Armag 3 Bar ECM

White Paper

Introduction

The Armag 3-Bar Earth Covered Magazine (ECM) is a prefabricated magazine that can store up to 50,000 lbs. net explosive weight (NEW) of ammunition or explosives. The Armag design is an industry first for a prefabricated fully compliant steel box ECM. The ECM is fabricated off-site and delivered for installation on a concrete pad at the intended location. Earth cover can be immediately backfilled for rapid deployment. The prefabricated nature of the Armag ECM offers many advantages to traditional construction, including cost, lead time, and quality assurance.

Figure 1 - An Armag 3-Bar ECM during installation. The fold-out steel retaining walls facilitate quick and easy installation.

The Armag ECM is fully approved by the Department of Defense Explosives Safety Board (DDESB) for reduced ECM separation distances, and is officially referenced in DDESB Technical Paper 15 (References 1 and 2). ECMs are designed to protect the munitions and explosives within from nearby explosions (e.g., from adjacent magazines or other operations). The earth cover and the robust headwall design allow these specialized facilities to be located at significantly reduced separation distances compared to standard Above Ground Magazines (AGM). The greatest benefit of ECMs is the ability to save space

(land) by grouping multiple facilities in close proximity. This also reduces the total area encumbered by Explosives Safety Quantity Distance (ESQD) hazard arcs.

Tables 1 and 2 illustrate the reduced separation distances between various types of magazines. Table 1 presents the required K-factor scaled separation distances between facilities sited in a row side-to-side as well as multiple rows sited front-to-back (Table V3.E3.T6 of Reference 3). Table 2 presents the calculated required distances for 50,000 lbs Hazard Division (HD) 1.1 NEW in each facility.

Table 1 - ECM Intermagazine K-factors

	7-Bar ECM	Armag 3-Bar ECM	Undefined ECM	Barricaded AGM	Unbarricaded AGM
Side to Side	1.25	1.25	1.25	6	11
Front to back	2	4.5	6	6	11

Table 2 - ECM Intermagazine ESQD for 50,000 lbs HD 1.1

	7-Bar ECM	Armag 3-Bar ECM	Undefined ECM	Barricaded AGM	Unbarricaded AGM
Side to side – ft (m)	46.1 (14.1	46.1 (14.1)	46.1 (14.1)	221.0 (67.4)	405.2 (123.5)
Front to back – ft (m)	73.7 (22.5)	165.8 (50.5)	221.0 (67.4)	221.0 (67.4)	405.2 (123.5

ECM reduced separation criteria lowers the required side-to-side spacing of individual magazines by up to 89%. Front-to-back required standoff distances can be reduced by up to 60% compared to unbarricaded AGMs. These reduced separation distances reduce the area required for development, but also more compactly overlay ESQD arcs from multiple magazines to encumber less surrounding land.

Design

The Armag ECM is designed as a “3-bar” ECM. The term 3-bar is a measure of pressure (equivalent to 300 kPa or 43.5 psi) applied to the headwall of the ECM. This strength designation falls between the upper bound of 7-bar ECMs and the lower bound of an “Undefined” ECM. The 3-bar design allows the user to take advantage of the significant

benefits of ECM criteria without the cost of the higher 7-bar design and material requirements. The design of the Armag ECM is also limited to 50,000 lbs HD 1.1 NEW due to the reduced total footprint of the magazine (13.5' x 40').

The Armag ECM is a steel box ECM with vertical walls and a flat roof. This allows for significantly better space utilization within the magazines compared to arch roof ECMs. The roof load is designed for both standard loads (e.g., soil, dead load, snow, etc.) and blast loads per Reference 3.

The primary design load on the structure is the headwall blast pressure and impulse loads. The headwall does not have the mass benefit of being covered by soil to absorb the incoming blast load. The headwall and door care carefully designed to carry and transmit the load to the top and bottom of the headwall. Specially designed longitudinal beams run the length of the magazine above the roof and below the floor. The headwall blast load is transferred to these longitudinal beams which incrementally disperse the load throughout the structure. A combination of concrete anchors in the floor as well as friction from the surrounding soil mass are used to resist the headwall load.

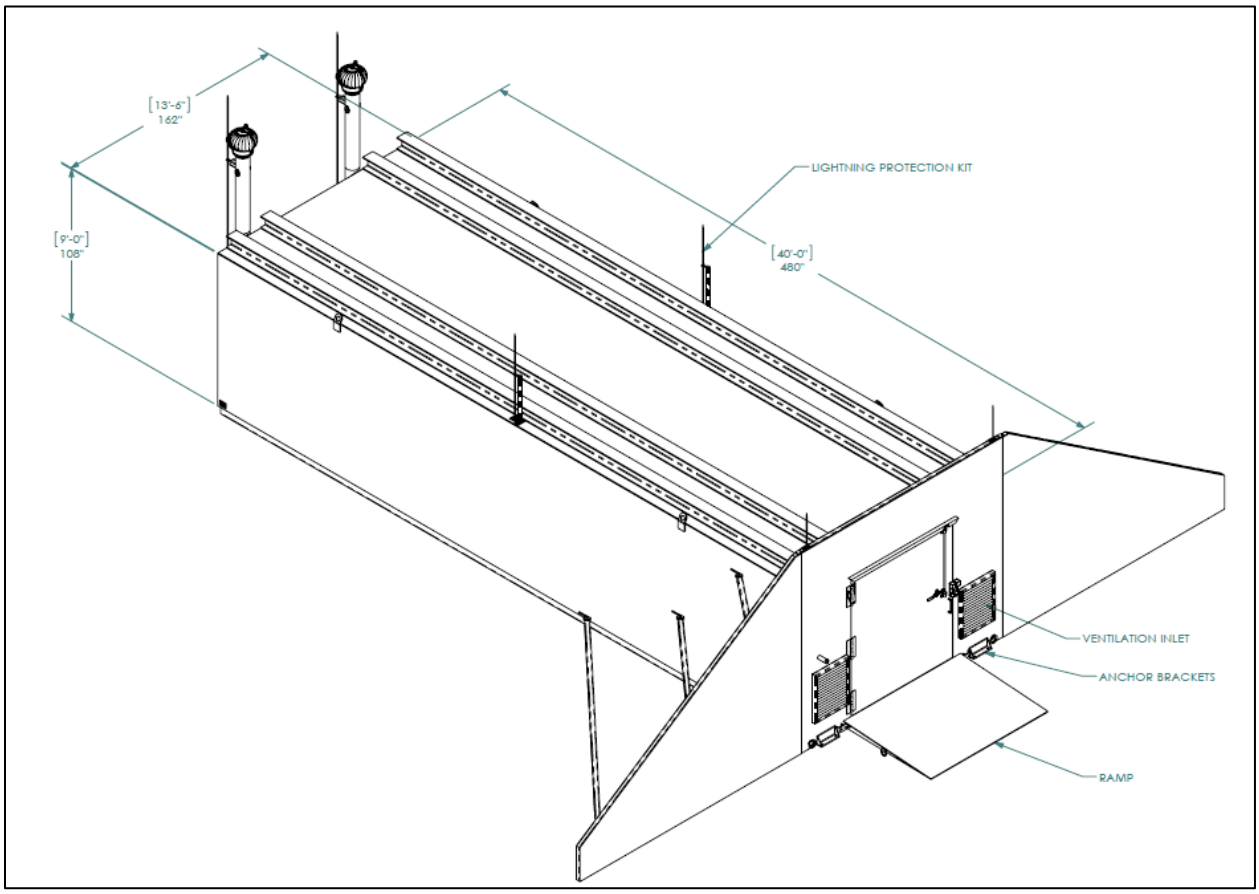

Figure 2 - Armag ECM Configuration

Durable Construction

The Armag 3-Bar ECM is designed to last for several decades with minimum upkeep. Armag has manufactured other types of ECMs for many decades, but has limited data to suggest the true longevity of the product. However, there are some advantages to steel plate construction over concrete. For instance, steel plate will not crack over time. The Armag 3-Bar ECM is designed purposefully to survive in all environments for as long as possible. Some of the primary considerations are outlined below.

The steel headwall of the ECM is protected with a factory-applied zinc-rich primer and polyurethane top coat, which is suitable for marine environments, or environmental severity classification (ESC) C5. Armag estimates that the headwall will require a new paint application once every 10 years in an ESC C5 marine environment, or less frequent in a mild environment.

The body of the ECM is coated with a thick layer of polyurea; common equivalents being Line-X®. The polyurea is an abrasion resistant coating system that ensures the steel coating is not damaged when the earth cover is placed on the magazine. Additionally, the polyurea provides moisture resistance to keep water from direct contact with the steel. The body is continuously welded on the inside and out, which provides additional assurance against water leaks into the ECM.

Condensation is a common problem within ECMs because the earth cover insulates the walls from the exterior environment. If a rush of warmer air floods the inside of an ECM, then the interior can condensate. The interior of the Armag 3-Bar ECM comes standard with insulation in the walls and ceiling to reduce the amount of potential condensation.

Security

The headwall of the Armag 3-Bar ECM is engineered and tested to provide 10 minutes of forced entry resistance against a threat severity level III attack, as defined by UFC 4-026-01. The standard configuration is equipped with an internal locking device (ILD) generation II, for maximum security. As an alternate, the Armag 3-Bar ECM can be equipped with a NAPEC Hasp meeting MIL-DTL-29181C in lieu of the ILD. The Armag 3-Bar ECM is equipped with “rough-in” conduit, boxes, and penetrations for the installation of an Intrusion Detection System (IDS).

Manufacturing, Delivery, and Installation

The Armag 3-Bar ECM is premanufactured and delivered as a single piece, ready for installation. Installation time and costs are significantly less than traditional ECM

construction. A single Armag 3-Bar ECM can be installed in less than 2 days, provided a suitable foundation is in place at time of delivery.

Manufacturing

The Armag 3-Bar ECM is premanufactured to the greatest extent possible. The body of the ECM, headwall, door, parapet, and retaining walls are all singularly adjoined elements. The soil retaining wing walls, attached to the headwall, are designed to fold back to facilitate over-the-road transport. Final assembly of the ECM requires mounting of the ventilators to the back wall and installation of the lightning protection system.

Transport

The Armag 3-Bar ECM is carefully designed for over-the-road and ocean transport. It is designed to be delivered to world-wide locations from the US. The overall shipping dimensions are 41’0”L x 14’10”W x 11’11”H and weighs 65,000 lbs. The Armag 3-Bar ECM is typically shipped with “low-boy” trailers. For ocean transport, the Armag 3-Bar ECM is typically going to ship “break-bulk”, but can also be loaded on a flat-rack. A final route survey is required to ensure passage to the end destination.

Figure 3 - Armag ECM in transport mode

Installation

Installation of the Armag 3-Bar ECM includes the laydown of a newly constructed concrete pad, grounding system, earth cover, and drainage. A simple concrete pad is designed to meet the local conditions, but additionally requires the installation of “embed” plates for anchoring of the ECM. The 24”x14” embed plates have 6 headed studs and will be placed in 6 locations within the concrete slab. The ECM is then welded to the embed plates to anchor it to the foundation. The retaining walls fold-out and are braced against the body of the ECM. The ventilation stacks are simply bolted to the backwall. Lightning protection air terminals and bonding cables are connected to the grounding system in accordance with NFPA 780. Armag recommends installation of drainage tile along the sides and rear of the ECM body prior to earth cover (see Figure 4). Finally, the Armag 3-Bar ECM is required to be covered with 2ft of earth in accordance with DESR 6055.09M V2 E5.5.3. A minimum of 2ft of earth covering must be maintained over the top of the ECM and must be free from toxic matter, trash, debris, and stones heavier than 10lbs or larger than 6inches in diameter. Soil or wet clay is not permitted.

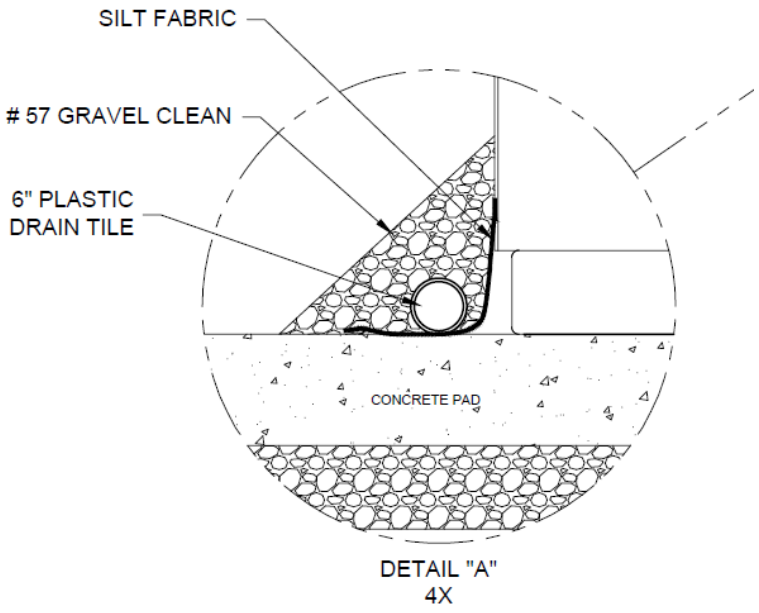

Figure 4 - Armag drainage recommendation

Figure 5 - installed Armag ECM

References

1. *DDESB Approval of 3-Bar Structural Strength Designation for the ARMAG Steel-Box Earth-Covered Magazine (ECM) Design*, Department of Defense Explosives Safety Board, 16 January 2025
2. DDESB Technical Paper 15, "*Approved Protective Construction*," Revision 4, 26 July 2020
3. Defense Explosives Safety Regulation 6055.09, Edition 1, Change 1, 23 February 2024
4. Unified Facilities Criteria 4-026-01 Design to Resist Forced Entry, 4 March 2020