

# UNIFIED FACILITIES CRITERIA (UFC)

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## **FINAL DRAFT** **DESIGN: AMMUNITION AND EXPLOSIVE STORAGE MAGAZINES**



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**UNIFIED FACILITIES CRITERIA (UFC)**

**DRAFT DESIGN: AMMUNITION AND EXPLOSIVE STORAGE MAGAZINES**

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U.S. ARMY CORPS OF ENGINEERS

NAVAL FACILITIES ENGINEERING COMMAND (Preparing Activity)

AIR FORCE CIVIL ENGINEER SUPPORT AGENCY

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

Change No.	Date	Location

## **FOREWORD**

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

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- Unified Facilities Criteria (UFC) Index [http://65.204.17.188/report/doc\\_ufc.html](http://65.204.17.188/report/doc_ufc.html).
- USACE TECHINFO Internet site <http://www.hnd.usace.army.mil/techinfo/index.htm>.
- NAVFAC Engineering Innovation and Criteria Office Internet site <http://dod.wbdg.org/>.
- Construction Criteria Base (CCB) system maintained by the National Institute of Building Sciences at Internet site <http://www.ccb.org/>.

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## **CHAPTER 1**

### **INTRODUCTION**

**1-1 PURPOSE AND SCOPE.** This UFC serves as a reference tool to assist in the planning and/or design of Ammunition and Explosive (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 DDESB. The individual DoD services ~~can~~<sup>may</sup> also provide additional guidance on the selection of magazine designs.

A web site designed to be a companion resource to this UFC is located on the Whole Buildings Design Guide and can be accessed at:  
<http://www.wbdg.org/design/index.php?cn=1.3&cx=0>. This web site provides the following additional information and resources:

- available electronic copies of referenced codes 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, and thus are not approved for new construction,
- available drawings for barricade design utilizing various construction materials, and
- 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 available information and resources needed in the selection and design of new storage magazines and in the evaluation of existing facilities.

**1-2 BACKGROUND.** The Department of Defense Explosives Safety Board (DDESB) has established uniform 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 Department of Defense.

| Magazines are used to store AE materials. Magazines ~~are~~may be defined as AGM or ECM; 7-Bar, 3-Bar, or Undefined.

DoD explosives safety standards are contained in DoD 6055.9-STD, *DoD Ammunition and Explosives Safety Standards*. The latest version of this document can be obtained at [http://www.dtic.mil/whs/directives/corres/pdf/p60559std\\_100504/p60559s.pdf](http://www.dtic.mil/whs/directives/corres/pdf/p60559std_100504/p60559s.pdf), or the DDESB web site <http://www.ddesb.pentagon.mil/>. Service-specific explosive safety standards that implement the DoD standards are contained in the following documents:

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

**1-3 APPLICABILITY.** This UFC applies to all service elements and contractors involved in the planning, design, and construction of AE storage facilities worldwide. The source for table C-1 is table AP-1 of DDESB TP-15. This table and the accompanying notes identify additional limitations, restrictions, or conditions associated with the use of these designs.

**1-4 CONFLICTS.** This UFC and the companion web site supplement the information contained in the DoD and service-specific explosive safety standards, and in the DDESB publications and memorandums. In the event of conflict or disagreement, the DoD and service-specific explosive safety standards and the DDESB documents govern. All apparent conflicts must be brought to the attention of the authorizing design agency for additional guidance as necessary.

**1-5 REFERENCES.** Appendix A contains a list of references used in this UFC.

**1-6 WAIVERS AND EXCEPTIONS.** For Waiver and Exception policy and guidelines refer to the DoD and service specific explosive safety standards.

## CHAPTER 2

### PLANNING CONSIDERATIONS

**2-1 MAGAZINE TYPES** AE storage magazines are classified as either Covered Magazines (ECM) or Aboveground Magazines (AGM). Magazines are considered uninhabited structures and there do not require a mass notification system and according to UFC 3-600-01, a fire suppression system and a fire alarm system are not required

**2-1.1 Earth-Covered Magazines.** Within DoD, ECM's are classified based upon their structural strength and corresponding ability to withstand blast loadings. Siting criteria based on the ECM classification are applied to ensure a consistent level of protection regardless of the classification. DoD 6055.9-STD defines three basic ECM classifications: "7-Bar", "3-Bar" and Undefined. These classifications are based primarily on the relative strength of the magazine headwall and doors. Design criteria for each of the ECM classifications has been established and can be found in DoD 6055.9-STD. The DDESB has classified previously designed ECM and summarized protective construction designs in Technical Paper TP-15, Approved Protective Construction. In general, ECM are magazines with a minimum of 2'-0" ( 0.61 m) earth cover. Typical features of ECM are described in Appendix B. Appendix C provides general descriptions of the physical properties of several of the different ECM types that have been used in the past. [Note: One exception to this is the "High-Performance" Magazine (HPM) concept design that is technically not earth covered. However it is considered to be equivalent to a "7-Bar" ECM.]

**2-1.1.1 "7-Bar" (Standard) ECM.** A "7-Bar" ECM provides the highest resistance to blast loading. Magazines classified 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 classification was established as an intermediate classification between the former classifications of "Standard" and "Non-standard".

**2-1.1.3 Undefined (Non-Standard) 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 classified as Undefined were referred to as "Non-standard" magazines prior to 1997.

**2-1.2 Aboveground Magazines.** All above grade magazines that are not earth covered are considered AGM. This also includes storage pads for AE. [Note: One exception to this is the HPM concept design that is technically not earth covered. However due to its design, it is considered to be equivalent to a "7-Bar" ECM.]

**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 Potential Explosion Site (PES) and other facilities. The minimum separation distances, commonly referred to as explosives safety Quantity-Distance (QD), are based upon several factors including

- The level of protection mandated by the applicable explosive 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 Exposed Site (ES).
- The potential presence of effective barricading.

Minimum explosives safety QD relationships are defined in the applicable DoD and service-specific explosive safety standards for various applications. These relationships 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. Use greater distances than those shown in the explosive safety standards whenever practicable.

Explosives safety site plans are required for construction projects involving new facilities (explosive or non-explosive) within QD arcs of existing PES, as well as for the upgrading or renovation of existing facilities (explosive or non-explosive), that might be impacted by explosives safety criteria (e.g., hardening for fragmentation or blast, intermagazine separation, explosive safety QD). These site plans reviews allow for a higher-level of evaluation to insure explosives safety criteria are being met by the proposed work. DoD requires certain explosives safety site plans to be forwarded to the DDESB for review and approval. Each Service provides guidance as to what level of site planning review and approval must be accomplished prior to commencing projects.

**2-2.1 Magazines as Potential Explosion Sites (PES).** DoD 6055.9-STD defines minimum explosive safety QD relationships between a magazine as a PES and surrounding ES including other magazines, operating buildings, inhabited buildings, and public traffic routes to ensure uniform minimum explosive safety standards for DoD facilities. As a PES, all classifications of ECM are considered the same. In general, the required separation distances are generally greater from an AGM than an ECM.

**2-2.2 Magazines as Exposed Sites (ES).** Minimum explosive safety QD relationships have been established between a PES and a magazine as an exposed site. 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 explosive safety QD relationship between magazines is commonly referred to as the intermagazine distance (IMD). The required IMD is dependent on

- The physical orientation of the magazines.

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

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” (Standard) ECM. This is because ECM are approved on the basis of their ability to withstand an external explosion acting as an ES.

For example, a “7-Bar” ECM approved for 350,000 lbs (158,760 kg) of Hazard Division (HD) 1.1; such as the RC Box Type ‘F’ ECM; would provide “7-Bar” protection from the effects of an external explosion from a PES containing 350,000 lbs (158,760 kg) and separated by the appropriate “7-Bar” IMD. The RC Box Type ‘F’ ECM will not provide “7-Bar” protection to its contents from an explosion of more than 350,000lbs (158,760 kg), unless the separation distance is increased and it can be demonstrated that the effects of an explosion of the PES will not exceed the effects of an explosion of 158,760 kg (350,000 lbs) NEW at the IMD.

A very common situation found in military installations usually involves a large number of ECM's with no designation. Using available structural drawings and the 3-bar or 7-bar load indicated in DoD 6055.9-STD, we can analyze the ES ECM under the 30bar or 7-bar load with a reduced capacity in the PES (less than 500,000 lbs). if the deformation criteria is met, then the ES could obtain a 3-bar or 7-bar structural designation with the corresponding reduced capacity. An additional advantage is that loading this information in siting computer programs such as ASHS, allows the installation to determine more efficient separation distances for future storage construction.

The tables provided in the Appendices C identify the NEW rating of magazines and containers approved for new construction.

**2-2.3 Barricades.** Barricades are used to decrease the required minimum separation distances between magazines and between magazines and ordnance operating buildings. .

Specific requirements on the design and siting of 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 explosive safety standards. Army Definitive Drawing 149-30-01 illustrates several conceptual barricade designs utilizing various construction materials. When properly sited and constructed barricades offer protection against high-velocity, low angle fragments and reduced blast over pressures immediately behind the barricade. They do not offer protection against high angle fragments and are ineffective in reducing blast overpressures at distance from the barrier.

To be effective in reducing low angle fragments barricades must be high and wide enough to intercept the ballistic trajectories of the fragments and thick enough to reduce the fragment velocity to acceptable limits.

Earth cover on the sides and rear of an ECM qualifies as barricaded if the cover depth and slope requirements are met and the application of barricaded distance is allowed for the situation being considered. DoD 6055.9-STD provides specific permissible exposures where barricaded distances are permitted from an ECM to an explosives operating location.

**2-3 SITE AND DESIGN APPROVALS.** Site and construction plans for AE storage facilities must be approved by the DDESB or the service-specific safety organizations to ensure that the minimum DoD and service-specific explosive safety standards have been addressed. An exception to this allows the approval of service specific safety organizations for security and limited amounts of ammunition without DDESB approval. Situations requiring approval include, but are not limited to:

- New construction or major modification of facilities either involved in AE operations or in proximity to AE operations so as to be potentially exposed to hazards and
- Changes in the utilization of facilities that ~~could~~~~may~~ affect the minimum required explosive safety QD relationships.

Specific guidelines and procedures for approval of site and construction plans are contained in the DoD and service-specific explosive safety standards. Plans must be approved prior to commencing construction.

**2-3.1 Magazine Design Approval.** The design for all new AE storage magazines must be reviewed and approved by the DDESB to ensure that minimum explosive safety standards have been addressed. For a magazine to be sited within the explosive safety QD relationships corresponding to approved “7-Bar” and “3-Bar” ECM, it must be demonstrated that the design will provide the corresponding level of protection against unacceptable damage or injury.

The approval of a “7-Bar” or “3-Bar” ECM requires the submission of test results and/or detailed structural calculations. Prior to the start of a design, it is essential to closely coordinate the requirements with the DDESB to avoid excessive problems and delays in completing the design and obtaining the necessary approvals.

Once a “7-Bar” and “3-Bar” ECM design has been approved by the DDESB, the design does not have to be reapproved for subsequent uses.

New Undefined ECM and AGM designs require DDESB or the service-specific safety organizations to ensure that the minimum DoD and service-specific explosive safety standards have been addressed and to ensure that they comply with minimum design and construction criteria, including earth cover depth and slope, grounding, and lightning protection. An exception to this allows the approval of service specific safety organizations for security and limited amounts of ammunition without DDESB approval

**2-3.2 Approved Magazine Designs.** To facilitate the design and approval

process for AE storage magazines several approved designs have been developed for “7-Bar” and “3-Bar” ECM and for magazines and containers approved for restricted use. Appendices B and C include a listing and basic description of “7-Bar” and “3-Bar” ECM designs approved for new construction. Appendix C includes a listing of magazines and containers with reduced NEW and/or reduced explosive safety QD that are approved for use with restrictions.

The most current construction drawings, approval letters, and additional information and notes related to the approved designs can be accessed at the following web site:

<http://www.wbdg.org/design/buildingtypes.php> .

The source for tables DC-1 are tables AP1-1 of DDESB TP-15. These tables and the accompanying notes identify additional limitations, restrictions, or conditions associated with the use of these designs.

Approved designs can be site-adapted or tailored to the requirements of a specific site. Site specific adaptation primarily involves minor modifications to the foundation and the drainage systems to suit local soil and site characteristics. In addition, certain AE ~~magazines may~~ require additional consideration for utilities, security, electrical, grounding, or humidity and temperature limits.

Any changes to the approved designs, other than minimal site adaptation, that may affect the explosive safety of a magazine design must be approved by the appropriate service-specific explosive safety office and the DDESB prior to construction.

### 2-3.3 Other Magazine Designs.

**2-3.3.1 “7-Bar” and “3-Bar” ECM Designs no Longer Approved for New Construction.** The Whole Building Design Group web site and DDESB TP-15, Table 1-2 contains a listing 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 primary intent of this list is to assist activities in siting additional magazines. NEW limitations and/or restrictions associated with their DDESB approval must be observed. These designs ~~may~~can be used as the basis for new ECM designs, but they must not be used for construction until they are updated to comply with current explosive 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 the approved designs can be accessed at the following web site:

<http://www.wbdg.org/design/buildingtypes.php> .

**2-3.3.2 Undefined ECM Designs.** DDESB TP-15, Table AP1-3 contains a listing of ECM designs that are classified as undefined. These designs have not been shown by analysis or testing to have the structural capacity of either a “7-Bar” or “3-Bar” ECM.

An undefined ECM can be structurally analyzed in accordance with the Joint Service Manual Army TM5-1300/NAVFAC P-397/AFR 88-22, *Structures to Resist the Effects of Accidental Explosions*, to determine its structural capabilities and potentially upgrade the classification. HNDED-CS-93-4, *Guide for Evaluation Blast Resistance of Nonstandard Magazines*, illustrates procedures that can be used to determine the adequacy of the headwall and doors of an existing ECM to provide an acceptable level of protection from a given quantity of explosive at a known distance. The DDESB must review and approve the structural analysis and ensure that the design complies with current explosive safety requirements as well as current construction methods and criteria, prior to reclassifying the ECM design.

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

**2-3.4 Magazine Construction and Explosives Safety Site Approval.** The explosive safety site plan for all new AE storage magazines must be reviewed and approved by the DDESB and the applicable service-specific explosive safety representative to ensure that the magazine has been sited in accordance with the minimum explosive safety QD appropriate to the magazine type and classification. An exception to this allows the approval of service specific safety organizations for security and limited amounts of ammunition without DDESB approval

If only approved magazine designs are used in a project, and the designs have not been changed other than for minimal site adaptation, only the project site plan along with the core drawing numbers of the approved magazine design selected for construction must be submitted for site approval

**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 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, and AE non-compatibility. Some of these factors are discussed below.

The use of an approved standard designs for new magazine construction is mandatory within the DoD except where a preapproved design is not suitable due to special circumstances.

**2-4.1 Net Explosive Weight (NEW) Limits.** Each of the approved magazine standard designs is rated for a maximum quantity of HD 1.1 AE that can be stored, expressed as maximum NEW. A magazine is sited using explosive safety QD relationships corresponding to the maximum amount of NEW that will be stored within the magazine. However the quantity of AE stored must never exceed the maximum rated value.

## **2-4.2 Magazine Characteristics.**

**2-4.2.1 Shapes and Sizes.** Some ECM shapes that have been used in the past are shown in appendix C. The physical dimensions and shapes of “7-Bar” and “3-Bar” ECM designs approved for new construction are provided in Tables C-1 and are graphically depicted in Appendix C.

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

**2-4.2.2 Door Openings.** The approved “7-Bar” and “3-Bar” magazine designs have various door opening sizes. To minimize construction cost, the door opening shall be the smallest necessary to accommodate the size of packaged AE to be stored and the anticipated delivery and storage methods. Size openings to accommodate anticipated future requirements.

**2-4.2.3 Door Types.** Magazine doors are vertical swinging or sliding type. Doors are either manually or electrically operated. The HPM concept design has electrically operated horizontal sliding doors that cover the top of the AE storage compartments.

**2-4.2.4 Storage Options.** AE is stored within a magazine utilizing forklifts. An overhead bridge crane storage option has been developed in the RC Box, Type “M” magazine. The HPM concept design requires the use of an overhead bridge crane for storage and retrieval of AE.

**2-4.2.5 Land Availability Constraints.** The HPM concept design was developed to accommodate storage of relatively large amounts of AE at sites that are restricted due to land availability or neighboring site development. This magazine consists of a group of isolated compartments designed to prevent the propagation of an explosion between compartments. Thus siting of the HPM concept design is based on the maximum credible event (MCE) in a single compartment as opposed to the total quantity of AE in all compartments of the magazine.

**2-4.3 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 Material Command provides Storage and outloading drawings for various AE within certain ECMs. These drawings, 19-48-75-5, may be obtained at the Defense Ammunition Center web site:

<https://www3.dac.army.mil/DET/order/draworder.html>.

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

*Standards.*



## CHAPTER 3

### DESIGN CONSIDERATIONS AND REQUIREMENTS

**3-1 EARTH COVER.** The minimum earth cover over the top of a magazine shall be 2'-0" (0.61m). The maximum slope must be maintained at 2 horizontal to 1 vertical unless means are provided to control erosion. The earth cover above, to the sides, and to the rear of a ECM is the critical element of its design. The material for the earth cover shall be reasonably cohesive material, and must be free from deleterious organic matter, trash, debris, and stones heavier than 10 pounds or larger than 6 inches in diameter. Solid or wet clay should not be used due to its excessive cohesiveness. Limit larger stones to the lower center of fills and do not use for earth cover over the magazines. Compact the material and prepare as necessary to maintain structural integrity and provide erosion control. In locations where it is impossible to use a cohesive material 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.

The HPM concept design is considered to be the structural equivalent of a "7-Bar" ECM in terms of protecting the stored ordnance by preventing propagation of an explosion that ~~could~~~~may~~ occur in an adjacent magazine. This concept design uses earth berms on the exterior walls but utilizes lightweight reinforced concrete covers in lieu of an earth cover over the top of the ordnance storage area.

**3-2 FLOOR LOADING.** The design floor live load shall be the maximum anticipated loading of stored material within the magazine during its useful life. Considerations shall 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 give location based on the actual anticipated usage. In such case, the maximum design floor live loading shall be prominently posted at the entrance and within the magazine structure. Under all cases, the minimum floor live loading for any magazine type shall be 500 PSF.

**3-3 FOUNDATIONS.** Foundations shall be provided with a safe working static load capacity equivalent to or greater than the safe working static load capacity of the foundation shown on the Standard Approved Magazine Drawings. Foundations for earth retention walls shall 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 shall have an ultimate dynamic load capacity equivalent or greater to the ultimate dynamic load capacity of the foundations shown on the Standard Approved Magazine Drawings. Elements of the magazine that are required to resist the loading from a PES typically include structural walls and columns supporting roof elements. Unless a more detailed analysis is warranted, it is recommended that foundations redesigned for poor soil conditions shall have a safe working static load capacity equal to or greater than the safe working load capacity of



the foundations of the Standard Approved Magazine Drawings

**3-4 WATERPROOFING AND DRAINAGE.** Ensure that the magazine is watertight and offers adequate protection to the stored AE from water intrusion. An elastomeric membrane is appropriate for concrete magazines and a bituminous waterproofing is more suitable for steel magazines. Protect the waterproofing membrane from backfilling and compaction operations during construction. (**Note:** The **Navy** currently has a prohibition against the use any types of steel ECM's for new construction due to difficulty of properly waterproofing these magazines.)

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

**3-5 VENTILATION.** 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. The HPM concept design requires additional forced ventilation considerations in the ordnance storage compartments.

**3-6 TEMPERATURE AND HUMIDITY CONTROLS.** Most AE do not require temperature or humidity controls beyond standard ventilation. However, some specialized missiles have restrictions on the temperature and humidity at which they can be stored. At some locations, these restrictions will necessitate ADDITIONAL temperature and humidity controls within the magazines. When adding equipment or openings to an approved magazine design, the addition must not affect the rating or the explosive safety aspects of its design; such as lightning protection, structural integrity, etc. Changes to approved designs must be reviewed and approved by the service-specific explosive safety office and the DDESB prior to construction. Design of temperature and humidity control systems shall be in accordance with UFC 3-400-10N.

**3-7 OPTIONAL SUBSTANTIAL DIVIDING WALL.** A Substantial Dividing Wall (SDW) is used to prevent prompt detonation reactions or propagation of burning reactions involving AE between adjacent bays within a magazine and to provide personnel protection from remotely controlled operations. DDESB-KT memorandum of 15 January 2003 provides updated guidance on the usage, applicability and limitations of a SDW. If the SDW guidance is adhered to, the NEW of each room or cubicle can be considered independently for the purpose of establishing minimum explosive safety QD relationships as described in the DDESB-KT memorandum.

**3-8 PHYSICAL SECURITY.** The approved magazine standard designs only identify limited physical security features. The designs include a high security hasp on the doors, steel bars at openings, and **couldmay** also include conduit for electronic security systems. Security requirements for a specific magazine must be determined by the using agency and the installation security personnel.

Minimum DoD physical security standards and criteria are contained in DoD 5100.76-M,

*Physical Security of Sensitive Conventional Arms, Ammunition, and Explosives*. Service specific guidance implementing DoD 5100.76-M are contained in AR 190-11, *Physical Security of Arms, Ammunition, and Explosives*, and OPNAVINST 5530.13C, *Physical Security Instruction for Conventional Arms, Ammunition, and Explosives*.

The Internal Locking Device developed by the Naval Facilities Engineering Command has been approved as an alternate to the current high security padlock and hasp for High Security Magazines. The Internal Locking Device provides improved forced entry resistance, and durability (UFC 4-010-03 (DRAFT)).

**3-9 CATHODIC PROTECTION.** Provide cathodic protection for steel arch magazines in areas where the soils are susceptible to galvanic action.

**3-10 LIGHTNING PROTECTION.** Provide lightning protection in accordance with NFPA 780, *Standard for the Installation of Lightning Protection Systems*. The completed magazine requires a UL Lightning Protection Inspection Certificate. This certificate verifies compliance with NFPA 780 and UL 96A, *Standard for Installation Requirements for Lightning Protection Systems*, and is explained further at <http://www.ul.com/lightning>.

The lightning protection system must feature air terminals, low impedance paths to ground, sideflash protection, surge suppression or ground of all conductive penetrations into the protected area, and earth electrode systems. Design the system to intercept lightning at a 100 ft or less striking distance arc. Provide surge suppression for all entrances to the magazine to the type and protection level specified in NFPA 780.

**3-11 GROUNDING.** Provide earth electrode grounding of the electrical system in accordance with NFPA 70 and the additional criteria specified here.

Install an exterior earth electrode grounding system around the entire circumference of the magazine; this grounding system is referred to as the *grounding girdle*. Install ground rods at each change in direction in the grounding system and for each down conductor. All inaccessible connection points in the earth electrode grounding system shall be an exothermic weld connection.

Provide test wells at two ground rod locations, with one test well near the front of the facility, and one test well located near the rear of the facility. Determine the precise test well locations during the project design to consider periodic access to the test wells given the installation location. Assemble test wells with bolted connections to facilitate future testing.

Bond all magazine structural steel to the grounding system. Ensure that all structural steel is electrically connected to the grounding girdle. Tie structural steel joints with #6 awg wire and use a minimum of 2/0 awg copper wire for the connection to the grounding girdle.

Ground bars are not required inside the magazine as an ordnance ground unless

specified by the using agency. Instead, install a minimum of one ground stud inside the facility in accordance with the magazine design drawings. This ground stud does not require periodic testing until it is placed in service. A ground bar can be installed onto the ground stud if determined to be necessary.

**3-12 ELECTRICAL HAZARD CLASSIFICATION.** The Designer of Record is responsible for determining the type of classification based on the anticipated use and interior environment for each magazine. Ordnance storage magazines that store only "fleet issue" ammunition would typically only need to meet industrial standards for electrical service. A magazine storing raw explosives material in shipping containers, for use in weapons, or other explosive processing operations, would qualify as a Class 1, Division 2 location. Explosive-proof fixtures and equipment are not required unless the magazine is classified as a hazardous location.

**3-13 INTERIOR ELECTRICAL DESIGN.** Regardless of the electrical hazard classification, all interior conduit shall be galvanized steel rigid metal conduit. Ground all lighting fixtures, receptacles, devices, motors, and enclosures with a separate ground wire provided in each conduit. Locate duplex receptacles and electrical control equipment 48 inches above the floor. Refer to the approved magazine design drawings for additional design detail requirements.

**3-14 DDESB AND SERVICE-SPECIFIC EXPLOSIVE SAFETY CONTACTS.**

**DDESB:** Department of Defense Explosives Safety Board (DDESB)  
Room 856C Hoffman Building I  
2461 Eisenhower Avenue  
Alexandria, VA 22331-0600

**Air Force:** Air Force Safety Center (AFSC)  
Attn: AFSC/SAEW  
9750 Avenue G, Suite 264  
Kirtland AFB, NM 87117-5670

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

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

Defense Ammunition Center (DAC)  
Attn: SJMAC-EST  
1C Tree Road

McAlester, OK 74501-9053

**Marine Corps:** Commander, Marine Corps Systems Command  
(MARCORSYSCOM)  
Attn: AM-EES  
Barnett Avenue, Suite 315  
Quantico, VA 22134-5010

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

Naval Facilities Engineering Command (NAVFAC)  
Attn: NAVFAC Criteria Office (Code EICO)  
6506 Hampton Blvd  
Norfolk, VA 23508-1278

Naval Facilities Engineering Service Center (NFESC)  
Attn: ESC62  
1100 23<sup>rd</sup> Avenue, Building 1100  
Port Hueneme, CA 93043-4370

## **GLOSSARY**

### **ACRONYMS**

<b>AE:</b>	Ammunition and Explosives
<b>AGM:</b>	Aboveground Magazine
<b>DDESB:</b>	Department of Defense Explosives Safety Board
<b>DoD:</b>	Department of Defense
<b>ECM:</b>	Earth Covered Magazine
<b>ES:</b>	Exposed Site
<b>HD:</b>	Hazard Division
<b>HPM:</b>	High Performance Magazine (Concept Design)
<b>HSILS:</b>	High Security Integrated Locking System
<b>IMD:</b>	Intermagazine Distance
<b>MCE:</b>	Maximum Credible Event
<b>MSM:</b>	Munitions Storage Module
<b>NEW:</b>	Net Explosive Weight
<b>NFPA:</b>	National Fire Protection Association
<b>PES:</b>	Potential Explosion Site
<b>QD:</b>	Quantity-Distance
<b>RC:</b>	Reinforced Concrete
<b>SDW:</b>	Substantial Dividing Wall
<b>UN:</b>	United Nations

### **DEFINITIONS**

**Ammunition and Explosives (AE):** Includes, but not limited to, all ammunition; propellants, liquid and solid; pyrotechnics; high explosives; guided missiles; warheads; devices; and chemical agent substances presenting real or potential hazards to life, property and the environment. Does not include inert items and nuclear warheads and devices

**Barricade:** A barrier, natural or artificial, capable of limiting, in a prescribed manner, the effect of an explosion on an ES.

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

**Earth-Covered Magazine (ECM):** A Magazine with a minimum 0.61 m (2'-0") thick protective earth cover, and the required earth cover slope. Three structural classifications exist for ECM:

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

**Hazard Division (HD) 1.1:** One of six divisions designating the predominant hazard within United Nations (UN) Class 1, Explosives.

**High-Performance Magazine standard design (HPM):** An approved design concept for a magazine that is not earth covered but is considered to be the equivalent of a “7-Bar” ECM.

**Intermagazine Distance (IMD):** The minimum explosive safety QD relationship between two magazines.

**Magazine:** Any building or structure, except an operating building, used to store AE

**Maximum Credible Event (MCE):** The worst single event that is likely to occur at a PES based on a reasonability of occurrence considering the explosion propagation, burning rate characteristics, and physical protection given to the items at the PES.

**Net Explosive Weight (NEW):** The total quantity of AE at a PES.

**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 relationship between the quantity of explosive material at a PES and the separation distance that provide defined types of protection. These relationships are based on minimum levels of risk considered acceptable for various types of ES. Separation distances are not absolute safe distances, but are relative protective or safe distances. Greater distances than those shown in the explosive safety standards should be used whenever practicable.

**Substantial Dividing Wall (SDW):** A reinforced concrete wall for the prevention of prompt detonation or propagation of burning reactions between separated areas within a magazine. The SDW must having the physical characteristics and be subject to the guidelines and limitations defined in the updated guidance for substantial dividing walls contained in the DDESB-KT memorandum of 15 Jan 2003.

## **APPENDIX A**

### **REFERENCES**

#### **GOVERNMENT PUBLICATIONS:**

**1. Department of Defense**

Defense Technical Information Center  
8725 John J. Kingman Road  
Suite 0944  
Fort Belvoir, VA 22060-6128  
<http://www.dtic.mil/whs/directives/corres/pub1.html>

DoD 6055.9-STD, *DOD Ammunition and Explosives Safety Standards*

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

DoD 5100.76-M, *Physical Security of Sensitive Conventional Arms, Ammunition, and Explosives*

**2. Department of Defense Explosive Safety Board**

Department of Defense Explosive Safety Board Internet Site  
<http://www.ddesb.pentagon.mil/>.

Technical Paper No. 15, *Approved Protective Construction*

**3. Department of the Army**

HQDA, Army Safety Office (DACs-SF)  
200 Army Pentagon  
Washington, DC 20310-0200

AR 385-64, *U.S. Army Explosives Safety Program*

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

Director, U.S. Army Technical Center for Explosives Safety  
1 C Tree Road, Bldg. 35  
McAlester, OK 74501-9053

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

U.S. Army Ammunition Center and School (USDACS)  
<https://www3.dac.army.mil/DET/order/draworder.html>

US Army Material command Drawings 19-48-75-5

Commander  
US Army Engineering and Support  
Center, Huntsville  
ATTN: CEHNC-ED-CS-S  
PO Box 1600  
Huntsville, AL 35807-4301

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

HNDED-CS-93-4, *Guide For Evaluating  
Blast Resistance of Nonstandard  
Magazines*

4. Department of the Air Force

Air Force Safety Center  
Attn: AFSC/SAEW  
9750 Avenue G, Suite 264  
Kirtland AFB, NM 87117-5670

AFM 91-201, *Explosives Safety  
Standards*

5. Department of the Navy

Office of the Chief of Naval Operations  
2000 Navy Pentagon  
Washington, DC 20350-2000  
<http://ned.s.daps.dla.mil/>

OPNAVINST 5530.13C, *Physical Security  
Instruction for Conventional Arms,  
Ammunition, and Explosives*

Naval Sea Systems Command  
Naval Ordnance Safety and Security  
Activity  
Farragut Hall,  
Bldg D323 Strauss Avenue,  
Indian Head, MD  
[https://intranet.nossa.navsea.navy.mil/D  
isclaimer.asp](https://intranet.nossa.navsea.navy.mil/D<br/>isclaimer.asp)

NAVSEA OP 5 Volume 1, *Ammunition  
and Explosives Safety Ashore*

NAVSEAINST 8024.2, *Magazine  
Stowage Layout Standards*

6. Departments of the Air Force, Army,  
Navy

Standardization Documents Order Desk  
700 Robbins Avenue, Bldg. 4D  
Philadelphia, PA 19111-5094

Army TM5-1300/NAVFAC P-397/AFR 88-  
22, *Structures to Resist the Effects of  
Accidental Explosions*

**NON-GOVERNMENT PUBLICATIONS:**

National Fire Protection Association  
Batterymarch Park  
Quincy, MA

NFPA 70, *National Electrical Code*

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



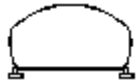
## APPENDIX B

### TYPES OF ECM IN USE

The following are descriptions of the predominant types of magazines that are in use.



**Arch**—Also known as a circular arch. A single radius is used to define the interior face of the arch, which ~~is may be~~ constructed of reinforced concrete, steel (corrugated, laminated, or single gage), or a combination of reinforced concrete and steel to form a composite arch (steel interior arch with overlying concrete).



**Arch, Oval**—This arch is in the shape of an oval, with the lower portion of each sidewall bowing in towards the direction of the centerline. The arch can be constructed of steel, reinforced concrete, or a composite of both. The shape is defined by the use of a single radius for the majority of the arch, with a separate radius for the lower portions of the arch. The modified FRELOC-Stradley ECM design is an example of an oval-arch.



**Arch, Semi-Circular**—The sidewalls are elongated with the arch defined by a radius that originates approximately 3 to 5 feet above floor level. A radius originating at the opposite sidewall defines the lower portion of the arch. The arch can be constructed of either reinforced concrete or steel.



**Stradley**—This reinforced concreted ECM is characterized by vertical sidewalls that blend into the arched roof. Three radii are used to define the arch and the transition from the vertical sidewalls to the roof arch. Another feature of the Stradley ECM is that its walls are significantly thicker at the base of the sidewalls and thinner at the crown of the arch.



**FRELOC-Stradley**—The FRELOC-Stradley ECM is constructed of reinforced concrete. Its interior shape is similar to a Stradley ECM, except that the sidewalls and arch have the same thickness.



**Modified FRELOC-Stradley**—This ECM design was the first ECM constructed with an oval arch. See the information above for the oval arch.



**Box**—This term describes any ECM that has an internal box shape. Box magazine are constructed from reinforced concrete.



***Dome***—The domed shape is used only by the Corbetta ECM design. This ECM is constructed from reinforced concrete.

## APPENDIX C

### “7-BAR” AND “3-BAR” ECM APPROVED FOR NEW CONSTRUCTION (IP Units)

**C-1** Table C-1 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. Table C-1 presents the information in U.S. customary inch-pound (IP) units.

The source of this table is DDESB Technical Paper TP-15 (Version 2), Table AP1-1.

**C-2** Figures C-1 through C-16 graphically depict the approved designs for “7-BAR” AND “3-BAR” ECM. The most current version of the approved design drawings, approval letters, and additional information related to the approved designs can be accessed at the following web site: <http://www.wbdg.org/design/index.php?cn=1.3&cx=0>.

**TABLE C-1 “7-BAR” AND “3-BAR” ECM APPROVED FOR NEW  
CONSTRUCTION (IP Units)**

<b>Description</b>	<b>Drawing Number</b>	<b>Dimensions (Internal)</b>	<b>Door Opening</b>	<b>Maximum NEW (a)</b>
RC Box Type 'C'	1404430 through 1404444	94'-8" Wide x 50'-0" Long x 13'-8" (Rear) To 15'-10" (Front) High	(3) Sliding 25'-0" Wide x 11'-0" High	500,000 lb
RC Box Type 'D'	6448522 through 6448554	158'-8" Wide x 50'-0" Long x 13'-8" (Rear) To 15'-10" (Front) High	(5) Sliding 25'-0" Wide x 11'-0" High	500,000 lb
RC Box Type 'D' (HSILS)	6448555 through 6448588	158'-8" Wide x 50'-0" Long x 13'-8" (Rear) To 15'-10" (Front) High	(3) Sliding 25'-0" Wide x 11'-0" High	500,000 lb
RC Box Type 'E'	1404523 through 1404537	94'-8" Wide x 50'-0" Long x 13'-8" (Rear) To 15'-10" (Front) High	(3) Sliding 16'-0" Wide x 11'-0" High	500,000 lb
RC Box Type 'F'	6448589 through 6448621	158'-8" Wide x 50'-0" Long x 13'-8" (Rear) To 15'-10" (Front) High	(5) Sliding 16'-0" Wide x 11'-0" High	500,000 lb
RC Box Type 'M'	10400001 through 10400027	81'-0" Wide x 124'-0" Long x 24'-6" (Min) High	(2) 14'-0" Wide x 14'-0" High	500,000 lb

<b>Description</b>	<b>Drawing Number</b>	<b>Dimensions (Internal)</b>	<b>Door Opening</b>	<b>Maximum NEW (a)</b>
RC Box	421-80-06 (Modified)	25'-0" Wide x 20'-0" Min. to 80'-0" Max. Length x 11'-0" High	Hinged 24'-0" Wide x 10'-4" High	500,000 lb
RC Box	Munitionslagerhaue (MLH)90B			165,000 lb
RC Box	Munitionslagerhaue (MLH)180B	25'-1" Wide x 77'-9" Long x 13'-11" High	(1) 13'-1 1/2" Wide x 9'-10" High	165,000 lb
RC Box	Modular Storage Magazine (MSM)	25'-0" Wide x 20'-0" Min. to 80'-0" Max. Length x 14'-8" High	Hinged 24'-0" Wide x 13'-11" High	500,000 lb
RC Box (Multi-cell)	High Performance Magazine (HPM) - Concept Design - Drawings not complete	Four cells each 21'-0" Wide x 83'-0" Long x 16'-0" High	Horizontal Rolling Covers Max Opening 21'-0" x 37'-11"	Varies depending on configuration 240,000 lb Max
RC Circular Arch	1404310 through 1404324	25'-0" Wide x 80'-0" Max. Length x 11'-11" (Rear) High	(1) Sliding 10'-0" Wide x 10'-0" High or 16'-0" Wide x 10'-0" High	500,000 lb
RC Arch	421-80-05	26'-7 1/4" Wide x 90'-0" Max. Length (normally length is 60' or 80') x 14'-0" (Rear) High	(1) Sliding 8'-0" Wide x 8'-0" High or 10'-0" Wide x 10'-0" High	500,000 lb
RC FRELOC Stradley	33-15-74	25'-0" Wide x 90'-0" Max. Length (normally length is 60' or 80') x 14'-0" (Rear) High	(1) Sliding 8'-0" Wide x 8'-0" High or 10'-0" Wide x 10'-0" High	500,000 lb
RC FRELOC Stradley	(Korean Version) 33-15-74	25'-0" Wide x 90'-0" Max. Length (normally length is 60' or 80') x 14'-0" (Rear) High	(1) Sliding 10'-0" Wide x 10'-0" High	500,000 lb
Steel Oval Arch	Munitionslagerhaue (MLH)90S			165,000 lb

<b>Description</b>	<b>Drawing Number</b>	<b>Dimensions (Internal)</b>	<b>Door Opening</b>	<b>Maximum NEW (a)</b>
Steel Oval Arch	Munitionslagerhause (MLH)180S			165,000 lb
Steel Oval Arch	421-80-03	28'-2" Max Wide x 21'-0" Min. to 89'-0" Max. Length x 14'-11" (Max) High	(1) Sliding 8'-0" Wide x 8'-0" High or 10'-0" Wide x 10'-0" High	500,000 lb
Steel, Semi-Circular Arch	421-80-01	Approx. 26'-0" Wide x 19'-0" Min. expandable up to most commonly used 89'-0" Length x 14'-0" (Max) High	(1) Sliding 8'-0" Wide x 8'-0" High or 10'-0" Wide x 10'-0" High	500,000 lb
Composite Circular Arch	1404375 through 1404389	25'-0" Wide x 80'-0" Max. Length 13'-2" (Rear) High	(1) Sliding 10'-0" Wide x 10'-0" High or 16'-0" Wide x 10'-0" High	500,000 lb
Composite Oval Arch	1404390 through 1404398	28'-2" Max Wide x 20'-0" Min. to 80'-0" Max. Length x 15'-2" (Max) High	(1) Sliding 10'-0" Wide x 10'-0" High	500,000 lb

**Notes to Table C-1, "7-BAR" AND "3-BAR" ECM APPROVED FOR NEW CONSTRUCTION (IP Units)**

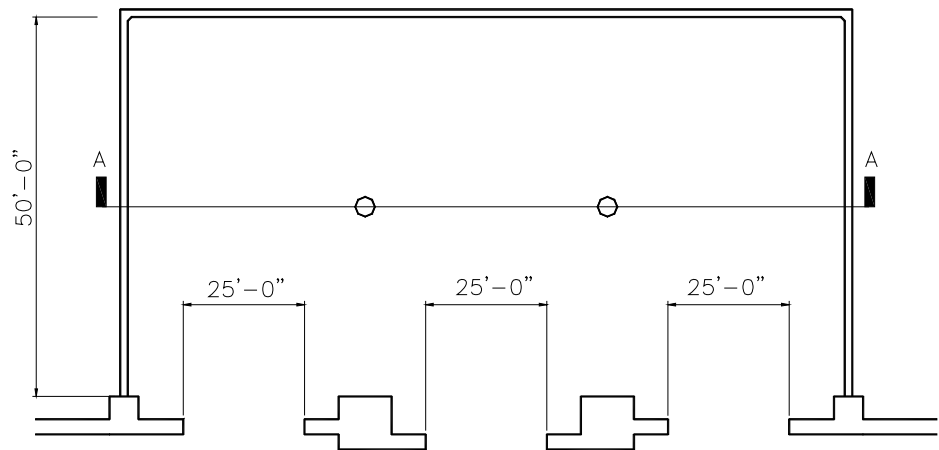
**Note (a) – Refer to paragraph 2.2.2 for siting considerations of ECM as exposed sites with approved maximum NEW less than 500,000 lb.**

**Figure C-1. RC Box, Type 'C' (IP Units)**

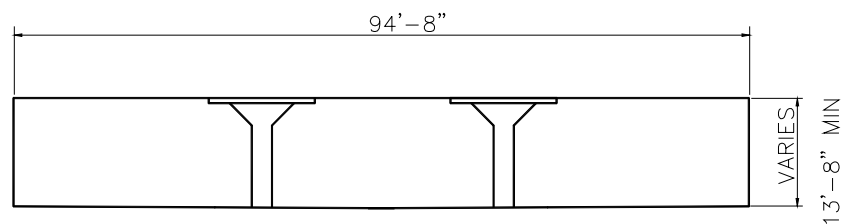
ECM Designation	Designer & Drawing Number	Maximum Allowable Net Explosive Weight (NEW)	Dimensions (Internal)	Door Opening	DDESB Approval Date
<b>7-BAR</b>	<b>NAVFAC 1404430-1404444</b>	<b>500,000 lb</b>	<b>94'-8" Wide x 50'-0" Long x 13'-8" (Rear) To 15'-10" (Front) High</b>	<b>(3) Sliding 25'-0" Wide x 11'-0" High</b>	<b>5 NOV 1985</b>

Comments/Design Considerations:

- May be built with or without a loading platform
- Single piece sliding doors
- High security hasp door lock



PLAN VIEW



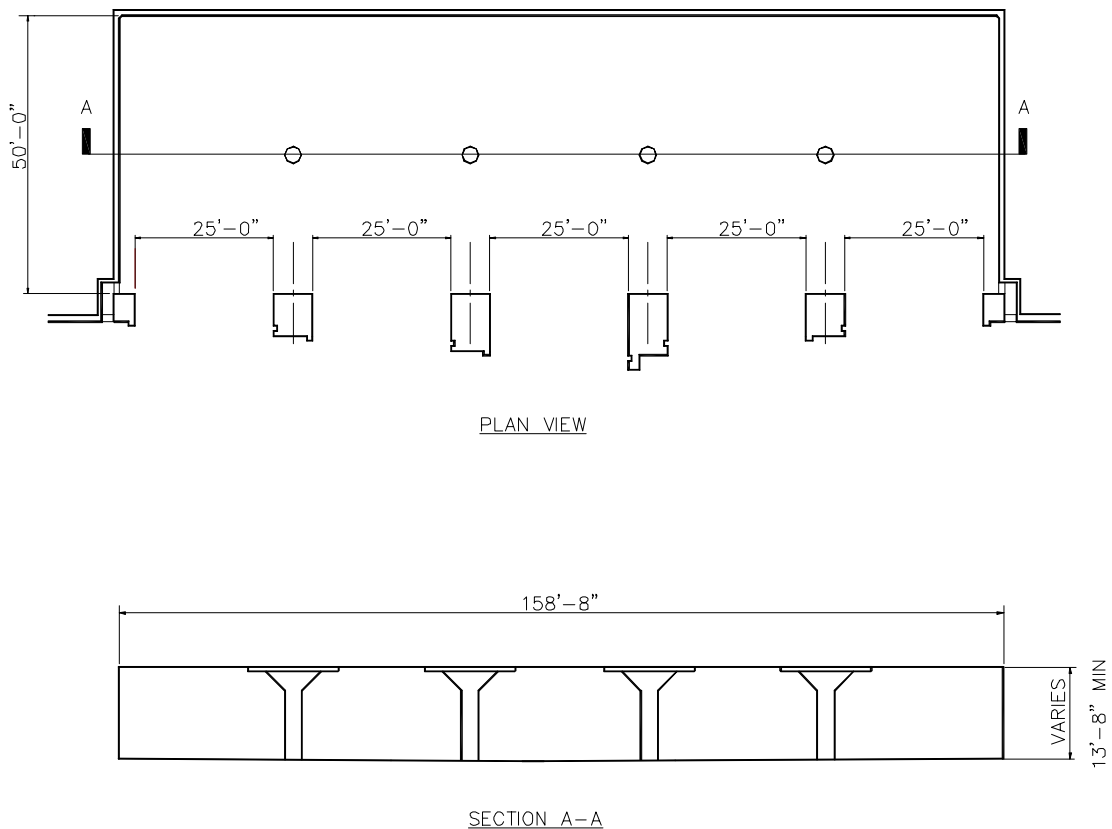
SECTION A-A

**Figure C-2. RC Box, Type 'D' and RC Box, Type 'D' (HSILS) (IP Units)**

ECM Designation	Designer & Drawing Number	Maximum Allowable Net Explosive Weight (NEW)	Dimensions (Internal)	Door Opening	DDESB Approval Date
<b>7-BAR</b>	<b>NAVFAC 6448522-6448554</b>	<b>500,000 lb</b>	<b>158'-8" Wide x 50'-0" long x 13'-8" (Rear) To 15'-10" (Front) High</b>	<b>(5) Sliding 25'-0" Wide x 11'-0" High</b>	<b>5 NOV 1985</b>

Comments/Design Considerations:

- Superseded NAVFAC 1404465 through 1404478.
- May be built with or without a loading platform
- Single piece sliding doors
- High security hasp door lock
- Type D HSILS incorporates a High Security Integrated Locking System (HSILS)

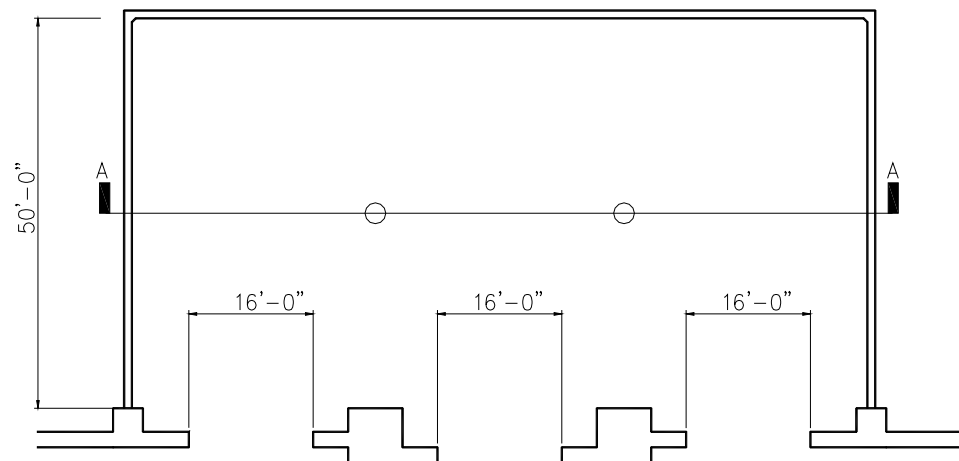


**Figure C-3. RC Box Type 'E' (IP Units)**

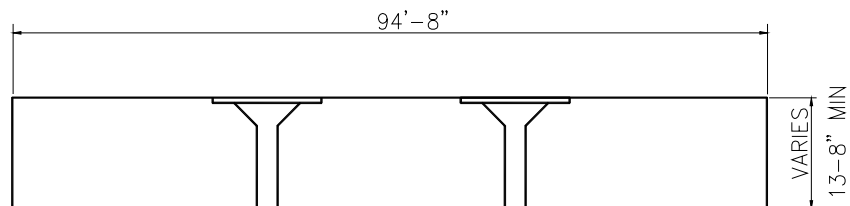
ECM Designation	Designer & Drawing Number	Maximum Allowable Net Explosive Weight (NEW)	Dimensions (Internal)	Door Opening	DDESB Approval Date
<b>7-BAR</b>	<b>NAVFAC 1404523- 1404537</b>	<b>500,000 lb</b>	<b>94'-8" Wide x 50'-0" Long x 13'-8" (Rear) To 15'-10" (Front) High</b>	<b>(3) Sliding 16'-0" Wide x 11'-0" High</b>	<b>17 JUL 1987</b>

Comments/Design Considerations:

- May be built with or without a loading platform
- Single piece sliding doors
  - High security hasp door lock



PLAN VIEW



SECTION A-A

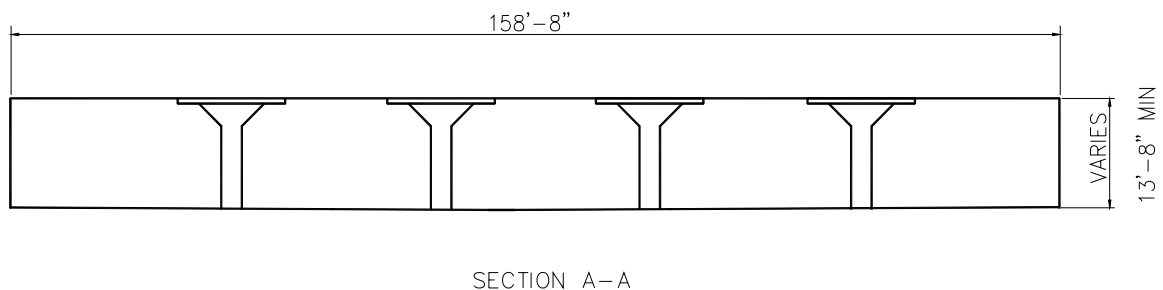
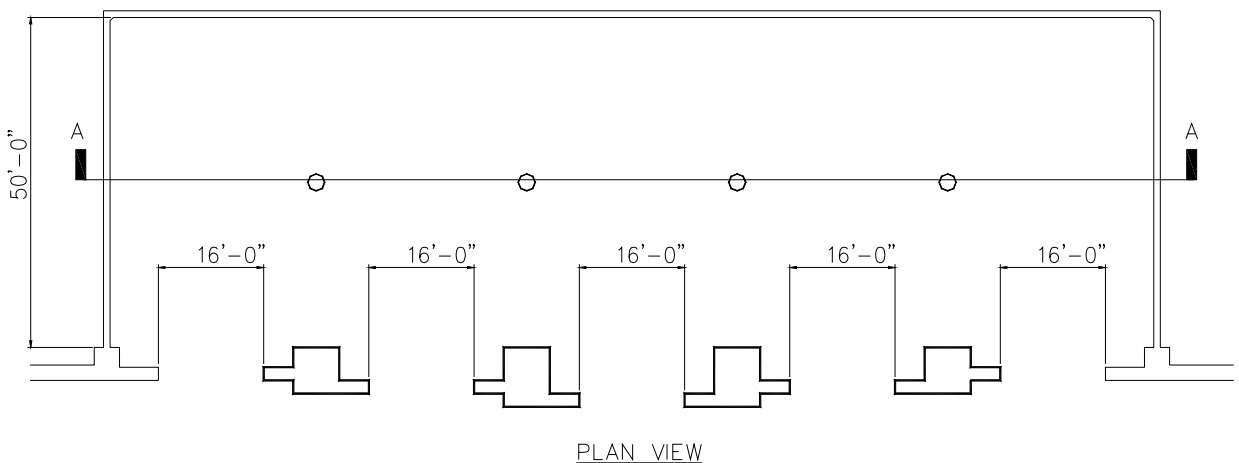


**Figure C-4. RC Box Type 'F' (IP Units)**

ECM Designation	Designer & Drawing Number	Maximum Allowable Net Explosive Weight (NEW)	Dimensions (Internal)	Door Opening	DDES Approval Date
<b>7-BAR</b>	<b>NAVFAC 6448589-6448621</b>	<b>500,000 lb</b>	<b>158'-8" Wide x 50'-0" Long x 13'-8" (Rear) To 15'-10" (Front) High</b>	<b>(5) Sliding 16'-0" Wide x 11'-0" High</b>	<b>17 JUL 1987</b>

**Comments/Design Considerations:**

- Superseded NAVFAC 1404541 through 1404555.
- May be built with or without a loading platform
- Single piece sliding doors
- High security hasp door lock

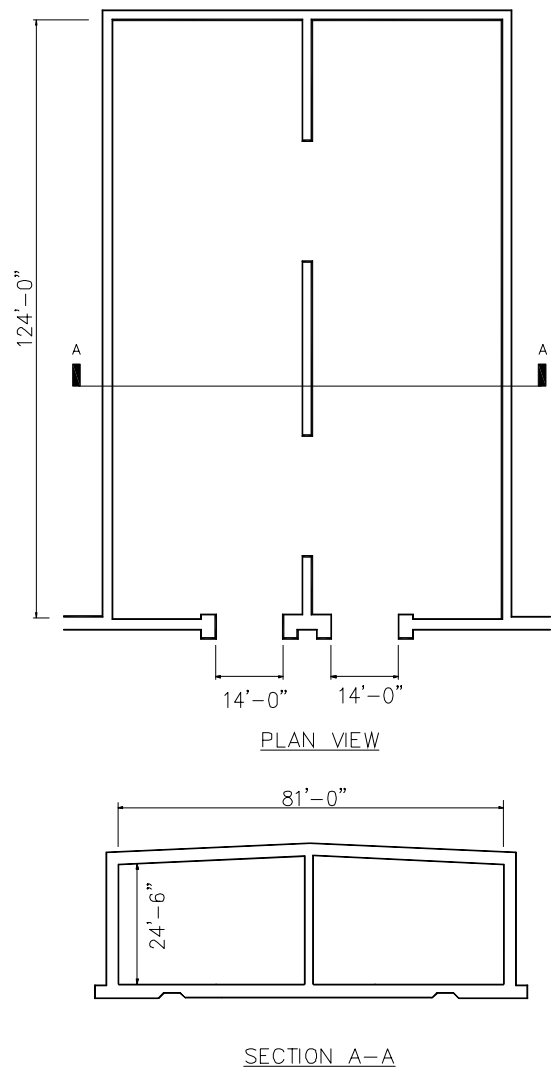


**Figure C-5. RC Box Type 'M' (IP Units)**

ECM Designation	Designer & Drawing Number	Maximum Allowable Net Explosive Weight (NEW)	Dimensions (Internal)	Door Opening	DDESB Approval Date
<b>7-BAR</b>	<b>NAVFAC 10400001-10400027</b>	<b>500,000 lb</b>	<b>81'-0" Wide x 124'-0" Long x 24'-6" (Min) High</b>	<b>(2) Sliding 14'-0" Wide x 14'-0" High</b>	<b>1 DEC 1999</b>

Comments/Design Considerations:

- Provides for internal magazine access by rail and truck.
- Designed for automated ordnance stowage and retrieval by bridge crane and lifting devices. Alternately forklift may be used.
- May be built with or without a loading platform
- Single piece sliding doors
- High security hasp door lock

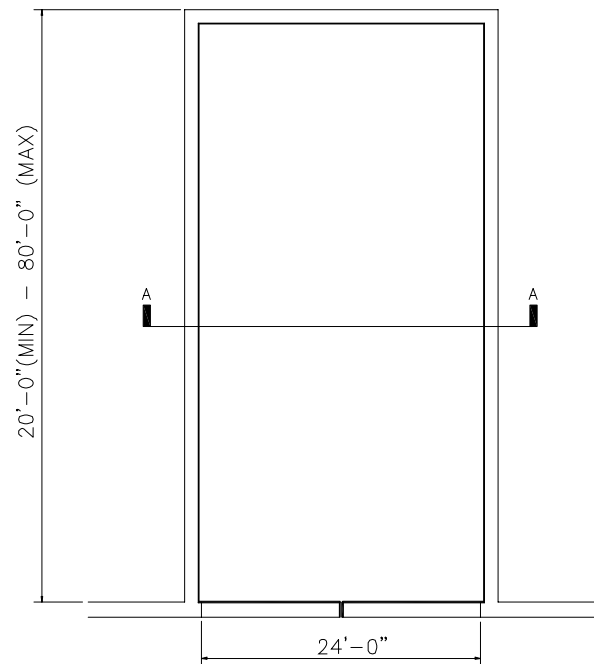


**Figure C-6. RC Box (421-80-06) Modified (IP Units)**

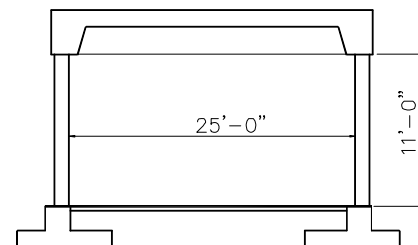
ECM Designation	Designer & Drawing Number	Maximum Allowable Net Explosive Weight (NEW)	Dimensions (Internal)	Door Opening	DDESB Approval Date
<b>7-BAR</b>	<b>COE 421-80-06 (Modified)</b>	<b>500,000 lb</b>	<b>25'-0" Wide x 20'-0" Min To 80'-0" Max. Long x 11'-0" High</b>	<b>Hinged 24'-0" Wide x 10'-4" High</b>	<b>17 APR 2002</b>

**Comments/ Design Considerations:**

- This design reflects a modified version of the original design 421-80-06 dated 1 Oct 99. The original design was downgraded to undefined. For the magazine to be sited as a 7-Bar approved ECM the design must be modified with the revised drawings, S-9 through S-13. See the DDESB memo of 17 April 2002 for specific requirements for both new construction and for a retrofit to upgrade an existing magazine built to the original design."
- Double hinged doors



PLAN VIEW



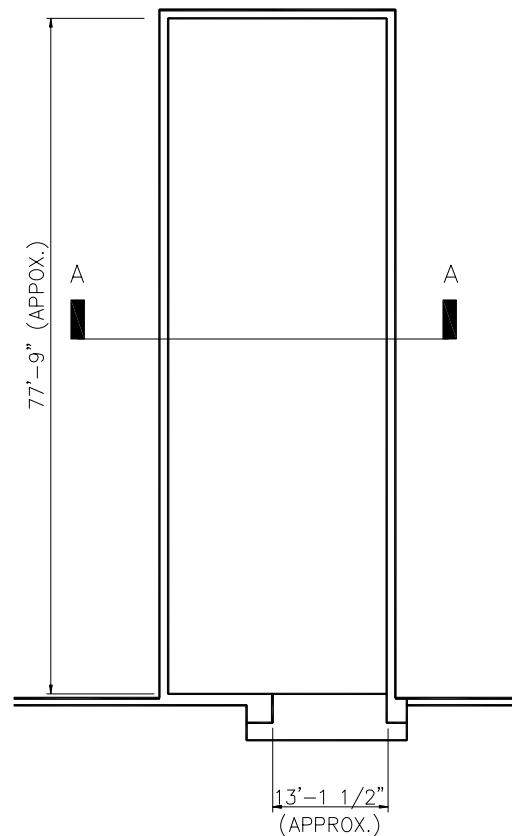
SECTION A-A

**Figure C-7. RC Box (MLH) 180B (IP Units)**

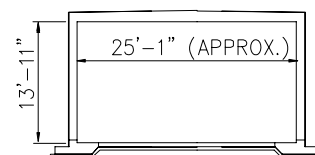
ECM Designation	Designer & Drawing Number	Maximum Allowable Net Explosive Weight (NEW)	Dimensions (Internal)	Door Opening	DDESB Approval Date
<b>7-BAR</b>	<b>German Munition-slagerhouse (MLH) 180B</b>	<b>165,000lb</b>	<b>25'-1" Wide x 77'-9" Long x 13'-11" High</b>	<b>(1) 13'-1 1/2" Wide x 9'-10" High</b>	<b>12-DEC-77 18-AUG-87</b>

Comments/Design Considerations:

- NATO explosives safety standards limit this magazine to an HD 1.1 of 165,000 pounds NEW. For siting at U.S installations, where encumbered land is completely within U.S. owned or controlled property, magazine can be sited as an Undefined ECM with an Explosives limit of 250,000 pounds NEW. Considered as a 7-Bar ECM for sitings involving 165,000 pounds NEW or less.
- Single piece sliding door



PLAN VIEW



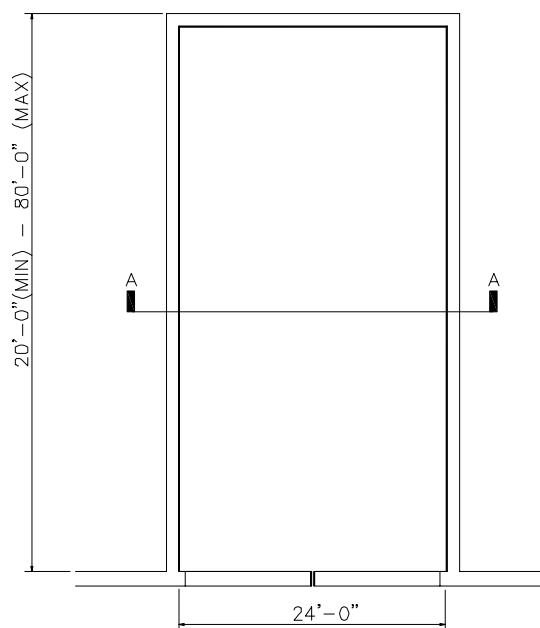
SECTION A-A

**Figure C-8. RC Box (MSM) (IP Units)**

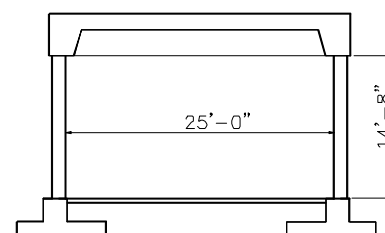
ECM Designation	Designer & Drawing Number	Maximum Allowable Net Explosive Weight (NEW)	Dimensions (Internal)	Door Opening	DDESB Approval Date
<b>7-BAR</b>	<b>Modular Storage Magazine (MSM)</b>	<b>500,000 lb</b>	<b>25'-0" Wide x 20'-0" Min. to 80'-0" Long x 14'-8" High</b>	<b>Hinged 24'-0" Wide x 13'-11" High</b>	<b>11 Jul 2002</b>

**Comments/ Design Considerations:**

- This 14'-8" ceiling height Modular Storage Magazine (MSM) design was developed for construction of magazines 2580 and 2581 at Hill AFB, Ogden, Utah, and is basically a larger version of the MSM (11 foot ceiling height) shown on drawings 421-80-06.
- Double hinged doors



PLAN VIEW



SECTION A-A

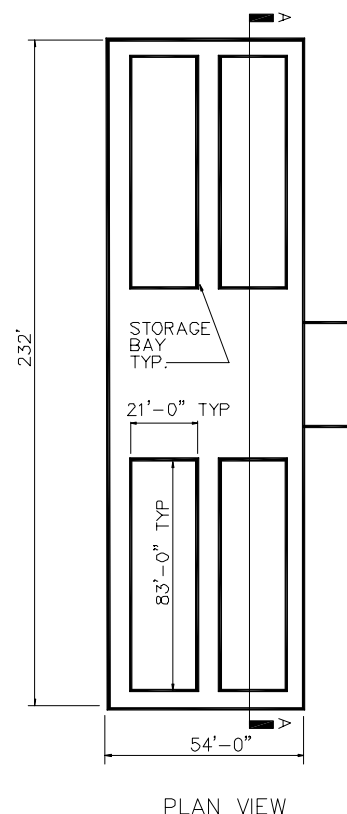
**Figure C-9. RC Box (Multi-Cell) (IP Units)**

ECM Designation	Designer & Drawing Number	Maximum Allowable Net Explosive Weight (NEW)	Dimensions (Internal)	Door Opening	DDESB Approval Date
<b>7-BAR</b>	<b>RC Box (multi-cell), HPM – Concept Design</b>	<b>Varies Depending On Configuration 240,000 lb Maximum</b>	<b>Four Cells Each 21'-0" Wide x 83'-0" Long x 16'-0" High</b>	<b>Ordnance Bay: Maximum 21'-0" x 37'-11"</b>	<b>27 Jan 2000</b>

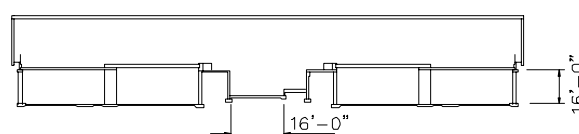
Comments/Design Considerations:

- The HPM design concept was approved by DDESB 27 Jan 2000. A preliminary concept design was completed 3 July 2001. The HPM consist of four separate ordnance storage bays that are treated as independent magazines (i.e., independent MCE). Each storage bay can store up to 30,000 lbs. or can be subdivided into two storage areas with the use of the Modular Wall. Each subdivided area can store up to 30,000 lbs NEW. The separation of the storage bays allows for storage of incompatible ordnance in adjacent bays. The maximum storage capacity of a HPM with no subdivided bays is 120,000 lbs. NEW or 240,000 lbs NEW if all bays are subdivided. Due to the separation of ordnance in non-propropagation cells the HPM is sited based on 60,000 pounds NEW.. The HPM is not earth-covered but is earth-bermed (except for the truck entrance) with moveable RC covers over the storage cells. The area above the storage cells is enclosed by a lightweight metal building. A bridge crane with lifting devices is used for stowage and retrieval of AE.

- No HPM has been built to date and the final Design drawings must be finalized and approved by the DDESB prior to construction.



PLAN VIEW



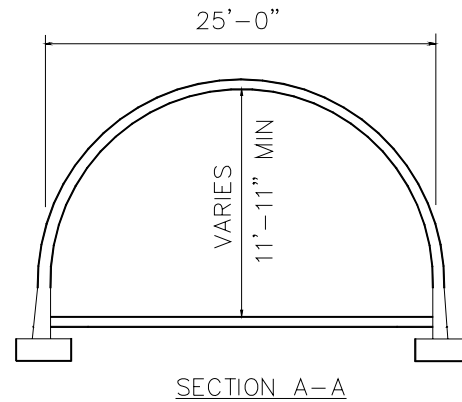
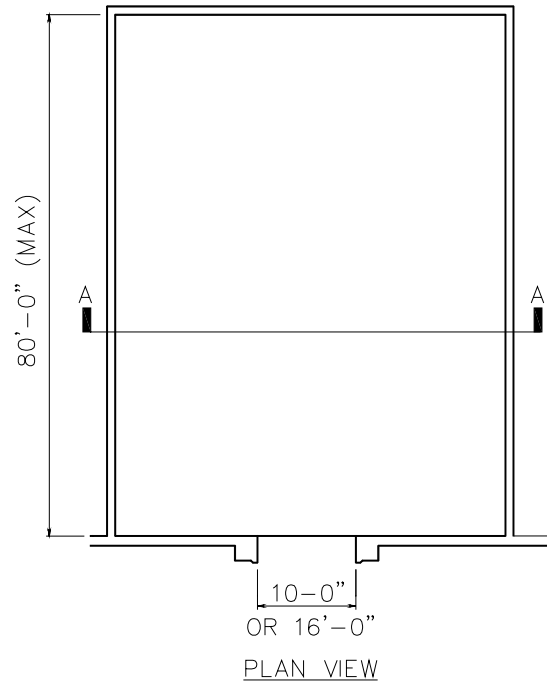
SECTION A-A

**Figure C-10. RC Circular Arch (IP Units)**  
**C**

ECM Designation	Designer & Drawing Number	Maximum Allowable Net Explosive Weight (NEW)	Dimensions (Internal)	Door Opening	DDES Approval Date
<b>7-BAR</b>	<b>NAVFAC 1404310-1404324</b>	<b>500,000 lb</b>	<b>25'-0" Wide x 80'-0" Max. Long x 11'-11" (Rear) High</b>	<b>(1) Sliding 10'-0" Wide x 10'-0" High or 16'-0" Wide x 10'-0" High</b>	<b>15 JUL 1983</b>

Comments/ Design Considerations:

- Superseded NAVFAC's original (1954) Standard Drawings 627954 thru 627957, 649602 thru 649605, 658384 thru 658388, 724368, 751861, 764596 thru 764597, 793746 thru 793748, 803060, and 822978 thru 822989.
- May be built with or without a loading platform
- Single piece sliding door
- High security hasp door lock

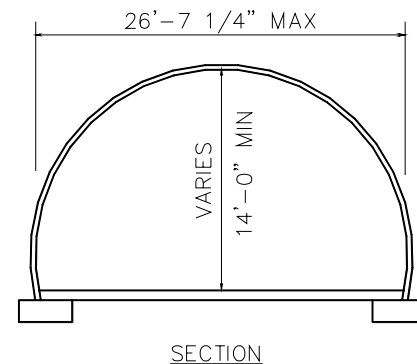
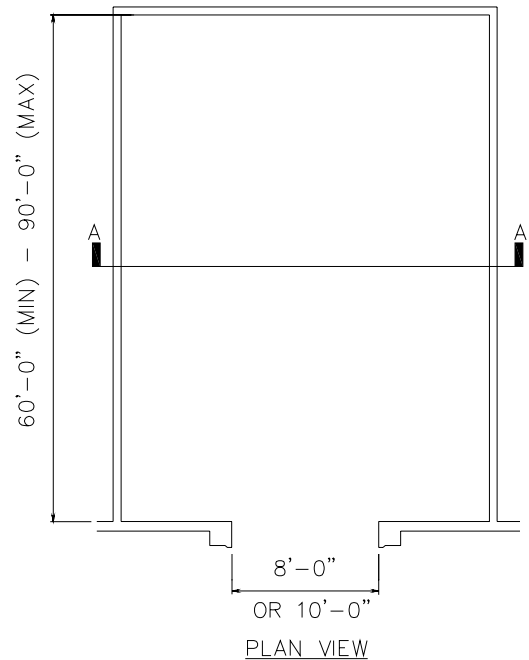


**Figure C-11. RC Arch (421-80-05) (IP Units)**

ECM Designation	Designer & Drawing Number	Maximum Allowable Net Explosive Weight (NEW)	Dimensions (Internal)	Door Opening	DDESB Approval Date
<b>7-BAR</b>	<b>COE 421-80-05</b>	<b>500,000 lb</b>	<b>26'-7 1/4" Wide x 90'-0" Max. Long (normal length is 60' or 80') x 14'-0" (Rear) High</b>	<b>(1) Sliding 8'-0" Wide x 8'-0" High OR 10'-0" Wide x 10'-0" High</b>	<b>8 SEPT 1998</b>

Comments/ Design Considerations:

- Constructed using the Techspan Precast Concrete System, developed by the Reinforced Earth Company, for arch construction. The headwall and door are derived from 33-15-74.
- Single piece sliding door
- High security hasp door lock



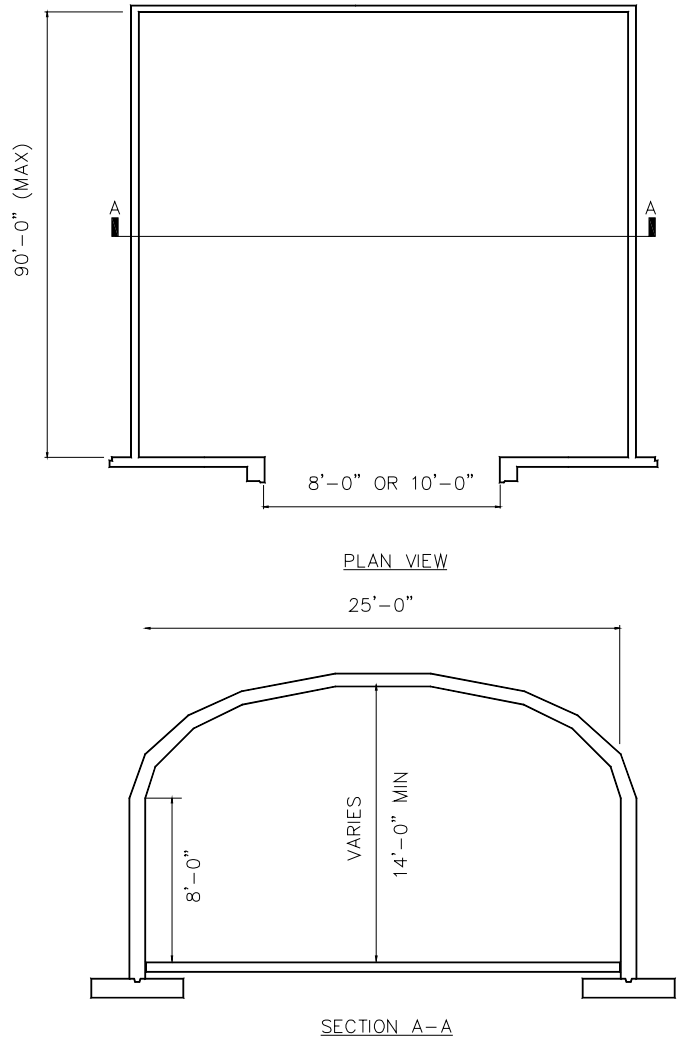


**Figure C-12. RC FRELOC Stradley (33-15-74) (IP Units)**

ECM Designation	Designer & Drawing Number	Maximum Allowable Net Explosive Weight (NEW)	Dimensions (Internal)	Door Opening	DDESB Approval Date
<b>7-BAR</b>	<b>COE 33-15-74</b>	<b>500,000 lb</b>	<b>25'-0" Wide x 90'-0" Max. Length (normally length is 60' or 80') x 14'-0" (Rear) High</b>	<b>(1) Sliding 8'-0" Wide x 8'-0" High or 10'-0" Wide x 10'-0" High</b>	<b>22 Jul 1980</b>

Comments/ Design Considerations

- A variation on this design was approved as Republic of Korea Army (ROKA) drawing 33-15-74. The Korean drawings assure that all reinforcing steel is electrically continuous. The ROKA version of this magazine was approved by the DDESB as a 7-bar magazine on 23 September 2003.
- Single piece sliding door
- High security hasp door lock

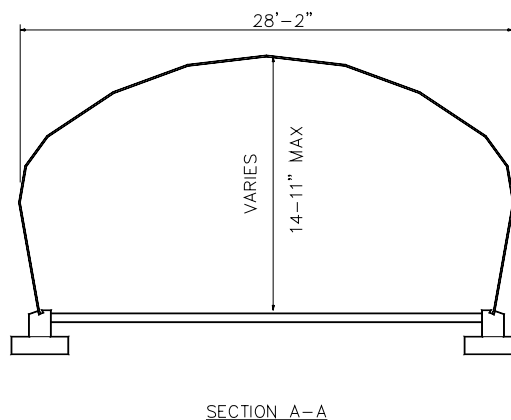
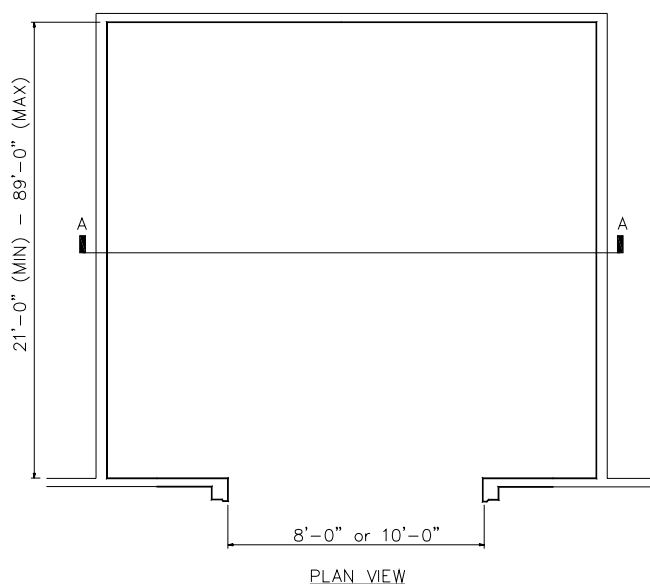


**Figure C-13. Steel Oval Arch (421-80-03) (IP Units)**

ECM Designation	Designer & Drawing Number	Maximum Allowable Net Explosive Weight	Dimensions (Internal)	Door Opening	DDES Approval Date
<b>7-BAR</b>	<b>COE 421-80-03</b>	<b>500,000 lb</b>	<b>28'-2" Max Wide x 21'-0" Min. to 89'-0" Max. Length x 14'-11" (Max) High</b>	<b>(1) Sliding 8'-0" Wide x 8'-0" High or 10'-0" Wide x 10'-0"</b>	<b>28 DEC 1992</b>

Comments/Design Considerations:

- Replaced 33-15-73. Arch design composed of a 1 gage (0.280 inch) corrugated steel arch.
- Single piece sliding door
- High security hasp door lock

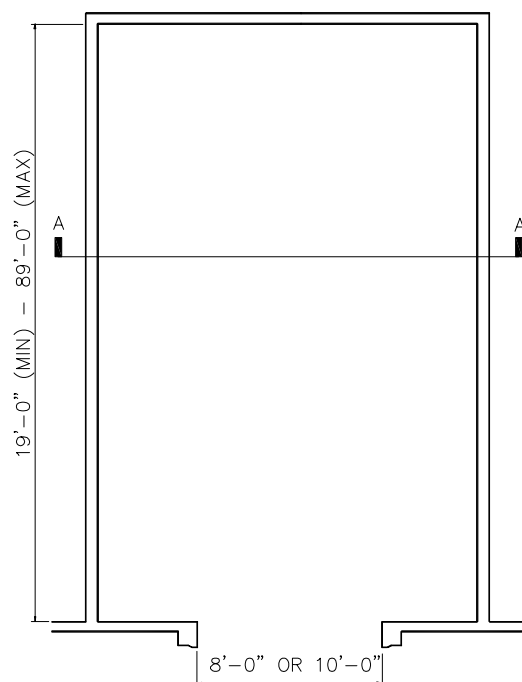


**Figure C-14. Steel Semi-Circular Arch (421-80-01) (IP Units)**

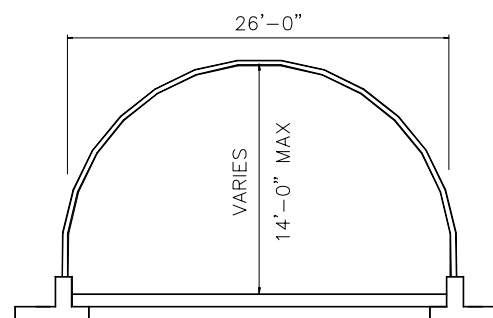
ECM Designation	Designer & Drawing Number	Maximum Allowable Net Explosive Weight	Dimensions (Internal)	Door Opening	DDES Approval Date
<b>7-BAR</b>	<b>COE 421-80-01</b>	<b>500,000 lb</b>	<b>Approx. 26'-0" Wide x 19'-0" Min. expandable up to most commonly used 89'-0" Length x 14'-0" (Max) High</b>	<b>(1) Sliding 8'-0" Wide x 8'-0" High or 10'-0" Wide x 10'-0" High</b>	<b>28 JUN 1988</b>

Comments/Design Considerations:

- Replaces 33-15-73.
- Drawing permits the use of 2" deep or 5.5" deep corrugated steel arch.
- Single piece sliding door
- High security hasp door lock



PLAN VIEW



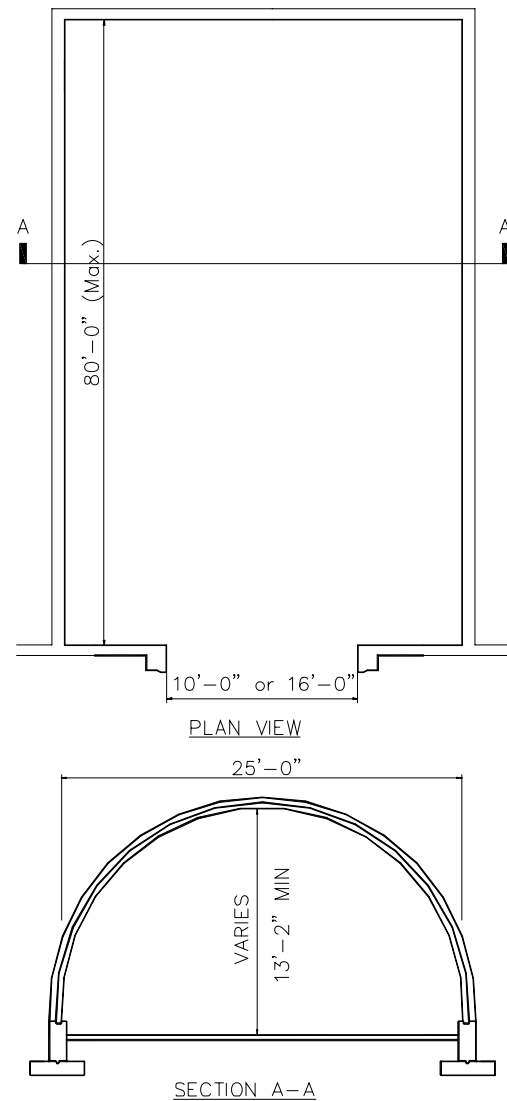
SECTION A-A

**Figure C-15. Composite Circular Arch (IP Units)**

ECM Designation	Designer & Drawing Number	Maximum Allowable Net Explosive Weight (NEW)	Dimensions (Internal)	Door Opening	DDESB Approval Date
<b>7-BAR</b>	<b>NAVFAC 1404375- 1404389</b>	<b>500,000 lb</b>	<b>25'-0" Wide x 80'-0" Max. Length x 13'-2" (Rear) High</b>	<b>(1) Sliding 10'-0" Wide x 10'- 0" High or 16'-0" Wide x 10'-0" High</b>	<b>14 JAN 1986</b>

Comments/Design Considerations:

- Composite circular arch design composed of an internal 10 gage (0.138 inch) corrugated steel arch with reinforced concrete overlay.
- May be built with or without a loading platform
- Single piece sliding door
- High security hasp door lock



**Figure CE-16. Composite Oval Arch (IP Units)**

ECM Designation	Designer & Drawing Number	Maximum Allowable Net Explosive Weight (NEW)	Dimensions (Internal)	Door Opening	DDES Approval Date
<b>7-BAR</b>	<b>NAVFAC 1404390-1404398</b>	<b>500,000 lb</b>	<b>28'-2" Max Wide by 20'-0" Min. to 80'-0" Max. Length x 15'-2" (Max) High</b>	<b>(1) Sliding 10'-0" Wide x 10'-0" High</b>	<b>14 JAN 1986</b>

**Comments/Design Considerations:**

- Composite oval arch design composed of an internal 10 gage (0.138 inch) corrugated steel arch with reinforced concrete overlay.
- Single piece sliding door
- High security hasp door lock

