Indoor Range Design Guide
How We Help the Range Planner

Thank you for requesting a copy of the Meggitt Training Systems’ Indoor Range Design Guide. This comprehensive booklet contains information on equipment, planning and design recommendations, drawings and editorials beneficial to successful range development.

Planning a shooting range facility is a major undertaking. The requirements demanded with live-fire shooting are unique and require careful planning. We encourage you to contact Meggitt Training Systems during the early stages of range planning so we may offer our assistance and guidance through the critical issues.

If required, we can visit the proposed range site and provide recommendations based on our evaluation of the potential site. Once building plans or sketches are available, our knowledgeable Account Managers can assess your needs and recommend realistic and cost effective equipment options.

We also offer turn-key installation services. Our field service technicians will assist during installation or can be retained to perform the complete equipment installation from beginning to final inspection. This assures the equipment is installed to specifications and allows the owner to focus on other aspects of getting the facility open for business.

A feature many customers use is our comprehensive Maintenance Service Contract option. The contract can be tailored to provide quarterly, biannual or annual service calls. A range technician will inspect and operate all range equipment during their visit and make necessary adjustments or repairs. A maintenance service contract minimizes the occurrence of major equipment failure and ensures the customer receives the full benefits of their Meggitt Training Systems range equipment.

If you have any questions on the material covered in the Range Design Guide, please contact us at the phone number or email address below. Thank you for your interest in Meggitt Training Systems range services and products, and we look forward to hearing from you soon.
## Indoor Range Design Guide

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About Meggitt Training Systems

Meggitt Training Systems was born from the merger of two industry leaders, FATS® and Caswell International, combining the best in virtual and live fire training systems. Meggitt provides integrated live fire and simulated weapons training for marksmanship, sustainment, and judgmental training including force escalation/de-escalation, use of force, and shoot/no shoot.

With 90 years as a pioneer and leader in the live fire industry, Meggitt Training Systems continues to develop highly tailored solutions to meet firearms training requirements and for today, tomorrow and the future. Our line of range products includes everything required to equip a firearms training facility. This includes sophisticated target and range control systems, a wide array of bullet traps, environmental bullet containment systems, ballistic baffles and guards, virtual simulation systems, and supplementary range equipment.

We are ISO 9001:2000 certified with a longstanding commitment to manufacturing excellence and customer satisfaction. Meggitt continually measures the effectiveness of our processes to ensure quality objectives are being met. Meggitt Training Systems has fielded over 13,000 ranges around the world, including:

- U.S. Department of Justice
- U.S. Department of Energy
- U.S. Treasury Department
- U.S. Federal Reserve Bank System
- U.S. Postal Service
- U.S. Department of Homeland Security
- Federal Bureau of Investigation
- Federal Bureau of Prisons
- U.S. Navy
- U.S. Marine Corps
- U.S. Army
- U.S. Air Force
- U.S. Coast Guard
- Federal Law Enforcement Training Center
- Los Angeles Airport Police, CA
- Chicago Police Academy, IL
- Los Angeles County Sheriff's Dept., CA
- West Point Military Academy, NY
- New York Metro Transit Authority, NY
- Maple Grove LE Training Center, MN
- Cook County Sheriff, IL
- Royal Canadian Mounted Police
- Defense Threat Reduction Agency, Russia
- Ministry of Defense Agency, Saudi Arabia
- Grampian Council Police, Scotland
- Taipei Police Department, Taiwan
- Ministry of Interior Police Academy, Egypt
- Morelos State Police, Mexico
- Australian Federal Police
- Ministry of Defense, UK
- ...and thousands of police departments worldwide
Planning and Design Considerations for Indoor Firing Ranges

Meggitt Training Systems cannot preempt the role of the professional architect or engineer. However, we are happy to pass on the benefits and vast knowledge from 90 years of experience. We can help you determine space requirements, cost considerations, basic and supplementary equipment, and structural specialties based upon your range needs. Meggitt welcomes the opportunity to review customers’ plans and furnish estimates, bills-of-material and specifications.

Shooting ranges present special challenges that need thoughtful planning and consideration. Meggitt Training Systems has designed, built, and installed over 13,000 shooting ranges worldwide. Our extensive experience allows us to better assist you in planning, designing, and equipping your range. Before any realistic planning and design can begin, it must be determined what shooting activity will be conducted in the range. The use of an indoor range can vary from shooting handguns at bull’s eye targets for basic marksmanship training to highly sophisticated tactical training ranges where shooters advance downrange and shoot at close range. The type of range activity and space selection dictates design and equipment considerations.

Space Requirements: The greatest cost in any shooting range is the building and real estate. The cost can escalate if planning is inadequate. For example, if construction or renovation of a building to house the range is done before consulting with a range equipment manufacturer, you may find the structure unsuitable. There may be inadequate space for ventilation, a bullet trap or a target system — any of which could require later modification to the building itself. As a result, space is the first consideration when planning a range.

Basic Length: The majority of indoor shooting activities can be conducted on a range that provides 50 or 75 feet between the firing line and the target line. For law enforcement/security training, a 75-foot range is typically mandatory and may extend to 150-feet for longer target distance applications.

Width of Shooting Points: A 42 to 60-inch wide shooting point is industry standard, but widths down to 36 inches are still acceptable for most shooting activities.

Room Height: A structural ceiling height of 10 to 12 feet is the most effective. Ceiling heights lower or higher than this can be accommodated; however they do present additional costs for ballistic protection, lighting, and target retrieval systems.

Ancillary Areas: Depending on the use of the range, the designer must also make allowances for the range control station, ready room, spectator area, and adequate storage areas. To provide better visibility of the firing line, we recommend that you plan for a raised platform for the range master’s station.
Structural Considerations

In their desire to provide ballistic protection, some range planners have designed highly specialized structures that become unusable for any other purpose. This may not necessarily be of great importance in a municipal range. However, it does impact a public or commercial range building. Meggitt specifically designs shields and guards to contain misdirected shots within the range and maintain ballistic integrity. Range planners should avoid heavy earthen berms and overly thick concrete walls and ceilings in their building design.

Walls: Range walls should be of poured concrete or concrete block filled with cement or grout, not gravel. This type of construction provides maximum noise attenuation and ballistic security. Blocks filled with sand are not recommended as any crack or penetration of the block will cause leakage onto the range floor. For additional ballistic protection, steel plating can be applied to the side walls downrange.

Flooring: The most suitable type of flooring for the range is a smooth, non-absorptive hardened concrete floor from the firing line to the bullet trap. The floor will take a lot of low shots, so a smooth floor results in less erratic ricochets. The firing line and the area behind it are typically covered with vinyl or rubber flooring. Due to environmental considerations, floor drains require filtering systems to collect range contaminate. These systems are typically expensive, so the vast majority of range planners today exclude floor drains and sloped floors from their design.

Ceiling: A slab or precast ceiling is most suitable because it normally requires minimal baffles and guards. Guards are still required for lighting, plumbing, conduit, ducts, or protuberances in the ceiling downrange. Therefore, when using a slab or precast ceiling, the range designer should attempt to route pipes, conduit, etc., on the outside of the range and enter into the range only at the points absolutely required. For other types of ceilings, a series of angled air-space baffles or redirective guards suspended at various locations are usually required. The exact placement is determined by ceiling height, range length, and if any shooting activity will be conducted beyond the primary firing line. Meggitt Training Systems provides these suggested placements and load weight computations to the range planner as a part of the drawing package.

Dividing the Range: Dividing the range into bays should be considered if the range will exceed ten shooting points. Generally a ten-point range will function more efficiently if divided into two bays of five points each; a twelve-point range into two bays of six points, etc. By dividing the range into bays, several advantages can be realized. Among the most significant are:

- Only lighting and ventilation of the shooting bays being used at the time are in operation.
- Range does not have to be completely shut down for maintenance and cleaning.
- Shooters can be separated by type of firearms use or skill level.
- Special training classes may be conducted without interference from others.

A solid or a minimum 8-inch fully grouted block wall is recommended for separating the bays. The type of shooting activities planned for the range will dictate the thickness. The separating wall should be continuous from the front to the rear wall of the range and extend from the floor to ceiling. This is required for range safety, noise reduction and ventilation integrity. Doors between adjoining ranges may be required to meet fire regulations so the range planner should verify this with the local fire department. Spectator area walls separate the firing line from the ready room or lobby area. Bulletproof glass must be specified for the viewing area that is capable of stopping the largest caliber round that will be shot on the range.
**Interior Building Systems**

**Range Ventilation:** An adequate ventilation system accounts for a substantial amount of the cost for interior equipment for a range. Federal and state health standards must be recognized and adhered to when specifying the range ventilation system. Interestingly, the major concern of regulators isn’t as much for the patrons of the range as it is for the employee or range master who will be spending much of their time in the shooting environment. Find out what the regulations are and build to conform. Advice here is to plan for state-of-the-art ventilation equipment rather than risk being forced later to upgrade or totally retrofit an inadequate system at considerable expense.

The Occupational Safety and Health Administration (OSHA) regulation 1910.1025 sets the Permissible Exposure to Lead (PEL) at 0.05 milligrams per cubic meter of air. This standard is based on an eight-hour time weighted average. The National Institute of Occupational Safety and Health (NIOSH) recommends the ventilation system provide an air flow of a minimum of 50 FPM past the shooter toward the bullet trap, with exhaust points located downrange. Range planners must take into account the use of recirculating types of ventilation to provide comfort conditioning or purging-type systems. Meggitt suggests that the range planner utilize the services of a professional HVAC engineer to design the most appropriate ventilation system consistent with current government regulations, and can recommend one on request.

Other ways to mitigate the lead problem include the use of Meggitt’s GranTrap™ rubber bullet trap designed to prevent bullet fragmentation, thus reducing airborne lead dust. Also, by specifying the type of ammunition that may be used in the range, barium pollutants from primers and lead from bullets can be eliminated.

**Range Lighting:** Two types of illumination are required in the range; general and target lighting. General illumination is normally provided by fluorescent fixtures and target lighting consists of incandescent reflector-type lamps. Typically two swivel fixtures are provided at each target stop. The wattage is dependent upon the length of throw, but usually 150 watt lamps will provide the desired 100 mfc at the target face. The lights are placed in a protected area in the ceiling in banks across the range. All lights for each target stop, (i.e., 21-foot line target stop) are on one bank and controlled by a dimmer switch to provide variable light conditions for law enforcement training.

**Noise Abatement:** There are two primary noise considerations in a shooting range; lowering the sound level within the range and preventing the transmission of noise outside of the range. Acoustical applications are of some benefit to lowering the noise level. The walls from twelve feet forward of the firing line to the back wall should be covered with acoustical material. In addition, the horizontal ceiling above the firing line and the front surface of downrange baffles should also be treated. The most widely used material for this application is Class 1 acoustical foam. Check with your local fire department for class requirements.

For additional information, range planners can refer to the Indoor Firing Ranges: Industrial Hygiene Technical Guide. This technical manual was produced by The US Navy Environmental Health Center to provide general information on indoor firing ranges to assist users in recognizing, evaluating, and controlling safety and health hazards inherent to indoor ranges. NEHC TM6290.99-10 Rev 1 May 2002 http://www.med.navy.mil/sites/nmcphc/Documents/policy-and-instruction/ih-indoor-firing-ranges-technical-guide.pdf

The walls, ceiling, and floor surfaces within twenty feet of the bullet trap receive most misdirected shots and should not receive acoustical treatment due to the high frequency of repair that would be required. Any surface downrange of the firing line that does receive acoustical material should have an air-space between the hard and soft surfaces, even if it’s just the thickness of furring strips.

Reducing the transmission of noise to areas outside the range requires close attention to sound leakage. Even small cracks will allow sound to escape, therefore, all openings should be sealed and all doors weather-stripped. Pipes, ducts, conduit, etc. will transmit noise to the outside if not enclosed in heavy masonry. Do not line exhaust air ducts with acoustical material because of accumulating unburned airborne gunpowder.

Doors leading into the firing range are great offenders of noise transmission. For best sound attenuation, two solid-core doors should be installed at right angles to each other to create an air-lock at the range entrance. One of the benefits of installing an environmental rubber bullet trap is the elimination of noise associated with bullet impact and...
deceleration on steel bullet traps. This is particularly important when the range shares a common wall with other occupants of the building.

**Ballistic Security:** Air-space baffles, steel guards, and redirective guards are used to protect protrusions in the range, minimize ricochet threats, and close off the paths that may allow shots to escape. Each device has its own particular function in a range. An air-space baffle is composed of a wood or rubber facing, separated from a steel sheet by a wooden or rubber frame. By separating the surfaces, a misdirected shot will penetrate the front wood or rubber surface and traverse the air space. The round strikes the steel sheet backing and loses its velocity so it is less likely to return to the open space of the range.

The area extending from the firing line to twelve feet downrange is one of the most critical areas in a range where a misdirected shot can compromise shooter’s safety. Utilizing an air-space ceiling system reduces the risk of injury or damage from a vertically directed shot by stopping the path of the round and trapping it in an air-space panel. The air-space panels are suspended horizontally from the ceiling. Typically these panels start at the firing line and extend twelve feet downrange. On occasion, coverage is required behind the firing line and beyond the 12-foot expanse downrange. After installation, acoustical material may be applied to the exposed panel surface to assist in noise abatement.

A series of air-space baffles are often required to protect the ceiling, lights fixtures and pipes located further downrange. The baffles are suspended from the ceiling at a described angle to the floor in intervals determined by ceiling height, range length, and shooting activity. The last row(s) of baffles, immediately in front of the bullet trap, take the greatest number of high shots. Rubber air-space guards should be specified for these baffles in range facilities using rubber bullet traps and redirective steel guards for ranges with steel bullet traps.

Steel guards are often used in place of air-space baffles on flat, slab or precast ceilings. The angled steel guards protect downrange protrusions such as light fixtures, conduit, and ducts from impact and deflect bullets in the direction of the trap. If shooters will be allowed to advance downrange beyond the primary firing line, Combat Walls should be considered for the side-walls of the range. Using the proven design of air-space baffles, a misdirected round impacting the Combat Wall will be safely contained or redirected towards the bullet trap.
Specific Range Types

Determining the type of range to build and specifying the equipment is a function of the planned type of shooting activity that will take place. There are typically four types of indoor range designs; private, commercial, military service, and law enforcement/security training. In many instances, commercial ranges have dual purposes. Normally a range larger than five positions will be equipped to accommodate law enforcement training in one bay and public shooting in the other. The following describes the basic types of ranges and discusses in detail the various items of equipment, including the optional items that can greatly extend the overall usefulness of the range.

**Private:** Included in this category are crime labs, research and test facilities, home ranges, and other low volume applications. The equipment consists of a rubber granular bullet trap and a manually operated or electrically-driven guide wire target retrieval system.

**Military Service:** Advocated for National Guard armories, reserve training centers, and ROTC schools, these ranges are normally 50 feet in length. The firing line and ready area are not separate areas. The equipment consists of a rubber granular bullet trap, shooting stalls to separate the shooters, and a manually operated guide wire target retrieval system.

**Commercial:** The equipment for a commercial range must be rugged, simple to use, and suitable for a wide variety of shooting activities. Equipment typically specified includes a granular rubber bullet trap, electrically driven guide wire target retrieval system, and shooting stalls. If there are plans to conduct law enforcement or security training in the range, the range designer must give consideration to equipping one bay with equipment designed for that application (see description below).

**Law Enforcement:** The range equipment selected for use by law enforcement or security agencies must be flexible to allow precision firearms training, simple mandatory re-qualification, and advanced reactive exercises. In addition, considerations must be made for tactical training situations that often require the shooter to advance downrange and engage multiple targets. A granular rubber bullet trap and combat walls are ideal for this application because they provide a safer range environment for close and cross range shooting.

The target retrieval system must provide turning targets and be capable of being controlled individually by the shooter and from a central range control station. Another desirable target system feature is an on-board target light to allow training under variable light conditions. Shooting stalls with barricades and acoustical blast shields are typically specified for law enforcement ranges.
Range Equipment

Bullet Traps

Every shooting range project presents a unique set of circumstances that must be considered when selecting the bullet trap. Knowledge of the various shooting activities to be conducted on the range is very important. Determining if the range will have a fixed firing line or if the shooters will advance downrange to engage targets will dictate what type of trap is acceptable. In some instances, the bullet trap selection will also be guided by available space in the range. The first steel bullet trap manufactured commercially was the venetian blind type. Venetian blind traps were a great improvement over plate-and-pit backstops and perform satisfactorily for marksmanhip ranges. A series of angled impact plates direct bullets downward into a deceleration chamber where the bullet’s energy is depleted through friction. The trap is free standing and only requires 36 inches of floor space.

Gallery ranges gained popularity for police training more as a result of the introduction of the steel escalator bullet trap than from any other single factor. This trap features a sloping armored plate surface that guides incoming bullets into a deceleration area rather than the rounds hitting the exposed leading edges of the venetian blind trap. The steel escalator bullet trap was proven to be a better alternative and became the industry standard for many years.

During the early 1980’s, federal, state, and local regulations began to increase with regard to lead and its impact on the environment. By then, Meggitt had already begun researching new technologies with the intent of improving overall bullet trap performance. Through extensive research and testing, Meggitt developed the world’s first practical environmental trap to significantly reduce bullet fragmentation and lead dust at the trap area — the rubber lamella trap.

The rubber lamella trap features a patented design of multiple layers of rubber strips suspended from a steel support frame. Bullet velocity of incoming rounds dissipates and is absorbed through friction within the lamellas and the bullet is captured virtually intact. Range applications for the rubber lamella trap include crime labs, residential ranges, and other low volume applications.

After the introduction of the rubber lamella trap, bullet trap technologies evolved into the current and most effective environmental bullet trap, the Reclining GranTrap™. Meggitt holds nine patents on this technological design that created a revolutionary advance in bullet trap performance. Meggitt’s GranTrap utilizes granular rubber as a containment medium.

The rubber granulate material, called GranTex™, is supported by an inclined structure and covered with a self-healing rubber cover. The cover allows projectiles to penetrate into the GranTex while keeping shooting debris and other contaminants out. The GranTrap bullet containment system safely deenergizes incoming rounds and contains them intact with virtually no lead dust or bullet fragmentation. This is ideal for ranges that will be conducting tactical training or firing close range or at acute angles in the range. In addition, Meggitt’s GranTrap is superior in reducing range noise by eliminating bullet impact and deceleration on steel plates.
Shooting Stalls

Shooting stalls organize the firing line into defined shooting positions and provide a location for mounting range support equipment for the individual shooter. They also serve to provide protection for the shooter from adjacent shooting positions by minimizing side blast interference and the hazard of misdirected shots. Each stall should be equipped with a shelf, built-in controls for the target retrieval system and complementary range systems, and provide optional features such as blast shields and shooting barricades.

Meggitt’s bastion shooting stalls are pylon style shooting stalls fabricated of steel and molded ABS, and are edged with tough vinyl bumper strips. The slanted rear edges provide greater cross-range misfire protection along with better visibility of the shooters by the range master.

The large shooter’s shelf features an ample area for holding ammunition and a muzzle stanchion to rest the firearm. When not in use, the shelf can be dropped out of the way by simply unlatching one side. The bastion shooting stall also features a molded alcove that provides a small storage area when the main shooter’s shelf has been dropped. Local target system controls are positioned in the alcove area of the stall so the shooter can see them without turning their head, as is required when controls are mounted on a wall stall.

Meggitt’s clear-view shooting stalls have become the standard for academy style ranges. The divider is a clear ballistic panel that provides the range master with an unobstructed view of the firing line. This is particularly important in ranges when the instructor must monitor and observe the shooting activity at the firing line. Individual range controls are mounted in an enclosure to the left of the shooter.

Target Retrieval Systems

Target retrieval systems provide a convenient and safe method of placing targets downrange without requiring the shooters to leave the firing line. The type of shooting activity planned for the range will determine the appropriate target retrieval system. Law enforcement, shooting sports, and advanced firearms training typically require turning targets for timed fire and reactive skill exercises. If the range is to be used primarily for bulls-eye target shooting, only one or two intermediate target distance stops are necessary, and a manual or electrically driven guide wire system will be adequate.

Meggitt’s hand-crank target carrier is inexpensive, easy to use, and highly efficient. The target is transported manually by turning a hand wheel mounted at the firing line. With minor exceptions, the only place hand-crank target systems are used is when electric power is not available.

The CEB electric trolley wire target system, also referred to as a guide wire driven system, is rugged in design and simple to operate. The CEB target carrier travels along a taut guide wire that is suspended between the firing line and the bullet trap. The shooter controls the forward and return target transport with a control switch mounted in the shooting stall. Target oscillation is not available the CEB trolley wire system.

An overhead steel track provides the platform for Meggitt’s CEE turning target retrieval system. The CEE target carrier travels along the steel track and provides friend/foe target presentation for reactive response and judgmental training. The CEE...
turning target system provide multiple distance target stops and is capable of being controlled by the individual shooter and from a central computer range control system. An optional on-board light illuminates the target when exposed to the shooter and offers adjustable light intensity. This greatly enhances reactive skill exercises for law enforcement training and is ideal for training under variable light conditions.

Meggitt’s latest innovation in target systems is the XWT GEN3 wireless target carrier. The original XWT was the industry’s first wireless, 360º turning target retrieval system. The XWT GEN3 moves along a rail system, powered by an internal direct drive, dual motor system, with anti-static wheels for quieter, smoother operation. It features a rechargeable battery that automatically charges upon return to the home position via a self-docking charge station. The XWT’s unique closed track design provides smooth target transportation and does not collect lead fragments, casings and other debris. The carrier offers speed control options for “Advance / Retreat” type training exercises, and is easily programmable through a wireless controller, allowing uncomplicated intuitive screen operation for even the most complex scenarios.

The XWT GEN3 targets may be directly controlled either at the stall or in the control room through the RangeMaster™ Control System. A variety of maneuvers can be programmed to allow users to engage in an assortment of scenarios, helping them develop skill sets and train more effectively. Basic and advanced user interfaces support the operator's preferred courses of fire, whether basic qualifications or more advanced reactive and decision making shooting exercises. The XWT GEN3 includes 3/8" AR500 Front Armor Plate Prow and features both indoor and outdoor versions, providing a weather resistant system for use in extreme environments.

RangeMaster™ Control System

Target systems can be controlled by an individual control unit located in the shooting stall, from a central control booth, or a combination of these operations. The capabilities of a range control system are dependent upon the type of target system being used. Meggitt’s RangeMaster™ Control System (RMCS) is a menu driven computer system that offers the most efficient and sophisticated controls available for turning target systems.

The RMCS provides numerous control options and programming capabilities. Frequently used training scenarios only need to be entered into the range controller once and assigned a file name. After that, it only requires a few keystrokes to retrieve and execute the training exercise. The training program can also be downloaded to individual control units at the firing line or the range operator can command all of the target lanes or any combination of them as required. The range control computer system should also provide a real-time visual display of range layout and target conditions.

In addition, the tablet option for RMCS puts total control of the range at the range operator’s fingertips. Utilizing state-of-the-art range control software, range personnel can
operate their range via a wireless tablet. The RMCS controls targetry, range security systems, target lighting, and supplemental range systems. Highly sophisticated in function but easy to use, the RMCS satisfies the needs of departments to conduct precision training for the new recruit and advanced training exercises for specialized units.

**Communication Systems**

Audio and visual communication systems enhance range safety and efficiency. Intercom systems, signal lights and security systems allow the range operator and shooters to communicate with each other and be alert to changing safety conditions on the range, without leaving their positions.

An audio system allows the range operator to call, listen, and converse with an individual shooter. Each shooting stall should be equipped with an audio terminal to receive and send voice communications. When the messages concern maintained states, and need to be acted upon almost instantly, the universal method of communication is the use of signal lights. The signal light system is a series of three signal lights in the shooting stall. The red light indicates cease firing. The green is ready on the range and the amber is alert to receive command. The signal system also provides a range master call switch for each shooter. When used, it activates a red light at the shooting stall and at the range master’s control station. When the question or concern has been addressed, the call switch is returned to the normal off position at the firing line.

In conjunction with the signal light system, a firing line security system is recommended. Personnel who regularly shoot in a firing range are aware of normal range procedure in that no one moves forward of the firing line unless it is cleared by the range operator. However, to preclude the chance of an unknowing or forgetful shooter inadvertently advancing beyond the line, a firing line system should be a requirement. A violation at the firing line will trigger an audible alarm and activate all red indicator lights at the firing line and on the range master’s console. The system does not reset automatically, but must be reset by the range master when the violation has been corrected.

In ranges where a full audio communication system is not necessary or desired, a standard paging system provides the range operator with a means of communicating with occupants in the range. Transmissions are delivered through wall-mounted or overhead speakers. Occasionally one-way audio speakers are provided at each shooting stall.

**Advanced Training Systems**

The addition of stress targets for advanced training can expand the usefulness of a range. Pop-ups, running target systems, and other tactical training systems are available both as permanent or portable emplacements. Range operators may want to consider adding law enforcement virtual training systems that offer realistic and powerful video scenarios for marksmanship and judgmental training.

Bringing the best of virtual and live fire training systems together, Meggitt Training Systems FATS® L7 virtual training system can provide a total weapons training capability for marksmanship, sustainment, and judgmental training including force escalation/de-escalation, use of force, and shoot/no shoot.

Contact us at MGTTS-LESales@meggitt.com for further information.
Division of a Range into Bays

During the early planning of a range with ten or more shooting points, dividing the range into bays should be considered. Generally, a range of ten points will function more efficiently if divided into two bays of five points each, a twelve point range into two bays of six points each, and so on. As ranges increase in size, the split into bays may well depend on the multiple uses planned for the range and simultaneous activities conducted. There are several advantages of dividing a range into bays. Some of these include:

- Separate controls for lighting and ventilation systems, saving energy and reducing daily operation costs.
- The ability to clean one bay while others are in operation.
- Repair or routine maintenance while other bays are in full operation.
- Use of big bore “magnum” handguns in one bay while .22 gallery shooters shoot undisturbed in an adjoining bay.
- Conducting special training classes without interference from others.
- Providing one bay to accommodate police and security training while other sport shooting activities are conducted on the adjoining range. This concept allows each bay to be equipped with range systems suitable for a particular shooting activity.

Additional equipment and design requirements of a range separated into bays include:

- A set of sidewall fairings for the bullet trap is required in each bay.
- Construction of the wall separating bays. A solid or minimum 8” full grouted block wall is recommended.
- Individual lighting and ventilation controls for each bay.

General Design Comments

- Walls separating bays should be continuous from the front to the rear wall of the range, and extend from the floor to ceiling.
- A doorway may be provided just ahead of the trap to allow mobility of portable training equipment from bay-to-bay.
- An access door between bays behind the firing line is strongly recommended and may be required to comply with local fire regulations.
- Acoustical material may be applied to walls separating bays.
- A minimum 32” door should be provided to gain access behind the bullet trap.
Safety on the Range

This range design guide is not intended to be your final source of information on the subject of lead exposure, contamination, and range safety precautions. The purpose is to advise you that there are many current requirements, and more can be expected in the future. The best resource is your local state Occupational Safety and Health Administration (OSHA) office. Visit www.osha.gov for more information.

Range operators must make every effort to address safety concerns. The obvious concerns over the years are the direct safety of the shooters and employees that operate the range, specifically:

- The potential loss of hearing by the continued discharge of firearms.
- The hazard of backs platter or ricochet fragments.
- The potential damage caused by excessive exposure to lead contamimates.

Ballistic Safety

Most range owners/operators are fully aware of the fact that if something can be seen, it will be shot. This means the design of the range, be it indoor or outdoor, must be accomplished with the number one objective being care and planning for safety.

Hearing/Sound Concerns

Most experienced shooters understand the need for hearing protection while on the firing line. It is mandatory in most facilities and is the range operators' responsibility to ensure that this policy is enforced.

Eye Protection

Since the typical range has become increasingly complex with more advanced target equipment, additional lighting, and other related "safety" equipment, the hazard of redirected particles, backs platter and ricocheted fragments of bullets have increased the risk of eye and facial injuries. Accidents can and will happen.

With today's ammunition and extensive use of jacketed or semi-jacketed bullets, there is an increased chance that a small particle can return towards the firing line and cause injury to the shooters. The enforcement of a policy requiring the use of shooting glasses or safety glasses is a must. No one should be on the firing line without appropriate safety eyewear!

Lead Exposure

For years, we were not aware of the need to be concerned about excessive exposure to heavy metals like lead. But after years of studies and testing, the problems lead can cause have been pinpointed and are now identifiable. Lead can be a silent killer. It can build up in your body's organs and bones and slowly cause permanent, irreversible damage to your body. In most cases, it is not the shooters that are at risk, but rather the employees that are exposed day-in and day-out to excess levels of lead in a range facility. It is not good enough to just have an adequate ventilation system in your range. The biggest dangers of lead exposure are to the people that must handle the lead cleanup or general range cleanup and maintenance duties.

Whether your range operation is a private, commercial, law enforcement or military type facility, your employees are covered under various laws and regulations that dictate how you will handle safety measures as they relate to lead. It is not acceptable to just supply a cleanup suit and protection mask for the person that cleans up lead materials from
the range. You are required to keep records of tests (air quality and personnel blood/lead levels), provide training sessions, ensure the proper air supply mask fits correctly, and document the amount and disposition of the lead generated and recovered from the range. Some lead is recyclable (from commercial bullet traps and indoor range cleanups), while other lead contaminants are not (from sand berms, filters, [air and water], contaminated ranges, etc.) All lead must be quantified and disposed of in a safe and responsible manner.

Guidelines for the Range Operator:

- Under NIOSH, OSHA and EPA standards, lead is classified as a highly toxic heavy metal.
- Records are required to monitor the air quality of a range.
- It is highly advised to conduct lead safety training programs. Employees must be taught the proper way to handle lead and what to do with the collected lead.
- Training records are required as proof that you have complied with your responsibilities as an employer to ensure a safe working environment for your employees.
- You must supply the proper safety equipment, supplies and direction on how to use these items.
- You must provide a changing area and shower facility to allow your employees to thoroughly wash after exposure.

Again, this range design guide is not meant to be a final document on range safety. It is provided with the expectation that any potential range owner/operator will check with local authorities and government agencies to ensure they are up-to-date on current regulations that apply to their range.

Additional References Available Online

There are many additional resources pertaining to range design that can be viewed on the internet. Some areas to explore include:

CDC – Indoor Firing Ranges
http://www.cdc.gov/niosh/topics/ranges/

Firing Range – Whole Building Design Guide
http://www.wbdg.org/design/firing_range.php

Technical Track: Indoor Range Design - NSSF
nssf.org/ranges/rangeresources/library/NSRS/09TechnicalTrackIndoor/Designcriteria.pdf

NRA Shooting Range Services
http://rangeservices.nra.org/

Range Design Criteria – The Permaculture Project
GranTrap™ Rubber Bullet Trap

Utilizing the latest technology in bullet capture and containment, Meggitt Training Systems’ GranTrap is designed to stop incoming rounds by employing the most efficient, safe and proven practices available in the industry. The GranTrap’s granulated rubber material, GranTex, not only stops bullets, but provides environmental benefits by minimizing airborne dust, ricochets and reducing noise levels. Rounds are safely de-energized and captured predominately intact, providing little-to-no lead dust or bullet fragmentation. With proper range configuration, the GranTrap allows shooters to advance downrange and engage targets at close distances and acute angles.

The GranTrap is constructed with structurally rigid tube steel frames, formed steel stepped bed plates, and covered with GranTex media. All standard models incorporate upper replenishment bins which help maintain proper depths of GranTex media within the primary impact areas -- while providing further ballistic protection and extending time between service intervals. Meggitt’s GranTrap is available in a variety of models to meet the unique needs of each range with all standard models having the following beneficial features:

- Constructed with rigid tube steel support stanchions.
- Engineered with Meggitt’s patented 10 gauge steel “stepped” bed plates which provide greater volumes of GranTex media within the primary impact areas for maximum round collection.
- Incorporates supplemental safety bins to provide additional ballistic protection.
- Capable of capturing handgun and rifle rounds up to 3600 feet per second.
- Designed for rifle capabilities with only a 12'4” footprint, allowing more flexibility with range configuration.
- Available with optional rear access door panels located underneath the trap primary impact areas or “hot spots”.
- Designed to capture up to 75,000 rounds per shooting point.
- Available in standard and custom heights to meet all range requirements.

Meggitt Training Systems can provide assistance to determine which GranTrap model best meets your range application needs. GranTrap model variations include:

**LE7500-OT GranTrap**
- Includes 3/8” AR500 angled armor plate replenishment bin facing to provide additional downrange coverage.
- Engineered with extra-large upper replenishment bins with greater quantity of GranTex media.
- Configured with exposed and uncovered GranTex media.

**LE7500-OTR GranTrap**
- Includes a rubber faced 3/8” AR500 angled armor plate replenishment bin facing to provide additional downrange coverage.
- Engineered with extra-large upper replenishment bins with greater quantity of GranTex media.
- Incorporates gum rubber covers atop the GranTex™ media for cleanliness and containment.

**LE7500-50CAL GranTrap**
- Captures up to 8,100 ft-lbs of energy, excluding incendiary or tracer-type rounds.
- Designed to stop limited single fire rounds with up to 13,000 ft-lbs of energy, such as 50 BMG, with a limited and controlled rate of dispersion and under specific conditions with proper monitoring.
- Installed within a 14’ footprint depth for more flexibility with range configuration, as compared to the 25’-30’ footprint depths required for most steel rifle traps.

All Meggitt GranTraps are available for outdoor applications and engineered to withstand harsh environmental conditions by using non-corrosive materials. Outdoor versions utilize galvanized steel and custom designed structural frames which shed water and condensation for long term durability.

*Detailed specifications for MTSI Products are available. GranTrap™ is Licensed and Manufactured Under U.S. Patent No. 5,171,020; 5,340,117; 5,435,571; 5,607,163; 5,848,794; 5,901,960; 6,000,700; 6,027,120; 6,293,552. Other patents pending.*

**LE5000 Steel Escalator Rifle Trap**

Meggitt Training Systems’ LE5000 Steel Escalator Rifle Trap is a completely dry, all steel scroll-style bullet trap. Meggitt’s advanced engineering ensures each trap component utilizes industry standard steel shapes, sizes, and processes to reduce the customers’ cost without sacrificing safety or performance. The trap supports are made of structural steel for long-lasting durability of the trap’s operation. The trap features:

- Major seam reinforcement by a secondary steel barrier to minimize splatter and dust penetration.
- Side walls in multiple thicknesses, as well as impact plate thickness and widths according to customer needs.

Range environments are improved through the raised and open-throat design of the Meggitt LE5000. By placing a scroll mouth at the height where most rounds impact, dust generation and lower impact plate fragment deposits are substantially reduced. This translates into a cleaner trap, reduced exterior maintenance, and the elimination of vertical supports in the bullet path to prevent lead build up and ricochet. The system contains interchangeable and reversible main trap impact plates for longer service life.

**Ease and convenience**

The LE5000 Steel Escalator Rifle Trap features a bucket retrieval system with a one-handed, no-tools-required unlocking system for quick bucket removal and replacement. Additionally, Meggitt offers the option of a separate lead conveyor and/or trap dust collection system to further contain lead dust for safer, cleaner range air quality. Meggitt’s LE5000 Steel Escalator Rifle Trap offers range durability, minimizes environmental concerns, and is available in a variety of models to meet each customer’s specific needs.
XWT GEN3 Wireless Target Carrier

Meggitt Training Systems offers the Next Generation Wireless Target System (XWT) GEN3 to meet the need for efficient, reliable and user-friendly training systems.

The XWT was the industry's first wireless, 360º turning target retrieval system, and the XWT GEN3 is available in both indoor and outdoor versions, providing a weather resistant system for use in extreme environments. The innovative XWT GEN3 moves along a rail system, powered by an internal direct drive, dual motor system, with anti-static wheels for quieter, smoother operation. It features a rechargeable battery that automatically charges upon return to the home position via a self-docking charge station. The XWT's unique closed track design provides smooth target transportation and does not collect lead fragments, casings and other debris.

Meggitt’s XWT GEN3 pioneering technology provides a host of advantages over other carriers on the market:

- No more drive cables or pulleys to break or replace.
- No bulky and noisy drive motors above the shooters head.
- No track mounted power feed rails or wires to be impacted and damaged.
- No debris in tracks to clean or interfere with target operation.
- Speed control options – making it great for "Advance / Retreat" type training exercises.
- Easily programmable through a wireless controller, allowing uncomplicated intuitive screen operation for even the most complex scenarios.
- Targets are locally controlled using the Lane Controller (LC) or from a control room area using the Primary Master Control Computer.
- A variety of maneuvers can be programmed to allow users to engage in an assortment of scenarios, helping them develop skill sets and train more effectively.
- Basic and advanced user interfaces support the operator’s preferred courses of fire, whether basic qualifications or more advanced reactive and decision making shooting exercises.
- Includes 3/8" AR500 Front Armor Plate Prow.

The XWT GEN3 is the next level of innovative range products available from Meggitt Training Systems. The quiet, smooth, low maintenance wireless carrier is easily operated and programmable, essential for successful training and usability.
XCT Target Retrieval System

Meggitt’s XCT Target Retrieval System offers the ruggedness and stability of a track system with the simplicity of a non-turning target carrier. The XCT target carrier operates on an overhead monorail track, allowing smooth and rapid transport of the target up or down range in increments of feet, yards or meters. The XCT is operated via touchscreen controller at the firing line, and provides a myriad of target commands at the touch of a button. The target carrier may be stopped at any distance from the firing line through the tablet by one of two control methods. The first option allows the carrier to be moved via the “GO” setting by pressing the + button until the desired distance is displayed on the touchscreen controller. The user then presses the “GO” button to send the carrier out to the set distance. The second option features six programmable presets for a variety of range distances and training requirements. Additional features of the XCT include:

- Formed steel monorail track (up to 50 meters) provides a stable platform for target transport
- Durable, low profile target carrier with armored front plate made with 3/8” AR500 steel (armor prow) facing the shooter to limit damage from bullet impacts
- Enclosed drive unit offers easy accessibility to motor components
- Target holders attached to the target carrier for interchangeable offhand, kneeling and prone shooting, and differing types of targets

The XCT target retrieval system is suitable for handguns, submachine guns and shotguns to allow a full spectrum of training and usage by customers. Target carriers are capable of holding bull’s eye to full-size police silhouette targets.

CEB Trolley Wire Target Retrieval System

Meggitt Training Systems’ CEB Target Retrieval System is a fixed speed, electric trolley wire target system. Controlled by the individual shooter, the forward and return target transport is regulated with a shooting stall mounted control switch. In the absence of a shooting stall, Meggitt can utilize the CEA Target Retrieval System, positioning the control switch into the base of the target system’s drive unit. With both the CEB and CEA systems, intermediate target stops are manually set by disengaging the control switch during target transport.

Other features included in the CEB Trolley Wire Target Retrieval System:
- Shooters are afforded independent control of their lane through the E4P individual target control unit, located at each firing position.
- Maximum achievable target distance with trolley wire systems is 25 meters.
- A variety of target holders are available.
RangeMaster™ Control System

Meggitt’s RangeMaster Control System is easy to use, offering instructors and range personnel the ability to write, store and run fully-customizable training scenarios through a master control or wireless tablet. These scenarios can also be downloaded to the individual control units at the firing line or to another controller.

The master control scenario files are easily retrieved and launched, with vivid display delivery of real time range target conditions. The targets are directed to initiate a command to travel, conceal, expose or edge, as directed by the control system. It displays all of the target locations, presentations and other optional features through icons of changing colors and images. Targets are shown in increments of feet, yards or meters.

Meggitt’s master control system can govern any, all, or a combination of lanes with the simple click of the mouse. Enhanced optional systems may be added, including:

- Control of pop-up and secondary target systems to improve the user’s performance in a variety of scenarios.
- Variable range lighting controls for one or multiple lanes to be lit or dimmed at the command of the range operator.
- Security systems for facility lock down and safety while training exercises are in progress.
- Interactive ventilation system interface packages are available.

In addition, the wireless tablet offers advanced touch screen technologies for convenience and flexibility in range operations. Complete system control can be managed through tablets, allowing personnel to leave the control room while maintaining complete control of the range. The tablet’s portability delivers instructors the freedom to interact with shooters at the line and provide immediate feedback and correction.

The wireless tablet utilizes the latest technology in an intuitive, easy-to-navigate manner. Range personnel may choose from multiple options on one screen, including the menu bar, target commands and arrangement. Accepted commands of “friend”, “foe” and “edge” are standard; or optional, random target actuations may be executed. The random commands direct the target to present a complete, unexpected turn to the right or left, in increments of up to 360º, allowing for real life scenarios and enhanced target training.
Lane Control

Individual target control units located at each firing position allow shooters to have independent control of their lane. With just a few keystrokes, shooters can enter a sequence of commands for the target system to perform. The LCD display prompts the shooter during program entry for specific target distances, delay time, expose and conceal times and also communicates operational messages such as target status during program execution.

When a target command requires a numeric entry a prompt message appears on the display and the keypad automatically switches to numeric mode. After the program has been entered the shooter simply presses the “Run” button to execute the program.

If the shooter prefers to not enter a program and wants direct control of target activities, the individual control unit can be switched into direct mode. Target commands entered from the keypad will be performed directly by the target system and will not be saved in the controller’s memory. Most basic target commands are entered with a single keystroke making the control unit simple to use.

The individual control unit is also capable of receiving, storing and executing programs that have been developed and stored in the master control console. Once downloaded, the shooter simply presses the “Run” button to start the program.
Clear View Shooting Lane Dividers

Meggitt Training Systems offers several types of Clear View shooting lane dividers, in both pistol and rifle versions. The lane dividers can include features such as wing barricades, full gate barricades, acoustical blast shield extensions to further shelter adjacent shooters and a swing down shooters shelf. The shooters shelf features a resilient surface, raised edges to prevent accidental drop off, and a recessed tray area.

The target system individual range controls are conveniently mounted in an enclosure to the left of the shooter and a spent brass receptacle is located on the stall to the shooter’s right. The Clear View stalls provide enhanced visibility between lanes, enabling the shooter a more comprehensive environmental view.

Bastion Shooting Lane Dividers

Meggitt Training Systems offers several types of Bastion shooting lane dividers, in both pistol and rifle versions. Bastion dividers are constructed of a double wall steel liner enclosed in a molded – Black in Color - ABS shell. The lane dividers include features such as wing barricades, full gate barricades, acoustical blast shield extensions to further shelter adjacent shooters, and a swing down shooters shelf. The shooters shelf features a resilient surface, raised edges to prevent accidental drop off, and a recessed tray area.

The target system individual range controls are conveniently mounted in an enclosure to the left of the shooter and a spent brass receptacle is located on the stall to the shooter’s right. The bastion shooting lane dividers provide a more contained lane experience. This provides shooters with greater privacy and less exposure and distraction from external situations.
Ballistic Baffles and Guards

The area extending from the firing line to twelve feet downrange is typically one of the most critical areas in a range where a misdirected shot could compromise shooter’s safety. To reduce the shooter’s risk of injury, Meggitt’s Air-Space Ceiling System is comprised of mixed layered panels, strategically engineered to contain a misdirected round.

The mixed-material layered ceiling panels are designed to contain misdirected shots via the wood facing, containing them within the air space chamber after striking the steel backing plate. This prevents the bullet from exiting the panel or returning to the open range area.

The air-space panels are suspended horizontally from the ceiling structure, starting at the firing line and extending downrange the distance desired—specific to the customer’s range design. After installation, acoustical material may be applied to the panel surfaces to assist in noise reduction. Meggitt offers a variety of range containment and redirective panels in various sizes and thicknesses (pistol through rifle rated), pending the specific range design needs.

Air-Space Baffle, Model JA4
- The ceiling, lights, ducts, pipes and range equipment are protected downrange by a series of angled air-space baffles.
- Suspended from the ceiling at prescribed angles to the floor, intervals are determined by ceiling height, range length and shooting activity.
- To complement the Meggitt Training Systems’ drawing package, load weight computations and suggested baffle placements are provided.

Rubber Air-Space Guard, Model JA8
- The rubber air-space guard is typically utilized for the furthest downrange panels nearest the rubber bullet trap.
- The panels are suspended vertically from the ceiling structure at a prescribed angle

Steel Redirective Guard, Model JR5
- The redirective “bare steel” guards are typically utilized for the furthest downrange panels nearest the rubber bullet trap.
- The guard shelters the ceiling area and redirects rounds toward the bullet trap. Panels do not utilize any facing/acoustic materials.

Steel Light Cove Guard, Model JR7
- The “bare steel” light cove guards are typically utilized for ranges that have a smooth/flush concrete ceiling structure.
- The light cove guard protects the light fixtures, pipes, columns, and other ceiling obstructions. Panels do not utilize any facing/acoustic materials.
- All standard panels are available in 10-gauge, 3/16” AR 225, ¼” AR 500, 3/8” AR 500, and ½” AR 500.
Communication Systems

Audio and visual communication systems enhance range safety and efficiency. Intercom systems, two-way radio headsets, signal lights and security systems allow the range operator and shooters to communicate with each other and be alert to changing safety conditions on the range.

Audio Communication
With an audio communication system, the range operator can call, listen and converse with an individual shooter, a select group, or all shooters in unison by simply pressing a selector button on the master station. The master station console contains a channel selection panel, a talk/listen release switch, an All Call button and volume controls for outgoing and incoming communications. The console is available with an open voice speaker or a handset to provide listening privacy and diminish background noise. Open voice communications from the master station simply requires the range operator to engage the talk/listen switch - *push to talk, release to listen*. When the master station is provided with a handset communications are initiated through voice activation.

Each shooting station has an audio terminal in the shooting stall to receive and send voice communications. A call tone alerts the shooter of a transmission from the range operator. The shooter responds simply by speaking - hands free. To contact the range operator, the shooter momentarily depresses the call button on the terminal. An electronic tone is heard at the master station and the corresponding LED channel selection will light up on the master station. The audio communication system is available with 10, 20, 30 or 40 channels. Optional features available on the 10 channel system include remote activation of devices such as lights, alarm contacts, surveillance cameras, video monitors and door releases.

Electronic Headset
The headset has built-in electronics to allow sounds at normal dB levels, such as voice communications, to be heard. Noises that exceed safe dB levels are blocked. When an external noise exceeds safe dB sound levels, the electronic amplifier shuts down to protect the shooter’s hearing. The wearer can adjust the sound level to their hearing comfort with the volume controls located on the earmuff.

Firing Line Security System
The firing line is monitored by a photoelectric system for indiscriminate movement forward of the line. A violation will trigger an alarm to alert all range occupants of the intrusion. In addition, a security violation will automatically edge the targets and halt further target movement on ranges equipped with a XWT wireless target retrieval system. The alarm and red signal lights remain active until the violation has been corrected and the range operator resets the system. Optionally, sensors can be connected to doorways that lead into the range to activate an alarm when movement is sensed.

Range Condition Signal Light System
In conjunction with the firing line security system, a signal light system is recommended to enhance range safety. Located on the shooting stall, the signal lights provide shooters with a continuous visual indication of range conditions.

The system consists of three colored lights (red-amber-green), a rangemaster call switch, and a control at the range operator’s control console. The red signal light indicates to shooters to *stop firing*, the amber light warns shooters to be *alert* for a condition change, and the green light signifies the *range is clear*. The range operator selects the condition light for the full range from the master control console. When the signal lights are interfaced with the firing line security system, a security violation at the firing line will activate the red signal lights at all shooting positions. The lights will remain red until the range operator resets the system. In circumstances where a shooter at the line needs the attention of the range operator, the shooter activates the rangemaster call switch that is mounted on the shooting stall. This action simultaneously flashes the red signal light at the stall and provides an indicator on the range operator’s console.
Technical Bulletin

The Reclining GranTrap™

Background

During the early 90’s, Meggitt Training Systems began researching various new technologies with the intent of improving overall bullet trap performance. The ultimate goal was to design an environmentally friendly bullet trap that would lead the firearms industry well into the next century. Through extensive research, development and testing, a granular rubber medium (GranTex™) was selected as the best choice for such a trap. GranTex showed certain energy absorbing characteristics needed to keep the bullet intact while safely de-energizing incoming rounds. One component of GranTex used a recyclable rubber product which kept within the company’s environmental policies. This media had a relatively low cost, keeping the overall bullet trap price very reasonable for our customers.

The first Reclining GranTrap design was introduced with a straight back plate mounted on angled stanchions. GranTex was then tested for its natural “angle of repose”. This was one of the determining factors for the angle used in the placement of the back plate (tiered/stepped bedplates). Further testing and “in field” usage revealed the benefits of tiered bedplates, which transferred the weight directly to the floor through the support stanchions.

Although the need to separate the spent lead shot from GranTex on the GranTrap is infrequent, one more improvement was made to the Reclining GranTrap. Meggitt Training Systems added sliding access doors to the tiered bedplates that allows for easy access and removal of concentrated spent rounds. With the intermediate removal of spent rounds though the access doors, the need for complete recycling of the trap is greatly reduced, if not eliminated. The Reclining GranTrap was prototyped with thorough and rigorous testing, both, in our research and development facility, and through practical use in the field. The Reclining GranTrap is a product that has evolved to become a simple, straightforward solution for the problems facing the shooting industry. Meggitt Training Systems was issued the first patent on this technology in 1992 and has subsequently received eight additional patents.

Performance and Environmental Impact

The following performance evaluation is a synopsis of independent testing that was performed on the Reclining GranTrap at the Naval Surface Warfare Center located at Crane, Indiana. A performance specification was developed specifically for Reclining GranTrap, as this technology was not covered by Mil-Hdbk 1027-3A. The rigid specification required the trap to decelerate and contain all handgun rounds, as well as rifle rounds, including .50 cal. The specification also included this environmental requirement, “The Bullet/Bullet Containment Trap System shall contain all lead particles and contaminated material within the trap system. No atmospheric release of lead or other contaminants shall occur from within the trap system.”

The testing and evaluation of GranTrap began on April 20, 1998 and ended on April 27, 1998. Over the course of the week, six different types of weapons were employed. The handgun rounds were shot from the MP5 submachine gun (9mm) and the MK-23 pistol (.45 cal.) The rifles used were M-14 (.308 or 7.62 NATO), M-16 (.223 or 5.56 NATO), Model 500 A2 shotgun (12 gauge), and SASR (.50 cal.). A total of 20,608 rounds of the above calibers were shot into the Reclining GranTrap at a rate of 500 rounds per hour. In addition 2,530 rounds of similar calibers were shot into test cells that had been installed at the six shooting positions of the range. These test cells were then removed and x-rayed to determine the penetration depth and dispersion of various calibers, as well as condition of the spent rounds.

The results of the test cells were as follows: The 9mm and .45 cal. ammunition stopped at depths within the range of 14” to 17”. The 5.56 NATO and 7.62 NATO ammunition stopped within a 16” to 24” range. The 12 gauge rifled slugs penetrated approximately 18”. The .50 caliber round stopped between 30” to 37” of depth. The final conditions of the rounds were as follows: The 9mm and .45 cal. remained mostly intact. The 5.56 NATO round entered the trap and tended to break-up as this is the design of the bullet. The 7.62 NATO and 12 gauge rifled slug had slight deformation while the .50 caliber tended to shed their jackets as designed. All caliber rounds showed signs of horizontal and vertical dispersion as well as tumbling.
One test cell was used to characterize the effects of tracers on GranTex. Twenty rounds of 5.56 NATO and twenty rounds of 7.62 NATO tracer ammunition were fired at the test cell at a distance of 75 yards. This distance allowed the tracer to ignite prior to impact with Reclining GranTrap. No ignition of GranTex occurred when the fully ignited tracer round entered the trap. It became apparent to all the engineers present that insufficient heat, along with the confined space and limited supply of oxygen, allowed the tracer to burn without igniting the rubber granulate. To further test temperature, a thermal imager was used throughout the testing period. The temperature was observed to gradually increase from ambient to the maximum temperature recorded during sustained fire. The maximum temperature recorded at the point of entry of each round was 155 degrees F, well below GranTex's flash point of 573 degrees F. The temperature quickly decreased before the next round entered the trap.

During the second phase of testing, five guns were concentrated on one point of GranTrap in order to increase the rate of fire. The objective was to generate an extreme, or worst case scenario, for GranTrap with regard to frictional heat build-up. With this increase rate of fire, the trap would also experience an increase in the amount of rounds at a given point. This allowed for a "quick" look as to capacity at that position of the trap. The rate of fire approached 250 rounds per minute at a maximum temperature of 145 degrees F, measured at the point of impact. With the additional 9,000 rounds fired into that position, there was no noticeable difference in the appearance of the bullet trap or the GranTex material.

Throughout the testing of GranTrap, the range ambient air was monitored for airborne lead. Afterwards, the air monitoring equipment was removed from the firing line positions and the trap locations for further analysis. The filters were sent to the industrial hygiene center located on base. In all, five pumps were used for sampling of the airborne lead. Three pumps were located above the monorail target system at Reclining GranTrap at positions 2/3, 3/4 and 4/5. The last two pumps were located at the firing line above shooting positions 2/3 and 4/5. A 60 minute collection test was performed on April 22, 1998 as 2,660 rounds of 7.62 M80 ammunition was fired. The data collected showed 948.6μ g/m3 of lead present at the bullet trap, while 1109.7μ g/m3 was present at the firing line. The data collected and tested CLEARLY indicated that there was no lead or lead dust generated at the bullet trap. Meggitt Training Systems Reclining GranTrap does, "...contain all lead particles and contaminated material within the trap system. No atmospheric release of lead or other contaminants shall occur from within the trap system".

Summary

Meggitt Training Systems Reclining GranTrap successfully passed the ballistic and environmental performance criteria set forth in the Government's Performance Specification for the Naval Surface Warfare Center located at Crane, Indiana. The bullet trap evaluation was so successful the indoor range was certified as full automatic fire and .50 caliber capable. This rating was realized because the bullet trap contained all rounds that were fired at point blank range as well as at acute angles of fire. During testing, there was absolutely no backspatter or ricochet observed. A secondary benefit realized from Reclining GranTrap, in addition to its environmental performance, was the elimination of the noise associated with impact and deceleration of bullets on steel bullet traps. GranTrap also reduces the vibrations in the floor/ foundation that are created from the energy being transferred from a steel trap to any of the supporting structures. This was another positive benefit, as the office personnel that share a common wall with the range at Crane can attest.

Conclusion

The Navy's formal acceptance of Meggitt Training Systems Reclining GranTrap was on May 26, 1998. The official test results used in this report, as well as the performance specification, can be obtained through Meggitt Training Systems at 296 Brogdon Road, Suwanee, GA 30024, phone 678-288-1090.
Terminal Ballistics

Many users of bullet traps do not know what to expect from them. Under estimates and over estimates are common and both can prevent the best utilization of the traps. When particles of lead are found on the floor of a new range, these questions always arise: "Is this trap safe? Is it installed properly? Is it an efficient trap? How close can we shoot? What safety precautions should be taken?" This discussion attempts to provide answers to these questions.

With steel traps, most bullet particles found on the floor do not come from the bullet trap. The majority of lead particles found on the floor of a gallery range are created by bullets striking target carriers, target holders, and target transport systems. Even the shaving of lead by revolvers must not be overlooked as a source of particles. We often hear a range officer proudly proclaim that nothing whatsoever escapes from his trap. That can only be interpreted in one of two ways. Usually it means that he is satisfied that nothing dangerous escapes from his trap. The other interpretation is that the range receives so little use that he is not aware of the escaping particles. Unfortunately such remarks create an erroneous idea about bullet trap performance. When one expects 100% efficiency and discovers a piece of lead the size of a half-dollar at the firing line, alarm is understandable.

It is now possible to build a bullet trap so no lead particles can return towards the shooters from the bullet trap. Meggitt's GranTrap is one such bullet trap. The trap is made from heavy steel support sheets which support the loose GranTex, rubber particles about 1/2-3/4” in size, and is covered by a thin gum rubber curtain on the top. This patented design allows all bullets to enter the soft trap surface and be totally contained in one piece in the soft rubber media. This means no bullet particles can breakup and return towards the shooters.

Range operators should be concerned with three (3) kinds of particles; backspatter; ricochet; and "floor sliders". The latter is also called "skidders", "bounders", "skippers", plus various unprintable terms. The term "slider" is also applied to bullets that are fired into the walls, ceiling or floor and travel along these surfaces, leaving long streaks. In this discussion the term "slider" relates only to returning bullet particles. Backspatter and ricochet particles travel under the initial energy imparted to the bullet. In contrast, floor sliders travel chiefly from gravitational energy. Except at very low velocity when a bullet hits an impenetrable object point blank, it is entirely broken up into particles that go off in a 360° pattern. As the impact surface is tilted away from vertical, more and more of the mass continues in the approximate direction that the bullet was originally traveling. In a steel bullet trap, these are the large pieces of lead that result.

However, some of the bullet particles always leave the 360° cone pattern, and are the particles that comprise the backspatter. The exact amount and pattern is a function of many variables including the bullet alloy, the angle of the plate, and the velocity of the impact. It is too complicated for further discussion here. Let it suffice that the measure of ballistic efficiency is the relationship of the quantity of large massive pieces as compared to the quantity of fine dust and small shavings in the lead debris. For shooting range considerations, ricochet is considered to be any rebounding particle that is capable of inflicting property damage or bodily harm. Thus, a backspatter particle could be considered ricochet if it traveled in the direction of the shooters, and if it contained sufficient energy to do harm.

Fortunately, the greater the energy in a particle, the greater the tendency for it to follow the originally aimed path of the bullet; i.e., in the direction of safe containment. The lower the energy in a particle, the more likely it is to behave as a billiard ball, and after a series of rebounds to get back to the firing line. Most people are surprised to learn that it is the relatively low velocity particle that can be the potentially dangerous ricochet.

By providing surfaces that will interrupt those particles that are traveling in a direction that could conceivably get back to the shooter, backspatter particles are prevented from becoming ricochets. In an escalator type trap, these surfaces are the sidewall fairings, the floor fairings, and the diversion plate. In a venetian blind type trap, the principal method is the anti-splatter edge that is provided along the leading edges of the impact plates. The closer these backspatter interrupting members are located to the areas of bullet impact, the more backspatter they will catch. That is why under ideal conditions a venetian blind type trap results in slightly less backspatter on the floor than an escalator type trap.
Unfortunately, in practical use the anti-splatter edges themselves receive a proportional share of the incoming bullets. Thus, instead of being the principal backsplatter eliminating feature, they become backsplatter and ricochet generating problems themselves.

The longer travel those backsplatter particles make, the larger proportion will pass over the various members intended to stop them. A very wide trap will result in more backsplatter particles escaping than a narrow trap. However, even in a five or six point trap, bullets fired into the lower extreme right or left side will result in noticeably more backsplatter escaping than those fired into the center or anyplace higher up on the trap. Not so obvious, however, is the effect of the overtrap fairing. If the overtrap fairing is relatively short because of a low ceiling or ceiling baffle system, very little backsplatter results from the high shots that hit it. If the overtrap fairing is as long as it frequently is in a high ceiling range without a baffled ceiling system, it is inevitable that many bullets will hit its upper surfaces. This will result in backsplatter, some of which may end up on the floor. Where as in the use of an environmental bullet trap like the GranTrap, the range can be particle free from backsplatter and ricochets from the bullet trap. The bullets will not come back out of the soft rubber media and return towards the shooters. This is the safer design to consider.

**Floor Sliders - A Nuisance**

Floor sliders are particles that have been properly enervated by the bullet trap but for some reason have not followed the usual course through the trap. Although they are numerically fewer than backsplatter particles, they usually receive more attention because some of them may be very conspicuous. Propelled by gravity they come sliding down the face of the trap. Sometimes a particle will roll as a cartwheel. Usually they are not symmetrical and will make successive rebounds until they have jumped clear of the floor fairing and/or sidewall fairing and escaped.

Once out of the steel trap, they may slide a long distance before coming to a halt. This is aggravated by two features of good range design. It is desirable to have the floor fairing at only a slight angle to the floor so that low shots that are sliding along the floor are efficiently directed into the trap proper. Of course, this makes an excellent ski jump for the particles coming back down and landing on the top of the floor fairing.

Second, for ease of housecleaning, good ranges have well finished floors. Thus, they are veritable skating rinks for the returning sliders. Although this is most noticeable for the large particles, it applies also to the small particles that escape. The slighter the angle of the floor fairing and the better the finish of the floor, the further back towards the firing line some of these particles will be found. The sprinkling of backsplatter particles found on the floor of an active range is not cause for alarm. The main thing that they indicate is that the range is in use. Potential danger lies in the true ricochets.

**Ricochets – The Real Danger**

Theoretically, a bullet striking a flat surface perpendicular to its line of travel will break up into backsplatter. However, any irregularity in either the bullet or the plate can cause ricochets. Whenever bullets are split by leading edges, some ricochets are inevitable unless the edge can be permanently maintained in a sharpened condition. Similarly, any steps in the trap members upon which bullets may impinge during their course through the trap may also cause ricochets. It should not be overlooked that irregularities in the bullets themselves are a frequent cause of ricochets.

In view of the fact that bullets are regularly reported to have ricocheted off of wood into which they were expected to imbed, it is not surprising that some ricochet particles occur from bullets fired into bullet traps. Therefore, it can never be assumed that any bullet trap is 100% safe. The primary concern is the protection of the eyes. A ricochet particle too small and low in energy to break the skin is still capable of injuring an eye. **Shooting glasses are mandatory!** Low velocity jacketed ammunition such as the .45 caliber ACP usually leave their jackets intact and occasionally these bounce out of the traps as sliders. Higher velocity jacketed bullets such as the 9mm and semi-automatic cartridges usually have the jackets torn apart by the impact. Because the jacket particles are relatively light and have relatively high air resistance, they do not always follow the intended course for the lead.

The sharp edges of these particles make them particularly dangerous. This is why shooting should take place from as far away from the face of a steel bullet trap as is practical, a twenty-five foot minimum is mandatory.
What Will It Take?

The most frequently question asked of a steel bullet trap is, "What will it take (i.e., what can it withstand)?" Virtually any commercial area type bullet trap will "take" all conventional handgun, rim fire rifle, shotgun and submachine gun ammunition. "Conventional" ammunition is considered to have bullets primarily composed of lead. They may be partially or entirely jacketed with gliding copper. However, they may not contain any hard materials such as steel or zinc. Obvious exclusions are all armor piercing or metal piercing ammunition, all center fire rifle ammunition (except those traps specifically designated “RIFLE”), and all steel shot such as BB's.

Important Note: For best results, do not restrict any Meggitt Training Systems steel bullet trap to .22 caliber rim fire ammunition. The scouring action of heavier loads is beneficial to them. The better alternative to the steel bullet trap is the GranTrap. It will safely handle all types of bullets, including frangible and non-toxic bullets, from .22 caliber and up to 50 caliber on specified models. The bullets are safely soft captured in the rubber media inside the bullet trap.

Steel Bullet Trap Maintenance

Maintenance on steel traps is very simple and does require special techniques or protection devices for employees or technicians. Lead collection pans must be emptied before they overflow and the floor in their area must be kept clear of lead debris. Failure to do this defeats the benefits of this method of lead collection.

No matter how tightly a trap is bolted together, the constant pounding may cause some fasteners to loosen. On Meggitt Training Systems traps none of these are exposed to direct hits. Therefore, the trap should be inspected from behind no less than four (4) times a year. All loosened fasteners must then be tightened and the trap inspected for signs of malfunction that might have resulted from loosened parts. If any fissures have developed, the escaping particles will abrade the surfaces above and behind the trap. All such walls, ducts, etc., should be examined. If unchecked, escaping particles can cut through masonry surfaces. Concrete block walls are particularly vulnerable.

If eroded surfaces are discovered, Meggitt Training Systems should be notified. We will gladly make recommendations for the correction of the problem. The use of a respirator and disposable suits and gloves are required whenever performing trap maintenance. This is particularly true if only one person performs this work and/or he is also an instructor, competition shooter or reloader.

Rubber Trap Technology

Meggitt Training Systems has addressed backsplatter, ricochet and environmental problems with its GranTrap bullet traps. Instead of the use of friction, deformation and heat to remove the bullet's energy, these traps absorb the bullet's energy. These designs essentially capture the bullet whole and little or no deformation occurs. As in the steel escalator or venetian blind type traps, weekly inspections are required. The rubber pieces and the granular rubber levels will need to be inspected from time-to-time, but no loosening of hardware should occur.

Summary

Even in an efficient and well-installed escalator or venetian blind type trap, some backsplatter particles can be expected on the floor. Furthermore, it is not unusual for an occasional floor slider to travel nearly the full length of the range. However, there should be no airborne particles from the trap to the firing line when using soft-nose ammunition. When using jacketed ammunition, there may be such particles and caution is advocated.

The vast majority of backsplatter particles and ricochet in an active range are caused by bullets hitting the structure and other equipment rather than from the bullet trap. There is no way to anticipate the compound ricochets that are possible. These do send potentially hazardous particles back to the firing line. Therefore, the universal rule that everyone on the range wears eye protection during shooting must be strictly enforced.
Proper maintenance is required for safety as well as for convenience in use. The chief acts are keeping the lead tray area clean on steel traps, regular inspection of the back of the trap, and checking the rubber granular level on rubber composite traps. The matter of lead poisoning has not been exaggerated. Anyone with above average exposure to lead particles, whether instructor, competitor, reloader, or maintenance person, should have regular checks for lead. Usually if a build-up is detected, it is easily alleviated before any harm occurs. Finally, when in doubt, contact Meggitt Training Systems. We are glad to help in any appropriate manner.
Guidelines for Designing an Indoor Firing Range Ventilation System

Introduction

A properly designed indoor firing range ventilation system introduces adequate airflow into the range to ensure that lead contaminated air is quickly removed from the shooter’s breathing zone. Dependent upon the range’s geographic location and code requirements, supply air is tempered to provide comfort to the shooter during firing. The American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE) and the National Institute of Occupational Safety and Health (NIOSH) recommend that a minimum of 50 fpm (feet per minute) be supplied at the firing line with 75 fpm being optimum; that downrange air flow conveyance through the range be at least 35 fpm; and that the ventilation exhaust capacity should exceed supply capacity by at least 10%. Air distribution at the supply diffuser/airwall is also a very critical consideration; a laminar wall of air needs to be provided evenly at the firing line.

Ventilation Supply and Exhaust Capacities

A common rule for estimating ventilation system requirements is to use a cross section area of the range; the width multiplied by the height of the range at the firing line, multiplied by the velocity required at the firing line in feet per minute (fpm). To determine ventilation supply and exhaust capacities, utilize the following formula:

\[ \text{cfm} = \text{width of range} \times \text{height of range at the firing line} \times \text{velocity at the firing line in feet per minute (50 fpm is minimum with 75 fpm as optimum)} \]

\[ \text{cfm} = \text{cubic feet per minute required on the supply side} \]

Once the supply capacity in cfm is determined, utilize the following equation to determine the exhaust capacity.

\[ \text{ec} = \text{cfm} \times 1.1 \]

\[ \text{ec} = \text{exhaust capacity in cubic feet per minute} \]

The reason exhaust capacity needs to exceed supply capacity is you want to create a negative pressure in the range proper. In another words, air tends to enter the range from adjacent areas. Negative pressure serves two purposes. First, it provides the pull to move contaminated air from the firing line down range and out through the exhaust ducting, and secondly, it does not allow contaminated air to escape into other adjacent areas. A new exhaust system should come complete with HEPA filtration. Currently, there is a standard for lead emissions outlined in the Clean Air Act of 10 tons per year from a stationary point source. Some states have lowered this level down to ½ a ton per year. In most cases, a range would not exceed the federal level at any given point, however, those ranges that do not filter their air will have to clean up the lead deposits found outside the building at some point. Utilizing HEPA filtration prevents this exterior contamination. It is pay me now or pay me later. The more prudent thing to do is to incorporate HEPA filtration into the exhaust system.

Air Distribution

Design of the diffusing system is also critical. The most widely used and successful method of diffusing air behind the firing line is through an airwall. An airwall is basically a perforated plenum, floor to ceiling, spanning the backwall the entire width of the range. Supply air should be fed evenly into the plenum at the ceiling. The duct-work diffusers into the airwall should be evenly balanced. The airwall is typically 12 to 16 inches in depth and perforations should be ¼
inch in diameter centered every 1 inch. The distance from this airwall to the firing line should be at least 10 feet, optimally 15 feet. The reason this is critical is that air is turbulent and needs time to stabilize. Depicted below in Figure 1 is an example of an airwall section. Improper air distribution, even with adequate velocities, can lead to shooter overexposure. Air distribution is often overlooked in the design of the system. This one factor is the most critical part of the total system design.

Current Ranges

The previous discussion is based on current industry standard ventilation system capacity design and is most utilized to design ventilation systems in new firing ranges. In ranges where there is an existing system that does not meet the current criteria as determined by a qualified firm performing tests and measurements during a live shoot, other options can be used to offset complete ventilation system replacement which can include:

- Administrative Controls - limiting time spent in the range.
- Other Controls - use of target return systems.

Summary

Proper ventilation system design is not for amateurs and should be developed by a competent qualified firm with actual range ventilation design and installation experience. A mechanical engineer and a certified industrial hygienist should be involved in the development of the design and installation. For more information on testing, design and installation of a current and new indoor firing range ventilation system, contact Meggitt Training Systems.
Lead Implications in Indoor Ranges

Introduction

Any person who frequents, uses, or maintains a range may be exposed to lead by merely being at the range. The Occupational Safety & Health Administration (OSHA) has set standards for exposure to airborne concentration of lead and has established maximum concentrations for lead in the bloodstream. Likewise, the Environmental Protection Agency (EPA) has established national primary and secondary ambient air quality standards for lead.

Overexposure to lead is poisonous and can cause serious health effects. To protect people from exposure to lead in indoor ranges, owners and operators need to evaluate and determine typical exposure to lead during the various unique activities that occur in the range itself. Having this exposure information will allow range owners and operators to determine if people are being adequately protected. It also serves to assist in identifying administrative and engineering controls and work practices that will assist in reducing exposure back to safe levels. This guide serves to provide background information on lead and its effects on the body as it pertains to poisoning through overexposure and its impact on indoor firing ranges.

Background

Pure lead (Pb) is a heavy metal at room temperature and pressure and is a basic chemical element. It can combine with various other substances to form numerous lead compounds. Exposure to lead occurs in several different occupational categories in indoor ranges including users, range masters, trainers, maintenance personnel, and others who may use or frequent an indoor firing range.

Exposure to lead in indoor and outdoor firing ranges is primarily caused by airborne lead. Airborne lead is produced during firing from various sources including lead styphnate in the primer, melting of the bullet base by hot gases, shavings produced as the bullet leaves the casing and travels through the barrel, and bullet fragmentation at the backstop. OSHA has established a permissible exposure limit (PEL) of 50 micrograms of lead per cubic meter of air (50 μg/m³), averaged over an eight-hour workday. Furthermore, OSHA has established an action level of 30 micrograms of lead per cubic meter of air (30 μg/m³). The action level triggers several ancillary provisions of the OSHA standards such as exposure monitoring, medical surveillance and training.

When absorbed into your body in certain doses, lead is a toxic substance. The object of the OSHA lead regulations is to prevent absorption of harmful quantities of lead. Lead can be absorbed into your body by inhalation (breathing) and ingestion (eating). Lead cannot be absorbed through your skin. When lead is scattered in the air as a dust, fume, or mist, it can be inhaled and absorbed through your lungs and upper respiratory tract. Inhalation of airborne lead is generally the most significant source of occupational lead absorption. Lead can also be absorbed through your digestive system if lead gets into your mouth and is swallowed. If range personnel handle food, cigarettes, chewing tobacco, or make-up, which may have lead in them, or handle them with hands contaminated with lead, this will contribute to ingestion.

A significant portion of the lead that is ingested gets into the bloodstream. Once in the bloodstream, lead is circulated throughout the body and stored in various organs and body tissues. Some of this lead is quickly filtered out of the body and excreted, but some remains in the blood and other tissues. As exposure to lead continues, the amount stored in the body will increase if you are absorbing more lead than the body is excreting. Even though people may not be aware of any immediate symptoms of disease, this lead stored in your tissues can be slowly causing irreversible damage, first to individual cells, then to your organs and whole body systems.

Long-term overexposure to lead may result in severe damage to the blood-forming, nervous, urinary and reproductive systems. Some common symptoms of chronic overexposure include loss of appetite, metallic taste in the mouth, anxiety, constipation, nausea, pallor, excessive tiredness, weakness, insomnia, headache, nervous irritability, muscle and joint pain or soreness, fine tremors, numbness, dizziness, hyperactivity and colic. In lead colic there may be severe abdominal pain. Damage to the central nervous system in general and the brain (encephalopathy-acute
exposure) in particular is one of the most severe forms of lead poisoning and is a result primarily of large acute exposures to lead. The most severe and often fatal form of encephalopathy may be preceded by vomiting, a feeling of dullness progressing to drowsiness and stupor, poor memory, restlessness, irritability, tremor, and convulsions. It may arise suddenly with the onset of seizures, followed by coma and death.

There is a tendency for muscular weakness to develop at the same time. This weakness may progress to paralysis often observed as a characteristic "wrist drop" or "foot drop" and is a manifestation of a disease to the nervous system called peripheral neuropathy. Chronic overexposure to lead also results in kidney disease with few, if any, symptoms appearing until extensive and most likely permanent kidney damage has occurred. Routine laboratory tests reveal the presence of this kidney disease only after about two-thirds of kidney function is lost. When overt symptoms of urinary dysfunction arise, it is often too late to correct or prevent worsening conditions and progression to kidney dialysis or death is possible.

Chronic overexposure to lead impairs the reproductive systems of both men and women. Overexposure to lead may result in decreased sex drive, impotence and sterility in men. Lead can alter the structure of sperm cells raising the risk of birth defects. There is evidence of miscarriage and stillbirth in women whose husbands were exposed to lead or who were exposed to lead themselves. Lead exposure also may result in decreased fertility and abnormal menstrual cycles in women. The course of pregnancy may be adversely affected by exposure to lead since lead crosses the placental barrier and poses risks to developing fetuses. Children born of parents either one of whom were exposed to excess lead levels are more likely to have birth defects, mental retardation, behavioral disorders or die during the first year of childhood. Overexposure to lead also disrupts the blood-forming system resulting in decreased hemoglobin (the substance in the blood that carries oxygen to the cells) and ultimately anemia. Anemia is characterized by weakness, pallor and fatigability as a result of decreased oxygen carrying capacity in the blood.

**Health Protection Goals for Ranges**

Prevention of adverse health effects for most indoor firing range users, maintenance personnel, and others who frequent the range from exposure to lead throughout a working lifetime, requires that the person's blood lead level (BLL, also expressed as PbB) be maintained at or below forty micrograms per deciliter of whole blood (40 ug/dl). The blood levels of range users, maintenance personnel and others who frequent the range (both male and female) who intend to have children should be maintained below 30 ug/dl to minimize adverse reproductive health effects to the parents and to the developing fetus. Some studies suggest that BLLs below twenty-five micrograms per deciliter (25 ug/dl) are necessary to avoid adverse health effects.

The measurement of blood lead levels (BLL) is the most useful indicator of the amount of lead being absorbed by the body. Blood lead levels are most often reported in units of milligrams (mg) or micrograms (µg) of lead (1 mg = 1000 µg) per 100 grams (100g), 100 milliliters (100 ml) or deciliter (dl) of blood. These three units are essentially the same. Sometime BLLs are expressed in the form of mg percent or µg percent. This is a shorthand notation for 100g, 100 ml, or dl. (References to BLL measurements in this document are expressed in the form of ug/dl.) BLL measurements show the amount of lead circulating in the blood stream, but do not give any information about the amount of lead stored in the various body tissues.

BLL measurements merely show current absorption of lead, not the affect that lead is having on your body or the affects that past lead exposure may have already caused. Past research into lead-related diseases, however, has focused heavily on associations between BLLs and various diseases. As a result, your BLL is an important indicator of the likelihood that a person will gradually acquire a lead-related health impairment or disease.

Once blood lead levels climb above 40 ug/dl, the risk of disease increases. There is a wide variablity of individual response to lead, thus it is difficult to say that a particular BLL in a given person will cause a particular affect. Studies have associated fatal encephalopathy with BLLs well below 80 ug/dl. The BLL is a crucial indicator of the risks to a person's health, but one other factor is also extremely important. This factor is the length of time the person has had elevated BLLs. The longer a person has an elevated BLL, the greater the risk that large quantities of lead are being stored in the organs and tissues (body burden). The greater the overall body burden, the greater the chances of
substantial permanent damage. The best way to prevent all forms of lead-related impairments and diseases -- both short term and long term -- is to maintain your BLL at least below 40 ug/dl.

Employers have the prime responsibility to assure that the provisions of the OSHA regulations are complied with both by the company and by individuals. Personnel who frequent ranges, however, also have a responsibility to assist their employer in complying with the regulations. Range users, maintenance personnel and others who frequent ranges can play a key role in protecting their own health by learning about the lead hazards and their control, learning what the regulations require, following the regulations where it governs a person’s own actions, and seeing that employers comply with provisions governing his or her actions.

Environmental Protection

Emissions of lead into the environment can be detrimental to both human health and to the environment in general when those emissions exceed natural background levels prevalent in the area as well as when they exceed levels established by the Environmental Protection Agency (EPA). The EPA regulates ambient air quality and disposal for inorganic lead. The EPA under the authority of the Clean Air Act (42 U.S.C. 7409, 7501) has established national primary and secondary ambient air quality standards for lead. This standard is 1.5 micrograms per cubic meter (ug/m³), maximum arithmetic mean averaged over a calendar quarter. This standard is primarily aimed at ensuring that ambient air in the geographic area adjacent to and in the proximity to a lead emission source is not in excess of 1.5 ug/m³. The standard was originally directed at large industrial lead smelting operations, and other operations involving the mining, production, and smelting of lead and lead compounds.

Emissions of lead from firing range ventilation systems eventually enter the ambient air in the geographic area adjacent to and in the proximity to a ventilation system exhaust. If these emissions are less than 1.5 ug/m³ at the emission source of the ventilation system, then it is not possible to exceed the ambient air quality standard as a result of the lead emitted from the indoor firing range via the ventilation system. In any instance, most ranges should be equipped with high efficiency filtration systems. Range owners and operators can insure they are adequately meeting these standards by conducting tests that establish source emission airborne lead levels and/or ambient air lead levels. These tests will determine if the ventilation filtration system is adequately filtering, which in turn, identifies the extent in which the environment is being protected.

Lead bullets generated during firing are typically trapped and collected at the base of a bullet trap. This spent lead if handled and packaged properly is exempt from the requirements under the Resource, Conservation, and Recovery Act (RCRA-EPA 40 CFR 261). Not all lead dust and lead waste streams can be recycled. An example would be a ventilation filter. With these materials, special testing is required to determine if the wastes are hazardous as defined by current EPA regulations. The EPA specifies that the Toxic Characteristic Leaching Procedure (TCLP-EPA SW-846) be used to classify by-product lead wastes to determine if they are hazardous under current regulatory definitions. Under current federal law, a TCLP test result of 5 mg/l or greater will classify the material as hazardous under RCRA.

Summary

Exposure to lead in indoor firing ranges can be minimized and controlled through awareness, proper ventilation, medical surveillance, administrative controls, and work practices and procedures. Critical to controlling this manageable problem requires that owners and operators understand lead and its impact on range operations. Verifying existing range conditions is the first step to take to identify the impact of lead in the range. This includes ventilation evaluation and airborne lead testing during range use and operations, a review of existing maintenance practices and procedures, and a review of general range procedures. From this effort, range modifications, medical surveillance programs, work practices and general range operations procedures can be modified, developed and instituted to minimize exposure to lead. For more about airborne-lead management, including useful guidelines to help you get the lead out of your range environment, visit the National Association of Shooting Range’s website, www.rangeinfo.org.
Firing Ranges - The Airborne Lead Hazard

Exposure to lead dust and fumes at the firing range can present a potential health risk to shooters, firearms instructors and other range employees. Protecting the health of range employees and shooters, while minimizing environmental contamination from lead exposures, is an important element in the safety plan for firing ranges.

How does lead affect the body? Adults can be exposed to lead by breathing in lead dust or fumes from shooting or work activities, by eating, drinking or smoking in work areas, or by handling contaminated objects - and accidentally swallowing lead dust. Workers and shooters in many firing ranges have so much lead in their bodies that they are slowly being poisoned. The symptoms may hardly be noticeable at first. But over time, lead can damage the brain, blood, nerves, kidneys and reproductive organs. This damage can cause serious disability: memory loss, extreme tiredness, emotional problems, even kidney failure, coma or death. Young children are especially affected by lead. Lead dust can collect on clothes during the day. When those clothes are worn home, the lead can contaminate shooters' and workers' cars and homes, thereby exposing young children to lead-contaminated dust.

What are the signs of lead poisoning? There are many symptoms or signs that suggest a problem with lead, but they can also be symptoms of other illnesses. It is also possible to have lead poisoning without noticing any symptoms. If you work around lead you should regularly see your doctor, whether or not you are experiencing the following symptoms:

Early Signs and Symptoms
- Fatigue
- Headache
- Uneasy stomach
- Sleeplessness
- Irritability or nervousness
- Metallic taste
- Poor appetite
- Reproductive problems

Later Signs and Symptoms
- Aches/pains in stomach
- Memory problems
- Constipation
- Muscle and joint pains
- Nausea
- Weak wrists or ankles
- Weight loss
- Kidney problems

Lead Dust in a Firing Range
- Exploding primers containing lead stynphate and the friction from lead slug against the gun barrel create airborne lead.
- High lead dust levels can accumulate inside indoor ranges with inadequate ventilation.
- Slugs hitting the bullet trap, walls, floors, or ceiling of the range also create lead dust.
- Airborne lead dust can concentrate in outdoor ranges, depending on weather conditions.
- Spent bullets and settled dust can contaminate both indoor and outdoor ranges.
- Improperly cleaning the range also can cause settled dust to become airborne.
Steps to Minimize Lead Absorption

- Make sure the range is correctly ventilated and that the ventilation system is working properly.
- At the range, wash your hands and face before eating, drinking or smoking.
- Wash hands and face before leaving the range.
- Wash range clothes separately from the rest of the family’s clothes.
- Always load bullets in a ventilated area.
- Do not load bullets in the home or in areas where children frequent.
- Do not allow children into the bullet loading area.
- Keep the bullet loading area clean by using detergent.

Outdoor Ranges

Airborne lead dust is a concern in outdoor ranges and can contaminate the surrounding environment. Lead dust exposure to employees or shooters can occur. Lead contamination in an outdoor environment can occur through water runoff and from wind carrying the lead offsite. The process of removing spent bullets, or the face of a berm, can generate large quantities of lead dust. Bullet traps or steel backstops, similar to those constructed in indoor ranges, can be used instead of earthen backstops. Although the initial cost may be high, the spent bullets can be recovered and sold without soil removal. The trap holds the bullets and fragments, minimizing the amount of lead pollution in the soil.
Sound and Noise

Sound

For purposes of this presentation, sounds are vibrations in the air that can be sensed by the auditory nerves of the human ear. Sound is the result of pressure changes in air caused by vibrations. The amplitude (height of the sound waves) is stated in terms of sound level (decibels dB), and the rapidity of the waves generated is the sound's frequency in cycles per second (hertz Hz). The third factor of sound is duration, or the time pattern in which it occurs. Sound level in decibels is a logarithmic rather than a linear measure of the change in air pressure with respect to a reference pressure level. For example, an increase of 3 dB represents a doubling of sound energy and an increase of 10 dB represents a tenfold increase. The human ear perceives a 10 dB increase as a doubling of loudness.

The human ear has a wide range of response to sound amplitude. Painful sound is 10 million times greater in sound pressure than the lowest audible sound. In decibels, this 10 million to 1 ratio is expressed logarithmically as 140 decibels.

Sound pressure levels of two sounds cannot be added. For example if a sound of 70 dB occurs with another sound of 70 dB, the total is 73 dB. Consequently, multiple firearms being fired would not increase the loudness of the sound. Another important aspect is the duration of the sound, and its distribution over time. Continuous sounds do not vary over time, such as a waterfall. Intermittent sounds are interspersed with quiet times, i.e. the ringing of a telephone, or the over flight of an airplane. Impulsive sounds are of high sound levels with very short duration such as a pistol shot, or clapping of the hands. Fluctuating sounds vary in level over time such as traffic noise on an interstate highway.

Sound spreads from its source in ever-widening spheres. You can visualize this by using the image of waves on water that are created when you drop a rock into it. Sound waves travel in a three-dimensional sphere. It radiates from its source in all directions. Obstacles, weather, terrain, and distance can affect sound waves. Sound waves can also be reflected and absorbed.

Noise

Noise is sound that is not wanted. It may be loud, disagreeable, objectionable, and hazardous. The duration and level of the noise, and its frequency determine the effects of noise. High level sounds that are long lasting tend to damage hearing and are generally most annoying. High frequency sounds are more hazardous and annoying than low frequency sounds. Sound distribution over time is also important. Intermittent sounds are less damaging to hearing. Intermittent and impulsive sounds tend to be annoying because they are unpredictable.

Objectionable levels of sound are usually not quantified because they are subjective in nature. It is unwanted, untimely and annoying. Water dripping in the tub at night is a good example of unwanted noise. Several factors have been found to influence people's reaction to noise and include:

- Duration of noise and frequency of occurrence
- Time of year (windows open or closed)
- Time of day
- Outdoor noise level in area (ambient noise) when intruding noise is not present
- History of prior exposure to noise source.
- Attitude towards the noise source
- Presence of tones or impulses

Factors that have been associated with annoyance noise include interference with communication and sleep disturbance, disruption of one's peace of mind, and the enjoyment of one's property.
Measuring Sound

The EPA has adopted a system of four "sound descriptors" to summarize how sound is heard and measured, and to determine the impact of noise on health and welfare.

"A-weighted sound level": Sound is measured by a sound meter. The "A" scale on a sound meter approximates the sound received by the human ear. It compares well with hearing damage and annoyance from noise. People hear sounds more readily when the sound energy occurs at frequencies between 1000 and 6000 Hz. The sound meter measures this energy in decibels and is indicated as dBA.

"Sound Exposure Level Ls": This measures the sound's change from moment to moment, as sound itself constantly varies. This varied duration measurement combines the maximum sound level with the length of time during which the sound level is greater than a certain number of decibels below the maximum level. One can then measure the total energy of the sound by summing the intensity by the exposure duration.

"Equivalent Sound Level Leq": This measurement quantifies the noise environment as a single value of sound level for any desired duration. This descriptor correlates well with the effects of noise on people.

"Day-Night Sound Level Ldn": This is the A-weighted equivalent sound level for a 24 hour period with an additional 10 dB imposed on the equivalent sound levels for night time hours of 10 p.m. to 7 am.

Summary

- (dBA) Decibels, or a-weighted sound level to describe a sound
- (Ls) Sound exposure level to describe noise from a varied source
- (Leq) Equivalent sound level to measure average noise levels
- (Ldn) Day-night sound level to describe average residential sound levels throughout the day and night

Other definitions include:
- (TWA) Time Weighted Average. Usually the amount of time is shown first such as 8hour TWA which would be an average of sound readings over an 8 hour period
- (REL) Recommended Exposure Limit. The maximum time one should be exposed to the noise

Noise Sources

Road traffic noise is the leading source of community noise. In residential areas, most noise comes from transportation, construction, industrial, and human and animal sources. It can be highly variable. Day- Night (Ldn) sound levels in different areas can vary over a range of 50 dB. Outdoor levels in wilderness areas occur as low as Ldn 30 to 40 dBA, and as high as Ldn 85-90 dBA in urban areas. Most urban dwellers live in areas of Ldn of 48 dBA and higher. Rural residents enjoy lower sound levels generally lower than Ldn of 50 dBA. Job workplace equipment can create moderate to extremely high noise levels. Some examples of sound levels are:

- 42 dBA Whisper at 3 feet
- 63 to 65 dBA Normal speech at 3 feet
- 70 dBA City street
- 70 dBA Vacuum cleaner at 10 feet
- 80-90 dBA Dog barking at 10 feet
- 60-92 dBA Helicopter at 500 feet
- 88-98 dBA Train at 50 feet
- 90 dBA Interstate traffic
- 120 dBA Propeller plane on take off
- 125 dBA Threshold of pain
- 130 dBA Jet plane at 100 feet
While sports shooting, peak sound pressure levels at the ear can range from about 110 dBA to more than 170 dBA. Firearms shooting produces two types of noise: the report from the muzzle of the firearm, and the sonic boom (crack) produced by some bullets breaking the sound barrier. Any bullet that travels faster than 1080 feet per second will create a sonic boom. A study “Annoyance Caused by Noise from Shooting Ranges” (Journal of Sound and Vibration) concludes that the threshold for small arms noise annoyance occurs about 60 to 65 dBA.

**Health Issues**

Hearing loss is one of the most obvious and quantified effects of exposure to noise. As it develops slowly over time, a person can suffer hearing loss before it is noticed. Noise is the most common form of sleep disturbance. Sleep disturbance is a critical factor of noise-related annoyance complaints. Intermittent and impulsive noise is more disturbing than other noise types. After effects of sleep disturbance, include mood changes and reduction of performance. Noise affects humans as a stressor. One after-effect of noise exposure is reduced tolerance for frustration. Noise exposure has been implicated in other health problems from hypertension, psychosis, high blood pressure, increased prescription drug use (tranquilizers, sleeping pills, antacids, and cardiovascular).

**Various Standards**

All measurement levels are made at the area to be impacted (receptor). No standards are based on noise measured at the property line of the project (source).

**NATIONAL RIFLE ASSOCIATION**
- Do not exceed an outside level of 65 dBA more than 8 hours out of 24. No night shooting from 10 pm to 7am

**US EPA PROTECTIVE NOISE LEVELS**
- Yearly Ldn Values that Protect Public Health and Welfare
- Hearing Leq (24-70 dBA). All areas at the ear
- Outdoor Activity
  - Interference and annoyance Ldn <55dBA Outdoors in residential areas and farms where people spend varying amounts of time in which quiet is a basis for use
  - Interference and annoyance Leq(24)<55dBA Outdoor areas where people spend limited time such as playgrounds
- Indoor activity
  - Interference and annoyance Ldn<45dBA Indoor residential areas
  - Interference and annoyance Leq(24)<45dBA Indoor areas with human activities
  - To protect against hearing damage, one's 24-hour noise exposure at the ear should not exceed 70 dBA

**US FEDERAL AVIATION ADMINISTRATION**
- Do not exceed Ldn of 65 dBA

**US FEDERAL HIGHWAYS ADMINISTRATION (Includes ADOT and MCDOT standards)**
- Do not exceed 57 dBA Leq outdoors in quiet areas
- Do not exceed 67 dBA Leq at the exterior of a home or other public outdoor areas
- Do not exceed 72 dBA Leq at developed lands or properties
- Do not exceed 72 dBA leq at developed lands
- Do not exceed 52 dBA Leq in the interior of a home
- Must use abatement procedures where traffic noise is 15 dBA or higher than ambient neighborhood noise
- Provides funds for use to purchase "noise easements"
US HOUSING AND URBAN DEVELOPMENT
- 55 dBA Ldn average is optimum
- Do not exceed outdoor level of 65 dBA over 24 hrs Time Weighted Average
- Add 10 dBA to measurements made from 10 pm to 7 am
- Measurements are made 2 meters from house

US NIOSH (NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH)
- Do not exceed 85 dBA over 8 hour Time Weighted Average

US OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION
- Do not exceed 90 dBA over 8 hour Time Weighted Average.

Abatement

Inverse Square Law: Because sound pressure is logarithmic rather than linear, for every doubling of the distance from the source, the sound pressure levels will be reduced by 6 decibels over a free field. Note: a “free field” is defined as a flat plane with no obstructions. For example: If the first measurement is 1.25 feet from the muzzle of a rifle. Distance in feet

<table>
<thead>
<tr>
<th>Distance in feet</th>
<th>Decibel Level</th>
<th>Distance in feet</th>
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</table>

- A quarter mile is 1320 feet (approximately 128 to 72)
- A half mile is 2640 feet (approximately 128 to 66)
- A mile is 5280 feet (approximately 128 to 60)
- Note: these figures represent sound pressure traveling over a free field. This is the minimum reduction. Any obstructions will increase the amount of decibels lost.

Attenuation

The disruption of sound pressures waves which reduces sound is called attenuation. **Excess attenuation** is the additional attenuation gained by factors other than distance over a free field. Some engineering measures that have been used by shooting ranges to attenuate noise are:

- Purchasing of sound buffer areas, vegetation screening, depression or elevation, sound baffling, acoustical walls, earthen berms, acoustical tiles. Administrative measures include: limiting the hours of shooting, limiting the types of firearms and ammunition used, agreements with local residences, purchase of noise easements, and zoning.

Vegetation has been measured to reduce sound pressure as a reduction of 5 to 10 dBA for every 250 meters of grass, up to 23 dBA for every 100 meters of shrubs 3 dBA for every 100 meters of bare trees, and up to 23 dBA for every 100 meters of evergreen woods. These figures are approximate and the local attenuation depends upon types of vegetation and terrain.
For total sound reduction, the distance attenuation and excess attenuation would be combined. As a rough example (from our sound attenuation table above), traveling 320 feet over a free field drops the sound to 86 dBA. If this sound traveled 100 meters (328 feet) over shrubs, an additional 23 dBA reduction could occur, dropping the sound to 63 dBA. Depressing a range below the ground level by 12 feet will yield from 7 to 10 dBA attenuation at all distances. Elevating a range will yield between 2 to 10 dBA up to 100 yards, after that, no change. Non porous walls can attenuate sound up to 52 dBA. Buildings can attenuate sound between 15 and 20 Dba (outside measurements).

Locating a range in an area with high ambient noise and no residences within a half-mile will also provide a noise barrier. This technique is practical only if zoning does not change to residential. The costs of sound surveys conducted by commercial acoustical engineering companies vary considerably depending on the depth and intensity of the study.

References: The study was prepared by the AZ Joint Legislative Committee on Firearms Safety and Shooting Sport Ranges
DP65 “Running Man” Pursuit Moving Target System

Meggitt Training Systems’ DP65 Pursuit System (“the Running Man”) is designed for both permanent and portable applications. The target carrier and drive components simply slide onto the track for easy set up and dismantle. This makes the system ideal for training situations when dedicated range space is not obtainable or at unsecured ranges. For permanent range installations the track can be secured to a concrete pad, mounted to a ballistic wall, or suspended from the ceiling at the target line.

The hand-held range control unit operates on 120-volt AC power. It allows the operator to control target speed, direction, and start/stop functions. Target speed can be set from 0 to 100% and direction of travel can be changed at any time, whether the target is in motion or stationary. Meggitt’s DP65 Pursuit System provides one target carrier and offers the option of adding a second carrier for tandem operation on a single drive unit. The DP65 Dual Target Pursuit System provides two target carriers than run independently of each other, simultaneously. Each target assembly has its own drive unit that mounts easily to the end of the beam track.

The DP65 Pursuit System can be integrated with other range equipment. Features of the DP65 Pursuit Target System include:

- Variable target speed controller
- Dynamic braking
- 30’ i-beam track included - can be extended to 100’
- Ground-mounted, wall-mounted or suspended from ceiling
- 120-volt AC powered
- Single or dual target systems available

360° Turning, Pop-up Target

The 360° Pop-Up Turning Stationary Target movements are precise, dynamic and respond quickly to commands to expose, conceal, slice, and turn in any combination. It is equipped with a highly accurate hit sensor that detects, responds to and reports hits, making it suitable for any scenario. Meggitt Training Systems' 360° turning target system provides a unique ability to expose from multiple angles with a friend or foe target. It can respond to shooter actions or a pre-programmed scenario, ensuring that the trainees do not anticipate target actions, and providing a realistic environment for specialized training.

The pop-up turner unit is electromechanical, lightweight and portable, so it can be easily transported or stacked for storage. In addition to the standard pop-up target commands of expose and conceal, the turning pop-up target can turn a full 360°, slice or swing-out to expose friend or foe. Each target holder has an embedded hit sensor that responds to a range of munitions. Target hit sensitivity is remotely set from the range controller to be consistent with the ammunition being fired. The pop-up turner is capable of operating as an individual unit or in groups. One or more hits on one target can cause all targets in the group to fall or otherwise respond as commanded.
Technical Specifications:

- Communications Systems: Hard Wired
- Hit Sensing Up to 600 hits/minute
- Actuations and Hit Modes: Expose, Conceal, 360 degree Rotation, Hit-Hold, Hit-Fall, Hit-Bob, Hit-Stop
- Variable Hit Sensitivity Remotely Adjustable With Fifteen Settings
- Expose/Conceal Time: .5 Second
- Turn time 90 degree .33 Second
- Maximum Target Weight 10 pounds
- Target Size: Holds multiple target sizes
- Power Supply: AC Power 115 VAC/230 VAC 50Hz power
- Weight of Unit 66 lbs. (30kg)
- Dimensions with target holder in the concealed position:
  - Height 7" (18 cm) – Width 20" (51 cm) – Length 20" (51 cm)
- Dimensions with target holder in the exposed position:
  - Height 12" (30 cm) – Width 20" (51 cm) – Length 16" (41 cm)
- Operating temperature range: -20F to +120F (-29C to +49C)
- Non-operating temperature range: -40F to +140F (-40C to +60C)
- Additional equipment required for normal use and operation:
  - RangeMaster™ Control System
- Pop-up turner is also available as a Moving Personnel Target

Pop-up Target System

Meggitt Training Systems Pop-up Target exposes and conceals an E, F or 3-D target and is available in either hardwire or battery powered versions to allow great flexibility in range design and usage. The system is electromechanical and does not use compressed air. The units are lightweight and portable, so they can be easily transported or stacked for deployment or storage.

The Pop-up Target System performs all of the standard target commands such as expose, conceal, hit-fall, hit-hold, and hit-bob. The target actuator is also available with a double or triple target arm to present multiple targets simultaneously. Each target holder has an embedded impact hit sensor that responds to a range of munitions. Target hit sensitivity is remotely set from the range controller to be consistent with the ammunition being fired. The Pop-up Target is capable of operating as a master target or slave target.

Up to 100 individual Pop-up Targets can be assigned to a group and will respond in-unison to commands from the range control station. One or more hits on one target can cause all targets in the group to fall or otherwise respond as commanded. Each target within a group retains its own unique address and is also capable of reacting to commands individually. No cabling is necessary to interconnect target mechanisms in the master/slave configuration. With more than 19,000 units successfully fielded, Meggitt’s Pop-up Target System has proven to be reliable in even the harshest climates and environmental conditions.
Pneumatic Target System

Each pneumatic target actuator is independent and requires an air supply and electrical signal for operation. Compressed air is supplied through a main tube that branches through a “T” to a supply tube for each actuator. A range interface unit provides a low voltage control signal to the target turner.

The expose/conceal position and the actuation speed settings are factory set but can be adjusted in the field to be consistent with the weight and size of the target. All internal components are protected from the elements by a removable housing. Any number of target actuators can be linked together and controlled individually, in unison, or sequentially.

Delta Turning Target System

Delta turning target system consists of a series of target stands linked by connecting tie rods to a single drive unit to assure all targets expose and conceal precisely in-unison. The target stands are secured to a concrete pad or suitable foundation and can be sheltered by a berm or other ballistic guard. Delta turning target system is suitable for both indoor and outdoor ranges.

Timed target turning is controlled by a range course timer that can selectively control up to six banks of targets. The range timer is portable and weatherproof to provide mobility for the range operator.

Other configurations are available for permanent placement in a control room or tower. Expose, conceal, and pre-course delay times are set in one second increments from zero to 999 seconds. The course can be programmed to repeat up to 999 times.

When powered on, the range timer automatically loads a preset training course from its internal memory. The current course settings are displayed in the LCD display, and if acceptable, the user simply presses a key to execute the course. This means that a course only needs to be programmed once.

If a new training course is desired, the user simply enters different time and cycle values. The LCD display provides operator prompts to help the user through each programming step. Targets can also be exposed and concealed manually from the range timer when no course is running.

- Model AD20: One drive unit, up to 10 target stands with U-hoop target frames. Slip-on target backers for the target frames are available to accommodate paper targets.
- Model AD10: One drive unit, up to 24 target stands with 2x2 wood frame target holders.
Single Turning Target System with Hit Sensing

Meggitt Training Systems’ Single Turning Target System (Model AA2) improves live fire training through unpredictable, fast-action target presentation to the shooter. Easily programmed to randomly maneuver the target holder to the left, right, or in 90 degree increments up to 360 degrees, the system may also present a complete, unexpected turn at the direction of a predetermined scenario. The ability to rotate a target up to 360 degrees in random directions ensures the shooters target actions are not anticipated, providing a realistic environment for specialized training. The highly accurate hit sensor detects, responds and reports hits, and responds to the received hit sensor signal, making it suitable for any training scenario. The system also provides a myriad of range scenario opportunities:

- May be programmed with the RangeMaster™ Control System to a variety of hit scenarios, including conceal, conceal and expose, or conceal after a predetermined numbers of hits are received.
- Through a series of pull-down menus or pre-written scenario scripts, the RangeMaster™ allows manual and programmed control of the Single Turning Target System.
- Targets are controlled individually, simultaneously, or sequentially, with the RangeMaster™ monitor providing a graphic representation of the range layout a real time display of target conditions.
- Fabricated from ¼” AR 500 armor plate, the target holder consists of two jaws, including a fixed jaw welded to the target holder shaft and a movable jaw fastened to the fixed jaw by a heavy-duty spring-loaded hinge. The highly accurate hit sensor simply clips to the top edge of the target silhouette.
- Aggressive teeth inside the target holder pierce the target, securing it firmly in place to allow the use of a variety of target backing materials.
- Ceiling or ground mount options and slim profile allow for an extensive variety of placements throughout any firing range.

Special Purpose Bullet Containment

Safe-N-Clear™ Clearing Trap

Safe-N-Clear provides a secure and safe method for checking a firearm when loading or unloading. It is an ideal safety measure for police stations, firing ranges, correctional facilities or any other location where firearms are handled. The chamber of the Safe-N-Clear is filled with a thick bed of GranTex, a granular rubber material that will safely de-energize and contain a round. A reinforced rubber screen secured across the trap opening provides a slot for muzzle insertion and serves as a protective barrier against backsplatter. In the event of a discharge, the round is captured in the GranTex material and is securely contained inside the Safe-N-Clear. Safe-N-Clear is a floor model clearing trap so it does not require a stand or special mounting hardware. Model LE1213 accommodates rounds fired at 2000 fps and 2200 ft/lbs muzzle energy and Model LE1216 Rifle Model will withstand rounds at 3600 fps and 3600 ft/lbs muzzle energy.
Ballistic Projectile Recovery System

Forensic labs find it easier to match and analyze bullets because of the simplicity, safety and capabilities of our Ballistic Projectile Recovery System. It provides a safe and reliable method for recovering spent bullets that are free of surface damage for use in forensic examinations. The ballistic tank is made of sturdy 10-gauge stainless steel and has external measurements of 36” inches wide by 101.5” inches long and 50.5” high. A raised walkway encompasses one end and a sidewall of the tank to provide easy access when recovering projectiles. For safety and sure footing, a resilient, all weather rubber coating is applied to the surface of the walkway.

The tank is filled with chlorinated water that is circulated and filtered by a pump. In addition to keeping the water clear and removing algae, the water pump creates turbulence to break the surface tension and reduce the chance of bullets skipping over the surface. The pump and filter only need to be operated during shooting or at least thirty minutes a week when the tank is not in use to keep the water free of algae growth. Ventilation ports in the tank allow lead, unburned powder and gases to be vented externally. After firing into the tank, the operator can retrieve the round through an access door on the top of the tank. An interior light illuminates the tank so a round can be easily located and retrieved.

Live Fire Subsystem

Meggitt Training Systems Live Fire Subsystem provides customers the ability to train on the FATS L7 virtual simulation system using live fire weapons. The Live Fire Subsystem includes a self-healing screen that integrates directly into the training system and uses the same video software and courseware used with Meggitt’s laser-based weapons.

The Live Fire Subsystem includes a commercial self-sealing rubber display screen with shot position determined by microphones, and position transmitted to the simulator via an interface box. The Subsystem supports the entire scope of firearms training to improve accuracy and speed, develop and build decision-making skills, and acquire weapon handling techniques and procedures.

- **Composition.** The Live Fire Subsystem is made of natural rubber. When a bullet strikes the screen, the hole that remains is only a fraction of the size of the bullet.
- **Screen Durability.** The self-healing screen can withstand up to 100,000 rounds without serious deterioration. During video training, shots are typically fired at varying locations on the screen (i.e. larger area), which should slow down screen deterioration. Even when shots are fired in a smaller area, the screen maintains impressive durability.
- **Shot Detection Technology.** The Subsystem uses acoustics to determine the position of the round hit. The accuracy of the live fire subsystem is +/- ½ inch.
  - The screen consists of two parts: a front screen of 5mm thickness and a rear screen of 3mm thickness.
  - The rear screen does not stop bullets, and is made of the same material as the front screen.
The space between the two screens acts as a sound chamber so that the array of eight (8) microphones can record the sound when the bullet passes through.

- **Supported Gun/Ammo Types.** The Live Fire screen can be used with a variety of customer live fire weapons, from revolvers to submachine guns, with firing rates up to 800 rounds/minute. The Live Fire screen is constructed using self-sealing rubber.

- **Screen Size.** The Live Fire screen size is 6.5 x 6.0 feet. Due to the aspect ratios of the displayed video scenarios being different than that of the live fire screen, the very top portion of the screen is not used.

- **Ballistic Protection.** The Live Fire Screen utilizes armoured plating that attaches to the screen base frame for overall frame protection. A polyethylene covering is placed over the armour plating to trap the bullet and prevent ricochet.

- **Screen Portability.** The Live Fire screen can be easily rolled into position for live fire training with the FATS L7, and then moved out of the way when laser-based, simulation weapon training is desired. Once in position, the system can be quickly and easily calibrated.

- **Screen Repair.** An optional patch kit is available for screen repairs.

- **Limitations.** The Live Fire System is optimized for training one person at a time, but can train additional officers simultaneously with minimal adjustments.

- **Subsystem Components.** The Live Fire Subsystem includes a commercial live fire screen and an interface box that associates the live fire screen to the system.

### BlueFire® Weapon Simulators

Megitt Training Systems originated wireless weapons technology with BlueFire weapons – smart weapon simulators that look and perform exactly like their live counterpart. The innovative BlueFire weapons replicate the fit and function of live weapons using wireless communications, and provide the same accurate, real-time training diagnostics as tethered weapon simulators.

The user is afforded a broader range of motion as BlueFire weapons are wireless with no external components. They also provide magazine reloading simulation and realistic weapon recoil, replicating that of a live weapon. To further aid in realistic training conditions, every detail of the weapon has been duplicated, even down to the number of rounds contained in its magazine.

BlueFire weapons identify the same training diagnostics as tethered weapons, including point-of-aim, weapon status, trigger pressure and cant. The weapons are compatible with other FATS system-controlled weapons simulators and do not require system modifications.

The current product line of BlueFire weapon simulators include:

- ARX160
- Browning HP
- Glock 17
- Glock 17 Gen4
- Glock 19
- GLX160
- H&K G36E
- M16
- M16A2/A4
- M4
- M9
- OC Spray
- S&W M&P 9/40
- SA80
- Sig 226
- Sig 229DAK
- Taser M26 and X26
- Walther P99QA
BlueFire Accessories

Hostile Fire Simulator (HFS)

Meggitt Training Systems Hostile Fire Simulator (HFS) makes judgmental, use of force, and firearms training as realistic as possible, short of employing live opponents. This optional simulator increases training realism by discharging projectiles at trainees to stress the importance of cover and concealment.

When the launcher discharges the projectiles, students immediately know they are “under fire”, thus increasing their stress level. With the HFS as a valuable training tool, instructors will maintain a better assessment of each student’s performance.

- Connections are simple, promoting quick system setup.
- Monochrome camera and monitor require no setup, with system operation via a commercial joystick.
- Low light camera is mounted on cannon for aiming accuracy.
- Full motion, 180 degree elevation control offers wide coverage for maximum freedom of movement.
- System can fire three different 60 or 68 cal soft foam projectiles, including soft foam, medium foam and hard nylon.
- Single shot, three-round burst, and fully auto firing modes are all supported.
- Simulator works both with FATS simulators and other third-party systems.

Taser® X26

Meggitt’s BlueFire® Taser X26 provides accurate displays of impact locations on the training screen, while allowing full functionality of the built in flashlight and laser designators. Built in sensors determine actual Taser X26 canting and trigger squeeze. Actual safety features such as Taser shutdown with safely actuation during simulated discharge, and cartridge detection and discharge sensing, provide more realistic weapon training.

- Uses advanced features of Meggitt’s BlueFire weapon systems and RF integration, including wireless pistols and rifle simulators.
- Meggitt’s total training solution is contained within a replacement cartridge within the Taser X26 body.
Flashlight

The flashlight option provides increased training value by simulating night training or training in dark areas where a flashlight is required. This allows any video scenario to become a “night scenario” without the time, labor and expense of re-filming the scenario. With the flashlight option, trainees gain experience in managing a firearm and flashlight simultaneously. Multiple flashlights can be used concurrently when training in groups.

- The flashlight works with all video scenarios.
- Includes a flashlight camera, two-inch flashlight IR filter and video keyer.
- Additional filter options available for weapon-mounted flashlights.
- Flashlight can be used in any position—standing, kneeling, prone—or any other position required by the user.

Chemical Spray

Meggitt’s BlueFire chemical spray has the same appearance, feel, and function as its live spray counterpart. A laser device installed in the spray canister fires an invisible laser light pulse that shows the simulation system where the spray has been aimed. This allows for accurate, traceable after-action review by the instructor to gauge the trainee’s performance.

The spray requires minimal maintenance and comes with a long-life battery for sustained, continual use in training scenarios.
Training Courseware

Training Courseware is the linchpin of Meggitt Training Systems virtual training systems. Standard generic packages are available to support marksmanship, judgmental, and collective and tactical training. For a user specific customized solution, Meggitt Training Systems staff of Subject Matter Experts work with the client to develop solutions that fit their situation.

Marksmanship range courses include, but are not limited to the following weapon types:
- Handguns
- Rifles
- Shotguns
- Grenade launchers
- Live fire guns
- Heavy machine guns
- Sub machine guns
- General purpose machine guns
- Light machine guns

Video Scenarios to support Judgmental Training include, but are not limited to:
- Lessons learned
- Use of force
- Officer down
- Plain clothes officer
- School and workplace violence
- TASER scenarios - Disc 1 and 2
- SWAT
- Courtroom security
- Off duty
- Home invasion

Collective and Tactical Training Scenarios include, but are not limited to:
- Anti-personnel ambush 1 and 2
- Behind friendly lines
- Combined arms defense
- Door gunner
- Falling plate team shoot
- Hasty desert defense
- IFT training
- Island assault
- MOUT
- Movement to contact
- Night defense
- Street patrol
- Truck ambush
- Vehicle ambush
Technical Support Services

Meggitt Training Systems has a 90 year history of product reliability, superior customer service and solid corporate values. Our position as an industry leader in live fire and virtual simulation training equipment validates our “customer first” business approach and the breadth of our resources and experience. Planning, designing and equipping a live fire range is a major undertaking. Meggitt Training Systems can provide the necessary expertise to ensure your range is built to match your budget and requirements. Our engineers and designers will analyze your project and provide recommendations to guide you through the complex stages.

Meggitt recognizes that a proper and safe functioning range is critical for you to attain your training goals. Our technicians conduct on-site training for range operators on the proper procedures for operating and maintaining their systems to ensure the continuity and uninterrupted usage of their range.

Meggitt is dedicated to developing new and innovative range systems. We also strive to support our long-standing customers with continuous product improvements that enhance the capabilities and functionality of existing range systems. Often times the most appropriate solution for upgrading a range isn’t necessarily total replacement. Retrofitting existing equipment with the newest technologies or features will increase the system’s dependability, minimize range downtime, and reduce maintenance expenses. Meggitt has equipped over 13,000 live fire ranges worldwide and provides support, superior service and innovative training systems.
Conditions for Installed Contract

Most bid solicitations do not set forth sufficient information for careful bidding. Whenever there is doubt, the bidder must add enough to protect themselves. To remove uncertainties, the following conditions are assumed to prevail and the bid to which this bulletin is appended is based upon them. If any of them cannot be met, Meggitt Training Systems (MTS) will gladly adjust its bid accordingly, but, unless so notified, MTS shall be entitled to charge on a time and material basis for any additional expenses that may result.

1. **PERSONNEL ACCESS TO AREA** - The installation crew shall have free access to the range area during regular working hours. As required to complete the installation on schedule, it also shall be permissible to work at times other than normal working hours upon notice.

2. **EQUIPMENT ACCESS** - Equipment and materials may be taken in and out of the range area during normal working hours without undue delay or restrictions. If there is an elevator, it shall be available to transport equipment and materials as well as personnel.

3. **UNLOADING ZONES** - If there is no shipping and receiving dock, arrangements shall be made upon notice to bring shipments into a convenient location. This may require use of a no parking area, barricading an access route, etc.

4. **UNLOADING** - The customer shall receive the materials, unload them and place them in the range area upon delivery. We will advise shipping schedule so that customer may be prepared and we expect the customer to advise us when the equipment is in the range area so that we may schedule the crew arrival.

5. **ELECTRICAL SERVICE** - MTS will advise the size and location of all 115 VAC electrical services needed but shall not provide such service. The service shall be available when needed to test the equipment. Such service shall be on properly fused and switched circuits. Electrical service (115 VAC) also shall be available within the range area for use by the installation crew.

6. **LIGHTING AND VENTILATION** - Not furnished by MTS. However, MTS will, upon suitable arrangements prior to fabrication, provide space for the controls for these services on the master control console.

7. **ACOUSTICAL WORK, PAINTING AND DECORATING** - Not part of MTS contract unless so stipulated in the solicitation.

8. **OBSTRUCTIONS** - The range area is assumed to be clear space, wall-to-wall and from the floor to a height of ten feet. It shall be free of columns, pilasters, and pipes that could cause ricochets, conduits and ducts or items stored in the area that could be damaged. Except as set forth in this solicitation, MTS shall not relocate or protect such obstructions. If such obstructions require the relocation and/or alteration of the equipment to be installed, MTS shall be reimbursed for the added expense.

9. **SECURITY OF AREA** - The range area shall be secured when the installation crew is not present, or a secure area adjacent to the range shall be provided for safe storage of tools and small parts.

10. **TAXES, LICENSES, DUTIES AND OTHER FEES** - Imposed by any government body having jurisdiction over the project are excluded unless stated otherwise by MTS in its quotation. Any such charges levied against MTS are to be paid by the customer upon receipt of invoice.

11. **FREEDOM TO WORK** - MTS installation personnel are working technicians. If union or trade restrictions interfere with their installation and operation of the equipment, the additional costs incurred will be added to the contract.

12. **FIELD DIMENSIONS** - Only the largest contracts can justify an additional trip for the purpose of site inspection and verifying field dimensions. Therefore, verification of the field dimensions and other information necessary for fabrication shall be provided upon request.

13. **ADDITIONAL TRIPS** - If progress of the installation is interrupted, the installation crew may not be effectively employed. Because of installation backlog, it is seldom possible for the crew to remain idle while waiting for the situation to be corrected. If the interruption is from causes over which MTS has no control, the installation will be rescheduled in the first available opening, and the additional expenses added to the contract.

14. **CLEANUP** - MTS will leave the range area broom clean providing that there is a place on the premises to place trash. On small contracts it is not feasible to engage scavenger service just for the range.

15. **LOAD BEARING STRUCTURE** - It is assumed that the structure is sound and capable of supporting the floor and ceiling loads of the equipment specified. MTS can furnish the necessary load data for its equipment but cannot provide professional judgments of the structure.
16. **SOUNDNESS OF STRUCTURE** - It is assumed that the surfaces to which attachments must be made are sound. Based on visual inspection, appropriate anchors will be used. If remedial action is needed, due to concealed flaws or deterioration, this shall either be provided by the customer or performed by MTS on a time and material basis.

17. **IN-TRANSIT STORAGE** - There shall be an unloading area where materials may be left during the installation period between the time of delivery and the availability of manpower to get them into the range.
Range Technician Services

Meggitt Training Systems range technicians can be retained to assist with customer installations. The customary need for technician service occurs at the beginning and the completion of installations for final inspection, adjustment and training. Unless otherwise specified, the technician is charged for at the prevailing daily rate for such services plus all transportation expenses. The purpose of this bulletin is to set forth the conditions under which Meggitt Training Systems will accept the inclusion of technician services in a contract unless by mutual agreement and in writing prior to the contract, any changes are required.

What the Range Technician Does

The primary function of the range technician is to inspect the installation of equipment, rig the target carrier systems, adjust the mechanical equipment, hook up the low voltage control wiring, check all systems for proper functioning, and provide basic instructions in the operation and servicing. When service is included prior to the installation, the range technician will assist the installer in the layout of all range equipment. The inspection is confined to details required for proper operation of the equipment, general safety and ease of servicing. If defective installation is discovered, the range technician will call it to the attention of his designated contact so that it may be corrected. Meggitt Training Systems technicians are working technicians and will perform any work necessary provided that:

1. They are not restrained by union or other outside imposed rules
2. The correction of the defects does not leave insufficient time for their other functions
3. They are provided with the help, tools, electrical power, lights, hardware or other considerations necessary to perform the correction

What the Range Technician Does Not Do

Although the range technician is a working technician as explained previously, he is not an installer or an installation foreman. Those responsibilities remain with the customer even though the technician has been retained. Similarly, while glad to assist to whatever extent practical, he is not obligated to provide cleanup services, touch-up of painting, alter 115 VAC electrical wiring, make repairs to acoustical or other surfaces damaged by the range installation, nor perform any other services that are covered by other subcontracts relating to the overall contract. The technician is not empowered to act as an agent of Meggitt Training Systems except strictly as specified in this guide. For example, he may not change the conditions of contracting or the terms of warranty.

Preparation for the Inspection Visit by the Range Technician

The bullet trap should be entirely erected including sidewall fairings, overtrap fairing, and floor fairing. The shooting stalls should be completely erected and trimmed including the shelves, barricades, blast shields, view panels, etc. The various control members should be in place but not secured. The target carrier systems should be fully erected except for their rigging. This includes the rails, tracks or trolley wires as required. The target carrier cars need not be in place. In order to facilitate the rigging, terminal stops and drive unit covers - although in place - need not be secured.

Similarly, all mechanical equipment, supports, and guards of other target systems and control systems should be fully installed, but access plates, etc. that must be removed for wiring or rigging, should not be secured. All 115 VAC electrical wiring must be completed and connected to the service so that regular operating power is available. All low voltage wiring must be pulled in conduit or laid in place between interconnected units. However, the cables need not be cut to length, stripped or brought inside Meggitt Training Systems furnished equipment, nor connected to their terminations. To minimize the technician's wiring time, the cables should be identified by a coding system. The technician will connect communications terminals (speakers, signal lights, etc.) in areas outside of the range, but all installation and wiring for them must be provided.
Conditions Governing Range Technician Services

Unless otherwise agreed upon, only one (1) round trip is included in the provision for technician services. If conditions over which Meggitt Training Systems has no control prevent the completion in one trip, the expenses for any subsequent trips accrue to the customer. Whenever possible, Meggitt Training Systems will schedule the technician's visit for greatest economy of both time and money. Therefore, three (3) weeks advance notice is desired. If changed schedules, etc. necessitate short notice, Meggitt Training Systems can nearly always oblige.

Ready access to the range must be arranged in advance of the technician's arrival. This includes directions for locating the facility, instructions for entering the property and for locating the contact to whom he is to report. Security clearance procedures should be known, forms obtained (and forwarded to Meggitt Training Systems for advance preparation) and security personnel alerted. The same liability and insurance considerations of the customer that apply to employees of other subcontractors apply to the range technician while on the job site or while discharging duties necessitated by the contract. Meggitt Training Systems responsibility of the technician is similarly governed by the conditions applying regularly to employees of subcontractors, and is limited to them. Whereas this guide sets forth general conditions, Meggitt Training Systems is quite willing to modify them for special circumstances in order to assure efficient, orderly and economical range installation. Any such departures or additions must be written and acknowledged by all parties to be binding.
Limited Warranty

Meggitt Training Systems (Meggitt) hereby warrants to the original purchaser that products manufactured by Meggitt shall be free from defects in material or workmanship for a period of twelve (12) months from date of shipment. Meggitt will replace or repair, in its factory or other location designated by Meggitt, any part or parts manufactured by Meggitt and returned to Meggitt, which, upon Meggitt’s examination, shall show to have failed under normal use and service within twelve (12) months from the initial shipment. Meggitt’s obligation under this warranty is conditioned upon receipt of prompt notice of claimed defects, which shall in no event, be later than thirty (30) days following the expiration of the twelve (12) month warranty period.

Equipment furnished by Meggitt but manufactured by others will carry the standard warranty of that manufacturer. Unless notified to the contrary in writing by Meggitt, all parts to be replaced or repaired must be returned with transportation charges prepaid, to Meggitt, after a Return Authorization is issued to the original purchaser. This is the purchaser’s sole remedy. This warranty shall not cover failure or defective operation resulting from:

1. Improper or inadequate maintenance by the buyer
2. Unauthorized modification or repair, misuse, negligence or accident
3. Operation outside of the environmental specifications of the product
4. Use of weapons or ammunition with bullet weights, velocities, or constructed of materials not specifically authorized in published specifications or other documents
5. Operation in excess of recommended capacity
6. Improper site preparation or installation
7. Damage due to acts of nature such as lightning, flooding, earthquake and other natural disasters

Warranty on a part, component or assembly installed to correct a warrantable failure is limited to the duration of the unexpired warranty on the Product in which such part, component or assembly is installed. This warranty shall not cover failure of, or be attributable to, fuses, batteries or indicators after ninety (90) days of shipment. Except as set forth herein, there are no other warranties, expressed or implied, including the warranties of merchantability and fitness for a particular purpose, all of which are hereby excluded.

Meggitt makes no warranty or representation with the respect to the compliance of any product with safety or product standard codes established by any governmental or other regulatory agency, and any failure to comply with such code shall not be considered a defect of material or workmanship under this warranty. Meggitt shall not be liable for any direct or consequential damages arising out of such noncompliance.

Except as stated herein, Meggitt will not be liable for any loss, injury, or damage to persons or property, nor for direct, or consequential damage of any kind resulting from failure or defective operation of said materials or equipment. Nothing pertaining to firearms use can be considered safe by itself. Although Meggitt Training Systems places safety ahead of all other considerations, no representation is made that a shooting range is safe even when our equipment is used according to instructions. The exercise of due diligence rests with the range owner and user. Furthermore, the equipment requires reasonable care in use on these reservations; Meggitt Training Systems provides a full one-year warranty. This warranty may be altered only in writing by Meggitt Training Systems, Suwanee, GA, USA.
1. Ordinary window glass is generally used. The additional cost of polished plate glass is not usuallly advocated unless the window is very large. Even the plate finished plate may be considered. The safety record of ranges does not mandate use of bullet proof or safety glass.

2. Glazing on range side should be a ninety degree to floor. Glazing on spectator side should be at small angle as shown to reduce reflections.

3. There is no absolute rule regarding window size. It should be as large (horizontal dimension) as practical to allow spectators to view firing line. Its height will vary according to viewing area if spectators are standing it may be narrower than if they are seated.

4. Glazing should be as widely separated as possible for best noise attenuation. Therefore, commercially available double glazing for thermal insulation is not connected.

5. One or the other side must be removable for periodic cleaning. Even though sealed, interior surfaces require cleaning approximately once a year.

6. Drapes or blinds are needed if security and law enforcement courses are to be conducted. These may be between the panes.

7. The walls into which the windows are fitted should be as massive as practical. Acoustical surfacing does not effectively prevent noise transfer. Shallow mounting of glazing is believed to reduce transmission.