UFC 4-420-01
16 January 2025

UNIFIED FACILITIES CRITERIA (UFC)

AMMUNITION AND EXPLOSIVE STORAGE MAGAZINES

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UNIFIED FACILITIES CRITERIA (UFC)

AMMUNITION AND EXPLOSIVE STORAGE MAGAZINES

Indicate the Military Department Preparing Activity responsible for the document.

U.S. ARMY CORPS OF ENGINEERS

NAVAL FACILITIES ENGINEERING SYSTEMS COMMAND (Preparing Activity)

AIR FORCE CIVIL ENGINEER CENTER

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

Change No.	Date	Location

This UFC supersedes UFC 4-420-01, dated 1 May 2015.

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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, its territories, and possessions 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 Military Department's responsibility for providing technical criteria for military construction. Headquarters, U.S. Army Corps of Engineers (HQUSACE), Naval Facilities Engineering Systems Command (NAVFAC), and Air Force Civil Engineer Center (AFCEC) are responsible for administration of the UFC system. Technical content of UFC is the responsibility of the cognizant DoD working group. Defense Agencies should contact the respective DoD Working Group for document interpretation and improvements. Recommended changes with supporting rationale may be sent to the respective DoD working group by submitting a Criteria Change Request (CCR) via the Internet site listed below.

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

- Whole Building Design Guide website https://www.wbdg.org/dod.

Refer to UFC 1-200-01, *DoD Building Code*, for implementation of new issuances on projects.

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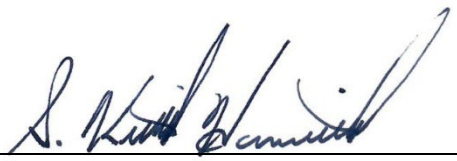

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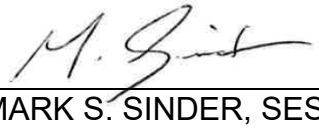

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CHAPTER 1 INTRODUCTION

1-1 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). Magazines are 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 a magazine is to mitigate a sympathetic detonation of either AE or an adjacent magazine. The structure is designed to resist an external detonation, thereby interrupting the propagation chain.

DoD explosives safety standards are contained in Defense Explosives Safety Regulation (DESR) 6055.09. 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.
- **Air Force**: DESR 6055.09 AFMAN 91-201 Explosives Safety Standards.
- **Army:** AR 385-10, *U.S. Army Safety Program* and DA PAM 385-64, *Ammunition and Explosives Safety Standards*.
- **Navy**: NAVSEA OP 5, Ammunition and Explosives Safety Ashore.

1-2 REISSUES AND CANCELS.

This UFC supersedes UFC 4-420-01 dated 05-01-2015 with Change 1 dated 10-12-2022.

1-3 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: https://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.

1-4 APPLICABILITY.

This UFC follows the same applicability as UFC 1-200-01, APPLICABILITY for the planning, design, and construction of DoD AE storage facilities worldwide.

1-5 EXCEPTIONS

Specialized magazines, such as containers and magazines with reduced net explosive weights (NEWs) and/or reduced quantity-distances (QD) are not covered by this document. DDESB TP 15 provides a listing of specialized magazines (both Earth-Covered and Aboveground) and shipping containers that have been approved with a reduced NEW and/or a reduce QD, along with requirements, restrictions, and conditions for use in Table AP1-4.

1-6 GENERAL BUILDING REQUIREMENTS.

Comply with UFC 1-200-01, *DoD Building Code*. UFC 1-200-01 provides applicability of model building codes and government unique criteria for typical design disciplines and building systems, as well as for accessibility, antiterrorism, security, high performance

and sustainability requirements, and safety. Use this UFC in addition to UFC 1-200-01 and the UFCs and government criteria referenced therein.

1-7 CYBERSECURITY.

All facility-related control systems (including systems separate from a utility monitoring and control system) must be planned, designed, acquired, executed, and maintained in accordance with UFC 4-010-06, and as required by individual Service Implementation Policy.

1-8 GLOSSARY.

APPENDIX C contains acronyms, abbreviations, and terms.

1-9 REFERENCES.

APPENDIX D contains a list of references used in this document. The publication date of the code or standard is not included in this document. Unless otherwise specified, the most recent edition of the referenced publication applies.

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CHAPTER 2 TECHNICAL REQUIREMENTS

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 a preapproved standard design for new magazine construction is strongly recommended. A non-preapproved design may be used where a standard preapproved design is not suitable due to special circumstances, and the design meets all applicable requirements of DESR 6055.09.

For identification of various magazine types, the *Magazine Identification and Codex Development Guide* developed by the Ammunition & Explosives Facilities Working Group (AEFAC-WG) can be referenced. https://flankspeed.sharepoint-mil.us/sites/NAVFACLANTAMMagazineCriteria.

2-1.1 Earth-Covered Magazines (ECM).

In general, an ECM allows for lesser separation distances than an Aboveground Magazine (AGM) based on the same net explosive weight (NEW). ECM design criteria are specified in DESR 6055.9, Volume 2, Enclosure 5. DESR 6055.09 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*. In addition, the earth cover for ECMs must meet specific requirements, including minimum top cover thickness and slope, per DESR 6055.09 V2.E5 and DDESB TP-15. If the magazine design or earth cover requirements are not met, the ECM must be sited as an AGM and the storage capacity of adjacent PESs is significantly reduced. Storage capacity of magazine will also be downgraded.

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.

2-1.1.4 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 are not designed for, nor do they provide containment of, effects from an internal explosion. Thus, magazines pose a hazard to surrounding ESs due to the potential for accidental explosions, which may result in blast overpressures, primary fragmentation, secondary debris, cratering and thermal effects. DESR 6055.09 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.

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 (for arch-type ECMs) or AGM (for box-type ECMs). If, using the available structural drawings, an ECM (as an ES) cannot be shown by structural analysis to meet the loading requirements for a 7-Bar or 3-Bar ECM 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 DESR 6055.09. When properly sited and constructed, barricades offer protection against high-velocity, low angle fragments.

2-2.5 Floodplain.

The finished floor level of the magazine must be at or above the minimum Design Flood Elevation per UFC 3-201-01.

Verify the required elevation of the finished floor level with local, regional, and other required governing jurisdictions. The highest required elevation must govern.

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 or physical security 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 Accidental Explosions*, to validate compliance with the blast design requirements of DESR 6055.09.

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 available on the WBDG website.

2-3.1.1 Quality Control Review

Per the DDESB-PD Policy Memorandum, a quality control review is required by a competent DoD blast design agency, such as the Naval Facilities Engineering and Expeditionary Warfare Center (NAVFAC EXWC) or the U.S. Army Engineering and Support Center Huntsville (CEHNC). These organizations operate on a cost reimbursable basis and early coordination for funding and schedule is advised. 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.

2-3.1.2 Lightning Protection

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.

2-3.1.3 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.

2-3.1.4 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.

2-3.2.2.1 Risk Category

The risk category for the standard ECM and AGM designs is III, as outlined in UFC 3-301-01, Table 2-2. If the government directs the DOR to change to a higher risk category, this could potentially change the structural components of the magazine which could adversely affect the 7-bar and 3-bar structural designation. These changes must be approved by the sponsoring service's explosives safety organization and subsequently by the DDESB prior to construction.

2-3.2.2.2 Project Start

When beginning a project, the DOR must go to the Whole Building Design Guide website and download the standard magazine design drawing. The DOR must not use previously site adapted drawings from another installation. After downloading the drawings, the DOR must begin the site adaption process.

2-3.2.2.3 Modifications

Throughout design and construction, 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. 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. Any modifications or changes to the above must be referenced back to the service-specific explosive safety office. See Figures 2-1 and 2-2 for a graphic showing the typical elements of an ECM and typical blast-resisting elements of an ECM.

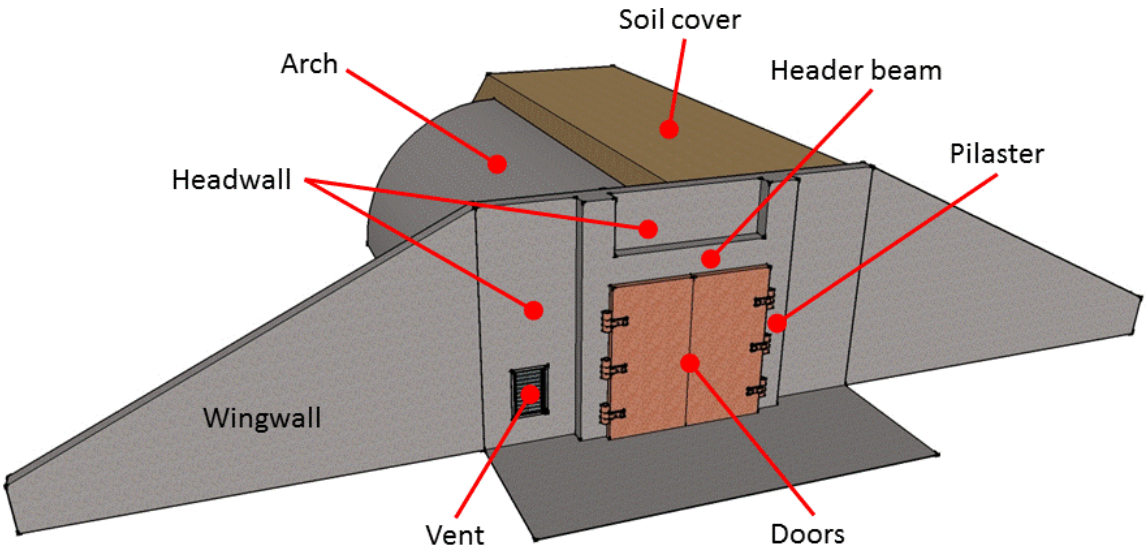
2-3.2.2.4 Navy standard magazines approved for new construction:

If Navy standard drawings are used, the Designer of Record (DOR) must adhere to all standard drawing "NOTES TO DESIGNER" and "DEPARTMENT OF DEFENSE EXPLOSIVE SAFETY BOARD (DDESB) APPROVAL NOTES". A CAD version of the standard drawings is available upon request. When using Navy standard drawings for NAVFAC projects, a new set of drawings, with unique NAVFAC Drawing Numbers must be created using the Navy standard border, customized for the project. The drawing numbers associated with the original unedited standard magazine drawings must also be listed on the title sheet of the set with a note clearly identifying the source, name and date of the standard design.

The DOR is responsible for the site-adapt design and must provide a Designer of Record Note on a General Notes sheet indicating that they have reviewed the standard drawings and that the DOR's site adapted design satisfies all design requirements. The DOR must edit the notes (on the notes sheet) as appropriate to include the pertinent site adapt information. Such information includes but is not limited to foundation design, wind, seismic, and any other transient and static load data used in the site-adapted

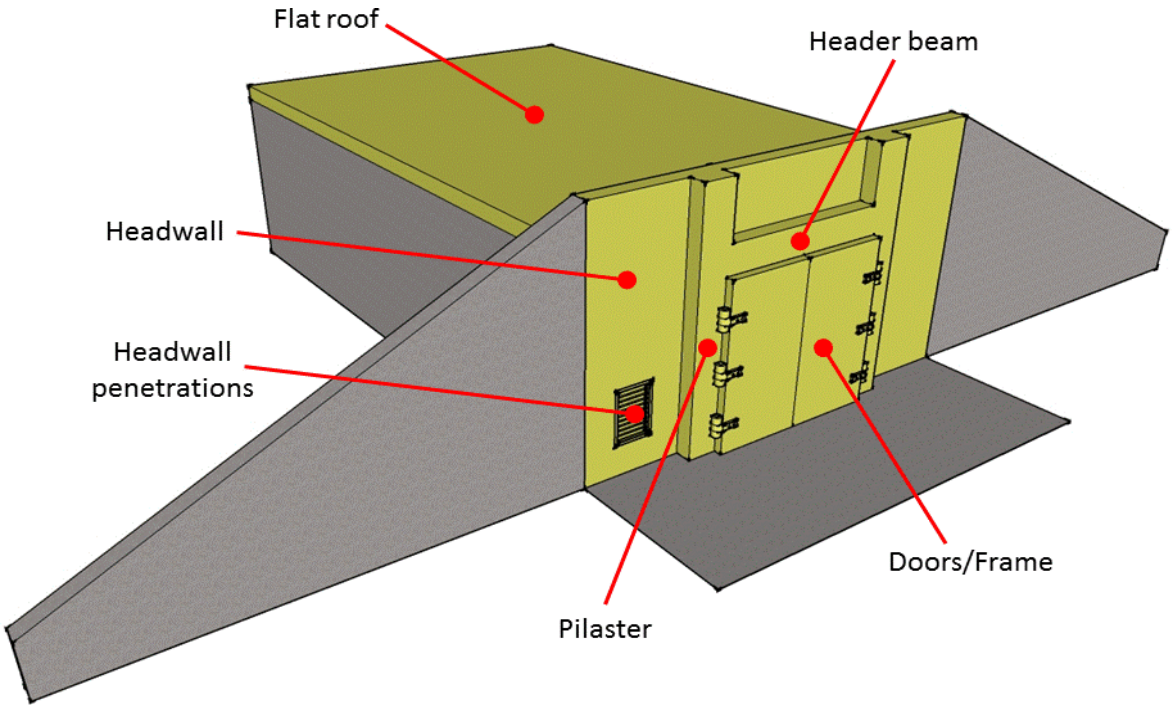
design. Portions of the new drawing set, which have been edited to include the required site adapted design, must be clearly identified in the drawing package.

Figure 2-1 Typical ECM Components



Note: Second vent location may vary with design and not shown for clarity.

Figure 2-2 Typical ECM Components Resisting Direct Blast Loads



Note: Second vent location may vary with design and not shown for clarity.

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. This table and the accompanying notes identify additional limitations, restrictions, or conditions associated with the use of these designs.

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.

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 DESR 6055.09 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.
- Trench or no-trench at base of magazine door.

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 strongly recommended within the DoD except where a preapproved design is not suitable due to special circumstances.

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 in adjacent PESs, expressed as maximum NEW, for the structure to be considered an ECM as an ES. Most ECMs approved for new construction are rated up to 500,000 lbs HD 1.1 NEW, but that should be verified in the selection of the ECM type. However, it is likely that existing legacy ECMs at the site may have NEW rating restrictions which may provide a constraint that prevents the new ECMs from being sited for the full 500,000 lbs HD 1.1. See Section 2.3 for additional details.

2-4.2.1 QD Relationships.

A magazine is sited using explosives safety QD relationships corresponding to the maximum amount of NEW that will be stored within the magazine, the NEW rating of adjacent magazines, and applicable criteria to surrounding exposures. The quantity of AE stored must never exceed the maximum sited NEW value.

2-4.2.2 Installation-Level Control of Stored Quantities.

Lastly, a magazine may have a licensed NEW that is less than the sited NEW. The licensed NEW represents an installation-level control of stored quantities based on mission requirements. Often a magazine will be sited to store the maximum capacity based on available space to maximize mission flexibility. Licensing is sometimes used to restrict quantities located within a magazine to match the needs of the mission. This allows the installation additional control of the quantity of explosives within facilities while maintaining mission flexibility.

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. Doors and door hardware must not use dissimilar metals or must be dielectrically insulated from each other.

- Refer to UFGS 08 39 55.00 20 for Navy's ECM door specification.
- Refer to UFGS 08 39 53, Blast Resistant Doors (Earth-Covered Magazines) specification.

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 for some magazine designs (e.g., the CLWS magazine). A self-supporting built-in crane can be installed after construction; however,

the planner must consult with the service-specific explosive safety office to ensure the crane does not affect the explosive safety classification of the 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 Acquisition University web site: https://www.dau.edu/cop/ammo/page/AMC-Drawings
- For Navy applications, additional standard layout plans for palletized ammunition, missiles, and torpedoes within ECMs are provided in FC 2-000-05N, Series 420. https://www.wbdg.org/dod/ufc/fc-2-000-05n

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.

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 DESR 6055.09 can be achieved.

2-6 MAGAZINE RETROFIT CONSIDERATIONS

Structural elements of existing magazines may need to be retrofitted or replaced due to deterioration of structural properties or performance, or due to changes in the site plan, siting criteria, or other changes that result in an increase of the current demands. Planners and designers must follow project-specific design requirements and criteria to be developed by the controlling DoD Service for the project. DDESB site approval is required for the retrofit design before commencing work. General considerations for retrofit of the blast elements of existing magazines are provided below.

2-6.1 Replacement of ECM Doors.

When doors of existing ECMs are replaced, except for undefined magazines, the ECM will lose its rating and subsequently requires reapproval. When doors of existing ECMs are replaced the doors and locking system must be upgraded to meet current Physical Security requirements.

Attention must be given to the blast load capacity of the new door and the associated loads transferred by the new door to the supporting structural elements of the magazine (e.g., header beam, headwall, pilasters). In general, when the new replacement door has a higher blast load capacity than the existing door, the associated loads that are transferred to the supporting structural elements are higher than those of the existing door. All the structural elements in the load path of the loads transferred by the new door must be verified to be able to withstand the associated loads within the applicable response limits as defined by the project-specific design requirements.

2-6.2 Strengthening of Blast-Resisting Structural Elements.

When required, strengthening of existing ECM's structural blast elements (e.g., header beam, headwall, pilasters, roof) must be designed to meet the project-specific design requirements as determined by the controlling DoD Service for the project. When increasing the flexural capacity of a structural blast element, other limit states where the design load is based on the flexural capacity of the element (such as diagonal tension and direct shear) must be verified for the new loads based on the increased flexural capacity of the element. Similarly, other structural elements that must withstand loads that are transferred by the strengthened element must be verified. For example, if a header beam's flexural capacity is increased, in addition to verifying the diagonal tension and direct shear capacity of the header beam, the pilasters must be verified for the loads transferred by the strengthened header beam. Similarly, if the roof slab's flexural capacity is increased, in addition to verifying the diagonal tension and direct shear capacity of the slab, the columns and walls may need to be verified for the loads transferred by the strengthened roof slab. If needed, shear, torsional, or axial load capacity of structural blast elements must be also increased through retrofits to resist the increased demands resulting from the increased flexural capacity of a strengthened structural element.

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CHAPTER 3 DESIGN

3-1 EARTH COVER.

The earth cover over the top of an earth-covered magazine must be a minimum of 2 feet (0.61 m). The steepest incline must be maintained at 2 horizontals 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 earth slope to the sides and rear of the magazine should continue to grade level and should not be terminated with a retaining wall or otherwise interrupted. Standard ECM designs are validated through detonation tests in which the earth cover to the sides and rear of the magazines continue to grade level. Elimination of a portion of this earth cover may invalidate this testing, and the magazine may not be considered an ECM as an ES and/or a PES for siting purposes without an accompanying engineering analysis providing justification approved by DoD review authorities. Additionally, while use of common earth cover between ECMs (e.g., earth cover between two ECMs intersecting above ground level) is allowed per DoD criteria, it is not recommended. DoD IMD criteria is based on ECM tests without common earth cover (e.g., two horizontals to one vertical slope), limited scaled tests suggest that an acceptor ECM which shares common earth cover with an adjacent donor ECM may sustain greater damage in an accidental detonation. Other explosives safety criteria (e.g., NATO) require increased separation distances when common earth cover is used between ECMs. If the earth cover between two adjacent ECMs intersects at a height greater than one-half the exterior magazine height (not including the earth cover), the planner must coordinate with their service-specific explosive safety office to assess siting impacts.

3-1.1 Material.

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 (15.24 cm) 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. Gravel or crushed stone must not be used as it does not comply with DESR 6055.09 requirements for reasonable cohesiveness. 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.

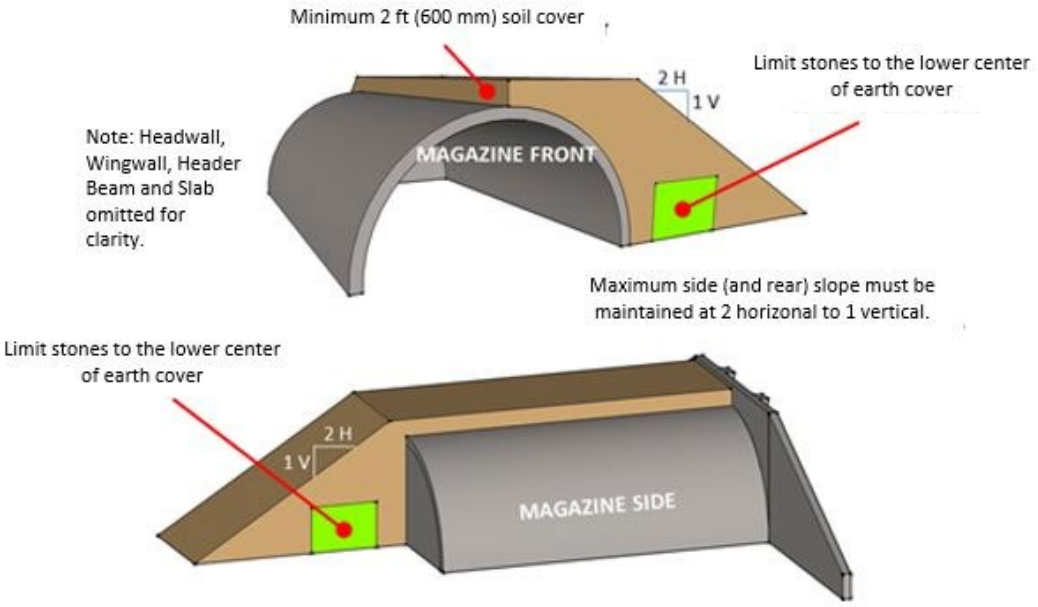
3-1.2 Additional Guidance

For additional guidance, refer to Engineering Research & Development Center (ERDC) study *Erosion Control of Earth-Covered Magazines to Maintain Minimum Cover Requirements* conducted in 2019.

3-1.3 Roof Live Load

The roof of the ECM must be designed for a minimum of 100 psf live load. This live load must not be reduced.

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/SLABS.

3-3.1 Magazines based on Standard Approved Magazine Drawings

When considering a magazine based on Standard Approved Magazine Drawings:

- 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
- 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.

3-3.2 Floor Flatness and Levelness

Provide the following minimum flatness and levelness: F-numbers: Ff=35, Fl=25.

3-4 WATERPROOFING, DRAINAGE, AND CORROSION PROTECTION.

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.

- Provide a subsurface drainage system around the ECM to adequately channel the water away from the structure. Subsurface drainage systems must consist of perforated drain piping surrounded by gravel and protected with landscaping fabric. Extend subsurface drainage systems between magazine and mechanical room walls where necessary to ensure proper drainage is provided.
- Provide an interior perimeter trench drain system within the magazine to accept incidental leaks and condensation. Mechanical rooms must be provided with floor drains or floor sinks to accept condensate produced by mechanical equipment.
- Where blast door trenches are included in the design, provide means of drainage at low points. Ensure that blast door trench drains are accessible for cleaning and maintenance. All floor drains must be provided with a

strainer. Drain openings within the mechanical room or magazine must be protected from rodent entry with holes no larger than 1/4-inch (0.635 cm).

- Consult with the installation public works department regarding the termination of drain piping. Comply with applicable federal, state, and local codes when connecting to storm or sanitary drain systems. Indicated drainage systems are not intended to be the only permitted systems. Designer must develop systems that meet the specific project drainage requirements.

3-4.2 Ordnance Handling, Loading and Offloading Area.

For new construction of magazines, a concrete area may be required by the service or activity in front of the magazine for handling, staging, inspection, loading and offloading ordnance. This paved area, if required, will ensure adequate space is available to handle ordnance in accordance with required safety. The area provides critical space and clearances for ordnance staging, set down, and maneuvering containerized weapons and/or pallets to/from flat bed and enclosed commercial conveyances. The paved area must not be part of an adjacent road but must connect with the adjacent road with an adequate turning radius or short access road. The paved area must be measured from the face of either, the magazine headwall where there is no loading dock or from the face of the magazine loading dock.

3-4.2.1 Paved Area Slope

The paved area must drain away from the magazine in a single continuous plane and the grade must be 0.5% minimum with a 2.0% maximum slope away from the magazine.

3-4.2.2 Navy Only Paved Area Requirements

For the Navy only, where the above required paved area is not available in front of the magazine, the planner must coordinate with the Local Ordnance Handling Activity and the respective Echelon III command must review and assess the impacts to ordnance handling safety. If the appropriate area is not provided, the Echelon III command must provide written (via email) concurrence of the proposed alternative to ensure all risk management concerns have been addressed or mitigated.

3-4.3 Corrosion Protection

Reference UFC 3-301-01 and other UFC documents for corrosion protection requirements. For structural concrete: provide 2-1/2" (6.35 cm) concrete cover to primary reinforcement at exposed concrete or a waterproof coating in Environmental Severity Classification (ESC) C4 through C5 project locations.

When constructing a magazine in accordance with standard drawings: If the concrete cover changes or the design exceeds the concrete cover required by the approved

standard drawings, changes must be approved by the sponsoring service's explosives safety organization and subsequently by the DDESB prior to construction.

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."

3-5.1.1 Natural Ventilation Systems.

Provide natural ventilation systems in accordance with *ASHRAE Handbook, Fundamentals*. Intake and relief opening free areas should be approximately equal wherever practical. Vertically separate intake and relief opening elevations as much as possible to promote airflow induced by temperature differentials. Intake louvers must be hinged with a locking hasp for access and inspection.

Natural ventilation openings may consist of louvers, stacks, or both. Provide the size and quantity of openings required to meet the natural ventilation systems criteria:

- The smallest opening in the path of flow must have a free area to floor area ratio not less than 0.05%.

- The smallest opening in the path of flow must have a free area to space volume ratio of not less than 0.0025%.

Natural ventilation openings must be designed to resist forced entry in accordance with UFC 4-026-01. Consult with the using activity regarding additional special security requirements and the inclusion of fire dampers at the natural ventilation openings.

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:

- Consider potential mechanical systems based on ability to achieve environmental control, availability of thermal utilities such as (installation chilled water or steam utilities), remoteness of installation, maintenance requirements, the availability of service and parts, and familiarity of proposed systems with facility management staff.
- Mechanical systems employing the use of natural gas are not permitted.
- Determine location of mechanical equipment. Indoor mechanical equipment must be located in a dedicated mechanical room wherever possible. To mitigate debris hazards, do not locate outdoor mechanical equipment in or on the earth cover.
- Avoid mechanical utility/piping penetrations into the roof structure of the magazine or mechanical room.
- Determine acceptable paths of connection from mechanical equipment to interior of magazine. Penetrations through the walls of the magazine and mechanical room must be waterproofed. Provide modular compression seals or cast-in-place sleeves or other elements that must be securely embedded in walls.
- Underground ductwork materials and joining methods must be carefully selected to ensure longevity of installation in the project environment. Give special consideration to corrosion from soils and moisture. Installation must be constructable and must withstand the pressure of compacted soil.
- 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 90.1.
- 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. Class 1, Division 2). Provide equipment with spark-proof construction and explosion proof motors where required.
- Consider the use of air curtains at the blast door to mitigate air exchange with the outdoor air where indoor environmental control requirements justify their inclusion.
- Evaluate the need for pneumatic door sealing systems and consult with the using activity regarding their inclusion. Coordinate installation and operational requirements with related disciplines including architecture, electrical, and structural.
- Mechanical openings into the magazine must be designed to resist forced entry in accordance with UFC 4-026-01.
- 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.
- Control panels for HVAC controls must be located in the mechanical room such that they may be accessed without entering the magazine. Sensors located within the magazine, if any, must be intrinsically safe.

3-5.2.1 System Design Calculations

Refer to UFC 3-410-01 for requirements regarding mechanical system design calculations. Confirm and document the indoor and outdoor design conditions with the using activity. Heat loads must reflect the installation conditions including the thermal mass effect of earth fill and cover. Assembly U-value calculations must be provided. Blast door U-value calculations must account for thermal bridging that may be inherent to the door's design.

3-5.2.2 Engineering Weather Data

Refer to UFC 3-400-02 Design – Engineering Weather Data for information on access to and use of weather data in the required heat load analyses.

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.
- If required by the using activity, coordinate installation requirements of snow/ice melt systems with structural slab/foundation design and electrical grounding.
- Note that any mechanical penetration into the blast-resistant elements of an ECM (aside from those specifically noted in the Standard drawings) must be reviewed by a competent DoD blast design agency to ensure they do not compromise the protective construction of the structure.

3-6 FIRE PROTECTION AND LIFE SAFETY.

Fire Protection and Life Safety must comply with the requirements outlined in the paragraph entitled "*Ammunition and Explosives Storage Facilities*" within UFC 3-600-01, *Fire Protection Engineering For Facilities*. AE storage facilities may be ECMs or AGMs as defined by DESR 6055.09. 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.

For Navy Projects, contact Government Project Manager or Contracting Officer for NAVSEA OP5 information.

3-7 PHYSICAL SECURITY.

Design AE facilities in accordance with DoDM 5100.76 and DESR 6055.09. Additional Service-specific guidance implementing DoDM 5100.76 are contained in OPNAV Instruction 5530.13D 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.
- ILD Locks and associated Boltworks as a locking system are required for all new ECM doors or planned upgrades to ECM doors for Security Risk Category I and II.

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 https://exwc.navfac.navy.mil/DoD-Lock-Program/

3-8 ELECTRICAL DESIGN.

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

- Site Electrical Utilities may include distribution service entrance equipment, overhead power distribution, underground electrical systems, service entrance grounding electrode, metering, and exterior site lighting.
- Lightning protection system, grounding and bonding system may include catenary system, faraday cage system, exterior buried grounding ring electrode, air terminals, lightning conductor, mast system, guardrails on headwall as air terminal components, down conductors, ground rods, test wells, static and ordnance grounding.
- Interior distribution systems may include distribution equipment, surge protective devices (SPDs), wiring devices, raceways, conductors, interior lighting and power systems, bridge crane system, and hazardous locations.
- Communications and electronic security includes telecommunications systems and electronic security systems (ESS). Telecommunications rooms (TR) are not required within each magazine. Individual/remote

magazines may utilize a telecommunications enclosure (TE) within the structure, however, either space conditioning must be provided or the equipment must be rated for the environment, and the TE must be NEMA 3RX rated. Sites with multiple magazines must provide one centralized TR located in one of the adjacent site buildings where all telecommunications equipment is to be located. The telecommunications equipment at this location must be in a conditioned space. The telecommunications equipment must be located such that the maximum cable length from the patch panel through the structured cabling system to the furthest outlet of the magazines being served does not exceed 295 feet (90 m). No distance restriction when using fiber optic cable. If telecommunications needs are minor, a TE may be substituted in lieu of a TR.

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

3-8.1 Hazardous (Classified) Location.

Coordinate with local tenant to determine if the magazine is classified as a hazardous location established as outlined in Chapter 2, paragraph titled “Electrical Planning”. For Navy projects only, NCC/NAVFAC must contact local tenants to complete the NCC form (identifying hazardous classified location).

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 m) from the facility. The electric lines must be installed in metal conduit, as required by DESR 6055.09, V2.E3.6.2.

The service entrance equipment can be installed inside of the magazine or on the exterior magazine headwall. Any electrical service entrance equipment or external disconnecting means, which serves as power disconnection to the magazine, must be readily accessible. Ensure to provide working clearances in front of electrical equipment as defined per NFPA 70 as continuous and unobstructed to egress pathway. Ensure to provide dedicated space above the equipment in accordance with NFPA 70 for conduits routing if located on wall surfaces. Coordinate the location of the equipment with the user. All interior conduits must be galvanized steel rigid metal conduit. If required on site, locate ground fault circuit interrupted (GFCI) duplex receptacles and electrical control equipment 48 inches (121.92 cm) 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. Incorporate manual on/off lighting controls. However, DORs must coordinate with users for the Activity within the magazines as identified within the provisions of ASHRAE 90.1.
- Lighting design must follow UFC 3-530-01. Provide footcandles or lux requirements as shown on illumination performance table.

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. The ground ring electrode must be installed at a depth of 30 inches (76.2 mm cm) instead of 18 inches (45.72 cm). 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. Single point ground bus bar, static ground bus bar and ordnance ground bus bar (if required to be provided) must be bonded to the ground ring electrode outside of the magazine.

d. Provide at least two ground test wells at opposite corners of the magazine. Additional test wells must be provided for the single point ground bus bar and ordnance ground bus bar. When possible, locate all test wells in front of the magazine and install the rear test well outside the earth-covered mound with extension of grounding conductors for accessibility. 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.

e. 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.

f. If an additional demising wall is added, obtain an approval from the service authority for any additional static & ordnance ground bus bars as required.

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 at a maximum of 5 feet (1.22 m) in each direction. Note that welding is not permitted for reinforcing bars used in ECMs or other magazines that rely on protective construction for reduced NEW/ESQDs.
- Bond between structural elements (roof to wall, wall or arch to floor slab, wall panel to wall panel) or other areas where reinforcing steel is discontinuous.
- For Navy magazines, welding or brazing to the reinforcement in structural reinforced concrete members, (including walls, beams, slabs and columns, etc.) is not permitted.
- 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 (30.48 m) or fraction thereof; equally space the connections around the magazine's perimeter.
- Bond other points (test wells, ground rods, lighting protection system down conductor, electrical panel, ordnance and static inserts, doors' metallic parts, metallic equipment enclosures, and single point ground bar) to the ground ring electrode. The ground ring electrode must be permitted to service as the single-point ground required by the NEC.
- 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 minimum 2/0 AWG (133 kcmil) insulated conductor in PVC conduit to isolate from metallic objects. If a cathodic protection system is used, it must be a galvanic system and comply with requirements in UFC 3-570-01 *Cathodic Protection*.

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 DESR 6055.09, then lightning protection is not mandatory.

- Lightning protection will incorporate the metallic (Faraday-like) cage type system by bonding together the rebar as mentioned in 3-8.5 and bonding together the structural components of the magazine as required by NFPA 780, or other services applicable requirements. Additionally, 3/16-inch (0.476 cm) thick minimum and 42-inch-high (106.68 cm) maximum metal guardrails may be utilized as strike termination devices on the magazine headwalls, which will be bonded to the ground ring electrode at both ends. This will provide a two-way path to ground ring electrode and will be bonded via ground rods (one is minimum) at each end of headwall.
- The lightning protection system must be bonded to the ground ring electrode. An air terminal with two down conductors for each ventilator will be provided and bonded to the ground ring electrode.
- For these magazine facilities, ensure compliance with the 100-feet (30.5 m) radius striking distance requirement in NFPA 780.
- Third party inspections must be required based on service requirements. Refer to paragraph 3-10 for additional special inspection requirements.

3-8.7 Bonding of Horizontal Sliding Doors.

Provide bonding from door's grounding reel and door's railing to the structure (steel/re-enforcing steel).

- Bonding path should continue with/through the structure steel to grounding ring electrode. Bond door's rail at three locations: one at each end and one at middle of the door's rail.
- 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 Communications.

Communications outside plant pathways and cabling for phone lines or electronic security at the magazine is optional based on munition category and branch of the military.

- At a minimum each magazine will include one 4” (10.16 cm) conduit extended 10 feet (3.048 meters) outside the foundation for potential future use when the requirement arises.
- Any communication lines must be buried underground in metal conduit for a minimum of 50 feet (15.24 meters) before entering the facility, as required by DESR 6055.09, V2.E3.6.2.
- Phone services at the magazine are optional. When phone is required a POTS, phone will be mounted on the exterior headwall of the magazine. Locate to not be obscured when the magazine door is open.
- Communications infrastructure and cabling will be designed and installed in accordance with UFC 3-580-01, Telecommunications Interior Infrastructure Planning and Design.

3-8.10 Electronic Security.

Electronic security systems (ESS) are optional based on the type and classification of munitions to be stored.

- When electronic security systems are required, they will be designed and installed in accordance with UFC 4-021-02, Electronic Security Systems. When ESS is included the following magazine specific criteria will be incorporated into the design.
- When Internal Locking Devices (ILD) are deployed the internal contact of the ILD must be integrated with the Intrusion Detection System (IDS), if equipped with an IDS.
- Keypads for arming and disarming of the magazine must be mounted exterior on the magazine head wall. Locate to not be obscured when the magazine door is open.

3-8.11 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 https://www.wbdg.org/navy/cad/electrical-details-magazine. 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 for positive contact between individual bars. Document with photographs at 10-feet (3.048 m) 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 bus bars.
- Single point ground bus bar.
- Ground cross connection cables and other connections as identified in Service standard designs.

3-9.1 Lightning Protection System, Bonding and Grounding Quality Control Submittal Requirements to be included in the project specifications.

The Lightning Protection System, Bonding and Grounding Quality Control Plan must:

- Indicate the contractor's understanding and explanation of the QC process.
- Include Special Inspector (SI) qualifications and responsibilities.
- Include shop QC Manager (or in-house inspector) qualifications and responsibilities.
- A list of challenging issues (available material challenges, shipping challenges, schedule challenges, etc.)
- Special procedures and processes.
- Include a discussion of SI record keeping and required bi-weekly submittals and any other submittals to the contractor’s QC Manager, etc.
- Show coordination between Special Inspector, In-House Inspector, Shop QC manager, Contractor QC manager.

3-9.2 Lightning Protection System, Grounding and Bonding Quality Control Pre-Construction Meeting to be included in the project specifications.

The contractor must conduct a quality control pre-construction meeting to review the grounding and bonding quality control plan submittal. The meeting must include the

Designer of Record (DOR), Contractor QC manager, Special Inspector, Grounding/Bonding Contractor, Contractor Superintendent, government Engineering Technician (ET), the government Construction Manager (CM), and a government representative familiar with lightning protection, grounding and bonding systems for magazines.

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 D for an example schedule of Special Inspection items.

3-11 STRUCTURAL OBSERVATIONS.

Provide structural observations per UFC 3-301-01 for structures.

3-12 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:
Department of the Army projects for ammunition and explosive storage magazines, Per USACE Engineering Regulation 1110-1-8169 U.S. ARMY CORPS OF ENGINEERS FACILITIES EXPLOSIVES SAFETY MANDATORY CENTER OF EXPERTISE, inclusion of representative(s) from the USACE Facilities Explosives Safety Mandatory Center of Expertise as part of the project delivery team is mandatory. Contact information can be found at: https://mrsi.erdc.dren.mil/coe/mcx/fes/

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

Marine Corps:

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

Navy:

Naval Ordnance Safety and Security Activity (NOSSA)
Attn: N41
3817 Strauss Ave., Suite 108
Indian Head, MD 20640-5151

Naval Facilities Engineering Systems Command (NAVFAC)
Attn: NAVFAC Atlantic, PDC1
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

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://exwc.navfac.navy.mil/DoD-Lock-Program/

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APPENDIX A BEST PRACTICES

A-1 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; https://www.wbdg.org/building/ammunition-explosive-magazines. The source of this information is DDESB 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: https://www.wbdg.org/dod/ecm/ecm-approved-new-construction approved-new-construction

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APPENDIX B 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 B-1 Special Inspection Schedule/Verification

Item	Extent of Inspection[1]	Reference	Comments/Scope
Concrete Construction			
Reinforcing Steel Placement	P	ACI 318: 20, 25.2, 25.3, 26.6.1-26.6.3	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. For magazines with precast walls, verify that the vertical footing dowels have been located per the contract documents.
Welding of Reinforcement	C	AWS D1.4, ACI 318: 26.6.4	Inspect all reinforcing steel welds. Verify weldability of reinforcing steel. Inspect pre-heating of steel when required. Welding of reinforcement in structural concrete is not allowed without approval.
Concrete Placement	C	ACI 318: 26.5	Inspect placement of concrete. Verify concrete conveyance and depositing avoids segregation or contamination. Verify concrete is properly consolidated. Observe installation of precast panels.
Sampling and Testing of Concrete	C	ASTM C172 ASTM C31 ACI 318: 26.5, 26.12	
Curing and Protection	P	ACI 318: 26.5.3-26.5.5	Inspect curing, cold weather protection, and hot weather protection procedures.
Formwork	P	ACI 318: 26.11.1.2(b)	Inspect formwork for shape, location, and dimensions of the concrete member being formed. For precast wall construction, verify ducts to receive the footing dowels are located per the contract documents.
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

Item	Extent of Inspection[1]	Reference	Comments/Scope
Electrical Construction		NFPA 780, DESR 6055.09	
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. Include photo documentation of the electrical bonding construction phase.
ECM Grounding	P		Inspect the bond between the floor slab and the Ground Ring Electrode. Include photo documentation of the electrical grounding construction phase.
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, and to ensure no damage, breakage, or corrosion has occurred.
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.
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 C GLOSSARY

C-1 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
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

C-2 DEFINITION OF TERMS.

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 are AE storage magazines that are covered by soil above, on the sides, and the rear. 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.

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 DESR 6055.09. These separation distances do not provide absolute safety or protection. Greater distances than those specified in DESR 6055.09 should be used if practical.

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APPENDIX D REFERENCES

AMERICAN CONCRETE INSTITUTE

https://www.concrete.org

ACI 318, *Building Code Requirements for Structural Concrete*

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR CONDITIONING ENGINEERS

https://www.ashrae.org

ASHRAE Handbook, *HVAC Applications*

ASHRAE Handbook, *Fundamentals*

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

ASTM INTERNATIONAL

https://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

https://www.aws.org

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

DEPARTMENT OF DEFENSE

https://www.denix.osd.mil/ddes/

DESR 6055.09, *Defense Explosives Safety Regulation*

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

https://www.denix.osd.mil/ddes/

Technical Paper 15 (TP 15), *Approved Protective Construction*, https://www.denix.osd.mil/ddes/denix-files/sites/32/2020/08/DDESB-TP-15-Rev-5-Final.pdf

DDESB-PD Policy Memorandum, *Minimum Requirements to Validate Explosives Safety Protective Construction,* dated 21 October 2008, https://www.wbdg.org/FFC/DOD/ddesb_memo.pdf

DEPARTMENT OF DEFENSE, UNIFIED FACILITIES CRITERIA

https://www.wbdg.org/dod/ufc

FC 2-000-05N, *Facility Planning Criteria For Navy and Marine Corps Shore Installations*

UFC 1-200-01, *General Building Requirements*

UFC 3-301-01, *Structural Engineering*

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

UFC 3-400-02, *Design: Engineering Weather Data*

UFC 3-410-01, *DoD Minimum Antiterrorism Standards For Buildings*

UFC 3-501-01, *Electrical Engineering*

UFC 3-530-01, *Interior And Exterior Lighting Systems*

UFC 3-570-01, *Cathodic Protection*

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

UFC 3-580-01, *Telecommunications Interior Infrastructure Planning And Design*

UFC 3-600-01, *Fire Protection Engineering for Facilities*

UFC 4-021-02, *Electronic Security Systems*

UFC 4-026-01, *Design To Resist Forced Entry*

UFC 4-021-02, *Electronic Security Systems*

DEPARTMENT OF THE ARMY

https://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*

ARMY AMMUNITION CENTER AND SCHOOL (USDACS)

US Army Materiel Command Drawings 19-48-75-5, https://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

DESR 6055.09 AFMAN 91-201, *Explosives Safety Standards*
https://www.wbdg.org/dod/dod-manuals/desr-6055-09

DEPARTMENT OF THE NAVY

NAVSEA OP 5 Revision 8, *Ammunition and Explosives Safety Ashore,* Contact Government Project Manager or Contracting Officer for NAVSEA OP5 information.

OPNAVINST 5530.13D, *U.S. Navy Conventional Arms, Ammunition, and Explosives Physical Security Policy Manual*
https://www.secnav.navy.mil/doni/Directives/

INTERNATIONAL CODE COUNCIL

http://www.iccsafe.org

IBC, *International Building Code*

NATIONAL FIRE PROTECTION ASSOCIATION

https://www.nfpa.org

NFPA 70, *National Electrical Code*

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