NATIONAL RIFLE ASSOCIATION

RANGE DESIGN AND RANGE SAFETY HANDBOOK

Issue 1 – December 2022

NATIONAL RIFLE ASSOCIATION

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Preface

In 1862 the Corps of Royal Engineers laid out rifle ranges at Wimbledon Common in accordance with designs prepared by the National Rifle Association. The NRA and the Ministry of Defence (MOD) continued to collaborate on range design for many years, reflecting their shared interest in safe, effective shooting ranges for use with a variety of firearms.

Parliament has never imposed regulations for range design. Instead, the MOD publishes DSA OME Pt3 Vol 2 (previously JSP 403), which sets out range design standards for military ranges. It was originally based on tradition and experience of shooting over many years, rather than empirical evidence. The publication was developed further by trials during 1994-1996 on the ricochet characteristics for ammunition at various distances and angles.

The MOD also provided range inspection services for military, police and civilian ranges, but discontinued this service in 2005.

DSA OME reflects military firearms usage, which varies significantly from civilian firearms usage in a number of important respects. Ranges for military use need to take into account the different shooting positions and tactical practices of military shooting, the use of automatic weapons and a wide range of different ammunition types. Range designers also traditionally applied “worst-case” design criteria to military ranges. The growing number of private ranges means there is a need to provide an equivalent to DSA OME that reflects the conditions of civilian shooting.

The NRA is a charity whose objectives include promoting the efficiency of the armed forces through combined military and civilian marksmanship activities. The NRA has no legislative power to regulate range design or operation. It has published this Handbook in order to assist civilian range operators in applying best practice to the operation of civilian rifle ranges, as part of pursuing its charitable objectives. Commercial advice on the design of specific ranges, as well as range inspection services, are available from National Shooting Centre Limited, the wholly-owned commercial subsidiary of the NRA.

This Handbook is based on the ballistic safety principles contained in DSA OME where that is the best information available on ballistic properties of materials, ricochet, penetration and backsplash. It applies that data to the operation of ranges in the context of civilian marksmanship activities.

References to legislation and regulations are current at the date of issue of this Handbook but users should check in each case whether there have been any updates.

This Handbook will be updated as new information becomes available, following a risk-based approach on best available evidence. It should be read in conjunction with the NRA Range Manager’s Guide, Issue 1 2018.

Finally, the NRA would like to acknowledge the considerable contribution of Maj (Retd) FS Compton MBE RE in the production of this Handbook.

December 2022
Amendments

Amd. No	Chapter	Detail	Name	Date

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Abbreviations

ADA	Air Danger Area
ADH	Air Danger Height
AofS	Angle of Sight
CAA	Civil Aviation Authority
CGR	Converted Gallery Range (Fitted with electric targets)
CLAW	Control of Lead at Work/Regulations 2002
CoF	Cone of Fire (accuracy of the firearm and firer around a point of aim)
CVL	Clear Vision Line
DA	Danger Area
ERV	Emergency Rendezvous Point (Provided for emergency responders)
ETR	Electric Target Range
FDA	Full Danger Area (2900m based on a maximum QE of 150 mils)
FEDA	Full Energy Danger Area (Maximum range a weapon can reach)
FET	Fixed Electric Target
FP	Firing point
FPI	First Point of Impact
g	Gramme
gr	Grain
GR	Gallery Range (as defined in DSA OME Pt3 Vol 2)
GZ	Grouping and Zero
HV	High Velocity
J	Joule
JSP	Joint Service Publication
LDA	Limited Danger Area (A danger area less than 2900m)
LofF	Line of Fire
LofS	Line of Sight
LV	Low Velocity
ME	Muzzle energy
mils	Military Mil (6400 mils in a circle)
MMTTR	Mechanised Moving Target Trainer Range
MOD	Ministry of Defence
MPI	Mean Point of Impact
MV	Muzzle velocity
NRA	National Rifle Association

NSC	National Shooting Centre
OEL	Occupational Exposure Limit
Pam	Pamphlet
PH	Posture Height
PPE	Personal Protection Equipment
QE	Quadrant Elevation
RCO	Range Conducting Officer
RDA	Range Danger Area
RSO	Range Safety Officer, Range Standing Orders
SA	Small Arms
TAN	Tangent
TCH	Target Centre Height
TE	Tangent Elevation
WDA	Weapon Danger Area

CHAPTER 1

1-1 - THE NRA SAFE SHOOTING SYSTEM

1-1-1. Safe Person

A safe person is competent in the use of firearms and ammunition and demonstrates that capability at all times. The NRA Shooter Certification Card system is one example of an auditable record that the responsible officer of the club, normally the Chairman, has satisfied himself that, at the time of certification, the shooter has the ability to use firearms and ammunition safely.

1-1-2. Safe Equipment

The individual shooter is responsible for ensuring:

A. that the chosen firearm is serviceable and properly maintained
B. that the ammunition employed in combination with the firearm results in performance within muzzle velocity (MV) and muzzle energy (ME) restrictions for the range
C. that the combination of firearm and ammunition is safe and suitable for the circumstances in which it is being used

1-1-3. Safe Practice

Range Safety Officers (RSOs) and Range Conducting Officers (RCOs) are responsible for the safe running of ranges. Additional qualifications are required if pistols, moving targets, target shotguns, muzzle loading firearms, firearm/ammunition combinations developing a ME greater than 4500 Joules or event-specific courses of fire are being used. The NRA Rules of Shooting contain regulations detailing the conduct of shooting for each of its disciplines.

1-1-4. Safe Place

A safe place is one in which the controls that are necessary to enable shooting to be conducted safely have been identified by a site specific risk assessment and implemented through Range Standing Orders (RSO). All ranges should have site specific Range Orders (RO) which must be complied with at all times. lt is one of the responsibilities of the RCO/RSO to ensure compliance by shooters under his control. Ranges must be maintained regularly and subject to regular inspection.

1-2 - ESTABLISHING A NEW RANGE

1-2-1. Environmental Issues

A) **Environmental Planning Issues.** When selecting the site for a range, the visual and acoustic effects on the environment and the general public, as well as any measures to reduce those effects, are to be considered. This is particularly important for sites in or near National Parks; areas used for public leisure and inhabited areas. Consideration should also include whether the area chosen for a range is suitable and whether there may be planning authority sensitivities which require consultation with Statutory Bodies. Outdoor ranges where possible should face north in order to keep direct sunlight out of shooters faces

B) **Environmental Health Issues.** For each new and existing range the following issues should be considered

1) **Lead.** Lead contamination on open ranges where the majority of rounds are not captured by a stop butt. This will involve the retention of range records to accurately capture the number and type of ammunition fired
2) **Carbon Monoxide**. Indoor ranges, including tube ranges without controlled ventilation and enclosed firing point ranges should consider the presence of carbon monoxide
3) **Noise**. Covered by Personal Protection Equipment (PPE) by the use of hearing protection
4) **Unburnt Propellant**. Where indoor ranges are considered, emissions from firearms not only expel lead dust but also explosive unburnt propellant. The design should provide smooth surfaces for ease of cleaning and ensure there are no areas where dust might accumulate out of sight

1-2-2. Range Safety Criteria Check

Before funds are committed to any new range, major refurbishment or alteration of an existing range, the Operator should consider passing plans and details to a range design adviser to confirm that the proposal complies with current range safety criteria.

1-2-3. Compliance to Current Legislation

All ranges should be inspected at least once each year as set out in the Management of Health and Safety at Work Regulations. More information is provided in Chapter 9.

1-2-4. Sustainable Range Development and Use

Range development must provide safe, effective facilities and ensure that the effect on range structures and the environment is minimised. Designers are to specify low maintenance solutions and where possible lead bullet debris is to be captured for recycling or easily recoverable for recycling.

CHAPTER 2
RANGE DESIGN CRITERIA

2-1. INTRODUCTION

2-1-1. Aim

This chapter sets out the general ballistic criteria that are applied to all ranges. It is mainly derived from military ammunition trials. It is not practical to assess the ballistic properties of all common types of ammunition, particularly hand loaded ammunition. For this reason the ballistic criteria in this document will relate to Muzzle Energy (ME) and Muzzle Velocity (MV).

2-1-2. Category of Range Elements

Not all range elements affect the safety of a range, however it is important to understand those parts of a range that could make the range unsafe if not maintained correctly. Safety critical elements of a range are highlighted in this and subsequent chapters.

2-1-3. Assessing Range Safety

Ranges up to 100 m are assessed by straight line trajectories. This provides a small margin of safety and it is where novice shooters will start to develop shooting skills. Beyond 100 m trajectory may be taken into account.

2-2 - DEFINITIONS AND RANGE SAFETY TERMS

2-2-1. Definitions

The definitions and range safety terms that relate directly to the contents of this Handbook have been included in this chapter.

2-2-2. Air Danger Area

An Air Danger Area (ADA) is the airspace above a range which has been notified as such within which activities dangerous to the flight of aircraft may take place or exist at such times as may be notified. Airspace below 500 ft may be used by light aircraft, helicopters and military flights. Only those ranges registered with CAA will have a notified ADA.

2-2-3. Air Danger Height

The Air Danger Height (ADH) is the maximum height above ground level (AGL) at which a hazard may exist (see Notes 1 and 2). Table 1 below gives ADH for ammunition up to 8.6mm.

Ser	Ammunition	Constructed open ranges		Open Ranges		Remarks
		No exposed hard surfaces	Exposed hard surfaces	QE <8.5deg	QE 8.5 - 35 deg (Note 3)	
(a)	(b)	(c)	(d)	(e)	(f)	(g)
		(ft)	(ft)	(ft)	(ft)	
1	5.56 mm	500	1000	1000	8000	
2	7.62 mm	750	1500	1500	8800	
3	12.7 mm	Not used	Not used	3000	14300	
4	9mm	500	500	1000	3200	
5	0.22 in Ball	500	500	1000	1000	
6	8.6mm Ball	500	500	3000	3000	(Note 5)

Table 1 - Ammunition ADH

Notes;

1. *The ADH is either the vertex height of the ammunition nature or its maximum ricochet height*
2. *An ADH is measured in feet (ft) AGL. Altitude is measured in ft Above Mean Sea Level (AMSL)*
3. *For High Elevation Fire (HEF) (QE 8.5 - 35 deg), this ADH provided should be applied when the cone of fire is not captured by the ground*
4. *7.62mm ball may be fired on a Gallery Range with an ADH of 500ft providing an air sentry is provided and the air sentry has clear vision of the air space over the range (typically the RSO/RCO acts as the air sentry)*
5. *8.6mm ammunition fired under the specific control measures authorised by the NRA at NSC ranges*
6. *Other ammunition natures may perform differently, where there is a concern over proximity of airports and the like, advice must be sought*

2-2-4. Ammunition Danger Area.

See Range Danger Area Template (2-2-21).

2-2-5. Angle of Sight

The Angle of Sight (AofS) is the acute angle between the Line of Sight (LofS) and the horizontal plane. (For details of further ballistic angles see Figure 2-1.)

2-2-6. Approved Range

A range which varies from the design and build criteria specified for its type in this Handbook. However, the resultant risk is assessed not to exceed the level for a compliant range of the same type.

2-2-7. Backsplash

Backsplash is fragmentation or target debris thrown backwards at any angle produced by projectile impact.

Ser	Firearm	Fragment/Earth Throw Distance Hard Tgt (m)	Fragment/Earth Throw Distance Ground Tgt (m)
(a)	(b)	(c)	(d)
1	Rimfire, centrefire pistol and carbine	22	10
2	Centrefire rifle	50	22

Table 2 - Backsplash Zone (Safety Distances)

Note;

Backsplash from well maintained stop butts into the gallery on gallery ranges should not exceed 5m. For NDA ranges authorised practices may be undertaken down to 7m from targets providing the bullet catcher is well maintained. Backsplash distances may vary from this dependent on ammunition/firearms/targets and backstop/bullet catcher combination. A well maintained stop butt and bullet catcher is one where no bullet debris is permitted to build up around the MPI and any scooping raked over after each days use.

2-2-8. Clear Range Procedure

A procedure initiated by the Range Operator applied to ensure that the Range Danger Area (RDA) is clear of unauthorised persons before firing commences and that it remains clear throughout the time firing is in progress. The procedure includes provision for the timely cessation of firing before it poses a risk of hazard to an intruder in the RDA.

2-2-9. Clear Vision Line

Clear vision lines are projected from above and below the firer to the target to ensure there are no distracting protrusions within the firer's peripheral field of vision in all firing postures, see Figure 1 below. The extent of clear vision required is set out in the relevant sections and chapters of this handbook. Clear vision lines are established to ensure that:

A. there is no risk of backsplash to the firer
B. the firer maintains an unrestricted view to the target and its immediate surroundings; and
C. the firing point accommodates the physical build of an individual fire

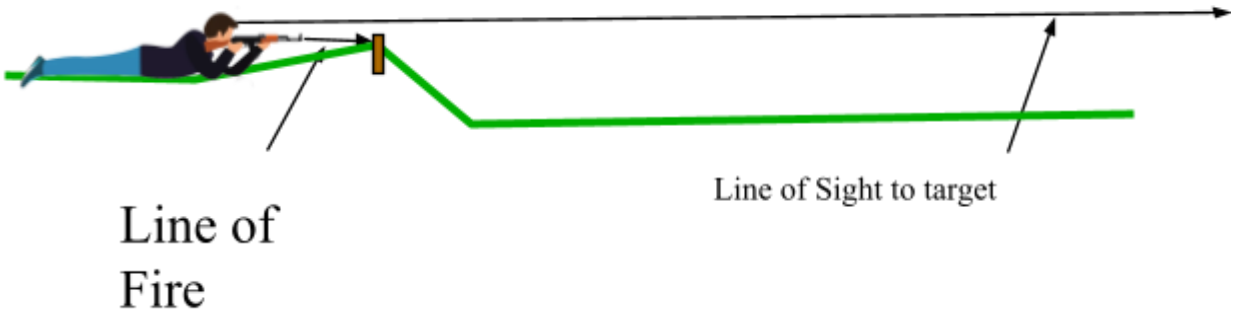


Figure 1 - Clear Vision Line

2-2-10. Cone of Fire

The Cone of Fire (CoF) is the distribution of fired projectiles within a margin of error in the vertical and horizontal planes. For design purposes the CoF figures in Table 3 below are applied around each Line of Sight (+elevation, - depression and +/-azimuth). The CoF accounts for acceptable deviation caused by errors associated with the firer and machining or manufacturing tolerances, and allows an additional margin for unacceptable firer error. Table 3 lists the CoF applicable on NRA ranges.

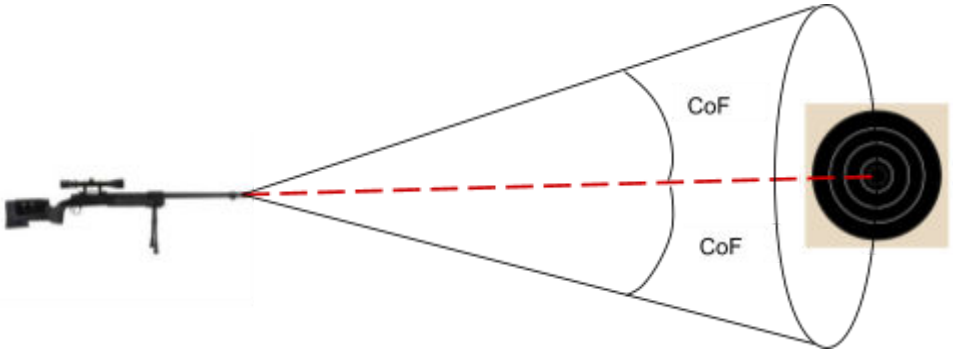


Figure 2 - Cone of Fire around Point of Aim

Ser	Practice (All single shot deliberate shooting)	Cone of Fire (mils/deg)	
		Azimuth	Elevation
1	Rifle / Carbine static to static unsupported	40 / 2.25	40 / 2.25
2	Rifle / Carbine static to static supported	21.5 / 1.15	21.5 / 1.15
3	Rifle / Carbine moving to static or static to moving	120 / 6.75	60 / 3.38
4	Rifle competition target shooting	12 / 0.6	12 / 0.6
5	Pistol double hand static to static	135 / 7.7	135 / 7.7
6	Pistol single hand static to static	190 / 10.7	190 / 10.7
7	Pistol double hand moving to static or static to moving	250 / 14	190 / 10.5

Table 3 - Cones of Fire - NRA Practices

Notes;

1. *Range officer must monitor all fall of shot, bullet strike and target grouping to confirm the detail in this table and where necessary increase safety measures if there is evidence of a lar*ger CoF
2. *A further reduced CoF of 21.5mils recommended by the NRA may be applied only under the following conditions;*
    a. *Use is restricted to competent marksmen using a rifle zeroed or check zeroed at not more than 200m each time the firearm is brought onto the range*
    b. *The reduced CoF is for single shot supported shooting practices; or*
    c. *Where the shooters are known and have proven shooting skills backed up by the actual fall of shot in the stop butt. An entry in the range risk assessment should be provided to justify the reduced CoF*
3. *Maximum range of the firearm system is normally achieved with a barrel elevation of about 35 deg. Above and below this elevation the bullet falls short of maximum range*
4. *CoF for Target Shotgun and Practical Shotgun Practices will be included in revisions to this Handbook in 2023. Interim advice may be sought from the NRA*

2-2-11. Design Certification

Design certification for a new range is a signed statement by a competent person that the design wholly or partially meets or complies with the approved specification(s). The NSC is able to advise on compliance on range works and projects.

2-2-12. Ground Target (also called Soft)

Ground target refers to all surfaces which, when impacted at low angle (<30^0), will deform or break up. Water surfaces and ice are also classified as a ground target. In this document, the term `Soft' will be used.

2-2-13. Hard Target

Hard target refers to all material which possesses sufficient strength and surface hardness that at low angles of impact the target suffers little or no deformity. When hard surfaces are exposed to the firer, additional Danger Area wings are applied.

2-2-14. Hill Background

A hill background exists when ground immediately behind the targets rises to form a hill beyond which no projectile hazard is predicted to exist. If the criteria are met, consideration can be given to reducing the RDA. Illustrated at Figure 2 – 3.

A. **For Hills or Cliffs (>56^0) directly behind the Target Line.** The hill has a minimum mean slope of 56^0 rising immediately behind the target line and has a minimum height of 50 m above the point at which the LofS from the 100 m firing point meets the perpendicular from the summit. When such a slope spans the full width of the RDA trace, the reduced probability of escapement enables the length of the trace to be reduced to the 50 m point

B. **For Hills or Slopes (>30^0) behind the Target Line**. Alternatively, the hill has a minimum mean slope of 30^0 rising behind the stop butt and has a minimum height of 100 m above the point at which the LofS from the 100 m firing point meets the perpendicular from the summit. When such a slope spans the full width of the RDA trace, the reduced probability of escapement enables the length of the trace to be reduced to the 100 m point described

2-2-15. Line of Fire

The Line of Fire (LofF) is an imaginary straight line from the barrel of the firearm to the target. The LofF is used by range designers to ensure safety from all firing positions. The distinction between Line of Sight (LofS) and LofF is critical when shooting from the prone position as although the sight to target is clear, the Line of Fire may not be. For example, a rifle fitted with an optical sight 50mm above the centre line of the barrel. (Figure 3)

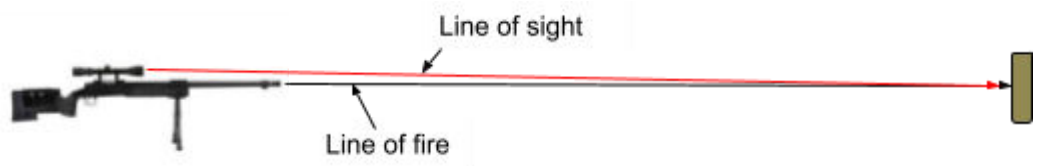


Figure 3 - Line of Fire

2-2-16. Line of Sight

The LofS is a straight line passing through the aiming device (sight) of the delivery system and the point of aim on the target so that the firer can see the target he is engaging. (Figure 3)

2-2-17. Military Measurement

The military use an angular measurement of a “mil”. A mil subtends approximately 1 mm at 1 m and 1 m at 1 km. This simple unit of measurement aids setting out and estimating angles and distances in the field.

Example: The height of a range component is required to be 6 mils measured from the firing point. If the distance from the firing point to the component is 30 m, the height required is:

$\frac{6 \times 30}{1000}$ = *0.18 m or 180 mm*

Note; 1 *mil* = 0.0562 deg *and* 1 deg = 17.778 *mils*

2-2-18. Quadrant Elevation

The Quadrant Elevation (QE) is the angle between the horizontal plane and the axis of the bore when laid (sighted). For the purposes of range design, in this publication the following sub definitions are provided:

A. a. QE_{TCH} = QE to the Target Centre Height (physical point on a range that can be measured)
B. b. $QE_{Actual} = QE_{TCH}$ + CoF
C. c. QE_{Max} = QE Restriction applied

2-2-19. Range

A range is a space reserved and equipped for hazardous firing. The following are types of range:

A. **Indoor Range.** An indoor range is fully contained within a building or other structure.
B. **Open (Outdoor) Range**. An open range is exposed to the natural effects of light, wind and other meteorological conditions. The range may be completely open or contained partially by a structure such as a covered firing point
C. **No Danger Area Range**. A No Danger Area (NDA) range is a range where, for all practical purposes, the design precludes risk of injury or damage to persons or property beyond the range floor caused by shot, direct or ricochets, fired in accordance with authorised procedures and aimed within the bounds of acceptable aimer error
D. **Limited Danger Area Range**. A Limited Danger Area (LDA) range is an open range for which the minimum design requirements are to capture shot so that any resultant ricochet remains within the LDA
E. **Full Danger Area Range.** A Full Danger Area (FDA) range is an open range where hazard is only limited by the elevation of the delivery system and the skill of the firer
F. **Total Energy Range**. A total energy range is a range where a firearm may be fired without QE restriction

2-2-20. Range Danger Area

The RDA is the space within a range in which there may be a risk to personnel, equipment or property from firing authorised firearms within specific arcs. The RDA must be within the controlled area boundary. Access to and movement within the RDA are controlled through Range Orders. RDA includes the Air Danger Area (ADA) and is better described as Range Danger Zone (RDZ)

Note; *Boundaries on land should have appropriate control measures in place to warn the public and to deter access, e.g. signs, fences, flags, lights and sentries*.

2-2-21. Range Danger Area Template

A RDA template is a technical drawing which defines the boundary of prescribed risk from firing authorised firearms within specific arcs on a range built to approved criteria. The RDA template is to be worked to a given scale and produced on appropriate material for convenient application to a map, or should be worked in an electronic medium for application to photographic or survey material by a suitable program.

Notes;

1. *Elements of construction including firing point alignments with targets will affect hazard contours and hence change the shape of specific RDA*
2. *The RDA template will only apply to a range built to the specifications and criteria set out in this Handbook*
3. *The RDA template is range type, firearms type, ammunition type and QE_{Max} specific*
4. *In areas where there is limited land available, particularly if there are hills in the direction of fire, it is possible, using alternative assessment and allied to additional controls, to allow the use of a reduced danger area*

2-2-22. Range Danger Area Trace

A RDA trace is a technical drawing of a common composite Danger Area (DA) which is deduced from an amalgamation of a number of WDA templates. The trace is worked to a given scale and produced on appropriate material for convenient application to a map.

2-2-23 Range Floor

The range floor comprises the ground from the furthest firing point to the target including any range construction intended for or capable of capturing correctly aimed shots or reducing ricochet.

2-2-24. Range Operator

The Range Operator is responsible for certifying on the Range Safety Certificate the firearms and ammunition which can be used on the range. They are also responsible for ensuring the safe use and maintenance of the range.

2-2-25. Ricochet

A ricochet is the change of direction and velocity, induced in a projectile or fragment caused by its impact with a surface. For design purposes ricochet is generally taken as 30^0 off soft targets and 45^0 off hard surfaces in elevation and azimuth for high velocity ammunition. For low velocity ammunition the ricochet angles are taken as 15^0 off ground and 45^0 off hard. For specific range advice the NRA may utilise data provided by MOD from trials. Ricochet greater than 90^0 is regarded as backsplash.

2-2-26. Small Arms

Small Arms (SA) is a general term for small calibre firearms.

2-2-27. Tangent Elevation

Tangent elevation (TE) is the angle between the LofS to the target and the axis of the bore.

2-2-28. Template

A template is a technical drawing worked to a given scale and produced on appropriate material for convenient application. See also RDA & WDA Template.

2-2-29. Trace

A trace is a technical drawing of an amalgamation of WDA templates worked to a given scale and produced on appropriate material for convenient application to a map.

2-2-30. Trajectory

Defined as the path followed by a projectile flying or an object moving under the action of given forces is an important issue on outdoor ranges with limited danger areas. Each firearm has a maximum potential range generally at a barrel elevation of around 35^0. Range templates are based on maximum trajectory of 70 mils (4^0) for gallery ranges and 150 mils (8.5^0) for other high velocity ranges. These elevation limits are reduced to take account of the expected CoF to determine maximum barrel elevation. The safety margins on maximum trajectory for limited danger areas is very small. The difference for example between the gallery range limit of 1830m and 2900m danger area limit is just 4^0.

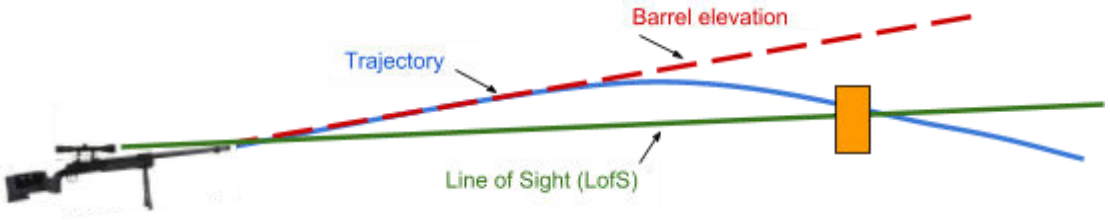


Figure 4 - Trajectory

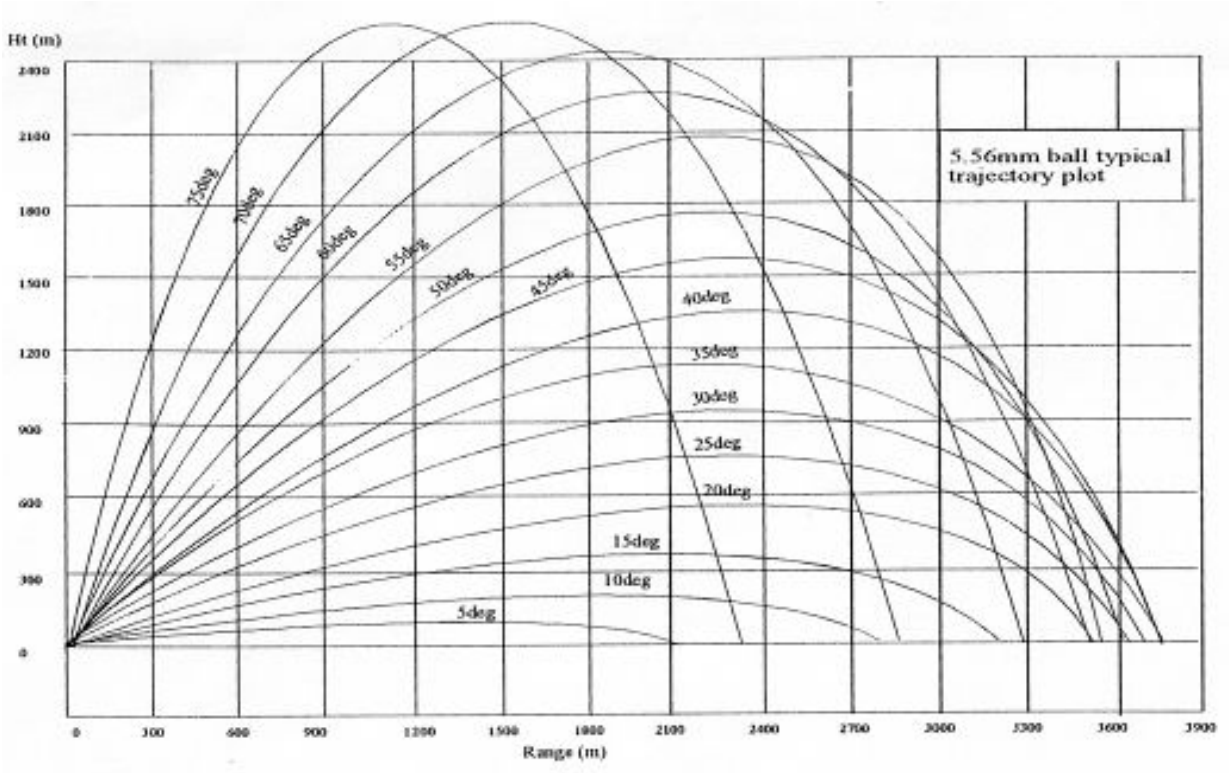


Figure 5 - Trajectories for 5.56mm ammunition.

2-2-31. Vector Angle

A vector angle is an angle with a horizontal and vertical component. Vector angle is not used in assessing range compliance as the ricochet angle used represents total turn and not the elevation and azimuth components of ricochet.

2-3 - RANGE SAFETY STANDARDS

2-3-1. General

The risk of a projectile leaving a range is minimised by a combination of design, skill and control i.e. Safe Place, Safe Person and Safe Practice.

2-3-2. Design Parameters

Range design is based on historical evidence contained in MOD publications and documents. This Handbook advises on ballistic data generated from trials and considered opinion, based on appropriate ballistic and statistical calculations, on reasonable levels of range safety. NDA and other ranges are not designed on the absolute worst case. They are designed to capture all properly aimed projectiles with an additional degree of safety for acceptable aimer error and ricochet. Ranges are not designed to capture all projectiles from accidental or negligent discharge. Ranges that were designed to established standards have given no cause for concern and still meet the current minimum level of safety. New ranges and major refurbishment of ranges should be constructed to the design criteria in this Handbook; advice from specialist range designers may be sought. Legislative requirements of the Health and Safety at Work Act and the Management of Health and Safety Regulations are satisfied by the design process undertaken by consultants and contractors commissioned by the Range Operator under the conditions provided in this document. The detail provided in this document addresses identified and predictable hazards, to which it provides engineering solutions to reduce the perceived risk to As Low As Reasonably Practicable (ALARP). Engineering to ALARP is not necessarily a sufficient solution to achieve an acceptable level of risk. Additional controls through training, usage limitations and supervision may be needed to reduce risks to acceptable levels.

2-3-3. Accuracy of Construction

This publication provides the minimum standards that should be achieved. Where an element is fundamental to the level of safety it is identified as such. These elements should be subjected to compliance checks on completion of any works. On existing ranges, elements that do not conform to the standard should be included in the range Risk Assessment to determine if the level of safety provided is affected. Where the level of safety is reduced, control measures must be applied to maintain the level of safety required. Where this cannot be achieved the range may only operate under suitable restrictions until such time as a full assessment is completed by a range adviser and the range is approved as safe to use.

2-3-4. Compliant Ranges

A range which meets the design and build criteria specified for its type in this Handbook. Most ranges have some degree of non conformity. Although different from those illustrated in this Handbook they will conform to the safety critical elements described in the respective chapters. Where doubt exists, a range adviser is to be consulted.

2-3-5. Maintenance

To ensure that ranges in use conform to current safety criteria, effective maintenance is essential. The Range Operator should appoint a competent person to carry out these duties. The frequency of maintenance and inspections is given in Chapters 8 & 9. A range works inspection guide is provided in Chapter 9.

2-3-6. Conduct and Use

A range is designed and built only for specific use with specific firearms under proper supervision and in accordance with the Range Operators' safety rules.

2-3-7. Population Density

When planning a new range consider population density and public sensitivity around a proposed range before determining location and orientation.

2-3-8. Siting Preferences

Outdoor ranges should be sited facing north in the Northern Hemisphere so that firers do not engage targets into direct sunlight. The range should also be sited as far as possible from habitation as it is difficult to reduce impulse noise generated without modification to the firearm. When siting ranges, aligning the direction of

fire away from habitation when possible should take precedence. The total energy template should be considered when assessing population and habitation in the area of the proposed new range.

2-4 - LIMITATIONS OF BALLISTIC PERFORMANCE ON RANGES

2-4-1. General

This section applies to all firearms used on civilian and military ranges.

2-4-2. Performance

The performance of firearms can be expressed in several ways. For the design of ranges, muzzle velocity (MV) and muzzle energy (ME) are used. These performance criteria are directly related to current MOD ammunition types in determining WDA, penetration data, backsplash and ricochet. However, it is essential to specify the firearm performance limits for each range type to ensure that the range remains safe during use. Firearm performance may vary depending on several factors, two of which are:

A. **Type of Ammunition.** Certain types of ammunition can significantly enhance the effects of a firearm that could result in its performance exceeding the design criteria of the range (e.g. mono-metal bullet use)
B. **Cartridge Loading**. In the case of hand loaded cartridges, altering the quantity or quality of propellant to meet performance specifications can be dangerous. The MV and ME specifications for the particular range are not to be exceeded

2-4-3. Authorised Firearms

As the requirement is to limit firing to those firearms that perform safely within the design criteria of the range, only those firearm and ammunition combinations whose MV and ME do not exceed the criteria stated on the Range Safety Certificate may be fired on constructed ranges. When only one performance criterion conforms to the authorised limits the NRA should be consulted. For example, a light, small calibre bullet with an MV higher than the specification for the range may have an ME within the specification but such a bullet is likely to have very different ricochet characteristics to the slower, heavier bullet for which the range has been designed.

2-4-4. Muzzle Velocity and Muzzle Energy Limitations

Each range will be authorised for specified firearms and ammunition. The limitations for firearms contained in Table 4 and any other limitations on how a range can be used will be stated on the Range Orders (RO) and in Range Standing Orders (RSO). The commonly used term "Low Velocity" (LV) is related to serials 1 to 3 in Table 4 below. "High Velocity" (HV) refers to firearms with MV greater than 655m/s (2145ft/sec).

Ser	Firearm Type	Indoor		Open	
		MV(m/s)	ME (J)	MV(m/s)	ME (J)
(a)	(b)	(c)	(d)	(e)	(f)
1	Air rifle	N/A	16 (12ft lbs)	N/A	16 (12ft lbs)
2	Rimfire firearm only	530 (1735ft/sec)	285 (210ft lbs)	610 (2000ft/sec)	480 (350ft lbs)
3	Centrefire pistol/carbine	520[2] (1705ft/sec)	645[2] (475ft/bls)	655 (2145ft/sec)	2030 (1495ft lbs)
4	Centrefire rifle NDA ranges	1000 (3280ft/sec)	7000 (5160ft lbs)	1000 (3280ft/sec)	7000 (5160ft lbs)
5	Centrefire rifle on ranges with GR LDA			1000 (3280ft/sec)	4500[1] (3319ft lbs)
6	Centrefire rifle on other ranges			No ME/MV limits – Refer to Chapter 19 Figure 19-2 to determine extent of RDA required.	

Table 4 - SA Ammunition Maximum MV and ME Limitations

Notes;

1. Firearms with ME greater than 4500J but less than 7000J may be used on gallery type ranges providing authorised control measures are in place. Where there may be any doubt about the ammunition or practice, civilian clubs and police are to be restricted to MAX 4500J, 1000m/s
2. These figures relate to defence structure specification in Table 7a below
3. Civilian clubs may only use copper or steel jacketed lead core or solid lead rounds on MOD ranges
4. Range structures such as control buildings on the range floor have sufficient protection for firearms up to 7000J
5. Authorised control measures are those adopted by the Range Operator for the relevant cartridge

2-4-5. Black Powder Firearms

Black powder or black powder substitute propelled firearms may be fired on open ranges. MV and ME must not exceed the specified limits for that range. Black powder firearms should not be fired in indoor ranges due to the hazardous emissions unless a forced air ventilation and filtration system is installed and operating and is included in the Range Orders for the indoor range.

2-4-6. Shotgun

Use of shotguns with solid slug may be authorised on approved ranges. Use of birdshot/buckshot does not require a constructed range. Use of birdshot/buckshot on private land (including constructed ranges) is at the discretion of the land owner/range operator. CoF for Target Shotgun and Practical Shotgun Practices will be included in revisions to this Handbook in 2023. Interim advice may be sought from the NRA.

2-4-7. Conversion of Ballistic Data

It may be necessary to convert ballistic data to make a comparison with data available in this Handbook and elsewhere. This paragraph provides simple equations to calculate ME when MV and weight are known, and to convert weight expressed in grains (gr) to an expression in grams (g).

A. **Calculation of Energy**. When MV and bullet weight are known, ME in joules (J) may be calculated:

$\frac{1}{2}NV^2 = ME_J$ N = Bullet weight in kg

V = MV in m/s

e.g. Eley Tenex 0.22 in

Bullet weight (N) = 2.59g or 0.00259kg

MV(V) = 331 m/s.

Answer: $ME = 0.5 \times 0.00259 \times 331^2 = 142J$.

B. **Conversion of Bullet Weight.** Bullet weight expressed in grains (gr) may be converted to grams (g):

1gr = 0.065g 1g = 15.432gr.

C. **Energy**. ME expressed in foot pounds (ft lbs) may be converted to Joules (J).

1J = 0.738ft lbs 1 ft lbs = 1.3556J

D. **Velocity**. MV expressed in feet per second (ft/s) may be converted to metres per second (m/s):

1ft/s = 0.3048m/s

1m/s = 3.281ft/s

2-5 - RANGE DETAILS AND DRAWINGS

2-5-1. General

When a Range Operator produces drawings for a new range, for development of an existing range or to seek compliance they should include all safety critical criteria such as;

Ser	Detail
1	Range type – outdoor, indoor, NDA, LDA, FDA
2	Location - Post Code or other method of location (e.g. What3Words)
3	Distance firing point to target
4	Number and height of firing points
5	Target details (static / moving) height at target centre
6	Bullet trap detail
7	Back wall height

Table 5 – Details for Range Drawings

2-5-2. Construction/Record Drawing

Construction drawings will be specific to the site with the details of the shape of the range floor, foundations and all that is listed in 2-5-1 above. If during the construction of the range there are no fundamental changes to the design, the construction drawing serves as the record drawing and should be retained by the club.

2-5-3. Change Records

Any subsequent significant changes to the range must be recorded onto the range drawing or where there is substantial change, a new drawing is produced. This will ensure a clear audit trail is maintained and that all changes are properly checked for compliance. Significant changes include adding or changing firing points or target types and positions.

2-6 - RANGE TYPES

2-6-1. Types of Ranges

This Handbook deals with all ranges designed for a specific purpose. The range types included in this Handbook include:

2-6-2. No Danger Area (NDA) Ranges

To be classed as an NDA range, all anticipated shot must be contained within the range with a substantial margin of safety. The following range types may be classed as NDA ranges;

A. Indoor Ranges including tube ranges
B. 25m Barrack ranges
C. The 1908 design 30m range (now only used from the 25m firing point)
D. Some test ranges
E. Non standard open NDA ranges

2-6-3. Limited Danger Area (LDA) Ranges

Ranges where some rounds are expected to leave the area of the range floor either from direct fire or ricochet have a limited danger area to ensure all rounds are contained in a controlled area. Such ranges include;

A. **The Gallery Range (GR).** The Gallery range has a limited danger area based on the principle that the CoF is lifted from the range floor by the mantlet thereby reducing the incidence of ground ricochet, the primary source of rounds escaping a range. A 1830 m RDA is applied from the target line. Most existing GR ranges have a QE restriction (QE_{max}) of 70 mils, which equates to QE_{tch} of 30 mils to ensure the limited danger area is sufficient. Gallery ranges with modified mantlet and stop butts that have been increased in height to capture the whole CoF do not need to impose the QE restriction as all predicted direct fire from the 100 m firing point will be captured. A further reduction in the length of the RDA from 1830m may be considered if and when hill background criteria is met
B. **The Converted Gallery Range (CGR)**. This range is a Gallery range with the gallery frames and Fixed Electric Targets (FETs) mounted into the top of the mantlet
C. **The Electric Target (Limited Danger Area) Range (ET(LDA)R).** This range has no gallery, and has Fixed Electric Targets (FETs) mounted into the top of the mantlet often with Automatic Marking Systems (AMS) fitted
D. **Baffle Ranges**. Open baffle ranges are no longer considered cost effective designs as they do not as previously thought capture all rounds. UK Baffle ranges are designated as Approved ranges
E. **25m Barrack Range and centerfire non-standard No Danger Area Ranges.** These ranges without a canopy are classed as LDA ranges as they have a 100m RDA beyond the back wall
F. **Hill Background Ranges**. A few ranges have met the criteria in Fig. 2-3. Open ranges with a hill rising behind the stop butt may be assessed by the NRA to determine the actual RDA required on such ranges

2-6-4. Full Danger Area (FDA) Ranges

A. **The Electric Target Range (ETR) – 600m –** A flat range floor with FETs located at 100, 200 & 300m from the main firing point. All shot is automatically recorded and targets are able to fall when hit. A WDA is usually applied with hard target wings when necessary
B. **Pistol Ranges.** Pistols are often fired on NDA and other ranges. When fired on LDA / FDA ranges the pistol template is applied in accordance with the principles illustrated in Chapter 4 using the CoF for pistol under LDA/FDA ranges in Table 3. A 1500m RDA is usually applied

2-7 - CIVILIAN RANGE DESIGN

2-7-1. Design Principles

Safety on and around ranges is provided by the provision of safe firearms, training, control measures, supervision and for constructed ranges, safe design. To ensure ranges remain safe the design must also take into account cost in use by minimising the maintenance effort. There are four categories into which all ranges fall to provide a safe shooting environment:

A. **Total Energy Range**. A total energy range will have a template large enough to capture all shot fired in a particular direction without further restriction. Large land or sea danger areas are required to capture the maximum projectile trajectory
B. **Full Danger Area (FDA) Range**. A Full Danger Area (FDA) range is an open range where the hazard is limited by the elevation of the delivery system and the skill of the firer. The amount of land or sea danger area required is minimised by controlling the elevation of the firearm
C. **Limited Danger Area Range**. A Limited Danger Area (LDA) range is an open range for which the minimum design requirements are to capture direct shot and any resultant ricochet remains within the RDA. A combination of limiting elevation and the inclusion of range structures to capture shot and or minimise ricochet enables the danger area to be further reduced
D. **No Danger Area Range**. A No Danger Area (NDA) range is a range where, for all practical purposes, the design precludes risk of injury or damage to persons or property outside the range

2-7-2. Safe Design

The standard details provided have proven to be safe over a long period of extended use. The margins of safety in the standard 25m designs extend far beyond the predicted CoF. For non standard open NDA ranges for instance, following application of CoF criteria in Fig 2-2, should allow for all predicted shot and ensure the defence structures are sufficient. Minor changes have been made to particular elements to ease maintenance and therefore become more cost effective in use. Factors considered to ensure a safe range include;

A. **Direct Fire.**Predicted direct fire is either stopped by defence structures, limited by Quadrant Elevation (see Fig. 2-1) or a full energy template is provided. For design purposes, direct fire is that shot which falls within the Cones of Fire (CoF) set out in Table 3. Experience, trial evidence and advice indicate that these CoF are more than adequate for authorised practices
B. **Ricochet**. Ricochet from range structures and surfaces are generally the limiting factor for the range designer. Ricochet must be expected off all surfaces that a round may strike at angles of less than 30^0 including standing water. Ricochet is minimised off slopes of 30^0 or more and eliminated off slopes of 56^0 or more. Ricochet will influence the size of defence structures and danger areas including the air danger height. The use of ricochet pits can reduce the height of capture structures when using logical design principles. On all ranges, rounds that strike the range may;
    1. Be captured by the ground or structure
    2. Break up on impact and fragment over a small area
    3. Remain intact, change direction, exit at shallow angle and tumble with sufficient residual energy to achieve medium range potential
    4. Remain intact, change direction, exit at shallow angle, re-stabilise, with sufficient residual energy to achieve longer range potential
    5. Deflect off target frames or other range components with little loss of energy
C. **Backsplash**. Provision has to be made to prevent backsplash from any structure, fixtures or fittings that may otherwise reach back to the firing point. Table 2 gives backsplash distances and the relevant chapters give further details. There is an additional hazard from poorly designed or fitted protective measures. If a round is able to pass through a timber baffle, protective material, target backing, target holder or post, it may decelerate sufficiently so that it does not penetrate through the anti-splash curtain but bounces back from the curtain and could reach the firing point with a hazardous velocity. This problem may occur on indoor, tube, test or other ranges where anti splash curtains are used
D. **Hidden Attrition**. High velocity rounds penetrate soft material such as timber losing very little energy and leaving only a slight indentation at the point of entry. When a round strikes the dense material behind all energy is dissipated often causing extensive damage (attrition) behind the softer protective

material. Defence structures should be capable of taking all predicted shot over a long period without undue attrition and should be designed to eliminate the possibility of hidden attrition. Where this is not possible procedures will need to be put in place to ensure the ballistic element is not penetrated. This will entail ease of access to facilitate inspection of the hidden element

E. **Fixings.** When fixing a material to the structure in the ballistic zones, care is required to ensure unwanted ricochet or backsplash is not caused. Oval head nails (not round head nails) are to be used to fix timber onto hard surfaces and the nail heads punched in. Bolts and screws are to be countersunk and plugged. Any other metal fixings should also be countersunk or protected. The wider heads of round head nails will cause rounds to shatter on impact sending fragments of nail head and bullet in many directions. Industrial staples may be used to fix targets to timber supports

2-7-3. Design Criteria

The following criteria are common to all range design:

A. **Line of Fire (LofF).** The LofF is an imaginary line taken from the barrel of a firearm to the point of aim on a target. Range structures in front of the barrel and down range such as baffles are designed by applying the respective CoF to the LofF or Lines of Fire where more than one points of aim or firing points exist. On 25m Barrack ranges assessment for compliance is taken only from the 25m firing points

B. **Line of Sight (LofS).** The LofS is the line from the firearm sight to the point of aim on a target. Clear vision parameters are applied to the LofS. Structures close to the firer may not block the LofS but are directly in the LofF

C. **Firing Postures**. In the design of ranges, no account is taken of the respective stability of the three postures listed below. However it is acknowledged that supported firing positions provide a more stable firearm platform and this is often used as a restriction on non standard ranges. Supported practices allow smaller CoF to be used (see Table 3)

D. **Posture Heights**. The following posture heights are used as standard design criteria. There will inevitably be some variation due to individual physical characteristics, but as these are not predictable, a standard has been adopted for design purposes:

1. Standing unsupported - 1500mm;
2. Kneeling / sitting / squatting - 800mm; and
3. Prone / standing in a fire trench - 300mm

E. **Clear Vision Line (CVL).** Although primarily used in the development of indoor shooting facilities it is also a good principle to apply to outdoor ranges. A CVL is projected from each firing posture to avoid distractions directly in front of the firer and to help minimise the risk of backsplash from protruding structures down range. The CVL should extend:

1. **Vertically.** The upper line is projected from 600 mm above the highest firing posture used on the range to 250 mm above the highest target centre. The lower line is projected 300 mm below the lowest posture height used on the range to 250 mm below the lowest target centre (see Figure 7 and 8 below); and
2. **Horizontally.** 500 mm clear range space should be allowed parallel to the flank LofF at all firing points down the complete length of the range

Note; *The CVL does not apply when the barrel is clamped or specifically positioned within an aperture e.g. in a test or tube range*

F. **Trajectory.** The trajectory of a bullet on the LofF is used to determine the position of down range structures to minimise attrition

2-7-4. Range Components

Specific component details provided in this Handbook are derived to provide confidence that the required level of safety is provided irrespective of location and detail of any particular range. Common to all ranges are;

A. **Firing point**. Firing points could be at almost any distance and height although each needs careful consideration to determine the appropriate lines of fire for subsequent application of criteria to establish requirements for protective structures. Each firing point should be accurately positioned

and marked on the ground to assist in maintaining correct lines of fire in accordance with the original design. Distance markers should be provided on both flanks. Where elevated fire towers are provided it is essential to ensure that the elevated LofF will not expose mechanised target systems, or other items, to direct strike

B. **Firing Point Spacing/ Lane Widths**. To establish sufficient space for the firer taking account of distraction, ejected cases, smoke and noise the following guidelines are provided.
    1. Rimfire rifle (single shot bolt action) - 1000mm;
    2. Rimfire & centrefire pistol / carbine - 1000mm with benches & screens, 1800mm without; and
    3. Centrefire rifle - 1800mm (Standing unsupported), 2500mm

C. **Backsplash and Ricochet Protection**. On all ranges exposed hard surfaces, services and the like must be protected from direct fire and ricochet. Traditionally timber is added to the face of hard surfaces and steel baffles to prevent backsplash and excessive ricochet but other materials may be just as suitable. The material used must prevent the bullet back splashing or ricocheting back out from the protection. To reduce attrition, the protection material is off-set from the hard surface to allow the bullet to break up on the hard surface without causing excessive damage to the protection material. Where softwood timber is used the following is considered best practice compliant:
    1. **Rimfire.** 25 mm boarding on 25 mm battens; and
    2. **Centrefire**. 50 mm boarding on 50 mm battens

    Note; *The use of oval nails in fixing such boarding will minimise potential backsplash hazards.*

D. **Target Positioning**. The design target centre height and flank target positions should be permanently marked. Such marking ensures the correct relationship with defence structures is maintained. As the structure size is directly related to the target position, the targets should be positioned as close as is practicable to the base of the bullet catcher/stop butt to minimise construction requirements. Positioning of targets in accordance with the following guidelines should assist in providing sensible parameters for target positioning and enable realistic lines of fire whilst not compromising the safety of the range
    1. **Target Heights**. The target centre (highest aiming point) should generally correspond to the height of the firearm to achieve a near level line of fire, although there are circumstances which may demand either elevated or depressed lines of fire. Typical target centre heights of between 450mm lowest and 1500mm highest are recommended. Standard details are provided in subsequent chapters
    2. **Target Spacing.** The target centre spacing should generally correspond to the spacing of the firers although converging lines of fire are acceptable. Typical spacing may be as close as 600mm from centre to centre with the usual maximum spacing being parallel to the firer spacing (diverging lines of fire are not normally used as this would increase the size and cost of protective structures and danger areas)
    3. **Multi Point Targets & Target Screens.** Multi point targets are mainly used only on 0.22" and air pellet ranges. Target screens are often used on outdoor 1908 barrack ranges. Where such targets are used the minimum defence structure dimensions provided in Table 6 are applied as illustrated in Figure 8. Once established the max target centre height and flank target positions should be clearly marked
    4. **Target Positional Markings**.
        i. **Maximum and Minimum Target Centre Height.** The highest and lowest permitted target centre height should be indicated at the target line on both flanks (a recommended method of marking can be seen below). These markings should be in high contrasting colour paint and be permanent

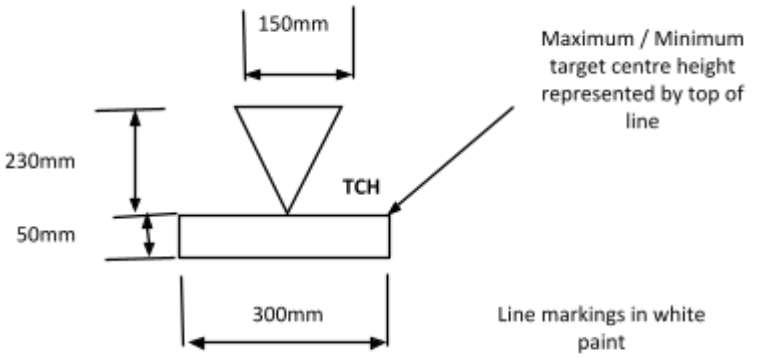


Figure 6 - Recommended Target Centre Height (TCH) markings

ii. **Target Flank Markings**. These should be clearly indicated at the target line, for both left and right flank targets. These markings should be in a contrasting colour and permanent. No target should be positioned outside of these marks. The flank target markings should be marked, either on the floor or the mini mantlet, but in front of the target line. The markings should be easily visible to all range users. A recommended method of marking can be seen in Figure 7

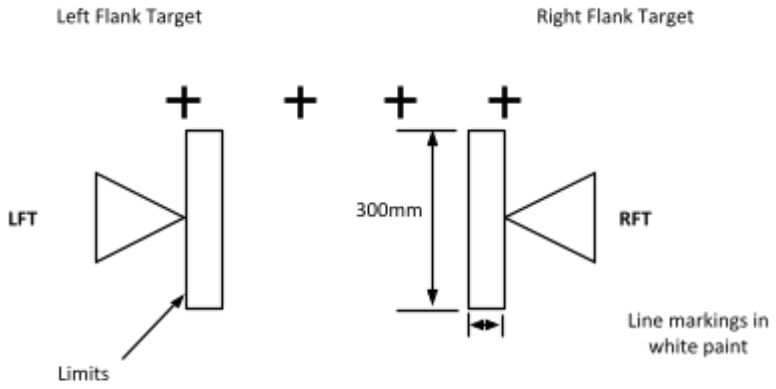


Figure 7 - Recommended Flank Target markings

iii. **Multi Point Targets & Target Screens**. The target centre height, left and right extent markings must be applied to the highest, left and right flank most aiming points as shown in Figure 8

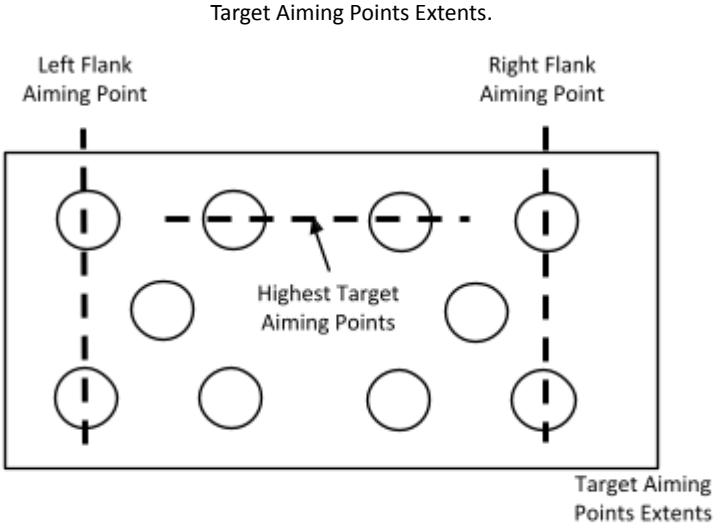


Figure 8 - 10 Bull Aiming Card

iv. **Range Floor Markings**. To assist effective control of practices, each lane should have corresponding firing point and target numbers numbered from the left for commonality

E. **Bullet Catcher.** Bullet catchers are provided in all cases. The bullet catcher is designed to capture the majority of rounds fired at each target. Bullet catchers may be a proprietary design, steel plate with anti-splash curtain or traditional sand / earth bank. For economic, logistical and environmental reasons, indoor bullet catchers are often constructed with a combination of a bullet catcher and a backplate. Granulated rubber traps provide cost effective and environmentally friendly trap solutions as rounds do not tend to break up causing lead dust. This form of trap is suitable for indoor or outdoor use. It will be seen that the use of a bullet trap and backplate indoors provides the same dimensions overall as sand traps used on outdoor ranges. Where details are not provided the details in Table 6 may be used

F. **Stop Butts.** Stop butts are located around or behind bullet catchers to capture wide shot and low ricochet. Where stop butts are provided the criteria to determine height and width are contained in the respective chapters. For Non Standard NDA ranges the minimum criteria is provided in Table 6

Ser	Range	Axis	Height And Width (C)			
	Component	Measured from the LofS	Rimfire		Centrefire	
			Rifle	Pistol	Pistol	Rifle
(a)	(b)	(c)	(d)	(e)	(f)	(g)
Indoor Ranges (Not Tube ranges)						
1	Defence zone	Vertical (mils) Horizontal (mils)	125 75	200 125	215	215
2	Backplate	Vertical (mils + mm) Horizontal (mils + mm)	3 + 700 3 + 450	6 + 850 6 + 600	6 + 1500 6 + 1400	n/a
3	Bullet catcher Indoor	Vertical (mils + mm) Horizontal (mils + mm)	3 + 250 3 + 250	6 + 400 6 + 300	6 + 450 6 + 450	1 + 1700 3 + 1400
Outdoor Ranges						
4	Bullet catcher Outdoor	Vertical (mils + mm) Horizontal (mils + mm)	3 + 700 3 + 450	6 + 850 6 + 600	6 + 1500 6 + 1400	1 + 1700 3 + 1400

Table 6 - Defence Structure Dimensions

2-7-5. Range Materials

Many materials have been tested for resistance to bullet penetration providing some evidence that may be used in the design of defensive structures. Below are performance details of the ballistic materials known to date.

A. **Steel Specifications.** When steel is specified, the requirement is for the following BS specification or similar performance steel:
   1. Mild Steel – BS970 070M20 EN 10027-2
   2. Armoured Steel - AR 400 - 500 or similar has proven effective where high velocity ammunition is used

Ser	Ammunition	Defence Zone Plate Thickness (mm)		Backplate Plate Thickness (mm)		Bullet Catcher Plate Thickness (mm)
		Flank	Direct	Flank	Direct	
(a)	(b)	(c)	(d)	(e)	(f)	(g)
1	Rimfire	3	4	4	5	6 or 4 armoured
2	Centrefire pistol/carbine	4	5	5	6	8 or 6 armoured
3	Centrefire pistol/carbine jacketed	5	6	6	8	12 or 8 armoured
4	Centrefire rifle	12 or 8 armoured		proprietary system only		

Table 7a - Steel Protective Plating for Ranges

B. **Other Material**. Table 7b provides minimum depth of the material required to prevent penetration on ranges dependent upon angle of strike. Minimum material specification for concrete is 20 Nmm^2 , Solid (void free) Class B engineering brick, 15 Nmm^2 dense concrete block or hollow block filled with min 15 Nmm^2 concrete. Concrete, brick and block defence structures should prevent bullets penetrating more than 10% into the surface of the structure

Ser	Ammunition	Concrete	Solid brick	Concrete block	Timber	Remarks
(a)	(b)	(c)	(d)	(e)	(f)	(g)
At all angles multiple strike.						
1	Rimfire	75	100	100	125h/w or 150s/w	h/w = hardwood s/w = softwood
2	Centrefire pistol carbine	150	215	215	175h/w or 200s/w	
3	Centrefire rifle	200	215	215	250h/w or 375s/w	No AP ammunition permitted.
Defence Zone - Single shot at 90^0 (1600 mils) to surface or less.						
4	.22"	25[1]	75[1]	50[1]	125s/w	(Note 1 & 2)
Defence Zone - Single shot at 7^0 (124 mils) to surface or less.						
5	.22"	25[1]	75[1]	50[1]	12s/w	(Note 1 & 3)

Table 7b - Minimum thickness (mm) of construction materials considered to be impenetrable to bullet strike.

Notes;

1. *These dimensions have been rounded up to reflect sizes available*
2. *Or combinations of MDF25mm + Redland plain tile, Plywood 25mm + Redland plain tile, s/w50mm+ Glasuron terracotta tile should contain one .22" round*
3. *Alternate Material Indoor Range Defence Zone only - 0.22" ammo - Roof or wall material which includes: Redland plain tile, Natural slate, Double roll tile, Glasuron Terracotta tile, Plasterboard 12.5mm, T&G board 12mm, Plywood 12mm, Chipboard 12mm, MDF12mm, Strandboard 18mm. Condition of materials may be variable: this table reflects material in perfect condition*

C. **Bullet Proof Glass**. Where bullet proof glass is required refer to BS EN1063, Class BR1 to BR7

2-7-6. Maintenance

Where range structures are contained within the ballistic envelope they must be maintained to retain the original properties. The maximum depth of attrition that should be permitted before repairs are affected is 10%. Back walls above the sand for instance are generally at least 225mm thick. Attrition up to 22mm should not adversely affect the performance of that component. Repairs to anti splash curtains could cause backsplash if more than two layers are in the line of fire, i.e. repairs where sheet overlap occurs.

2-7-7. Environmental Hazards and Sustainability

Range design must take account of the effect of lead, carbon monoxide, unburnt propellant and noise. Below in Table 8 are indications of the design issues to be addressed. Note compliant ranges are expected to fire less than 1 million rounds a year on any one range. At this rate of fire it is predicted that there will be no unacceptable environmental or health hazard impact. Ranges with enclosed or semi enclosed firing points that have rates of fire in excess of this should be assessed for emission hazards.

Range Type	Lead	Carbon monoxide	Unburnt propellant	Noise
GR all types	Majority of lead is removed periodically from the range.	No issue	No issue	(Note 1 , 2 & 4)
25 m ranges	All lead is removed periodically from the range.	No issue	No issue	(Note 1, 2 & 5)
Tube ranges with enclosed firing room.	Lead will be present in any dust. All lead is contained and recovered during deep clean.	With mechanical ventilation no issue. Without ventilation CO monitor required.	In any dust	(Note 1)
Other ranges with enclosed or semi enclosed firing points.	Lead will be present in any dust. Maintain record of rounds fired on each range for future Land Quality Assessment.	With mechanical or sufficient natural ventilation no issue. With insufficient ventilation CO monitor required.	In any dust	(Note 1 & 5)
Indoor ranges	Lead will be present in any dust. Lead is contained and recovered during deep clean.	With mechanical ventilation no issue. Without ventilation CO monitor required.	In any dust	(Note 1,3 & 5)

Table 8 - Environmental Hazards and Sustainability.

Notes;

1. *Hearing protection must be worn on all firing points during practice.*
2. *The Range Operator is to ensure new ranges are sited as far away from populated areas or offices as possible*
3. *For indoor ranges and non standard ranges with enclosed or semi enclosed firing points refer to Chapter 6*
4. *Where a fullbore rifle is fired regularly (more than 50,000 rounds per lane per year) on a range into sand or earth stop butts the Range Operator should commission an analysis of the MPI to determine levels of antimony against current EU limits*
5. *Where close engagement (15m or less) takes place on ranges with granulated rubber the club should be aware that if the granulate is exposed it could absorb unburnt propellant that will increase the risk of fire*

2-7-8. Noise

All those exposed to firearm noise must wear suitable hearing protection. If there is a requirement to reduce noise levels further by applying additional control measures. Such control measures generally take the following two forms:

A. **Noise Containment.** The building fabric, doors, ducting etc, are designed to reduce transmitting noise to the outside environment and to the surrounding structure. Dense materials should be selected for the building fabric of the firing points and bullet catcher chambers. Doors, ducts and other openings can be specified to give a similar level of noise insulation. See also Chapter 7

B. **Noise Attenuation**. The nature and treatment of internal surfaces are selected to attenuate reflected noise (reverberation) but these measures will not reduce the initial high level of noise produced by the firearm. There are many materials available, such as wood, wool slab, rockwool and glass fibre, which are very effective in reducing reflected noise. However, these materials will also harbour lead dust and unburnt propellant, and are difficult or impossible to clean as the fibrous materials are

susceptible to damage. Whilst these materials may be suitable for ceilings, walls should be clad with a material which withstands knock and abrasion, and which can be appropriately cleaned

Granulated rubber tiles and tiles of resin bound flint sand have been found effective. Proper selection and detailing of the noise attenuation system will further enhance noise containment. Particular care is required for tube ranges. See also Chapter 7

2-7-9. Lead Pollution, Unburnt Propellant and Carbon Monoxide

The requirements to control lead pollution, unburnt propellant and carbon monoxide in ranges are given in Chapter 6.

2-8 - SAND BULLET CATCHERS

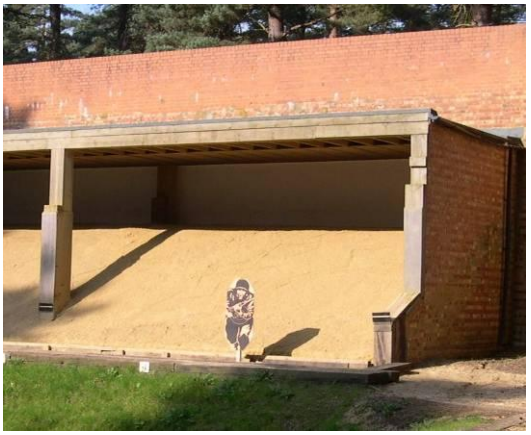


Figure 9 - Sand Bullet Catcher on a Barrack Range

2-8. General

Sand has been generally used in bullet catchers and stop butts on many of the ranges described in this Handbook. This section specifies the quality of the sand, its profile and maintenance that are necessary to capture shot without causing ricochet or backsplash. Wet sand will have the tendency to form tunnelling on ranges where tight grouping is expected which may result in penetration of the bullet catcher.

2-8-1. Quality

It is recommended that sand conforming to BS EN 12620: 2002 description "0/4 Concrete Sand". Grading should conform to BSI PD 6682-1 Table D1, "0/4 Concrete Sand CP" with angular shape for slope stability and sound physical properties to resist natural breakdown. This grade is fine enough not to cause ricochet yet coarse enough to retain the required profile effectively without likelihood of setting or forming a surface crust; it is also relatively stable in high winds. This specification also provides for a material that will not readily break down naturally, such material should not crush to fine dust when rubbed between the hands. Over time bullets pounding the sand reduce it to fine dust behind the MPI, at this point the sand will need to be replaced.

2-8-2. Construction

The core of the bullet catcher or stop butt may be constructed of any stable inert fill material. However, the surface must be covered by sand as specified in the relevant Chapter for the range. Generally the depth of sand is related to the type of firearm fired. For high velocity firearms (see Table 4), the minimum depth measured on a line parallel to the Lof should be 1000 mm, 900 mm minimum on NDA ranges and 750 mm 500 mm minimum on other ranges. For low velocity firearms the minimum depth should also be 750 mm 500 mm minimum in the direction of the line of fire.

2-8-3. Profile

34^0 is the minimum recommended slope for the front face of the bullet catcher in order to reduce the risk of ricochet. Rounds impacting into, or the natural settlement of the sand, may reduce the slope which must never be allowed to fall below 30^0 as this may cause ricochet to leave the RDA.

2-8-4. Maintenance

Regular maintenance of the sand is essential to the range remaining safe for use. There are several factors to be considered and these are described below. Renewal or replacement of the sand may be achieved by rotating the existing sand or by replacing it with sand from another section of the bullet catcher. The following measures are particularly important.

A. **Profile.** Sand in the bullet catcher is to be raked to prevent tunnelling at the MPI behind targets to keep the surface of the sand in a loose state and to restore the profile to the slope of 34 deg

B. **De-Leading**
    1. **7.62 mm**. When large quantities of 7.62 mm rounds or similar are fired or there are excessive quantities of jacket and bullet debris, balls of lead and other hazardous debris build-up in the sand. Bullets tend to remain intact after impacting into the sand and can fuse together into a ball, which often occurs below the surface of the sand at the MPI behind the target after about 20,000 rounds have been fired in a lane. When subsequent bullets striking the ball no longer drive it deeper into the sand, backsplash and ricochet become hazards. So it is important that any such build-up of lead is removed before the hazards arise, with evidence of de-leading to be retained
    2. **5.56 mm.** This round tends to break up on impact at close range causing debris which is often smaller than the sand particles in the bullet catcher. In this case the sand cannot always be sieved without altering its stability. Provided the lead particles and debris are small and well spread over the area behind the MPI, the sand will remain stable and the probability of ricochet or backsplash will remain low. It is prudent to rotate the sand to ensure that the smaller particles are well spread. If there is any sign of lead balling and debris building up to the extent that a backsplash hazard is perceived, the sand is to be treated as described in sub-paragraph (1) above
    3. **Other Ammunition Natures**. When other ammunition natures have been fired (such as 9 mm, black powder ball or bullet, shotgun slugs etc), the sand should be monitored regularly to ensure lead does not build up around the MPI. As a guide, the sand should be checked for lead build-up when the slope is raked after heavy use to restore its profile. For a range that is only used occasionally, the sand should be checked monthly or after 20,000 rounds have been fired on a lane, whichever occurs first

C. **Weathering.** In time, continuous impact by shot will break the sand down to a fine powder which will blow away in the wind or bake hard in the sun. Fine sand will also cause the slope to lose its stability. When this occurs, which will be evident by inspection, the sand will no longer be of the prescribed grade and should be replaced. The following additives and reinforcements have been found useful in maintaining the shape of the sand;
    1. **Wood Shavings or Chips.** A mixture of wood shavings or chips in proportions by volume of about 2:1 sand/wood helps retain moisture and stability of the mass in sand under canopies. The wood will itself break down in time and more will need to be mixed in
    2. **Salt**. Adding 1-2% of salt by dry weight of sand also helps retain moisture in the sand and will reduce the danger of freezing in winter;
    3. **Netting**. Mesh netting or geogrid may be used to reinforce the face angle. The mesh is placed just below the surface of the sand and is held in place with wooden pegs. Light galvanised wire mesh may also be used as it is effective against burrowing rabbits; and
    4. **Timber support.** Timber supports in the form of boxes or herringbone within the sand clear of the MPI can assist the retention of the sand profile

D. **Cleaning**. Sand bullet catchers should be checked at least weekly to ensure surface bullet debris is removed and de-leaded after 20,000 rounds have been fired on a lane to ensure there is no build-up of lead which can generate a backsplash hazard. Rotation of the sand within the bullet catcher may prolong the life of the sand. The sand should be replaced when the maintenance of the 34^0 face

becomes difficult. The hazard of lead contamination when working on sand bullet traps must be considered. The club Range Operator is responsible for:

1. Observing the requirements of the Control of Lead at Work Regulations;
2. The safety of working practices;
3. Providing the appropriate personal protective clothing and, when necessary, respiratory protective equipment;
4. Providing washing and changing areas which avoid cross-contamination of clothing; and
5. Disposing of sand, soil and debris, which might contain or be contaminated by lead, as contaminated waste in accordance with the Local Authority Environmental Control Department's instructions

2-9 - GRANULATED RUBBER BULLET CATCHERS

Figure 10 - Granulate Bullet Catcher on a Barrack Range

2-9. General

Granulated rubber is a good alternative to sand in terms of slope retention and cost. However the fall of shot is not so clear in the rubber.

2-9-1. Material description

The granulated rubber should be used in the same form as sand traps, 34^0 slope with profile line marked on barrack range side walls. The rubber elements are shredded from rubber that has no steel or fabric reinforcement. The rubber used must be fire resistant or treated with a fire retardant.

A. **Shape.** Shredded rubber with elongated elements removed to produce angular rubber fragments that are of regular shape approximately 10 – 25 mm in any direction producing tight interlock properties. There are sufficient suppliers who are able to meet this specification so the club should not accept granulate for bullet traps with any visible contamination or elongated rubber
B. **Durability**. The rubber material will not break down in the short term unless there is an exceptional high rate of fire over extended periods. The granulated rubber traps are de-leaded regularly (see below) and any fine particles removed and replaced by topping up with new material. With effective maintenance these traps should never need total replacement
C. **De leading**. The material should take up to 35,000 rounds per lane before inspection is required to ensure there is no build up of lead behind the MPI. Frequent prodding of the area behind the MPI will extend the interval for de-leading. On ranges where black powder firearms or shotguns are fired, more frequent de-leading may be necessary. Contractors involved in de-leading are to ensure all bullets, bullet debris, fine rubber dust and target debris is removed from the granulate
D. **Fire resistance**. The material is fire resistant but there are some circumstances where the rubber may be ignited. The rate of burn is slow and allows plenty of time for range staff to extinguish the flame before it moves to adjacent rubber fragments. A light rubber sheet placed over the granulate will prevent contamination of the granulate from timber and paper debris thrown out from targets. On ranges where engagement closer than 10m is permitted, a rubber sheet over the granulate is essential to prevent unburnt propellant falling into the granulate increasing the risk of fire. A fire

retardant coating may be applied to the granulate if required. Typical coatings may be sprayed on to coat the granulate, however it should not cause the granules to stick or clump together

E. **Stability**. Due to the interlock properties the 34^0 slope should withstand many days of use without raking. Only with a high rate of fire will a depression become apparent behind the MPI
F. **Frost resistance.** The material may be used outside during frost conditions without any change in performance
G. **Washout resistance**. The material allows water to pass through it without disruption of the slope

2-9-2. Environmental Impact

Rounds are captured either intact or in constituent parts, lead dust is not generated in the trap to the same degree as in a sand trap. The rubber granulate should not break up into fine dust like sand so there is no particulate thrown into the air during firing or maintenance of the trap. Like sand, there is no impact noise. The granulate may be recycled many times on site to remove spent bullets. The granulate is then placed back into the trap.

2-9-3. Maintenance

As the material has good interlock properties the compliant slope is maintained without slip at the MPI this will reduce the maintenance effort considerably. As there is little or no lead dust, any maintenance of the trap will not expose range staff to excessive levels of lead in air. The material will not breakdown so readily as sand so replacement or rotation of the trap need not be so frequent. Rabbits do not like tunnelling in this material. Most suppliers are able to provide a de leading or replacement service using a recycling process on site. To ensure the granulate is not contaminated by wood and paper debris from targets on barrack ranges it is advisable to provide a light rubber sheet covering the granulate. Regular and effective maintenance is essential as rubber dust generated at the MPI mixed with bullet and target debris will increase the risk of fire.

2-9-4. Potential Use

This material may be used in outdoor ranges or indoors. When used on gallery type ranges it should be used only in shooting in boxes fitted into the stop butt to minimise costs and reduce the area affected should there be a fire. For use near environmentally sensitive or populated areas the addition of a suitable fire retardant should be considered. Complete bullet catchers on barrack ranges may be converted to this material. No additional works are required except to retain the material at the base of the bullet catcher. This material is suitable for indoor ranges including test facilities and tube ranges. It will reduce considerably the amount of lead dust in the range. Some German and US ranges used the material sandwiched between rigid plastic sheets in the vertical form. These have proven very expensive to maintain due to the need to dismantle the trap when the supporting sheets are shot out at the MPI.

2-9-5. Depth of Granulate

The granulate is expected to stop 5.56mm and 7.62mm rounds within 300-400mm. The depth of the granulate in line with the line of fire at the top of the trap for high velocity ammunition is between 900mm and 1000mm. For low velocity weapons the minimum depth should be 500 mm in the direction of the line of fire. For shooting in boxes in stop butts the depth should be 500mm.

2-9-6. Disposal

This material may be recycled by the supplier. At no time should the granulate as a whole need to be removed for disposal as the regular maintenance will remove and replace broken down granulate.

2-10 - CONTROL OF ACCESS

2-10 General

This section specifies the various measures used to control access on open ranges. Which method is best suited to a particular site will be apparent from the site specific risk assessment. In some cases the measures are influenced by local Byelaws, sea danger areas and local tradition. The risk assessment will determine the minimum requirement to ensure adequate control measures are in place to effectively control public access into the range danger area. Control of access between ranges on range complexes should also be included in local risk assessments. Where public access is permitted between the range boundary and a Range Danger area boundary, warning triangles should be used on the outer boundary indicating "Danger Shooting Range" and where horses are known to use the area, "Sudden Noise". Prohibition signs and flags / lights are placed at the range danger area boundary.

2-10-1. Fences

Four classes of fencing are specified for various conditions and levels of access control onto open ranges. All are used in combination with signs. The levels of access control are:

A. to provide demarcation;
B. to discourage access;
C. to prevent access; or
D. to provide security

2-10-2. Selection

The selection of the type of fence or marking will depend upon local risk assessments. Factors that will influence the choice will include;

A. Extent of public access. - Authorised, unauthorised, children;
B. Nature of the hazard and the degree of risk;
C. Ground conditions - practicalities of constructing a fence;
D. Possible overreaching the fence from trees or ground;
E. Whether the fence will be shot away; and
F. Whether animals or bird life will be caught in the fence

2-10-3. Demarcation

Demarcation of the range boundary may be all that is necessary in remote areas where there is no immediate threat to life and limb. However, thought should be given to the marking of designated routes for public access. Three strand fences or marker posts may be used to denote particular areas. Inter-visible safety signs are to be provided on fencing. Colour coded demarcation posts may only be effective where there is no public access. In areas prone to deep snow or snow drifts, the posts may have to be taller.

2-10-4. To Discourage Access

In areas where occasional public activity may be expected, a fence to discourage access is to be provided. Such fences should not be crossed or climbed through easily. Consideration should be given in the risk assessment for the protection of minors. In farming areas where animals graze, stock fencing should be provided. BS 1722 provides guidance on fence systems.

2-10-5. To Prevent Access

In areas where the hazard is such that the risk assessment determines that uncontrolled access must be prevented, a more substantial fence is required. Chain link is designed in such a way that it is difficult to climb but it is easily cut and unwound. Weld mesh fencing is a more substantial barrier but is more expensive. The Health and Safety at Work Management Regulations require a suitable fence to meet the risks identified in the risk assessment.

A. **Type of fence.** If there is no evidence of vandalism or of children breaking through existing fencing a chain link fence may be suitable. Where such problems are known to exist a more substantial fence or combination fence may be needed

B. **Height of the Fence**. The fence must be high enough to prevent access by all but the determined trespasser. In low risk areas a 1.4 m fence is sufficiently high to prevent an adult stepping over it from flat level ground. In high risk areas where children are known to climb existing fences, more substantial fencing will be required

2-10-6. To Provide Security

Security fences are normally 2m high with a canted top section.

2-11 – SIGNS & NOTICES

2-11. Signs & Notices

Club ranges present a variety of hazards that may affect all those entering the area of the range. Risk assessments should identify the hazards and their level of risk. Safety signs are provided to prohibit and warn those at risk of the hazards. When it is impracticable to use signs within a range area to separate areas with different levels of hazard, demarcation posts may be used. Notices are also used to provide additional information and clarification but they must not replace safety signs.

2-11-1. Current Legislation

Signs and notices are used in conjunction with fences on boundaries and demarcation lines to prohibit, warn and inform people of the potential consequences of entering range areas. Current legislation is contained in The Health and Safety (Safety Signs and Signals) Regulations.“Keep Out” or “No Entry” without qualification should only be used where it is necessary to prohibit access at all times.

2-11-2. Definitions and References

There are a number of sign systems in place, each supported by different legislation or regulation. Notices are not regulated and should only be used to inform or supplement safety signs, and not to replace them. The following types of sign may be required on ranges.

A. **Byelaw.** Civil clubs on private land are not able to use Bye Laws to control access.
B. **Safety Signs**. Standard safety signs must be provided when the risk cannot be managed by other means. Safety signs are covered in H&S (Safety Signs & Signals) Regulations. A safety sign must include a symbol and may have text. However, text alone is insufficient. The proportion of symbol colour against the overall size of the sign is provided in brackets below. The five types of safety sign, which are illustrated below are:
    1. Prohibition. (Symbol at least 35% of the area of the sign);
    2. Warning. (Symbol at least 50% of the area of the sign);
    3. Mandatory. (Symbol at least 50% of the area of the sign);
    4. Safe condition. (Symbol at least 50% of the area of the sign); and
    5. Fire. (Symbol at least 50% of the area of the sign)
C. **Demarcation Posts.** When it is not practicable to sign an area where two levels of risk exist within a range area, demarcation posts may be used. These should be clearly visible, and their meaning and location explained to those entering the area
D. **Traffic Signs**. To avoid confusion, roads across club property used by the public should be signed as for national public roads. When on public roads these signs are subject to planning controls and are the responsibility of the Local Authority. In the UK signs are regulated by the Traffic Sign Regulations and General Directions 1994
E. **Notices.** Notices, such as "OUT OF BOUNDS", are not regulated and they are used to inform or provide additional information. Notices may supplement safety signs but must not replace them
F. **Night Signing.** Although red lights are used when a range is in use at night, it may be impracticable to use lights or illuminated signs around or across a large area

Ser	Colour and Shape	Meaning or Purpose	Examples of Use	Contrast Colour	Symbol Colour
(a)	(b)	(c)	(d)	(e)	(f)
1	Red circle with diagonal band	Stop. Prohibition	No entry, No Access	White	Black
2	Yellow triangle	Caution Warning Risk of Danger	Hazard indication (fire, explosion, chemical etc)	Black	Black
3	Blue circular	Mandatory action	Obligation to wear personal safety equipment	White	White
4	Green square	Safe condition	Identification of safety. Fire escape routes	White	White
5	Red Square	Fire	Fire equipment Fire point	White	White

Table 9 – Safety Sign Colours and Shapes

2-11-3. Shape and Colour of Safety Signs

BS 5499 defines the colours and shapes of safety signs. Safety signs differ from traffic signs. Examples are provided below and on Figure 2 – 5

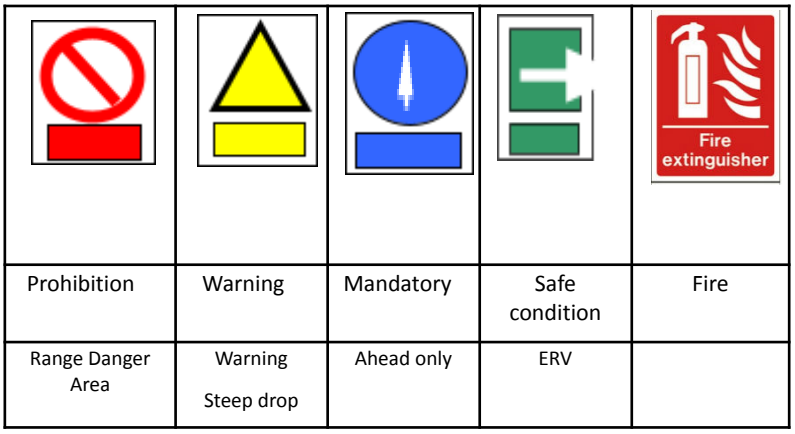


Figure 11 – Safety Sign Colours and Shapes

2-11-4. Approved Signs

The prohibition and warning signs for use on range boundaries are shown in Figures 2-4 and 2-5. If an appropriate symbol is not shown, other symbols may be used provided they are as simple as possible and omit details not essential to their understanding. To maintain conformity on ranges in the UK range operators should use the standard symbol. Supplementary text may be added below the symbol to denote one of the categories given in Table 9 above.

2-11-5. Supplementary Text and Notices

Supplementary text may be used in conjunction with a safety sign to aid understanding. Where there are known concentrations of people who may not fully understand English, dual or even triple language notices may be necessary. A supplementary notice is oblong or square. The background colour is the same as the safety colour used on the safety sign it is supplementing with the text in the relevant contrasting colour. Supplementary text is provided on a rectangular background, colour coded to match the sign. For example, it

is wrong to supplement a prohibition sign with the text "Danger", which is the subject of a warning sign. In this case it may be appropriate to display two signs:

A. A prohibition sign with supplementing text prohibiting entry under certain conditions; and
B. A warning sign with a symbol and supplementing text which warns of the danger

2-11-6. Lettering Style

The preferred letter style is Helvetica Medium or similar. The initial letter of a sentence or proper noun shall be upper case and the remainder in lower case. However, all the letters of a heading, an imperative or a cautionary word may be upper case.

2-11-7. Sign Size

Neither the Health and Safety Executive nor BS provide guidance on safety sign sizes. However, both state that the size must be sufficient so that the safety sign is clearly seen by those to whom it is directed. Therefore, each sign has to be judged on its importance.

2-11-8. Positioning of Signs

Care has to be exercised in positioning safety signs to ensure that they are displayed where people might reasonably expect to find them, such as at barriers, gates, junctions, clearings, footpaths etc. On long runs of fencing the interval between signs will be dictated by the importance of the information displayed on the sign. In any event people should not be expected to follow a fence for too long before being informed of its significance. When demarcation posts are used, these should be inter-visible. Safety signs must not be obscured by vegetation, open gates, parked vehicles or other obstructions, and must be checked and cleaned at regular intervals. Too many signs can be confusing and should be avoided. Byelaws should provide all necessary details leaving safety signs to emphasise the major areas of concern. The aim is to ensure a clear message is passed to the public to ensure their safety.

2-12 – FLAGS & LIGHTS

2-12 Flagging & Red Lights

There are three common use red flags used on ranges: (Red lights are normally provided for use at night).

A. **Boundary Flags.** - It is best practice to fly red flags, and at night show red lights, around a RDA to indicate that a range is in use and/or a residual hazard remains. They are normally located in areas of maximum visibility or next to main access points where signs and notices provide an explanation
B. **Range in Use Flagging**. Respective chapters provide advice on the location of these flags. It is important that they are flown in prominent positions on a particular range. Local conditions will dictate the most appropriate position where they are most easily seen by those approaching a range. Where there are a combination of range types such as one range half converted to CGR only one range in use flag is required unless the ranges are allocated separately
C. **Butt Flag.** Used to indicate safe access from and into the butts on gallery type ranges. When the butt flag is raised all firing must stop

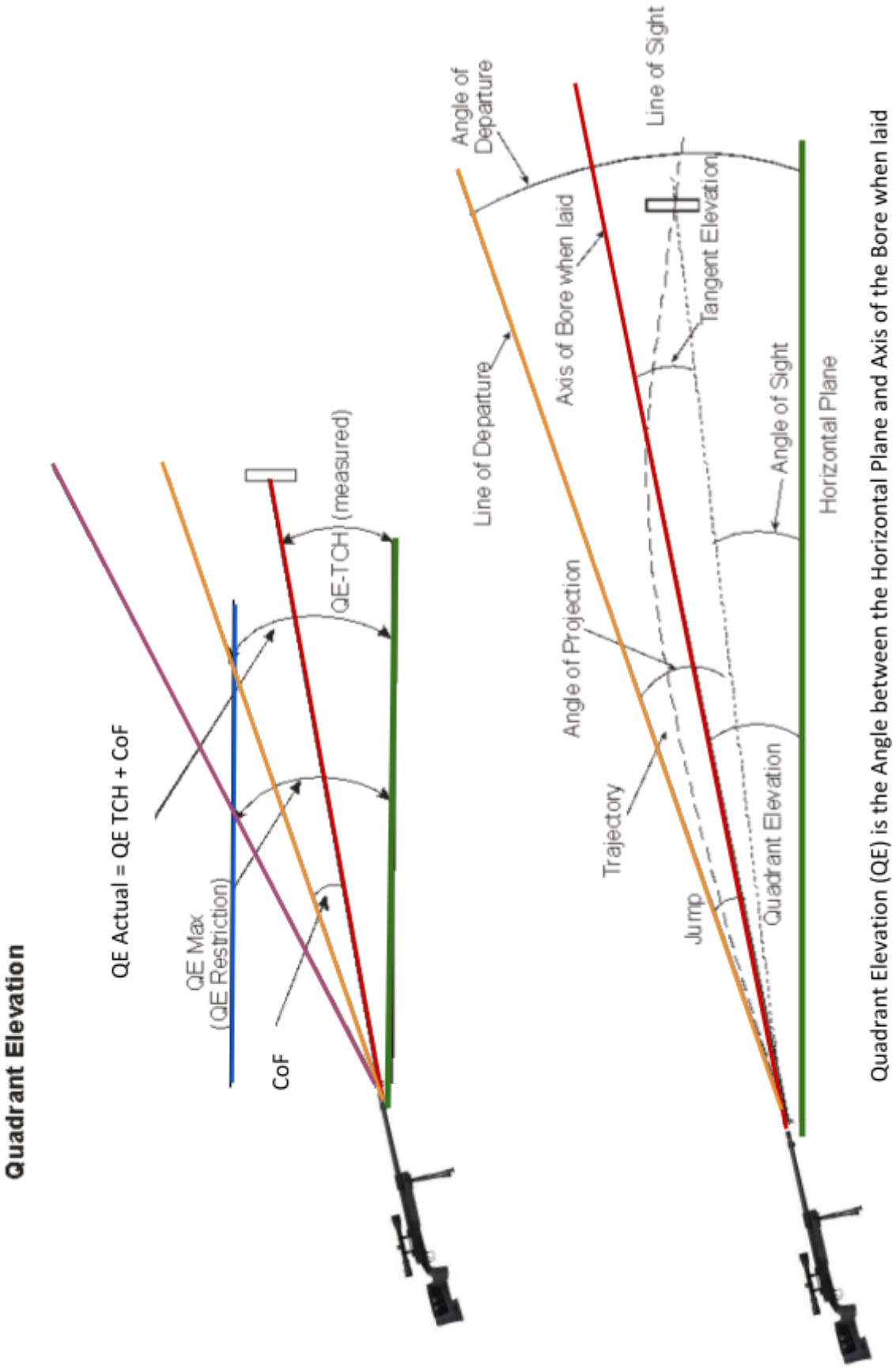


Figure 2-1 - Ballistic & Design Angles

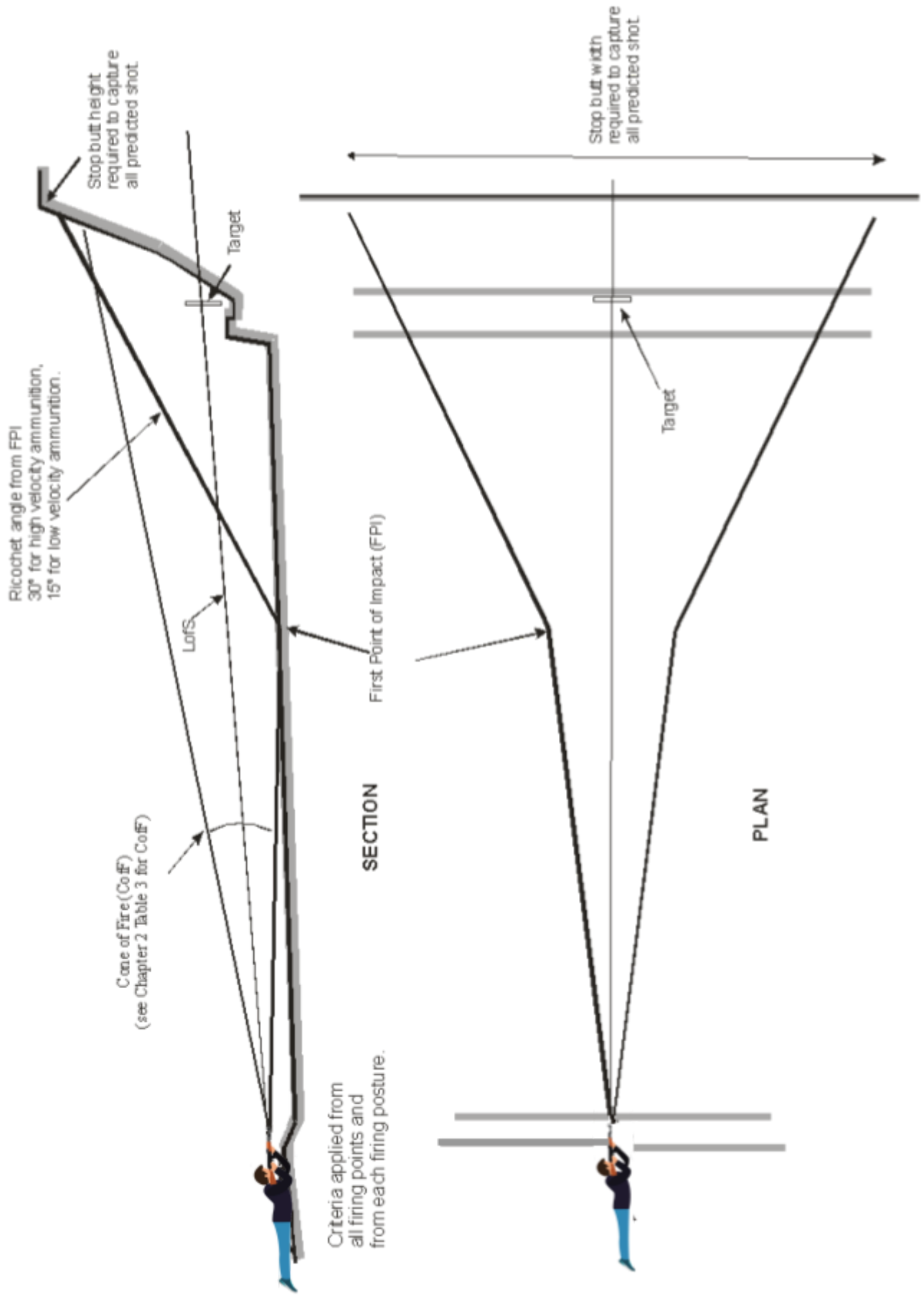


Figure 2-2 - Cone of Fire Criteria Illustration

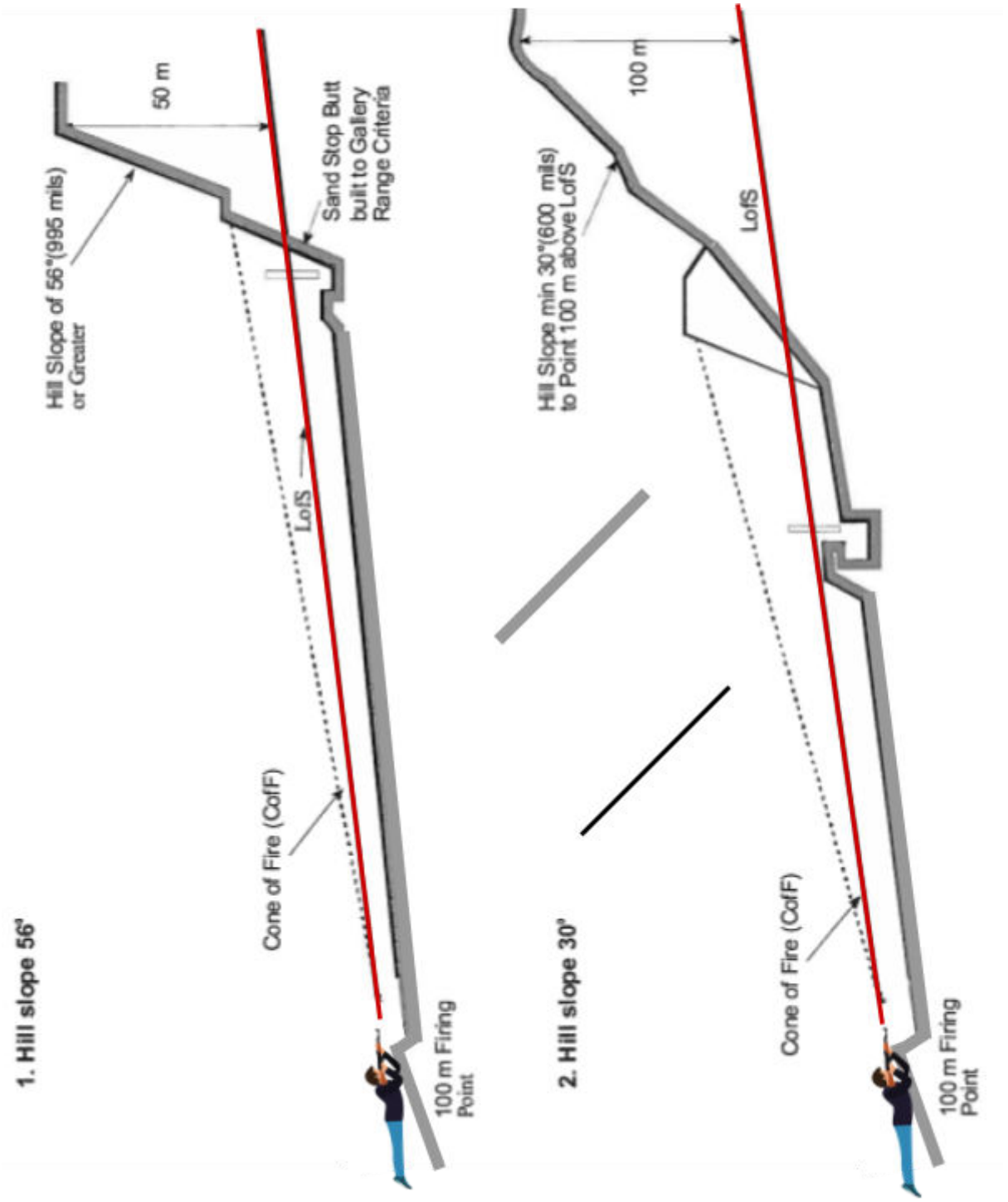


Figure 2-3 - Hill Background Criteria

Note;

1. *The logic behind the hill background criteria applied to standard ranges is that the hill will capture any rounds without inducing further ricochet. No hill provides an even slope. However, to prevent ricochet the slope must exceed 30* (533 mils). Slopes around 30* (533 mils) will generally have areas where ricochet might occur, hence the increased height requirement. Slopes that average 56* (995 mils) are unlikely to have ricochet inducing surfaces and therefore the height is reduced to 50 metres*
2. *Trees and scrub cannot substitute for hill background. There is no proven data on the ability of trees and scrub to capture high velocity projectiles*
3. *On hill backgrounds that rise directly behind the stop butt, all backsplash or ricochet inducing material in the hill should be removed or screened*

Normally used around the Range Danger Area (RDA) in conjunction with red flags and red lamps at main access points. Where there is sufficient land around the RDA for dry training and or public access, these prohibition signs are placed around the actual RDA with warning signs around the outer perimeter or training area boundary. Where this is not the case, these signs are normally placed clear of the actual RDA using natural features such as fences and hedges to help define the controlled area

Figure 2-4 - Range Danger area Boundary Prohibition Sign with Example Text

Where a particular hazard is reflected in the specific warning sign examples provided, these should be used. Where there is no specific warning symbol available, use the non specific examples illustrated below.

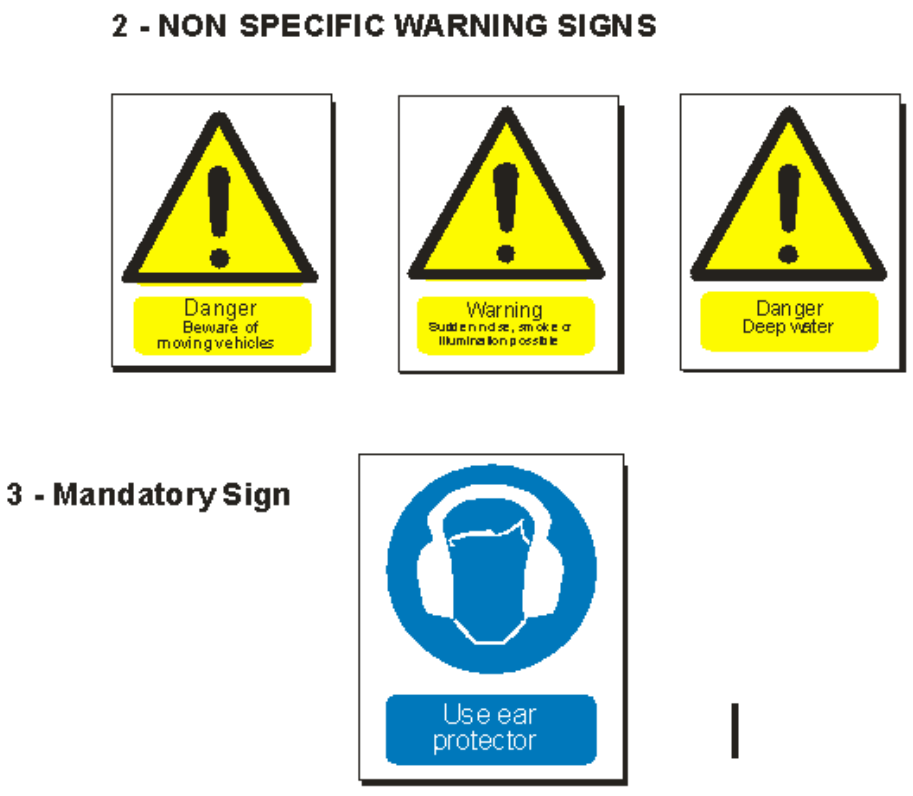


Figure 2-5 - Warning and mandatory signs

CHAPTER 3
INDOOR RANGES

3-1 – INTRODUCTION

3-1. Aim

The aim of this chapter is to provide the design and construction details for existing and new LV and HV indoor ranges.

3-1-1. Description

Indoor ranges are constructed to meet many requirements. The main advantage of indoor ranges is that they provide protection from the elements and external noise can be reduced. The main disadvantage is that noise is more of a problem for range users and firearm emissions become a key safety issue. These disadvantages also affect any range with enclosed or semi enclosed firing points. Indoor ranges may be constructed to meet specific ballistic requirements and practices. Ranges are at times constructed in tunnels or in existing buildings converted for range use. Proprietary purpose built indoor ranges are available provided in modular sections or constructed on site. The primary differences between LV and HV ranges are the bullet trap and ballistic protection.

Figure 1 – Typical LV range

Figure 2 – Typical HV range

3-1-2. Purpose

The indoor range was developed primarily for rimfire firearms. There is now a demand for indoor ranges which, like the tube range, allow any authorised HV firearms as well as the LV firearms.

3-1-3. Environmental Issues

In all cases reference should be made to Chapter 6, Control of Hazardous substances in Indoor Ranges.

3-2. General

Indoor ranges present ballistic and potential environmental problems for the designer. The structure must contain all shot without causing damage or injury from ricochet or backsplash. Environmental problems include noise, particularly reverberation, airborne contaminants including lead, carbon monoxide pollution and unburned propellant. An outline layout of a traditional LV rimfire range is illustrated in Figure 3-1. Existing ranges were generally designed with a maximum range of 25 m. New ranges can be constructed for many situations and distances with the design based on the ammunition nature and using both the vertical and horizontal components of the worst case firing positions. The backsplash hazard and ballistic limitations are given in Tables 1 and 2 below.

Ser	Firearm	Fragment/Earth Throw Distance Hard Tgt (m)	Fragment/Earth Throw Distance Ground Tgt (m)
(a)	(b)	(c)	(d)
1	Rimfire, centrefire pistol and carbine	22	10
2	Centrefire rifle	50	22

Table 1 - Backsplash Zone (Safety Distances)

Ser	Firearm Type	Indoor		Open	
		MV(m/s)	ME (J)	MV(m/s)	ME (J)
(a)	(b)	(c)	(d)	(e)	(f)
1	Air rifle	N/A	16 (12ft lbs)	N/A	16 (12ft lbs)
2	Rimfire firearm only	530 (1735 ft/sec)	285 (210 ft lbs)	610 (2000 ft/sec)	480 (350 ft lbs)
3	Centrefire pistol/carbine	5202 (1705 ft/sec)	6452 (475 ft/bls)	655 (2145 ft/sec)	2030 (1495 ft lbs)
4	Centrefire rifle NDA ranges	1000 (3280 ft/sec)	7000 (5160 ft lbs)	1000 (3280 ft/sec)	7000 (5160 ft lbs)
5	Centrefire rifle on ranges with GR LDA			1000 (3280 ft/sec)	45001 (3319 ft lbs)
6	Centrefire rifle on other ranges			No ME/MV limits – Refer to Chapter 4 to determine extent of RDA required.	

Table 2 - Ammunition Maximum MV and ME Limitations

3-2-1 Components

The capture of bullets fired in an indoor range relies upon defence structures, the sizes of which are deduced from a series of safety distances and angles. The required degree of protection increases with the probability of strike. The structures (safety features) which produce the level of protection are called components. These and their purpose are:

A. **Defence Zone**. The defence zone is the part of a range which may be struck by unintentional shot, ricochet or backsplash. The zone is specifically designed to resist penetration of the occasional single shot

B. **Backplate.** The backplate is constructed behind and around the bullet catcher, and is designed to capture predicted shot that misses the bullet catcher. Therefore the backplate must resist the penetration from multiple direct fire and ricochet

C. **Bullet Catcher.** The bullet catcher is designed to stop and contain the majority of direct fire and ricochet and must withstand continuous attrition

D. **Floor.** The floor of the range is to have a smooth surface free of any protrusion or indentation which could generate a high ricochet or backsplash

3-2-2. Component sizes

The data given in Table 3 below is used to calculate the required sizes of the bullet catcher, back plate and defence zone (see also Figure 3-2). Table 4 and 5 below provides the material thickness considered suitable to prevent single round penetration.

Ser	Range Component	Axis Measured from the LofS	Height And Width (C)			
			Rimfire		Centrefire	
			Rifle	Pistol	Pistol	Rifle
(a)	(b)	(c)	(d)	(e)	(f)	(g)
1	Defence zone	Vertical (mils) Horizontal (mils)	125 75	200 125	215	215
2	Backplate	Vertical (mils + mm) Horizontal (mils + mm)	3 + 700 3 + 450	6 + 850 6 + 600	6 + 1500 6 + 1400	n/a
3	Bullet catcher Indoor	Vertical (mils + mm) Horizontal (mils + mm)	3 + 250 3 + 250	6 + 400 6 + 300	6 + 450 6 + 450	1 + 1700 3 + 1400

Table 3 - Defence Structure Dimensions

Ser	Ammunition	Defence Zone Plate Thickness (mm)		Backplate Plate Thickness (mm)		Bullet Catcher Plate Thickness (mm)
		Flank	Direct	Flank	Direct	
(a)	(b)	(c)	(d)	(e)	(f)	(g)
1	Rimfire	3	4	4	5	6 or 4 armoured
2	Centrefire pistol/carbine	4	5	5	6	8 or 6 armoured
3	Centrefire pistol/carbine jacketed	5	6	6	8	12 or 8 armoured
4	Centrefire rifle	12 or 8 armoured		proprietary system only		

Table 4 - Steel Protective Plating for Ranges

Ser	Ammunition	Concrete	Solid brick	Concrete block	Timber	Remarks
(a)	(b)	(c)	(d)	(e)	(f)	(g)
At all angles multiple strike.						
1	Rimfire	75	100	100	125h/w or 150s/w	h/w = hardwood s/w = softwood
2	Centrefire pistol carbine	150	215	215	175h/w or 200s/w	
3	Centrefire rifle	200	215	215	250h/w or 375s/w	No AP ammunition permitted.
Defence Zone - Single shot at 90^0 (1600 mils) to surface or less.						
4	.22"	25[1]	75[1]	50[1]	125s/w	(Note 1 & 2)
Defence Zone - Single shot at 7^0 (124 mils) to surface or less.						
5	.22"	25[1]	75[1]	50[1]	12s/w	(Note 1 & 3)

Table 5 - Minimum thickness (mm) of construction materials considered to be impenetrable to bullet strike.

Notes;

1. *If a raised firing point is to be used, its height is to be added to the firing posture height*
2. *The LofS from all firing postures is projected from all firing distances to target centres. From the line so produced, the distance and angle or angle taken from Table 3 is struck to determine the height of the appropriate range component*
3. *The range component is taken to extend down to the range floor in all cases. Where there are penetrable floors with occupied rooms or services below the defence structure must extend over the floor area concerned*

3-2-3. Design

Each component may be sized using the following guidelines;

A. **Vertical Axis.** The LofS is established by determining:
   1. The maximum and minimum target centre height to be permitted on the range.
   2. All firing postures applicable to that range:
   3. Standing 1500 mm (C)
   4. Kneeling 800 mm (C)
   5. Prone 300 mm ©

B. **Horizontal Axis**. The LofS is established from the centre of all flank firing positions to that flank target centre. The distance and angle found in Table 3 is projected to determine the minimum width of the range component

3-2-4. **Backsplash Hazard**

Care is needed to ensure any structure down the range either stops the bullet or is sufficiently weak to allow the bullet to pass through without great loss of energy. Where a low velocity bullet is decelerated on it's way down range it may not penetrate the anti-backsplash curtain and therefore may bounce back to the firing point. To minimise this hazard targets should be fixed with light material, timber less than 25mm, plastic, cardboard, string, netting or Hessian. Where timber is increased in thickness to capture bullets, be sure there is no chance of a round cutting through the corners of the timber generating a backsplash hazard.

3-3. General

A building with a minimum length of firing distance plus sufficient room to allow for the construction of firing points and bullet catcher is required. Some bullet catchers have bigger footprints than others. Each firing lane should be in accordance with Table 6 below. A clear height of 600 mm should be provided above the LofS at the firing points and 250 mm above the LofS at the target. The floor, ceiling or roof and all walls within the defence zone should contain shot. The thickness of various types of construction to contain shot is given in Table 4 and 5 above.

Ser	Firearm	Width
1	Rimfire rifle (single shot bolt action)	1000mm
2	Rimfire & centrefire pistol / carbine with benches & screens,	1000mm
3	Rimfire & centrefire pistol / carbine without benches & screens,	1800mm
4	Centrefire rifle	1800mm

Table 6 - Firing Point Spacing/ Lane Widths

3-3-1. Adjoining Rooms

Where other occupied rooms or passageways adjoin the range, or where the range floor or ceiling separate it from other floors, the complete area of the separating structure must be suitably protected from bullet penetration. Timber floors or ceilings may have to be protected over their complete area the details of which are given in Table 4 and 5. Alternative shot resistant materials may be used on ranges. The reduced material specification for engagement at 7^0 (125 mils) or less should not be used where there are adjoining rooms. Noise reduction measures may be required if the adjoining rooms are occupied.

3-3-2. Doors and Windows

In new ranges, the inclusion of windows in the protected area should be avoided. The inclusion of doors should be avoided though in some instances, such as fire doors, this may not be possible. In existing buildings all windows and unnecessary doors must be sealed up and rendered impenetrable. The range entrance door should be located behind the rearmost firing point. One other door may be required by the Fire Officer for emergency exit, located down-range. All down-range doors within the protected areas should be flush with the wall otherwise the reveal shall be baffled or clad to prevent backsplash. Down-range doors within the defended area must be impenetrable to any direct fire, ricochet or backsplash with all furniture protected from strike. These doors should be fitted with a panic bolt, fitted so that its status is obvious to the RCO, or a push bar regardless of other locks, fitted so that its status is obvious to the RCO. All down range doors are to be controlled by the RCO. Where it is possible to open down range doors from the outside, an audio visual alarm should be fitted. Control measures are required outside the main access door warning against entry when the range is in use. Where a range opens onto a public area, a secondary outer door may be necessary to overcome the problem of vandalism or to reduce noise. Red lights or notices, or a combination of the two may be used to provide the control measures. Where it is difficult to see a red light in daylight a sign on or near the door that indicates “Range in use Keep out” or “Range not in use” may be used.

3-3-3. Ventilation

The requirements for ventilation in all indoor training ranges are given in Chapter 7. New ranges should be designed to minimise the potential for air turbulence. Services and other obstructions in the range should be baffled for protection and such baffles will cause air turbulence in the range. To overcome this, the envelope may be designed to minimise this effect by sloping floors, walls and ceiling to provide recesses in which services or obstructions may be safely placed. See Fig 3 - 9 for details.

3-3-4 Dust Control

Dust in the range will contain contaminants such as lead and unburnt propellant, both cause environmental problems and should be removed. All indoor ranges should be constructed to minimise the accumulation of

dust and ease cleaning. All unnecessary surfaces such as shelves, open cupboards or roof members should be removed or sealed. Walls, ceiling and floors should be designed or covered with surfaces which are impervious and easily cleaned.

3-3-5. Safety Signs

The risk assessment for the range will determine what safety signs are required. Details of the ballistic related signs are illustrated below.

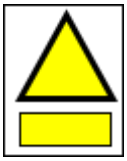
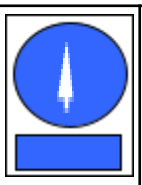
				
Prohibition	Warning	Mandatory	Safe condition	Fire
No Entry when red light is on	Explosive dust	Ahead only	Exit	

Figure 3 - Safety Signs

3-4 - DEFENCE ZONE

3-4. Requirements

The positions of the defence zone in the range structure are shown in Figure 3-2. It is essential that all parts of the structure within the defence zone are impenetrable to shot see Tables 4 & 5. Alternatively, the defence zone may be protected by baffles as specified in section 12 below. No services or other obstructions whether temporary or permanent, which could cause ricochet or backsplash, should be in the defence zone. Any protrusion unavoidably in this area should be protected and obstructions clad to prevent backsplash. The area of the defence zone is calculated using Table 3.

3-4-1. Fixings

Any fixings used in the defence zone must not cause backsplash or excessive ricochet.

3-5 - BACKPLATE

3-5.

A backplate is used where necessary to provide added protection around the bullet trap. In low velocity ranges the backplate is the part of the back wall, around or behind the bullet catcher, which is designed to be struck by a poorly aimed shot. The complete backplate area should be protected by steel plate except where the bullet catcher is sized to include the backplate. On very narrow or low ranges this area may extend down the sidewalls, floor and ceiling. The size and thickness of the backplate are calculated using Tables 3, 4 & 5. To prevent backsplash the backplate area in direct line of fire and any protruding surfaces or baffles in this area should be protected by the anti splash curtain or be clad by a material, typically timber boarding generally fixed to battens, that will prevent backsplash. The battens provide a gap where the bullet energy can dissipate without damaging the back of the boarding and are fixed vertically to allow bullet debris to drop out.

3-6 - BULLET CATCHER

3-6. General

The bullet catcher must safely stop and contain all correctly aimed shot. There are many variations available. Examples with respective advantages and disadvantages are illustrated in-Fig. 3-5 to 3-8. This section covers traditional down range in lane shooting bullet traps where there is an Mean Point of Impact (MPI) behind each target.

3-6-1. The Sand Bullet Catcher

The traditional sand faced bullet catcher is suitable for all firearms. Details of sand bullet catchers are provided in Chapter 2. It is however not the ideal solution indoors due to the dust and cleaning problems associated with such traps.

3-6-2. Vertical Steel Plate with Anti-Splash Curtain

Existing low velocity ranges traditionally have the minimum requirements outlined in Figure 3-5. In this case the bullet catcher and the backplate are to be firmly fixed to a sound brick, block work or concrete wall. Steel plates should be mounted so that sheets are flush to each other, preferably with fixings made flush. The bullet catcher plates should be so arranged that the target positions will not coincide with the edges of the steel sheet. This design is the minimum requirement for rimfire firearms. It is simple and reliable, and breaks up the round on impact. Backsplash is prevented by an anti-splash curtain in front of the plate. A timber batten on the floor behind the curtain helps contain lead fragments. The main disadvantage of this trap is noise and the lead dust generated by bullet impact on the steel plate. The size and thickness of steel plate may be determined from Tables 4 & 5. To minimise reverberation and noise when the bullet catcher is struck, an absorbent layer should be sandwiched between the steel sheet and the back wall. A sacrificial plate will increase durability at the MPI. As continued strike will buckle this plate, it should be fixed to allow for creep. Fixing bolts and screws should be countersunk.

3-6-3. Angled Steel Plate with Anti-Splash Curtain

A single steel plate deflects LV rounds downwards to a bullet stop at floor level. It is effective but less safe and reliable than the vertical plate. Deflected rounds may not behave in a predictable manner and there is a much higher reliance placed on the anti-splash curtain. Multiple deflectors of the "Venetian blind" type are only to be used with an anti-splash curtain fixed in front of and clear of the bullet catcher.

3-6-4. Snail Bullet Trap

This trap is a patent design by Savage Arms Corps of USA and is suitable for all lead based ammunition types. During 2006 the specification of the “Snail” trap had been upgraded to cater for the introduction of steel ammunition. The use of steel ammunition in existing “Snail” traps should not cause sudden failure but inspection of the impact surfaces in the throat of the trap will be necessary to ensure wear is not taking place. The bullet catcher works by directing the bullet into a tight spin allowing the round to decelerate whilst contained within the trap. Lead dust is still produced but is contained. Noise remains a problem with this type of catcher. Such catchers once properly installed should need little maintenance. It is however expensive and the range must be designed to accept the high point loads and component size of the Snail Bullet catcher which does have a large footprint. See Fig. 3-6a.

3-6-5. Granulated Rubber Traps

The vertical granulated rubber trap was not successful in use however the granulated rubber trap used at a natural angle of repose is a very cost effective and environmentally friendly solution. Details of this trap are provided in Chapter 2 and it is illustrated at Figure 3-6b.

3-6-6. Other Bullet Catcher Systems

There are many bullet catchers available commercially, more for low velocity than for high velocity. Whichever trap system is selected it should meet the following safety criteria;

A. It must be fit for the purpose for which it was intended. It must capture all rounds safely without inducing ricochet or backsplash

B. Where centre bull targets are used the trap must be able to withstand heavy localised attrition without excessive deterioration
C. The catcher must be easily inspected in depth to provide assurance that penetration resistance is effective
D. The bullet catcher ideally should capture rounds intact eliminating lead dust problems in the bullet catcher
E. Impact noise should be minimised
F. The bullet catcher should require only occasional maintenance and there should be no element that cannot be maintained by range staff
G. It should be cost effective in use

Bullet catcher type	Ammo type	Advantages	Disadvantages
Sand	All	● Traditional system Inexpensive ● No noise ● Fall of shot visible	● Dust in range and catcher (lead & propellant) ● Maintenance costs ● Lead breaks up ● Environmental hazard ● Disposal costs ● Attrition at MPI
Flat steel plate & Anti - backsplash curtain	Low velocity only	● Traditional system ● Inexpensive ● Small foot print	● Dust in catcher (lead & propellant) ● Lead break up ● Cost of Linatex ● Fall of shot not clear. ● Attrition at MPI
Snail escalator trap	All	● Low cost in use ● Minimal maintenance	● Lead break up ● Noise ● High initial cost ● Large footprint ● Fall of shot not clear. ● Older versions suitable for lead ammo only.
Granulated rubber	All	● Little round break up No lead dust No noise Low maintenance Low cost in use	● Same footprint as sand ● Fine rubber dust on high use ranges. ● Fall of shot not clear. ● Cover sheet attrition at MPI ● Fire risk particularly when not fully maintained
Curtain (Open) Polymer / PVC Compound sheet	Low velocity only	● No round break up ● No lead dust ● No noise ● Very low maintenance ● No cost in use ● Low cost in use (Target shooting) ● Effectiveness visible	● Large footprint ● Low velocity use only
Curtain /herringbone Rubber recycled conveyor belt	All	● No noise ● Smaller footprint	● Attrition at MPI ● Rounds captured in rubber ● Effectiveness not visible ● Anti backsplash sheet required ● High maintenance cost

Table 7 - Bullet Catcher Characteristics

3-7 - ANTI-SPLASH CURTAIN

Figure 4 – LV bullet trap MS plate and Anti backsplash curtain

3-7-1. Material

Any bullet catcher that may generate backsplash must always be provided with an anti-splash curtain. Only the sand bullet catcher, the Snail Bullet Trap and granulated rubber traps may be used without a curtain. The curtain material is 6 mm thick soft latex rubber or similar material. It is required to resist penetration by a deflected round and to contain backsplash without damage to the rear of the curtain. It is known that where there are more than two layers of this 6mm material, 0.22" ammunition may not fully penetrate presenting a backsplash hazard. Patching in areas of overlap is therefore not wise. The use of wadcutter and similar ammunition may render the anti splash curtain unsafe. These materials are available in a variety of colours, painting proprietary anti splash curtains is not recommended as it may alter the ballistic performance.

3-7-2. Fixing

The anti-splash curtain is clamped to or fitted with hooks and eyelets to hang it onto the pelmet to cover the complete area of the bullet catcher in such a way that deflected rounds or backsplash cannot escape (see Figure 3-5). Alternatively, the anti-splash curtain may be fitted into a timber ply sheet covering only the expected area of impact on or around each target. Curtains should be hung in such a way to enable rotation of worn sheets and ideally shifting the MPI to extend the life of the curtain.

A. The curtain hangs approximately 300 mm in front of the bullet catcher to ensure the rear of the sheet is not damaged by the breakup of the rounds on the steel plate
B. It overlaps the pelmet side cheeks which require protection from backsplash
C. Each sheet overlaps the adjacent sheet by approximately 150 mm ensuring that even if the hanging curtain is not exactly vertical, full coverage will be achieved
D. To prevent the curtain curling, a timber batten is fixed near the bottom of each sheet, staggered back and front on alternate sheets
E. The curtain is to hang just clear of the floor
F. The maximum number of layers of anti splash curtain that can be used to ensure there is no backsplash is two. Patching over the areas of overlap may generate backsplash
G. Where a range is used for air firearms it will be necessary to make provision to remove the backsplash curtain or fit an additional pellet catcher curtain of hessian or similar material

3-7-3. Pelmet

The pelmet is a timber shelf with side cheeks to prevent deflected rounds or backsplash escaping. The inner surfaces of the pelmet are lined with 3 mm thick steel to reduce the attrition caused by continued strike.

3-7-4. Anti-Splash Curtain Repair

Latex rubber curtain is expensive. It can however have a very long service life, even on a heavily used range. The curtain should be moved around to prevent holing at MPI. Holes in the curtain can be patched once with material cut from another sheet and fixed with a suitable adhesive available from the manufacturer. Precautions must be taken when handling lead contaminated sheets. Latex rubber is inflammable and must be kept clear of heat sources such as target lights.

3-8. Targets

There are many target systems available for indoor ranges. Static projected target or scenic, video film or live relay and computer generated target arrays. Traditionally fixed target frames are fitted to most indoor ranges. However, the electrically operated turning target mechanism may be used. A lane width of 1.6 m is required to give half target width separation within a lane and a full target width separation between lanes. Where multi point targets are used the sizing of components is taken from the outer points of aim.

3-8-1. Target Mechanisms

Target mechanisms should be protected against damage, backsplash and ricochet. The protection required is established from the worst case line of fire. Fixed target frames are locally manufactured. They should be of lightweight construction with no fixings that may cause ricochet or backsplash. Timber used should be softwood and the total thickness not greater than 25mm thick to ensure after penetration there is sufficient energy to penetrate the anti backsplash curtain. Many suitable fixing methods are available for target cards. A convenient target frame can be constructed with cellular plastic board.

3-8-2. Moving/Advancing Targets

Moving targets on the target line may be possible in some indoor ranges. The sizing of range components will clearly be taken from the extreme ends of target runs. Where retrievable targets are used in lane (especially where retrofitted), great care must be applied by the club to ensure all points of aim at each distance and from each firing position direct bullets into the bullet trap and not the roof of the range.

Figure 5 - Retrievable targets

3-8-3. Target Positions

The maximum target centre height and flank target positions are essential features in the design of the range as they determine the size of all range ballistic elements. Safe operation of the range cannot be assured if the proper target height and position are not maintained. In the case of multi-point targets or screens, the target centre of the outermost targets is used to place the targets. The ruling target centre height and flank target positions must be marked on the range sidewalls and floor respectively. This may indicate maximum and minimum heights when the range is designed for a variety of targets.

3-8-4. Target Lighting

A simple row of fluorescent strip lights in an angled reflector, set into the range floor, ceiling or surface mounted with baffle or angled component protection will be found adequate for most shooting. Tungsten spotlights can be fitted either at floor or ceiling level. Where retrievable targets are installed lighting will be needed all the way down range.

3-9 - FLOOR

3-9-1. Floor Surfaces

Any protrusions that may generate backsplash or ricochet on the range floor will require additional protection. Preferred materials are thick rubber, thermoplastic, vinyl sheet or timber. Timber floors should be sealed and have filled joints to prevent a build up of lead dust and unburnt propellant. Where pistols are

fired without bench rests provision will need to be made to control bullet strike in front of the firing point. See paragraph 3-13-2.

3-9-2. Lower Clear Vision Line

There are to be no obstructions on the floor that interrupt the lower clear vision line (see Chapter 2 and Figure 3-3).

3-10 - WALLS

3-10. Walls and Sound Attenuation

Walls outside the defence zone should be clad with a sound attenuating material which will effectively reduce reverberation. The defence zone should also, where possible, be similarly clad. It will be necessary to consider the effect of strike on the material selected for the defence zone. The detailed design of sound attenuation may vary considerably from one building to another. Raking in the walls and stepping back for services will also provide some reduction in reverberation back up the range. Rimfire ranges may not require such a high level of attenuation as centrefire ranges. Selected wall finishes need to be durable to resist the knock and abrasion inevitable in a club range. The finish should be smooth, joint-free, and withstand frequent cleaning and wet scrubbing with agents to remove and neutralise lead dust and unburnt propellant.

3-11 - CEILING

3-11. Ceiling or Roof and Upper Clear Vision Line

The ceiling or roof, ceiling or roof members including baffles, and all fixtures and fittings should be above the upper clear vision line so as to provide sufficient clear height for safe firing (see Chapter 2 and Figure 3-3).

3-11-1. Sound Attenuation

In buildings with a high ceiling or roof above about 3.5 m, sound attenuating linings to the roof or ceiling may be less necessary. With low ceilings or roofs, sound attenuating lining or a suspended ceiling may be required. The need for durability and to withstand cleaning, as previously described, is less essential.

3-12 - BAFFLES

3-12. Purpose

Baffles are used on an indoor range to:

A. Protect fixtures and fittings from strike
B. Prevent rounds escaping where the walls or roof in the defence zone are not sufficient to prevent penetration by shot. The effect of baffles is however limited if firers move down range to engage targets

3-12-1. Locations

Baffles are generally placed only to prevent direct shot escaping or to protect fixtures and fittings. They will not completely eliminate the danger of ricochet in the range due to the random nature of ricochet angles. The range structure within the defence zone must in all cases be impenetrable to ricochet. As there is no data for ricochet, use the detail for low angle strike in Chapter 2 Table 7. Baffles may be vertical or horizontal. They are designed with respect to each firing point and from each firing posture for which the range is designed: standing, kneeling or prone. It must not be possible for the firer to see any item protected by a baffle or to see between baffles which are protecting the defence zone. Baffles protecting the defence zone are designed so that the soffit of each baffle overlaps subsequent baffles by at least 150 mm when viewed as just described. The clear vision height should be maintained below the soffit of each baffle and the clear vision line maintained. Baffles will disrupt laminar air flow so keeping the number of baffles to a minimum is recommended.

3-12-2. Angled Baffles

Any baffle in the defence zone within the backsplash distance of a firing point is angled to prevent backsplash and to ensure that strike will ricochet down-range and not towards the walls or roof (see Figure 3-4). Due to the proximity of the hazard and to provide greater backsplash protection, angled baffles should have an enhanced timber cladding as illustrated in Figure 3-4.

3-12-3. Materials

Materials used for constructing baffles are to conform with Chapter 2 Table 7 so that shot penetration is prevented. Cladding to prevent backsplash should be of a suitable ballistic material which allows the round to pass through and to capture backsplash without damage to that material. Where high velocity ammunition is used, particularly steel ammunition, the effectiveness of the steel can be extended by reducing the strike angle below 15^0. Detail of baffle construction is shown at Figure 3-4.

3-13 - FIRING POINTS AND LANES

3-13-1. Firing Points

When firing is conducted from the prone position on just one firing point a raised platform approximately 450 mm high should be provided. This reduces the possibility of ricochet from low shots hitting the range floor. It may be built into the range floor or be a free standing structure. It should be about 2.5 m from front to rear with a fall of 1:12 from the front edge. The firing point should be surfaced with a smooth impervious material that can be vacuum cleaned and washed down. Carpets or other items that will trap lead dust and unburnt propellant are not to be used in the range due to an explosive risk. Where free standing firing platforms are used, marks on the range floor indicating the correct positioning of the firing platform should be provided.

3-13-2. Pistol Benches or Ricochet Protection

If pistol is to be fired, using a bench to prevent the pistol being lowered below waist level is strongly recommended. This ensures that unintentional discharge during handling will not strike the range floor close to the firer and cause dangerous ricochet. If pistol benches are not used, the floor for 2 m in front of the firer should be constructed to capture shot and prevent ricochet. This may be achieved by either of:

A. A 2 m wide by 100 mm deep channel is formed across the full width of the range floor. The channel is clad with 50 mm timber boarding fixed on to 50 mm battens. Other shot absorbing material, such as rubber tiles or sheet flooring, may be used to capture shot
B. The timber or rubber flooring required by sub-paragraph a. above may overlay the range floor with the leading edge and back edge ramped to the range floor to eliminate the hazard of tripping

3-13-3. Firing Lanes

The position of each firing lane should be clearly indicated on the firing point and each lane numbered. Minimum permitted lane widths are:

A. **Rimfire Rifle**. 1 m
B. **Rimfire or Centrefire Pistol/Carbine.** 1 m with screens or 1.8 m without screens to provide protection from ejected cases and space for coaching
C. **Centrefire Rifle**. 1.8 m
D. **Flank Clearance.** Each flank should provide a 0.5 m clearance, parallel to the flank LofS, down the complete length of the range (see Chapter 2)

3-13-4. Firing Lane Width

In designing lane width and the depth of the firing point, consideration has to be given to:

A. **Screens**. These assist preventing adjacent firers being distracted by noise and ejected cartridge cases when firers are close together
B. **Coaches**. On any club range it is desirable that space is provided for a coach to work beside each firer

C. **RSO/RCO**. The RSO/RCO has to be able to move freely behind the firers and to have a clear view of all activity on the firing point

3-14 - FIRE HAZARD

3-14-1. Hazards

When specifying materials for range construction, the fire rating must be considered. Materials such as rubber compounds and timber can present a fire hazard. This, combined with factors such as heat from target lighting and the presence of unburnt propellant, require that careful consideration is given at the design stage to fire prevention. A light rubber sheet over granulate rubber traps will prevent target debris and unburnt propellant getting into granulated minimising the fire risk. This is particularly important where close engagement practices are undertaken. Means of escape must conform fully to the Fire Regulations.

3-14-2. Approval

Attention is drawn to the Building Regulations, Approved Document B1 and The Fire Precautions (Workplaces) Regulations 1997.

3-15 - COMMUNICATIONS

3-15. A means of summoning the emergency services must be available when the range is in use.

3-16 - INSPECTION & MAINTENANCE

3-16-1. Responsibilities

Maintenance is the responsibility of the Range Operating Authority/club. Maintenance should include;

A. Condition of the bullet trap and back wall
B. Stability of the structure
C. Warning signs and interlock safety systems
D. Prevention of dust accumulating out of sight
E. Ventilation system functioning properly (if fitted)
F. Repairing and servicing equipment

3-16-2. Frequency

Proper maintenance is dependent upon good liaison between the members of the club, and on properly scheduled maintenance periods. A heavily used range may need one day's maintenance each week. Two closed periods of a week or so may be needed each year for building and defence structure repair. For frequency of de-leading .22” ranges refer to Chapter 6, deep cleaning. Proprietary trap systems should be de-leaded in accordance with suppliers’ recommendations. The range operator should determine when low use ranges are de-leaded, and clubs should keep a log of ammunition fired on the range to inform frequency of maintenance tasks.

3-16-3. Range Cleaning

Range cleaning is an important factor in maintaining a safe range. Range cleaning including the requirements for routine and deep cleaning is contained in Chapter 6.

3-16-4. Bullet Catcher

Regular inspection of the bullet catcher backplate and pelmet lining should determine that no excessive buckling, displacement or splitting of the steel is evident. Steel plate which is showing signs of failure (ie cratering, visible splits and cracking or clear distortion of the plates) must be replaced. Bullet catchers may also need frequent emptying and frequent cleaning.

3-16-5. Range Structure

Other than the backplate area, it should be very rare for the range structure to be struck. Apart from the backplate, the range structure should be inspected regularly for damage from shot strike. Any strike is to be marked, and the cause investigated and recorded in the Range Log. When such damage in the defence zone is significant, it is to be repaired immediately.

3-17 - INSPECTION CHECKS

3-17.

When the club decides to carry out the annual inspection the following should be included in the inspection;

A. Authorised firearms, ammunition and practices
B. Bullet trap maintenance is effective
C. All surfaces free of dust
D. Floor, walls and ceiling clearly specified for sound absorption and dust inhibiting surfaces free from obstruction or correctly protected
E. Backsplash / ricochet hazards eliminated. Baffles (if any) correctly positioned and detailed
F. Targets and firing points correctly sized and positioned
G. Target centre height and flank positions clearly identified
H. Adequate ventilation and lighting
I. Correct safety signs number and location
J. Adequate access and egress

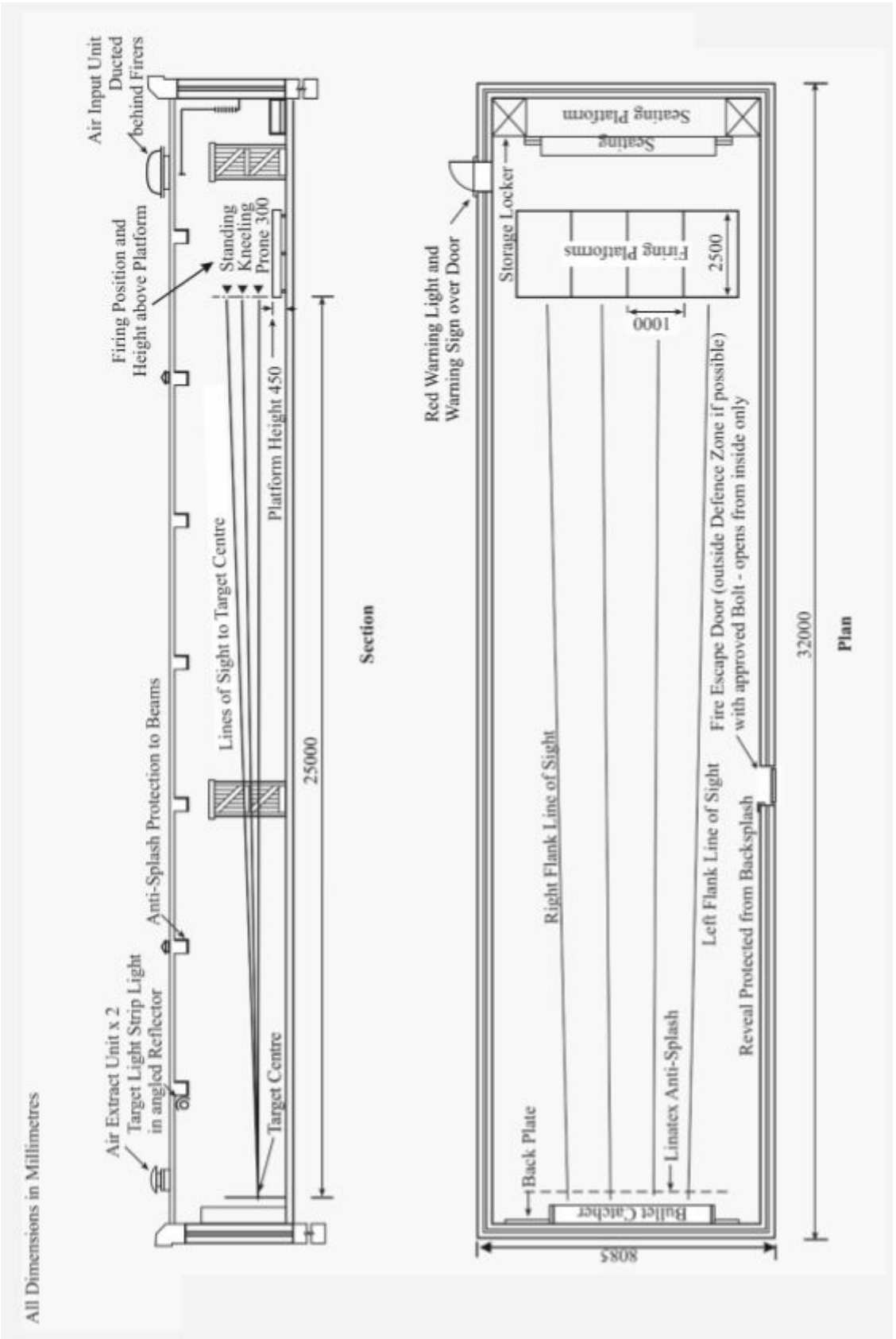


Figure 3-1 - Typical Layout Indoor 25 Metre Range

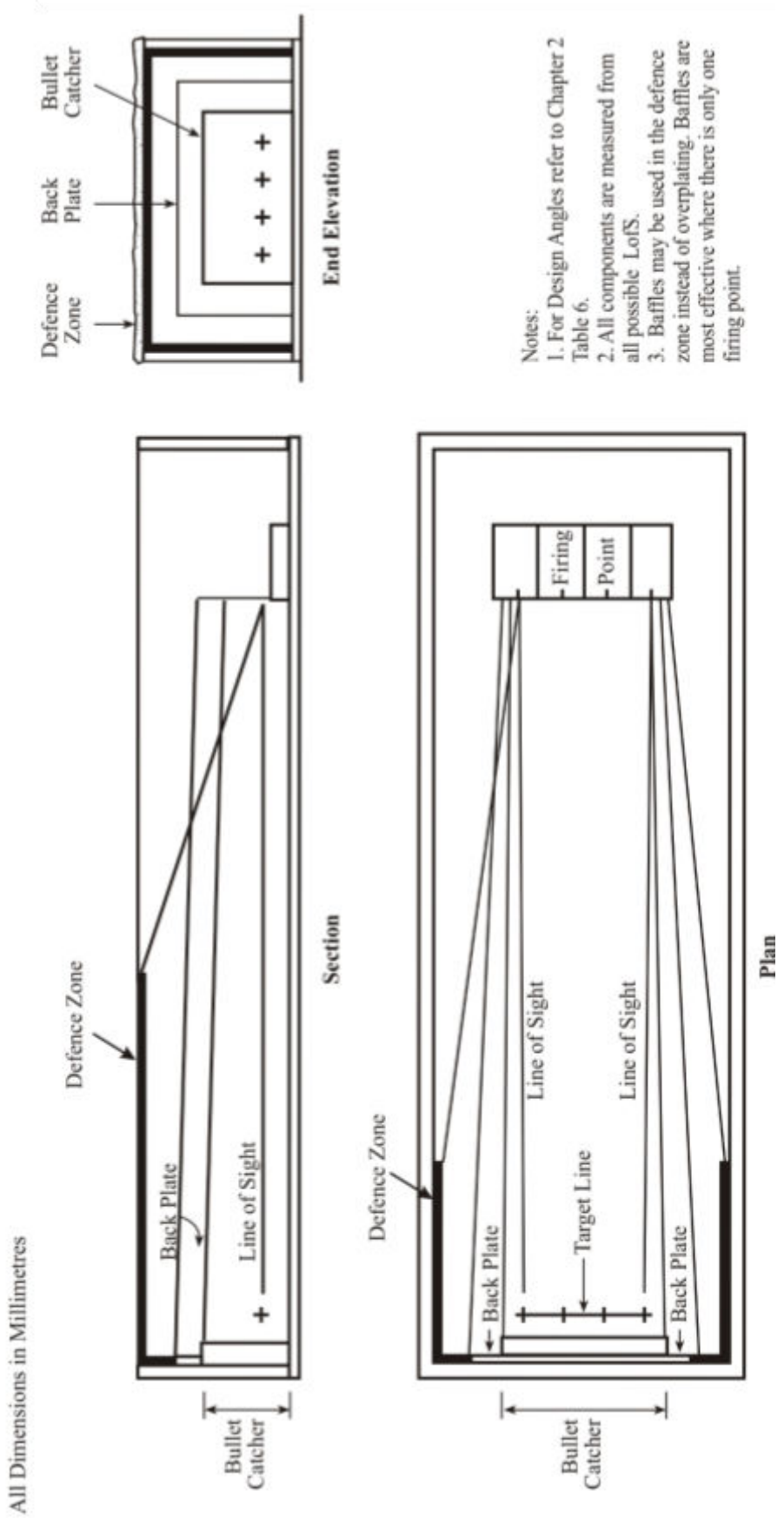


Figure 3-2 - Defended Structure Details

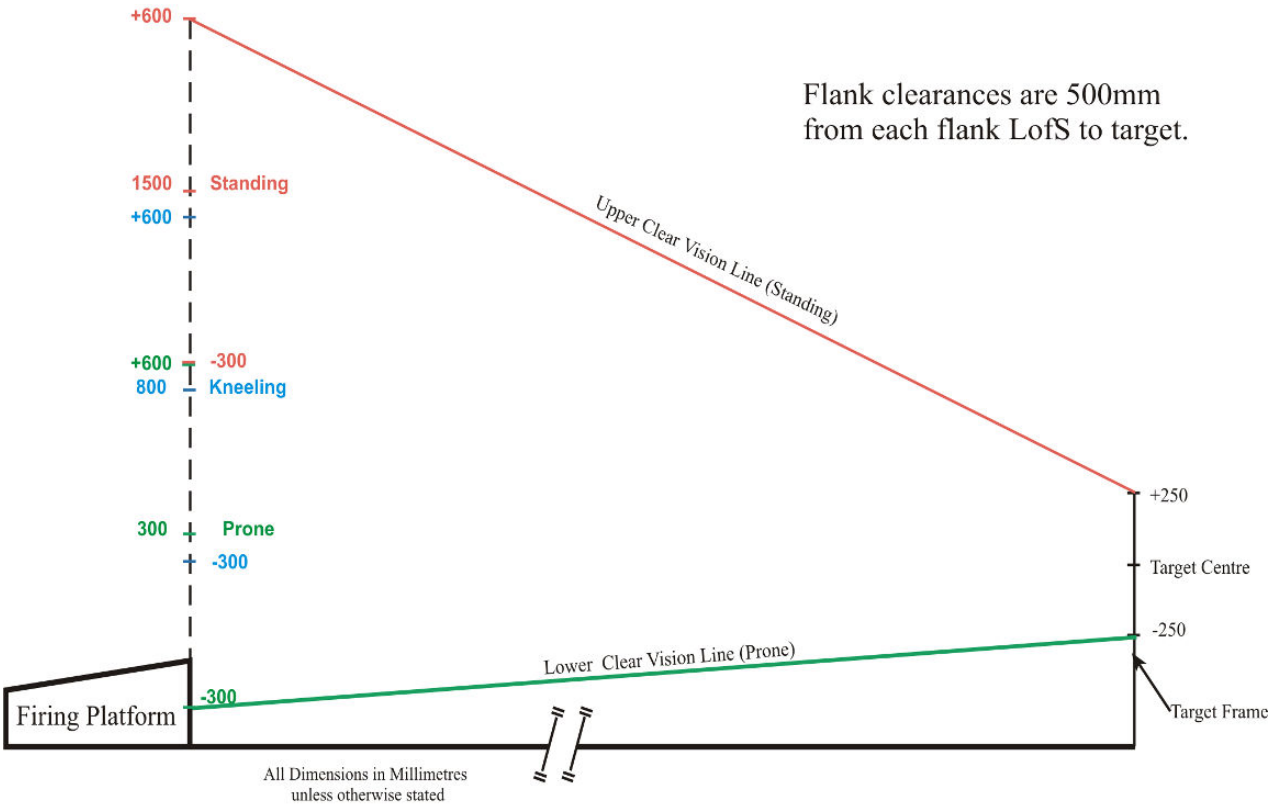


Figure 3-3 - Clear Vision Line (T)

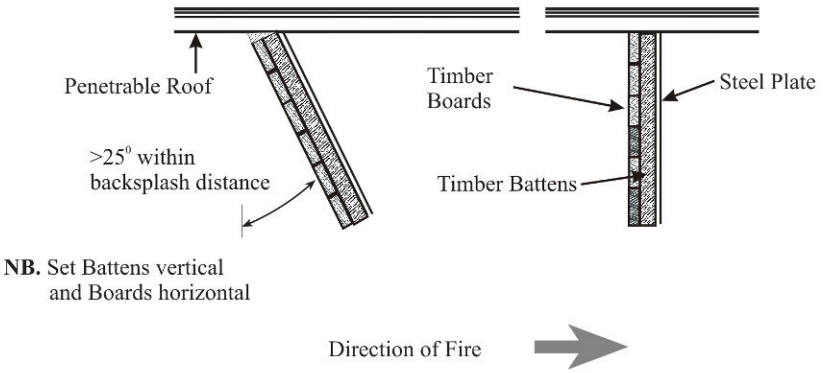


Figure 3-4 - Baffle Construction

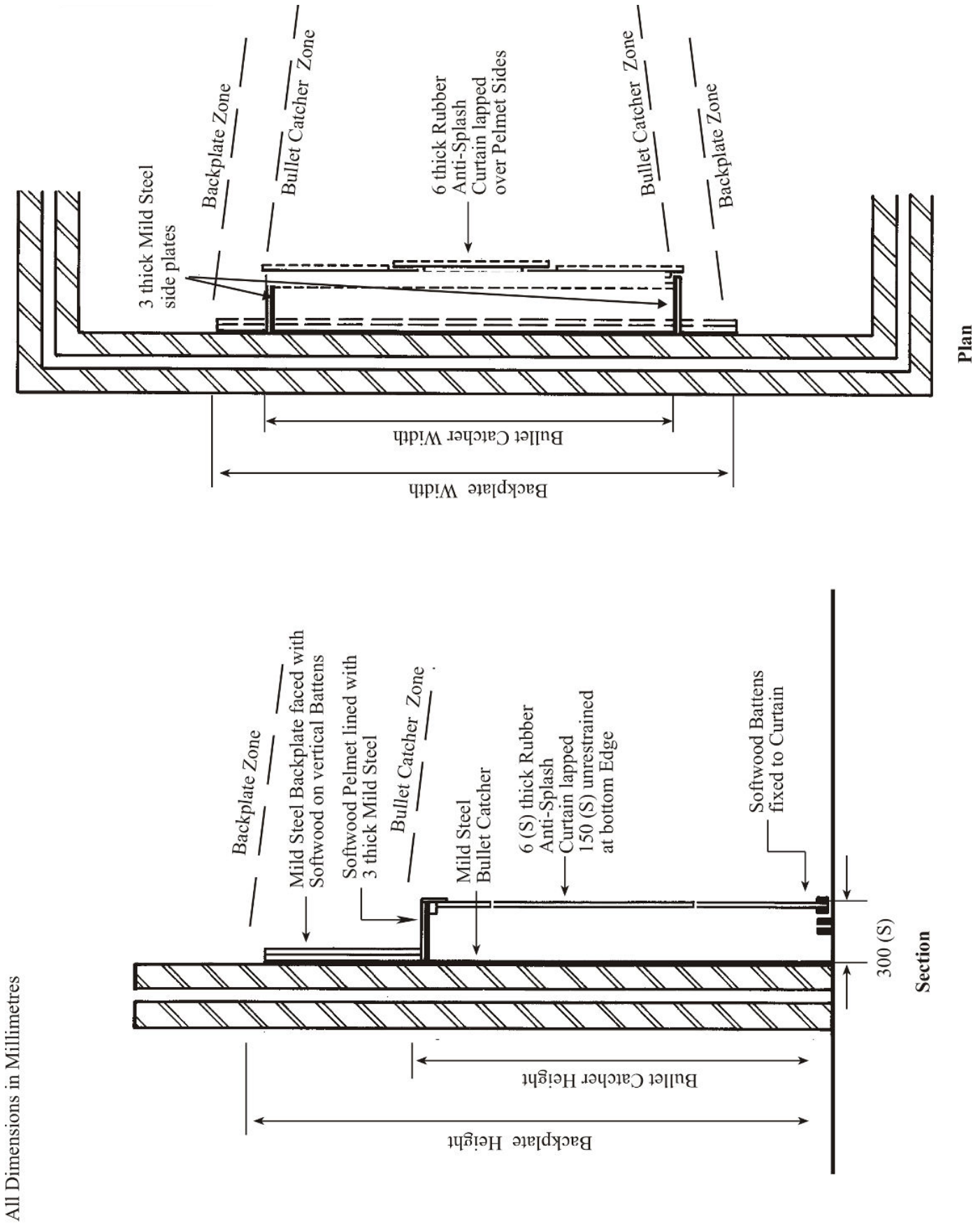


Figure 3-5 - Bullet Catcher Construction

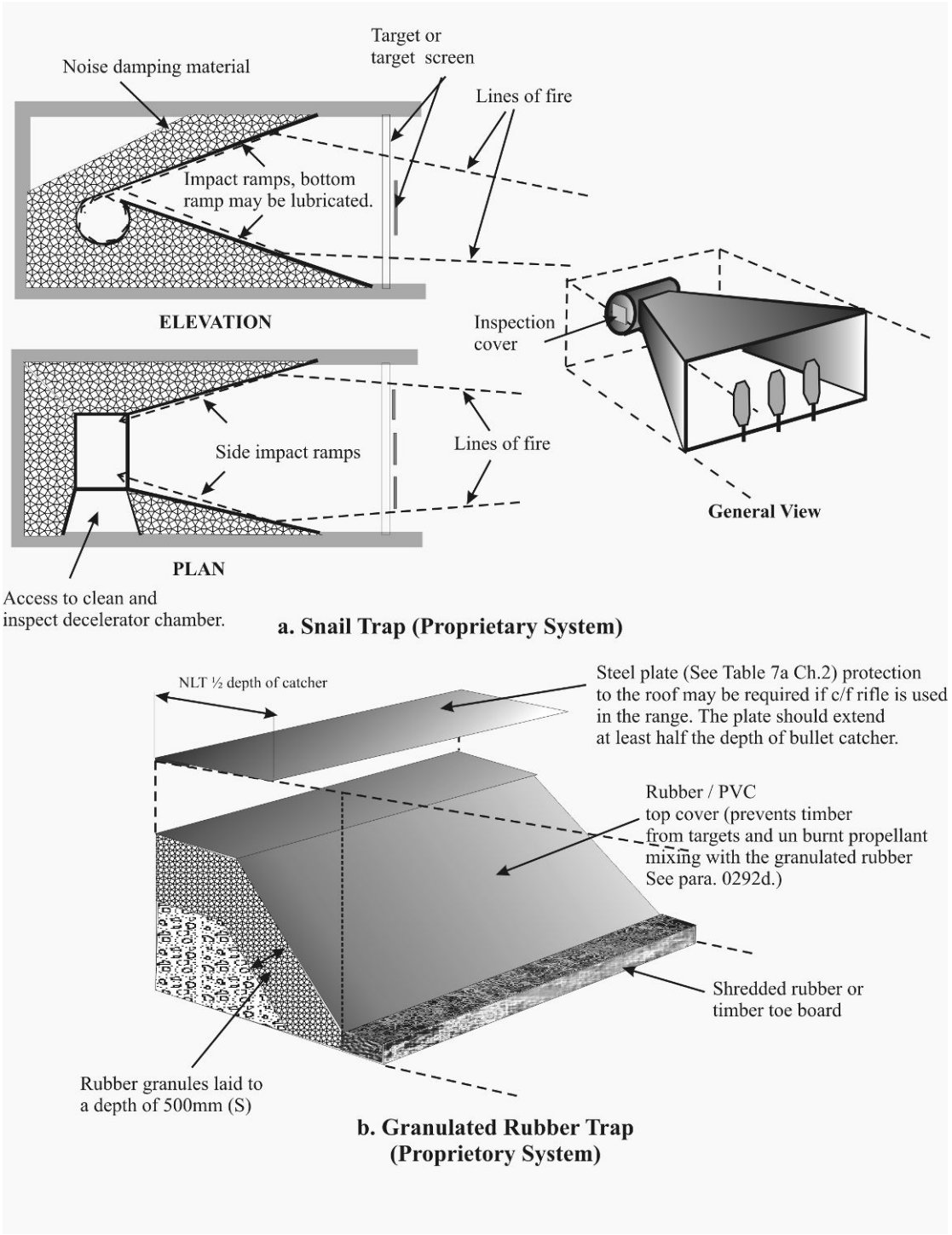
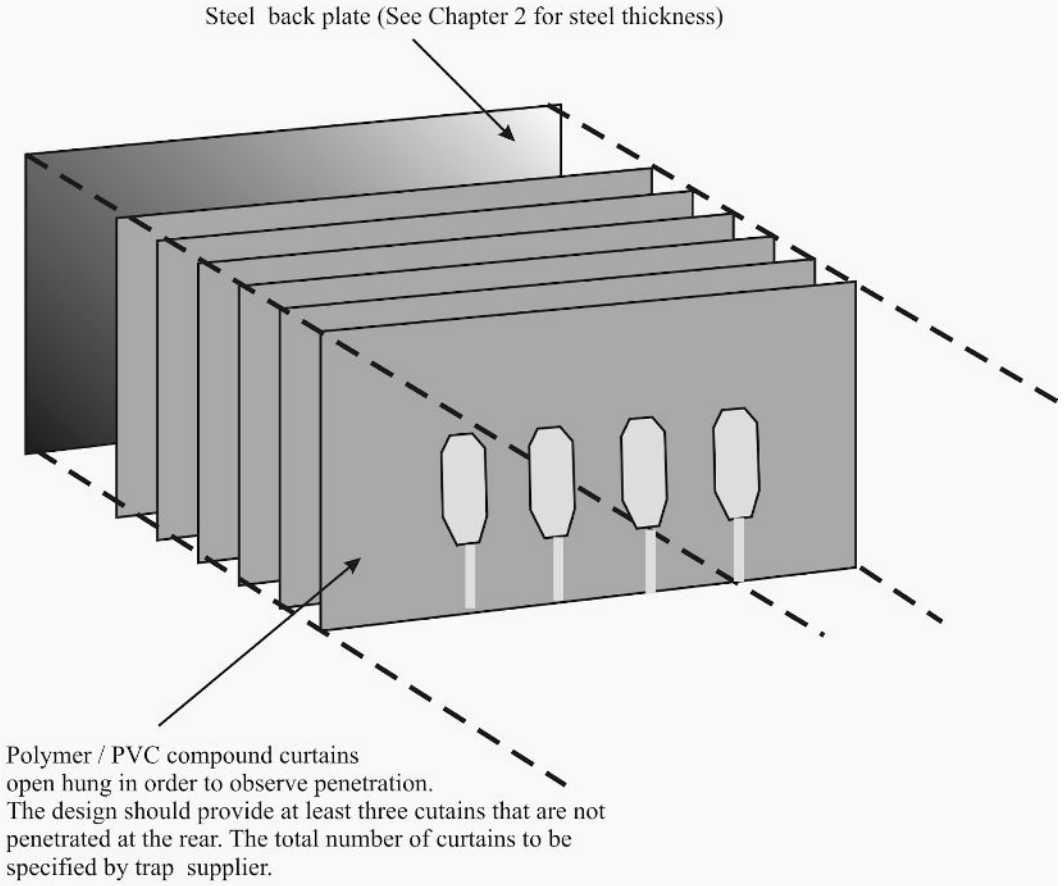


Figure 3-6 - Typical Indoor Range Bullet Trap Detail (High or Low Velocity ammunition)



c. Curtain Trap

Note:

A propietory system for 9mm or .22" ammunition only.

Figure 3-7 - Typical Indoor Range Bullet Trap Detail (Low Velocity ammunition)

Bullet Catcher Type	Ammunition type	Advantages	Disadvantages
Sand	All	● Traditional system ● Inexpensive ● No noise ● Suitable for target or judgemental shooting ● Fall of shot visible	● Dust in range and catcher (lead & unburnt propellant) ● Maintenance costs ● Lead break up ● Environmental hazard ● Disposal costs ● Attrition at MPI
Flat steel plate & Anti -backsplash curtain	Low velocity only	● Traditional system ● Inexpensive ● Suitable for target or judgemental shooting ● Small footprint	● Dust in catcher (lead & unburnt propellant) ● Lead break up ● Cost of Linatex ● Fall of shot not clear. ● Attrition at MPI
Snail	All	● Low cost in use ● Minimal maintenance ● Suitable for target or judgemental shooting	● Lead break up ● Noise ● High initial cost ● Large footprint ● Fall of shot not clear. ● Older versions suitable for lead ammo only.
Granulated rubber	All	● Little round break up ● No lead dust ● No noise ● Low maintenance ● Low cost in use ● Suitable for target or judgemental shooting	● Same footprint as sand ● Fine rubber dust on high use ranges. ● Fall of shot not clear. ● Cover sheet attrition at MPI ● Fire risk particularly when not fully maintained and with tracer.
Curtain (Open) Polymer / PVC compound sheet	Low velocity only	● No round break up ● No lead dust ● No noise ● Very low maintenance ● No cost in use (judge-mental shooting) ● Low cost in use (Target shooting) ● Effectiveness visible	● Large footprint ● Low velocity use only
Curtain / herringbone Rubber recycled conveyor belt	All	● No noise ● Smaller footprint ● Suitable for target or judge-mental shooting	● Attrition at MPI ● Rounds captured in rubber ● Effectiveness not visible ● Anti backsplash sheet required ● High maintenance cost for target shooting

Figure 3-8 - Advantages and Disadvantages of the Different Bullet Catchers (Reference: Type Standard TS/02)

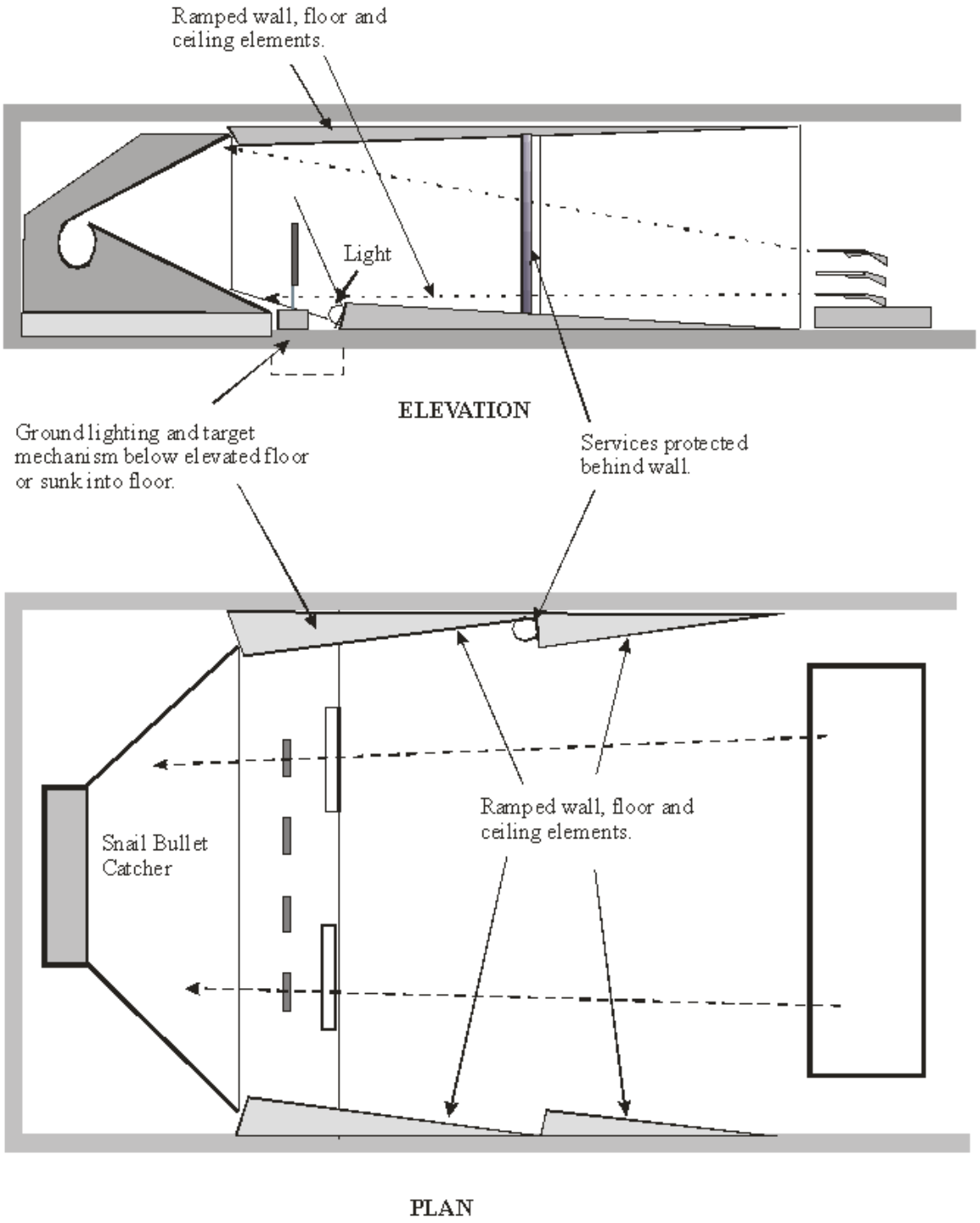


Figure 3-9 - Alternative to Baffles

Ventilation diffuser mounted above the rear firing point

Plenum wall - air is brought in pressurising the space forcing air out through the grill as a unifor flow over the firing point.

Ventilation filters on the roof of a range

Figure 3-10 - Modern Ventilation Systems

CHAPTER 4
OUTDOOR RANGES

4-1 - INTRODUCTION

There are several types of outdoor ranges. Most civilian outdoor ranges will be of the open range with danger area or Non Standard No Danger Area (NDA). The types covered in this section are;

A. Non Standard NDA
B. Standard NDA 25m range (1908 and 1986 design)
C. Gallery Range (Limited Danger Area)
D. Open ranges with or without a Range Danger Area

4-2 - OPEN NON STANDARD NO DANGER AREA (NDA) RANGE

4-2-1. General

A No Danger Area (NDA) range is a range where, for all practical purposes, the design precludes risk of injury or damage to persons or property beyond the range floor caused by direct shot or ricochet, fired in accordance with authorised practices and aimed within the bounds of acceptable aimer error. The Non Standard NDA range requires particular attention as each will differ in the way compliance is achieved dependent upon many factors. Therefore this chapter will define in some detail the process of design to achieve compliance with current authorised criteria.

Figure 1 – Typical Non Standard NDA Range

4-2-2. Preliminary Planning

Consultation at an early stage enables provision of advice regarding individual locations and also ensures that planned work complies with functional requirements and standards of ballistic resistance. Detailed ballistic designs, specifications and all relevant details should be submitted prior to works commencing.

4-2-3. Siting

During the preliminary planning process the following hierarchy of factors should be considered for the initial siting of an open NDA range:

A. **Population**. The orientation of the range should be such that where possible the direction of fire is away from habitation
B. **Sunlight.** To avoid direct sunlight affecting range users, firing in a northerly direction is preferred.
C. **Noise.** Since impulse noise such as that produced on an open range is difficult to contain, siting the range at the greatest possible distance from populated areas is the most effective way of reducing noise nuisance

D. **Environmental Impact**. Consideration should be given to bullet containment and recycling, the type of structure, materials used and overall appearance of the completed facility
E. **Ground Profile.** Ideally NDA ranges should be sited to achieve a Line of Fire (LofF) which is approximately horizontal or slightly depressed from firing point to target
F. **Local Factors.** Full consideration should be given to local factors, conditions, risks and any other relevant information when formulating site specific design solutions. Distraction visible from the firing point beyond the bullet catcher for instance should be avoided
G. **Access**. Access is required for range users and for maintenance works. The range boundary should have controlled access with respective areas suitably signed and, where appropriate, fenced or otherwise marked as described in Chapter 2. Local assessment of site specific risks is required to determine additional control measures necessary

4-2-4. Range Components

Full descriptions of range components are provided in Chapter 2. Specific to Open Non Standard NDA ranges are the following;

A. **Firing points**. For longer engagement distances elevated firing points will help avoid ground strike within the predicted CoF
B. **Targetry.** A suitable target area with clearly defined target positions provides easily identifiable points of aim. In the design process it is the aiming point of a target that is important. There may be more than one aiming point on a single target therefore worst case LofS must be applied to each from all possible firing positions. Placing targets at differing distances down range causes a ricochet problem and should be avoided. It is better for firers to move down range to engage targets at the stop butt
C. **Range Floor**. The range floor includes the length from the rear of the furthest firing point to the toe of the bullet catcher and the width between the flank firing points to the extents of the stop butt. The area of the range floor should be constructed to eliminate, so far as is reasonably practicable, any hard ricochet inducing materials and surfaces. The layout of the range floor requires detailed consideration; particular attention is required for each firing point, the likely first point of impact and potential for ricochet from the surface of the range floor
D. **Ricochet pit**. A potential for ricochet exists where the appropriate cone of fire criteria coincides with the range floor. The use of ricochet pits or sloping range floors may reduce the impact of designing to capture ricochet
E. **Bullet Catcher**. The bullet catcher is the area directly behind the target position which is subject to constant attrition; its purpose is to continually stop bullets in free flight and low ricochet while providing a structure which is easily maintained and cost effective. Sand is currently the most common material used for bullet catchers although granulated rubber is also used and may provide a more cost effective solution
F. **Stop Butt.** The stop butt is the area extending above and to the sides of the bullet catcher and should be subjected to lesser concentrations of fire. Its purpose is to stop direct shot in free flight within maximum predicted aimer deviation margins and ricochet from the predicted first point of impact. Where banks form the stop butt the minimum impact slope of 56^0 is required for NDA ranges
G. **Protection of Hard Surfaces**. Where exposed hard surfaces or objects are likely to be struck there is a potential for high angle ricochet or backsplash to occur. Where the hard surface or object cannot be removed features should be incorporated to provide protection, for example by the use of timber, earth (sloped at a minimum of 56^o) or other suitable material to cover the area of concern. This minimises the risk of injury to those within the range from backsplash and to those outside the boundary from ricochet. Care must be taken to avoid situations where hidden attrition may occur. Rounds passing through soft material leave almost no mark of their passing. However when high velocity rounds impact on a hard surface, that surface may break up. It is important that all defence structures can be inspected for such attrition to ensure the protection required is maintained

4-2-5. Design Factors

Every element within the range should be constructed in a way to ensure the capture of shot within the range including direct fire, ricochet and backsplash.

A. **Direct Fire**. Direct fire is the shot from barrel to target that will include some deviation around the Line of Sight (LofS). This is termed the CoF in which all direct fire is expected for most practices

B. **Cone of Fire (CoF).** The recommended CoF is set out in Table 1 below. Alternative CoF may be appropriate under controlled conditions

Ser	Practice (All single shot deliberate shooting)	Cone of Fire (mils/deg)	
		Azimuth	Elevation
1	Rifle / static to static unsupported	40 / 2.25	40 / 2.25
2	Rifle / static to static supported	21.5 / 1.15	21.5 / 1.15
3	Rifle / moving to static or static to moving	120 / 6.75	60 / 3.38
4	Rifle competition target shooting	12 / 0.6	12 / 0.6
5	Pistol double hand static to static	135 / 7.7	135 / 7.7
6	Pistol single hand static to static	190 / 10.7	190 / 10.7
7	Pistol double hand moving to static or static to moving	250 / 14	190 / 10.5

Table 1 - Cones of Fire - NRA Practices*

***Note;** Range officer must monitor all fall of shot, bullet strike and target grouping to confirm the detail in this table and where necessary increase safety measures if there is evidence of a lar*ger CoF

C. **Ricochet**. Ricochet from the range floor has proven to be a hazard and must be accounted for in the design. A ricochet may occur when a round strikes any part of a range surface, other than ricochet inhibiting slopes within the predicted cone of fire criteria. Apart from the sand bullet trap which should be 34^0, all other slopes on NDA ranges should be 56^0 to eliminate the potential for ricochet

D. **Backsplash**. Backsplash is a hazard to which firers, and others present on a range, may be exposed. It is caused when a bullet strikes any object and results in whole bullets or fragments (of the bullet, targetry, ground or structure) being thrown back towards the range users. Details are provided in Table 2. The risk of injury from backsplash is affected by proximity to the hazard, with the level of risk being dependent on the following factors:

1. **Target Type**. Penetrable (soft) target such as thin plywood, or impenetrable (hard) target such as steel
2. **Surface Type.** The nature of surfaces surrounding the target and the range floor - soft or hard. Soft ground and materials include earth, turf, sand, timber etc; hard ground or materials include stone, rock, steel, concrete etc.
3. **Firearm/ammunition**. Type used - low or high velocity
4. **Engagement Distance.** Target engagement distance or distance between personnel and the object likely to be struck
5. **Obstructions**. Objects in the CoF between the firer and target

Ser	Firearm	Fragment/Earth Throw Distance Hard Tgt (m)	Fragment/Earth Throw Distance Ground Tgt (m)
(a)	(b)	(c)	(d)
1	Rimfire, centrefire pistol and carbine	22	10
2	Centrefire rifle	50	22

Table 2 - Backsplash Zone (Safety Distances)

E. **Firearm** The cone of fire varies according to type of firearm. This affects the predicted initial point of impact with the range floor. A rifle is fired with two hands providing a firm firing position. Pistols fired one handed are considered to have a greater CoF due to the unstable hold and the extent of rotation on the wrist

F. **Ammunition Characteristics** Ricochet and backsplash potential varies with ammunition type; the departure angle and remaining velocity being affected by a number of factors including calibre, muzzle velocity and energy, nature and slope of the range floor, impact angle, exit velocity ratio, projectile damage and ability to re-stabilise in post ricochet flight

G. **Posture.** The firing posture adopted affects the relationship between the line of fire and the range floor. Variation in firing point height has less effect on the target centre height as the CoF rotates around the target centre

H. **Trajectory.** The line of fire is a theoretical straight line taken from the muzzle of the firearm through the point (or points) of aim at the target (the target centre). Bullets do not travel along the theoretical line of fire due to ballistic curve or trajectory; however, for the purposes of calculation the curve is ignored over short distances. Longer ranges with overhead baffles or partially enclosed tube ranges may be affected by trajectory. Shooting at targets over 600m away the trajectory is substantial and reduces the chance of ground strike

I. **Application of Criteria**. To determine lines of fire, each firing posture height / spacing at all firing distances should be linked to each relevant target aiming point in accordance with the planned shooting practices. As the constructed elements of a range are affected by application of criteria to these lines, it is essential that every line of fire is considered

4-2-6. Component Design

A. **Bullet Catcher**. The bullet catcher size requirements can be established by application of a parallel distance and an associated angle to the 'worst case' LofF In Table 3 below. Worst case is flank targets and highest target centre.

Ser	Range	Axis	Height And Width (C)			
	Component	Measured from the LofS	Rimfire		Centrefire	
			Rifle	Pistol	Pistol	Rifle
(a)	(b)	(c)	(d)	(e)	(f)	(g)
Outdoor Ranges						
1	Bullet catcher	Vertical (mils + mm)	3 + 700	6 + 850	6 + 1500	1 + 1700
	Outdoor	Horizontal (mils + mm)	3 + 450	6 + 600	6 + 1400	3 + 1400

Table 3 - Defence Structure Dimensions

B. **Stop Butts / Back Walls**. The required height and width of stop butt for a specific range can be determined by applying the relevant cones of fire and ricochet allowances. In all cases the greatest possible margin of error should be applied. See Figure 2 below and Figure 2-2 in Chapter 2.

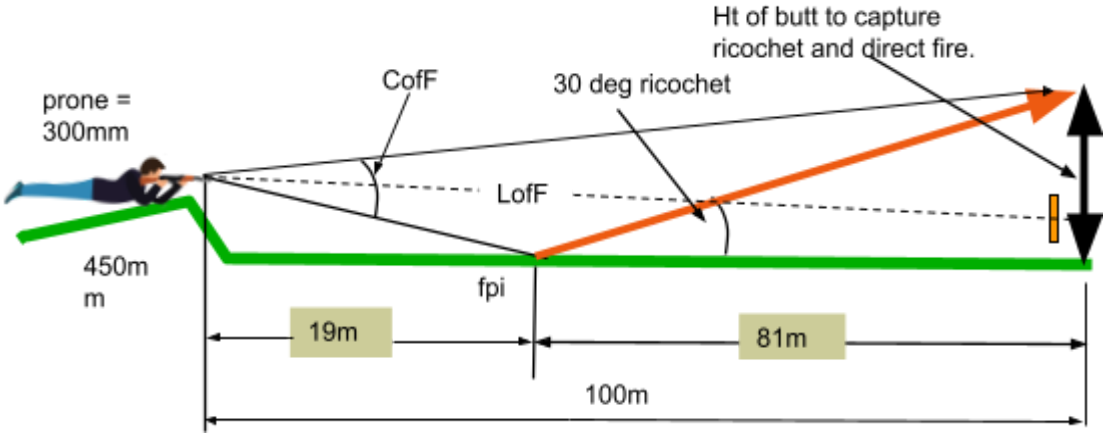


Figure 2 – Establishing the minimum height of the Stop Butt

1. **Cones of Fire (CoF)**. These are applied to all LofF to determine the extent of direct fire and predicted initial points of impact on the range floor. The stop butt should be sized and positioned to capture all predicted direct shot and ricochet from the range floor. Authorised NRA CoF are shown in Table 1.
2. **Ricochet Allowance**. To determine the extent of predicted ricochet, an angular allowance is applied from the initial point of impact where the appropriate cone of fire strikes the range floor. In many cases the resultant height and width of ricochet departure angle exceed the direct shot element of the cone of fire. With careful design of the ground profile it is possible to eliminate or minimise the effects of ricochet by providing a combination of sloped range floor, ricochet pit, and/or raised firing points. The ricochet angles to be used are 15^0 for low velocity firearms and 30^0 for high velocity firearms . Angles are to be measured from the range floor or any point forward of each firing point where ricochet is possible.

4-3 - CONSTRUCTION

4-3-1. Firing Point

Where the prone posture is adopted, the ground level should be raised to elevate firearms above the range floor. This reduces potential ricochet by increasing the distance to predicted first point of impact. Where benches are provided they should be of solid construction to provide a stable platform to shoot from. Where overhead cover is provided it can only be on the furthest firing point from the targets.

Figure 3 – Raised Firing Point

4-3-2. Targets

Typical target backing construction is thin plywood, corrugated plastic and hessian screens supported on timber framework; although any similar penetrable construction is acceptable. Various forms of target support and mechanisms may be used. Examples include simple timber posts and sockets, hand operated swivel target mechanisms and radio/remote controlled and programmable turning target mechanisms. It is also possible to use pop-up target mechanisms. In all cases the mechanism shall be either penetrable, or suitably protected from strike if consisting of any hard surface.

4-3-3. Range Floor

The range floor should be reasonably level, firm and free-draining to prevent ponding. It should have a depth of 150mm topsoil, sand or other soft material free from stones with a diameter of greater than 30mm. Soil should be seeded or turfed to prevent erosion. Particular attention is needed to cover any exposed hard surfaces / target mechanisms on the range floor. Range floors sloping down towards the targets are ideal.

4-3-4. Bullet Catcher

The bullet catcher should be positioned immediately behind the targets to achieve its function, the distance may vary although a distance of 1m from target line to bullet catcher toe-board provides sufficient space for access to targetry. As the distance from target to toe-board increases, the defensive structure requirements become greater. Details and specifications of sand and granulated rubber bullet catchers are provided in Chapter 2.

A. **Profile**. Provided the profile is maintained the majority of bullets should be contained within the catcher, the exception is some high velocity rounds which have a tendency to 'pop-over' - see below.
B. **Canopy**. Where high velocity centrefire rifle ammunition is to be used, an anti-ricochet or `pop-over' canopy is required to prevent vertical ricochet from the bullet catcher leaving the range. The canopy should be positioned to cover the full width of the bullet catcher and at least the rear half of the catcher as this is the area where vertical ricochet is most likely. The canopy should be impenetrable to ricochet with typical construction being a timber roof with 5mm minimum thick steel lining to the underside, although other materials may be considered acceptable. Where high velocity centrefire rifle ammunition is to be used without a canopy above the bullet catcher, a 100m radius danger area is required to the sides and rear of the range (measured from the flank target positions at sides and stop butt for extent of DA to the rear).

Figure 4 - Bullet Catcher with Canopy

4-3-5. Stop Butt.

Typical construction used for stop butts include vertical walls, natural earth embankments, manufactured bunds and cutting into natural hill features. The slope angle for an earth embankment stop butt is 56^0 from the horizontal which is traditionally accepted as the angle which eliminates ricochet. Table 5 below indicates the recommended thickness and type of materials often used in the construction of stop butts. There are many other solutions such as fabric cells or railway sleeper sandwich construction. These options are also often used to extend a stop butt that is too low or to allow shooting from longer distances.

Firearm/Ammunition Type	Material Type			
	Vertical Wall			Earth Embankment (Notes 4 & 5)
	Concrete (Note 1)	Brickwork (Note 2)	Blockwork (Note 3)	
Rimfire Rifle and Pistol	75	102.5	100	1000
Centrefire Pistol/Carbine	150	215	215	1000
Centrefire Rifle	200	215	215	1500

Table 4 - Stop Butt Material Requirements for NDA Ranges

Notes;

1. *Concrete - 20N/mm^2 20mm aggregate suitably reinforced*
2. *Brickwork - solid, void-free Engineering quality bricks*
3. *Blockwork - solid, dense aggregate blocks with a minimum compressive strength of 10 N/mm^2 and a minimum density of 1500 kg/m^3*
4. *Earth embankment to be suitably compacted stone-free soil incorporating geo-textile reinforcement where appropriate*
5. *The thickness indicated refers to the crest, where there is no additional protection or support behind. If a bank of greater thickness is faced with stone-free earth, it may be possible to reduce this dimension depending on anticipated ammunition usage and likely depth of penetration*

A. **Positioning**. The stop butt should be positioned as close to the target line as practicable. As the distance from the target line to the crest increases, the stop butt height and width requirement becomes greater to enable capture of all predicted shot
B. **Protection**. Where a vertical wall is used for centrefire rifle stop butt construction, the area visible above the sand and within the canopy is liable to receive strike fairly regularly; and additional protection should be provided to the front face. This is particularly important where the wall is near the backsplash distance
    1. **Concrete or other hard back wall surfaces**. Stop butts constructed of hard materials, such as concrete, should be faced with a covering to prevent ricochet and backsplash. Typically 50mm softwood timber planks on 50mm thick vertical battens is used. Great care is needed to avoid creating potential areas of unseen structural damage, for example bullets may produce only small holes and timber cladding can appear undamaged on the surface, while severe unseen spalling occurs behind. In such cases the cladding should be fixed so that it can be easily and regularly removed to monitor vulnerable areas
    2. **Brickwork**. Where brickwork is used to create the stop butt no additional ricochet protection is needed. However inside the canopy above the sand a render coat, 1:4 mix 20mm thick, is commonly applied. This is used to identify high shot, indicating problems such as incorrect target centre heights. Where sand bullet catchers are used the render should be continued down behind the sand to prevent moisture seeping into the brickwork

4-4 - COMMUNICATIONS

4-4. External

A means of summoning the emergency services is to be available, with notices on the range to include the emergency phone numbers.

4-5 - MAINTENANCE

4-5-1. Responsibility

Maintenance is the responsibility of the Range Operating Authority/club officials.

4-5-2. Frequency

The effects of weathering and soil movement will cause changes in the range profile. Periodic survey of the range is essential to ensure that the range geometry remains within design limits. The frequency of check surveys is dependent upon the natural foundation of the range its exposure and attrition; it is advised from 5 - 10 years. New ranges are to be re-surveyed 2 - 3 years after construction to check for any settlement of earth banks. Proper maintenance is dependent upon good liaison between the Range Operator and users, and on properly scheduled maintenance periods. A heavily used range may need one day's maintenance each week plus one or two days' maintenance by the club members each month.

4-5-3. Sand Bullet Catcher

Regular maintenance of the sand is essential to the range remaining safe for use. There are several factors to be considered and these are described below. Renewal or replacement of the sand may be achieved by rotating the sand in situ or by replacing it with sand from another section of the bullet catcher. The following measures are particularly important.

A. **Profile** Sand in the bullet catcher is to be raked to prevent tunnelling at the MPI behind targets to keep the surface of the sand in a loose state and to restore the profile to the 34 deg slope

B. **De-Leading**

1. **7.62 mm**. When large quantities of 7.62 mm rounds or similar are fired or there are excessive quantities of jacket and bullet debris, balls of lead and other hazardous debris build up in the sand. The bullets tend to remain intact after impacting into the sand and can fuse together into a ball, which often occurs below the surface of the sand at the MPI behind the target after about 20,000 rounds have been fired in a lane. When subsequent bullets striking the ball no longer drive it deeper into the sand, backsplash and ricochet become hazards. So it is important that any such build-up of lead is removed before the hazards arise
2. **5.56 mm.** This round tends to break up on impact at close range causing debris which is often smaller than the sand particles in the bullet catcher. In this case the sand cannot always be sieved without altering its stability. Provided the lead particles and debris are small and well spread over the area behind the MPI, the sand will remain stable and the probability of ricochet or backsplash will remain low. It is prudent to rotate the sand to ensure that the smaller particles are well spread. If there is any sign of lead balling and debris building up to the extent that a backsplash hazard is perceived, the sand is to be treated as described in sub-paragraph (1) above
3. **Other Ammunition Natures**. When other ammunition natures have been fired (such as 9 mm, black powder ball or bullet, shotgun slugs etc), the sand should be monitored regularly to ensure lead does not build up around the MPI. As a guide, the sand should be checked for lead build-up when the slope is raked after heavy use to restore its profile. For a range that is only used occasionally, the sand should be checked monthly or after 20,000 rounds have been fired on a lane, whichever occurs first

C. **Weathering**. In time, continuous impact by shot will break the sand down to a fine powder which will blow away in the wind or bake hard in the sun. Fine sand will also cause the slope to lose its stability. When this occurs, which will be evident by inspection, the sand will no longer be of the

prescribed grade and should be replaced. The following additives and reinforcements have been found useful in maintaining the shape of the sand:

1. **Wood Shavings or Chips.** A mixture of wood shavings or chips in proportions by volume of about 2:1 sand/wood helps retain moisture and stability of the mass in sand under canopies. The wood will itself break down in time and more will need to be mixed in
2. **Salt**. Adding 1-2% of salt by dry weight of sand also helps retain moisture in the sand and will reduce the danger of freezing in winter
3. **Netting**. Mesh netting or geogrid, may be used to reinforce the face angle. The mesh is placed just below the surface of the sand and is held in place with wooden pegs. Light galvanised wire mesh may also be used as it is effective against burrowing rabbits.
4. **Timber support.** Timber supports in the form of boxes or herringbone within the sand clear of the MPI can assist the retention of the sand profile

D. **Cleaning**. Sand bullet catchers should be checked at least weekly to ensure surface bullet debris is removed and de-leaded after 20,000 rounds have been fired on a lane to ensure there is no build-up of lead which can generate a backsplash hazard. Rotation of the sand within the bullet catcher may prolong the life of the sand. The sand should be replaced when the maintenance of the 34^0 face becomes difficult. The hazard of lead contamination when working on sand bullet traps must be considered. The club is responsible for:

1. Observing the requirements of the Control of Lead at Work Regulations
2. The safety of working practices
3. Providing the appropriate personal protective clothing and, when necessary, respiratory protective equipment
4. Providing washing and changing areas which avoid cross-contamination of clothing.
5. Disposing sand, soil and debris, which might contain or be contaminated by lead, as contaminated waste in accordance with the Local Authority Environmental Control Department's instructions

E. **Black Powder Firearms.** On ranges where firing black powder firearms is permitted, particular care is to be taken to avoid lead building up in the stop butt and mantlet

4-5-4. Rubber Granulate bullet trap

The requirements for maintaining a rubber granulate bullet catcher is given in Chapter 2.

4-5-5. Hidden Attrition

Where anti backsplash or ricochet protection surfaces have been added to hard defence structures, careful and regular inspection of the hard structure is required to ensure that the defence structure is not deteriorating behind the soft cladding. Such cladding must be readily moved to ease inspection.

Figure 5 – Hidden Attrition

4-6

The following compliance checks are detailed below

A. Authorised firearms, ammunition and practices
B. Firing point alignment, size, positioning and height
C. Range floor and ricochet pit profile, if applicable
D. Mantlet height & profile
E. Targets correctly sized, spaced and protected
F. Target centre height and flank positions accurately identified
G. Bullet catcher sizing and specification
H. Canopy construction against `pop over', if applicable
I. Stop butt wall height, width, face angle and crest depth, if applicable

4-7. STANDARD MOD NDA RANGE (1908 AND 1986 DESIGN)

4-7-1. MOD 25m / 25 yds NDA Ranges

Civilian clubs using existing or older MOD ranges may use them under the same ballistic limitations for which they were designed, ME max 7000J, MV max 1000m/s. During 1986 the MOD revised the detail for Barrack Ranges with greater defence structures and a flat range floor. For the MOD the old 1908 design is the minimum safe standard NDA design.

1908 Barrack Range 25yds

Back wall ht. 6.065m or 7.865m without a ricochet pit.

Canopy needed for HV rounds

Limited to ME 7000J, MV 1000m/s

Figure 6 - 1908 Barrack Range 25yds

Barrack Range 25m

Back wall ht. 8.4m without a ricochet pit.

Wing wall 11m on each side

Limited to ME 7000J, MV 1000m/s

Figure 7 - Barrack Range 25m

4-8. GALLERY RANGE (LIMITED DANGER AREA)

The Gallery Range has been established for over 100 yrs. It is understood that the design lifts the CoF off the range floor by setting targets on top of the mantlet. Behind the mantlet is a gallery where personnel raise and lower the targets. A stop butt behind the target line captures shot and low ricochet. Some direct shot and ricochet pass over the stop butt so there is an 1830m limited danger area behind the target line to contain these shot and ricochet, but only if all rounds are fired within the 70 mils rule.

Figure 8 - Gallery Range

Gallery Range

Range floor up to 900m.

LDA 1830m from target line

Limited to ME 7000J, MV 1000m/s

4-9. OPEN RANGES WITH OR WITHOUT A RANGE DANGER AREA

4-9-1. Hill background

There are areas in the UK where these criteria may be met. The criterion that meets Hill background requirements from DSA OME Part 3 (previously JSP 403) as illustrated in figure 2-3.

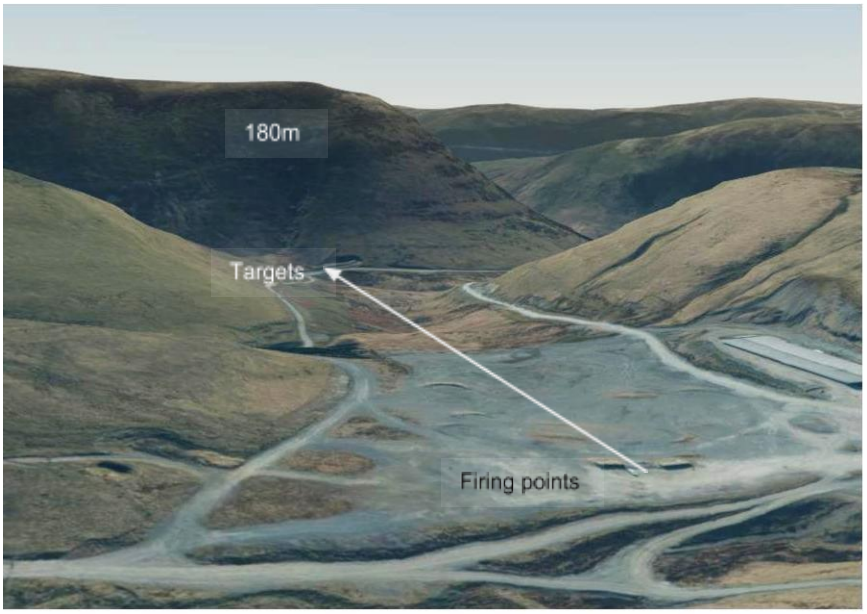


Figure 10 - An example of a hill background in North Wales.

4-9-2. Weapon Danger Area (WDA)

Each firearm will have different criteria for the danger area required. There will also be an Air Danger Height associated with the ammunition type. The examples below show examples of WDA for NATO ammunition.

4-9-3. Design Criteria

Those ranges with the ground for a RDA or WDA should apply the Danger Area on each firing position and target location. Even a slight diversion from parallel lanes will cause the template to swing left or right at the end of the template. It is also important to ensure the orientation of the firing lanes are plotted accurately. In Figure 12 below WDA is applied to a short range incorrectly producing restrictions on Range C. When the actual orientation of the range was checked it was seen that the restrictions should have been on Range B. Potentially a serious mistake.

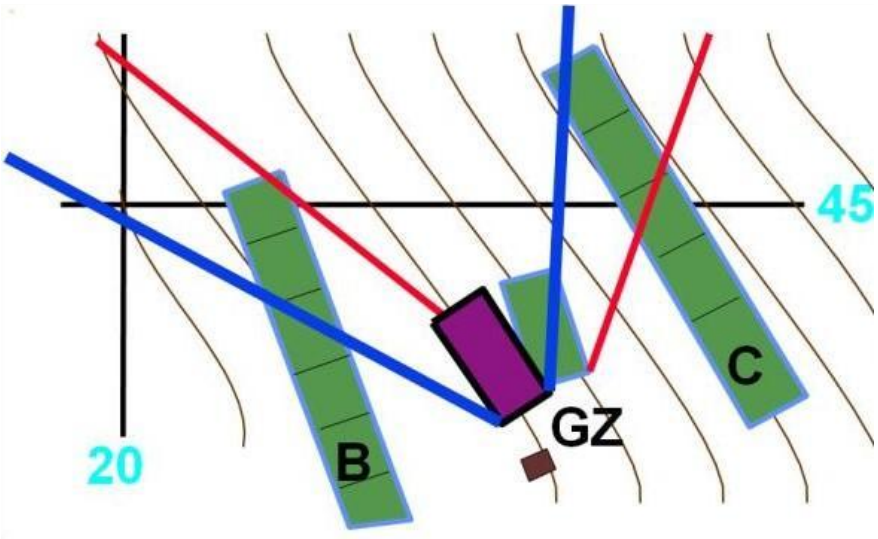


Figure 12 – WDA swing

4-9-4. Application of WDA Template 530 mils (30^0) Ground Ricochet Angle

The 530 mils (30^0) ground ricochet angle is applied from the firing position on the basis that the ground in front of the firer is clear of hard surfaces within his CoF for at least 50 m (the backsplash limit).

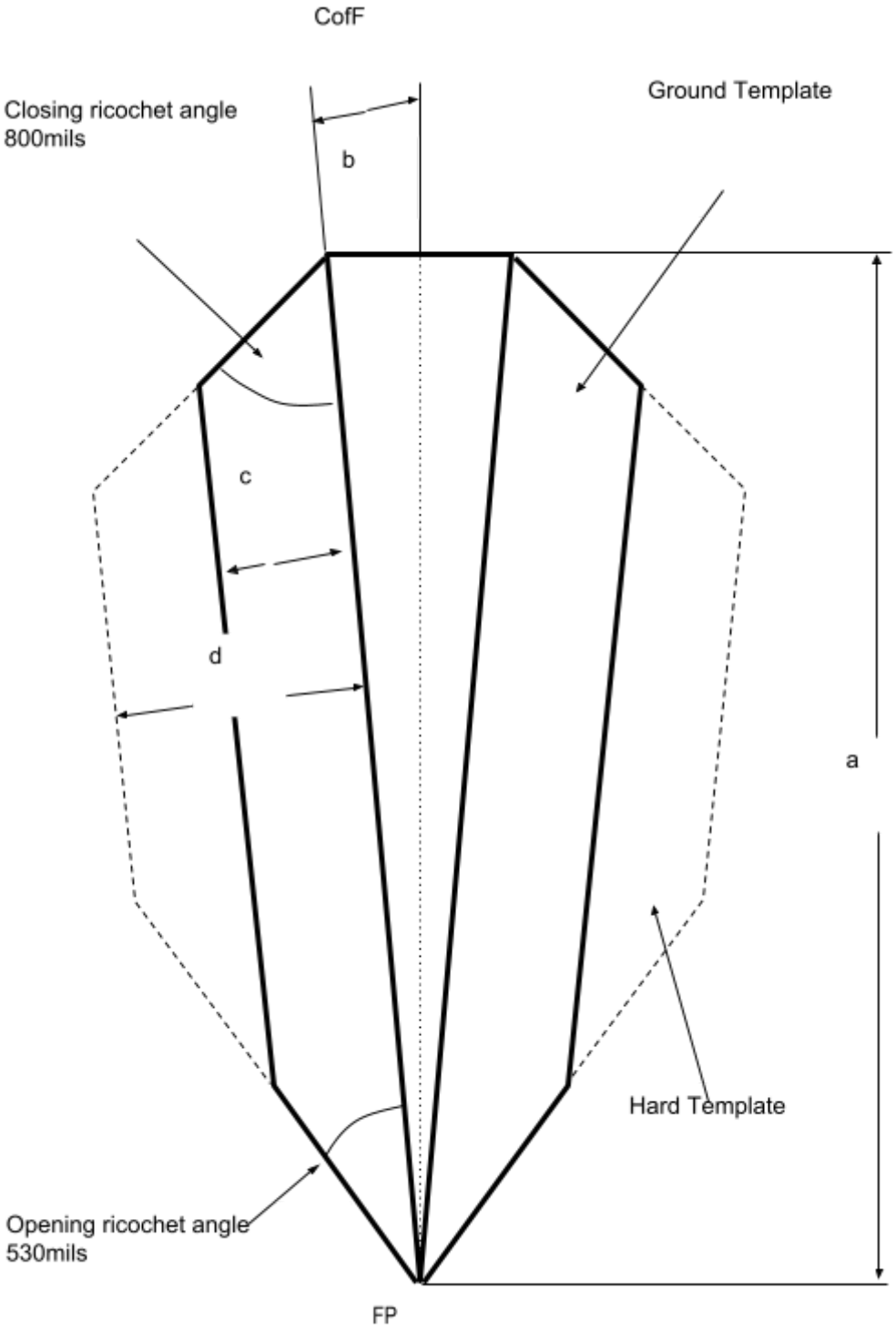


Figure 13 – Weapon Danger Area (WDA)

Ser	Ammunition Used	Measurements Applied			
		(m)	mils	(m)	(m)
		(a)	(b)	(c)	(d)
1	5.56 & 7.62mm CoF captured by the ground. No QE restriction.	2900	(Note 3)	400	800
2	5.56 & 7.62mm CoF not captured by the ground. QE < 150 mils	2900			
3	5.56 & 7.62mm CoF not captured by the ground. QE > 150 but < 1250 .	4000			
4	0.50inch. CoF captured by the ground, no QE restriction.	5200		650	1300
5	0.50inch. CoF not captured by the ground, QE < 150 mils.	5200	60/90		
6	0.50inch. CoF not captured by the ground, QE > 150 but < 1250.	6400			
7	9mm carbine QE < 220	1500		200	400
8	0.22inch MV < 330m/s QE <150mils	1200		150	300
9	0.22inch MV > 330m/s QE <150mils	1300		175	350
10	0.22inch QE > 150mils	1550		175	350
11	9mm Pistol QE < 220mils	1500	250	200	400
12	9mm Pistol QE >220mils	1825	250	200	400
13	.338" (8.6mm)QE <150mils ball	3700	(Note 6)	450	900
14	.338" (8.6mm) QE >150mils	5500	(Note 6)	450	900

Table 5 – WDA Data

Notes;

1. *The application of the WDA template is shown in Figure 12 above*
2. *The ground template is only to be used when penetrable targets are engaged on ground free from any hard ricochet or backsplash inducing material*
3. *Column b:*
    a. *Serials 1-10 static to static single shot = 60 mils; moving targets = 90 mils*
    b. *For other CoF angles see Chapter 2 Table 3*
4. *All ADH information is provided in Chapter 2 Table 1*
5. *This table refers to Ball*
6. *The CoF is contained within the overall template dimensions*
7. *As carbine - 60 mils as pistol (butt folded) - 250 mils*

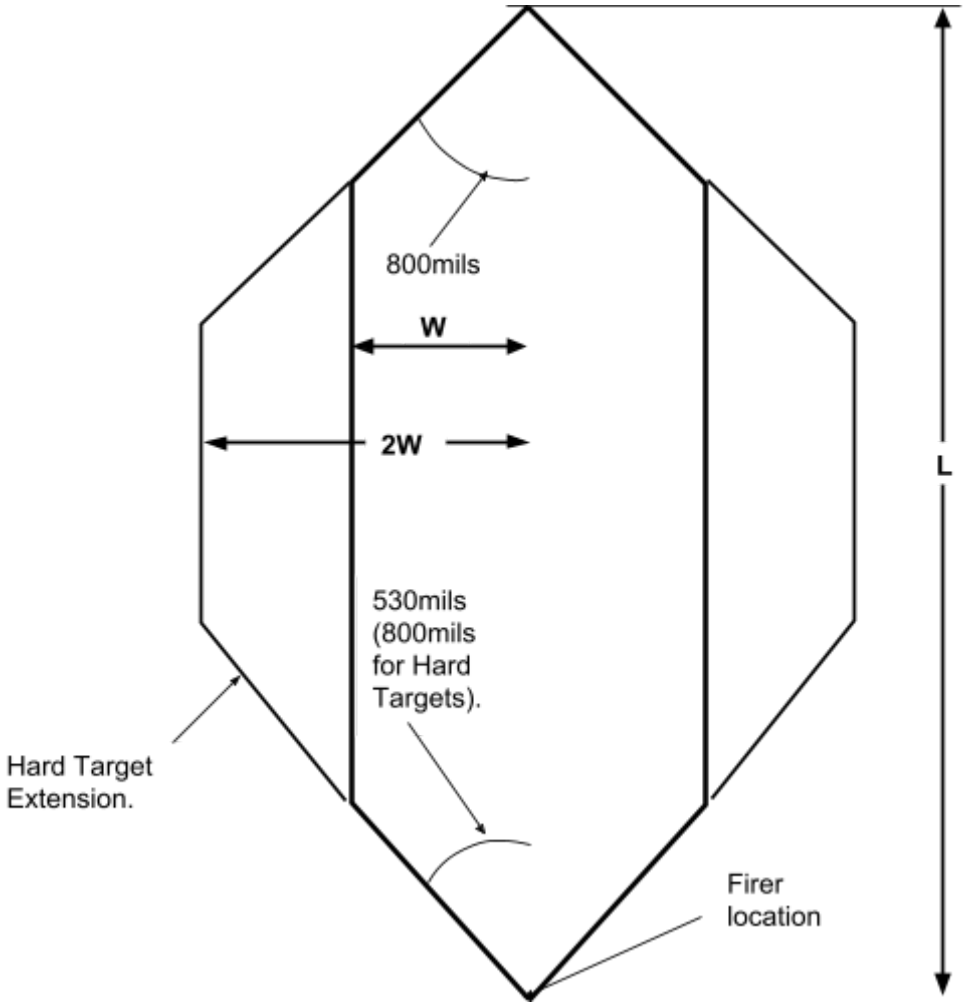


Figure 14 – 8.6mm (338”) Weapon Danger Area (WDA)

Notes;

1. *The CoF is omitted from the template as it has been included in the overall calculation*
2. *This template is for 8.6mm ball ammunition only*
3. *ADH – 3000ft*

Ser	CoF Conditions	L (m)	W (m)
1	CoF captured by the ground.	3700	450
2	CoF not captured by the ground. QE<150 mils.	3700	450
3	CoF not captured by the ground. QE>150 mils.	5500	450

CHAPTER 5
LONG RANGE SHOOTING

5-1 - INTRODUCTION

5-1-1. General

All ballistic detail in DSA OME Pt 3 Vol 2 is based on straight line design, ME^0 and MV^0. Shooting at longer distances will involve bullet trajectory and lower ME & MV at the point of intended impact. In addition the impact angle will expand the significance of the impact angle. The ballistic information required for each ammunition nature is provided by manufactures in Firing Tables. Handmade and loaded ammunition ballistic data must be computed using proprietary software.

5-1-2. Current Knowledge

Penetration, ricochet, backsplash and maximum potential range are the factors considered in the design of ranges. Environmental and maintenance issues are a separate consideration. Current knowledge of ballistic performance is based on MOD service weapons which were extensively proof tested prior to entering service. Manufacturer's data sheets and Jane's are other sources of ballistic data. For the MOD, providing all weapons fired on a range fall within the Muzzle Energy and the Muzzle Velocity at the barrel (ME^0) & (MV^0), the criteria in DSA OME will be valid. For firearms with ME or MV beyond these limitations trial data will be required before advice on the safety of a range may be determined. Higher velocity will generate different ricochet and backsplash patterns and higher energy will affect penetration and range. However on long ranges where there is no prediction of early ground strike the terminal MV and ME is likely to be similar to low velocity ammunition.

5-1-3. Skill

Long range shooting involves much more technical knowledge than sighting on a target between 100 – 300m. It is only through experience that accurate shooting is achieved at ranges beyond 900m. Having a spotter to watch for the fall of shot helps develop the skill needed for accurate shooting.

5-2 - BALLISTICS OF LONG RANGE SHOOTING

5-2-1. Range Tables

Bullet manufacture range tables are computer generated using proprietary software and can only be an approximation due to the following factors;

A. Condition of the barrel
B. Ammunition quality
C. Ammunition match with the barrel
D. Range elevation

5-2-2. Detail used for the range

The most important detail when considering the range the firearm is used on is;

A. The angle of descent – determines the potential ricochet
B. The maximum trajectory height and distance – for any baffles or overhead cables down range
C. MV and ME at the target

Example of Range Tables for 7.62mm NATO ammunition is illustrated below;

Maximum Range	3986	*m*
Launcher Elevation	34.94	*Degrees*

7.62mm	

Range	Remaining Velocity	Time Of Flight	QE	Angle Of Descent	Kinetic Energy	Drop	Drift	Vertex Height	Vertex Range	QE
m	*m/sec*	*sec*	*Gunner Mil*	*deg*	*joule*	*deg*	*deg*	*m*	*m*	*deg*
0	845	0	0	0	3331.9	0	0	0	0	0.00
100	768.98	0.124	0.74	0.04	2759.4	0.04	0	0	50.8	0.04
900	**311.21**	**1.8103**	**13.27**	**1.48**	**451.9**	**0.75**	**0.02**	**4.1**	**529.1**	**0.75**
1000	**293.72**	**2.1414**	**16.45**	**1.92**	**402.6**	**0.93**	**0.03**	**5.8**	**597.1**	**0.93**
1100	279.36	2.4911	20.1	2.4	364.2	1.13	0.03	8.1	663	1.13
1200	267.2	2.8576	24.21	2.92	333.2	1.36	0.04	10.9	725.5	1.36
1300	255.86	3.2407	28.76	3.49	305.5	1.62	0.04	14.3	784.2	1.62

Table 1 – Extract from 7.62mm Range Tables

5-2-3. Trajectory

To compute potential trajectory using calculators there are many factors to determine such as;

A. Bullet weight (g)
B. Drag coefficient (Cd)
C. ME
D. MV
E. Wind (not always constant between firer and target)
F. Air pressure (elevation of the range)
G. Temperature
H. Rifling (spin)
I. Barrel length

5-2-4. Mass & velocity = Energy (Joule)

Velocity of the bullet is achieved from the cartridge charge, efficiency of the firearm and the aerodynamics of the bullet. A projectile fired from a firearm will follow a curved trajectory caused by deceleration and gravitational pull. The rate of deceleration is influenced by time, air friction and drag. Energy may be calculated using;

½N(V2) = MEj where N = bullet wt in kg,[( ) used for clarity.]

V = MV in m/s.

5-2-5. Ballistic or Drag coefficient

A ballistic coefficient of 1 = zero drag and 0.5 = 50% drag. Ballistic coefficients (Cd) are related to bullet shape and weight;[3]

$Cd = w/id^2$ where w = wt of the bullet

i = bullet form factor

d^2 = bullet diameter^2

eg

Calibre	Wt (g)	Cd
5.56mm SS109	4.1	0.290
7.62mm	9.56	0.420
0.308 Win	12.35	0.560

5-2-6. Drag

Drag on a bullet in flight is influenced by Cd and velocity. With small arms ammunition there are three forms of drag influencing the flight of the bullet illustrated below[1];

A. Fore body drag - the air wave in front of the bullet
B. Base drag - low pressure and turbulence directly behind the bullet
C. Skin friction - the interface between the surface and the air

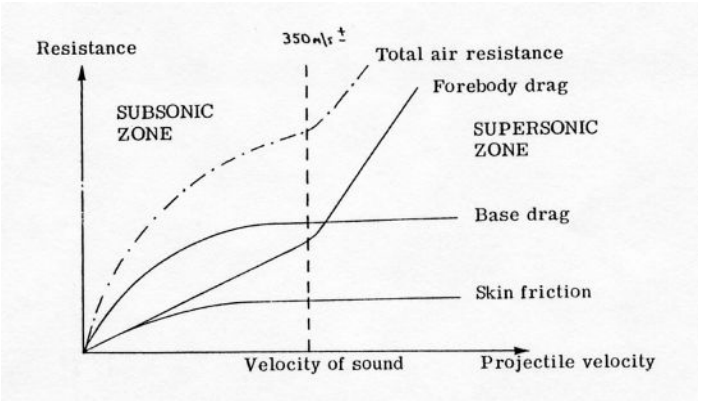


Figure 1 - Drag

5-2-7. Yaw

Except by chance, when a projectile is fired from a gun its axis does not lay exactly along the trajectory. The angle between the axis of the bullet and the tangent to the trajectory is known as the angle of yaw. A combination of cross winds and drag will have an influence on the degree of yaw and without an additional stability factor will cause the round to tumble.

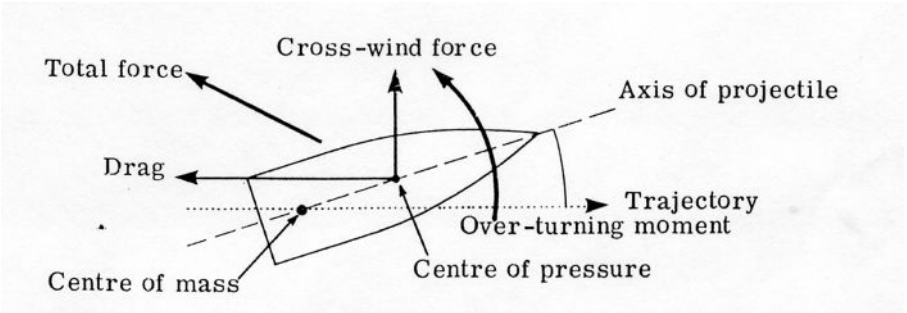


Figure 2 – Yaw

5-2-8. Rifling

In order to overcome the influences which would cause the bullet to tumble a rotation is set up as the round passes along the barrel (for 7.62mm ammunition it is about 3000 rev/sec). The rotation is provided by rifling on the barrel walls which cut into the heated compressed bullet giving it a twist to the right as it leaves the barrel. The amount of twist is variable but for small arms is one rotation between 225 - 325mm length of barrel. This gyroscopic action provides stability in flight.

5-2-9. Performance in flight

Bullets in flight, either direct fire or from ricochet are affected by the wind and the spin of the bullet from the rifling in the barrel. Drift caused by wind is influenced by the speed the bullet is travelling, the slower the bullet travels the greater the drift in the direction of any cross wind. The effect of head and tail winds is less marked. Bullet spin will cause the trajectory to veer to the right of centre. Maximum range achieved is dependent upon elevation and the bullet type.

ammo	bullet wt	MV^o	ME^0	ME^{500}	% loss	max range	
5.56mm	4g	944m/s	1782J	494J	72	3649m at 38 deg elev	SS109
7.62mm	9.65g	845m/s	3519J	1295J	63	3966m at 38 deg elev	NATO
0.338”	16.2g	915m/s	6781J	3957J	42		Lapua Magnum
9mm	7.25g	335m/s	407J	208J	49	1600m at 35 deg elev	

5-3 – ACCURACY

5-3-1. Computing Accuracy

As well as calculating trajectory it is necessary to consider other factors that will affect where the round will land.

5-3-2. Gyroscopic Drift (Spin drift)

Even in completely calm air, with no sideways air movement at all, a spin-stabilized projectile will experience a spin-induced sideways component. For a right hand (clockwise) direction of rotation this component will always be to the right. For a left hand (counter clockwise) direction of rotation this component will always be to the left. This is because the projectile's longitudinal axis (its axis of rotation) and the direction of the velocity of the centre of gravity (CG) deviate by a small angle, which is said to be the equilibrium yaw or the yaw of repose. For right-handed (clockwise) spin bullets, the bullet's axis of symmetry points to the right and a little bit upward with respect to the direction of the velocity vector as the projectile rotates through its ballistic arc on a long range trajectory. As an effect of this small inclination, there is a continuous air stream, which tends to deflect the bullet to the right. Thus the occurrence of the yaw of repose is the reason for bullet drift to the right (for right-handed spin) or to the left (for left-handed spin). This means that the bullet is "skidding" sideways at any given moment, and thus experiencing a sideways component. The following variables affect the magnitude of gyroscopic drift:

A. Projectile or bullet length: longer projectiles experience more gyroscopic drift because they produce more lateral "lift" for a given yaw angle

B. Spin rate: faster spin rates will produce more gyroscopic drift because the nose ends up pointing farther to the side
C. Range, time of flight and trajectory height: gyroscopic drift increases with all of these variables.

Doppler radar measurement results for the gyroscopic drift of several US military and other very-low-drag bullets at 1000 yards (914.4 m) look like this:

Bullet type	**M193 Ball**	**M118 Special Ball**	**Palma Sierra MatchKing**	**LRBT J40 Match**	**Sierra MatchKing**	**Sierra MatchKing**	**LRBT J40 Match**	**LRBT J40 Match**
Wt grain	55	173	155	190	220	300	375	419
Dia "	.223	.308	.308	.308	.308	.338	.375	.408
Dia mm	5.56	7.62	7.62	7.62	7.62	8.59	9.53	10.36
Drift mm	584	292	324	76	197	165	22	48

Table 3 - Table shows gyroscopic drift is variable and no clear trend easily distinguishable

5-3-3. Mirage

Heat generated shimmer at the target. (This can help determine wind by using the scope to see heat waves at various distances down range).

5-3-4. Range floor slope

Angle to target uphill or downhill. Uphill target gravity on the bullet is greater than shooting at a target below the horizontal line of sight.

5-4 - IMPACT CHARACTERISTICS

5-4-1. Impact characteristics

Range tables provide details of residual velocity and energy at differing ranges. Post ricochet impact characteristics are not so readily computed as the ricochet velocity is unpredictable.

A. **7.62mm NATO Ball.** As this is a solid bullet it generally remains intact on impact with all soft surfaces. It is prone to distorting on impact with slopes of 30+deg and can launch vertically from the point of impact. When fired at targets beyond 500m without risk of ground strike the round can be treated as a LV round at the target. Ricochet and penetration potential is therefore reduced
B. **5.56mm Ball.** It is clear from the evidence in sand bullet catchers on 25m Barrack ranges that this bullet breaks up on impact at closer ranges. This is no doubt due to the steel tip penetrator which breaks out of the case on impact shattering the lead and copper components into very small fragments. At ranges of 100m and beyond the round often remains intact without massive deformation. When fired at targets beyond 500m it can be treated as a LV round
C. **.338 Lapua Magnum.** With a bullet weight of 16.2g the ME^0 is rated at 6781J, just inside the ballistic limitations of 7000J. However the potential ricochet range is far greater than 7.62 or 5.56mm. This round becomes LV after around 1000m downrange

5-4-2. Ricochet Potential

When a bullet strikes a surface or object it has the potential to;

A. Pass through - penetrate
B. Be captured without breaking up
C. Break up on impact - fragments ricochet

D. Backsplash - whole or fragment
E. Ricochet intact (stable, little deviation, potential for long range)
F. Ricochet intact (tumble but re-stabilise, reduced potential range)
G. Ricochet intact (tumble with deviation, range potential much reduced)

5-4-3. Ricochet Impact Angle

The angle of strike will determine along with the type of surface, the extent of ricochet. Impact angles of 30^0 + are known to minimise the potential for ricochet. Impact angles of 56^0 or more are known to prevent ricochet. Impact angles between 0 - 30^0 may induce ricochet. With long range shooting there is an angle of fall at the end of the trajectory. This combined with the ground slope at the impact site provides the impact angle.

5-4-4. Ricochet Departure Angle

Ricochet is made up of several components, elevation, turn and total turn. Total turn is the combination of impact and exit angle. The three dimensional angle formed by elevation and turn is called the vector angle. In the design of range components the additional length of a vector angle may be countered by the first point of impact (fpi) on the CoF.

5-4-5. Ricochet Trajectory

Following ricochet, a round may retain its stability generated by ballistic shape and barrel spin. Stable ricochet is generally only possible following a glancing blow from a surface with little or no turn from the point of impact and therefore little loss of energy. Stable ricochet has the potential to reach close to full range with fairly flat trajectories. More often rounds will penetrate the ground until resistance is such that the round exits taking the route of least resistance. Such rounds inevitably tumble following impact. Once a round tumbles it loses its aerodynamic properties and its potential to travel far is reduced, the resultant ricochet trajectory is generally curved.

5-4-6. Ricochet Trials

The results of trials undertaken by the MOD show that 5.56mm often breaks up and the fragments travel little further than 300m. 7.62mm is by far the most aggressive in terms of ricochet potential. The main finding of the trials was that only stable ricochet had the potential to reach any great distance and to achieve stability the total angle of turn has to be very small. The greater the total angle of turn the less likely the round will re-stabilise after impact. A tumbling round will lose energy much more quickly and therefore the potential range is much reduced.

5-5 RANGE SAFETY

5-5-1. Ballistic Data

In order to predict range safety criteria with long range shooting the following information is needed;

A. Range to target (m)
B. QE (deg or mils)
C. Vertex Ht (m)
D. Vertex range (m)
E. Angle of decent (deg)
F. Terminal MV (m/sec)
G. Terminal ME (J)

5-5-2. Range Data

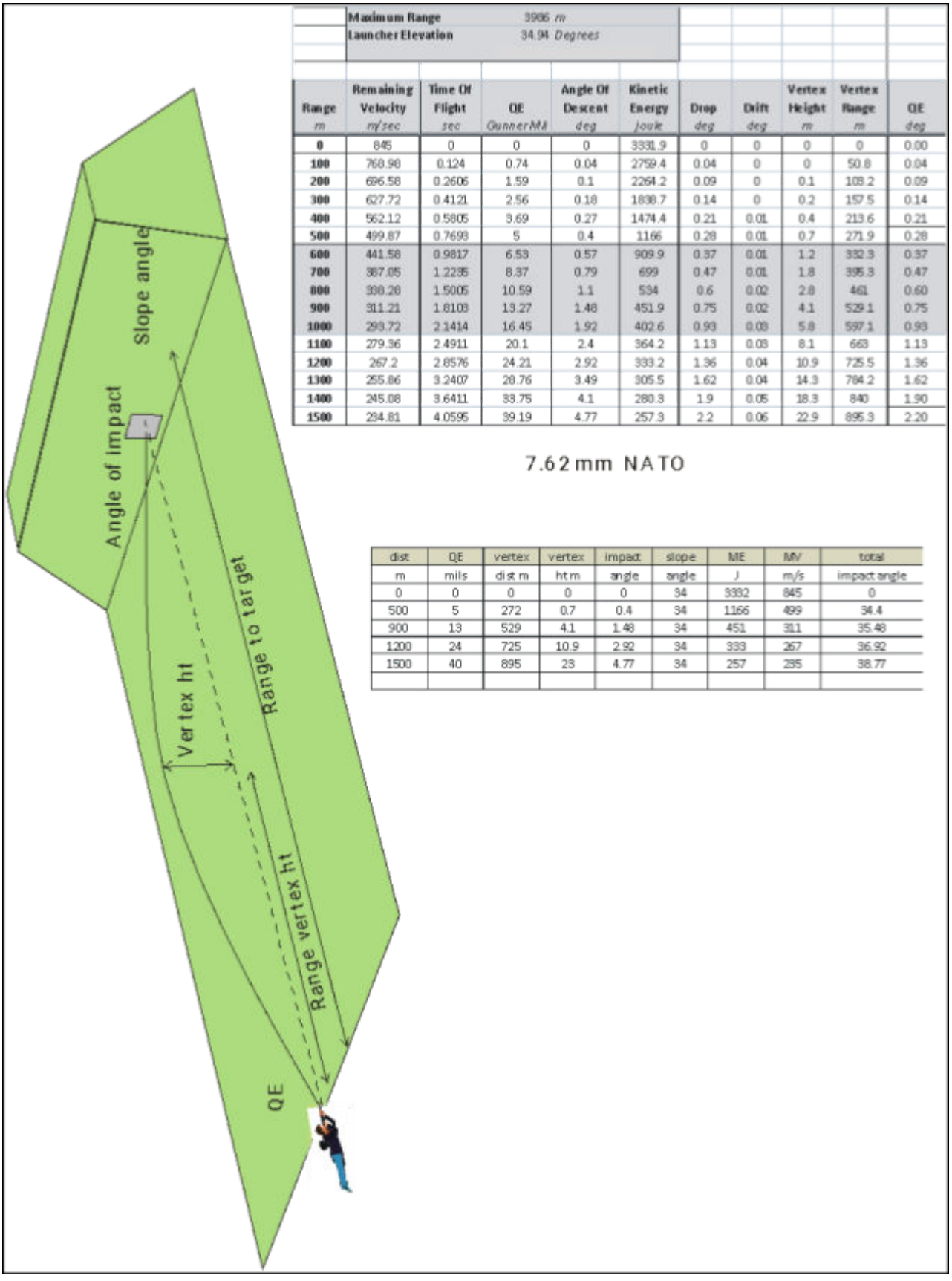
In order to consider the safety of a particular range the following range detail is required:

A. Firing point ht (m)
B. Firing point elevation (m) above target
C. Posture (prone / kneeling / standing / sitting / supported / unsupported)
D. Target elevation (m)

E. Target type (static / moving)
F. Ground (hard / soft)
G. Ground shape between firing point and target
H. Obstructions down range

5-5-3. Other Factors

A. Level of supervision
B. Zeroing policy
C. Skill of the shooter
D. Danger Area or NDA
E. Level of Risk (what is beyond the targets)



Maximum Range	3986 m
Launcher Elevation	34.94 Degrees

Range m	Remaining Velocity m/sec	Time Of Flight sec	QE GunnerMil	Angle Of Descent deg	Kinetic Energy joule	Drop deg	Drift deg	Vertex Height m	Vertex Range m	QE deg
0	845	0	0	0	3331.9	0	0	0	0	0.00
100	768.98	0.124	0.74	0.04	2759.4	0.04	0	0	50.8	0.04
200	696.58	0.2606	1.59	0.1	2264.2	0.09	0	0.1	108.2	0.09
300	627.72	0.4121	2.56	0.18	1838.7	0.14	0	0.2	157.5	0.14
400	562.12	0.5805	3.69	0.27	1474.4	0.21	0.01	0.4	213.6	0.21
500	499.87	0.7693	5	0.4	1166	0.28	0.01	0.7	271.9	0.28
600	441.58	0.9817	6.53	0.57	909.9	0.37	0.01	1.2	332.3	0.37
700	387.05	1.2235	8.37	0.79	699	0.47	0.01	1.8	395.3	0.47
800	336.26	1.5005	10.59	1.1	534	0.6	0.02	2.8	461	0.60
900	311.21	1.8108	13.27	1.48	451.9	0.75	0.02	4.1	529.1	0.75
1000	293.72	2.1414	16.45	1.92	402.6	0.93	0.03	5.8	597.1	0.93
1100	279.36	2.4911	20.1	2.4	364.2	1.13	0.03	8.1	663	1.13
1200	267.2	2.8576	24.21	2.92	333.2	1.36	0.04	10.9	725.5	1.36
1300	255.86	3.2407	28.76	3.49	305.5	1.62	0.04	14.3	784.2	1.62
1400	245.08	3.6411	33.75	4.1	280.3	1.9	0.05	18.3	840	1.90
1500	234.81	4.0595	39.19	4.77	257.3	2.2	0.06	22.9	895.3	2.20

7.62 mm NATO

dist m	QE mils	vertex dist m	vertex ht m	impact angle	slope angle	ME J	MV m/s	total impact angle
0	0	0	0	0	34	3332	845	0
500	5	272	0.7	0.4	34	1166	499	34.4
900	13	529	4.1	1.48	34	451	311	35.48
1200	24	725	10.9	2.92	34	333	267	36.92
1500	40	895	23	4.77	34	257	235	38.77

Figure 5-1 Trajectory Example

CHAPTER 6
CONTROL OF HAZARDOUS SUBSTANCES IN INDOOR RANGES

6-1 - GENERAL

6-1.1 Aim

This Chapter sets out recommendations to ensure that exposure to emissions from firearms in indoor ranges and ranges with enclosed or semi enclosed firing points do not generate a hazard to those who enter. In particular it sets out the control measures to be taken to protect those who enter such ranges. Where possible only those firing and the RO should be in the range during shooting activity to minimise the exposure to individuals.

6-1-2. Environmental Health Hazards Covered

Not all emissions from firearms are of sufficient quantity to present a measurable hazard. The following emissions from firearms and resultant dust have been identified as potentially hazardous in some circumstances:

A. Lead

B. Unburnt Propellant

C. Accumulated Dust

D. Carbon Monoxide

6-2 - HAZARDS

6-2-1. Lead

Inhalation and ingestion of lead can be hazardous to health. When a firearm is fired, the hot gases produced by the propellant burns the lead from the base of the bullet, producing lead fumes. Lead particles are also stripped from unjacketed bullets as they travel down the barrel and are subsequently released into the air around the firer. In addition lead dust is produced when the bullet impacts sand or steel bullet catchers at the end of the range. Lead will also be present in any dust filtered by any extraction system fitted. All personnel in an indoor range are exposed to the lead hazard produced by firing. In a clean range the degree of exposure is generally very low dependent upon the number and nature of rounds fired and mitigated by the effectiveness of any ventilation provided. Personnel such as ROs, supervisors and coaches are likely to be exposed for longer periods than the firers. Inspection, cleaning and maintenance staff will be exposed to residual dust in the range as a result of their activities. Movement forward of the firing point should be kept to a minimum as this is where some lead dust will settle. Provided that appropriate dust filters have been correctly installed and maintained within the extraction ventilation system there should be no risk of exposure, externally, from the exhausted air extracted from heavily used ranges.

A. **Low Use Ranges.** Low use is defined as 2 or 3 sessions per week and an average total of up to 500 rounds per week, 26,000 rounds per year. In exceptional circumstances such as an unexpected shortage of RCOs or coaches during a busy time for the range this limit may be extended to 1000 rounds per week provided the individual is not exposed to more than 2000 rounds per month.
B. **Full Time Use Ranges**. Full time use is defined as those ranges that are expected to be used on a daily basis or fire over 26,000 rounds per year

6-2-2. Unburnt Propellant

Unburnt propellant is also released into the range when a firearm is fired. It not only produces a hazard in its own right but also adds to the problem of controlling lead pollution. Long barrelled firearms with a good breech seal (obturation) may eject less than 2% unburnt propellant but some pistols can eject more than 7%. Most unburnt propellant falls in the area of the firing point and immediately in front of the firers but some will be distributed down range and may be collected in the dust filters. If unburnt propellant is allowed to accumulate in the range, particularly out of sight behind wall cladding or fixtures, it could become a significant explosive hazard. There is currently no simple means of measuring levels of unburnt propellant.

However, it can be assumed that it will always be present in dust, whether visible or hidden, in the range if that range has been used during the period.

6-2-3. Accumulated Dust

Any dust allowed to accumulate in a range is likely to contain both lead and unburnt propellant. If made airborne either by movement of air or the shockwave created by the blast from the muzzle, it can become an inhalation hazard. Firers in the prone position and personnel inspecting, cleaning or maintaining the range are most at risk from this hazard. When dust is collected, such as in a vacuum cleaner bag, or if permitted to accumulate, it may also become an explosive hazard.

Figure 1 – Explosive Hazard for Indoor Ranges

6-2-4. Carbon Monoxide

Carbon Monoxide (CO) is released into the air each time a firearm is discharged. The amount of CO expelled is dependent upon the ammunition cartridge used. These gases are light and will disperse in the direction of any air flow. This hazard need only be considered in ranges that have no mechanical or natural ventilation, ranges with small enclosed firing points and ranges with particularly high volumes of fire from inside a closed or semi-enclosed firing point.

6-3 - UK REGULATIONS

6-3-1. Control of Lead at Work (CLAW) Regulations

The following terms have been extracted with a summary from the CLAW Regulations and Approved Code of Practice. For a full explanation refer to the CLAW Regulations.

Ser	Term	Summary
1	Action level	Blood-lead concentration of: ● women of reproductive capacity 25µg/dl ● young person 40µg/dl ● others 50µg/dl
2	Biological monitoring	Includes measuring of a person's blood-lead concentration.
3	Control measure	Measures taken to reduce exposure to lead such as systems of work, cleaning, engineering controls and the provision and use of PPE.
4	OEL limit Reg.2	Occupational Exposure Limit for lead - 0.15mg/m^3
5	Risk assessment Reg.5	Identify those who may be exposed to significant levels of lead in air and apply standard Risk Assessment principles. [Identify hazards, eliminate those that may be eliminated, prioritise the remainder and

		apply control measures to reduce as far as possible the residual hazards.]
6	Significant exposure Reg.2	Where an employee is or is likely ● to be exposed to ½ OEL ie 0.075mg/m3 ● to ingest lead. ● to be exposed to lead alkyls.
7	Young person Reg.2	Has not attained the age of 18
8	Intermittent exposure Reg.5	Exposure to lead compounds for only a few hours over a 40hr week but that exposure may exceed ½ OEL over an 8 hr period, if: ● exposure level is below OEL when averaged over 8hrs ● is below ½ OEL when averaged over 40hrs ● no substantial risk from surface or skin contamination.
9	Control measures Reg.6	● ventilation - sufficient general ventilation ● reduce exposure to minimum ● regular cleaning - wet methods ● prohibiting eating and drinking ● provide washing facilities
10	Air monitoring Reg.9	● Required where the employer assesses that employees may be exposed to significant levels of lead in air. ● Maximum period between monitoring is 12 months.
11	Monitoring records Reg.9(5)	Kept for min 5yrs.
12	Medical surveillance	For those likely to be or are exposed to significant (Serial 6) levels of lead in air and all other control measures to avoid this situation are exhausted, those individuals are to be placed under Medical Surveillance. In such cases refer to the respective Service Environmental Health Authority for advice.

Table 1 – CLAW Regulations detail

6-3-2. Carbon Monoxide (CO)

The UK Regulations relating to the control of exposure to CO are contained in the Control of Substances Hazardous to Health (COSHH) Regulations. The Regulations state that control of exposure will only be

treated as adequate if the principles of good practice are applied and the workplace exposure limit is not exceeded. Specialist consultants are able to provide advice and support in this area. Below are the long and short term, Time Weighted Average (TWA), CO workplace exposure limits published in the Health & safety Executive's document EH40/2005.

Workplace Exposure Limit (WEL)			
Long term exposure limit (8hr TWA referenced period)		Short term exposure limit (15min reference period)	
ppm	$mg.m^{-3}$	ppm	$mg.m^{-3}$
30	35	200	232

Table 2 – CO Workplace Exposure Limit

6-3-3. Category of User

There are several categories of range user to be considered under the CLAW regulations and in terms of exposure.

A. Club members (low exposure)
B. Minors (under 18) and women of childbearing capacity (additional limits)
C. RCOs and Safety supervisors (low exposure)
D. Range Inspectors (high exposure)
E. Visitors (low exposure)
F. Cleaners / Contractors (high exposure)

6-4 - ASSESSMENT

6-4-1. Range Operator Responsibilities

Range operators should assess their indoor ranges to determine the level of exposure to lead in air and CO as set out in paragraph 6-2-1. Where ranges are used full time or exceed 26,000 rounds per year they are to undertake full lead in air monitoring to establish the OEL for that particular range and for each particular use.Clubs must keep a log of rounds fired. If a range is used by more than one group of users, each type of user should be assessed.

6-4-2. Factors Included in the Assessment

The lead and CO exposure assessment should take into account the nature of all activities taking place in the range including dry training, inspecting, maintaining, monitoring and cleaning, as well as all shooting practices. The assessment should consider both users and visitors. Personnel such as RCOs, supervisors and coaches, who are employed routinely in the range are potentially at the greatest risk as they may be in the range for extended periods whether or not firing is taking place. Cleaners, works officers, staff and range inspectors are likely to be exposed to higher levels of lead for shorter periods.

6-5 - AIR MONITORING

6-5-1. Requirement

Full lead in air monitoring is to be carried out in accordance with current CLAW Regulations where the risk assessment indicates that anyone using the range is liable to receive significant exposure to lead and in the following circumstances:

A. When a new or a refurbished full time use indoor firing range is commissioned
B. An existing indoor range has a change of use that may expose users to significant levels of lead or has more than 26,000 rounds fired in it each year

6-5-2. Air Monitoring

Air monitoring may be carried out by a specialist contractor. For CO it is a direct measurement undertaken in the range. For lead, air filters are placed on the firers and at several points down range during peak maximum capacity firing in the range. The amount of lead collected by these filters is then measured to determine the lead in air levels for that range.

6-5-3. Recording Results

All monitoring must be recorded in the range log. A certificate giving the results should be provided and displayed following each measurement of lead in air from air monitoring stating the conditions, if any, under which the range may operate.

6-5-4. Significant Levels of Lead in Air

If following lead in air assessment of a range indicates that exposure to lead is significant, i.e. greater than 0.075mg/m^3, then advice should be sought to determine the way forward. Where an assessment finds that

there is a significant level of lead at the target end of a range, personnel who maintain and inspect the bullet trap shall if not already doing so, undergo medical surveillance.

6-5-5. Significant Levels of CO

In ranges where there is little or no air flow, particularly in smaller firing ranges, it will be necessary to improve the ventilation arrangements if personal CO exposures exceed the Workplace Exposure Limit (WEL).

6-6 - RESPONSIBILITIES

6-6-1. Range Operator

The range operator is responsible for ensuring that anybody using or working in its indoor range is not put at unacceptable risk from hazards listed above. They should ensure the following:

A. **Works.** As those ranges with ventilation systems depend on the efficiency of the ventilation system to meet CLAW Regulations, all ventilation systems should be subject to inspection by a competent person at least annually. Range Operating Authorities/clubs are to ensure that deep cleaning by contract is properly completed
B. **Information and Training.** Range operators are responsible for ensuring that adequate information and training on the precautions to be observed are given to all personnel who operate, use, maintain or clean indoor ranges on the risks from lead and unburnt propellant. Local Health & Safety officers can provide information and training on the correct use and disposal of PPE. Fire Officers should be consulted where units collect and store dust from ranges that have been used for live firing that will contain small amounts of unburnt propellant
C. **Range Usage.** The CLAW Regulations require that the number of persons exposed should be reduced to a minimum. An indoor range should therefore not be used for any purpose other than target shooting. Where possible only those firing and the RCO should be in the range during shooting activity to minimise the exposure to individuals

6-7 - VENTILATION DESIGN

6-7-1. Design Concept

The design of indoor ranges must address each of the hazards listed in this chapter as far as is reasonably practicable. The aim of the design should be to provide sufficient fresh air into the range to ensure that lead particles generated on the firing point(s) are taken clear of the breathing zone. It will not be possible to take all lead dust out of the range as most will settle out between the firing point and bullet catcher. The range envelope should be designed in such a way to minimise air turbulence and have surfaces that are easily cleaned.

6-7-2. Design Solution

Each range will have different problems to address. Clearly the ideal solution is to remove contaminants at source with local exhaust ventilation. Where this might be possible in factory test ranges with fixed firing benches it will not be possible for variable firing positions on several firing points. A combination of local control (directed airflow) and dilution should be achievable in most circumstances.

6-7-3. Air Flow Within the Range

The ideal air flow is a laminar flow pulled down range with an extraction system rated 10% greater than the inlet producing a negative pressure down range. The optimum design to deliver steady air flows across a single firing point is to bring air into the range through a full cross sectional grill. This is clearly an expensive proposition as such volumes of air will need to be heated. An alternative solution is to provide positional grills behind the firers. Where firing takes place from prone, kneeling and standing positions, directional vents may provide the solution. All solutions should ensure there are no "dead zones" or excessive turbulence generated within the range.

6-7-4. Air Speed

During trials it was observed that the greater the air speed over the firers the more turbulence in front of the firers breathing zone. Optimum air speeds to minimise such turbulence recorded were 0.15 - 0.2m/s. Air speeds of 0.1m/s or less will not provide sufficient fresh air in the range. Air speeds in excess of 0.3m/s may need to be heated. In ranges with more than one firing point it may be necessary to increase the air flow at the rear of the range to ensure adequate air flow over the firing points down range. Complex solutions involving intermediate air intakes should only be considered in ranges that are heavily used on a daily basis. In low use ranges where there is a simple fan input (single or multiple) and simple extract fan (single or multiple) it is sufficient to ensure the fan is inputting air at the firing point and extracting air at the target end. A wet hand or strand of cotton is all that is required to check this. With these simple fans efficiency is not such an issue. Where there is air handling plant, ductwork and filters the inspection of the air handling system should be undertaken by competent mechanical engineers in accordance with the manufacturer's recommendations.

6-7-5. Air Changes

Domestic and office designs often revolve around the number of air changes per hour to establish comfortable conditions. In ranges the issues are local air flow and dilution. Air changes can of course be likened to dilution but it will not ensure local airflow over the firing points has been achieved. It is expected that for most ranges air change rates of between 6 – 10 changes/hr will deliver adequate dilution.

6-8 - AIR EXTRACTION

6-8-1. Extraction System

The air extraction system should provide an air extraction rate that is at least 10% greater than the air input to assist in pulling a laminar air flow down range. The extractor unit(s) will need to handle dust and unburnt propellant safely. Access for maintenance and inspection is essential. Air systems are to be switched on 20 minutes before use of the range and left on 30 minutes after use to ensure the systems are running to optimum capacity and that any residual dust is removed from the system after firing ceases.

6-8-2. Extract Filter

The extract filter system where fitted must be suitable to hold unburned propellant safely. Replacement instructions must be clearly displayed warning of the hazards presented by filters containing lead dust and unburned propellant. Refer also to Building Regulations Part F for location of the extract.

6-9 - INSPECTION

6-9-1. Inspection of Ranges

Between the annual and routine inspections the range operator is to ensure the following conditions are maintained:

A. The cleaning regime is effective. The cleaning regime must ensure there is no accumulation of dust in the range. Any visible dust will contain both lead and unburnt propellant
B. There are no areas to harbour dust. Equipment, material, apertures or areas in the structure where dust may gather out of sight are to be avoided
C. The bullet catcher is maintained to ensure backsplash will not result from attrition of the trap, a build up of bullets or bullets captured in the anti backsplash curtain where fitted. Cleaning the bullet trap including any anti backsplash curtain is to be undertaken only by a nominated competent personnel or specialist contractors
D. The ventilation system, when fitted, works correctly and filters (where fitted) are checked and maintained by contractors, at the intervals recommended by the manufacturer
E. Should there be any change in use of the range or any increase in the amount of dust generated, the range operator is to initiate a further risk assessment to determine if this results in a change in the level of lead exposure

6-9-2. Dust

The level of dust in the range is a matter of observation. Any dust generated from the firing of firearms must be considered a hazard from lead and unburnt propellant. Where this dust is gathered such as in a vacuum cleaner bag or permitted to accumulate, it becomes an explosive hazard. Only spark free vacuum cleaners are to be used.

6-9-3. Confined Spaces

Inspectors may need to work in tubes and behind anti-splash curtains to complete their inspection. In such cases inspectors should carry out a risk assessment to determine any additional control measures required by the Confined Spaces Regulations. The risk assessment will also determine what Personal Protection Equipment (PPE) will be necessary.

6-10 - RANGE CLEANING

6-10-1. Scope

Maintaining a clean range is the single most effective way to ensure that the risk of exposure to both lead and unburnt propellant are minimised. This section refers to all types of indoor ranges including tube, test ranges and ranges with enclosed or semi enclosed firing points. Ranges where dust from live firing is allowed to accumulate in the working areas, firing point and on surfaces down range due to inadequate cleaning, will potentially expose users to significant levels of lead in air and an explosive hazard. Ranges that do not have an effective cleaning regime to eliminate the potential for dust to accumulate will be subject to The Dangerous Substances & Explosive Atmospheres Regulations (DSEAR).

6-10-2. Frequency of Cleaning

The frequency of cleaning will be dependent on formal risk assessment and how the range is used. Ranges used only one or two evenings a week may need only a weekly clean. Ranges used more frequently and where more rounds are fired may need cleaning after each use. The aim is to ensure there is no build up of dust in the range working areas and this is a matter of observation. Factors that will influence the frequency of cleaning necessary to keep the work areas of the range free of visible dust include:

A. The type of ammunition fired, e.g. centerfire pistols firing unjacketed ammunition will create a need for more frequent cleaning than rimfire rifle. Pistols eject a considerable amount of unburnt propellant and unjacketed ammunition will create more lead dust than jacketed
B. The frequency of use and number of rounds fired
C. The efficiency of ventilation and extraction
D. The porosity of surfaces down range

6-10-3. Cleaning Methods

So as neither to create a risk from lead and unburnt propellant to cleaning staff or other personnel nor to spread contamination, cleaning the range ceiling, floor and walls, and adjoining rooms is to be by damp sweeping or, preferably, by a vacuum cleaner approved specifically for indoor ranges and used in accordance with the manufacturer's instructions. Dry sweeping and dusting is strictly forbidden.

A. **Routine Cleaning**. Cleaning the range between deep cleans should only be undertaken by staff with adequate PPE and who have received sufficient training on the hazards in the range and use of the PPE. It is essential to ensure the firing point and the area behind and directly in front of the firing point is kept clean and free of visible surface dust. Where it is necessary for firers to move forward to targets, the range floor is also to be kept free of dust. Routine cleaning should not include confined spaces or restricted areas such as that between steel plate and anti splash curtains. Where there are small tubes (<600mm diameter) routine cleaning should extend as far as possible into the tube with wet wipe without entering the tube. Routine cleaning should include wet wipe of all exposed surfaces to remove any dust and removal of any lead or debris build up in the trap area. Authorised vacuum cleaners may be used for the range floor and dependent upon type, vertical surfaces in the range. All dust collected in authorised vacuum cleaners is to be disposed of as a hazardous waste

Routine cleaning should not include confined spaces or restricted areas such as that between the steel plate and anti splash curtain except in the following circumstances:

1. Where staff ensure there is no build up of dust in the range and trap area by cleaning all surfaces after each shoot or regularly enough to ensure no accumulation of dust on any surfaces
2. Where during the monthly inspections a build up of lead is identified as generating a potential backsplash or ricochet hazard or preventing the anti splash curtains from hanging freely

B. **Deep Cleaning.** Deep cleaning should be undertaken by specialist contractors. An example of a deep cleaning contract for ranges is provided at ANNEX A. Deep cleaning involves removing all residual dust from the structure including roof spaces, tubes; target and bullet trap area including any anti backsplash curtains. It is sensible to de-lead and maintain bullet traps just before a deep clean as this process can generate considerable dust. A deep clean is necessary periodically dependent upon range use. As a guide for .22" ammunition:

Total number of rounds fired irrespective of number of lanes:	Frequency of Deep Clean
0-5000 rounds	Every 2yrs
5000 -10,000 rounds	Annually
10,000+	Every 6 mths

Table 3 – Frequency of Deep Clean

6-10-4. Dual Use Facilities

Range Operators with dual use facilities must ensure that prior to the alternate use of the room following use as a range, the surfaces are free of lead dust and unburnt propellant.

6-10-5. Personnel Involved in Cleaning

Only competent personnel provided with PPE and adequate training on the hazards involved and the use of the PPE should carry out cleaning in an indoor firing range. At no stage should those cleaning ranges enter small tubes (<900mm dia.) unless they are specialist contractors. Minors and women of childbearing capability must not be involved in the cleaning of ranges.

6-10-6. Waste Disposal

A. **General.** Waste generated from routine cleaning in low use .22" and air firearm ranges need not be treated as hazardous waste. Any waste from other indoor ranges which may be contaminated with lead and unburnt propellant is subjected to disposal in accordance with the Hazardous Waste (England & Wales) Regulations 2005. It is not to be dumped or disposed of as ordinary waste but stored in sealed containers for proper disposal. This includes:

1. Water and other fluids from a bullet catcher
2. Sand from stop butts and bullet catchers
3. Vacuum cleaner waste bag contents and used filters
4. Ventilation filters

B. **Approved Vacuum Cleaners**. Vacuum cleaners are to be emptied each time after use to avoid build up of potentially explosive dust. Emptying vacuum cleaners should be conducted with extreme care to avoid dust exposure to the individual and contamination of the surrounding area

C. **Storage.** The waste from ranges should be removed from the range or stored dry in sealed containers and placed in a secure area. Normal HAZMAT labelling should be used in accordance with Chemicals Hazard Information and Packaging for Supply Regulations 2002. Local Fire Officers will advise on the limits that may be stored dependent on the storage facility

D. **Disposal**. The Hazardous Waste (England and Wales) Regulations 2005 require sites producing hazardous waste to register annually with the Environment Agency. The regulations, together with the List of Wastes (England) Regulations 2005, stipulate how hazardous wastes should be classified and tracked during movement. Transportation of hazardous waste must be undertaken by a

registered carrier in accordance with the Controlled Waste (Registration of Carriers and Seizure of Vehicles) Regulations 1998 to a licensed hazardous waste treatment or disposal facility

6-11 - HEALTH & HYGIENE

6-11-1. Washing

Hand washing facilities are to be conveniently available as all who use the range will come into contact with dust and range orders are to stipulate that hands are to be washed on leaving the range.

6-11-2. Eating, Drinking and Smoking

Eating, gum chewing, drinking and smoking are forbidden in an indoor training range. The Range Operating Authority must tell all users that on leaving an indoor training range they are not to eat, drink or smoke until they have washed their hands. Club rest room facilities may be provided separated from the range.

6-11-3. Personal Protective Equipment

PPE, which is normally disposable coveralls, gloves and dust masks, may be required for routine cleaning but must be worn for working, inspecting, maintaining and cleaning in or around bullet catchers that have accumulated lead dust. Reusable PPE has to be maintained properly and facilities for its storage are to be provided in accordance with PPE Regulations (Personal Protection Equipment at Work Regulations 1992). Where disposable PPE is used, it should be bagged after use and sealed for disposal by authorised contractors.

6-11-4. Additional Measures for Minors

The CLAW Regulations require Range Operators to ensure minors and women of childbearing capacity receive particular care, supervision and training when exposed to lead in air at any level.

6-12 - KEEPING OF RECORDS AND SIGNS

6-12-1. Records

A. **General.** The dates of all assessments, maintenance, air monitoring, medical surveillance (excluding health records of identifiable individuals) and inspections of the range are to be recorded in the Range Log. The reports and details are to be kept in the Range File for a period of at least 5 years, as required by the current CLAW Regulations

B. **Monitoring.** The Club official / Secretary is to keep details of personnel who are exposed to significant levels (>0.075mg/m^3) of lead in air in an indoor range and the period they were present. The records are to be kept for 10 years and are subject to auditing

C. **Cleaning and De-leading**. All cleaning and de-leading is to be recorded in the Range Log together with the name or job status of the person responsible for the overall supervision

D. **Ventilation**. The dates of inspections, checks and any failures or defects found in the mechanical ventilation system if fitted are to be recorded with the name of the inspector in the Range Log

E. **Inspection and Audit**. Records are to be available for inspection by inspectors and, when required, by the enforcing authority (eg HSE). The procedures for completing and auditing the range usage record are to be stated in the range standing orders

6-12-2. Safety Signs.

Typical hygiene and PPE signs for indoor ranges are illustrated below:

ANNEX A
to Chapter 6
dated Dec 2022

GUIDELINES FOR DEEP CLEANING

FIRING RANGES

Typical Detail for a Range Deep Clean.	Ref. para.
1. Essential Information to be passed to contractors where pertinent	
a. Lead (Pb). All ranges contain significant levels of lead in the form of bullets, bullet fragments and dust	
b. Unburnt Propellant. Dust in ranges will also contain unburnt propellant which is an explosive hazard when collected in any quantity. In ranges where only airgun pellets are fired this hazard should not exist	
c. Antimony (Sb). In high use ranges that permit 7.62mm or similar ammunition to be fired there may be levels of Antimony in excess of EU recommended limits	
d. Risk Assessment – Confined spaces. There are some ranges particularly where there are small tubes or box sections where the work environment may be classed as a confined space. In all cases it would not be safe to allow personnel to work alone nor allow access into small tubes unless there are personnel monitoring activity from outside the small tube or box section	
2. Requirements	
a. Range Structure. All internal surfaces are to be free of dust. This includes any open roof structures, furniture and fixings. Surfaces that may absorb dust are to be pressure jetted where this is possible or vacuumed[1]. Particular care is required to clean out joints in any surface finishes. Mechanical scrubbing machines are particularly effective for use on floors	
b. Bullet Trap. Cleaning bullet traps will be dependent upon the type of trap	
i. Steel plate traps. Remove all bullet debris and wipe down all surfaces. This includes any anti splash curtain which may contain bullet debris and will be covered in fine lead dust. Buckled, loose or damaged steel surfaces should be reported to the authority	
ii. Snail traps. Remove all bullet debris and wipe down all surfaces. Empty and wash out any collection chambers. Report any damage or distortion on impact surfaces to the authority	

iii. Granulated rubber or sand traps. Arrange for de-leading prior to deep clean or combine with deep clean contract and ensure the de-leading is completed prior to starting the deep clean

iv. Lamella / curtain / Venetian traps. Remove all bullet debris and wipe down all visible surfaces. These traps should be dismantled if it is not easily determined that there is no build up within the trap

c. Baffles and vertical traps. Where baffles and vertical wall traps are sealed at the bottom, bullet debris will collect between the steel plate and the offset anti splash timber or tile. A deep cleaning contract should include removing any bullet debris from this gap. Baffles that show no indication of bullet strike may not need to be cleaned out

d. Electrical fittings. Dust is to be removed from all electrical fittings, lighting and any switch gear. Where there is an indication that dust is building up in or around any electrical fitting the authority is to be notified

e. Air handling plant and fans. All filters in air handling plant and fans are to be removed, cleaned or replaced in accordance with manufacturer's recommendations. All ductwork is to be cleaned through. Input and extract fan grills are to be removed and ducts, blades, grills and motors are to be cleaned free of dust

f. Requirement Tube Ranges. Small tubes or rectangular section ranges where it is not possible to enter the tube to deep clean are to be deep cleaned with methods that ensure all dust and bullet debris within the tube or box section is removed

3. Cleaning Guidelines

a. General. Deep cleaning contractors are to take every measure to avoid raising dust during cleaning operations

b. Ventilation. Any ventilation system in the range is to be run at full capacity during cleaning in the range. The ventilation system, once shut down at the end of cleaning operations is then to be cleaned as previously described

c. Cleaning methods. Dry sweeping is prohibited. Wash down, then wet wipe to limit airborne dust

d. Vacuums. Only approved spark free equipment is to be used in ranges with the exception of those ranges where only air pellets have been fired. ATEX equipment category 1D with T4 135°C is required as there is a Category B Zone 20 hazardous area within the vacuum cleaner

e. Cleaning small tube or box section ranges (where access is not possible). Below are some options that contractors might consider i. Pressure jetting the tube or box section would safely remove bullet debris and dust however the water will need to be collected and removed ii. Where pressure jetting is not possible and the target room could be sealed, the tubes or box sections can be dry brushed with a positive airflow directed down the tube. A vacuum/s at the target end inside the sealed space will take out the dust. Vacuum/s extract rate to exceed input air flow rate. Bullet debris can be collected once the dust has settled at the target end **4. PPE**. The deep cleaning contractor is responsible to assess the hazards in a particular range and provide all operatives involved with adequate PPE and instruction in its proper use **5. Compliance with Regulations**. The contractor is to ensure full compliance with the CLAW Regulations for all work undertaken within the range and the Hazardous Waste Regulations regarding all waste disposals from the range **6. Certification.** On completion of the works the Range Operator should confirm that all scheduled work has been completed and the contractor is to sign the Range Log to certify that the deep clean has been completed	

CHAPTER 7
CONTROL OF NOISE ON AND FROM RANGES

7-1 - INTRODUCTION

7-1-1. Aim

This Chapter provides advice on hearing protection and environmental noise related issues as they relate to club ranges. Range Operators should ensure club members are protected from noise on the range, particularly young members. The Chapter also helps those dealing with noise reduction around ranges so they have some insight into the issues and more particularly the control measures available. Typically high velocity firearms can generate peak noise at around 140 – 160dB. In semi rural areas an acceptable noise level would be around 65dB.

7-2 - HEARING PROTECTION

7-2-1. Control Measures

Noise in relation to ranges involves protection for those exposed to muzzle blast peak noise levels dealt with under the Control of Noise at Work Regs 2005 (CNWR).

7-2-2. The Control of Noise at Work Regulations 2005

This Regulation sets out three action levels to control, which determine the course of action an employer has to take if his employees are exposed to noise at or above the levels. These are:

A. First Action Level. Daily personal noise exposure (LEP,d) of 85 dB(A)
B. Second Action Level. Daily personal noise exposure (LEP,d) of 90 dB(A)
C. Peak Action Level. Peak sound pressure level of 140 dB unweighted peak sound pressure level or more

7-2-3. Indoor Ranges

Engineering solutions to minimise the effect of noise are only possible in indoor ranges or where there are enclosed firing points. When analysing the acoustic properties of a room, the sound arriving at the ears, can be considered under 3 headings:

A. **Direct Sound**. This is the sound which travels directly from the source to the listener. It is the first sound to reach the listener, having travelled by the shortest route at a velocity of approximately 340 m/s. Hearing protection is the only means of providing protection from direct sound
B. **Early Sound Reflections**. Shortly after the direct sound arrives, the listener receives a series of sound wave fronts which have been reflected one or more times from the walls, ceiling and any other reflective surfaces in the room. These wave fronts have taken a longer path than the direct sound and therefore arrive later. The later they arrive, the greater their potential for interfering with speech intelligibility. Open texture materials can absorb noise and there are many proprietary noise reduction surface finishes that are suitable for use in ranges – i.e. they do not absorb dust
C. **Reverberation.** Sound wave fronts are repeatedly reflected from the room surfaces and, as a result of absorption, gradually grow weaker and weaker. Acoustic surfaces in a firing room will ensure reverberation is minimised

7-3 - ENVIRONMENTAL NOISE

[Noise nuisance.]

7-3-1. The Environmental Issue

Noise is a particular issue for clubs with ranges close to domestic housing. It is also an issue when developing a new range or increasing the use of an existing range. EU environmental noise guidance provides three levels of acceptable noise dependent upon the area.

A. Urban areas (traffic / railway) 65dB(A)
B. Semi Urban areas 60dB(A)
C. Rural areas 55dB(A)

7-3-2. Environmental Noise can be affected by;

A. Weather – wind direction, cloud base, altitude
B. Duration of noise
C. Time of day
D. Local expectations
E. Location – urban, semi urban, rural
F. Distance from source to receptor

7-4 - NOISE SOURCE

7-4. Sound in the Open Air

As an observer moves away from a sound source, the sound pressure level diminishes. The rate which this occurs depends on the nature of the source itself and this principle is true as long as the observer is not too close. Most practical situations may be described in terms of two 'ideal' sources: point sources and line sources.

A. **Point Source**. The sound source is represented by a point and sound is radiated equally from it in all directions. Every time the distance from a point source is doubled, the level decreases by 6dB. A point source, such as a firearm, which produces a level of 130dB at 10m will produce a level of 124dB at 20m. At a distance of 30m, the level will have fallen by 10dB. In other words, when the distance is trebled, the loudness is halved
B. **Line Source**. A line source, such as a busy road, which produces a level of 70dB at 10m, will produce 67dB at 20m. For a 10dB reduction, half as loud as the level at 10m, the observer must retreat to a distance of approximately 100m from the source or ten times the original distance

7-5 - NATURAL DISSIPATION

7-5-1. Attenuation In Open Air

Attenuation due to distance has already been discussed. Wind and temperature gradients also affect sound. Sound travels faster in air as the temperature increases. The absolute speed also increases with wind speed (downwind propagation). When there is low cloud and wind in the direction of houses, firearm noise will travel further in that direction.

7-5-2. Attenuation from existing Screens and Barriers

In addition to the effect weather has on sound, there are often buildings or similar objects which lie between the source and the observer and prevent line of sight between them. When a sound wave meets an obstacle like a fence or a building, a proportion of it is reflected, and the rest of the wave carries on past the edge of the obstacle. However, the 'bare' edge of a sound wave cannot sustain itself in free space - the vibrating air molecules at the end start themselves to act like sources and radiate in all directions. The result is that a sound wave which has passed the obstacle, bends or diffracts round it

into the shadow zone behind the obstacle.

7-6 - NATURAL & ENGINEERING CONTROLS

7-6-1. Distance

This is a simple inverse square law relationship, which at frequencies between 300-600 Hz, would give attenuations of 66 dB and 68 dB at 1500 metres and 1650 metres respectively.

7-6-2. Ground Absorption

Sound travelling close to grass covered ground is attenuated as follows:

Distance from sound source in metres		Frequency (Hz)			
	37-75	75-150	150-300	300-600	600-1200
	Attenuation (dB)				
1500	4-5	15-0	34-0	45-0	34-0
1650	5-0	16-5	38-0	50-0	38-0

Table 1 - Ground Absorption

7-6-3. Trees

When trees are sufficiently dense, so as to mask a white moving object at 60 metres, the following attenuations apply:

Frequency (Hz)	37-75	75-150	150-300	300-600	600-1200
Attenuation (dB)	2	3	5	6	7

Table 2 - Attenuation from trees

7-6-4. Earth Banks

Although these block the direct path of sound between firearm and complaint area, earth banks have a complicated effect:

A. For example, the attenuation due to banks at 3 metres and 30 metres from the firearm would be 18dB and 9dB respectively. Should the side of the bank nearest the firearm be vertical the above attenuation would be reduced
B. A bank may however cut out, or reduce, the sound travelling close to the ground and hence reduce the ground absorption by about half. To gain 18dB attenuation by means of a bank 3 metres from the firearm, one could therefore lose between 22-5 and 25dB attenuation in lost ground absorption. This effect is uncertain, especially where the ground cover is bushy rather than grassy
C. The effect of a bank and its likely effect on ground absorption may be summarised as follows:

Bank sited at 3m from firearm	Frequency (Hz)				
	37-75	**75-150**	**150-300**	**300-600**	**600-1200**
Attenuation due To bank (dB)	9	12	15	18	21
Loss of ground absorption, in dB, due to bank:					
at 1500 m	2.3	7.5	17	22.5	17
at 1650 m	2.5	8.3	19	25	19

Table 3 - Attenuation from earth banks.

7-6-5. Wind and Turbulence

Turbulence at the top of a wall may assist the sound to diffract over the wall and reduce the dBs of attenuation as follows:

Wind Speed	Frequency (Hz)				
	37.75	**75-150**	**150-300**	**300-600**	**600-1200**
8 kph	0 dB	0 dB	0 dB	0 dB	0 dB
16 kph	0 dB	0 dB	1 dB	2 dB	4dB
32 kph	1 dB	3 dB	6 dB	8 dB	10 dB

Table 4 - Attenuation from wind.

7-6-6. Temperature and Humidity

A figure of 3 dB attenuation has been taken as typical for temperate summer climatic conditions. The figure represents atmospheric absorption at low frequencies. At high frequencies absorption will be much higher, so much so that high frequency nuisance over these sample distances can be ignored.

7-6-7. Temperature Gradients

These have effects like those of wind gradients and, similarly, are not as yet capable of prediction. An inversion may increase sound transmission but it is not known how often this condition may obtain in any given locale. However, at least it could not be combined with the adverse wind direction mentioned above.

7-6-8. Theoretical Prediction

An example is given below of a theoretical prediction of sound attenuation, at distances of 1500 metres and 1650 metres from a 7.62 Rifle. As high frequencies, i.e. above 1000 Hz, will be unimportant in the case of small arms, the octave 300-600 Hz is used in the example.

	See paragraph as under	Distances from Firearm			
		1500 metres		1650 metres	
		Without Bank	With Bank	Without Bank	With Bank
Distance	7-10	dB 66	dB 66	dB 68	dB 68
Ground absorption	7-11	45	22.5	50	25
Trees	7-12	6	6	6	6
Earth bank 3 m from firearm	7-13	-	18	-	18
Wind and Turbulence (assumed 32 kph)	7-14	-8	-8	-8	-8
Temperate and Relative Humidity	7-15	3	3	3	3
TOTAL Attenuation		112dB	107.5dB	119dB	112dB

Table 5 - Attenuation for sounds in the 300-600 Hz octave

The sound peak pressure, at the firearm, for a 7.62mm rifle is 159dB. From the table above, it can be seen that at 1500 metres from the firearm the sound peak pressure would be:

A. With Bank (159 -107.5) = 51.5dB
B. Without Bank (159 -112) = 47dB

These levels would be barely detectable in an average room and certainly not outside in a normal urban environment. It is emphasised that while these figures are theoretical, they were found to agree, within plus or minus 10%, with sound measurements taken in a similar situation.

ANNEX A
to Chapter 7
dated Dec 2022

MEASUREMENTS OF PEAK PRESSURE LEVELS (dB) AND PULSE DURATION (milliseconds) FOR TYPICAL FIREARM SYSTEMS

SER	FIREARM/ AMMUNITION	EAR POSITION									
		FIRER		LOADER		INSTRUCTOR OR ADJACENT PERSONNEL					
						0.3m to Side		1.2m Side		3.0m Side	
		dB	ms	dB	ms	dB	ms	dB	ms	dB	ms
(a)	(b)	I	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)	(l)
1	7.62mm										
	0.3M above Ground	160	5.0	-	-	-	-	-	-	-	-
	1.5M above Ground	151	0.9	-	-	169	0.5	160	0.5	155	0.5
				-	-	-	-	-	-	-	-
2	5.56mm	158	1.0	-	-	165	1.0	155	0.5	153	0.5
3	9mm	157	1.0	-	-	162	1.0	154	0.5	151	0.5
4	Shotgun/12 Bore	155	5.0	-	-	-	-	-	-	-	-
5	Pistol/38 Spl	157	5.0	-	-	-	-	-	-	-	-
6	Pistol/9mm	157	1.0	-	-	-	-	-	-	-	-
7	Rifle/22 LR	138	2.5	-	-	-	-	132	2.5	-	-

Note;

1. *The pulse duration is the total time taken for the pressure fluctuations to decay by 20 dB from the peak pressure level*

CHAPTER 8
RANGE MAINTENANCE

8-1 – INTRODUCTION

8-1. Policy

The Range Operator must carry out range maintenance of all range facilities throughout the life of a range. The aim of this guide is to provide those whose duty it is to maintain the ranges with specific guidance that will help meet this requirement. There are two areas that need to be maintained, the ballistic safety and the range structures. Those with the expertise to maintain ballistic safety may not have the skills to maintain range structures.

8-2 - BALLISTIC MAINTENANCE

8-2 Ballistic Maintenance

Range activity will continually cause attrition to all surfaces that bullets impact. The key issues that require maintenance to maintain the safety on a range are detailed below.

8-3 - OUTDOOR RANGES

8-3-1. Capture Bullets Effectively

Outdoor ranges have either a sand, earth or granulate bullet trap backed up by a stop butt or back wall to capture wide shot or ricochet. Bullets will generally build up behind the targets in the bullet trap at around 450 – 500mm deep. It is necessary to check the bullet trap to ensure the build up of lead will not generate backsplash. This can be done with a 1m long steel rod. On ranges where black powder firearms or 9mm are used the frequency of de-leading will be increased. De leading should be done by hazardous waste licensed contractors.

Figure 1 - Bullet debris

8-3-2. Prevent or Minimise Ricochet

It is known that slopes of 30 deg will minimise ricochet and slopes of 56 deg prevent ricochet. When bullets impact sand, earth or granulate the slope scoops causing impact slopes to reduce. Hence bullet trap slope angles are set at 34 deg, allowing for the scooping effect. It is necessary on most ranges to rake the bullet trap slope after each day's shooting or before firing again.

Figure 2 - A poorly maintained gallery stop butt with too much scooping

Figure 3 - Marking the 34 deg slope where it is possible to do so is good practice

8-3-3. Prevent Penetration of a Defence Structure

Each range operator will be aware of the ammunition type authorised on the range. The problem comes when there are too many shots missing the bullet trap and striking the back wall of a range. The back wall is designed to take some shot but not concentrated shot. An additional problem of shorter ranges is that to prevent backsplash timbers are used on the back wall. Bullets will pass through the timber leaving little or no indication of them passing as all the bullet energy dissipates on the hard surface behind. This is termed “Hidden Attrition”.

Figure 4 - Here timbers have been removed to check the back wall

8-3-4. Prevent Backsplash

Any hard surface on a range can generate bullet backsplash. Range operators should expect Low Velocity (LV) backsplash of 22m and High Velocity (HV) backsplash at 50m. To prevent backsplash all hard surfaces in the line of fire (LofF) should be protected with a soft material such as timber or rubber. The material should be offset from the hard surface to allow the round to break up in the gap.

Figure 5 - Here the timber protection has been shot away exposing firers to backsplash from a metal plate

8-3-5. Targetry

The position of targets is important to maintain safety on the range. Defence structures are measured from target centres. For moving targets defence structures are established from the ends of each target run. On most ranges the target centres are fixed so a marking on the range will ensure targets are always presented at the correct height.

Figure 6 – Target Centre Height (TCH) Marking

8-3-6. Ground Maintenance

Grass on the range floor should be kept short to enable clear visibility of the targets. Grass on slopes should also be kept short but great care is needed to avoid injury on steep slopes when cutting grass. Low areas prone to ponding should be levelled off and drained to avoid the ponding. Where there is a need to move down range to check or change targets a gravel path should be provided.

Figure 7 - Plastic grid used to form gravel path

8-3-7. Signs & Flags

Part of the ballistic safety is to ensure any range boundary safety signs and flags are in place and visible. Wind, vandals, trees and bushes can all cause signs to be no longer visible. Strong winds soon shred red flags.

Figure 8 – Examples of ineffective range boundary signs

8-4 - INDOOR RANGES AND TUBE / TUNNEL RANGES

8-4-1. Lead

The most important maintenance issue for indoor ranges is the build up of lead dust or unburnt propellant. Lead dust is carcinogenic (takes 30 years or more to naturally leave the body). Any visible dust in the range is a health hazard. Those involved in cleaning must use effective PPE.

8-4-2. Unburnt Propellant

Every time a firearm is discharged both lead and unburnt propellant is discharged into the range. Unburnt propellant is explosive and can destroy a range and cause significant injury or death to those exposed to an explosion. Great care is needed to ensure all visible dust in the range and particularly around the firing point is removed and not allowed to build up in any part of the range.

Example: Six military agents participating in a shooting training session were inside a shooting range when its floor was engulfed in flames and set off an explosion. The horrific explosion occurred at an undisclosed site the morning of November 23 2018 in the Brazilian state of Para. A military officer took four shots within a period of 19 seconds before the wooden floor panel burst into flames. A few seconds later a huge fireball pushed the agents back against a wall

Figure 9 - Fire started in front of the firing point followed by an explosion from residual dust in the range

8-4-3. Cleaning Surfaces

Cleaning range surfaces may be done with wet wiping or the use of a spark free vacuum. All waste collected will be contaminated waste and explosive waste so storage is not recommended. It is better to clean often so the amount of waste is minimal and could be discharged as waste water. This is only possible where the range is not used commercially, in that case all waste will need to be removed by a licensed Hazardous Waste company.

8-4-4. Approved Vacuum

Minimum specification should be “Approved for cleaning and dust extraction in ATEX Zone 22 environments with explosive dust”.

8-4-5. Maintain the Ventilation System

Check there is a positive air flow down range. The extract should be rated at 10% more efficient than the input. Clean extract fans and ducts (PPE required) to ensure there is no build up of dust.

8-4-6. Baffle Structure Stability

Check all overhead baffles with steel plate protection to ensure the fixings remain sound. Bullet strike can cause the steel plates to come loose and fall.

8-4-7. Electrical Fittings

Check all electrical fittings to ensure they are protected and are not collecting dust within the fitting.

8-4-8. Bullet Trap

There are many types of bullet trap found in indoor ranges for LV ammunition or HV ammunition.

A. **LV Bullet Traps**. Check the anti backsplash curtain has not been holed behind the targets. The curtain should hang straight without buckles between curtains. Check also the steel plate behind the curtain. Even 22 LR ammunition can penetrate steel plate eventually. (PPE to be used)

Figure 10 – Typical LV Bullet Trap

Figure 11 - .22” Penetrates Steel Plate

B. **HV Bullet Traps.** The traps used in indoor ranges for HV ammunition include;

1. Sand (Not recommended in indoor ranges). Ensure there is no build up of lead behind targets. De lead if there is any possibility of a backsplash from a build up of bullet debris. Replace sand when it is pounded to fine dust. Rake surface to 34 deg slope
2. Granulate Rubber. Ensure the light rubber cover sheet is serviceable. Check the rubber is not pounded to fine dust at the MPI. Fine rubber dust is a fire hazard. Rubber granulate is more stable than sand but still check the 34 deg slope is maintained

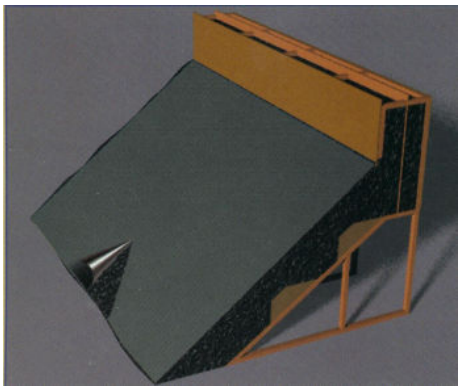


Figure 12 – Granulate Rubber HV Trap

3. Rubber Block / Tile. A recent concept is to capture HV bullets in a dense rubber block. If the blocks at the MPI show signs of bulging, it is time to rotate them up or down away from the MPI. Eventually new blocks will be needed

Figure 13 - Dense Rubber Block and Tile Bullet Trap system

4. Venetian Blind with anti backsplash curtain. This trap is made up of armoured steel plates set at an angle to deflect HV bullets down. The plates soon start to warp, and like the blocks, need to be moved while they remain loose, away from the MPI.

Figure 14 - Venetian Blind Bullet Trap system

ANNEX A
to Chapter 8
dated Dec 2022

MAINTENANCE & SAFETY CHECKS
GUIDE

Ser	Element	Remarks		
1.	Sand bullet traps	a. Check slope angle is 34 deg or more b. Check there is no severe scooping behind targets c. Check for lead balling at MPI. Prod sand to 500mm d. Check sand will not turn to dust by rubbing in hand		
2.	Granulate bullet traps	a. Check slope angle 34 deg or more b. Check granulate for paper or timber debris. Fire risk c. Check there is a light rubber cover over the granulate		
3.	Sand slopes	Stop butts and banks constructed entirely of sand are ballistically safe but stability during extreme wet weather must be considered. Timber frames or geogrids are suitable clear of the bullet impact areas. Earth banks with sand bullet traps are more stable		

4.	Drainage	Drainage on the range floor should prevent flooding. Ensure the range floor is not prone to ponding		
5.	Bullet damage, hidden attrition.	The annual inspector will determine why shot occurs in unexpected areas. He may not however look at the stability of damaged structural members or services The steel columns in the photo were protected with timber, when the timber was removed the inspector found the column penetrated with bullet holes	 	
6.	Structures on ranges	Cable pit or service markers made of a hard material on ranges must not be exposed to direct fire		

7.	Weakened defence structures.	Where walls provide ballistic protection, leaving dry joints or using hollow blocks or brick is dangerous		
8	Hidden attrition	Bullets pass through timber leaving a small hole that is not noticeable. The bullet loses all of its energy when it strikes a hard surface. Here is the effect seen when the maintenance team replaced the timber		

CHAPTER 9
RANGE INSPECTIONS

9-1 – INTRODUCTION

9-1-1. Policy

Range Operators should carry out range inspections of all range facilities at least once each year. The aim of this chapter is to provide those whose duty it is to inspect the ranges, with specific guidance that will help meet this requirement. There are two areas that need to be inspected, the ballistic safety and the range structures. Those with the expertise to assess ballistic safety may not have the skills to inspect range structures.

9-1-2. Inspections

The range works inspection supplements that carried out by the annual range inspectors who focus on the ballistic safety of the range. The ballistic inspection ensures compliance with the criteria set out in this Handbook. The annual inspectors will not necessarily consider constructional, electrical or mechanical problems unless of course the defect is obvious. They will however identify most environmental problems associated with shooting activity. To ensure all environmental problems associated with ranges are identified the works inspection should cover this aspect as well. The range works inspection should include the following:

9-2 - INSPECTION CYCLE

9-2-1.Daily Check

When a range is in use a daily check is recommended to be carried out, where practicable, by the Range Staff before firing takes place to ensure that the range is being presented in good order for users and is in all respects fit for use.

9-2-2. Monthly Inspection

A monthly inspection of the range is recommended to be organised by the Range Operator to ensure that range staff are maintaining the range to an acceptable standard of cleanliness and good order and that any maintenance work required is identified promptly and is followed up until completed. The Range Authority/club should maintain a record accordingly.

9-2-3. Annual Inspection

An annual inspection is recommended to be carried out by or on behalf of the Range Operator. This inspection will determine if the range is safe for continued use and that any restrictions or limitations stipulated by the Range Operator are being followed. The annual inspection should also review the following:

A. Range maps
B. WDA templates
C. A check that ADA, ADH are correct when compared with the current templates for firearms used on the range
D. Public use and/or access to check protective measures are current

9-3 - RANGE SAFETY DOCUMENTATION

9-3-1. Key Elements

Monthly and annual inspectors of ranges are required to be competent in assessing the following key elements of range safety as appropriate to the ranges in their areas of responsibility:

A. Range documentation
B. Range administration
C. Range control
D. Range structure and maintenance

9-3-2. Advice and Support

The NRA can provide advice and support to achieve the required range inspection competency.

9-4 - KEY ELEMENTS OF BALLISTIC INSPECTIONS

9-4-1. Indoor Ranges

The following should be checked:

A. Authorised firearms, ammunition and practices
B. Defence Zone, backplate and bullet catcher correctly sized and specified
C. Floor, walls and ceiling clearly specified for sound absorption and dust inhibiting surfaces free from obstruction or correctly protected
D. Backsplash / ricochet hazards eliminated. Baffles (if any) correctly positioned and detailed
E. Targets and firing points correctly sized and positioned
F. Target centre height and flank positions clearly identified
G. Adequate ventilation and lighting
H. Correct safety signs, number and location
I. Adequate access and egress

9-4-2. Non Standard NDA

The following compliance checks are detailed below

A. Authorised firearms, ammunition and practices
B. Firing point alignment, size, positioning and height
C. Range floor and ricochet pit profile, if applicable
D. Mantlet height & profile
E. Targets correctly sized, spaced and protected
F. Target centre height and flank positions accurately identified
G. Bullet catcher sizing and specification
H. Canopy construction against ‘pop over', if applicable
I. Stop butt wall height, width, face angle and crest depth, if applicable

9-4-3. Barrack Type

The compliance checks to be carried out are detailed below:

A. Authorised firearms, ammunition and practices
B. Constructed in accordance with an appropriate standard
C. Where precast – provision is to be made to avoid straight joints in ballistic elements

D. If not constructed to the current Standard MOD Barrack Range, then inspect in accordance with compliance checklist for Open Non Standard NDA Range

9-4-4. Tube Ranges

The following should be checked

A. Authorised firearms, ammunition and practices
B. Target House - Type of bullet catcher, bullet catcher sizing, defence zone sizing and structure, target material and fixing method, target centre height
C. Tube diameter, wall thickness, material, tolerance and cover
D. Any protrusion in the tube greater than 3mm that might generate backsplash
E. Firing Bay - Firing point height, width and spacing and intermediate firing distances, if applicable
F. Signage and lighting
G. Noise control measures
H. Ventilation arrangements

9-4-5. Gallery Range

The compliance checks to be carried out are detailed below:

A. Authorised firearms, ammunition and practices
B. Firing point dimensions, construction, lane identification, alignment and profiles
C. Visibility of required mantlet face from all firing points
D. Mantlet profile, height and width
E. Exposure of all targets from all firing points, spacing identification and target centre height
F. Minimum clearance over mantlet crest board
G. Minimum clearance over Hythe Frame
H. Stop butt alignment, distance from target line, size and profile
I. Falling plate target position and construction, if applicable
J. Quadrant Elevation to target centre. (CoF then added to determine max QE).
K. Template alignment

9-5 - WORKS INSPECTION

9-5-1. Introduction

All ranges are subject to attrition from bullet strike. Due to the requirement to prevent backsplash all hard surfaces are covered by timber or other soft material to absorb bullet strike. This can present a structural problem as any attrition behind the protective material can weaken the structure behind. This is termed hidden attrition and works inspectors should be aware of this issue. The range works inspection supplements that carried out by the annual range inspectors who focus on the ballistic safety of the range. The range works inspection should include the following:

A. All range structures
B. Boundary signs and flag poles
C. All environmental issues
D. Ground conditions including slope stability
E. Any HSAW and CLAW issues
F. Infrastructure, drainage, power, roads, plant and equipment etc

9-5-2. Frequency

Range facilities include buildings, walls, earth or sand banks or bunds, trenches, retaining walls, towers, unloading bays, any range with a structure of any nature. With the exception of ancillary buildings beyond the ballistic envelope, all range structures should be fully inspected at least every two years

unless the range is permanently closed. The actual frequency of inspection will be dependent upon the rate of attrition of any of the structures. Where an inspector becomes familiar with specific ranges the depth of inspection should be tailored to target areas where high attrition occurs.

9-5-3. Process

Inspectors need not be range specialists but familiarity with the respective roles, responsibilities and how the different ranges work is needed. Where possible, inspections should be coordinated with the annual inspection. Inspectors should provide a copy of the report for the range file.

9-6 - SAFETY

9-6-1. Control

When inspecting ranges inspectors must ensure they are briefed by the range staff prior to carrying out any inspection. It is possible that on range complexes live firing may be taking place on adjacent ranges; therefore inspectors must fully comply with safety instructions given. Because of the risk it would **not** normally be acceptable to sub - contract this work.

There are strict procedures in place to control access to most ranges. Where possible works inspectors should arrange to be accompanied during the inspection by range staff for the following reasons;

A. To ensure personal safety
B. So that targets and other equipment can be operated if necessary
C. For 1st hand reports on the range facilities
D. Local knowledge

9-6-2. PPE

Inspections of bullet traps and ventilation systems within indoor and tube ranges will expose inspectors to significant levels of lead dust and unburnt propellant. Inspections in such areas should only be undertaken wearing personal protective clothing and equipment.

9-7 - RANGE CATEGORY & ELEMENTS TO BE INSPECTED

9-7-1. Range Category

In broad terms ranges are split into 3 categories;

A. Indoor No Danger Area (NDA) ranges
B. Outdoor NDA ranges (Standard or Non standard)
C. Limited and full danger area constructed ranges

9-7-2. Elements to be Inspected

Under each category there will be different elements to inspect. Common to all ranges is the requirement to control access with the provision of safety signs, flags and lights. Range Operators will determine the extent of signing and method of controlling access. The works staff or club members will be involved in the installation and maintenance of these elements.

Specific elements for each range type are described in the following ANNEXES. It is impossible to itemise every aspect of range structures that require the attention of works inspections. The following details should be used as a guide only and inspectors should use their expertise to ensure important elements have been identified and inspected.

9-8-1. Open Ranges

With all open Limited Danger Area (LDA) and Full Danger Area (FDA) ranges there is a danger area associated with the range. The extent of the danger area is dependent upon range geometry and firearms used. It is important to establish that all range boundary data is as accurate as it can be. This includes range boundaries and areas of leased land for over firing rights. The Range Operator will determine the position and extent of public access control measures. Inspectors should ensure that the detail shown on maps is accurate.

ANNEX A
to Chapter 9
dated Dec 2022

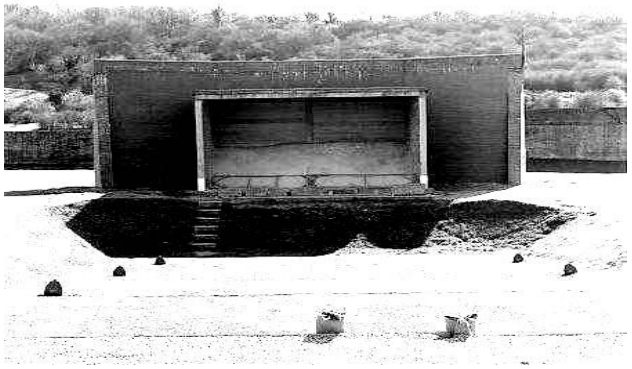
BARRACK and NON STANDARD NDA RANGES

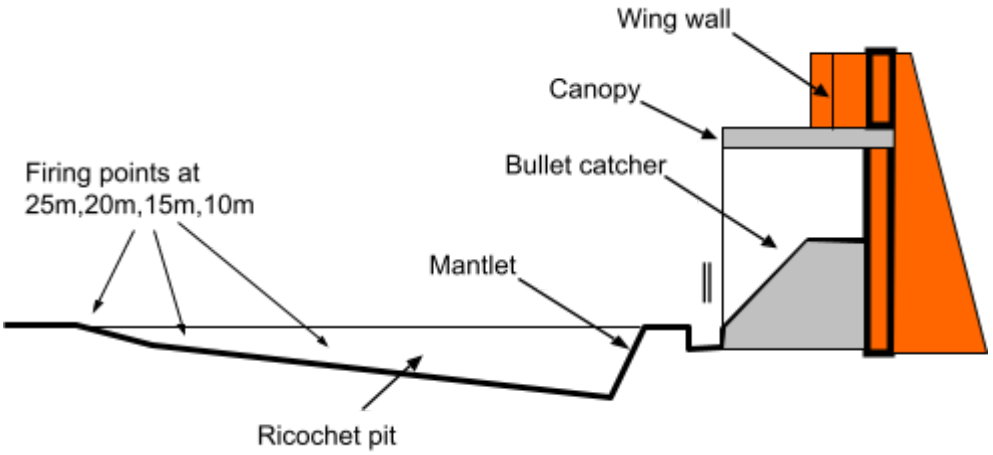
1. GENERAL DESCRIPTION

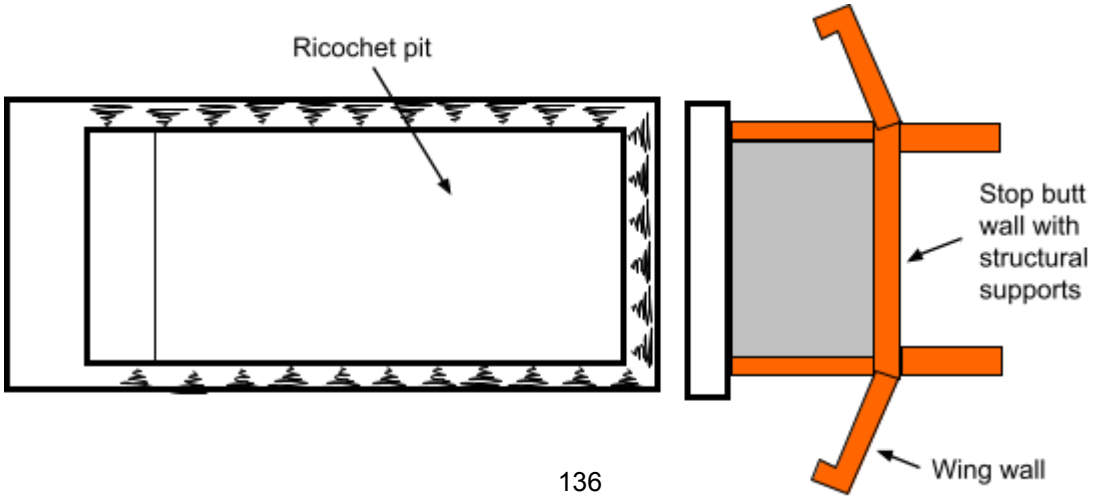
There are three main types of standard barrack range, the older brick 1908 design incorporating a ricochet pit, the RAF equivalent with or without a ricochet pit and the newer concrete design with a flat range floor. There are also non standard NDA ranges of varying design.

2. OLD STYLE 1908 DESIGN

When HV ammunition is fired a canopy is needed to capture ricochet .







3. NON STANDARD DESIGN

Often with flat range floor, with or without wing walls and sometimes with a covered firing point.

4. <u>NEW 25m DESIGN</u>

5. <u>NON STANDARD - EXAMPLE</u>

6. WORKS INSPECTION CHECKLIST COVERING EACH TYPE.

Ser	Element	Remarks	Inspectors Comments	X
1	Ricochet pit	a. Free of unprotected hard surfaces		
		b. Drainage / soakaway system effective and working		
		c. Steps sound and free from slip or trip hazards		
		d. Stable surfaces free from erosion		
		e. Grass well maintained		
		f. Pathways well maintained		
2	Target Pit / mechanism	a. Pit construction sound		
		b. Target mechanism working & properly maintained		
		c. Drains working		
3	Canopy	a. Check for structural defects		
		b. Front wall protection timber sound (New 25m range)		
		c. Steel plate fitted to underside of canopy secure. (1908 design). Fixings prone to erosion in coastal areas		
4	Bullet catcher (sand)	a. Check any new sand grading against specification		
		b. Ensure back and front toe wall is not overloaded		
5	Bullet catcher granulated rubber	If there is no top cover sheet check that there is no flammable contamination such as paper or		

		timber from targets or fabric in the granulate. The latter is specifically excluded in the specification for granulated rubber in bullet traps due to the fire risk		
6	Backwall above the sand	a. Check for structural defects		
		b. Check for bullet attrition (see photo) particularly just below the top of sand surface		
				
7	Stop butt wall and wing walls around the bullet catcher	Check for structural defects / stability		
8	25m firing point	a. Check any overhead cover for structural stability		
		b. Check firing point pits are sound and drainage is effective		
9	Associated buildings	Normal works checks		
10	Safety signs and range flags	a. Check for compliance to EU/UK legislation		

		b. Ensure flag poles are secured adequately		
11	Generally	a. Check any fencing and gates around the range		
		b. Check all electrical and mechanical fittings		
12	Other elements not listed	Describe:		
13	General Comments by the works inspector			

Certification:

Range Name Location……..

Works inspection carried out on this range and Range Log completed

on:……

Name of Inspector:……..

Contact Tel……..

Copy:

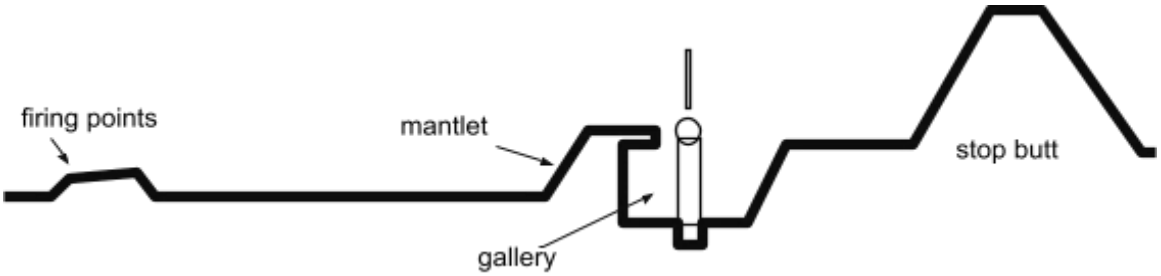
Range Operator for Range File

ANNEX B
to Chapter 9
dated Dec 2022

GALLERY RANGE

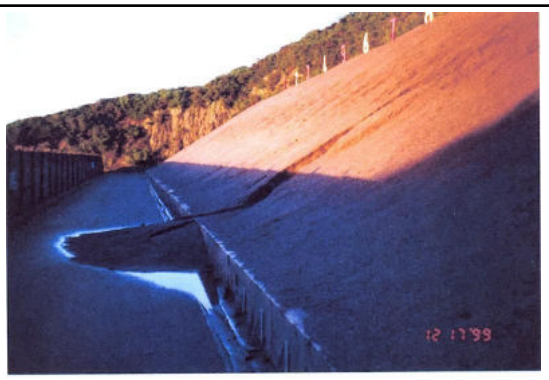
1. GENERAL DESCRIPTION

Gallery Ranges operate on the principle that the Cone of Fire is lifted off the range floor by mounting the targets high on top of the mantlet and that most shot and low angle ricochet will be captured by the mantlet or stop butt.



2. WORKS INSPECTION CHECKLIST.

Ser	Element	Remarks	Inspectors Comments	X
1.	Gallery	a. Structural check of retaining walls. (watch for overburden from sand or earth stop butt)		
		b. Structural check of supporting structures		
		c. Drainage, gallery pit and retaining wall weep holes		

		d. Stability of canopy (Target inspection)		
		e. Mechanical check on gallery frames		
		f. Check any handrail or guard rails		
2	Mantlet	a. Check stability		
		b. Check any handrail or guard rails		
3.	Stop butt	a. Stability of the bank. Check for slip at sides and rear. Complete sand stop butts should be stabilised to prevent collapse		
		b. Silting of drains around the stop butt		
				
4.	Workshops / stores attached to the gallery	a. Check as for industrial buildings		
		b. Structural check of any protection walls or banks		
5.	Electric targets	a. Electrical supply and circuits		
		b. Stability of gallery roof to take target units and any trolley / device used for transporting them		
6.	Firing points	a. Stability of any trenches		

		b. Drainage in trenches		
		c. There should be no settlement on the firing point		
7.	Range floor	a. Surface water drains and culverts are adequate. (see photo) 		
		b. Check any foot bridges or other structures on the range floor		
		c. Check for erosion or ground settlement. (Settlement could cause the range to become unsafe)		
8.	Access roads / bridges	Normal maintenance and stability checks. Class load of vehicle bridges should be in place		
9.	Associated buildings	Normal works checks		
10.	Safety signs	a. Check for compliance EU/UK legislation		
		b. Accuracy/ effectiveness of location		
		c. Replace any missing or defective signs		
11.	Generally	a. Check any fencing and gates around the range		
		b. Check stability of any flag poles		

		c. Check all electrical power points / lights		
12	boundary	Check to ensure boundary and danger area signs conform to any bye laws and reflect the control measures used by the Range Operator		
13	Other elements not listed	Describe:		
14	General Comments by the works inspector			

Certification:

Range Name Location……

Works inspection carried out on this range and Range Log completed

on:……

Name of Inspector:……

Contact Tel……..

Copy:

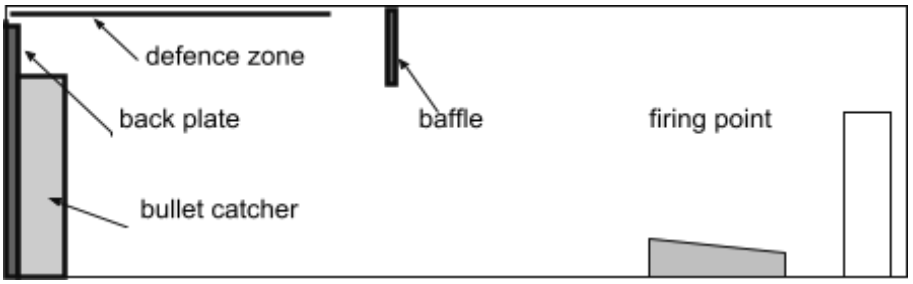
Range Operator for Range File

ANNEX C
to Chapter 9
dated Dec 2022

INDOOR RANGES

1. GENERAL DESCRIPTION

There are a number of indoor range types, rimfire, centrefire and air gun ranges. Test and tube ranges are covered separately. Indoor ranges are popular as they can be used all year round and at night however they present additional problems with noise and contaminated dust. Any dust in a range will contain both lead and unburnt propellant both of which should be eliminated by an effective cleaning regime.



2. WORKS INSPECTION GUIDE.

Ser	Element	Remarks	Inspectors Comments	X
1.	Structure	a. Check stability of roof and walls particularly in the defence zone where steel plate or other ballistic material may be added without confirming the structure can take the additional loading b. Structural check of all baffles		
		c Check exposed roof structure for any attrition		

		d. Check all services & fittings are protected from strike 		
		e. Inspect for elements where dust might accumulate out of sight		
		f. Inspect as for any other industrial building		
2.	Floor	a. The floor should be impenetrable and free of any structural cracks which would cause ricochet		
		b. If floor is penetrable check for services below		
3.	Ventilation	a. Check ventilation system is working correctly		
		b. Ensure all ducts are clear of obstructions		
		c. Check extract filter is functioning correctly and is maintained for optimum performance		
4.	Backplate and defence zone steel plate	Check for stability		
5.	Bullet catcher	a. Ensure manufactures maintenance and servicing instructions are being followed		
		b. Check that lead disposal procedures are followed		

6.	Associated buildings	Normal works check		
7.	Safety signs	Check for compliance		
8.	Generally	a. Confirm dust control measures (including use of approved vacuum) are effective		
		b. Check safety interlock system is functioning correctly		
		c. Check all electrical power points / lights		
		d. Check deep clean removes all dust from the range, adjacent rooms, roof structure and from all fittings and fixtures		
9	Other elements not listed	Describe:		
10	General Comments by the works inspector			

Certification:

Range Name Location……..

Works inspection carried out on this range and Range Log completed on:……

Name of Inspector:……..

Contact Tel……..

Copy: for Range File

CHAPTER 10
RANGE RECORDS AND FORMS

10-1 – INTRODUCTION

10-1. Policy

Range Operators should ensure they have done all they can reasonably do to ensure the ranges they are responsible for are safe for users, visitors, contractors and those beyond the range. There are a number of documents used to help ensure a range is as safe as it can be. Outdoor ranges can never be 100% safe as the safety depends on users doing what is expected. The range can however be made As Safe as is Reasonably Practicable (ASARP). Indoor ranges will only affect those inside the range. Range managers should understand and record all details and the potential hazards on a particular range. Only the key safety details should be provided to range users.

10-2 - RANGE RISK ASSESSMENT

10-2. Risk Assessment

In order for those responsible for a range or range complex to understand all aspects of the risks involved it is necessary to complete a Risk Assessment covering not just the range but the whole area of the range, access, perimeter, public use of the areas around the range and the implications of a round leaving the range. For ranges that employ more than 5 people the law requires a formal written Risk Assessment. For everyone else it is advisory.

10-2-1. Scope

A clear understanding of how the range and the areas beyond are used is essential to complete an effective Risk Assessment. Risk Assessments should cover range users, range staff, visitors, trespassers and the public around a range. Risk Assessments need to be reviewed at least annually and when there are changes to range use or the use of the areas around the range.

10-2-2. Duty of Care

Range Operators have a duty of care to people on the ranges, and those who might be affected by clubs' actions on or around ranges under the law of Occupiers' Liability. The club's duty is to take reasonable care to ensure that the visitor / user will be safe at all times. The duty of care also extends beyond those invited or permitted to be on a range, e.g. trespassers, or a member of the public adjacent to a range, if:

A. The club is aware of the danger or there are reasonable grounds to believe that it exists
B. The club knows or has reasonable grounds to believe that the other people are in the vicinity of the danger concerned or that they may come into the vicinity of the danger
C. The risk is one against which the club may reasonably be expected to offer other people some protection

10-2-3. Assessing Risk

When assessing the risks associated with range activity, the level of protection afforded must take into account both the likelihood of injury and the seriousness of the injury or damage to property. Where such risk exists the club has a duty to provide an appropriate level of protection. In most cases, the duty of care can be discharged by taking all reasonable steps to give warning of the danger concerned and, where necessary, to discourage persons from incurring the risk.

Essentially, the duty of care arises if it can be established that it was reasonably foreseeable that injury or damage may be suffered as a result of the club's act or omission to act and that the imposition of the duty of care is just and reasonable.

10-2-4. Information

Personnel should not be given access to a club range until they have received relevant range safety brief and health and safety information. Where access can be controlled, Range Managers are to set up a local procedure to ensure that all relevant safety information is absorbed and understood before access is authorised.

10-2-5. Category of User

The category of user on a range will dictate the level of risk to be assessed. On ranges where only competent marksmen or bench fired weapons are used, the risk of a misdirected shot will be low. However on ranges where corporate days are hosted and practical shooting takes place the risk of a shot leaving the range or causing injury on the range will be considerable.

10-2-6. Further Explanation

Further explanation and an example Risk Assessment for ranges is provided at Annex A to Chapter 10 with examples available on the NRA website.

10-3 - RANGE STANDING ORDERS

10-3. Range Standing Orders are provided by the Range Operator/club to record all details about the range complex for which it is responsible. This would include;

A. Range Address / Contact details
B. Details of Range Staff
C. Type of Range
D. Authorised distance to targets
E. Authorised firearms
F. Authorise practices
G. Authorised ME / MV
H. Range Location
I. Maps
J. Details of danger areas
K. Orders for access control
L. Orders for RSOs
M. Orders for Coaches
N. Record of works – development / maintenance
O. Fire prevention
P. Details of emergency contacts and RVs

10-4 - RANGE ORDERS

10-4. The Range Orders are directed at range users only. They need to know what they can do and cannot do on the range and any special safety instructions highlighted in the Risk Assessment. The type of practice permitted and those specifically forbidden. Emergency contact details should also be available on the firing point.

10-5 - RANGE LOG

10-5. The Range Log should be maintained to record daily activity; rounds fired, type of ammunition fired, incidents, inspections, bullet catcher de-leading etc.

10-6 - RANGE FILE

10-6. A Range File should be kept for all documentation related to the range including Safety Notices, Ballistic information relating to the range, register of club members, register of RSOs, attendance book etc.

ANNEX A
to Chapter 10
dated Dec 2022

EXAMPLE RISK ASSESSMENT – RANGES

There are many formats used to record specific risk assessments. The HSE encourages all risk assessments to be written down and for employers with more than 5 workers it is the law (MHSAW Regs). HSE provide example formats but emphasise as long as a written risk assessment is completed the format is not important. https://www.hse.gov.uk/risk/index.htm

Many industrial risk assessments require an activity to stop once it is found to be at risk. The HSE forms allow for this by adding columns for planning the additional works and date of completion. For ranges if there is an issue it is dealt with directly so the format for ranges is different. Additional controls are only recorded when you find an issue. During a Risk Assessment or at any time a safety issue not already covered is noticed you record Risk Not Acceptable and then record the additional controls you put in place to resolve the issue. In the remarks column you add risk now As Low as is reasonably Practicable (ALARP). Should there be an incident the HSE will first ask to see the Risk Assessment and they will see you have tried to identify all perceived risks. It is unlikely that others will know more about the risks on ranges as they will have no concept of firearms and the risks associated with them.

Risk assessments should be reviewed annually, and records kept.