UFC 4-420-01
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UNIFIED FACILITIES CRITERIA (UFC)

AMMUNITION AND EXPLOSIVES STORAGE MAGAZINES

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UNIFIED FACILITIES CRITERIA (UFC)

AMMUNITION AND EXPLOSIVES STORAGE MAGAZINES

U.S. ARMY CORPS OF ENGINEERS

NAVAL FACILITIES ENGINEERING COMMAND (Preparing Activity)

AIR FORCE CIVIL ENGINEER CENTER

Record of Changes (changes are indicated by **1**\ ... /**1**/)

Change No.	Date	Location

FOREWORD

The Unified Facilities Criteria (UFC) system is prescribed by MIL-STD 3007 and provides planning, design, construction, sustainment, restoration, and modernization criteria, and applies to the Military Departments, the Defense Agencies, and the DoD Field Activities in accordance with USD (AT&L) Memorandum dated 29 May 2002. UFC will be used for all DoD projects and work for other customers where appropriate. All construction outside of the United States is also governed by Status of Forces Agreements (SOFA), Host Nation Funded Construction Agreements (HNFA), and in some instances, Bilateral Infrastructure Agreements (BIA.) Therefore, the acquisition team must ensure compliance with the most stringent of the UFC, the SOFA, the HNFA, and the BIA, as applicable.

UFC are living documents and will be periodically reviewed, updated, and made available to users as part of the Services' responsibility for providing technical criteria for military construction. Headquarters, U.S. Army Corps of Engineers (HQUSACE), Naval Facilities Engineering Command (NAVFAC), and Air Force Civil Engineer Center (AFCEC) are responsible for administration of the UFC system. Defense agencies should contact the preparing service for document interpretation and improvements. Technical content of UFC is the responsibility of the cognizant DoD working group. Recommended changes with supporting rationale should be sent to the respective service proponent office by the following electronic form: Criteria Change Request. The form is also accessible from the Internet sites listed below.

UFC are effective upon issuance and are distributed only in electronic media from the following source:

- Whole Building Design Guide web site http://dod.wbdg.org/.

Hard copies of UFC printed from electronic media should be checked against the current electronic version prior to use to ensure that they are current.

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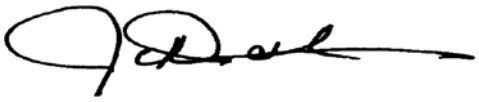

JAMES C. DALTON, P.E.
Chief, Engineering and Construction
U.S. Army Corps of Engineers

JOSEPH E. GOTT, P.E.
Chief Engineer
Naval Facilities Engineering Command

JOE SCIABICA, SES
Director
Air Force Civil Engineer Center

MICHAEL McANDREW
Director, Facilities Investment and Management
Office of the Assistant Secretary of Defense
(Energy, Installations, and Environment)

UNIFIED FACILITIES CRITERIA (UFC)
NEW DOCUMENT SUMMARY SHEET

Document: UFC 4-420-01, *Ammunition and Explosives Storage Magazines*
Superseding: None

Description: This document serves as a reference tool to assist in the planning, siting, and design of Ammunition and Explosives (AE) storage magazines. It is intended to assist in the selection of an AE storage magazine providing available options and information related to the use of standard designs that have prior approval by the Department of Defense Explosives Safety Board (DDESB). This UFC also defines and discusses various issues and requirements that need to be incorporated in the design of these unique facilities.

Reasons for Document: UFC 4-420-01 was created for the following reasons:

- To describe various design issues and requirements that need to be considered in the design of AE storage magazines, including lightning protection, grounding, electrical hazard classification, temperature and humidity controls, ventilation, physical security, etc.,
- To provide a concise description of the various classifications of AE storage magazines and related siting requirements, and
- To provide a description of the requirements for Service/DDESB site approval for all new AE storage magazines.

Impact: UFC 4-420-01 describes unique considerations particular to this facility type that must be correctly incorporated into a design to avoid potentially costly omissions or over-designs. As a supplement to this UFC, the Whole Building Design Guide (WBDG) website provides clear concise descriptions of all available DDESB approved standard designs for AE storage magazines so that they can be easily compared in order to facilitate the selection of the most suitable design for a given site and function: http://www.wbdg.org/design/ammo_magazines.php

Unification Issues

Waterproofing and Drainage: The Navy currently has a prohibition against the use of any types of steel ECM for new construction due to the difficulty of properly waterproofing these magazines.

Earth Electrode System (Grounding): The Navy has additional requirements for magazine grounding systems due to interpretation of NFPA 780 requirements.

Additional Electrical Requirements (Navy Only): The Navy has additional electrical requirements and details for the older “standard magazine designs” that will bring these designs up to current safety practices.

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CHAPTER 1 INTRODUCTION

1-1 PURPOSE AND SCOPE.

This UFC serves as a reference tool to assist in the planning and design of Ammunition and Explosives (AE) storage magazines for the Department of Defense (DoD), by providing definitions and information related to the design, selection, and siting of these unique facilities. This UFC is intended to assist in the selection of a magazine design by providing available options and information related to the use of designs that have been used in the past and have been approved by the Department of Defense Explosives Safety Board (DDESB). The individual DoD Services can also provide additional guidance on the selection of magazine designs.

A web site designed to be a companion resource to this UFC is located on the Whole Buildings Design Guide and can be accessed at: http://www.wbdg.org/design/ammo_magazines.php . This web site provides the following additional information and resources:

- Available electronic copies of referenced military regulations, manuals and standards.
- Available design drawings, approval letters, and specifications for 7-Bar and 3-Bar Earth-Covered Magazines (ECM) that have been approved for new construction.
- Available drawings and related information for the designs of 7-Bar and 3-Bar ECM that are no longer approved for new construction but still in use.
- Available drawings and related information for the designs of ECM and Aboveground magazines (AGM) and containers that have been approved for restricted use.
- A listing of the existing magazine designs that are classified as undefined
- Available drawings for barricade design utilizing various construction materials.
- Links to additional related resources and publications.

This UFC, when used with the companion web site, provides planners and designers of AE storage facilities access to up to date information and resources needed in the selection and design of new storage magazines and in the evaluation of existing facilities.

1-2 BACKGROUND.

The DDESB has established minimum AE safety standards for personnel and property that have the potential of being exposed to the effects of an accidental explosion. These standards govern the design, construction, and use of all AE storage facilities within the DoD.

Magazines are used to store AE materials. Magazines are classified as Aboveground Magazines (AGM) or Earth Covered Magazines (ECM). ECMs are further divided (7-Bar, 3-Bar, or Undefined). An ECM is not designed to resist the damaging effects of its own exploding contents; it is accepted that the exploding magazine will be heavily damaged or even destroyed if an internal explosion occurs. The intended function of an ECM is to mitigate a sympathetic detonation of either AE or an adjacent ECM. The structure is designed to resist an external detonation, thereby interrupting the propagation chain.

DoD explosives safety standards are contained in DoD 6055.09-M, *DoD Ammunition and Explosives Safety Standards*. DDESB Technical Paper 15 (TP 15) provides a ready resource for DDESB-approved protective construction as well as the explosives safety criteria associated with them. Service-specific explosives safety standards that implement the DoD standards are contained in the following documents:

- **DoD Contractors**: DoD 4145.26-M, *DoD Contractors' Safety Manual for Ammunition and Explosives.*
- **Air Force**: AFMAN 91-201, *Explosives Safety Standards and Air Force Munitions Facilities Guide.*
- **Army:** AR 385-10, *U.S. Army Safety Program* and DA PAM 385-64, *Ammunition and Explosives Safety Standards.*
- **Navy**: NAVSEA OP 5 Volume 1, *Ammunition and Explosives Safety Ashore.*

1-3 APPLICABILITY.

This UFC applies to all Service elements and DoD contractors involved in the planning, design, and construction of DoD AE storage facilities worldwide. Specialized magazines (Earth Covered and Aboveground), containers and modular systems with reduced net explosive weights (NEWs) and/or reduced quantity-distances (QD) are not covered by this document; however, DDESB TP 15 provides a listing of approved systems along with requirements, restrictions, and conditions for use in Table AP1-4.

1-4 GENERAL BUILDING REQUIREMENTS.

UFC 1-200-01, *General Building Requirements*, provides applicability of model building codes and government-unique criteria for typical design disciplines and building systems, as well as for accessibility, antiterrorism, security, sustainability, and safety. Use this UFC and the UFCs and government criteria referenced therein.

1-5 CONFLICTS.

This UFC and the companion web site supplement the information contained in the DoD and Service-specific explosives safety standards, and in the DDESB's publications and memorandums. In the event of conflict or disagreement, the DoD and Service-specific

explosives safety standards and the DDESB documents govern. All apparent conflicts must be brought to the attention of the authorizing design agency for additional guidance as necessary.

1-6 WAIVERS AND EXCEPTIONS.

For Waiver and Exception policy and guidelines refer to the DoD and Service- specific explosives safety standards.

1-7 REFERENCES.

Appendix A contains a list of references used in this UFC. The publication date of the code or standard is not included in this document. In general, the latest available issuance of the reference is used.

1-8 GLOSSARY.

Appendix E contains acronyms, abbreviations, and terms.

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CHAPTER 2 PLANNING CONSIDERATIONS

2-1 MAGAZINE TYPES.

AE storage magazines are classified as either Earth Covered Magazines (ECM) or Aboveground Magazines (AGM). Magazines are considered uninhabited structures and are used for storage only. The use of an approved standard design for new magazine construction is mandatory within the DoD except where a preapproved design is not suitable due to special circumstances and the design meets all applicable requirements of DoD 6055.09-M, *DOD Ammunition and Explosives Safety Standards*.

A High Performance Magazine (HPM) concept has also been developed. This document does not specify design requirements for the HPM; however, Appendix D provides background information and references for the HPM concept.

2-1.1 Earth-Covered Magazines (ECM).

DoD 6055.09-M defines three basic ECM designations: "7-Bar," "3-Bar," and "Undefined," based primarily on the relative strength of the magazine headwall and doors and the relative strength of the roof for non-arch or "flat roof" magazines. This designation is based on the structural strength and ability of the magazine to withstand blast loadings resulting from an accidental explosion of an adjacent magazine as a Potential Explosion Site (PES). Siting criteria, based on ECM designation, ensure a consistent level of protection across the AE storage area. Designations for previously designed ECM's are contained in DDESB publication TP-15, *Approved Protective Construction*.

2-1.1.1 **7-Bar ECM.** A 7-Bar ECM provides the highest resistance to blast loading. Magazines designated as 7-Bar were referred to as "Standard" magazines prior to 1997.

2-1.1.2 **3-Bar ECM.** A 3-Bar ECM provides a lower level of resistance to blast loading than a 7-Bar ECM, but more than an Undefined ECM. In 1997, this designation was established as an intermediate designation between "Standard" and "Non-standard."

2-1.1.3 **Undefined ECM.** An Undefined ECM has not been shown by analysis or testing to be capable of providing a level of resistance equivalent to either a 7-Bar or 3-Bar ECM. Magazines designated as Undefined were referred to as "Non-standard" magazines prior to 1997.

2-1.2 Aboveground Magazines (AGM).

All above grade magazines that are not earth covered, or an ECM with less than the minimum 2 feet (0.61 m) of cover, are considered AGM. This also includes storage pads for AE stored in the open.

2-2 SITING CRITERIA.

To ensure the prevention of unacceptable damage or injuries in the event of an accidental explosion, siting criteria have been established to define minimum required separation distances between a PES and surrounding Exposed Sites (ESs). The minimum separation distances, commonly referred to as explosives safety Quantity-Distances (QDs), are based upon several factors including, but not limited to:

- The level of protection mandated by the applicable explosives safety standard.
- The ES type and classification.
- The net explosive weight (NEW).
- The hazard classification of the AE at a PES.
- The physical orientation between the PES and the ES.
- The presence of effective barricading.

Minimum explosives safety QDs are defined in the applicable DoD and Service-specific explosives safety standards for various applications. These QDs are based on maximum levels of risk considered acceptable for various types of ES. Separation distances are not absolute safe distances, but are relative protective or safe distances. Whenever practicable, use of greater distances than those shown in the explosives safety standards should be considered.

Generally, explosives safety site plans are required for construction projects involving new PESs, new facilities (explosive or non-explosive) within the QD arcs of existing PESs, as well as for the upgrading or renovation of existing facilities (explosive or non-explosive) that might impact the explosives safety criteria applied to these facilities (e.g., removal of a protective feature that previously allowed the facility to be sited at a lesser distance or a change of mission that requires the facility to now be at a greater distance). These site plans are reviewed at various authority levels to ensure explosives safety criteria are being met by the proposed work. DoD requires most explosives safety site plans to be forwarded to the DDESB for review and approval (see the section in Chapter 2, entitled “Design Approvals”). See DoD and Service explosives safety criteria for more detail on when a site plan is required and what level of site plan review and approval must be accomplished prior to commencing projects.

2-2.1 Magazines as Potential Explosion Sites (PES).

Magazines pose a hazard to surrounding ESs due to the potential for accidental explosions, which may result in blast overpressures, primary fragmentation, secondary debris, and thermal effects. DoD 6055.09-M defines minimum explosives safety QDs between a magazine as a PES and surrounding ESs including other magazines, operating buildings, inhabited buildings, and public traffic routes to ensure uniform minimum explosives safety standards for DoD facilities. In general, the required separation distances are greater from an AGM than an ECM based on the same quantity of NEW.

2-2.2 Magazines as Exposed Sites (ES).

Minimum explosives safety QDs have been established between a PES and a magazine as an ES to provide appropriate protection. Tables specifying minimum QD requirements can be found in the DoD and Service explosives safety documents. In general, required separation distances are greater for an AGM than for an ECM. For ECM, required separation distances are generally greater for a 3-Bar ECM than a 7-Bar ECM and greater still for an Undefined ECM.

Note: ECMs are not designed for, nor do they provide containment of, effects from an internal explosion.

The minimum explosives safety QDs between magazines is commonly referred to as the inter-magazine distance (IMD). The required IMD is dependent on several factors including but not limited to:

- The physical orientation of the magazines.
- The structural classification of each magazine as an ES.
- The NEW and type of AE within each magazine as a PES.
- The presence of an effective barricade.

2-2.3 Approved ECM NEW Limits.

With respect to an ECM's structural strength designation, approved ECM NEW limits are based on their ability to withstand blast loads generated from an adjacent PES and **NOT** on their capacity for storage. Certain 7-Bar ECM have approved NEW limits that are less than the 500,000 lbs (226,800 kg) typically assigned to a 7-Bar ECM based on the limitations of their design as an ES and not on capacity as a PES.

Many military installations have ECMs that have not been evaluated against 7-Bar and 3-Bar strength requirements, and by default must be treated as Undefined. If, using the available structural drawings, an ECM (as an ES) cannot be shown by structural analysis to meet the 7-Bar or 3-Bar loads from an adjacent PES ECM containing 500,000 lbs (226,800 kg) NEW, then it may be possible to demonstrate that the ES ECM could meet 7-Bar or 3-Bar loading requirements if the surrounding PES NEWs

were reduced. In other words, the ES ECM design could be site approved as a 7-Bar or 3-Bar ECM for a quantity less than 500,000 lbs (226,800 kg) in an adjacent PES ECM. An advantage in doing this is that placing this information in automated explosives site planning software, such as Explosives Safety Siting (ESS) or Assessment Systems for Hazard Surveys (ASHS), allows the installation to determine more efficient separation distances for future storage construction. Selection of an appropriate magazine type to meet a specific siting requirement should be done in consultation with an experienced explosives safety site planning professional to ensure efficient use of existing real-estate and facilities while meeting mission requirements.

2-2.4 Barricades.

Barricades are used to decrease the required minimum separation distances between magazines and between magazines and other PESs. Specific requirements on the design and siting of front barricades as well as the reduction in the minimum separation distance resulting from a properly sited and constructed barricade are provided in the DoD and Service-specific explosives safety standards. Army Definitive Drawing 149-30-01 illustrates several conceptual barricade designs utilizing various construction materials. ECM front barricades should be located as close as possible to the front of the ES (protected) ECM. The side of the barricade facing the protected ECM front should be a vertical, or near vertical earth retaining structure with the opposite side meeting ECM side slope requirements of the section in Chapter 3, entitled, “Earth Cover”. The front barricade must also meet the barricaded IMD geometry requirements of DoD 6055.09-M. When properly sited and constructed, barricades offer protection against high-velocity, low angle fragments.

2-3 DESIGN APPROVALS.

Site and construction plans for AE storage facilities must be approved by the sponsoring Service safety organization and the DDESB to ensure that the minimum DoD and Service-specific explosives safety standards have been addressed. See DoD and Service explosives safety criteria for more detail on when a site plan is required and what level of site plan review and approval must be accomplished prior to commencing projects.

2-3.1 Magazine Design Approval.

The design for all new ECMs must be reviewed and approved by the sponsoring Service’s explosives safety organization and subsequently by the DDESB to ensure compliance with minimum explosives safety design and construction criteria, including earth cover depth and slope, grounding, electrical equipment and installation, and lightning protection. DDESB approval does not address conventional load requirements. In addition, the approval of all 7-Bar and 3-Bar ECMs, and all flat-roofed Undefined ECMs, requires the submission of test results and/or detailed structural calculations in accordance with UFC 3-340-02, *Structures to Resist the Effects of Accidental Explosions,* to validate compliance with the blast design requirements of DoD 6055.09-M. New designs or designs that involve modifications to blast resisting

elements of a magazine's design must meet the requirements specified in DDESB-PD Policy Memorandum "Minimum Requirements to Validate Explosives Safety Protective Construction" available on the WBDG website. It is important to note that new ECM designs require a substantial review process; consequently, adequate time and resources must be allocated to allow for appropriate Service and DoD review prior to approval for construction.

The lightning protection system design for all new AGM designs must be reviewed and approved by the DDESB. New AGM designs involving protective construction to either reduce the NEW for which the facility is to be sited, or to reduce the required QD, must be reviewed and approved by the DDESB; this approval requires the submission of test results and/or detailed structural calculations to validate the proposed protective construction characteristics.

2-3.1.1 **Use of Foreign Materials at OCONUS Locations.**

Approved standard designs must be checked for adequacy when adapted for construction with foreign materials at OCONUS locations. Specifically, steel strengths, bar diameters, plate thicknesses, structural steel member dimensions, and concrete compressive strengths may vary for OCONUS locations. In addition to ensuring such modifications do not impact the conventional load capacity of a magazine design, the dynamic response of blast resisting elements of the design needs to be checked by a qualified structural engineer to ensure UFC 3-340-02 response criteria are met. Modifications that alter the blast response of the magazine are to be treated as new ECM designs as detailed in the preceding paragraph.

2-3.1.2 **Coordination with Service Organizations.** The Service explosives safety office may require other explosives-safety related design information (e.g., ordnance ground system design) for review and approval. The Service design authority may require other non-explosives safety related design information (e.g., ability to withstand soil loads) for review and approval.

Prior to the start of a design, it is essential to closely coordinate the requirements with the sponsoring Service's explosives safety organization to avoid excessive problems and delays in completing the design and obtaining the necessary approvals. The Service explosives safety organization will coordinate as necessary with the DDESB.

2-3.2 Approved ECM Designs.

2-3.2.1 **7-Bar and 3-Bar ECM Designs Approved for New Construction.** To facilitate the design and approval process for AE storage magazines, several approved designs have been developed for 7-Bar and 3-Bar ECMs. DDESB TP-15, Table AP1-1, includes a listing and basic description of 7-Bar and 3-Bar ECMs approved for new construction.

The most current construction drawings, approval letters, and additional information and notes related to the approved designs can be accessed at the Whole Building Design Guide website: http://www.wbdg.org/design/ammo_magazines.php .

Table AP1-1 of DDESB TP-15 identifies additional limitations, restrictions, and conditions associated with the use of approved designs.

2-3.2.2 **Site Adaptation of Approved Designs.** Once a standard ECM or AGM design has been approved by the DDESB and listed in TP 15, the design does not have to be reapproved for subsequent uses unless changes affecting the explosives safety aspects of the design have been made. Approved designs can be site-adapted or tailored to the requirements of a specific site. Allowed, site specific adaptation primarily involves minor modifications to the foundation, subgrade preparation, and the drainage systems to suit local soil and site characteristics along with design of supporting facilities (utilities, physical security and pavement). Any changes to the approved designs, other than minimal site adaptation, that may affect the explosives safety aspects of a magazine design must be approved by the sponsoring Service's explosives safety organization and subsequently by the DDESB prior to construction. (Note: Even if using an approved design, a site plan is still necessary to validate that required QD is met to surrounding ESs and from surrounding PESs. With regard to the ECM design, the site plan need only identify the approved drawing numbers if using a previously approved design that has not been changed other than for minimal site adaptation.) When adapting approved designs, reference the drawings numbers of the Standard on the project plans.

The DOR must ensure that modifications made during the site adaption process do not impact the blast-resisting elements of the approved design. This typically includes the required soil cover geometry, magazine headwall, blast door(s) and frame, pilasters and header beams that support the doors against blast loads, and the roof elements of magazines with flat (non-arch type) roofs. For blast doors that include a bottom support, foundation/slab modifications must ensure that the door support conditions of the standard design are not altered. See Figures 2-1 and 2-2 for a graphic showing the typical blast-resisting elements of an ECM.

Figure 2-1: ECM Components

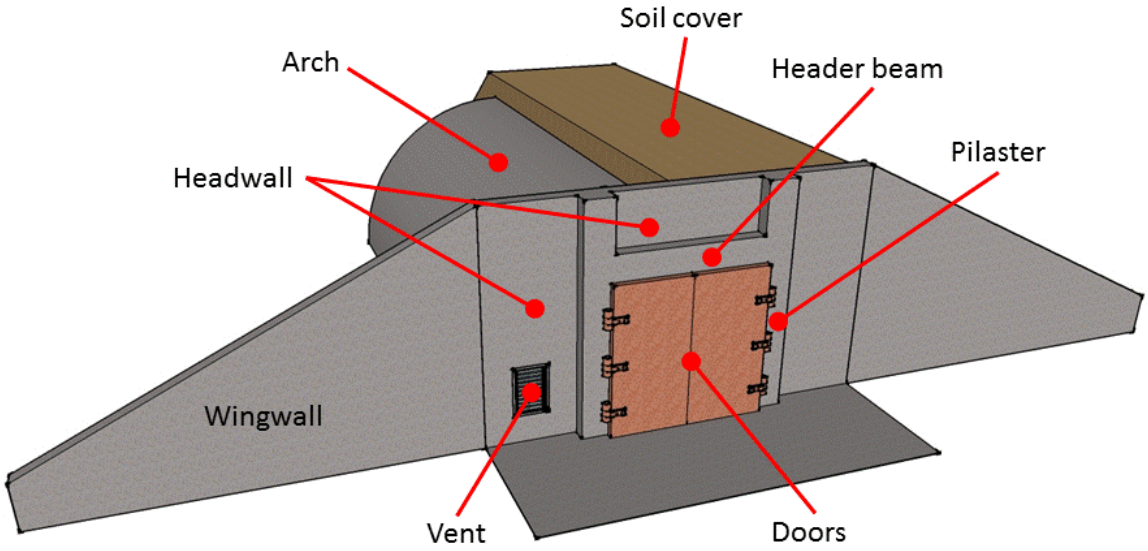
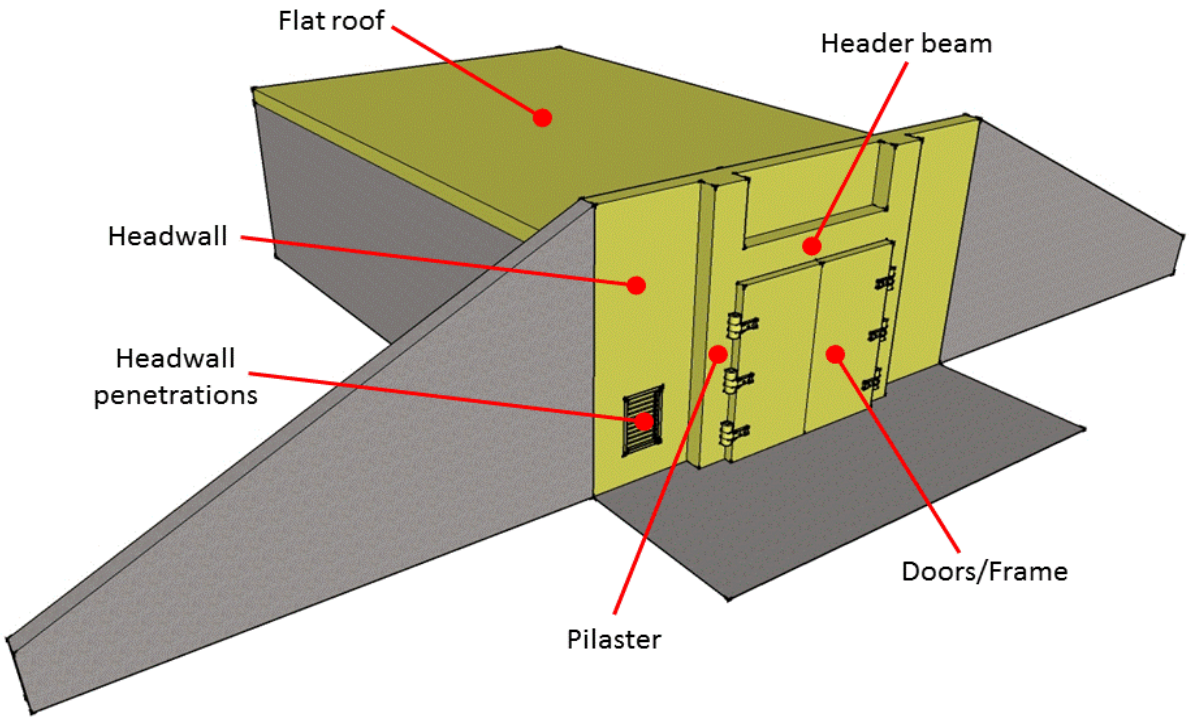


Figure 2-2: Typical ECM Blast Resisting Elements



2-3.2.3 **7-Bar and 3-Bar ECM Designs No Longer Approved for New Construction.** The Whole Building Design Guide web site and DDESB TP-15, Table AP1-2 contain lists of ECM designs that have been previously approved for 7-Bar or 3-Bar siting but are no longer approved for new construction. In most cases, these designs have not been updated to satisfy criteria changes. The intent of this list is to assist activities in sitings involving existing magazines. NEW limitations and/or restrictions associated with their DDESB approval must be observed. These designs can be used as the basis for new ECM designs, but they must be updated to comply with current explosives safety requirements, current construction methods and criteria, and are reviewed and approved by the DDESB. Any updated design drawings must clearly identify all changes and revisions made to the original design prior to approval.

Available electronic drawings, approval letters, and additional information and notes related to current approved designs can be accessed at the following web site: http://www.wbdg.org/design/ammo_magazines.php .

2-3.2.4 **Undefined ECM Designs.** DDESB TP-15, Table AP1-3 contains a listing of ECM designs that are classified as undefined. These designs have not been shown by analysis or testing to have the structural capacity of either a 7-Bar or 3-Bar ECM.

An undefined ECM can be structurally analyzed in accordance with UFC 3-340-02, *Structures to Resist the Effects of Accidental Explosions,* to determine its structural capabilities and potentially justify an upgrade to its classification. HNC-EDC-S-13-10, *Guide for Evaluating Blast Resistance of Existing Undefined Arch-Type Earth Covered Magazines*, illustrates procedures that can be used for a preliminary determination of the adequacy of the headwall and doors of an existing arch-type ECM to provide an acceptable level of protection from a given quantity of explosives at a known distance. A complete analysis is required to ensure the design complies with current explosives safety requirements as well as current construction methods and criteria, prior to reclassifying the ECM design. The sponsoring Service's explosives safety organization and the DDESB must review and approve the upgraded classification.

Table AP1-3 of DDESB TP-15 includes a listing of Undefined ECM designs. This table and the accompanying notes identify additional limitations, restrictions, or conditions associated with the use of these designs.

2-3.3 Magazine Construction and Explosives Safety Site Approval.

Prior to construction, an explosives safety site plan for all new AE storage magazines must be reviewed and approved by the sponsoring Service explosives safety organization and the DDESB to ensure that the magazine has been sited in accordance with the minimum explosives safety QD appropriate to the magazine type and classification. An exception to this allows approval by a Service explosives safety organization for security and limited amounts of ammunition without DDESB approval; refer to DoD 6055.09-M for exceptions.

2-4 MAGAZINE SELECTION CONSIDERATIONS.

Selection of the most suitable magazine design to use at a given site will depend on a number of factors including, but not limited to:

- The specific configuration (pallet or container size, and stacking requirements).
- Physical security
- The hazard classification and quantity of AE that is anticipated to be stored in the magazine.
- The cost of construction and maintenance.
- Siting limitations or restrictions.
- Ordnance storage and delivery operations.
- Flexibility for future revisions to operations or mission
- AE non-compatibility.

Some of these factors are discussed below. Facility planners / designers should involve both end user and installation explosives safety personnel in the earliest stages of the planning and design process to ensure the selection will both meet the users end requirements and be in compliance with explosives safety requirements.

The use of an approved standard design for new magazine construction is mandatory within the DoD except where a preapproved design is not suitable due to special circumstances. Design of a new magazine requires Service explosives safety organization concurrence that an approved standard design is not available to meet the requirements of a specific project.

2-4.2 Net Explosive Weight (NEW) Limits.

Each of the approved magazine standard designs is rated for a maximum quantity of HD 1.1 AE that can be stored, expressed as maximum NEW. A magazine is sited using explosives safety QD relationships corresponding to the maximum amount of NEW that will be stored within the magazine. The quantity of AE stored must never exceed the maximum rated value.

2-4.3 Magazine Characteristics.

2-4.3.1 **Shapes and Sizes.** ECM types that have been used in the past are shown in DDESB TP-15 and on the WBDG website. The physical dimensions and configurations of 7-Bar and 3-Bar ECM designs approved for new construction are provided in Table AP1-1 of TP-15.

Some approved ECM designs allow variable lengths to provide greater flexibility in sizing a magazine to its specific intended use.

2-4.3.2 **Door Openings.** The approved 7-Bar and 3-Bar magazine designs have various door opening sizes. The door opening size must be selected based on current and anticipated future usage requirements and in consideration of the usage requirements for material handling equipment (MHE).

2-4.3.3 **Door Types.** Magazine doors are vertical swinging or sliding type, single or double leaf. Doors are either manually or electrically operated. Electrically operated doors must have an option for manual operation.

Note: Doors are designed for specific bearing conditions under external blast loading and site adaption may not include altering the design bearing surface of the doors (top, side, and bottom).

2-4.3.4 **Storage Options.** AE is usually stored within a magazine utilizing forklifts. An overhead bridge crane storage option has been developed in the RC Box, Type “M” magazine.

2-4.4 Storage and Loading Plans.

AE packaging information and suggested storage loading plans have been developed for many of the approved magazine designs. These plans are to assist in the effective use of magazines and may be used to estimate the potential storage capacity of various types of ordnance within a given magazine.

The U.S. Army Materiel Command (AMC) provides Storage and out loading drawings for various AE within certain ECMs. These drawings, indexed in AMC 19-48-75-5, may be obtained at the Defense Ammunition Center web site: https://mhp.redstone.army.mil. Contact the help desk MHP (Munitions History Program) for access permission.

Email: usarmy.redstone.usamc.mbx.immc-mhp-helpdesk@mail.mil

Telephone: DSN 897-2143, COM (256) 313-2143

Additional standard layout plans for palletized ammunition, missiles, and torpedoes within ECMs are provided in NAVSEA Instruction 8024.2, *Magazine Stowage Layout Standards*.

2-5 ELECTRICAL PLANNING.

Perform an electrical hazards survey to determine the structure's hazardous location classification per NFPA 70 Article 500. This classification is based on the possibility of an explosive atmosphere existing within the magazine rather than the material stored inside the magazine. Ordnance storage magazines that store only "DoD-titled ammunition and explosives" (AE) in its original packaging will typically only need to meet industrial standards for electrical service. If an explosive atmosphere can exist because of the presence of raw explosive material exposed to air, the magazine might qualify as a Class 1, Division 2 location.

Perform a survey of the surrounding area to determine the grounding and lightning protection requirements for the facility. This survey might confirm that unique installation requirements apply to minimize the total resistance to ground. Ground connection locations must be established while ensuring that future maintenance can be accomplished. Verify that the exterior distribution requirements in DoD 6055.09-M, Volume 2, Enclosure 3, can be achieved.

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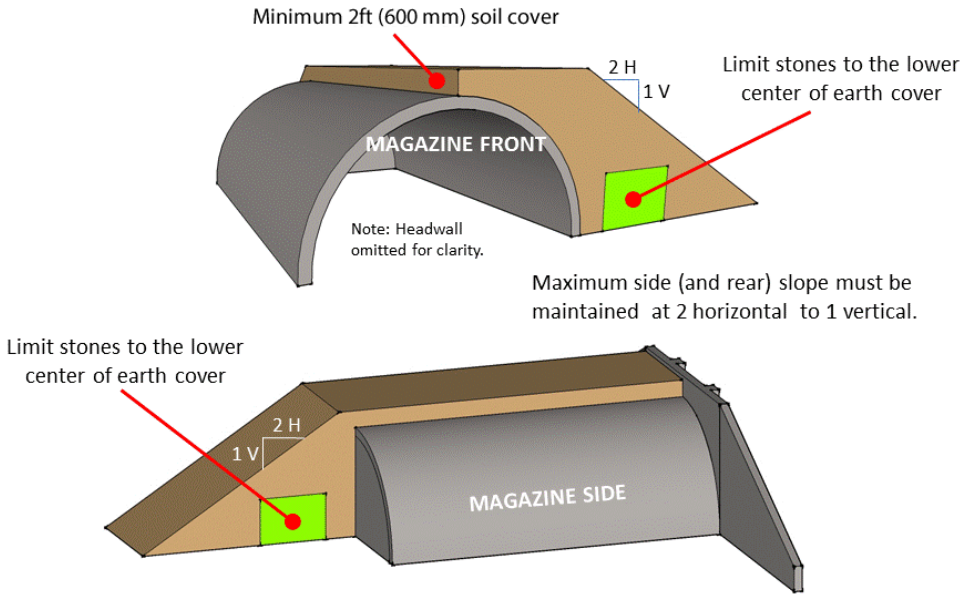
CHAPTER 3 DESIGN CONSIDERATIONS AND REQUIREMENTS.

3-1 EARTH COVER.

The minimum earth cover over the top of an earth covered magazine must be 2 feet (0.61m). The maximum slope must be maintained at 2 horizontal to 1 vertical. The earth cover above, to the sides, and to the rear of an ECM is the critical element of its design. The material for the earth cover must be free from deleterious organic matter (large tree roots and similar materials), trash, debris, and stones heavier than 10 pounds (4.54 kg) or larger than 6 inches (150 mm) in any dimension. The presence of large stones (cobbles) will be limited to the lower, central portions of the earth cover, and such stones will not be used as surface cover over the magazine soil cover where they may contribute to hazardous debris (refer to Figure 3-1). Clay soils must not be used due to excessive cohesion and the potential to contribute to hazardous debris. Compact the material and prepare as necessary to maintain structural integrity and provide erosion control. In locations where it is impossible to use a suitable material to maintain side slope or where rainfall is insufficient to maintain a grass cover, use other suitable materials and stabilization methods to ensure the structural integrity of the cover.

Figure 3-1: ECM Earth Cover



3-2 FLOOR DESIGN.

The design floor live load must be the maximum anticipated loading of stored material within the magazine during its useful life. Considerations must also be given to wheel loading from weight handling equipment (especially large or side loading vehicles). Floor live loading as shown on the Standard Approved Magazine Drawings is based upon the anticipated maximum loading for that particular magazine type. Where soil conditions are poor, the design floor live loading may be reduced if it can be demonstrated that a reduced floor loading will be acceptable at a given location based on the actual anticipated usage. In such case, the maximum design floor live loading must be prominently posted at the entrance and within the magazine structure. Under all cases, the minimum floor live loading for any magazine type must be 500 PSF (2441 kg/sm).

3-3 FOUNDATIONS.

Foundations must be provided with a safe working static load capacity equivalent to or greater than the safe working static load capacity of the foundation shown on the Standard Approved Magazine Drawings. Foundations for earth retention walls must be designed using conventional design methods. Foundations that support elements of the magazine that are required to resist dynamic incident pressures from an external explosion from a PES must have an ultimate dynamic load capacity equivalent or greater to the ultimate dynamic load capacity of the foundations shown on the Standard Approved Magazine Drawings. Elements of the magazine that are required to resist the loading from a PES typically include structural walls and columns supporting roof elements. Unless a more detailed analysis is warranted, it is required that foundations redesigned for poor soil conditions must have a safe working static load capacity equal to or greater than the safe working load capacity of the foundations of the Standard Approved Magazine Drawings.

3-4 WATERPROOFING AND DRAINAGE.

The soil cover of ECMs can lead to moisture issues within the structure, deterioration of structural components, and degradation of stored AE. Ensure that the magazine is watertight and offers adequate protection to the stored AE from water intrusion. An elastomeric membrane is appropriate for concrete magazines and a bituminous waterproofing is more suitable for steel magazines. Protect the waterproofing membrane from backfilling and compaction operations during construction.

Note: The **Navy** currently has a prohibition against the use of any types of steel ECM for new construction due to difficulty of properly waterproofing these magazines.

Provide a drainage system around the ECM to adequately channel the water away from the structure.

3-5 VENTILATION, TEMPERATURE AND HUMIDITY CONTROL.

Typically, ECMs contain some form of ventilation. This is usually accomplished by louvered openings in the headwall and ventilator stacks that exit through the rear wall and penetrate through the earth cover. Due to the broad range of possible storage products and weather conditions, the criteria for a specific project should be provided by the using activity. Coordinate with the user to confirm specific project requirements.

3-5.1 Ventilation Only.

Where the using activity identifies natural or mechanical ventilation only as sufficient space environmental control, verify the following and confirm potential consequences are acceptable to the user.

- If occasional interior magazine surface condensation is not acceptable to the user, prepare an analysis to determine the potential for that condensation. The large thermal mass of concrete and earth berm changes temperature more slowly than ambient air. Under certain circumstances, the ambient air can quickly become warmer and moister (a suddenly warm spring day) than it was a short time earlier. If the interior surface temperature remains cool (below the air dew point) for an extended period of time due to thermal mass, the result could be interior surface condensation.
- If condensation is likely and unacceptable to the user, determine a method to keep surfaces above dew point (i.e. heat space, insulate walls) or lower ventilation air dew point by mechanical cooling with reheat or desiccant system.
- All potential options must also be judged based on the considerations listed in “Temperature and Humidity Control.”

3-5.2 Temperature and Humidity Control.

In some cases, due to specific criteria or determination that ventilation alone is inadequate, the AE product being stored may require more than just ventilation control. Specific criteria for special storage requirements should be provided by the using activity. For this application, some form of heating and cooling will be required. For cooling, heating, and humidity control systems, the following must be considered:

- Determine location of mechanical equipment. Will mechanical equipment require its own space outside of the magazine?
- Determine acceptable paths of connection from mechanical equipment to interior of magazine. Are penetrations compliant with structural integrity?
- Coordinate lightning protection with mechanical equipment and establish bonding requirements to ensure continuity of duct and piping.

- Mechanical humidity control using mechanical cooling requires some form of reheat. Reheat must be in accordance with ASHRAE Standard 90.1, *Energy Standard for Buildings Except Low-Rise Residential Buildings*.
- Mechanical humidity control using a desiccant drying system requires some form of desiccant regeneration (either integral to a package unit or by desiccant replacement). Base final determination on a Life Cycle Cost Analysis.
- Determine the hazardous location classification of the atmosphere within the magazine and select equipment and materials compatible with that classification (e.g. Class1, Division 2).
- Coordinate with the user on the criticality of maintaining the space environmental conditions and determine if sensors and status points should be provided and connected to the base Energy Monitoring and Control System for remote monitoring or to another central monitoring site.

3-5.3 Structural Coordination.

Any mechanical work must maintain the structural integrity of the magazine design.

- If required, consider implementation of blast valves (explosion dampers) and/or blast attenuation chambers.
- Coordinate location of any mechanical penetration with structural requirements, including possible designed blow out walls or roofs.
- Consult with the Service explosive safety organization.

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3-6 FIRE PROTECTION AND LIFE SAFETY.

3-6.1 Ammunition and Explosives (AE) Storage Facilities.

AE storage facilities may be ECMs or AGMs as defined by DoD 6055.09-M. An AE storage facility can be used for AE storage only. An AE storage facility may not be used for handling; processing; testing; servicing; and inspection of ammunition, explosives, propellants, and oxidizers.

3-6.2 Sprinklers and Hydrants.

Automatic sprinklers and hydrant protection are not required for AE storage facilities.

3-6.3 Means of Egress.

Compliance with NFPA 101 means of egress requirements is not required for AE storage facilities.

3-6.4 Fire Alarm System.

A fire alarm system is not required for AE storage facilities.

3-6.5 Mass Notification.

Mass notification is not required for AE storage facilities.

3-7 PHYSICAL SECURITY.

Design AE facilities in accordance with DoDM 5100.76 and DoD 6055.09-M. Additional Service-specific guidance implementing DoDM 5100.76 are contained in OPNAV Instruction 5530.13C Department of the Navy *Physical Security Instruction for Conventional Arms, Ammunition and Explosives (AA&E)*, 26 September 2003, Army Regulation 190-11, *Physical Security of Arms, Ammunition and Explosives, 15 November 2006 (For Official Use Only)*, MCO 5530.14A Marine Corps Physical Security Program Manual, and AFI 31-101 Department of the Air Force Integrated Defense

Approved magazine standard designs identify minimum physical security features, including high security hasps on doors, steel bars at openings and conduit for electronic security systems. The goal is to provide a forced entry delay time that exceeds the response force response time. Coordinate the security requirements for a specific magazine with the Service and installation security personnel. The below information is provided to assist the end user in determining requirements for magazine door locking devices;

- MIL-DTL-43607J, Padlock, Key Operated, High Security, Shrouded Shackle states: *"The padlock shall withstand a concentrated forced entry* attack using battery powered tools for an accumulated work time of at least one minute." To improve forced entry resistance of structures with High Security Padlocks and Hasps, an Anti-Intrusion Barrier (AIB) can be added to protect the locking system and increase the forced entry delay times against hand and battery powered tools.

- The Internal Locking Device (ILD) is a government developed and patented High Security Locking System that mitigates the "exposure to attack" that external locking systems are prone to. This system has been tested to withstand 10 minutes of forced entry resistance against hand and battery powered tools. The ILD is an approved alternative to the current high security padlock and hasp requirement. The ILD is best suited to high security applications and in locations where extreme climate makes opening and securing externally mounted padlocks impractical.

3-7.1 Assistance with Physical Security Components and Requirements.

For help with information on security hardware selection, requirements, specifications, national stock numbers, purchasing, and troubleshooting of equipment failures, call the

Department of Defense Lock Program Technical Support Hotline (800) 290-7607, (805) 982-1212, DSN 551-1212, or send e-mail to:
W_NAVFAC_DoD_Lock_Program_Support@navy.mil

Additional information can be found at http://www.navfac.navy.mil/go/locks

3-8 ELECTRICAL DESIGN.

Provide site electrical utilities, interior distribution systems, and communications and security according to UFC 3-501-01, *Electrical Engineering*, and the latest installation design requirements.

- Site Electrical Utilities include equipment, overhead power distribution, underground electrical systems, grounding, metering, and exterior site lighting.

- Interior distribution systems include distribution and service entrance equipment, surge protective devices (SPDs), wiring devices, raceways, conductors, interior lighting systems, lightning protection systems, and hazardous locations.

- Communications and security includes telecommunications systems and electronic security systems (ESS).

In addition to the criteria identified above, comply with DoD 6055.09-M and the following Magazine-specific requirements.

3-8.1 Hazardous (Classified) Location.

The Designer of Record is responsible for determining the design based upon the classification established in Chapter 2 in the paragraph entitled, “Electrical Planning”. Explosion-proof fixtures and equipment are not required unless the magazine is classified as a hazardous location.

3-8.2 Power.

Electric lines serving the magazine must be installed underground from a point not less than 50 feet (15 meters) from the facility.

The service entrance equipment can be installed inside of the magazine or on the exterior magazine headwall. Coordinate the location of the equipment with the user. All interior conduits must be galvanized steel rigid metal conduit. Locate duplex receptacles and electrical control equipment 48 inches (1,220 millimeters) above the floor.

3-8.3 Lighting.

Provide two separate exterior lighting systems :

- Photocell-controlled for security lighting (0.2 foot-candles (fc), 2 lux).
- Switched lighting for loading activities (5 fc, 50 lux).

Provide interior lighting system:

- Switched lighting per bay or area for warehousing activities (30 fc, 300 lux). Incorporate manual on, vacancy off lighting controls.

Note: For Army projects, coordinate with the user and Activity to determine if there is a requirement for interior and exterior lighting, including lighting required to support electronic security systems. Otherwise, do not include in the project.

3-8.4 Earth Electrode System (Grounding).

Provide an earth electrode system (EES) for each facility including the following components:

a. A ground ring electrode around the entire circumference of the magazine in accordance with NFPA 780 at a depth of 30 inches (76 mm) instead of 18 inches (46 mm). Use a minimum of 2/0 AWG (133 kcmil) bare copper wire for the ground ring electrode and for all connections to the ground ring. For the Navy, the ground ring electrode is termed a “secondary ground ring”.

b. For the Navy, as a minimum, provide grounding electrodes at each change in direction of the ground ring.

c. Provide test wells at two ground rod locations, with one test well near the front of the facility, and one test well located near the rear of the facility. Determine the precise test well locations during the project design to consider periodic access to the test wells given the installation location. Assemble test wells with bolted connections to facilitate future testing. Ensure that the cables are not bonded to or touching the ground rod as they course up from the buried location to the bonding/connection point.

d. Connect all inaccessible connection points in the earth electrode grounding system using an exothermic weld connection or with a high compression connection using a hydraulic or electric compression tool to provide the correct circumferential pressure.

3-8.5 Bonding.

Provide bonding as follows:

- Bond together all reinforcing steel bars within the structure, forming an electrically continuous Faraday-like shield.

- Bond between individual reinforcing bars using metallic wire ties, brazing, or welding at a maximum of 5 feet (1.22 m) in each direction.

- Bond between structural elements (roof to wall, wall or arch to floor slab) or other areas where reinforcing steel is discontinuous.

- Bond between the floor slab to the ground ring electrode at or near each corner of the structure. For magazines with perimeters greater than 400 feet (122 m), provide one additional connection for each 100 feet or fraction thereof; equally space the connections around the perimeter of the magazine.

- Bond other points (test wells, ground rods, lighting protection system down conductor, electrical panel, ordnance and static inserts, and single point ground bar) to the ground ring electrode.

- The bonded connections between structural elements, and to the ground electrode ring, must be made with 2/0 AWG (133 kcmil) bare copper wire with exothermic or approved compression connections. For the ordnance ground, use 2/0 AWG (133 kcmil) insulated conductor in PVC conduit to isolate from metallic objects. If a catholic protection system is used, an impressed current system, conducting through the concrete reinforcing steel, is not permitted.

3-8.6 Lightning Protection.

Provide lightning protection per UFC 3-575-01, *Lightning and Static Electricity Protection Systems,* and the grounding requirements defined herein to protect the exposed portions of the facility. However, if justification can be provided per DoD 6055.09-M, then lightning protection is not mandatory.

For these magazine facilities, ensure compliance with the 100 foot (30.5 m) radius striking distance requirement in NFPA 780.

3-8.7 Bonding of Horizontal Sliding Doors.

Provide bonding with 1 ohm resistance maximum for lightning protection.

For Air Force and Army projects, if the door can be proven to be inherently bonded by their weight, then flexible bonding is not required. However, the resistance must be measured at initial construction and recorded in the base-line records for the facility.

3-8.8 Snow Melting System.

Snow melting systems are optional. When snow and ice are a concern, and Activity requires a “snow melting system,” use the appropriate heat intensity for the applicable geographic area per ASHRAE Handbook, *HVAC Applications*, Chapter “Snow Melting,” Class III.

3-8.9 Additional Electrical Requirements (Navy Only).

Incorporate details addressing specific electrical requirements for Navy occupied magazines that are available on the Whole Building Design Guide at http://www.wbdg.org/design/am_navy_electrical.php. Details are available in *.pdf and *.dwg formats.

3-9 ADDITIONAL ELECTRICAL CONSTRUCTION QUALITY CONTROL.

Incorporate the following inspection, testing and photographic documentation during construction of the Earth Electrode System and bonds into the project specifications. Include a plan view sketch identifying locations of photographs and tests.

a) Inspect all concrete reinforcing steel bonding connections (metallic ties, brazed or welded) for positive contact between individual bars. Document with photographs at 10 foot intervals.

b) Inspect bonding connections (2/0 AWG (133 kcmil) conductor) between structural elements at each location. Provide photographic verification and continuity testing of a random sample (10% minimum) of the connections. If any of the results are greater than 1 ohm, correct the deficiencies and sample additional 10% random sample. If any of the additional results are deficient, test 100% of the connections.

c) Test continuity and provide photographic documentation at all bonding connections to the ground ring electrode. Include:

- Each end of the floor slab connection.
- Each ground rod location and test well.
- Each lightning protection system down conductor.
- The electrical panel (service entrance grounding electrode conductor).
- All ordnance and static inserts / ground bars.
- Single point ground bar.
- Ground cross connection cables and other connections as identified in Service standard designs.

3-10 SPECIAL INSPECTIONS.

Special inspections must be performed during construction of magazines. When developing a new magazine design or site adapting a standard design, the DOR must

develop a list of Special Inspections in accordance with the International Building Code (IBC), Chapter 17. Special Inspections must include submittal of photographs and written inspection documentation on the bonding of the structural steel reinforcing bars for construction of concrete ECMs, as well as any other necessary IBC Chapter 17 requirements identified in consultation with the Service's explosives safety organization. See Appendix C for an example schedule of Special Inspection items.

3-11 DDESB AND SERVICE-SPECIFIC EXPLOSIVES SAFETY. CONTACTS.

DDESB:
DoD Explosives Safety Board (DDESB)
4800 Mark Center Drive
Suite 16E12
Alexandria, VA 22350-3606

Air Force:
Air Force Safety Center (AFSEC)
Attn: AFSEC/SEW
9750 Avenue G, SE
Kirtland AFB, NM 87117-5670

Army:
U.S. Army Technical Center for Explosives Safety (USATCES)
Defense Ammunition Center (DAC)
Attn: SJMAC-EST
1C Tree Road
McAlester, OK 74501-9053

Headquarters, U.S. Army Corps of Engineers
ATTN: CEMPT-ET
20 Massachusetts Avenue, NW
Washington, DC 20314-1000

U.S. Army Engineering & Support Center, Huntsville (USAESCH),
Attn: CEHNC-EDC-S
4820 University Drive
Huntsville, AL 35816-1822

Marine Corps:
Commander, Marine Corps Systems Command (MARCORSYSCOM)
2200 Lester Street
Quantico, VA 22134-5010

Navy:

Naval Ordnance Safety and Security Activity (NOSSA)
Attn: N54
Farragut Hall
Bldg D323 Strauss Avenue,
Indian Head, MD 20640-5555

Naval Facilities Engineering Command (NAVFAC)
Attn: NAVFAC Atlantic, CI ENG
6506 Hampton Blvd
Norfolk, VA 23508-1278

NAVFAC Engineering and Expeditionary Warfare Center,
Explosion Effects and Consequences
1100 23rd Avenue, Building 1100
Port Hueneme, CA 93043-4370

1)

NAVFAC Engineering and Expeditionary Warfare Center,
DoD Lock Program Technical Support Hotline
(800) 290-7607, (805) 982-1212, DSN 551-1212
e-mail: NFESCLock-TSS@navy.mil
https://portal.navfac.navy.mil/go/locks

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APPENDIX A REFERENCES

AMERICAN CONCRETE INSTITUTE

http://www.concrete.org

ACI 318, *Building Code Requirements for Structural Concrete*

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR CONDITIONING ENGINEERS

http://www.ashrae.org

ASHRAE Handbook, *HVAC Applications*

ASHRAE 90.1, *Energy Standard for Buildings Except Low-Rise Residential Buildings*

ASTM INTERNATIONAL

http://www.astm.org

ASTM C31, *Standard Practice for Making and Curing Concrete Test Specimens in the Field*

ASTM C172, *Standard Practice for Sampling Freshly Mixed Concrete*

AMERICAN WELDING SOCIETY

http://www.aws.org

AWS D1.4, *Structural Welding Code – Reinforcing Steel*

DEPARTMENT OF DEFENSE

http://www.dtic.mil/whs/directives/corres/pub1.html

DoD 6055.09-M, *DOD Ammunition and Explosives Safety Standards*

DoD 4145.26-M, *DoD Contractors' Safety Manual for Ammunition and Explosives*

DoDM 5100.76, *Physical Security of Sensitive Conventional Arms, Ammunition, and Explosives*

DEPARTMENT OF DEFENSE EXPLOSIVES SAFETY BOARD

http://www.ddesb.pentagon.mil/

Technical Paper No. 15, *Approved Protective Construction*

DDESB-PD Memorandum, "*Minimum Requirements to Validate Explosives Safety Protective Construction,*" dated 21 October 2008, http://www.wbdg.org/pdfs/ddesb_memo.pdf

DEPARTMENT OF DEFENSE, UNIFIED FACILITIES CRITERIA

http://dod.wbdg.org/UFC 1-200-01, *General Building Requirements*

UFC 3-340-02, *Structures to Resist the Effects of Accidental Explosions*

UFC 3-501-01, *Electrical Engineering*

UFC 3-575-01, *Lightning and Static Electricity Protection Systems*

DEPARTMENT OF THE ARMY

http://armypubs.army.mil/

AR 385-10, *U.S. Army Safety Program*

AR 190-11, *Physical Security of Arms, Ammunition, and Explosives*

DA PAM 385-64, *Ammunition and Explosives Safety Standards*

U.S. ARMY AMMUNITION CENTER AND SCHOOL (USDACS)

US Army Materiel Command Drawings 19-48-75-5, http://mhp.redstone.army.mil

Army Definitive Drawing DEF 149-30-01, *Standard Definitive Design of Barricades*

HNC-EDC-S-13-10, *Guide for Evaluating Blast Resistance of Existing Undefined Arch-Type Earth Covered Magazines*

DEPARTMENT OF THE AIR FORCE

AFMAN 91-201, *Explosives Safety Standards,* http://www.wbdg.org/ccb/browse_cat.php?c=127

Air Force Munitions Facilities Guide, http://www.wbdg.org/ccb/browse_cat.php?c=129

DEPARTMENT OF THE NAVY

NAVSEA INST 8024.2, *Magazine Stowage Layout Standards,* https://intranet.nossa.navsea.navy.mil/Disclaimer.asp

NAVSEA OP 5 Volume 1, *Ammunition and Explosives Safety Ashore,* https://intranet.nossa.navsea.navy.mil/Disclaimer.asp OPNAVINST 5530.13C, *Physical Security Instruction for Conventional Arms, Ammunition, and Explosives,* http://doni.daps.dla.mil/allinstructions.aspx

INTERNATIONAL CODE COUNCIL

http://www.iccsafe.org

International Building Code (IBC)

NATIONAL FIRE PROTECTION ASSOCIATION

www.nfpa.org

NFPA 70, *National Electrical Code*

NFPA 780, *Standard for the Installation of Lightning Protection Systems*

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APPENDIX B 7-BAR AND 3-BAR ECM APPROVED FOR NEW CONSTRUCTION (IP UNITS)

The Whole Building Design Guide web site provides a listing of 7-Bar AND 3-Bar ECM designs that have been approved for new construction including internal dimensions, door opening dimensions and the maximum NEW that can be stored in the magazine. All new ECM projects must use the most current version of the approved design drawings - refer to the following website for further information; http://www.wbdg.org/building-types/ammunition-explosive-magazines. The source of this information is DDESB Technical Paper TP-15, Table AP1-1.

Magazine types are graphically depicted in the approved designs for 7-Bar and 3-Bar ECM. The most current version of the approved design drawings, approval letters, and additional information related to the approved designs can be accessed at the following web site: http://www.wbdg.org/building-types/ammunition-explosive-magazines/ecm-approved-new-construction

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APPENDIX C SPECIAL INSPECTIONS

Special inspections are based on Chapter 17 of the IBC. The following Special Inspection Schedule must be revised to reflect specific project requirements and materials used. However, at a minimum the special items related to the blast structural strength designation must be inspected as shown on this schedule.

Table C-1 Special Inspection Schedule/Verification

Item	Extent of Inspection[1]	Reference	Comments/Scope
Concrete Construction			
Reinforcing Steel Placement	P	ACI 318: 3.5, 7.1 – 7.7	Inspect size, spacing, cover, positioning, and grade of reinforcing steel. Verify reinforcing bars are free of form oil or other deleterious materials. Inspect bar laps and mechanical splices. Verify bars are adequately tied and supported on chairs or bolsters.
Welding of Reinforcement	C	AWS D1.4, ACI 318: 3.5.2	Inspect all reinforcing steel welds. Verify weldability of reinforcing steel. Inspect pre-heating of steel when required.
Concrete Placement	C	ACI 318: 5.9, 5.10	Inspect placement of concrete. Verify concrete conveyance and depositing avoids segregation or contamination. Verify concrete is properly consolidated.
Sampling and Testing of Concrete	C	ASTM C172 ASTM C31 ACI 318: 5.6, 5.8	
Curing and Protection	P	ACI 318: 5.11-5.13	Inspect curing, cold weather protection, and hot weather protection procedures.
Formwork	P	ACI 318: 6.1.1	Inspect formwork for shape, location, and dimensions of the concrete member being formed.
Door Construction			
Fabricator Certification/ Quality Control Procedures	S		Review of fabricator's quality control procedures or AISC certification.
Fabricator Inspection	P		Inspect in-plant fabrication, or review fabricator's approved independent inspection agency's reports.

1 – Inspection Intervals are as follows:
C – Continuous: The full-time observation of work requiring special inspection by an approved special inspector who is present in the area where the work is being performed.
P – Periodic: The part-time or intermittent observation of work requiring special inspection by an approved special inspector who is present in the area where the work has been or is being performed and at the completion of the work.
S – Surveillance review of Shop Drawing submittal

Table C-1 Special Inspection Schedule/Verification (continued)

Item	Extent of Inspection[1]	Reference	Comments/Scope
Electrical Construction		NFPA 780, DoD 6055.09-M, V2.E4.3	
Reinforcing steel bonding connections	P		Inspect all components establishing the Faraday-like shield including concrete reinforcing steel bonds and bonds between structural elements to ensure electrical continuity.
ECM Grounding	P		Inspect the bond between the floor slab and the Ground Ring Electrode.
Earth Electrode System	P		Prior to burial, inspect the Earth Electrode System conductors to ensure no damage, breakage, or corrosion has occurred to the conductors.
Lightning Protection System (LPS)	P		Inspect LPS components for secure mounting and protection against accidental mechanical displacement.
Other Bonds	P		Inspect all other items bonded to the Ground Ring Electrode for corrosion and loose connections that might result in high-resistance connections.
Continuity Testing	P		Witness continuity testing.

1 – Inspection Intervals are as follows:
C – Continuous: The full-time observation of work requiring special inspection by an approved special inspector who is present in the area where the work is being performed.
P – Periodic: The part-time or intermittent observation of work requiring special inspection by an approved special inspector who is present in the area where the work has been or is being performed and at the completion of the work.

Table C-1 Special Inspection Schedule/Verification (continued)

Special Items Related to Blast Strength Designation			
Earth Cover	P		Inspect depth gauges on roof prior to earth cover placement for size and stability. Inspect earth cover depth and slope to ensure a 2 feet (0.61 m) minimum is provided above structure.
Door Laps	C		Inspect door laps at top and bottom of door frame.

1 – Inspection Intervals are as follows:
C – Continuous: The full-time observation of work requiring special inspection by an approved special inspector who is present in the area where the work is being performed.
P – Periodic: The part-time or intermittent observation of work requiring special inspection by an approved special inspector who is present in the area where the work has been or is being performed and at the completion of the work.

APPENDIX D HIGH PERFORMANCE MAGAZINE CONCEPT

The HPM is an earth-bermed, box-shaped structure. The first-story consists of the following components: a Loading Dock Area (LDA), up to eight ordnance storage bays, non-propagation walls to minimize the maximum credible event (MCE) of the HPM, moveable storage bay covers to allow access to stored ordnance, and an external earth-berm. The second-story of the HPM consists of a pre-engineered metal building (PEMB) which provides environmental protection during ordnance handling operations.

The primary objective of the HPM is to reduce the land encumbered by the inhabited building distance explosives safety arc by limiting the MCE to a fraction of the total explosive weight stored in the HPM. The MCE in the HPM is based on the sum of the explosive weight in the LDA and one open storage bay and is limited to 60,000 pounds. In case of an accidental detonation in a closed storage bay or during ordnance operations, the non-propagation walls and moveable storage bay covers prevent sympathetic detonation of ordnance in closed storage bays. The design of the non-propagation walls and moveable bay covers were validated in a series of certification tests. Based on test results, the DDESB approved the HPM concept for use as a 7-Bar Magazine.

Damage to assets in an acceptor HPM is dependent on the explosive weight in an adjacent donor magazine and the separation distance from the HPM to the donor magazine. Asset damage in an acceptor HPM can occur in response to a detonation in a donor magazine located between K6 and K9 from the HPM. Unless special design requirements are imposed on the second story PEMB, the PEMB can be heavily damaged at scaled distances less than K18 from the donor magazine. Extensive cleanup and a mobile crane may be required to access ordnance stored in HPMs less than K30 from a donor magazine.

The following references provide more information on the design of the HPM:

(1) Naval Facilities Engineering Command Atlantic Division, "Standard High Performance Magazine Preliminary Design," Norfolk, VA, 3 July 2001.

(2) Naval Facilities Engineering Service Center, "Basis of Design for the High Performance Magazine," Technical Report TR-2084-SHR REV (4), Port Hueneme, CA, May 2002.

(3) Naval Facilities Engineering Service Center, "High Performance Magazine - Concept of Operations, Operating Hazards Analysis and Mitigation," Special Publication SP-2053-SHR REV (1), Port Hueneme, CA, September 1999.

(4) Naval Facilities Engineering Service Center, "Test Report - High Performance Magazine Certification Test No. 1," Special Publication SP-2119-SHR, Port Hueneme, CA, May 2002.

(5) Naval Facilities Engineering Service Center, "Test Report - High Performance Magazine Certification Test No. 2," Special Publication SP-2120-SHR, Port Hueneme, CA, June 2002.

APPENDIX E GLOSSARY

ACRONYMS

AA&E	Arms, Ammunition & Explosives
ACI	American Concrete Institute
AE	Ammunition and Explosives
AGM	Aboveground Magazine
AIB	Anti-Intrusion Barrier
AISC	American Institute of Steel Construction
AMC	US Army Materiel Command
ASHRAE	American Society of Heating, Refrigerating and Air Conditioning Engineers
ASHS	Assessment System for Hazard Surveys
ASTM	American Society of Testing and Materials
AWG	American Wire Gauge
AWS	American Welding Society
DDESB	Department of Defense Explosives Safety Board
DoD	Department of Defense
DOR	Designer of Record
ECM	Earth Covered Magazine
EES	Earth Electrode System
ES	Exposed Site
ESS	Electronic Security Systems
ESS	Explosives Safety Siting
fc	Foot-Candles
HD	Hazard Division
HPM	High Performance Magazine (Concept Design)
HSILS	High Security Integrated Locking System
IBC	International Building Code
ILD	Internal Locking Device
IMD	Inter-magazine Distance
kg	Kilogram
lbs	Pounds
LDA	Loading Dock Area
LPS	Lightning Protection System
m	meter(s)
mc	meter-candle(s)
MCE	Maximum Credible Event
MHE	Material Handling Equipment
mm	Millimeter(s)

NEQ	Net Explosive Quantity
NEW	Net Explosive Weight
NFPA	National Fire Protection Association
OCONUS	Outside Continental United States
PEMB	Pre-engineered Metal Building
PES	Potential Explosion Site
PSF	Pounds per square feet
QD	Quantity-Distance
RC	Reinforced Concrete
sm	Square meter
SPD	Surge Protective Devices
SPGB	Single Point Ground Bar
TP	Technical Paper
UFC	Unified Facilities Criteria
UN	United Nations
WBDG	Whole Building Design Guide

DEFINITIONS

Ammunition and Explosives (AE): Includes, but is not necessarily limited to, all items of U.S.-titled (i.e., owned by the U.S. Government through the DoD Components) ammunition; propellants, liquid and solid; pyrotechnics; high explosives; guided missiles; warheads; devices; and chemical agent substances, devices, and components presenting real or potential hazards to life, property and the environment. Excluded are wholly inert items and nuclear warheads and devices, except for considerations of storage and stowage compatibility, blast, fire, and non-nuclear fragment hazards associated with the explosives.

Bar: Short for barometric pressure. It is a common expression of the peak design pressure for ECMs.

Barricade: An intervening natural or artificial barrier of such type, size, and construction that limits the effect of an explosion on nearby buildings or exposures in a prescribed manner.

Barricaded Magazine: A magazine with an intervening barricade between it and either a PES or an ES.

Earth-Covered Magazine (ECM): An aboveground, earth-covered structure that meets DoD criteria for soil cover depth and slope requirements. ECMs have three possible strength designations: 7-Bar, 3-Bar, or Undefined. The strength of an ECM's headwall and door determines its designation.

Exposed Site (ES): A location exposed to the potential hazardous effects from an explosion at a PES.

Hazard Division (HD): A division or subdivision denoting the character and predominant hazard within UN classes 1, 2,3,4,5 and 6.

High-Performance Magazine standard design (HPM): An earth-bermed, 2-story, box-shaped structure with internal non-propagation walls designed to reduce the NCE.

Intermagazine Distance (IMD): Distance to be maintained between two AE storage locations.

Magazine: Any building or structure used exclusively for the storage of AE.

Maximum Credible Event (MCE): In hazards evaluation, the MCE from a hypothesized accidental explosion, fire, or toxic chemical agent release (with explosives contribution) is the worst single event that is likely to occur from a given quantity and disposition of AE. The event must be realistic with a reasonable probability of occurrence considering the explosion propagation, burning rate characteristics, and physical protection given to the items involved. The MCE evaluated on this basis may then be used as a basis for effects calculations and casualty predictions.

Net Explosive Weight (NEW): The total weight of all explosive substances (i.e., high explosive weight, propellant weight, and pyrotechnic weight) in the AE, expressed in pounds (lbs). The metric equivalent is net explosive quantity (NEQ).

Potential Explosion Site (PES): A location of a potential quantity of AE that will create blast, fragment, thermal, or debris hazard in the event of an accidental explosion of its contents.

Quantity-Distance (QD): The quantity of explosive material and distance separation relationships that provide defined levels of protection. The relationships are based on levels of risk considered acceptable for specific exposures and are tabulated in applicable QD tables in DoD 6055.09-M. These separation distances do not provide absolute safety or protection. Greater distances than those specified in DoD 6055.09-M should be used if practical.