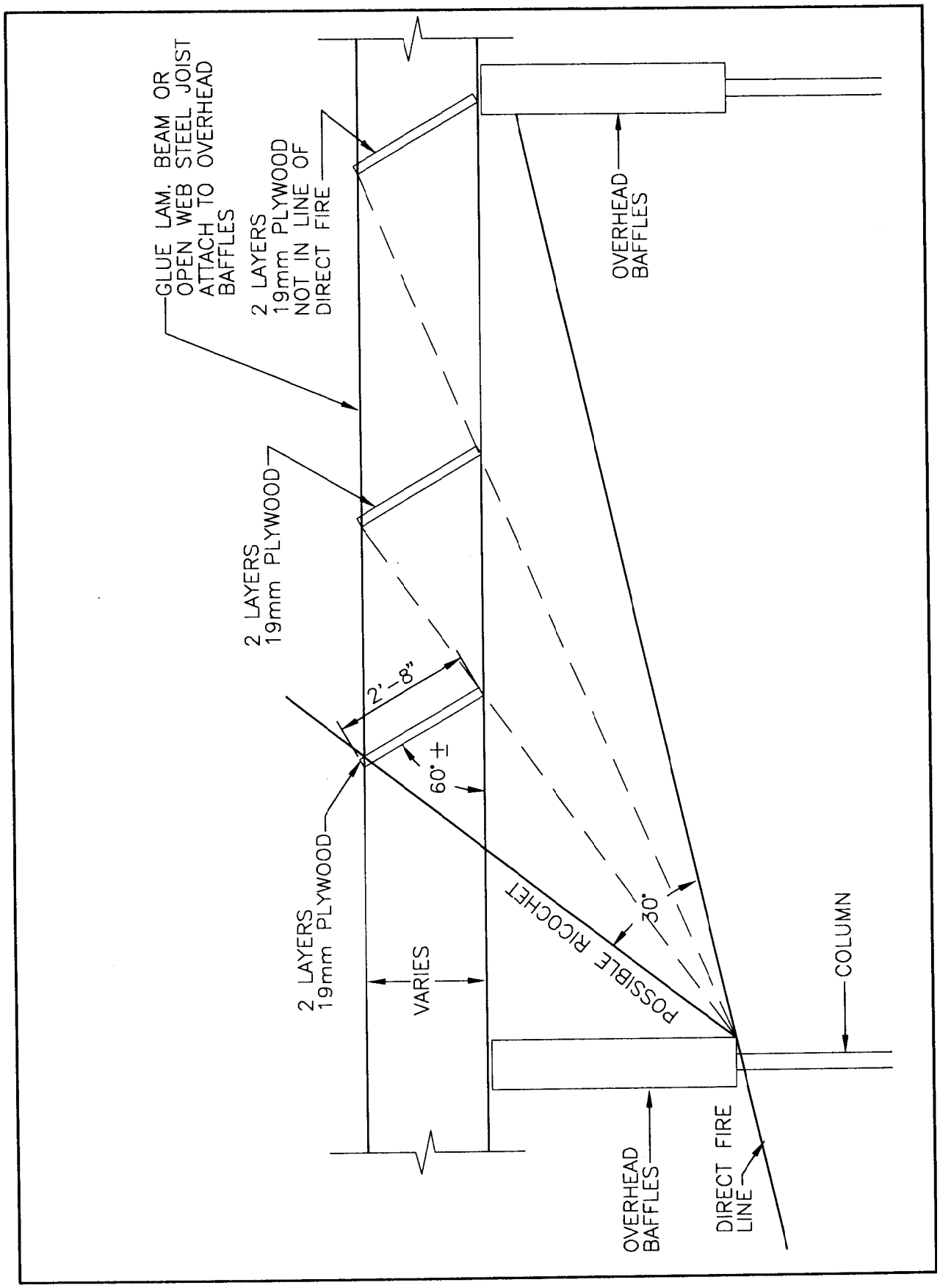
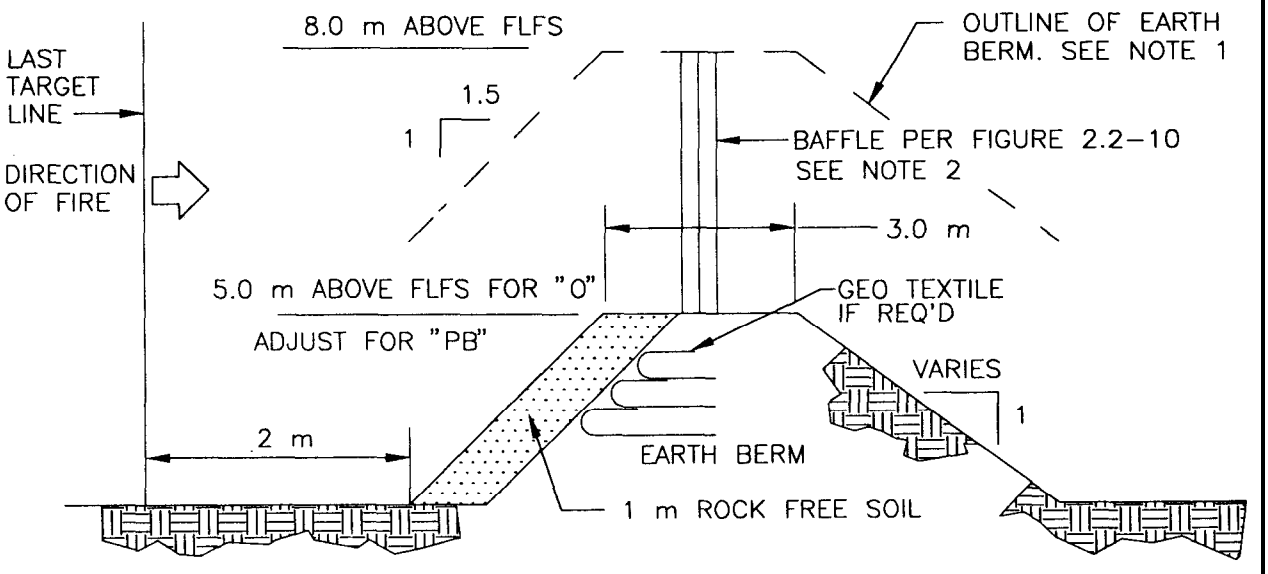


Figure 2.2-12
Ricochet Catchers



NOTE

1. OUTLINE OF IMPACT BERM IF ALL EARTH BERM IS USED IN LIEU OF COMBINATION EARTH BERM/BAFFLE.
2. BALLISTIC MATERIAL TO SPAN FULL HEIGHT.

Figure 2.2-13
Impact Berm for Types "0" and "PB" Ranges

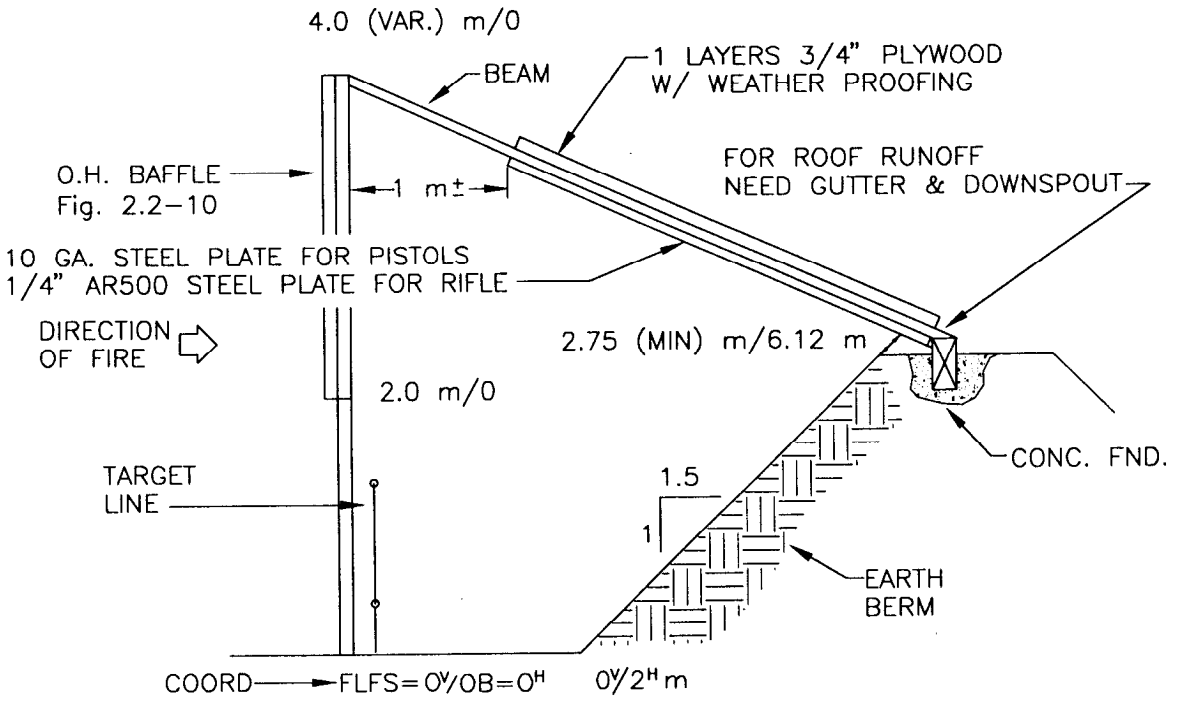


Figure 2.2-14
Bullet Trap

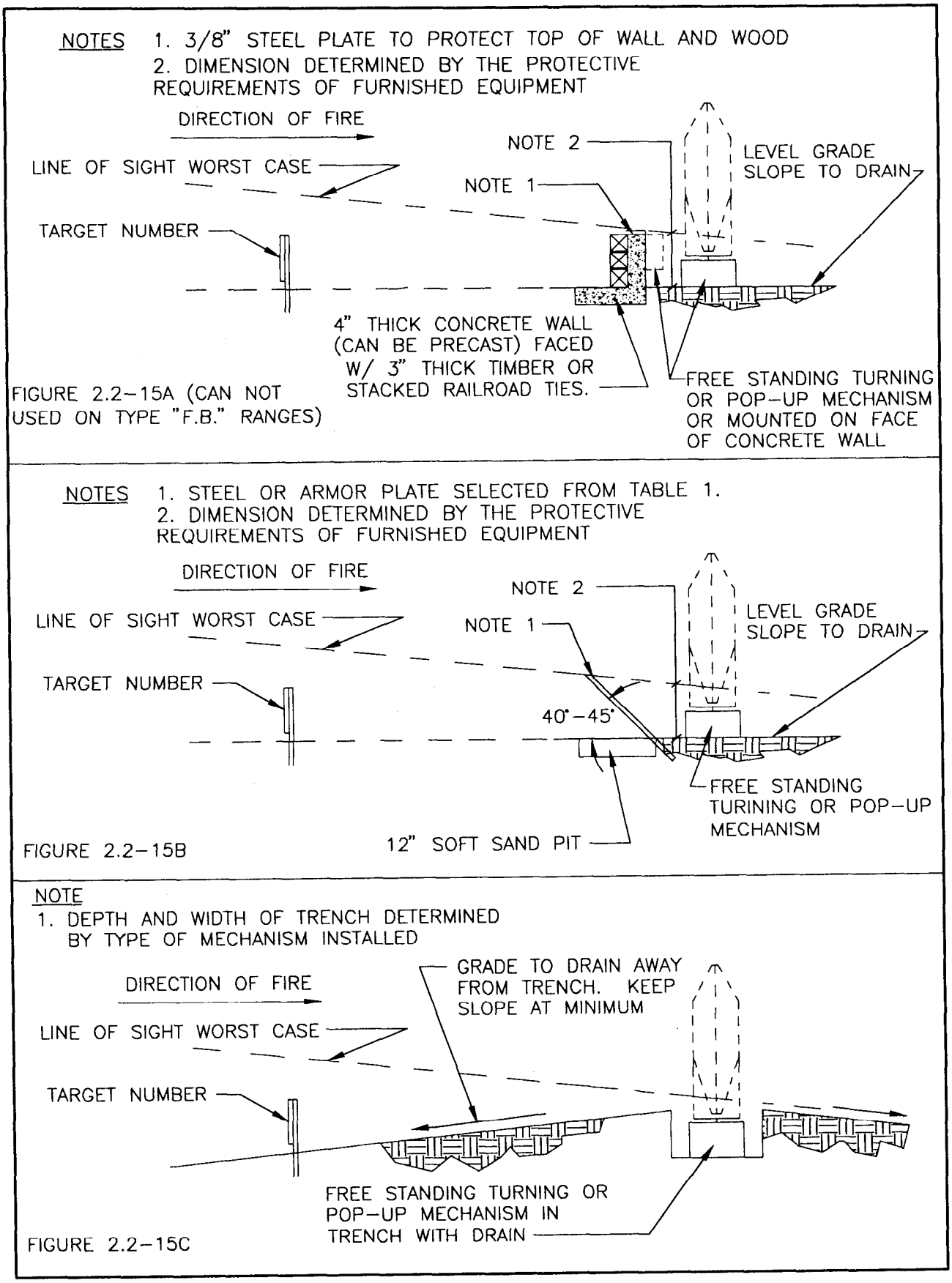


Figure 2.2-15
Ballistic Protection of Target Mechanism

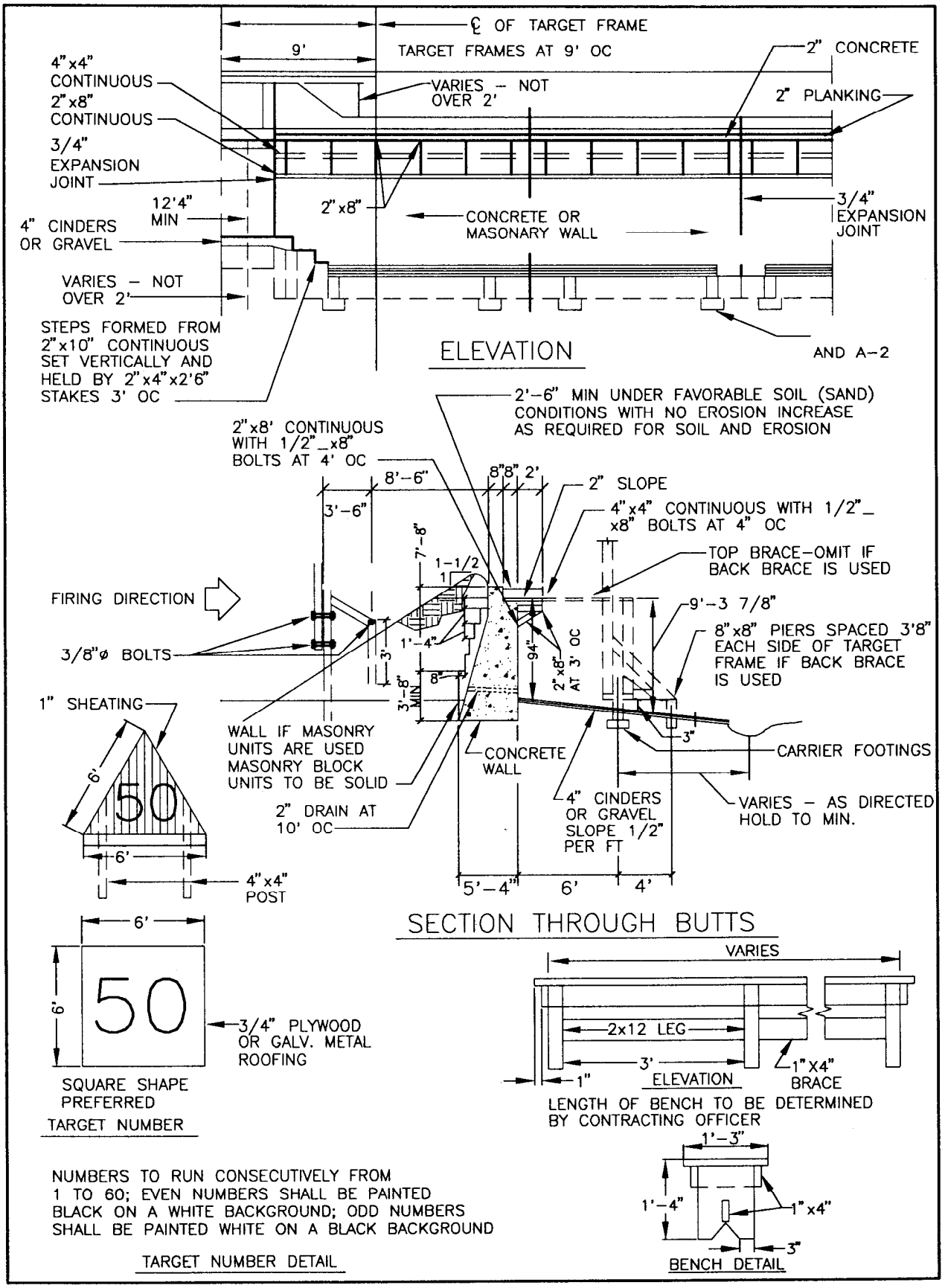


Figure 2.2-16
Target Butts Details

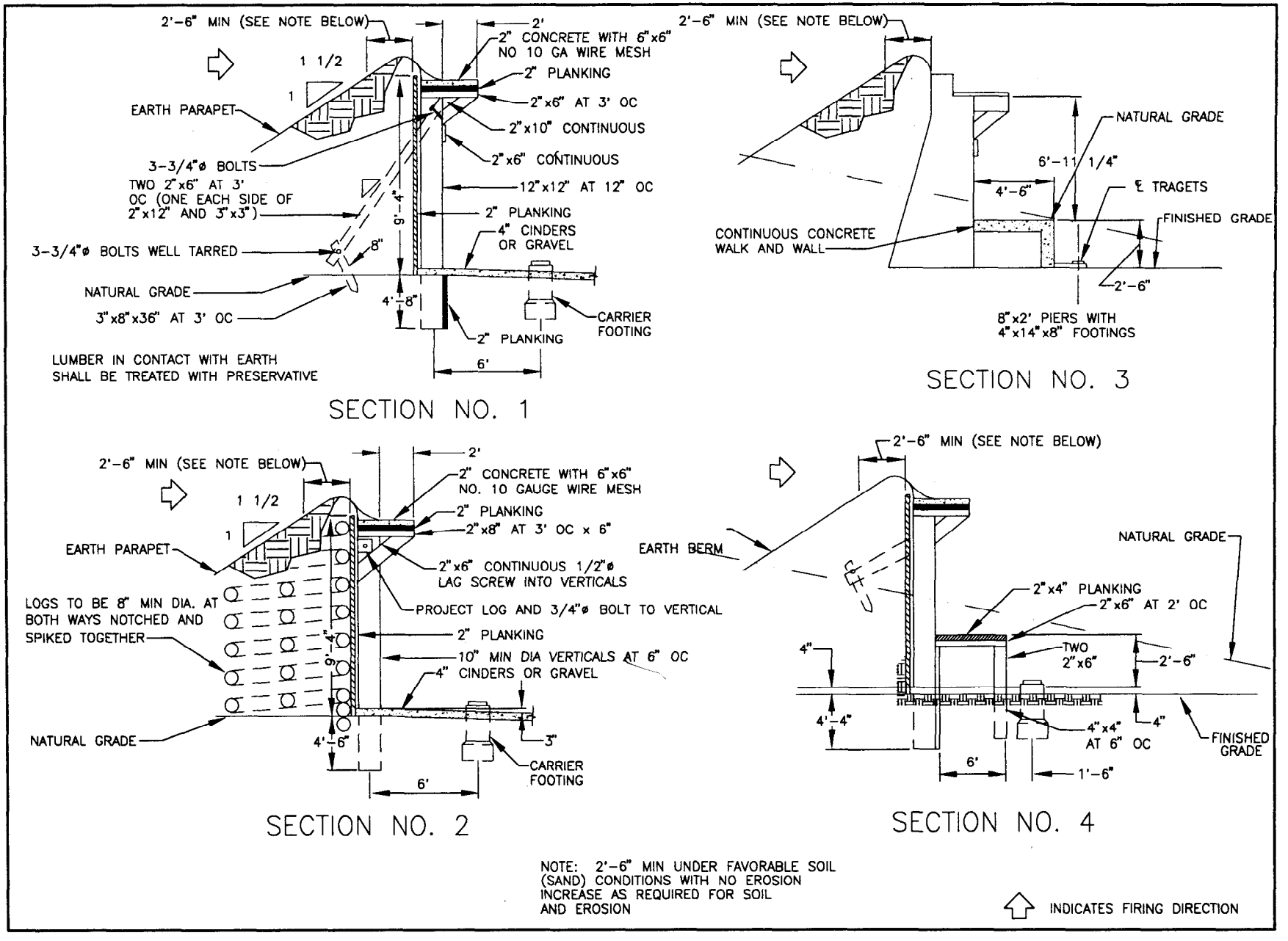
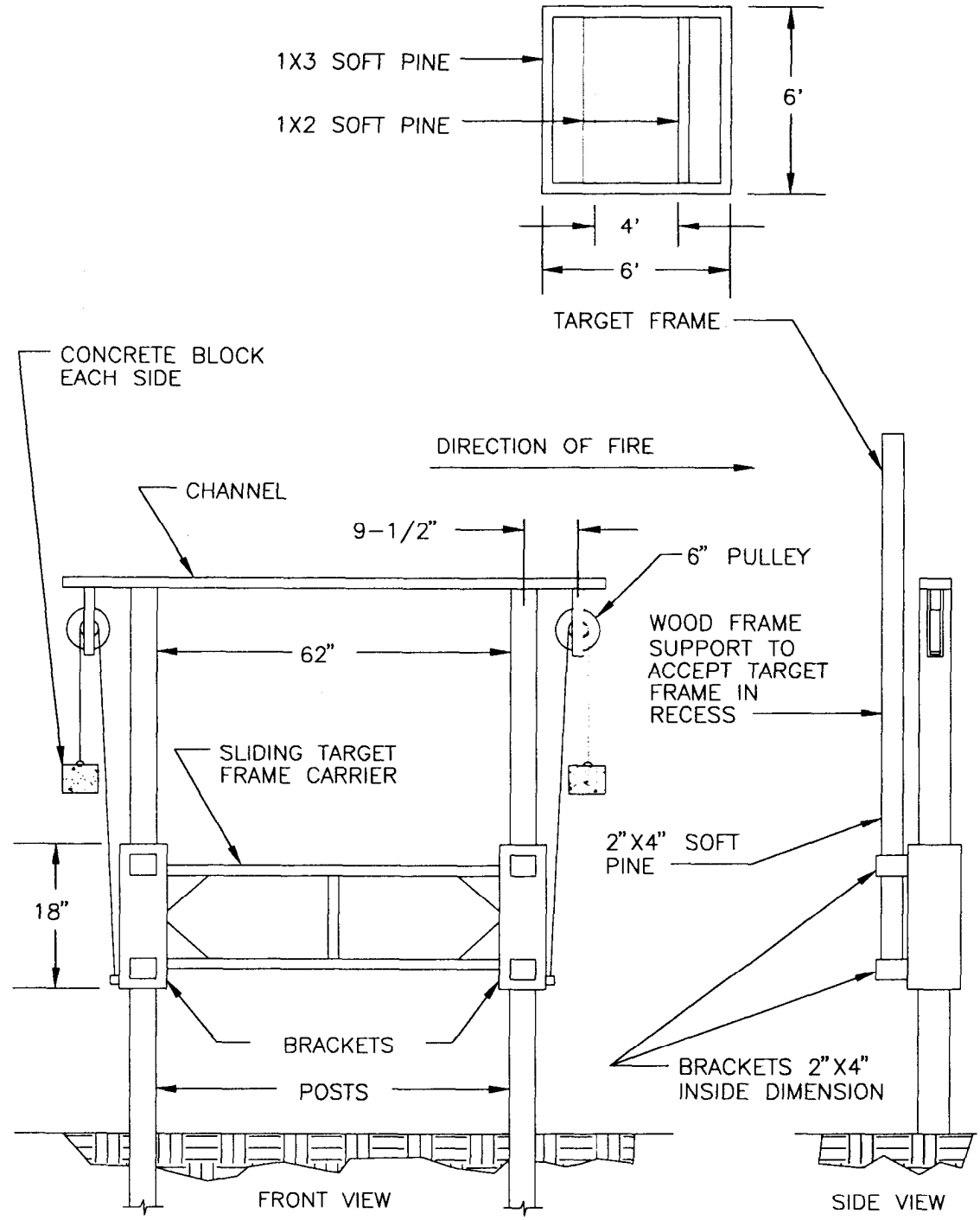
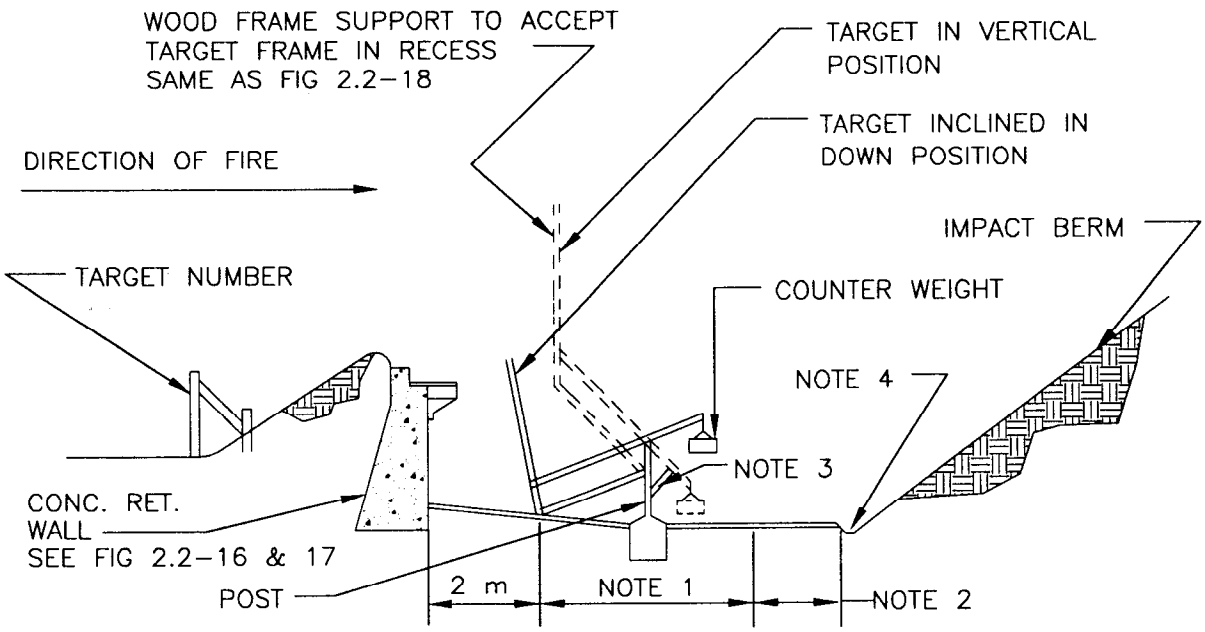


Figure 2.2-17
Alternate Target Butts



NOTE: ENTIRE TARGET IN RAISED POSITION MUST BE VISIBLE FROM EVERY SHOOTING POINT AND EVERY FIRING POSITION

Figure 2.2-18
Rifle Range Target Carrier



SECTION

NOTES:

1. **DISTANCE AS REQUIRED BY CARRIER MECHANISM HOLD TO MINIMUM.**
2. **DISTANCE TO ALLOW EQUIPMENT ACCESS FOR MAINTENANCE OF CARRIER AND SLOPE**
3. **MECHANISM STOP TO ALIGN ALL TARGETS AT CORRECT HEIGHT**
4. **MAKE PROVISIONS FOR DRAINAGE**
5. **ENTIRE TARGET MUST BE VISIBLE FROM EVERY SHOOTING POINT AT EVERY FIRING POSITION**

Figure 2.2-19
Paraleg Target Carrier

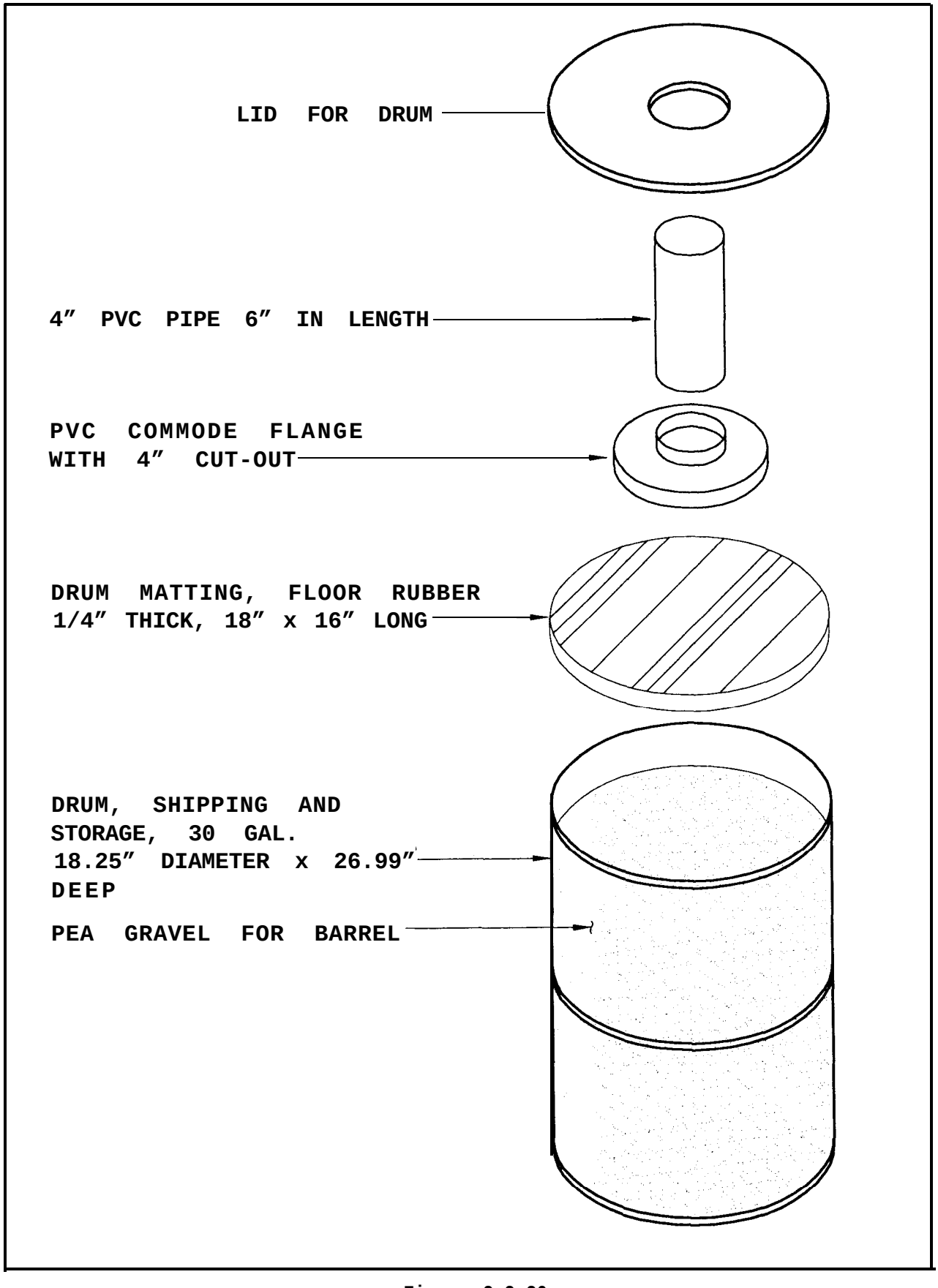


Figure 2.2-20
Weapons Clearing Barrel Parts List

Section 3: COMMON RANGE FACILITIES

3.1 Siting. Range geometrics and surface danger zones given in the design manual reflect ideal siting. Small arms ranges require point targets and prepared firing positions. Heavy weapons ranges are area oriented, have longer distances, and require mixed targets in target areas. Combining the use of surface real estate and joint use *of* support facilities in conjunction with a range complex or new weapons on existing range must be considered on an individual basis. Common impact areas and overlapping surface danger zones of adjoining ranges may be allowed *if* weapons system characteristics *are* compatible and training requirements are not compromised. As an example, artillery firing points should not be located adjacent to rifle ranges as the noise detracts from live-fire training. The station Explosive Ordinance Disposal (EOD) officer and the Safety Officer must be included in *any* discussion *of* impact area safety. Guidelines for siting ranges are as defined in paras. 3.1.1 through 3.1.6.

3.1.1 Location. Safety is the prime consideration in locating a range. The characteristics and ballistics of the weapons systems for which the range is designed determine the selection of the site. The use of training ammunition versus use *of* service ammunition will determine size of *area* required. Range design objective is to contain the firing ammunition and explosives within the range real estate during training and target practice. The locations *of* the firing points, impact areas, and surface danger zones for the weapons to be used must be laid out to form a ground footprint on the station maps. Then the aerial easements, approach altitudes, and run-in lines for aircraft ranges must be superimposed on the ground footprint to confirm appropriate siting. Determine acceptable noise levels on adjacent inhabited areas. Consider the added risk of accidental misdirected firing into adjacent areas.

Locate aircraft ranges and gunnery ranges so that firing and impact areas are at least the same distances from ammunition and gasoline storage as is required for inhabited buildings. Where available areas are limited, these distances may be reduced to that required for public highways. *For* purposes of maintaining safe distances, routes for public land and areas of intermittent public use (such as cemeteries, outdoor recreational areas, and private utilities) shall be treated the same as inhabited buildings: Navigable waterways and railroad lines shall be treated the same as public highways. *For* required Explosive Safety Arcs from inhabited areas and public highways, refer to NAVFAC P-80 and NAVSEA OP-5, Ammunition Ashore Handling, Stowing and Shipping.

Surface danger zones must be under U.S. Government control. If not under total Government control, area access shall be limited to prescribed times for commercial activities such as fishing, grazing or mining, or firing shall be limited to prescribed times.

Selection of the site will also consider the following:

a) The effect that range construction and range operation will have on endangered species of wildlife (if any) and on proper land use policies.

b) Preservation of important survey monuments in the area, especially those of U.S. Coast and Geodetic Survey.

c) Common use of roads, messhalls, other training facilities applicable to several ranges.,

d) Decontamination of unexploded ordnance and cleanup of inert debris.

e) Target setup, maintenance, and repair.

3.1.2 Orientation. All firings shall be conducted in a direction away from ammunition and gasoline storage and inhabited areas. Trajectories shall not pass over an ammunition or gasoline storage area. Orient the range so that gunners will not be firing into rising or setting sun.

3.1.3 Terrain. Firing into upward sloping land and land with natural backstop of hills or mountains is recommended. Land with good natural drainage and which is mostly barren of ignitable grass, timber, and underbrush is preferable. Firing platforms, access and range roads, and targets are to be elevated above flood level. The line of fire in rough terrain should be perpendicular to high ground. The line of fire on flat terrain should be free of knolls, ridges, and trees which reduce visibility. Known distance ranges should be as horizontal as possible. Firing points may be below the target provided the grade between the points and target does not exceed two percent. Ricochet cannot be completely eliminated, but can be reduced by level terrain, soft soil, and elimination of hard objects. For heavy weapons, impact areas must be clear of target debris and old projectiles. Earth berms should be used to the rear of target areas. Earth berms may be used on sides of the range to protect timber, game, recovery metal salvage, and possible reduction of impact areas.

Roads used for setting and servicing targets in impact areas and for maintenance of earth berm slopes may be graded pathways. Roads in areas not subject to disturbance such as vehicle parking area, projectile weapons firing and maneuvering areas, and roadways behind firing line or out of range of weapons, will be improved road of compacted subbase with compacted gravel base, or compacted gravel or crushed stone on compacted cement or asphalt stabilized sand, designed for anticipated vehicle weight and usage. Layout for tank trails and roads for other heavy tracked or lugged vehicles should be planned to avoid damage to improved roadway surfaces.

3.1.4 Access and Range Roads. Provide access roads for transporting personnel, supplies, and equipment to ranger and to service targets within target areas. Refer to NAVFAC DM-5.4, Pavements, and Army TM 5-822-2, General

Provisions and Geometric Design for Roads, Streets, Walks, and Open Storage Areas, for criteria for pavements and roads. Access roads to aircraft weapons ranges will be run diagonal to the aircraft run-in lines.

3.1.5 Restricted Area Airspace. For restricted area airspace criteria to be Applied to target and range requirements for aircraft weapons, refer to NAVFAC P-80. Requests for designation, alteration. establishment. or revocation of speciale airspace shall follow the procedures outlined In OPNAVINST 3770.2G, Airspace Procedures Manual. The Federal Aviation Act of 1958 charges the Federal Aviation Administration (FAA) with ensuring the safe and efficient use of the nation's airspace by military as well as civilian aviation.

3.1.6 Range Design Review. Range facilities shall be built in accordance with current safety standards at time of design. This is particularly important because of new weapons constantly coming Into the weapons arsenal and personnel training is often performed on existing ranges developed for older weapons and ammunition. Where existing range construction and surface danger zone characteristics are not in conformance with design criteria requirements, range evaluation and design recommendations nay be obtained by requesting assistance from COMNAVFACENGCOM.

3.2 Security. Provide manned or unmanned barriers to prevent passage of personnel or vehicles through the range during operation. Display red flags during firing and provide blinking red lights to supplement red flags at night. Install signs warning of danger, trespassing, and removal of items on ranges. Include security precautions for areas made hazardous because of jettisonned casings and links from aircraft firing at ground targets. Coordinate range security with explosive ordnance removal operations. At remote or unmanned equipment installations, security fencing may be necessary to protect Against vandalism and trespass. When security fencing is required, refer to NAVFAC DM-5.12, Fencing, Gates, and Guard Towers.

3.3 Support Facilities. Facilities which may be common to all ranges include the following:

a) Targets (expendable, not pert of design criteria).

b) Target storage.

c) Bunkers, trenches, and protective barriers for protection of personnel.

d) Range control towers.

e) Firing and maneuvering platforms for heavy weapons.

f) Toilets.

g) Range poles, banners, markers, and signs.

h) Communications systems.

i) Boat docks for water target areas.

j) Access and range roads.

k) Parking areas.

l) Bivouac facilities.

n) Potable water.

n) Demolition facilities.

o) Range grounds maintenance equipment.

p) Target maintenance.

q) Ammunition supply and service facilities. For arms and ammunition storage requirements refer to OPNAVINST 5530.13, Physical Security Instruction for Sensitive Conventional Arms, Ammunition and Explosives, and MIL-HDBK-1013/1, Design Guidelines for Physical Security of Fixed Land-based Facilities.

r) Vehicle service facilities.

s) Fire protection.

t) First aid-ambulance emergency service.

3.4 Design of Support Facilities

3.4.1 Illumination. If the ranges are used for night training, provide illumination for the aiming points and operational instruments, such as target rakes And plotting boards (if scoring is manual).

3.4.2 Utilities. Utility designs shall conform to the requirements of NAVFAC DM-3.01, Plumbing Systems; MIL-HDBK-1004/1, Preliminary Design Considerations; and MIL-HDBK-1005/3, Drainage Systems.

3.4.2.1 Electric Power. Where commercial power is unavailable, power generation equipment shall be provided.

3.4.2.2 Water Supply. Potable water is desirable at ranges and other training facilities; however, water supply provisions will be a site and project specific consideration. All water supply development should consider criteria contained in MIL-HDBK-1005/7, Water Supply Systems.

3.4.3 Structural Design. The design of structures required for ranges shall conform to the applicable sections of MIL-HDBK-1002/1, Structural Engineering Central Requirements.

3.4.4 Mechanical Requirements. Refer to NAVFAC DM-3.03 for mechanical requirements criteria.

Section 4: AIRCRAFT WEAPONS RANGES

4.1 Descriptions. Aircraft weapons ranges will be designed to provide areas and facilities for the training of air crews in gunnery, bombing, rocketing, missile delivery, strafing, mine laying, and close air support. Distances related to aircraft weapons ranges are given in nautical miles.

4.1.1 Restricted Area. This is an airspace identified by an area on the ground and prescribed height within which the flight of aircraft, while not wholly prohibited, is subject to restriction.

4.1.2 Surface Impact Area. The surface impact area is designated for the impact of ordnance material. hempassing is prohibited in this ground because of imminent danger. The impact area is within the approved surface danger zone which contains impact areas, appropriate ricochet areas, and secondary danger areas (when required) which are located around the impact area and are provided to contain ricochet projectiles and fragments from items exploding or ricocheting on the edges of the impact area.

The size of the appropriate surface danger zone will be determined during the planning phase. The surface danger zone must be under U.S. Government control. There are differing safety problems for inert and live ammunition and explosives on a design project. On live fire ranges, the handling of duds affects range clearance, setting of targets, and types of targets.

4.1.3 Water Danger Area. This is an area of water in which all craft operating on or beneath the surface, while not wholly prohibited, are subject to restrictions.

4.1.4 Air Space Requirements. The limitation on usable airspace is a major factor in planning aircraft weapons ranges. area requirement is based on the operational requirements for aircraft to complete firing runs involving time and speed, target towing and tow-track deviation, projectile envelope, and safety buffer zone. The restricted airspace established for the range must be coordinated through the Navy representative to the FM in the cognizant region in accordance with OPNAVINST 3770.2G.

4.1.5 Ricochets. Inert training weapons including rockets and bombs, pose problems that full-scale weapons usually do not. An inert weapon creates ricochet problems when the missile hits the ground at shallow or flat impact angles. One type of practice bomb includes water-sand fills that simulate the size, weight, and shape of general all-purpose bombs. The heavier Bomb Dummy Unit (BDU) say be 500 to 2,000 lb (227 to 909 kg) and after initial impact, the BDU still has most of its impact velocity. When defining the safe area where release of the heavy inert general purpose bombs is planned, the ricochet potential may dictate the deciding distances.

There is little documentation on ricochet phenomenon except from certain weapons testing ranges (usually larger than air crew training ranges). Information received from Naval Weapons Center, China Lake, CA, is as follows: For 20 mm ammunition fired at 10 to 30 degree attack angle on air-to-ground targets where the target area contains rock, boulders, hard pm, or where targets are hard, such as armored tanks, the maximum expected downrange ricochet distance is 12,000 ft (3657.6 m) from center of target, the maximum expected side-range ricochet distance is 4,000 ft (1219.2 m), from center of target, and maximum expected ricochet height is 3,500 ft (1066.8 m).

Where the target area is loose sand, soft clay or a material that is free from rocks, boulders, and large quantities of spent ammunition, the maximum expected downrange ricochet distance is 9,000 ft (2743.2 m) from center of target, the maximum expected side-range ricochet distance is 2,700 ft (823 m), and the maximum expected ricochet height is less than 3,500 ft. Current information should be obtained when designing ranges. The use of frangible bombs has been tested, but economic or other factors may preclude their general use on all ranges.

4.2 Siting. Aircraft ranges should be located within a maximum 100 ml (160.9 km) distance from the supporting air installation.

4.3 Strafing Range. A strafing range is used for air-to-ground firing Of aircraft weapons such as 20 mm automatic cannon.

4.3.1 Site. The strafing range shall consist of a restricted airspace With a minimum radius of five nautical miles, and a surface-impact area measuring 1 by 1/2 ml (1.6 km by 0.8 km) located in the center of the restricted area. See Facility Plate No. 179-10, Sheet 1, for strafing range. The restricted airspace is needed to encompass the flight pattern of high-speed jet aircraft during approach, recovery, and circling for new approaches to the target. The surface impact area should be sited in all areas approved by Station ordnance officer and in a remote location where ricochets, strays, and falling brass and links will not jeopardize surrounding property or personnel. Periodically sanitizing the impact areas is required maintenance.

4.3.2 Targets. Design criteria for strafing targets vary according to local training programs. See Facility Plate No. 179-10, Sheet 2, for acoustiscore strafing target. Targets may consist of automatic recording targets, simulated gun emplacements, aircraft, or portable target panels. For a typical strafing target, see Facility Plate No. 179-10, Sheet 3.

4.3.2.1 Cease Fire Point. A cease-fire point for strafing runs shall be indicated either by a 15 x 600 ft (4.57 x 183 m) white "foul" line on the ground or by pylons (with height and color readily visible to pilots) spaced 600 ft apart. The foul line or pylons shall be on a line projected from the control tower and perpendicular to the aircraft run-in line.

4.3.2.2 Target. The target proper shall be located at the center of the surface impact and shall be placed 1,200 ft (365.7 a) behind the foul line and on its perpendicular bisector.

4.3.2.3 Run-in Line. The run-in line shall be marked between the foul line and the target by placing a 2 ft wide (0.61 an stripe on the ground along the perpendicular bisector. The stripe may be broken with alternate 100 ft (30.48 m) lines and 50 ft (15.2 m) spaces.

4.3.3 Control Tower. The control tower shall be situated so that unobstructed vision of the target area and of the aircraft using the range is assured. The tower floor shall be at least 15 ft (4.57 m) above the ground and shall provide adequate weather protection for operating personnel and equipment. Provide the control tower with a water supply system, sanitary facilities and storage space for maintenance equipment. Air Conditioning may be necessary for equipment, if not for human comfort. Locate the tower 1,000 ft (304.8 m) from, and on a line perpendicular to, the run-in line. The perpendicular line will be located 1,200 ft (366 m) ahead of the target.

4.3.4 Equipment. The control tower shall be equipped for two-way radio communication with aircraft and with telephone or radio communication with the supporting station, and shall house the recording portion of the remote scoring device so that information regarding hits can be relayed to the pilot.

4.4 High-Altitude Level- Bombing Range. The high-altitude level-bombing range provides facilities for pinpoint bombing at altitudes up to approximately 50,000 ft (15 240 m) in level flight, with or without altitude maneuvering devices.

4.4.1 Site. The high-altitude level-bombing range shall comprise a restricted area having a minimum radius of 5 mi (8.05 km) and a central surface impact area with a radius of 3 mi (4.8 km).

4.4.2 Targets. Criteria for designing targets are described in paras. 4.4.2.1 through 4.4.2.5.

4.4.2.1 Aiming Point. Locate the aiming point to provide a line of sight from an aircraft 10 mi (16.09 km) away, approaching at an altitude of 50,000 ft (15 240 m).

4.4.2.2 Pyramids. Provide and locate mobile radar-reflective pyramids for offset-bombing exercises at established geographic positions as required by local range operations.

4.4.2.3 Clear Area. Provide a clear area having a radius of 1,500 ft (457.2 a) with the aiming point as its center. The area shall be free from vegetation and topographic features that can obstruct visibility from the control tower and from spotting towers.

4.4.2.4 Typical Aiming Point. A typical aiming point is a solid-white circular area on the ground, the size of which varies as visibility requirements change. Illuminate the aiming point for night training.

4.4.2.5 Trailer. The range area should also contain suitable locations for a radar-reflective trailer to be placed up to 10 mi (16.09 km) from the target for use as an offset aiming point in offset-bombing exercises.

4.4.3 Initial Points. The initial points of aim shall be radar-reflective pyramids, either fixed or mobile, depending on local requirements, and shall be elevated above any vegetation or obstruction so as to be clearly visible to pilots of approaching aircraft. A typical initial point should be pyramid shaped, of frame construction, painted international orange, 6 ft high (1.83 m) with a 6 sq ft base (0.56 sq m). (See Facility Plate No. 179-10, Sheet 4.)

4.4.4 Control Tower. Locate the control tower outside the 3 mi (4.8 km) radius of surface impact, on a line projected through the riming point, and perpendicular to the primary run-in line. Requirements for the control tower shall be the same as those for the strafing range control tower.

4.4.5 Spotting Towers. Where remote spotting devices are not used, two spotting towers are necessary. Spotting towers shall meet the same requirements as the control tower regarding elevation, visibility, weather protection, and distance from the aiming point. The spotting towers on Weapons Impact Scoring Set (WISS) instrumentation ranges will contain cameras and will be unmanned.

4.4.6 Equipment. Criteria for equipping the control tower and spotting towers are given in paras. 4.4.6.1 and 4.4.6.2. The designer should request appropriate Commander, Space and Naval Warfare Systems Command (COMSPAWARSYSCOM) criteria from the user for radio and telephone communication provision to be included.

4.4.6.1 Communication. Where a remote controlled spotting device is used, the control tower shall be equipped with two-way radio communication with aircraft. and with telephone or radio communication with the supporting station, and electronic equipment to record the position of bomb impacts. When manned spotting towers are used, the control tower shall be provided with additional equipment to provide telephone or radio communication to the spotting towers.

4.4.6.2 Range Instrumentation Equipment. The control tower may serve as the command and control center for the range or range complex. It may house the equipment to integrate all electronic scoring, data management, and communication with the air crews. The unmanned spotting towers will contain closed circuit television cameras remotely operated, sending signals to the control tower.

4.5 Multipurpose Target Range. The multipurpose target range is used for training in conventional dive bombing, high-altitude dive bombing, glide bombing, strafing, and in firing air-to-ground 2.75 (FFAR) folding fin aircraft rocket, or 5.0 FFAR Zuni rockets. Inert training weapons are normally used with small charges to facilitate spotting. See Facility Plate No. 179-10, Sheets 5 and 6, for Multipurpose Target Lunges.

4.5.1 Site. The range shall consist of a restricted area with a minimum radius of 5 mi (8.5 km) and a surface impact area with a radius of 1-1/2 mi (2.41 km) in the center. See Facility Plate No. 179-10, Sheet 6, for Multipurpose Range.

4.5.2 Targets. Provide a clear area having a radius Of 1,500 ft (457.2 m), with the aiming point as its center. The aiming point shall be a solid white circular area on the ground with a radius of 10 ft (3.05 m). There shall be a method of illuminating the aiming point for night training. The area shall be fully visible from the control tower and spotting towers. See Facility Plate No. 179-10, Sheet 7, for Multipurpose Target and Facility Plate No. 179-10, Sheet a, for Alternate Multipurpose Target. For an alternate rocket target, see Facility Plate No, 179-10, Sheet 10.

4.5.3 Initial Points. Depending on local requirements, initial points of aim shall be either fixed or mobile. When visual reference is necessary, the point shall be elevated above any vegetation or obstruction so as to be clearly visible to approaching pilots for a distance of 5 mi (8.5 km). Each range shall have available a supply of both radar-reflective and nonreflective initial points.

4.5.4 Flight Path Markers. The flight path may be marked at 500 ft (152.4 m) intervals for 3,000 ft (914.4 m) on either side of the aiming point. The markers may be 5 sq ft (0.46 sq m) whitewashed rock or three, painted, earth-filled oil drums lashed together.

4.5.5 Control Tower. The control tower shall conform to the requirements for the strafing range control tower. Locate the tower a minimum of 4,000 ft (1219.2 m) (6,000 ft (1828.8 m) is desirable) from the aiming point and on a. line projected through the aiming point perpendicular to the primary run-in line.

4.5.6 Spotting Towers. The spotting towers shall meet the same requirements as the control tower regarding elevation, vision, and weather protection. Criteria for spotting towers requirements are described in paras 4.9.6.1 and 4.5.6.2.

4.5.6.1 Air-to-Ground Range. Two spotting towers for the rocket range will be located on a line perpendiiular to and 1,500 ft (457.2 m) on each side, of the flight path. The perpendicular line will be located 1,500 ft ahead of the target.

4.5.6.2 Bombing Ranges. Two spotting towers will be located a minimum of 4,000 ft (1219.2 m) from the target and approximately equally spaced from each other and the control tower.

4.5.7 Rake Shacks (For Manual Scoring). Locate two rake shacks as shown for spotting towers in Facility Plate No. 179-10, Sheet 5, for rocket bombing target.

4.5.8 Dive Bombing Range. Multi-target flight path is shown In Facility Plate No. 179-10, Sheet 11. See Facility Plate No. 179-10, Sheet 12, for dive bombing range. The target for minimum altitude release is shown in Facility Plate No. 179-10, Sheet 13.

4.5.9 Equipment. Criteria for equipping the control tower and spotting towers are described in paras 4.5.9.1, 4.5.9.2, and 4.5.9.3.

4.5.9.1 Communication. Provide two-way radio communication with aircraft. telephone communication with the spotting towers, and telephone or radio communication with the supporting station.

4.5.9.2 Plotting and Recording (For Manual Scoring). Provide a dive-angle "harp" to obtain data during dive-bombing exercises, a theodolite or target rake for measuring the angular displacement of the bomb impact from the target center, and a plotting board for marking impacts as they are called in from the spotting towers. Equip each spotting tower with a target rake and a telephone for reporting to the main control tower.

4.5.9.3 Electronic Scoring. Refer to High-Altitude Level-Bombing Range for equipment for a WISS instrumentation range.

4.6 Loft-bombing. Loft Bombing enables a pilot to release a bomb in such a manner as to loft it, thus gaining time for the aircraft to escape from the impact area at low altitude. The loft-bombing range is highly Instrumented for practice bombing with simulated nuclear weapons and other conventional weapons. The loft-bombing range provides training in self-protection against nuclear-weapon effects (and special conventional weapons), detection, and retaliatory ground fire. This facility is used for training in the low-level delivery of special weapons, end is to include loft, toss, and over-the-shoulder techniques. See Facility Plate No. 179-10, Sheet 14, for Loft-Bombing Range.

4.6.1 Site. The loft-bombing range comprises an extensive area.

4.6.1.1 Restricted Airspace. The restricted airspace includes a five rile radius from target center, from surface to 24,000 ft (7315.21) above target, and multiple approach corridors extending 25 mi (40 hr) from target center. A 6 mi (9.66 km) width is required when alternate left or right escape maneuvers us performed. Clearance above the corridors is 3,000 ft (914.4 m) for the

first 10 mi (16.1 km) of the approach, 5,000 ft (1524 m) for the next a mi (12.8 km), and 9,000 ft (2743.2 m) for the remaining two miles to the airspace cylinder around the target center. See Facility Plate No. 179-10, Sheet 15.

4.6.1.2 Impact Area. The surface impact area has a minimum radius Of 1-1/2 mi and is centered on the target.

4.6.1.3 Single Direction Approach. The requirement for a single-direction approach to the target is a rectangular area one mile wide by 20 mi (32 km) long, preferably having its length aligned with the prevailing wind. This area is necessary to encompass the approach, pullup, and recovery of high speed jet aircraft using the range. See Facility Plate No. 179-10, Sheet 16, for flight path profile. The first 10 mi (16.1 km) of this primary approach lane is to permit speed stabilization of the aircraft before beginning the actual bombing run. The second 10 mi (16.1 km) of the primary approach is for recorded practice bombing runs, which necessitate installation of instrumentation and markers along the flight path.

4.6.1.4 Multi-Direction Approach. A multi-direction approach may be considered in range planning to avoid the detrimental effect on pilot training caused by frequent repetition of the single-direction approach. A minimum of two secondary approaches to the target is desirable, each measuring 1 x 20 mi (1.6 km x 32.18 km). See Facility Plate No. 179-10, Sheet 17, for flight path profile for primary and secondary approach. The two approaches shall be from directions as widely divergent as local conditions permit and shall be oriented to prevent training aircraft from passing over the control tower or spotting towers. Flights over the secondary lanes are not recorded except for the point of bomb impact; however, initial point markers are required at specified locations on the approach lanes. For one type of bull's-eye lighting for target requisition, refer to Appendix A, Figure A-12.

4.6.2 Targets. Provide a clear area having a minimum radius of 1,500 ft (457.2 m), with the aiming point as its center.

4.6.2.1 Aiming-Point Elevation. The aiming point shall have an elevation sufficient to provide a line of sight to it from an aircraft 50,000 ft (15 240 m) away, approaching at an altitude of 100 ft (30.4a m) above the extant terrain.

4.6.2.2 Aiming Point Construction. A typical aiming point in flat, open country should consist of three walls, each 30 ft high by 60 ft long (9.1 m by 18.3 m), forming an equilateral triangle. See Facility Plate No. 179-10, Sheet 18, for vertically-developed target. It should be of frame construction, painted international orange, and oriented so that the primary run-in line forms the perpendicular bisector of one leg of the triangle.

4.6.3 Initial Points. Initial points of aim shall be either fixed or mobile, depending on terrain conditions and local requirements, and shall be elevated above any vegetation or obstruction so es to be clearly visible to pilots Of approaching aircraft.

4.6.3.1 Spacing. Initial points shall be placed on each run-in line at 10,000, 15,000, 20,000, 30,000, 40,000, and 50,000 ft (304a, 4572, 6096, 9144, 12 192 and 15 240 m) from the target. The points on the primary run-in line shell be radar reflective. All others shall be nonreflective.

4.6.3.2 Details. Details of typical initial points shall be the same as for the High-altitude Level-bombing Range. (See Facility Plate No. 179-10, Figure 3.)

4.6.4 Distance Markers. The primary aircraft approach lane is normally marked, in the last 10 mi (16.09 km) to the target, every 5,000 ft (1524 m) with 8 x 12 ft (2.44 x 3.66 m) markers. The numeral indicating thousands of feet is 7 ft (2.13 m) high. (See Facility Plate No. 179-10, Sheet 19.)

4.6.5 Control Tower. The loft foot bombing range control tower shall be located approximately 20,000 ft (6096 m) from the primary run-in line on a line perpendicular thereto and a maximum of 12,000 ft (3657.6 m) ahead of the target. The tower floor shall be approximately 70 ft (21.34 m) above the ground.

4.6.6 Spotting Towers. Three spotting towers shall be located at 120 intervals on a circle 6,000 ft (1828.8 m) in radius, having the target as its center and the spotting tower furthest from the control tower being on a line perpendicular to the primary run-in line at the center of the target.

4.6.7 Equipment. Provide the loft-bombing range with electronic scoring equipment.

4.7 Aerial Mining Range. An aerial mining target range is used for training proficiency in the release of mines from aircraft. A water danger zone, as shown in Facility Plate No. 179-10, Sheet 20, is assigned for this purpose and only training shapes are used. Fleet operations using aerial mines during maneuvers have special areas designated by the Fleet Commander for a temporary period. The planning information contained herein pertains to training facilities associated with fleet Support air stations. The water depth and bottom conditions that apply to fleet operations are not applicable to a normal aerial mining range training facility.

4.7.1 Site. The airspace-restricted area shall measure a minimum of 3 x 8 mi (4.82 x 12.87 km) and shall be coincidental with the surface-impact area on the water. The length should be parallel to the coastline for maximum visibility from the control tower and spotting towers.

4.7.2 Targets. Normally, the target area should be located along an irregular coastline having readily identifiable landmarks. Specific pinpoint targets, if desired, shall be constructed and located recording to local range requirements. For typical water target, see Facility Plate No. 179-10, Sheet 21. For typical water target details, refer to Facility Plate No. 179-10, Sheet 22.

4.7.3 Initial Points. Initial points of approach may be prominent landmarks. Redar-reflective initial points may be used recording to local range requirements in lieu of, or in addition to, these landmarks (fixed or mobile).

4.7.4 Control Tower. The control tower shall conform to the requirements for the Strafing Range Control Tower (SRCT). Locate the control tower on the shoreline, a minimum of 3,000 ft (924 a) outside the surface danger area and as close as practicable to the midpoint of the length of the area.

4.7.5 Spotting Towers. Locate the spotting towers on the shoreline a minimum of 3,000 ft (914 m) outside the surface danger area and as close as practical to opposite ends of the longer dimension of the area. The spotting towers shall meet the same requirements as the strafing range control tower regarding elevation, visibility, and weather protection.

4.7.6 Equipment. The equipment required for the control tower and spotting towers shall be the same as that specified for the High-altitude Level-bombing Range (refer to para 4.4).

4.7.7 Small Boat Dock. If the range is located in a remote area, a small boat dock may be required for one or more 45 ft (13.72 m) picket boats. Refer to MIL-HDBK-1025/6, General Criteria for Waterfront Construction.

4.8 Close Air Support and Combat Training Area. A live ordnance Impact area is used for close air support training with live ordnance of various types, including high explosives, air-to-ground guided missiles, napalm bombs, and parachute flares.

4.8.1 Site. The range shall have a restricted area keeping other aircraft out with a minimum radius of 25 nautical ml. A rectangular surface-impact area of 16 x 20 nautical miles shall be located in the center of the restricted area. See Facility Plate No. 179-10, Sheet 23, for layout.

4.8.1.1 Description. Training ares will include remotely controlled pop-up, vehicle silhouette targets, and scored fire suppression strafing burners. The actual size pop-up targets should be consumables constructed of locally procured materials reproduced from centrally distributed patterns. The targets and pop-up operating mechanism should be mobile for redeployment within six hours. The pop-up mechanism should be buried and only the actuator arm(s) exposed to direct fire, inert practice ordnance (5.56 to S in. FFAR/155). Fire suppression/strafing banners should be scored, fixed sites. The banners should allow scoring over a 150 degree arc. This engagement latitude is necessary to properly score attack helicopter running fire (aircraft flight path different from turret firing direction), attack aircraft strafing engagements as well as suppressing fire from ground convoys and helicopter door gunners.

4.8.1.2 Surface Designation. The corners or extremities of the surface danger area shall be marked by permanent radar-reflective markers to facilitate positive identification from the air.

4.8.1.3 Fire Protection. In an area which is wooded or covered with other flammable vegetation, firebreaks shall be provided as required by the local fire protection engineer.

4.8.2 Targets. The impact area should encompass various types of terrain to provide more realistic training. Individual targets shall be determined by the local commands and may simulate the following: convoys, gun emplacements. mortar pits, airstrips, tanks, troops, and parked sircraft. Typical close air support targets are shown in Facility Plate No. 179-10, Sheet 24. For details of various targets, see Facility Plate No. 179-10, Sheet 25.

4.8.3 Control Tower. Provide one control tower for each target site. Control towers shall conform to the requirements for Strafing Range Control Towers with modifications as follow in paras 4.8.3.1 through 4.8.3.4.

4.8.3.1 Water and Sanitary Systems. If a range is operated on a full time basis, a water supply system and sanitary facilities shall be provided. All water supply and pollution control system development should consider criteria contained in MIL-HDBK-1005/7, Water Supply Systems, and MIL-HDBK-1005/8, Pollution Control Systems.

4.8.3.2 Security. Provide for locking and securing the tower if it is to be vacated for prolonged periods of time. In remote areas, provide fencing around tower to reduce tower access and control vandalism.

4.8.3.3 Safety. Locate towers to provide maximum safety for operating personnel.

4.8.3.4 Visibility. Locate towers to provide maximum visual coverage of range areas consistent with local topography and vegetation.

4.8.4 Spotting Towers. Provide two spotting towers for each designated target site. The spotting towers shall meet the same requirements as those specified for control towers.

4.8.5 Firehouse. In an impact area which is wooded or covered with other flammable vegetation, provide one building to house firefighting equipment. It shall meet the same requirements as those specified for control towers concerning weather protection, personnel safety, water supply, sanitary facilities, and locking and securing.

4.8.6 Equipment. For control towers and spotting towers, provide the same equipment as specified for High-altitudes Level-bombing Ranges (refer to para 4.4). If the firehouse is not immediately adjacent to the control tower, it

shall be provided with telephone or radio equipment for communication with the tower. Provide the type and number of pieces of firefighting equipment in accordance with local range requirements.

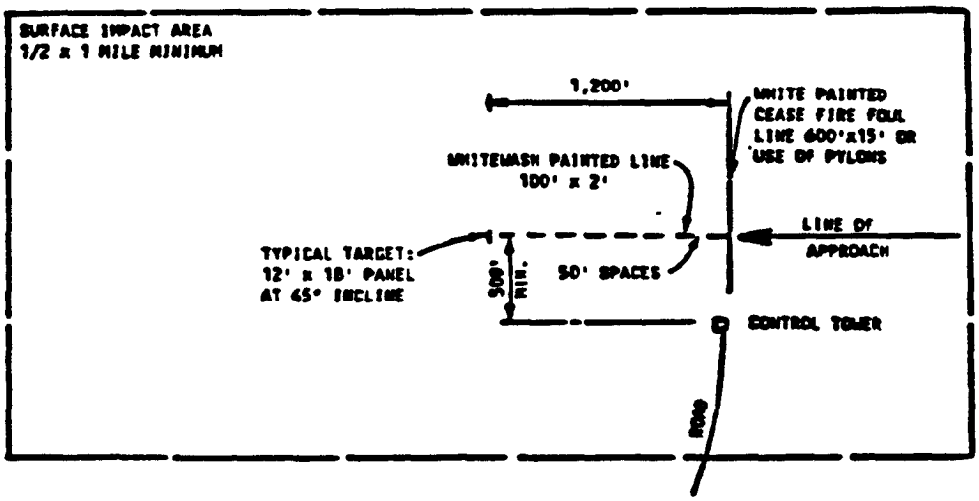
4.9 Guided Missile Range. The air-to-ground guided missile target range is used for training in controlled air-to-ground missiles. Refer to NAVFAC P-80 for airspace and impact area requirements and to the close air support and combat training area for target, towers, and equipment requirements. See Facility Plate No. 179-10, Sheet 26, for typical restricted area.

4.10 Air-to-Air Weapons Range. An air-to-air gunnery and rocket firing range is a rectangular area, preferably over water. Ground personnel and structures are not required. Refer to NAVFAC P-80 for surface impact areas. Facilities will be designed if requirements include Tactical Aircrew Combat Training System (TACTS). The TACTS provides real time monitoring and postexercise evaluation of aircrew performance in air combat maneuvering, simulated air-to-air and air-to-ground missile firings, no-drop bomb, and aerial ninelaying scoring. Banner drop areas and cable cutter are areas where towed aerial targets may be released and land to be retrieved and used again. Criteria for locations of area must be requested from user.

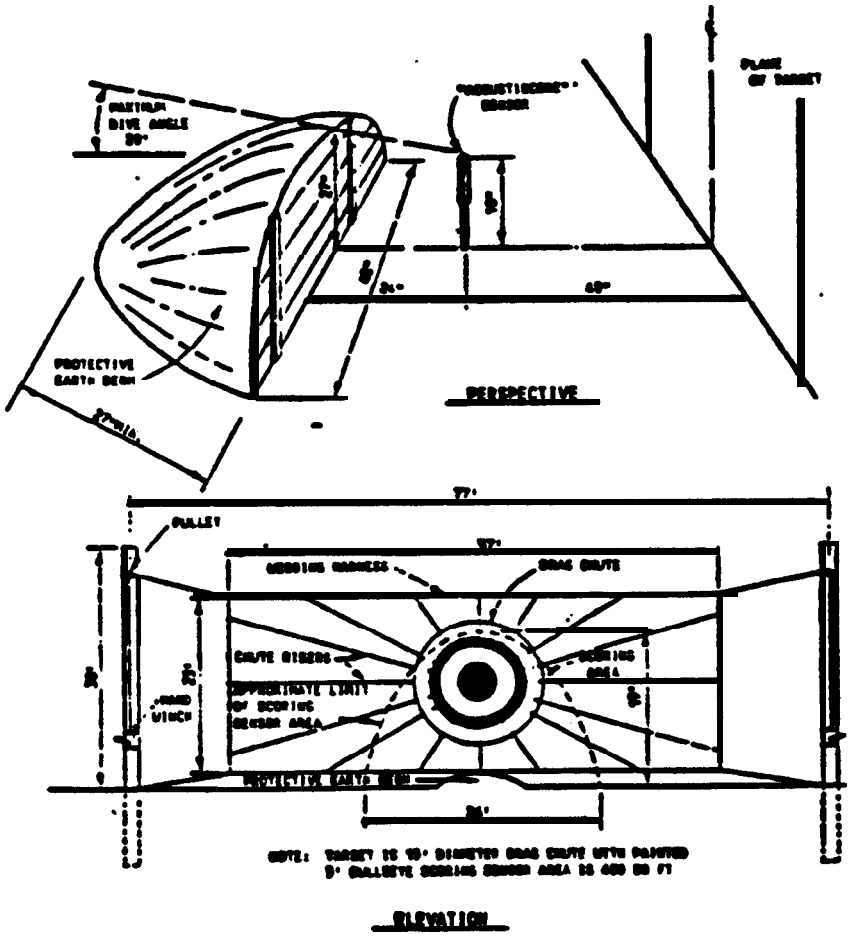
4.11 Radar Bomb Scoring (RBS) Facility

4.11.1 Layout. The mobile RBS equipment includes the operation trailer, acquisition radar, tracking radar, maintenance and spare parts trailer. power trailer, and trucks. Fixed RBS systems utilizing permanent structures may be situated at aircraft ranges or at remote sites. A permanent power supply of ll5/208 V, 3-phase, 4-wire, 60 Hz, 100 kW with capability of converting up to 35 kW from 60 to 400 Hz eliminates the power trailer requirements. See Facility Plate No. 179-70, Sheet 1, for Radar Bomb Scoring (RBS) Facility and Facility Plate No. 179-70, Sheet 2, for RBS typical layout. Designer should request from the user the latest information on required equipment when designing a facility.

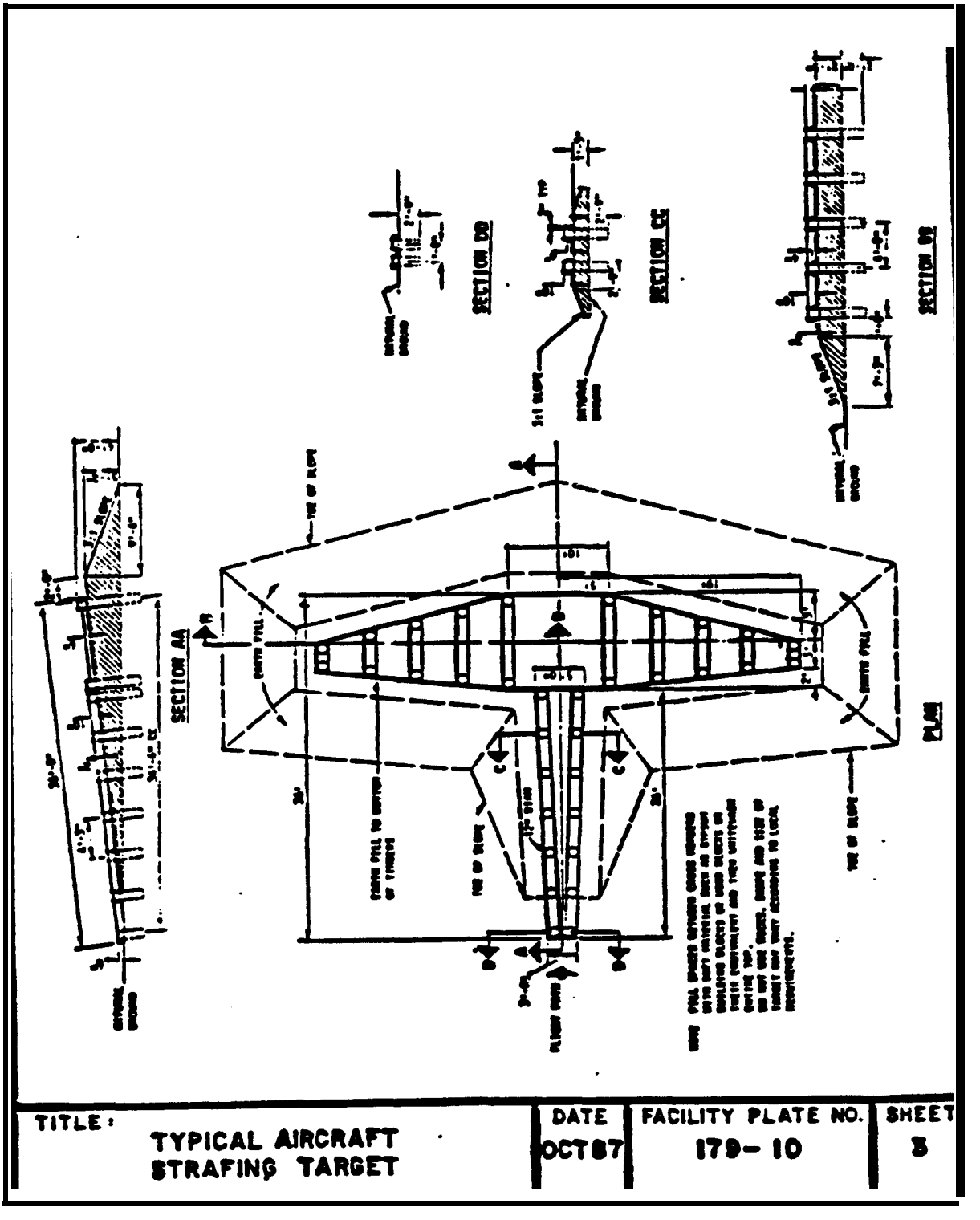
4.11.2 Function. The RBS facility provides for the evaluation of weapons delivery under realistic conditions. RBS is a technique for predicting the theoretical impact point of a bomb with respect to a target by means of a ground-based radar and computer system. The system tracks the aircraft. The system computes the theoretical trajectory and permanently records pertinent data including the miss distance and deflection of the predicted impact or burst from the position and velocity of the aircraft at the release time of a radio signal to the ground. Because it is not necessary to release an actual bomb, simulated attacks against realistic targets (such as cities, bridges, and factories) can be scored. The mobile RBS equipment allows for a variety of targets comparable to those which would be imposed under actual combat conditions.



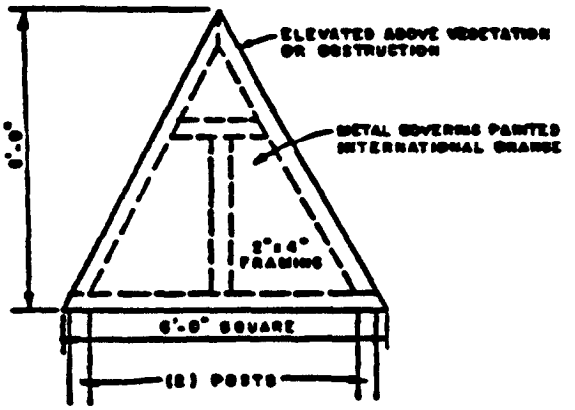
TITLE:	DATE	FACILITY PLATE NO.	SHEET
STRAFING RANGE	OCT 87	179- 10	1



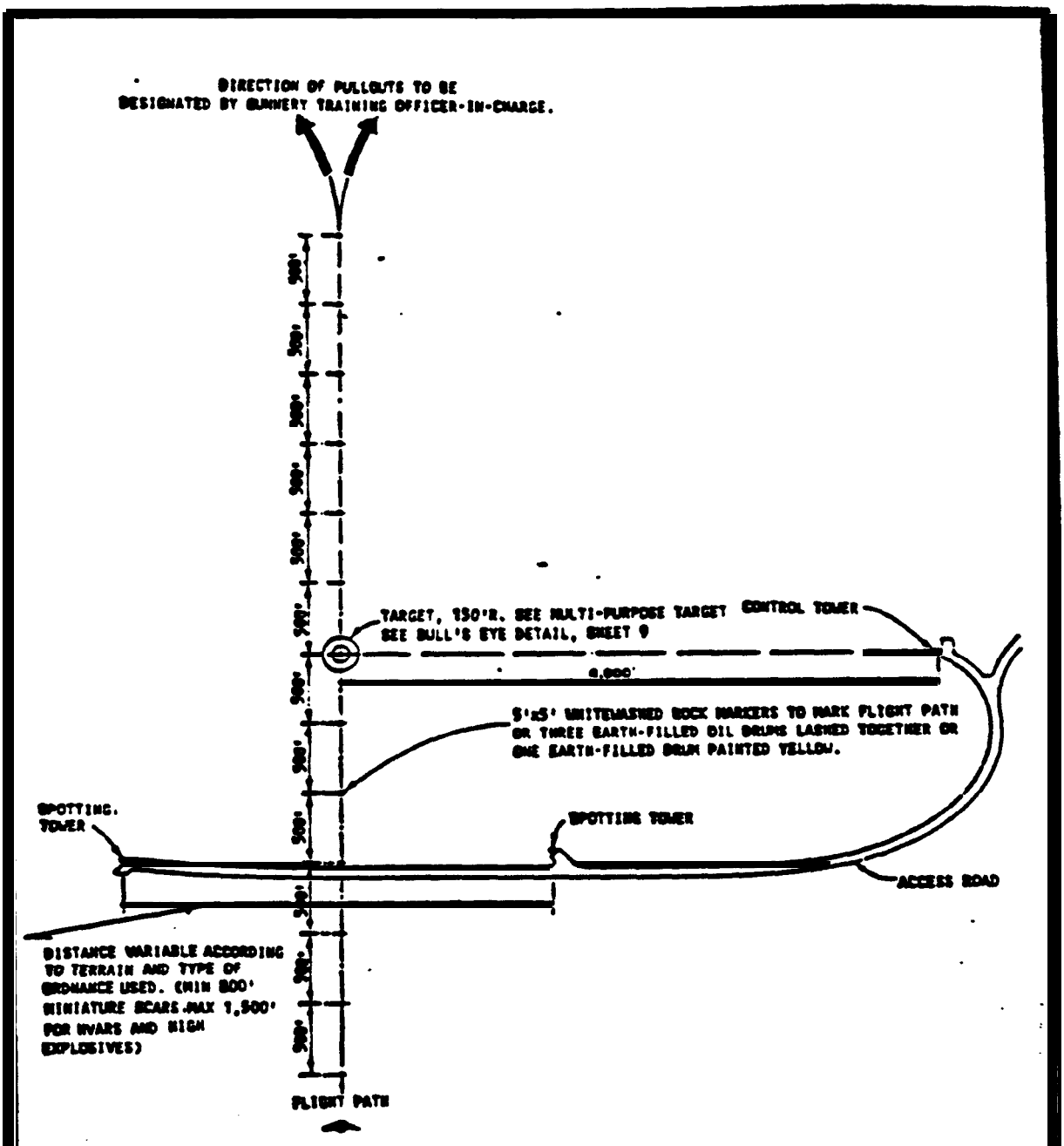
TITLE: ACOUSTISCORE STRAFING TARGET	DATE OCT 87	FACILITY PLATE NO. 179- 10	SHEET 2



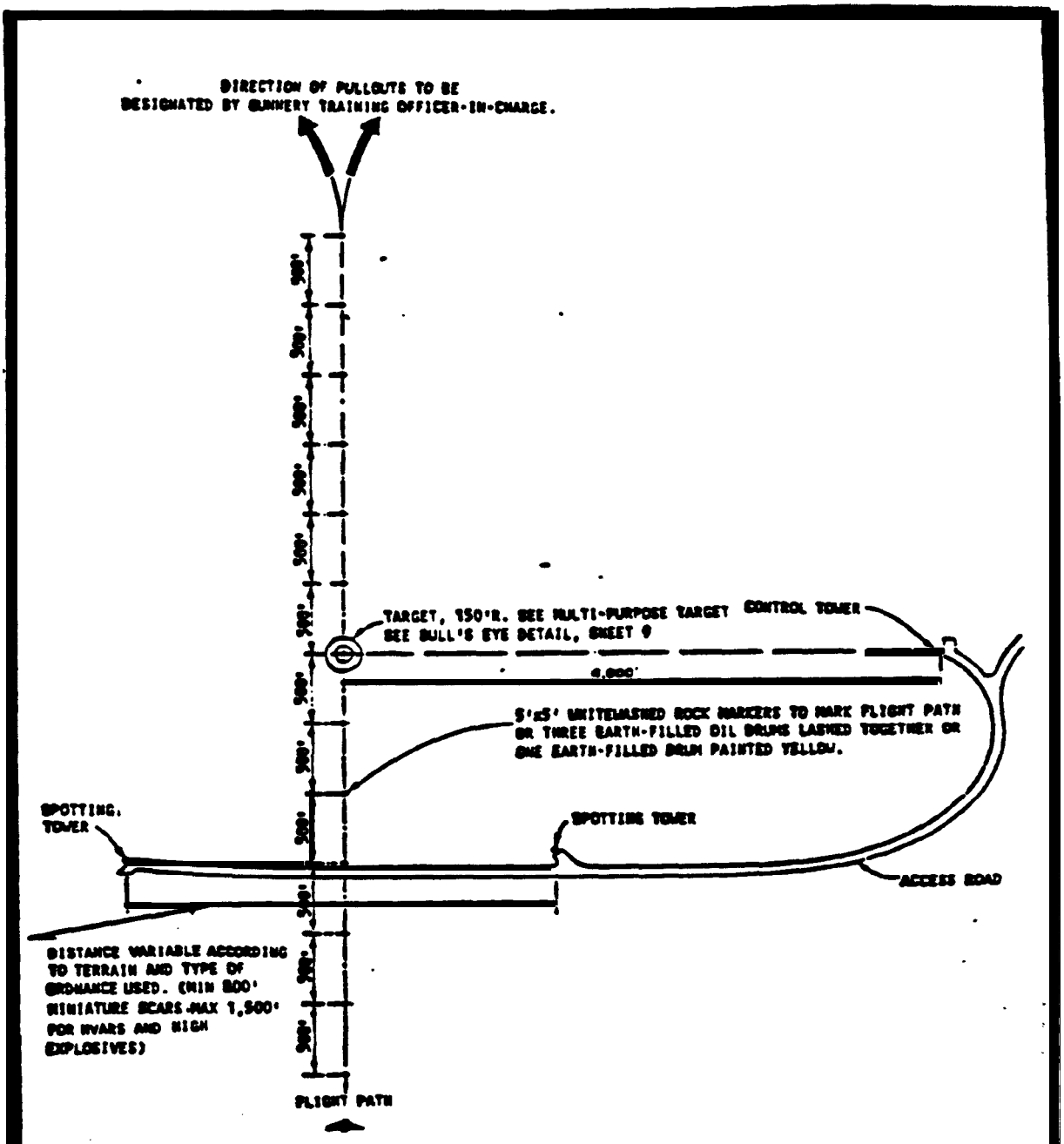
TITLE:	DATE	FACILITY PLATE NO.	SHEET
TYPICAL AIRCRAFT STRAFING TARGET	OCT 87	179-10	5



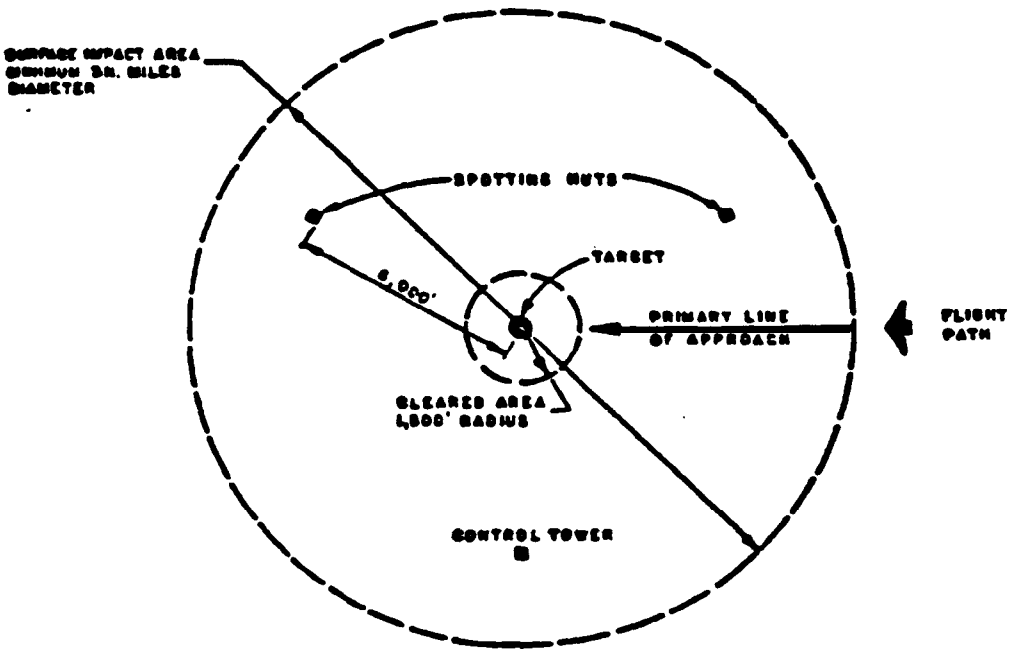
TITLE: FIXED INITIAL POINT MARKER	DATE OCT 87	FACILITY PLATE NO. 179- 10	SHEET 4



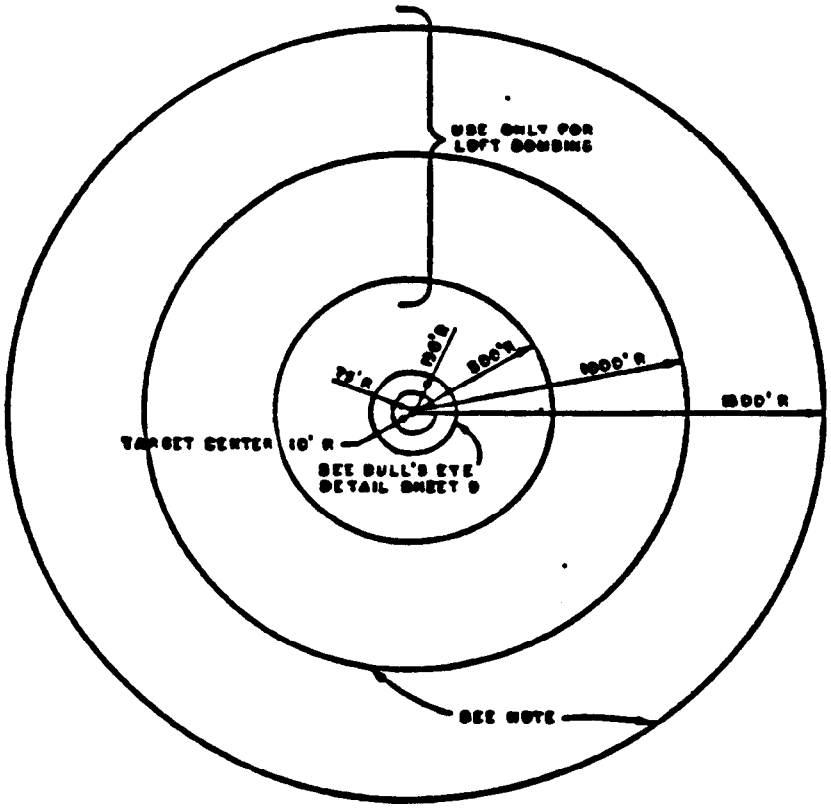
TITLE:	DATE	FACILITY PLATE NO.	SHEET
ROCKET/BOMBING RANGE	OCT 87	179- 10	5



TITLE:	DATE	FACILITY PLATE NO.	SHEET
ROCKET/BOMBING RANGE	OCT 87	179- 10	5

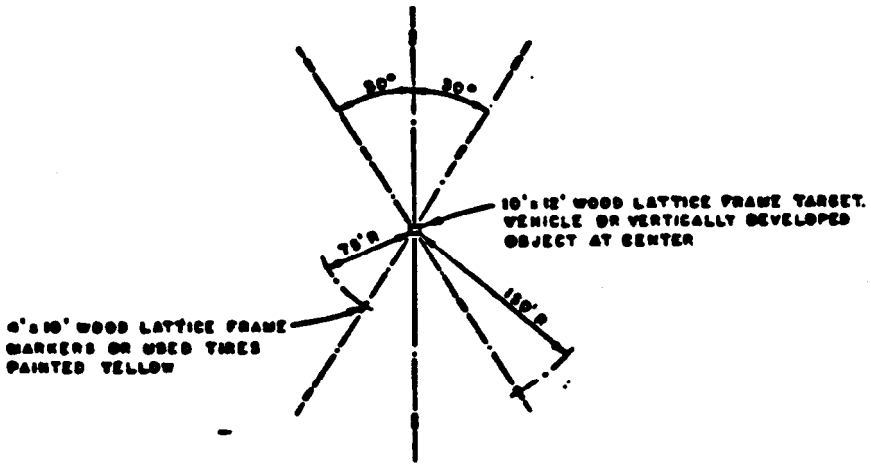


TITLE:	DATE	FACILITY PLATE NO.	SHEET
MULTI-PURPOSE RANGE	OCT 87	179-10	6

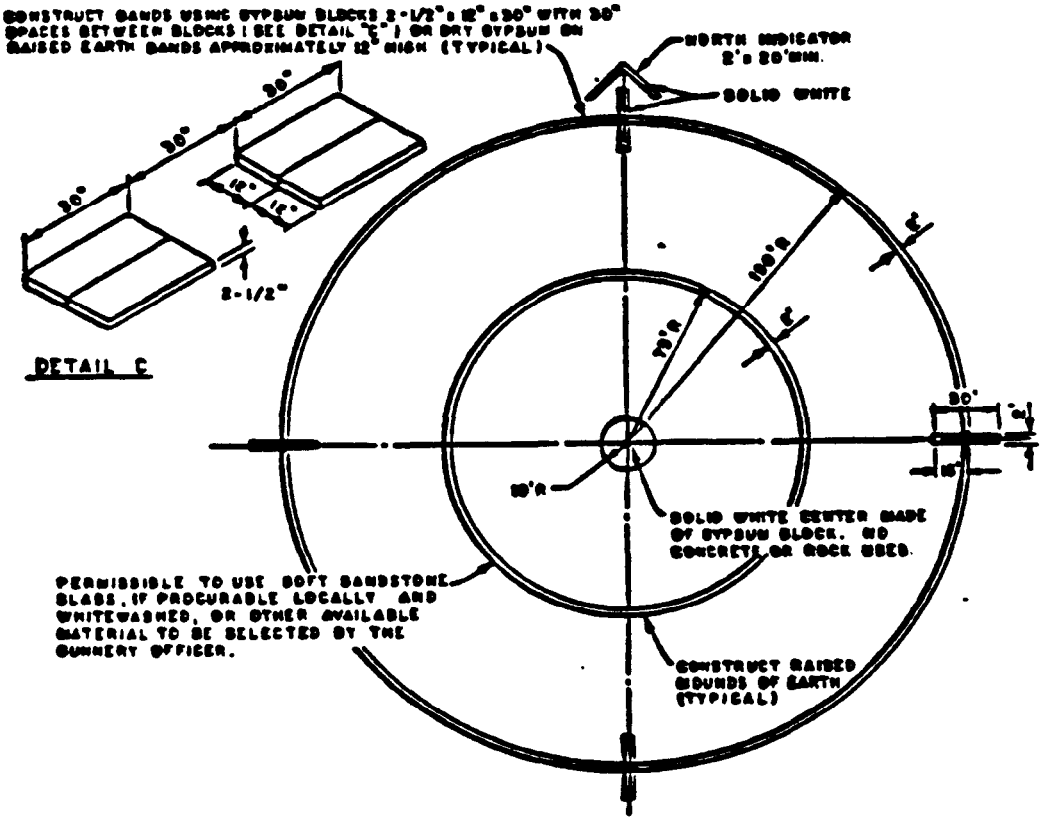


NOTE:
TARGET OUTLINES ON THE GROUND MAY BE: BARED BOUNDS OF EARTH; GYPSUM BLOCKS; SOFT SANDSTONE SLABS, WHITEWASHED; WHITEWASHED ROCK MARKERS (EXCEPT BULL'S EYE); PAINTED OIL DRUMS OR TIRES.

TITLE:	DATE	FACILITY PLATE NO.	SHEET
MULTI-PURPOSE TARGET	OCT 87	179-10	7

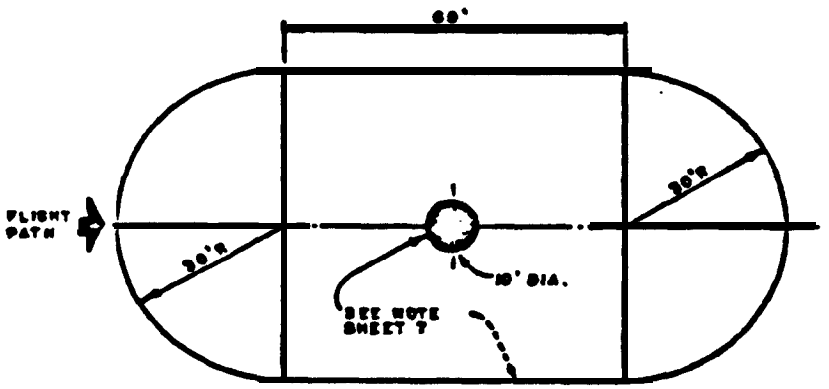


TITLE: ALTERNATE MULTI-PURPOSE TARGET LAYOUT	DATE	FACILITY PLATE NO.	SHEET
	OCT 87	179-10	8

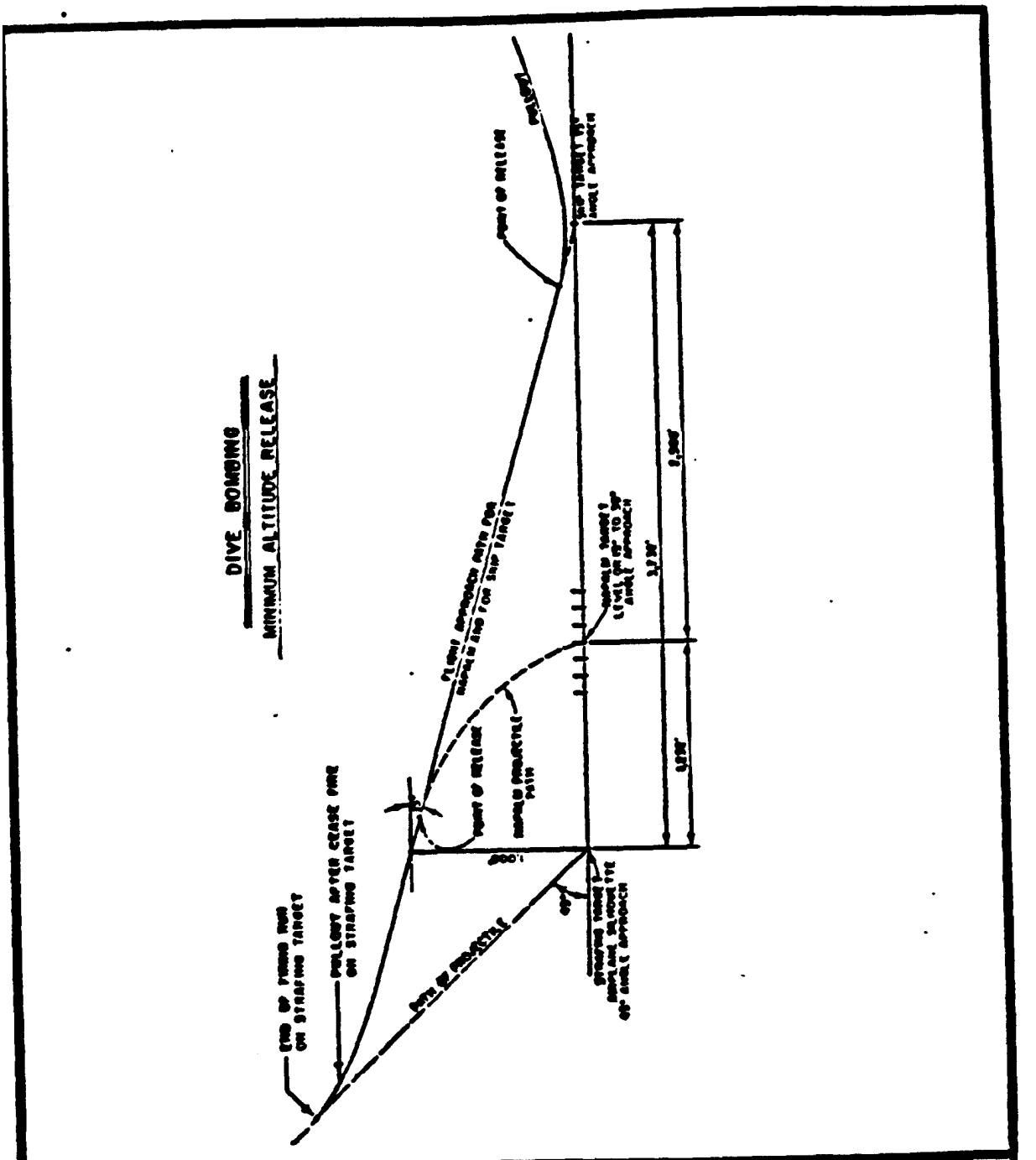


SEE NOTE SHEET 7

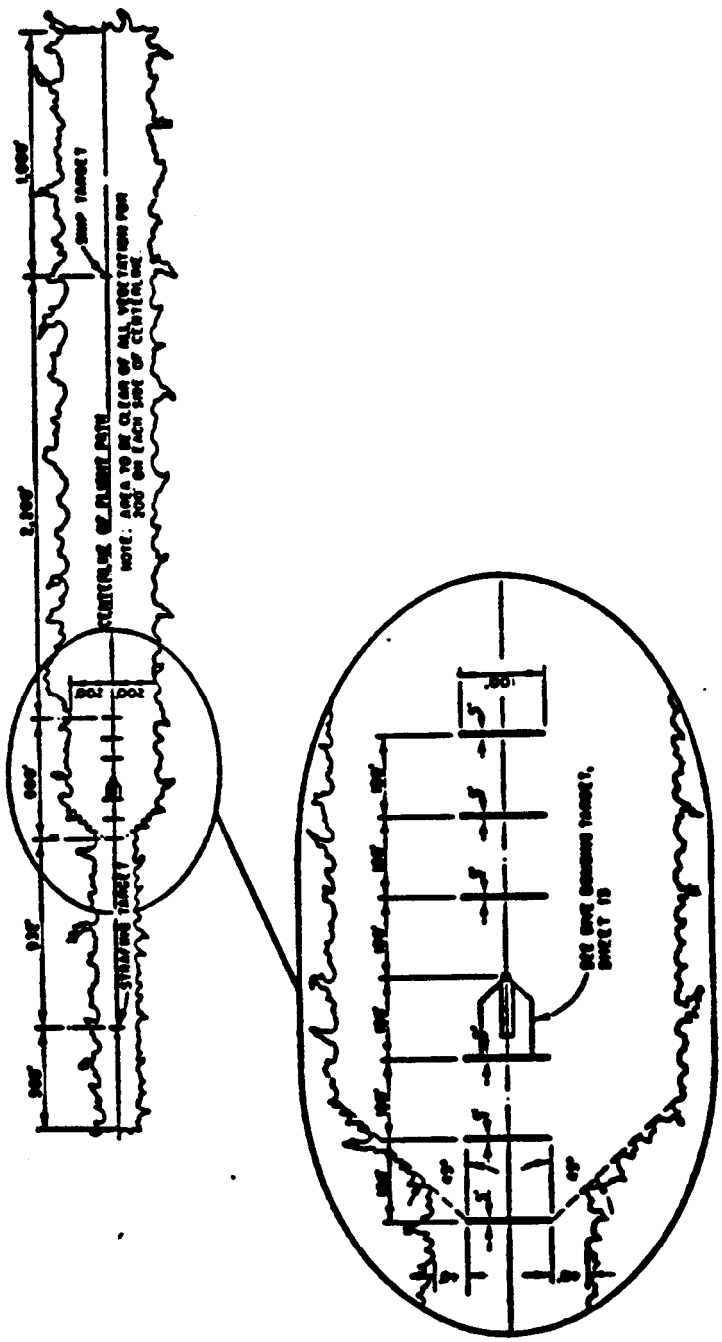
TITLE: BULL'S EYE DETAIL	DATE OCT 87	FACILITY PLATE NO. 179- 10	SHEET 9



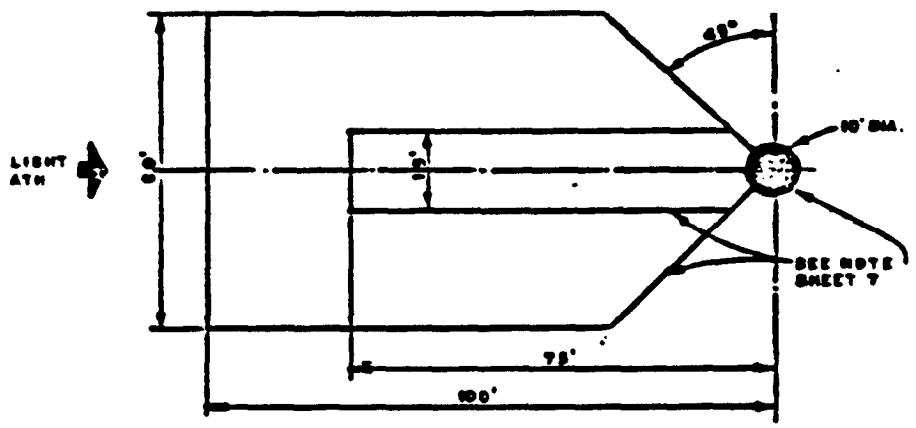
TITLE:	DATE	FACILITY PLATE NO.	SHEET
ALTERNATE ROCKET TARGET	OCT 87	179-10	10



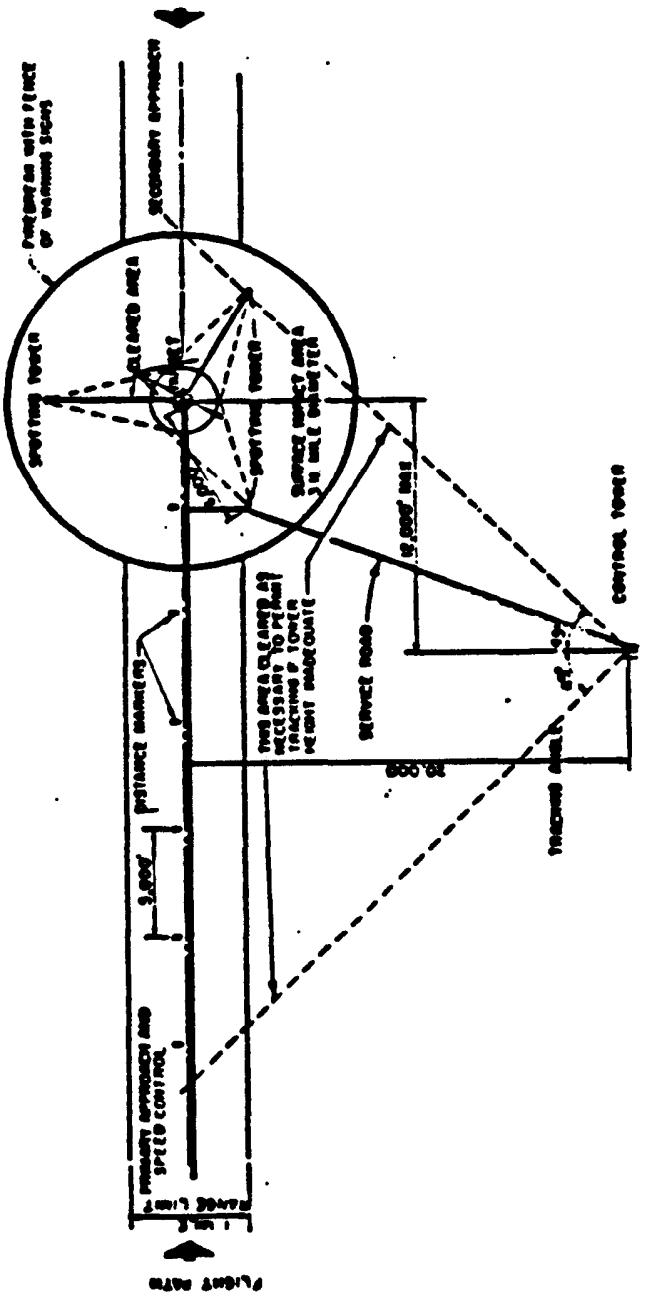
TITLE: TYPICAL MULTI-TARGET FLIGHT PATH	DATE OCT 87	FACILITY PLATE NO. 179 – 10	SHEET 11



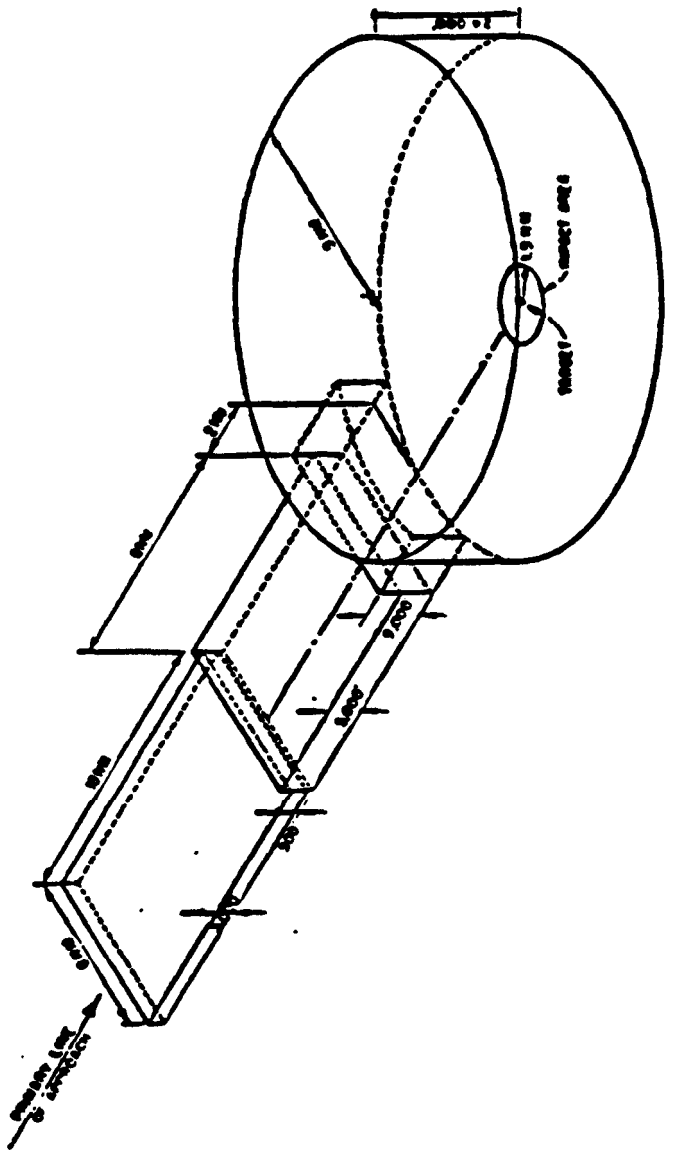
TITLE:	DATE	FACILITY PLATE NO.	SHEET
DIVE BOMBING RANGE PLAN	OCT 87	179- 10	12



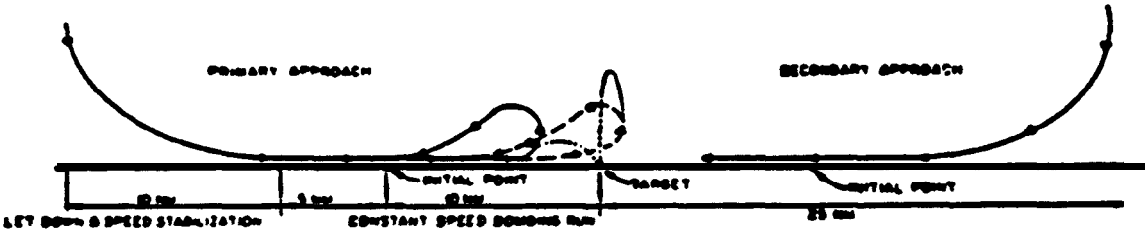
TITLE: DIVE BOMBING TARGET MINIMUM ALTITUDE RELEASE	DATE OCT 87	FACILITY PLATE NO. 179- 10	SHEET 13



TITLE:	DATE	FACILITY PLATE NO.	SHEET
LOFT BOMBING RANGE	OCT 87	179- 10	14

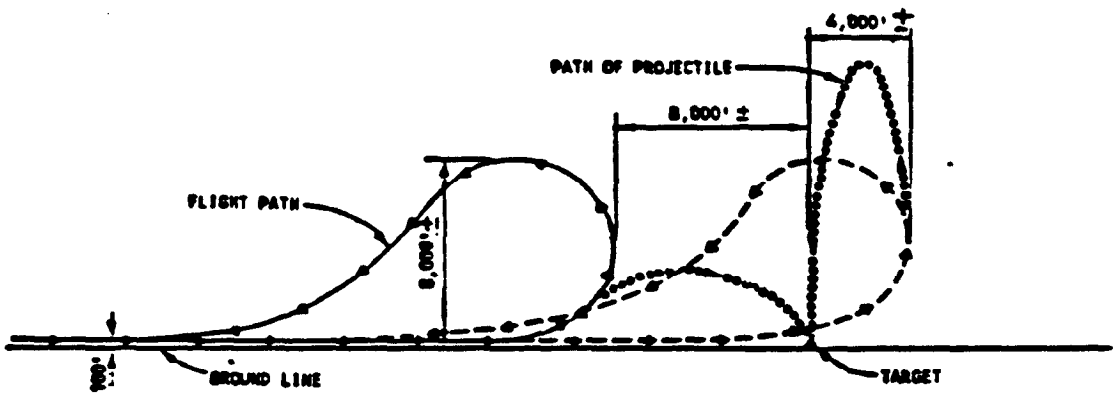


TITLE: LOFT BOMBING TARGET RESTRICTED ZONE PRIMARY APPROACH	DATE OCT 87	FACILITY PLATE NO. 179-10	SHEET 15

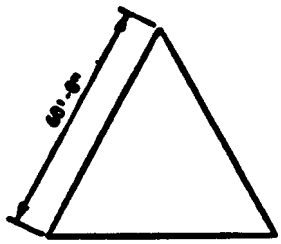


NOTE:
REFER TO SHEET 17 FOR TARGET AREA DETAIL

TITLE: FLIGHT PATH PROFILE	DATE OCT 87	FACILITY PLATE NO. 179-10	SHEET 16



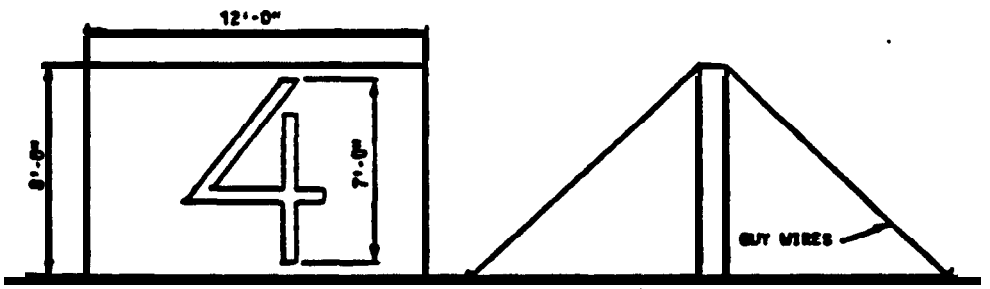
TITLE: FLIGHT PATH PROFILE TARGET AREA DETAIL	DATE OCT 87	FACILITY PLATE NO. 179- 10	SHEET 17



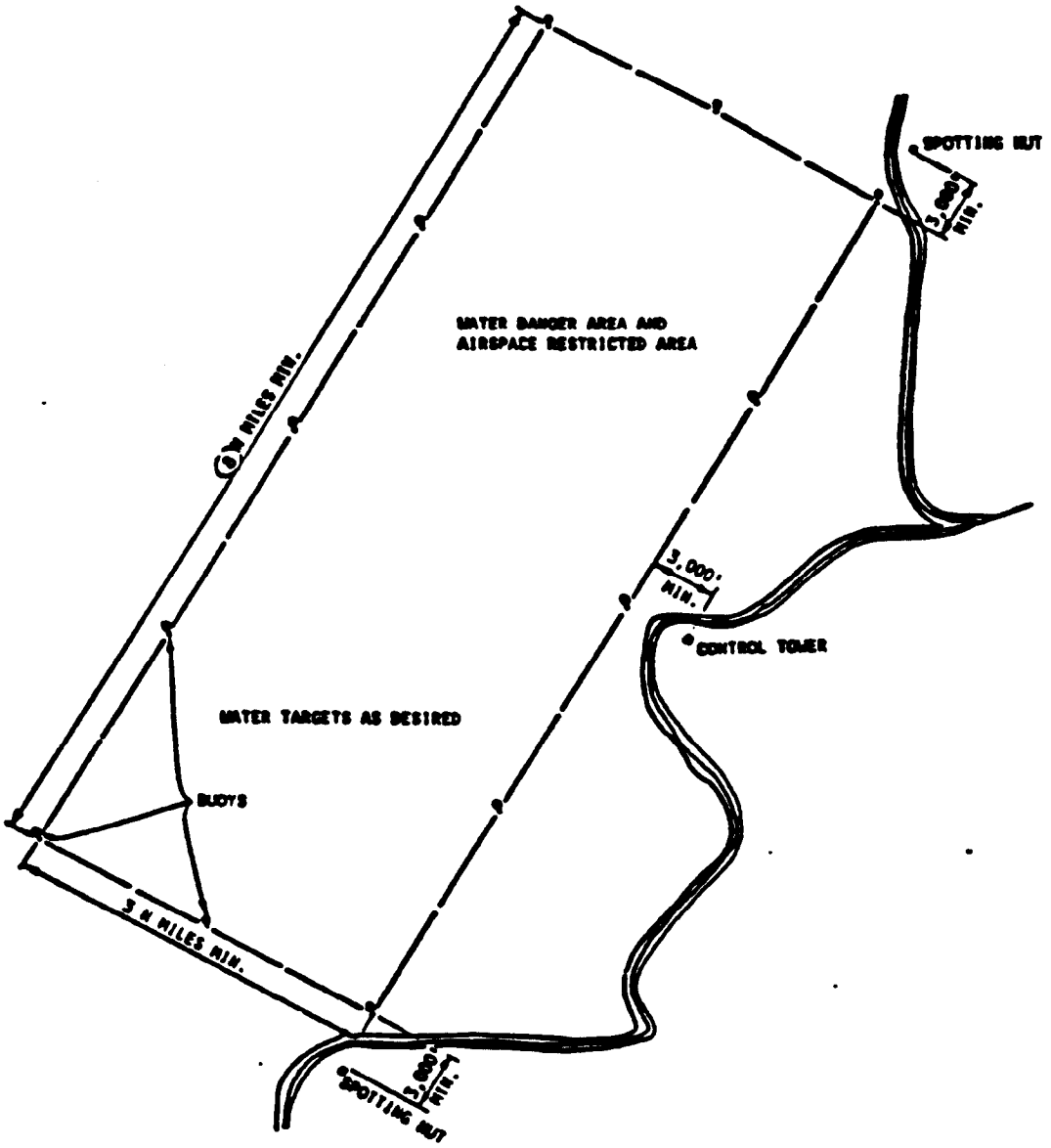
PLAN

ELEVATION

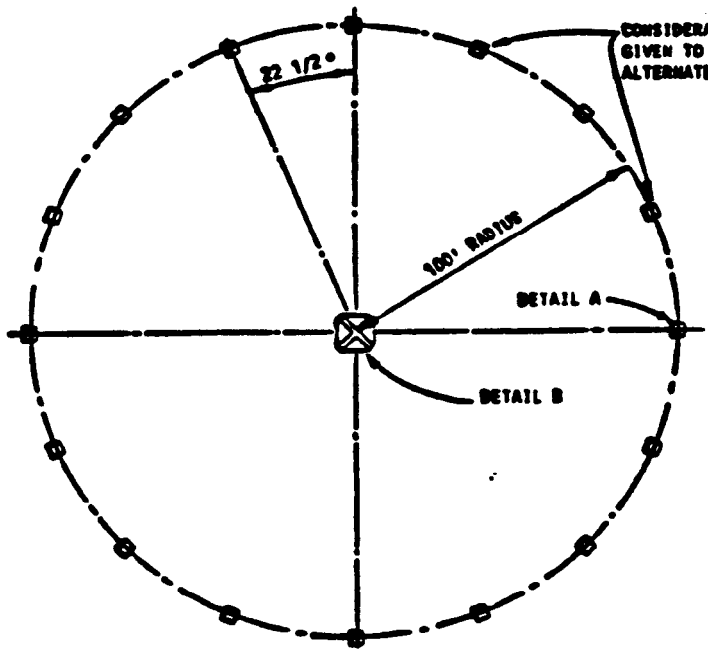
TITLE: TARGET CONFIGURATION FOR VERTICALLY DEVELOPED TARGET FOR HIGH ALTITUDE OR LOFT BOMBING	DATE OCT 87	FACILITY PLATE NO. 179-10	SHEET 18



TITLE:	DATE	FACILITY PLATE NO.	SHEET
DISTANCE MARKER	OCT 87	179- 10	19

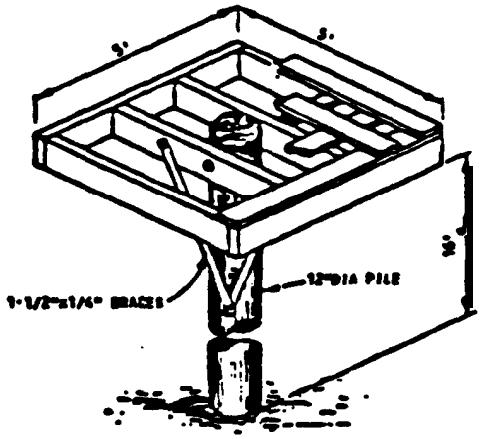


TITLE: AERIAL MINING RANGE	DATE OCT 87	FACILITY PLATE NO. 179-10	SHEET 20

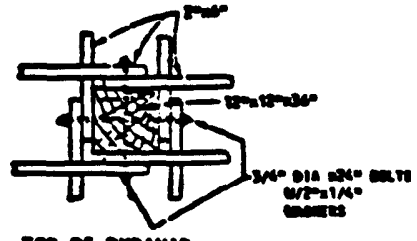


REFER TO SHEET 22

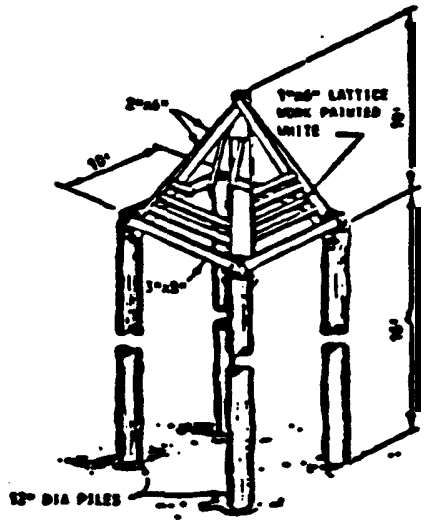
TITLE:	DATE	FACILITY PLATE NO.	SHEET
TYPICAL WATER TARGET	OCT 87	179-10	21



DETAIL A

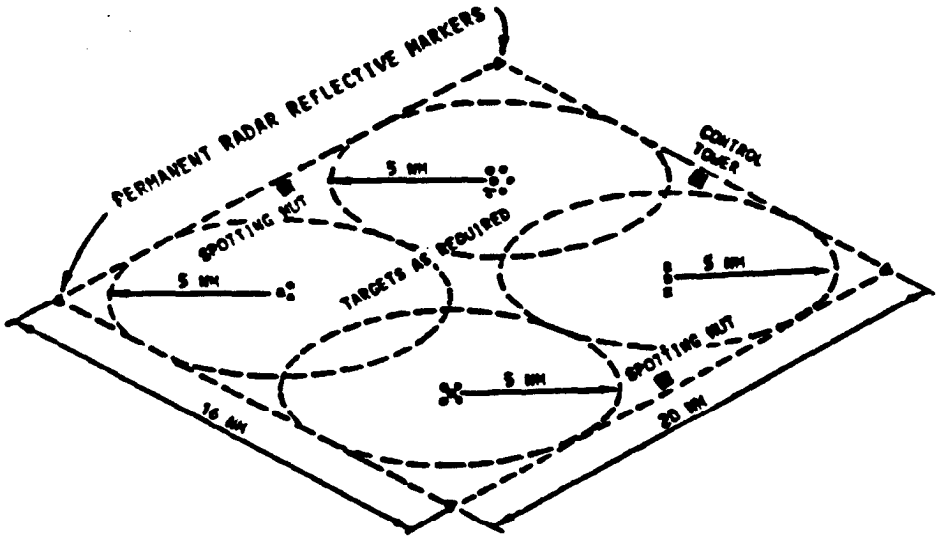


TOP OF PYRAMID

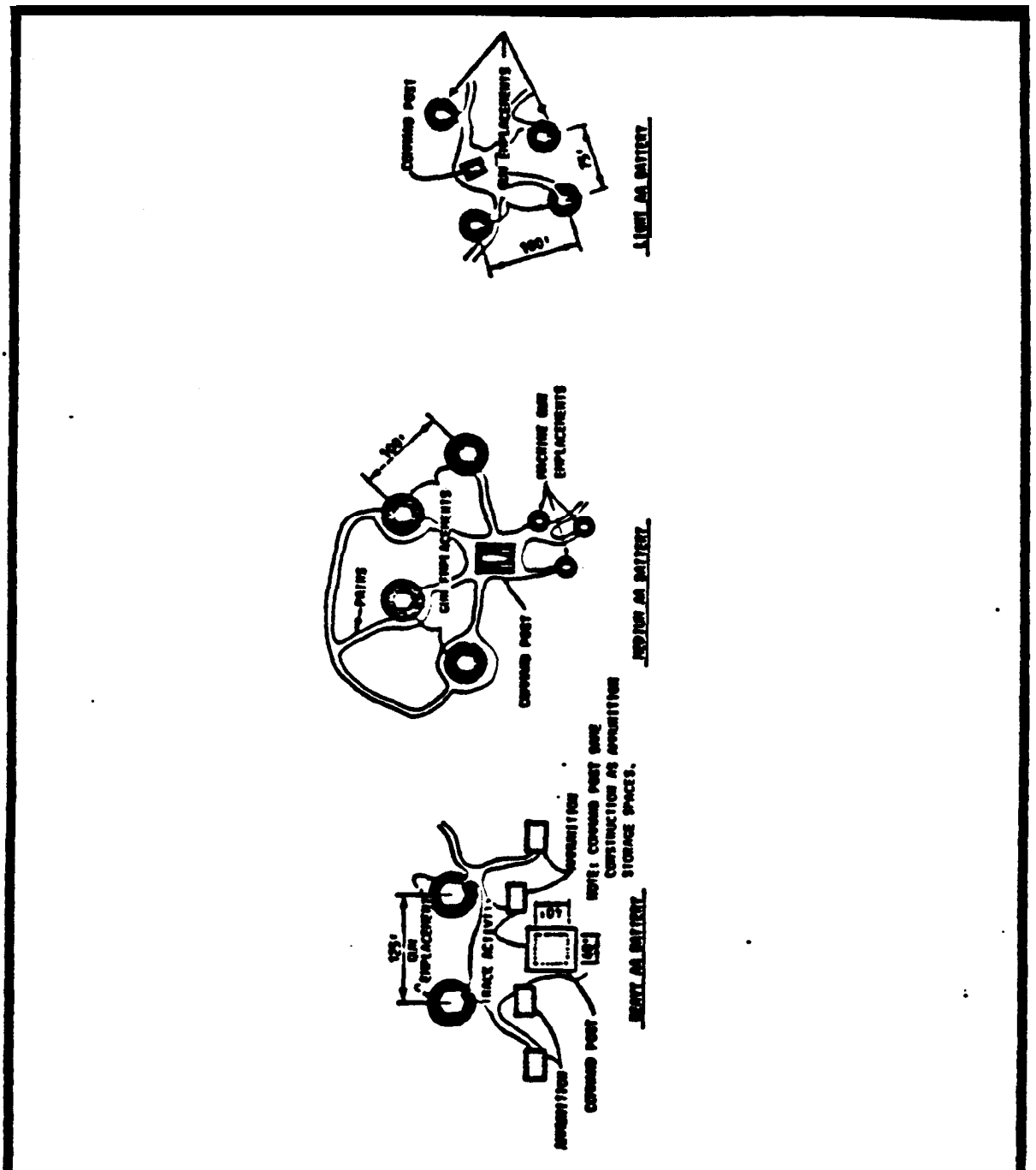


DETAIL B

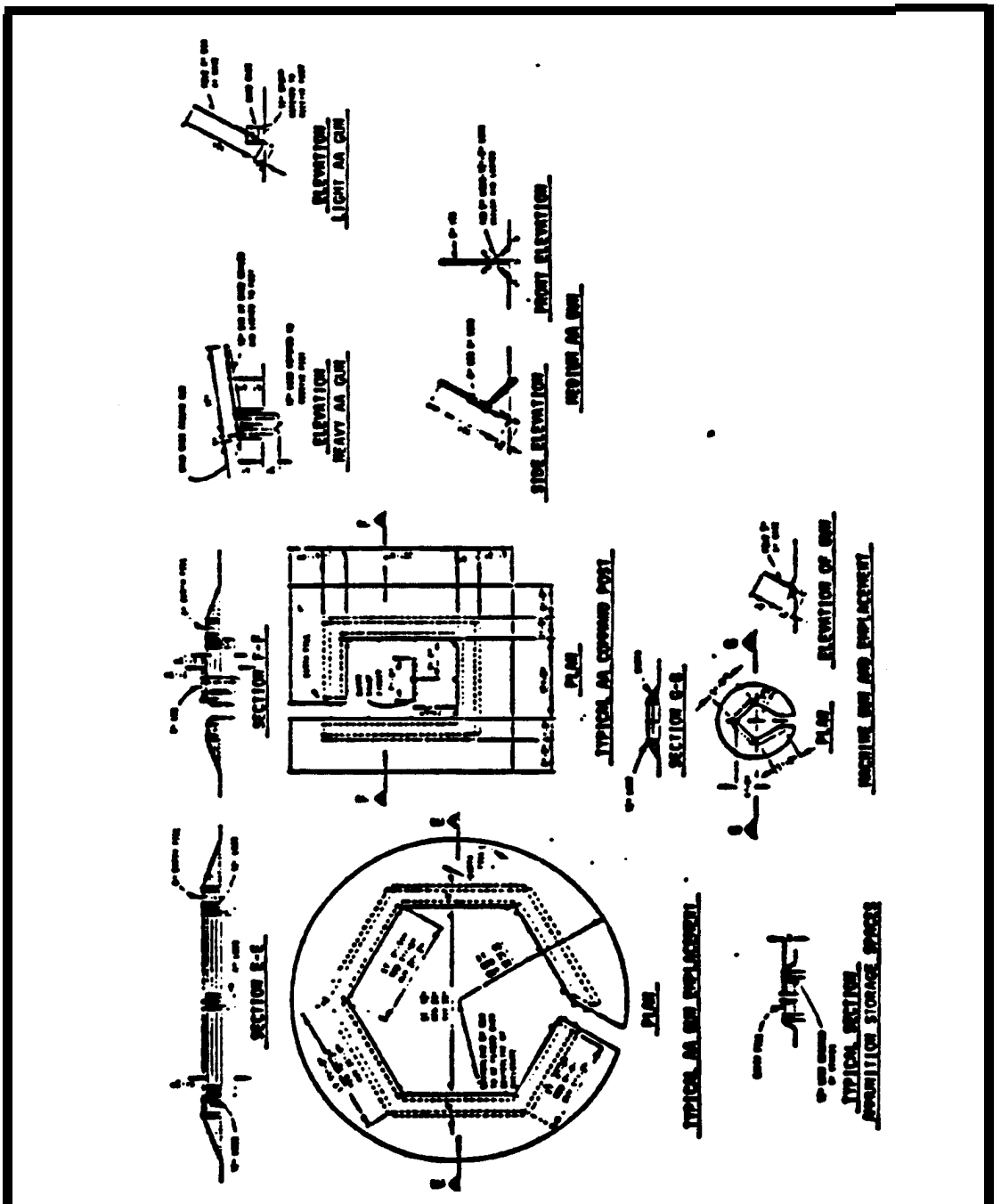
TITLE: TYPICAL WATER TARGET DETAILS	DATE OCT 87	FACILITY PLATE NO. 179-10	SHEET 22



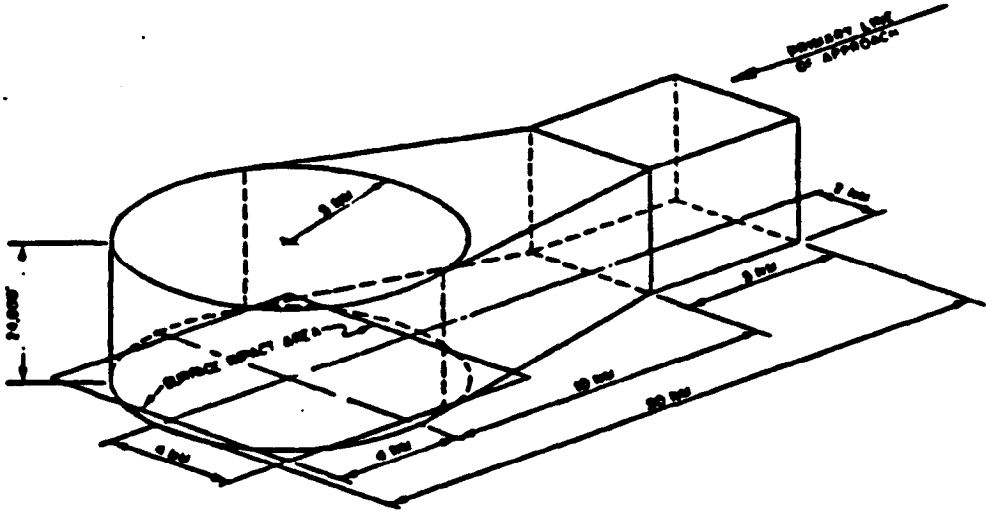
TITLE: CLOSE AIR SUPPORT AND COMBAT TRAINING AREA LIVE ORDNANCE MULTI-TARGET IMPACT AREA	DATE OCT 87	FACILITY PLATE NO. 179-10	SHEET 23



TITLE: TYPICAL CLOSE AIR SUPPORT TARGETS	DATE OCT 87	FACILITY PLATE NO. 179-10	SHEET 24

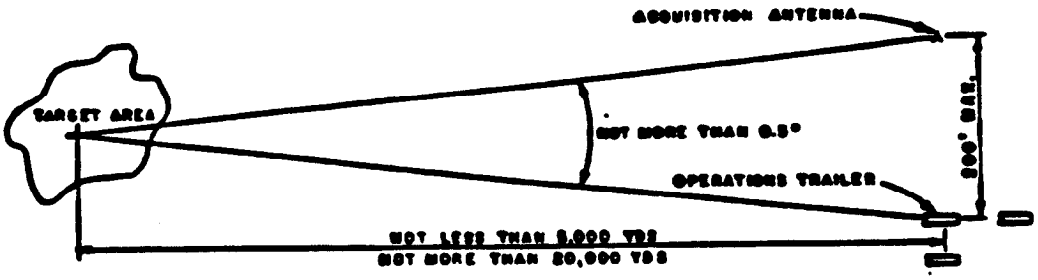


TITLE: CLOSE AIR SUPPORT TARGET DETAILS	DATE OCT 87	FACILITY PLATE NO. 179- 10	SHEET 25



DIMENSIONS ARE BASED ON PERFORMANCE CHARACTERISTICS OF SELECTED MISSILE

TITLE: TYPICAL AIR-TO-GROUND GUIDED MISSILE RANGE-RESTRICTED ZONE	DATE OCT 87	FACILITY PLATE NO. 179-10	SHEET 26



1. TYPICAL SITING OF MOBILE RADAR BOMB SCORING CENTRAL (AN/MSQ-44) REQUIRES THAT THE ACQUISITION ANTENNA (6' HIGH) BE NO HIGHER THAN THE TRACKING ANTENNA WHICH IS MOUNTED ON TOP OF THE OPERATIONS TRAILER (OVERALL HEIGHT 20') THAT THE ANTENNAS ARE MUTUALLY VISIBLE, AND THAT THE ACQUISITION ANTENNA HAVE AN UNOBSTRUCTED VIEW OF THE SECTOR IN WHICH THE MOST ACTIVITY IS EXPECTED.

2. THE POWER TRAILER PAD IS NOT REQUIRED WHERE COMMERCIAL POWER IS AVAILABLE AT THE OPERATIONS TRAILER SITE. PROVIDE FOUNDATION ADJACENT TO OPERATIONS TRAILER FOR 60 ~ /400 ~ CONVERTER.

3. POWER REQUIREMENTS:

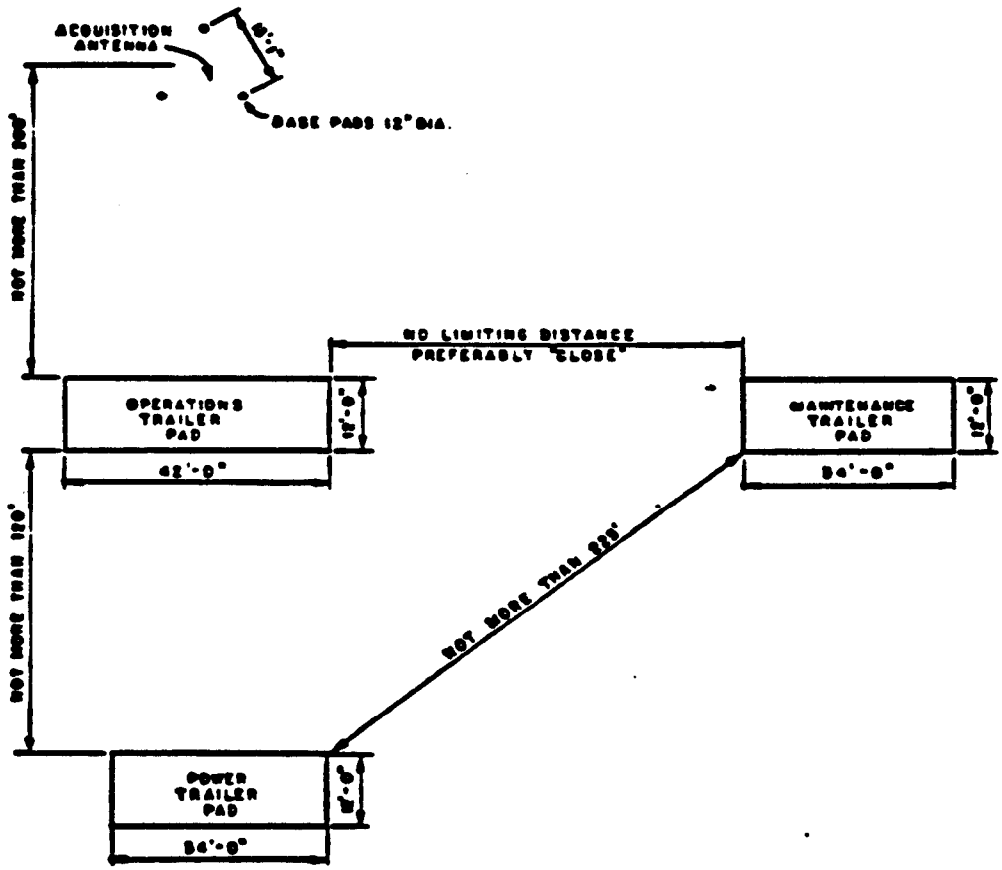
60 ~, 120/208 V, 3ϕ, 4W, 100 KW, 0.8 pf, TOTAL
400 ~, 120/208 V, 3ϕ, 4W, 35KW.

4. DESIGN PADS IN ACCORDANCE WITH NAVFAC DM-5.04 TRAILER WEIGHTS:

OPERATIONS	24,000 POUNDS
MAINTENANCE	18,000 POUNDS
POWER	35,700 POUNDS

5. REFER TO NAVAIR HANDBOOK 16-30 NS044-2 FOR CABLE INTERCONNECTIONS; PROVIDE CABLE TRENCH OR CONDUITS AT ROAD CROSSINGS.

TITLE:	DATE	FACILITY PLATE NO.	SHEET
RADAR BOMB SCORING FACILITY SITING	OCT 67	179-70	1



TITLE:	DATE	FACILITY PLATE NO.	SHEET
RBS-TYPICAL LAYOUT	OCT 87	179-70	2

Section 5: RANGE TOWERS

5.1 Function. The operational tower is used as an observation station at aircraft gunnery, bombing, and rocket ranges for scoring and control of all range activity. Included under operational towers are control (or main) tower and spotting (also called side, rake, or flank) towers.

5.2 Location. A control range operations tower and at least one spotting tower shall be located so that accurate three-dimensional rake information can be obtained. Refer to paras. 4.7.1 and 4.7.4 through 4.7.6 for tower locations at the various ranges. Towers shall be sited so as to obtain an unobstructed view of the target areas and aircraft using the range.

5.3 Architectural Requirements. Refer to Facility Plate No. 179-35, Sheet 1, for one type of control tower. layout should be planned to take into consideration proper egress and fire exits particularly where bunking facilities are required (refer to MIL-HDBK-1002/1). Towers may contain range and bearing radar equipment, photo-electric or mechanical timing devices, target rakes or theodolites, a dive-angle "harp" to obtain data during dive-bombing exercises remote scoring device recorders, plotting boar&, radio equipment for two-way communications with aircraft, and telephone or radio equipment for communications with the supporting station. One type of manned spotting tower is shown in Facility Plate No. 179-35, Sheet 2. Size and height of towers for electronic scoring systems depend primarily upon equipment requirements. These facilities are generally unmanned but must be air conditioned because of the electronic equipment. Towers should be fireproof and provided with smoke detectors. Requirements for security should be determined during planning stage. Criteria to be followed should be requested.

5.3.1 Electronic Scoring Systems. The Weapons Impact Scoring Set (WISS) is a manned video scoring set which scores the impact of air-to-ground delivered ordnance within a 4,000-ft (1219.2 m) radius of a defined land target under day or night conditions. The impact results are passed to aircrews by UHF communication and/or recorded on a computer printout. WISS spotting tower will house TV cameras and communication equipment for reporting to the range control center. Where located in remote and inaccessible areas, the towers will be fenced for security (refer to NAVFAC DM-5.12). Glass for camera portholes shall be bullet-resistant to rifle ammunition.

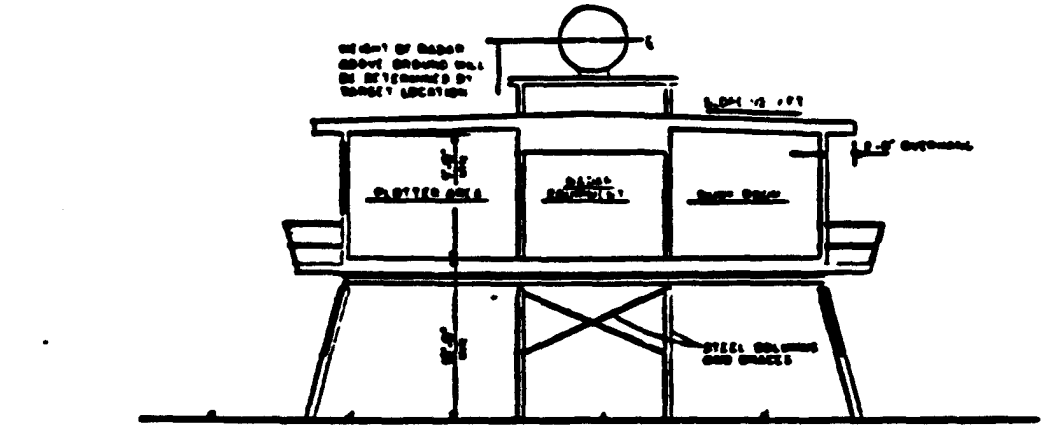
5.3.2 Support Facilities. For ranges which do not use the electronic scoring systems, facilities should be sized for personnel as described in Table 6.

5.4 Mechanical Requirements. Refer to NAVFAC DM-3.03 and Facility Plate No. 179-35, Sheet 3, for criteria for plumbing, heating and air conditioning requirements.

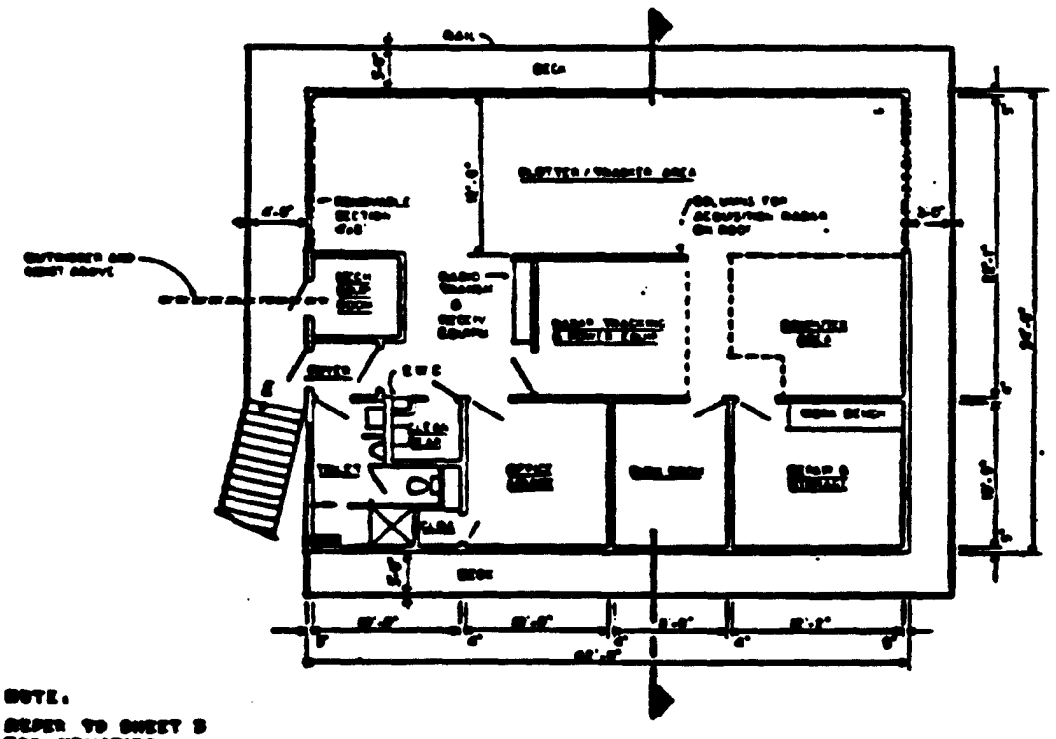
5.5 Electrical Requirements. Refer to MIL-HDBK-1004/1, for electric power criteria, and to Facility Plate No. 179-35, Sheet 3, for electrical requirements.

Table 6
Range Types and Facility Sizing for Tower Personnel

Type of Range	Control Tower	Spotting Tower
Strafing		Two men (minimum)
High-altitude bombing and aerial mining	Two men (minimum)	Two men
Multipurpose target	Four men (minimum)	Two men
Loft bombing	Six men (minimum)	Two men
Close air support and combat training area	Three men (minimum)	Two men
Firefighting	Varies according to amount and type of equipment.	



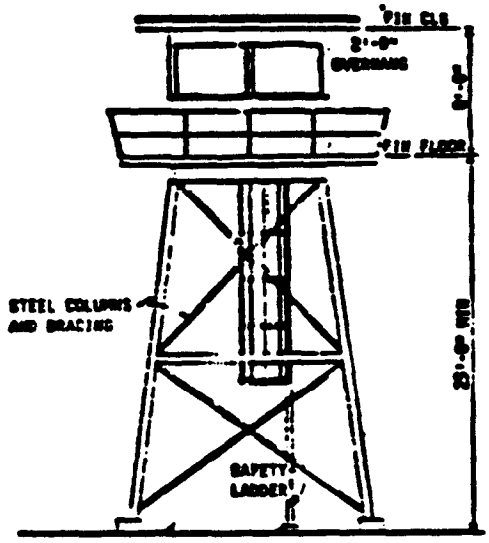
SECTION



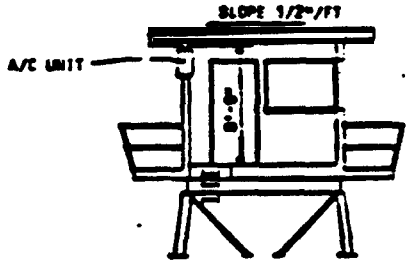
NOTE:
REFER TO SHEET 3 FOR UTILITIES.

FLOOR PLAN - CONTROL TOWER

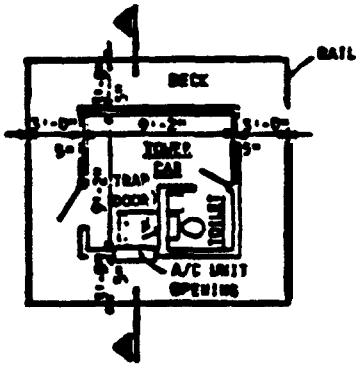
TITLE:	DATE	FACILITY PLATE NO.	SHEET
CONTROL TOWER	OCT 87	179-35	1



REAR ELEVATION



SECTION



FLOOR PLAN - SPOTTING TOWER

NOTE:

REFER TO SHEET 3 UTILITIES.

TITLE:	DATE	FACILITY PLATE NO.	SHEET
SPOTTING TOWER	OCT 87	179-35	2

NOTES

PLUMBING REQUIREMENTS

	CONTROL TOWER	SPOTTING TOWER
COLD WATER	40 G.P.M.	40 G.P.M.
HOT WATER RECOVERY RATE (FROM 100°F RISE) [1]	20 G.P.M.	0 G.P.M.
STORAGE	20 GAL	0 GAL

HEATING REQUIREMENTS (M BTU/HR)

OUTSIDE DESIGN TEMPERATURE: 0°F

OUTSIDE DESIGN TEMPERATURE	-5° F	-15° F	-25° F	-35° F
CONTROL TOWER	88	94	89	91
SPOTTING TOWER	6	6	6	9

AIR CONDITIONING REQUIREMENTS

	CONTROL TOWER	SPOTTING TOWER
OUTSIDE DESIGN TEMPERATURE	75°F.D.B.	75° F.D.B.
OUTSIDE DESIGN HUMIDITY	50%	50%
OUTSIDE DESIGN TEMPERATURE	95°F.D.B.	95°F.D.B.
OUTSIDE DESIGN TEMPERATURE	78°F.W.B.	78°F.W.B.
COOLING LOAD CAPACITY	45	6

ELECTRICAL REQUIREMENTS (KW)

	CONTROL TOWER	SPOTTING TOWER
LIGHTS		
CONNECTED LOAD	4.6	1.0
ESTIMATED DEMAND	4.3	0.9
POWER		
CONNECTED LOAD	29.8	1.0
ESTIMATED DEMAND	24.9	0.8
TOTAL		
CONNECTED LOAD	34.4	2.0
ESTIMATED DEMAND	29.2	1.6
ADDITIONAL DEMAND FOR AIR CONDITIONING	9.7	2.0

AREAS

GROSS AREA INCLUDING MECHANICAL EQUIPMENT ROOM	1,200 SF	720 SF

TITLE	DATE	FACILITY PLATE NO.	SHEET
UTILITIES-CONTROL AND SPOTTING TOWERS	OCT 87	179-35	3

Section 6: PROJECTILE RANGES

6.1 Related Criteria. The designer of projectile ranges and ranges outlined in Sections 7 and 8 must apply the requirements contained in MCO P3570.1A. Policies and Procedures for Firing Ammunition for Training, Target Practice and Combat. MCO P3570.1A includes ballistic data affecting surface danger zones.

6.2 Design Factors. Areas within the total surface danger zones applicable to ranges for field artillery cannon, tank cannon, antiaircraft cannon firing at aerial targets, air defense weapons firing at aerial and ground targets, mortars, rocket launchers, recoilless rifles, field artillery trainers, and cannon launched guided projectiles are described in the text. See Figure 9 for a composite diagram of various ranges which shows the firing line, impact areas, and target area that must be considered in laying out a range or a complex of ranges. The designer must refer to MCO P357O.1A for specific range dimensions. Area A is the lateral danger area. Area B is the downrange danger area. A and B are named secondary danger areas for direct fire mode. Area C is the danger area adjacent to the near edge of the impact area. Area C may be named a secondary danger area for indirect fire mode. Area D is the danger area located between danger Areas C and E. Area E is the danger area located immediately in front of the firing positions. Distance X will be equal to the maximum range of the weapon at the elevation to be fired and for the charge used. Paras. 6.2.1 through 6.2.4 contain descriptions of the areas in Figure 9.

6.2.1 Target Area. Width of target angle and target area depend8 on number of stationary target8 or traversing distance of roving targets. The far edge limit of the target area is net by maximum range of weapon or maximum range of weapon at maximum allowed quandrant elevation. The near edge limit of the target area is set by minimum range of weapon. Provide Z-marked stationary target8 within target area of known distances from firing line to use as zeroing targets.

6.2.2 Impact Area. Impact area includes the target area of required target angle and depth expanded in width and depth In terms of Probable Error (PE) of weapon (see Figure 9), to provide safety factors for impacts outside the target area because of mechanical errors, gun instability, and ordnance dispersion. For moving targets the impact area includes additional lateral areas within right and left limit angles. For firing in direct mode, the impact area includes additional lateral ricochet areas.

6.2.3 Firing and Maneuvering Area. The size and shape of firing and maneuvering areas depend upon the number of weapons, types of weapons, and nature of firing exercises. Ranges shall accommodate more than one type of weapon, and the firing and maneuvering area shall be sized and shaped for the most space-demanding firing exercise.

a) Firing circle for single cannon or single tank firing and maneuvering.

b) Firing line for row of weapons firing forward.

c) Rectangular area for maneuvering and firing short-range at close-up stationary or moving targets immediately in front of firing and maneuvering area, or may be for maneuvering and firing at long-range targets.

6.2.4 Buffer Area. Firing on adjacent or or superimposed range may necessitate buffer area immediately in front of firing and maneuvering area and clone-up target area to protect personnel occupying firing and maneuvering area.

Unprotected personnel occupying the maneuver and firing area or Area E, must be separated from engaged targets by a minimum distance equal to the engagement distance given In Table 11-1, MCO P3570.1A. This serves as a buffer area to protect personnel from hazardous fragments from the firing of high explosive projectiles at hard or fragment-producing targets.

6.3 Cannon Maximum Range. For &limiting safety tones, consider approximate maximum ranges for standard firing-table conditions. Local conditions may dictate some departure from these.

6.4 Cannon Except Tank and Aircraft Cannon. Criteria for &signing projectile ranges for cannon except tank and antiaircraft cannon, mortars, rocket launchers, and recoilless rifles are given in following paragraphs. Included are: Howitzer, 105 mm; Howitzer, 155 mm; gun, 175 mm; gun, 8 inch; gun, 90 mm (firing antipersonnel-type "Beehive" cartridges); Howitzer, 105 mm (firing antipersonnel-type "Beehive" cartridges); Field artillery trainer, M31 (firing 14.5 mm ammunition with charge 1 propellant); and M/12 cannon-launched guided projectile (Copperhead).

6.4.1 Definitions. See Figure 9 for general layout applicable to field artillery cannon ranges and to projectile firing weapons. Design first requires an available surface danger zone large enough to accommodate the required impact area for the planned exercise with the weapon (or the several to be used) that requires the greatest firing angle and the longest maximum range (distance X).

a) Area A and B. Area A provides lateral buffer area; Area B provides depth buffer area around periphery of impact area.

b) Area C. Borders the near ride (the minimum range edge) of the impact area and ray be occupied by protected personnel during indirect firing of field artillery cannon. Use of Area C must be wholly in control of the Navy Range Officer.

c) Area D. A minimal danger area over which field artillery cannon may be fired in Indirect rode while area is occupied. Use of Area D must be wholly under U.S. Government control.

d) Area E. Applies to field artillery cannon. Hazardous during indirect firing because of overpressure, noise, and ground and muzzle debris. Area E shall be unoccupied during all conditions of direct fire. During indirect firing, personnel must be protected by splinterproof cover.

a) Area F. Subject to hazards from back blast from recoilless rifler, rocket launchers, and missiles.

6.4.2 Surface Danger Zone. For firing at fixed or moving terrestrial targets, the surface danger zone consists of the impact area and the areas in Figure 9 as A, B, C, D and E. Figures and tables are reference8 to MCO P3570.1A. Variations in dimensions A, B, C, and E for 105 mm howitzer, 155 mm howitzer, 175 mm gun, and (1-inch gun are given in Table 11-1.

Surface danger zone criteria and variation8 in distance "X" and dimension "Y" for 90 mm gun and 105 mm howitzer firing antipersonnel-type "Beehive" cartridges are given in Figure 11-4 and Table 11-6. Surface danger zone criteria and variations in dimension "A" (lateral ricochet distance) and dimension "B" (downrange ricochet distance) for M31 field artillery trainer firing 14.5 mm ammunition with charge 1 propellant are given in Figure 11-5 and Table 11-7.

Surface danger zone criteria for M/12 cannon launched guided projectile "Copperhead" are shown in Figure 11-6 and Figure 11-7.

6.4.3 Impact Area. For field artillery cannon firing in direct or indirect mode, the dimensions of the impact area shall be not smaller than plus 8 and minus 12 range probable errors in depth by plus or minus 8 deflection probable errors in width, measured from the perimeter of the target area. For this computation, use the probable errors contained in the firing table corresponding to the range and related to the center of the impact area.

6.4.4 Maximum Range. Distance X for field artillery cannon shall be not less than the maximum range of weapons to be fired. In low-angle fire, this distance shall be not less than the range of the weapon corresponding to an elevation of 15 degrees (267 mils) for the charge used.

6.5 Tank Cannon. Criteria for designing projectile ranges for tank, M551, and CEV-mounted projectile firing weapons are given in the following paragraphs for 90 mm, 105 mm, and 152 mm (conventional ammunition) guns; 152 mm SHILLELACH missile; and 165 mm Combat Engineer Vehicle (CEV).

6.5.1 Surface Danger Zone. The requirements for impact areas, danger areas, and ricochet areas for tank, M551, and CEV-mounted cannon vary considerably from the range requirements for any other type of weapon because of the flatter trajectory and high muzzle velocity of tank cannon. Determine surface danger zone for 5 degrees (89 mils) maximum quadrant elevation for type of weapon to be fired. (See Figures 12-1, 12-2, 12-3, and 12-4, MCO P357O.1.A.)

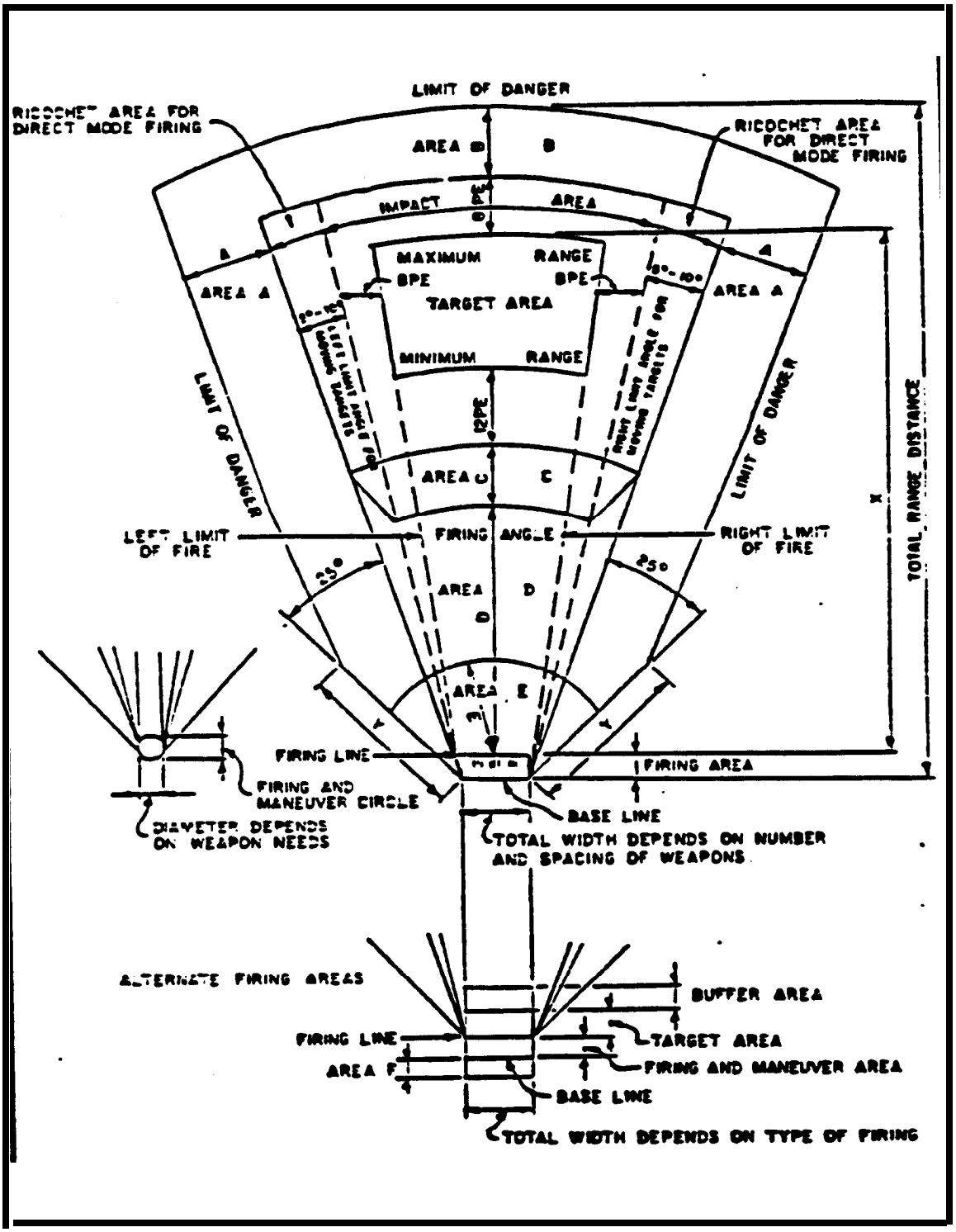


Figure 9
Projectile Range Danger Zones

6.5.2 Tank Grenade Launchers. See Figure 12-5, MCO P3570.1A, for surface danger zone guideline8 and personnel cover requirements.

6.5.3 Tank Cannon. Refer to Table 12-1, MCO P3570.1A, for surface danger zone dimension guidelines for tank cannon: Dimensions A, B, X, and direct fire safety distance8 for unprotected personnel.

6.5.4 Ammunition. The Range Officer shall authorize types of ammunition to be fired.

6.5.5 Subcaliber Tank Weapons. Refer to Table 12-2, MCO P3570.1A, for surface danger zone requirements.

6.5.6 Impact Area and Maximum Range. The length of the Impact area, distance X for one or more tank8 firing on the move or for single tank cannon direct fire from a static position or for tank cannon crossfire shall be not leas than the maximum range of the tank cannon firing the longest range TP or service projectiles permitted to be fired at an elevation of 10 degrees (178 mils). Refer to Table 12-1, MCO P357O.1A. for the maximum ranges of tank cannon, for 105 mm gun, 152 mm gun, and 165 mm gun. Thin restriction shall not apply to tank-mounted machineguns; the maximum range of these weapons is such that they will fire within the tank cannon safety limits when fired at any elevation. Refer to Table 12-2, MCO P3570.1A, for dimensions of surface danger zone for subcaliber tank weapons.

6.5.7 Other Requirements. Place targets no that no tank cannon will be fired at elevations greater than 5 degrees (89 mils) with the horizontal. The limitation of the length of the impact area to that required at 10 degrees (178 mils) maximum angle of elevation, for the longest range ammunition to be used, does not preclude the use of the higher angles of fire that are possible by using reduced charges or by other means within range limitation.

6.6 Air Defense Weapons Firing at Aerial Targets. Criteria for designing a projectile range for air defense weapons firing at aerial targets are shown in Figure 14-1, MCO P3570.1A. and is established for 20, 30, and 40 mm guns.

6.7 Air Defense Weapons Firing at Ground Targets. Criteria for designing a projectile range for air defense weapons firing at ground targets are shown in MCO P3570.1A, Figure 14-2, and in established for the 20, 30, and 40 mm guns. See Figure 14-2, MCO P3570.1A, for surface danger zone and refer to Table 14-1 for maximum range.

6.6 Mortars. Criteria are established in MCO P3570.1A for 60 mm, 81 mm, and 4.2 in. mortars; see Figure 10-l for surface danger tone, and for danger area dimensions, refer to Table 10-1. Dimensions A and B.

6.9 Rocket Launchers. Criteria are established for 35 mm X73 practice rocket, 66 mm M72 Light Antitank Weapon (LAW) rocket, 66 mm M74 incendiary rocket, and 3.5-in. rocket.

6.9.1 Surface Danger Zone. Requirements for surface danger zone for rocket firing differs from other weapons in that a danger area exists to the rear of the launcher as shown in Figure 9, Area F, of this handbook. For danger area dimensions and design criteria for designing range for rocket launchers, see Figure 8-1, and refer to Table 8-1, MCO P3570.1A.

6.9.2 Minimum Range. Provide minimum range (see Figure 9) from firing point to nearest target of at least 70 m (230 ft).

6.10 Recoilless Rifles. Range design criteria are established for the 57 mm, 75 mm, 90 mm, 105 mm, and 106 mm recoilless rifles.

6.10.1 Surface Danger Zone. Requirements for Surface danger zone for recoilless rifle firing differ from other weapons in that a danger area exists to the rear of the recoilless rifle as shown in Figure 33, Area F. Refer to MCO P3570.1A, Figure 9-1, for firing at quadrant elevation of 15 or more, and Figure 9-2 for firing at quadrant elevation of less than 15, and Table 9-1 for danger area dimensions and design criteria for recoilless rifle ranges.

6.10.2 Firing Points. For row of firing points with weapons firing forward, place firing points at least 65.6 ft. (20 m) apart.

6.10.3 Minimum Range. Provide minimum range from firing point to nearest target of at least 1312 ft (400 m) for weapons to 90 mm caliber, and of at least 1804 ft (550 m) for weapons 90 mm caliber and greater.

6.11 Field Artillery Trainer (Air Pressure). The minimum radius of surface danger zones shall be 13 yd (12 m) plus the distance necessary to provide safety from the ricochet of projectiles, as determined by actual examination of terrain by the local authority. For increases in air pressure, increase the danger area. If an observation post is located close to the line of fire, occupants must be protected by a sloping roof of suitable material.

6.12 Protection of Persons Near Firing Point. When high-explosive ammunition with fuses not classified as bore safe is fired in cannon, protection shall be provided against premature burst in or out of the bore.

6.12.1 Safe Distance. Provide positive protection for all personnel within the following distances from the firing post: 200 yd (183 m) for all calibers up to and including 3-in. (76.2 mm), and 300 yd (274 a) for all caliber8 over 3 in. (76.2 mm), up to and including 105 mm.

6.12.2 Positive Protection. Positive protection shall consist of one of the following forms:

a) Sandbags. Provide two thicknesses of filled sandbags for all calibers up to and including 3-in. (76.2 mm); use four thicknesses for all caliber8 greater than 3 in. Height8 shall be sufficient to provide cover for personnel standing erect.

b) Trench. Provide a narrow trench of sufficient depth for proper cover; for cannon detachments, the trench shall be perpendicular to the line of fire and to the rear of the cannon.

c) Concrete Walls. Make walls at least one foot thick (0.3 m) and of sufficient height to provide cover for personnel standing erect.

d) Tractors. Group tractors to afford proper protection (temporary).

Section 7: FLAME THROWERS AND GRENADE RANGES

7.1 Flame Throwers. For design criteria, see Figure 14-2 of MCO P3570.1A.

7.2 Grenades. Range design criteria for hand grenades, rifle grenades, grenade launchers, and tank grenade launchers are as &fined in paras. 7.2.1 through 7.2.5.

7.2.1 Burning Type Hand Grenade. When fired in place, at least 10 m distance for quick retreat of firer to avoid incendiary particles and fumes and at least 10 m throwing distance will be provided.

7.2.2 Fragmentation-Type and Bursting-type Hand Grenades. Trench or protective barrier equivalent to a screen of sandbags 0.5 m (20 in.) thick will be provided for personnel within 150 m throwing of bursting point of HE-loaded-type hand grenades. Figure 7-l of MCO P3570.1A shows surfaces danger zone for designing fragmentation grenade range. Design distances are:

a) At least 100 m between unprotected personnel and bursting point of white phosphorous burning-type M15 and M34 hand grenades.

b) At least 25 m between unprotected personnel and detonation point of bursting-type riot control M25 hand-grenade.

7.2.3 Rifle Grenades. Rifle grenades are fired from behind protective barrier equivalent to a screen of sandbags 20 in. (0.5 m) thick. At least 200 m between detonation point and unprotected personnel will be provided. Figure 7-3, MCO P3570.1A, shows surface danger zone for designing rifle grenade range.

7.2.4 Grenade Launchers. At least 300 m will be provided between unprotected personnel and grenade detonation point. Figure 7-2 of MCO P3570.1A shows surface danger zone for designing ranges for 40 mm grenade launcher I479 and X203 firing MK19, 40 mm MG (grenade).

7.2.5 Tank Grenade Launchers. Design criteria for range design is established for M176, M226, and I4239 grenade launcher8 in para. 12-7 and Figure 12-5 of MCO P3570.1A.

Section 8: LASER RANGES

8.1 Criteria. Refer to Table 19-1 of MCO P3570.1A for a list of laser devices for which range design criteria are established. Figures and Tables in this section are referenced to MCO P3570.1A.

8.1.1 Planning Factors. Special terms and considerations particularly applicable to laser range design criteria are as follows:

a) The distance within which the collimated laser bean present8 a potential eye hazard, the Nominal Ocular Hazard Distance (NOHD) nonmagnified, is comparable to the maximum range of projectile firing weapons.

b) The NOHD is greatly increased when viewing the collimated laser beam with a telescope and is termed the magnified NOHD.

c) Horizontal lateral buffer zones and vertical buffer zones at the periphery of the target area will be determined to accommodate inherent aiming accuracy and stability of laser device being used.

d) Buffer zones should be greatly expanded for situations liable to involve inexperienced personnel, improper target selection, or inaccurate target designation.

e) Use of natural backstops (mountains, hills, and treelines) is especially desirable to limit length of Laser Surface Danger Zone (LSDZ).

f) Airborne laser operations will require LSDZ to be clearly marked, visible, and recognizable from lasing aircraft.

g) The many types of laser devices and uses in conjunction with range firing, troop exercises, tank maneuvering, and operations outside range areas necessitates careful planning for location and delimiting of target area and LSDZ for each individual exercise.

h) Steps must be taken to avoid indirect lasing from specular (mirror-like) targets or icy or snowy ground surfaces.

i) Area S in Figures 19-5 and 19-6 is defined as the 100 ft. (30.5 m) radius around the target from which all specular surfaces should be removed, covered, painted, or destroyed.

j) Area T in Figures 19-5 and 19-6 is defined as an area distance T from laser firing point within which no targets will be lased.

8.1.2 Design Steps. The target area will be large enough to accommodate laser range danger fan for type of laser device to be used and type of exercise and maneuvering. When the laser device to be used is known, T, S, and NOHD and horizontal and vertical buffer zones can be determined from firing tables. Use of current firing range surface danger zones, in general,

will provide conditions and area adequate for safe ground-to-ground lasing if the beam impacts within range impact area. For design criteria refer to the following:

a) Laser Surface Danger Zone (LSDZ) (refer to Table 19-l).

b) Laser Range Danger Fan (see Figures 19-5 and 19-6).

c) Backstops for Laser Ranges (see Figures 19-7, 19-8, and 19-9).

Section 9: PARADE AND DRILL FIELDS

9.1 Siting and Dimensions. The terrain should be relatively flat, with a slight slope for drainage. Consideration should be given to using the parade and drill field for athletic and other recreational activities. Criteria for parade and drill fields follow.

9.1.1 Naval Training Station. Drill field will be 500 x 1,200 ft (152.4 x 365.76 m), centrally located within each 5,000-man group.

9.1.2 Marine Corps Recruit Depot. Parade and drill field will be 900 X 2,500 ft (274.32 x 762 m), adjacent to the troop billeting areas. A drill field within each regimental area will be 500 x 1,200 ft (152.4 x 365.76 m).

9.1.3 Major Marine Barracks. In the billeting area, an adjacent field will be 1,000 x 3,000 ft (304.8 x 914.4 m). In each regimental area, the drill field will be 500 x 1,200 ft (152.4 x 365.76 m).

9.2 Types of Surface. Where erosion is not a serious problem, a well-turfed field is preferable. Water outlets will be located every 250 ft (76 m) along each side of the field. For pavement criteria, refer to NAVFAC DM-5.4.

Section 10: TRAINING COURSE STRUCTURES

10.1 Obstacle Courses. Figure 10 shows a typical layout of an obstacle course. Small crushed gravel should be added to the entire length of the course to a depth of 2 in. (50.8 mm) to provide a firm all weather footing. Retails of individual obstacles are shown in Figure 11.

10.2 Confidence Courses. The course will be approximately 200 yd (183 m) long, with obstacles spaced at equal distances along its length. Typical details for confidence courses are shown in Figure 12.

10.3 Combat Towns. Construction will be repairable construction, such as lightweight precast concrete which will withstand projectile impact. Other materials will be acceptable. Combat town provides instruction and practical experience in cordon, search, clearing, and entry techniques in built-up areas or for use in training in controlling civil disturbances.

10.3.1 Size. Area is determined by training requirements, usually several intersecting streets and several multi-story buildings, including maneuver areas extending 300 yd (274.32 m) in all directions from center of facility.

10.3.2 Locations. If live fire exercises are to be conducted (demolition or small arms), appropriate safety zones and impact areas must be designated. Firing inside the structures is permitted if bullets impact approved backstops.

10.3.3 Construction. Structures will be designed to support floors, walls, roofs, and sandbags around doors and windows. Electric utilities at doors and windows will be required if electric/electronic target/&coring systems are used.

Ground level units may be concrete block construction. Upper stories may be wood. Interior will be sheetrock/plywood construction.

10.3.4 Warnings. Red flags or red flashing lights should be provided during daylight hours and red flashing lights from sunset until sunrise from flagpoles approximately 200 yd (183 m) from facility during use of live ammunition.

10.4 Combat Hut. A "combat hut" provides an opportunity for instruction in, and development of, advanced live fire techniques and execution of cordon, search, clearing, entry. and hostage recovery scenarios. Live-fire scenarios must be designed to be as realistic as possible. Design guidance may be received from: FBI Academy, Quantico, VA; Federal Law Enforcement Academy, Glynco, GA; National Rifle Assn. (Range Development Dept.), Washington, D.C.; NAVFACENGCOMHQ, Alexandria, VA; Weapons Training Dept., U.S. Naval Station, Annapolis, MD.

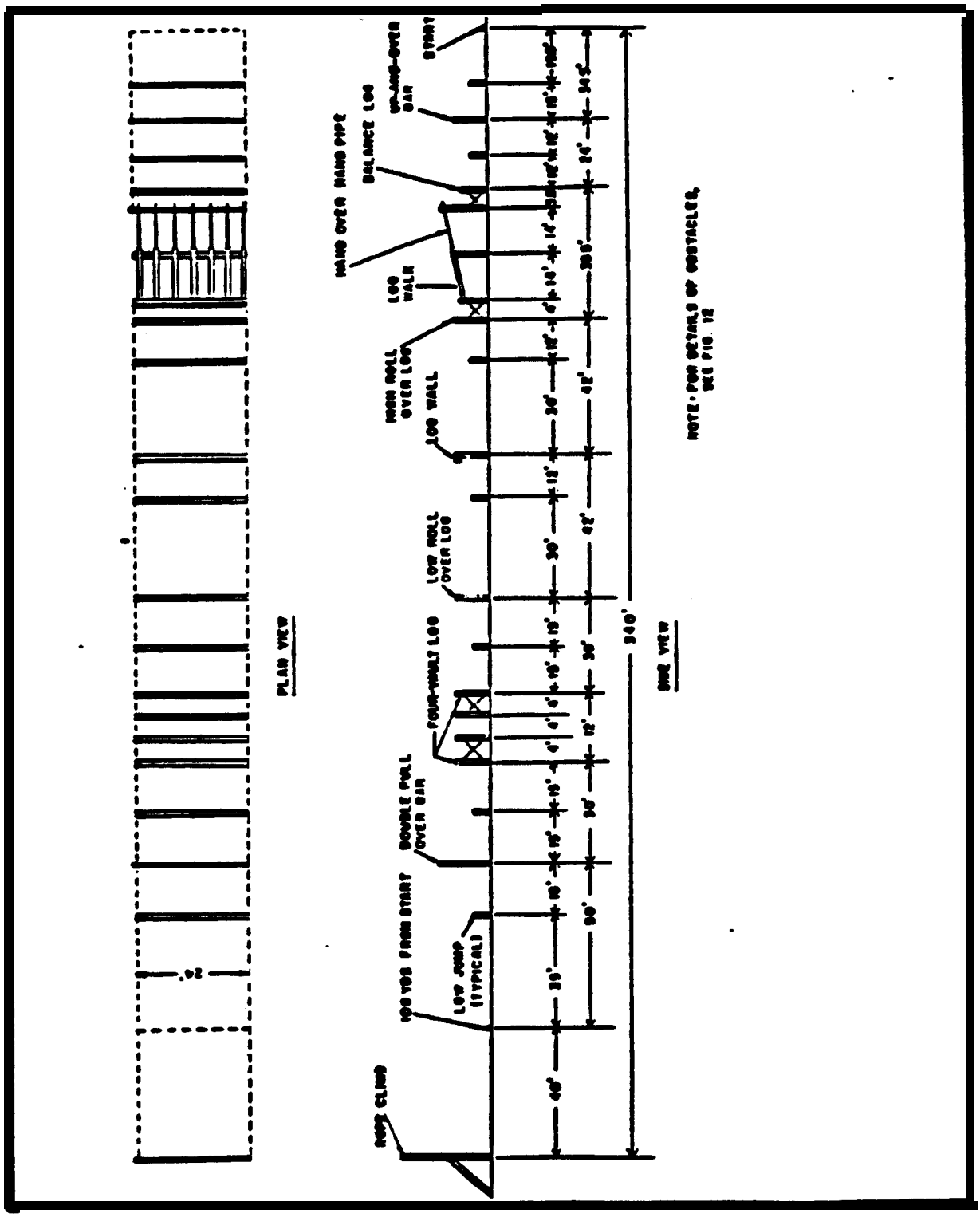


Figure 10
Typical Obstacle Course Layout

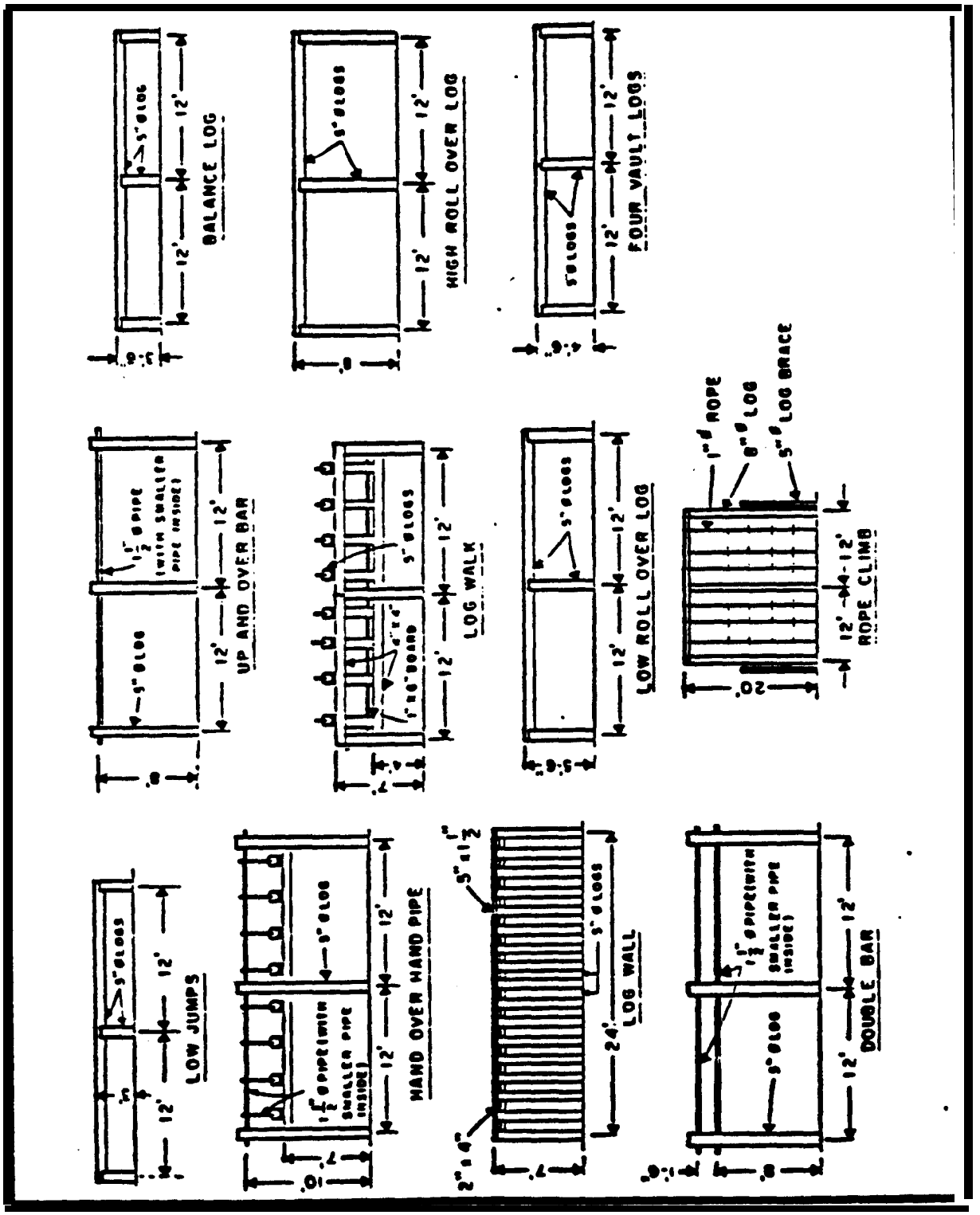


Figure 11
Details of Obstacles

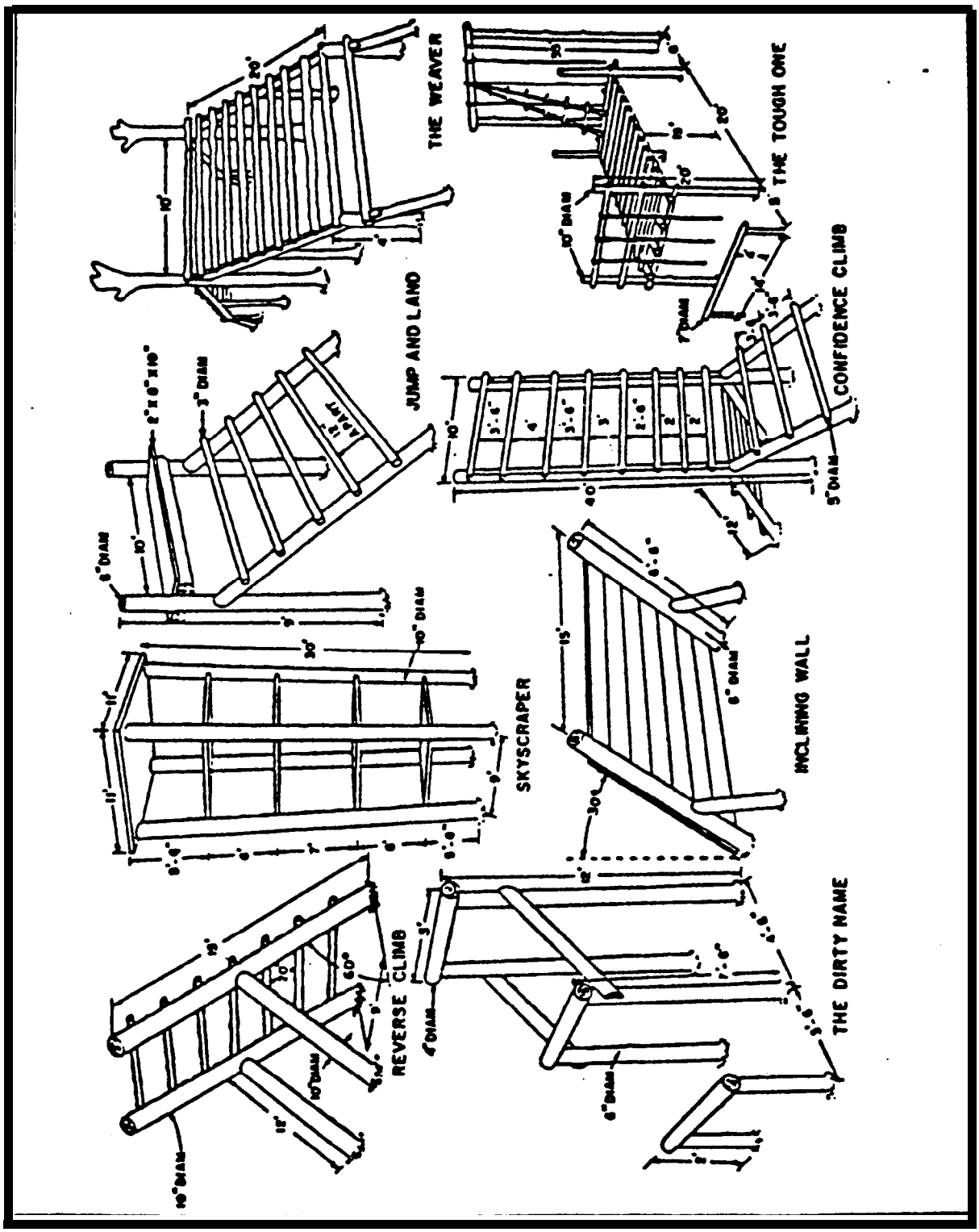


Figure 12
Confidence Course Obstacles

APPENDIX A
ADDITIONAL FIGURES

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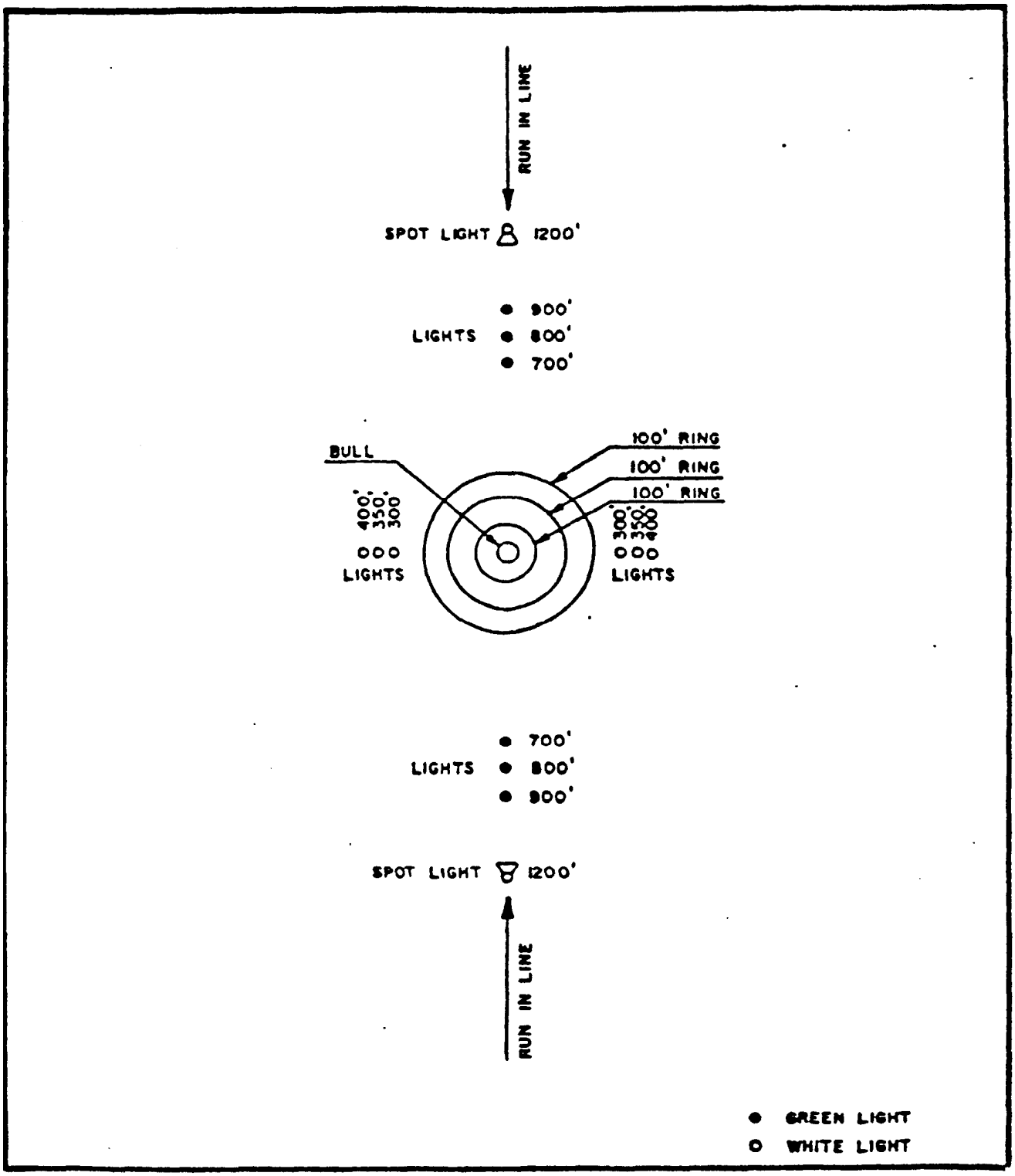

Figure A-12
Bull's Eye Lighting

APPENDIX B: ADDITIONAL INFORMATION AND SUPPLIERS LIST

1. The National Rifle Association publishes information on the design and construction of small arms shooting ranges and other information. Range suggestions may be obtained from the following point of contact:

National Rifle Association
Range Development Department
1600 Rhode Island Avenue
Washington, DC 20036
(202) 828-6190

2. The following partial list of suppliers is provided as an aid to the range designer in making initial contacts during the planning phase of range design.

Bullet Stops, Target Carriers, Turners

American Target Company
1346 South Jason Street
Denver, CO 80223

American Training Aids
750 Clemson Rd.
Columbia, SC 29206

Caswell Equipment Company, Inc.
1221 Marshall Street, NE
Minneapolis, MN 55413

Dentam Corporation
1346 South Jason Street
Denver, CO 80223

Dept. of the Army
Corps of Engineers
Construction Engineering Research Lab
P.O. Box 4005
Champaign, IL 61820
Phone: 1-800-USA-CERL

Detroit Bullet Trap Corporation
2233 North Palmer Drive
Schaumburg, IL 60172

Dixi-USA (Machine Tool) Corp.
1455 Veterans Highway
Hauppauge, NY 11787

Polytronic-ABA, Inc.
P.O. Box 500
Pinellas Park, PL 34290

Range Lighting

The Illuminating Engineering Society
345 East 47th Street
New *York,* NY 10017

Verd-A-Ray Corporation
1120 Connecticut Ave., N.W.
Washington, DC 20036

Range Ventilation Consultants

ETC, Inc.
3513 Leith Lane
Louisville, KY 40218

Safety Curtains, Backsplatter Protectors

Linatex Corporation of America
P.O. Box 65
Stafford Springs, CT 06076

Sound Attenuation Material

Illbruck/USA
3800 Washington Avenue, North
Minneapolis, RN 55412

Laminations Corporation
2254 Harrison Road
Neenah, WI 54956

Dixi S.A./Usine 1
Rue de la Cote 35
CR-2400 La Locle
Switzerland

APPENDIX C: OUTDOOR SMALL ARMS RANGE CRITERIA CHECKLIST

1. The following checklist is intended for use as an aid during field l valuations of an existing range. It may be modified and/or adapted to meet site-specific conditions during a field evaluation.

Design criteria are referenced to paragraph numbers and figures in MIL-HDBK-1027/3B, Range Facilities and Miscellaneous Training Facilities Other Than Buildings. This is intended to provide a basic reference; other paragraphs and figurer in MIL-HDBK-1027/3B may be applicable.

The form is self-explanatory except for the following points. "Description" means type of range, firing distances, fixed or moving targets, and similar descriptive information. "Known Interference" means a statement relating to encroachment, such as operation of adjoining range, waterborne traffic in nearby waterway, low-flying aircraft, or other. If none, insert "none."

QUONSET SMALL ARMS RANGE CRITERIA CHECKLIST

Location: _____
Description: _____

Authorized Firing:
☐ Rifle
☐ Pistol
Other: _____
Ammunition: _____

Most Powerful Weapon: _____
Known Interference: _____

Project: _____
Inspector: _____
Drawings Attached Yes ☐ No ☐
Date: _____
Sheet Number _____ of _____.

No.	Item	Basic Requirements	MIL-HDBK-1027/3A	Compliance w/Reqmts. Yes	No	N/A	Comments/Recommendations
	Physical Features						
1	Surface Danger Zone	Under Navy Control	2.2.1 ; 2.4.1				
2	Impact Area						
	Open Range and With Impact Berm	5 deg. Lft. & Rt. limit of fire	Fig. 2a				
	With Side Protection	50 yds. Lft. & Rt. limit of fire	Fig. 2b				
3	Ricochet Area						
	Open Range and With Impact Berm	5 deg. Lft. & Rt. impact area	Fig. 2a				
	With Side Protection	5 deg. Lft. & Rt. of 50 yd.	Fig. 2b				
	With Overhead Baffles	5 deg. Lft. & Rt. of limit of fire	Fig. 2c				
	With Ground Baffles	50 yds. Lft. & Rt. by 300 yds.	Fig. 2d				
4	Secondary Danger Area	30 deg. & 100 m Lft. & Rt. of ricochet area	Fig.2,2A				
5	Parallel Ranges	Safety arc not closer than 50 yds. of target pits, or 8 ft. high min. wall or berm	2.3.1, Fig. 5				

No.	Physical Features Item	Basic Requirements	MIL-HDBK-1027/3B	Compliance w/Reqmts. Yes	No	N/A	Comments/Recommendations
6	Target Line	Spacing same as firing line	Fig. 6, 8				
	Emplacement berms	Protection of mechanisms	¶2.2.8,Fig. 4				
	Spacing	Rifle=9 ft.; Pistol=5 ft.	¶2.3.4;2.4.3				
	Carrier	Full face of target visible from firing positions	¶2.3.4.3; 2.4.3				
	Target Butts		¶2.3.5, Fig.A-3,A-4				
	Turning Targets	Usually pistol only	¶2.2.10, Fig. 8				
7	Firing Line						
	Spacing	9 ft. rifle, 5 ft. pistols	Fig. 6, 8				
	Canopy	12 ft. forward firing line	¶2.5.2				
	Electronic scoring		¶2.3.7.4				
8	Impact Berm	Full width impact area	¶2.3.7; 2.4.5				
	Earth	Slope 1/1	¶2.3.7.1, Fig. 7				
	Open Range:	5 ft. above top of target + 15 ft. earth or vertical baffle	¶2.3.7.2				
	Baffled Range:	5 ft. above highest point of impact + 15 ft. earth or vertical baffle	¶2.3.7.2				
	Bullet catch	If slope less than 1/1	¶2.3.7.3				
	Eyebrow catch	When bullets are leaving range	¶2.3.7.3, Fig.A-5				
9	Side Protection	Earth berms, continuous walls, wing walls	¶2.5.5				

No.	Physical Features Item	Basic Requirements	MIL-HDBK-1027/3A	Compliance w/Reqmts. Yes	No	N/A	Comments/Recommendations
10	Overhead Baffles		12.5.3				
	Geometry	Minimize projectile leaving range	12.5.1, Fig. 3				
	Materials	Appropriate to weapon and ammunition	12.5.8, Fig. A-6, A-7				
11	Ground Baffles	Normally pistol only	12.5.4				
12	Site Characteristics						
	Grade	Between 1% & 2% side to side	12.2.4.2				
	Elevation	Firing/target - same elevation	12.2.4.2				
	Drainage	No impounded areas					
13	Range Floor	Clear of trees, free of rocks	12.2.4.2				
14	Landscaping		12.2.5				
	Grass cover	To prevent erosion	12.2.5.1				
	Walks		12.2.5.6				
15	Communications	On firing line, between firing line and target pits	12.2.11.1				
16	Safety Equipment		2.2.2; 2.2.3				
	Warning signs and flags	Danger firing in progress, approach roads, barriers	13.2, Appendix A				

No.	Physical Features Item	Basic Requirements	MIL-HDBK-1027/3A	Compliance w/Reqmts. Yes	No	N/A	Comments/Recommendations
17	Support Facilities		¶3.3				
	Control tower	Height to allow full view of danger zone, if surface danger area over water	¶2.2.2				
		Height to see target & personnel	¶2.9.2				
	Access roads		¶3.1.4				

REFERENCES

NOTE: THE FOLLOWING REFERENCED DOCUMENTS FORM A PART OF THIS MANUAL TO THE EXTENT SPECIFIED HEREIN. USERS OF THIS HANDBOOK SHOULD REFER TO THE LATEST REVISIONS OF CITED DOCUMENTS UNLESS OTHERWISE DIRECTED.

FEDERAL/MILITARY SPECIFICATIONS, STANDARDS, BULLETINS, HANDBOOKS, DESIGN MANUALS, AND P-PUBLICATIONS:

Unless otherwise indicated, copies are available from the Naval Publications and Forms Center, Standardization Documents Order Desk, Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.

MILITARY SPECIFICATIONS

MIL-A-12560G(1)	Armor Plate, Steel, Wrought, Homogeneous (for Use in Combat Vehicles and for Ammunition Testing), 12 February 1985.
MIL-S-16216J(1)	Steel Plate, Alloy, Structural, High Yield Strength (HY-80 and HY-100), 16 August 1982.

HANDBOOKS

MIL-HDBK-1001/1	Basic Architectural Requirements and Design Considerations.
MIL-HDBK-1002/1	Structural Engineering General Requirements.
MIL-HDBK-1004/1	Preliminary Design Considerations.
MIL-HDBK-1005/3	Drainage Systems.
MIL-HDBK-1005/7	Water Supply Systems.
MIL-HDBK-1005/8	Pollution Control Systems.
MIL-HDBK-1008	Fire Protection for Facilities Engineering, Design, and Construction.
MIL-HDBK-1011/1	Tropical Engineering.
MIL-HDBK-1012/1	Electronic Facilities Engineering.
MIL-HDBK-1013/1	Design Guidelines for Physical Security of Fixed Land-Based Facilities.
MIL-HDBK-1025/6	General Criteria for Waterfront Construction.

MIL-HDBK-1037/3	Outdoor Sports and Recreational Facilities.
MIL-HDBK-1190	Facility Planning and Design Guide.

DESIGN MANUALS

DM-1.03	Architectural Acoustics.
DM-3.01	Plumbing Systems.
DM-3.03	Heating, Ventilating, Air Conditioning, and Dehumidifying Systems.
DM-3.10	Noise and Vibration Control for Mechanical Equipment.
DM-5 Series	Civil Engineering.
DM-5.4	Pavements.
DM-5.12	Fencing, Gates, and Guard Towers.
DM-7.02	Foundations and Earth Structures.

P-PUBLICATIONS

NAVFAC P-80	Facility Planning Criteria for Navy and Marine Corps Shore Installations.

OTHER GOVERNMENT DOCUMENTS AND PUBLICATIONS:

NAVY

OPNAVINST 3770.2G	Airspace Procedures Manual.
OPNAVINST 5530.13	Physical Security Instruction for Sensitive Conventional Arms, Ammunition, and Explosives.
NAVFACINST 6260.2	Reviews for Health Hazards During Facility Design Process.
NAVFACINST 11010.44E	Shore Facilities Planning Manual: A System for the Planning of Shore Facilities.
NAVFAC MO-100.1	Natural Resources Land Management.
NAVSEA OP-5 Vol. 1	Ammunition Ashore Handling, Stowing, and Shipping.

(Unless otherwise indicated, copies are available from the Naval Publications and Forms Center, 700 Robbins Avenue, Building 4D, Philadelphia, PA 19111-5094.)

ARMY

AR 385-30	Safety Color Code Markings and Signs.
AR 385-63	Policies and Procedures for Firing Ammunition for Training, Target Practice, and Combat.
TM 5-822-2	General Provisions and Geometric Design for Roads, Streets, Walks, and Open Storage Areas.

(Unless otherwise indicated, copies are available from U.S. Army Adjutant General, Publications Center, 1655 Woodson Road, St. Louis, MO 63114.)

FEDERAL AVIATION ADMINISTRATION (FAA)

Federal Aviation Act of 1958

(Unless otherwise indicated, copies are available from Federal Aviation Administration, 800 Independence Avenue S.W., Washington, DC 20590.)

MARINE CORPS

MCO P3570.1A	Policies and Procedures for Firing Ammunition for Training, Target Practice, and Combat, 15 Oct 83, effective 15 Nov 83.

(Unless otherwise indicated, copies are available from Commandant Marine Corps, Code HQSP-2, Headquarters, USMC, Washington, DC 20380-0001.)

OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION (OSHA)

Department of Labor Handbook, CFR Title 29-1910.1025

(Unless otherwise indicated, copies are available from Occupational Safety and Health Administration, 1700 Constitution Avenue, N.W., Washington, DC 20402.)

NON-GOVERNMENT PUBLICATIONS:

AMERICAN CONFERENCE OF GOVERNMENTAL INDUSTRIAL HYGIENISTS (ACGIH)

Industrial Ventilation Manual, 18th edition

(Unless otherwise indicated, copies are available from American Conference of Governmental Industrial Hygienists, Bldg. D-7, 6500 Glenway, Cincinnati, OH 45211-4438.)

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM A36/A36M-87	Standard Specification for Structural Steel (DOD adopted)
ASTM A242/A242M-87	Standard Specification for High-Strength Low-Alloy Structural Steel (DOD adopted)
ASTM A441/1441M-85	Specification for High-Strength Low-Alloy Structural Manganese Vanadium Steel (DOD adopted)
ASTM A514/A514M-87	Specification for High-Yield-Strength, Quenched and Tempered Alloy Steel Plate, Suitable for Welding (DOD adopted)
ASTM A572/A572M-85	Standard Specification for High-Strength Low-Alloy Columbium-Vanadium Steels of Structural Quality (DOD adopted)
ASTM A607-85	Specification for Steel, Sheet and Strip, High-Strength, Low-Alloy, Columbium or Vanadium, or Both, Hot-Rolled and Cold-Rolled (DOD adopted)

(Unless otherwise indicated, copies are available from American Society for Testing and Materials (ASTM), 1916 Race Street, Philadelphia, PA 19103.)

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GLOSSARY

CNO. Chief of Naval Operations.

COE. U.S. Army Corps of Engineers.

DF. Direct Fire.

FB. Fully Baffled.

FL. Firing Line.

FLFS. Firing Line Floor Surface.

GDM. General Development Map.

LLF. Lower Limit of Fire.

MAD. Misdirected and Accidental Discharges.

OB. Overhead Baffles.

PB. Partially Baffled.

RC. Ricochets.

RF. Range Floor.

RSO. Range Safety Officer.

SAR. Small Arms Range.

SDZ. Surface Danger Zone.

SOP. Standard Operating Procedures.

ULF. Upper Limit of Fire.