US Army Corps
of Engineers
Huntsville Division

STANDARD DESIGN

MAGAZINE, STEEL AND CONCRETE BOX, EARTH COVERED
STD 421-80-02

VOLUME I
DESIGN ANALYSIS

HNDED-CS-93-1A
JANUARY 1993

STANDARD DESIGN

MAGAZINE, STEEL AND CONCRETE BOX, EARTH COVERED

STD 421-80-02

VOLUME I

DESIGN ANALYSIS

Huntsville Division
U. S. Army Corps of Engineers
Huntsville, Alabama

1 January 1993

TABLE OF CONTENTS

1.0 Introduction. 1
  1.1 General. 1
  1.2 Scope of Work. 1
  1.3 The Blast and Fragment Resistant Wall System 2
  1.4 Phase I Study. 2
  1.5 Phase II Design. 3

2.0 Detailed Requirements 3

3.0 Design Analysis 4
  3.1 Civil. 4
  3.2 Architectural. 6
  3.3 Structural 7
    3.3.1 General 7
    3.3.2 Overpressure Loadings 8
    3.3.3 Static Analysis 8
    3.3.4 Dynamic Analysis. 9
    3.3.5 Magazine Doors. 10
    3.3.6 Retaining Walls 11
  3.4 Miscellaneous. 12

Appendix A: Scope of Work . . . . A-1 to A-5

1.0 Introduction

1.1 General

A design directive from Headquarters, US Army Corps of Engineers (HQUSACE) identified the need to design a standard ammunition and explosives storage magazine using the Blast and Fragment Resistant (BFR) wall system as the primary structural system. The standard magazine concept is defined in DoD 6055.9-STD, "DOD Ammunition and Explosive Safety Standards." Magazines approved as standard are rated for storage of up to 500,000 pounds Net Explosive Weight (NEW) when located at specific, reduced intramagazine distances. The final design of the magazine was to be a US Army Standard Design, usable for any site upon adaptation by the final design agency. Huntsville Division, US Army Corps of Engineers, was tasked to produce this design.

1.2 Scope of Work

The original scope of work for this effort was divided into two phases. In Phase I, the BFR system was to be evaluated to determine its feasibility for use in a standard magazine. The original magazine concept was provided by Trade and Finance Establishment (TAFI) and Y. Y. Ltd. The Phase I effort was to evaluate the concept design and proposed details, compare the features of the proposed design to existing standard magazines, review actual explosive test data and reports for their applicability in design, and produce a final report of the evaluation and conclusions reached.

Phase II of this effort was to complete the actual definitive design for the "Magazine, Steel and Concrete Box, Earth-Covered," referred to herein as the BFR magazine. The design was to include drawings similar in scope and detail to existing magazine standard drawings, technical specifications, a design analysis, and a cost estimate.

The original scope of work for this effort is contained in the Appendix of this volume.

1.3 The Blast and Fragment Resistant (BFR) System

The BFR wall system, also known as the Agan Steel Panel (ASP) system, is a patented wall construction system. The BFR system is a composite of steel and concrete. The exterior surfaces consist of thin, lightly corrugated, steel face panels. The panels are available in widths of 200, 250 and 300 mm (approximately 8, 10 and 12 inches). Corresponding thicknesses are 0.8, 1.0 and 1.2 mm, respectively. The face panels are oriented vertically and interlock along the vertical edges to form an continuous exterior steel surface. The front and rear face panels are tied together with diagonal steel panels, called lacing panels. The lacing panels are arranged between the face panels in a zig-zag pattern and are attached to the vertical edge ribs of the face panels using sheet metal screws. The lacing panels vary in width to match the specific face panel dimensions and are 0.6 mm thick. Holes are provided in the lacing panels to allow flow of concrete between the panels. The assembly of steel sheets is filled with a high-slump concrete mix. When assembled, the thickness of the wall is equal to the width of the individual face panels. Therefore, finished BFR walls are available in widths of 200, 250 and 300 mm.

1.4 Phase I Study

The preliminary concept for the BFR magazine was evaluated in Phase I. The complete details of this evaluation, including analysis calculations, are in the Phase I report, included in its entirety in Volume III. The original magazine concept was to construct all structural elements out of the BFR system. These included the magazine headwall, side and rear walls, roof, door, and retaining walls. The preliminary study determined that the BFR system would be an outstanding material to use for the headwall, retaining walls, side and rear walls of the magazine. The study showed that the proposed BFR roof slab was actually an under-reinforced concrete roof slab that would not meet applicable design codes and would not support the static loading involved. Therefore, a conventional reinforced concrete slab was recommended in lieu of the BFR roof slab. The study also recommended using the standard steel, sliding, single leaf doors from existing magazine designs instead of a BFR door. The BFR door was not used primarily because of its high weight and resulting increased difficulty in operating the door. Also, the BFR door required a track mechanism at the threshold that would be difficult to maintain at some sites and in a long-term storage environment where maintenance might not always be reliable.

1.5 Phase II Design

The Phase II effort includes developing the final design of the BFR magazine. The remainder of this narrative includes the details of this effort.

2.0 Detailed Requirements

The design of the BFR magazine has been based on the requirements of the scope of work and related discussions with HQUSACE, TAFI, the US Army Technical Center for Explosive Safety, and the Department of Defense Explosive Safety Board. A brief summary of the detailed requirements is as follows.

A. Siting:

- Siting shall be in accordance with intramagazine distance requirements of DoD 6055.9-STD

- Design NEW shall be less than or equal to 500,000 pounds

B. Architectural and Structural:

- Interior dimensions: 24'-0' wide x 11'-2" high, length variable to 90'-0" maximum.

- Floor shall be a concrete slab, sloping toward front door for drainage

- Headwall, side and rear walls, and wingwalls shall be BFR walls

- Roof shall be a conventional reinforced concrete element

- Front door: Option of 8'-0" or 10'-0" square, steel, sliding, single leaf door, adapted from existing standard designs

- The magazine shall be a semi-buried structure, with headwall exposed and side and rear walls buried in earth cover; minimum thickness of earth cover is 2'-0" over the roof slab; earth cover shall slope 2:1 away from the sides and roof.

- Structural design shall be in accordance with TM 5-1300.

C. Mechanical/Electrical

- Optional louvers, with fragment defeating shielding, shall be provided in the headwall

- Optional ventilator shall be provided at the rear of the magazine

- Lightning protection system and lighting shall be adapted from existing standard magazine designs

3.0 Design Analysis

3.1 Civil

Siting criteria for standard magazines, as given in DoD 6055.9-STD, has been followed. No specific site plan has been provided, as the intramagazine distances can vary with intended NEW to be stored. No attempt has been made to show a grading plan due to the nature of the standard design being not site-specific. Siting will be the responsibility of the final design agency performing adaptation of the magazine design for a specific site.

Provisions have been made for placing a reinforced concrete pavement, or apron, in front of each magazine. The elevation of the pavement at the door of the magazine will be the same as that of the floor slab. The pavement is to be sloped to drain away from the structure. Pavement design will be the responsibility of the site adaptation agency.

The earth cover over the structure has been provided with a maximum slope of 2 horizontal to 1 vertical. This cover is to be placed around the side and rear walls of the structure. Retaining walls, or wingwalls, are provided at the front of the magazine, in line with the front wall. These wingwalls also maintain the 2:1 slope. The walls are extended a sufficient distance so that the toe of the earth cover will be at the same elevation as the floor of the magazine. Also, a minimum of 2 feet of earth cover is maintained over the entire magazine structure. The earth over the magazine roof is sloped slightly from front to back to promote drainage away from the headwall.

Material for the earth cover can be either a cohesive or cohesionless soil. For the standard design, a cohesionless soil was assumed. The design uses a soil with a unit weight of 110 pounds per cubic foot and an angle of repose of 33 degrees. Also, a live load surcharge of 100 pounds per square foot is assumed. A layer of impervious soil is placed directly over the magazine roof and extending 2 feet below the top of the earth cover. This layer helps minimize the amount of water reaching the structure.

Drainage of water away from the structure is provided by one of two drainage systems. The recommended system is the drainage composite system. This system uses a drainage mat material with a filter fabric backing. The drainage composite is placed against the roof, side and rear walls, headwall, and wingwalls. Water drains from composite material to the foundation drainage system. The alternate system is a sand-gravel filter system. In this system, a contiguous 6-inch thick layer of sand is placed over the roof and adjacent to the side and rear walls, headwall, and wingwalls. A continuous layer of gravel at the bottom of the sand fill drains the water to the foundation drainage system. Both drainage systems are terminated 2 feet below the top of the headwall and wingwalls to prevent surface runoff water from entering the system.

The foundation drainage system consists of 6-inch diameter perforated pipes sloped to drain toward the front to the structure and out through the magazine headwall and wingwalls. This system is provided around the magazine to provide positive drainage away from the buried steel faces of the BFR walls. An option for drainage out to the rear of the magazines is also provided. Exact elevations and slopes for the system is the responsibility of the site adaptation agency.

3.2 Architectural

The interior dimensions of the magazine are 24'-0' wide, 11'-2" minimum clear ceiling height, and variable length from 20'-0" to 90'-0". The floor slopes toward the front wall to promote drainage. Floor slope is limited to 1:15 to allow ease of operating fork lifts. The door in the headwall is a single leaf, steel, chain-operated sliding door. There are two sizes available, 8'-0" square and 10'-0" square. Details for the doors are adapted from the existing standard magazines. The door is held in place in the closed position using a steel shear pin and locking bars. The locks are the responsibility of the using agency to acquire and install.

A galvanized steel sheet metal hood is to be provided above the door to protect the door track mechanism from the weather. Design of this hood is the responsibility of the site adaptation agency.

Waterproofing of the magazine is provided to prevent water leakage into the structure and to prevent rusting and corrosion of the buried steel BFR face panels. Two waterproofing system options are specified. For the drainage composite system, all buried surfaces are covered with an elastomeric waterproofing membrane. Surfaces of this membrane that are not covered by the drainage composite are covered with protection board to prevent damage to the membrane during backfilling. For the alternate sand-gravel filter drainage system, all buried surfaces are covered with a fluid-applied waterproofing membrane. This entire membrane is covered with a protection board to prevent damage during backfilling. Intrusion of water from beneath the magazine is prevented by a capillary water barrier and vapor barrier placed under the floor slab.

3.3 Structural

3.3.1 General

The structural design of the magazine has been based on the methods in US Army Technical Manual TM 5-1300, "Structures to Resist the Effects of Accidental Explosions," published November 1990. The BFR elements were assumed to perform as typical reinforced concrete elements. Test data evaluated in the Phase I study showed that the BFR walls actually perform better than comparable concrete walls. The BFR walls exhibit a higher level of ductility, better resistance to shear stresses, and exceptional resistance to fragment penetration. In Phase I, comparison was made between actual performance in explosive tests and predicted response according to TM 5-1300. The study showed that using TM 5-1300 and assuming the elements to be normally reinforced concrete was conservative. All of the structural elements of the magazine were designed assuming simple supports. This was done to reduce the required shear resistance of the elements, since the required shear resistance is a function of flexural resistance. It also eliminated the need for shear reinforcement to resist diagonal tension failures. Direct shear at the supports is resisted completely by diagonal bars, since the BFR steel panels do not extend through the supports.

The magazine is designed to resist the leakage pressures from detonation of 500,000 pounds of TNT in an adjacent magazine, located at standard intramagazine distances. The donor cubicle is not designed to contain or withstand the overpressure effects of the internal explosion, and is expected to be severely damaged or completely destroyed in the event of an explosion. The intent of the design is not to contain an internal explosion but, rather, to prevent a sympathetic explosion in the adjacent, receiver magazines. As a criterion to prevent sympathetic explosion, or propagation, the magazine was designed to remain standing, although suffering severe damage, after the donor explosion. Available test data has shown that propagation is generally prevented at standard intramagazine distances even if there is collapse of the structure. Our intent was to go one step further an ensure prevention of propagation by limiting the damage to the receiver magazine.

3.3.2 Overpressure Loadings

Blast overpressures from the donor to the acceptor were derived from actual magazine explosive test data. Sources of data included the ESKIMO test series, the US Air Force Modular Igloo Test, and 1/50 scale tests by the Ballistic Research Laboratory. For each structural element, observed overpressure, duration, and impulse data were compiled from the test reports. Where applicable, the data were scaled up to the maximum charge weight of 500,000 pounds of TNT. The data for each test were compared, and the most reasonable and consistent blast load was selected. Test data from each explosive test, related calculations, and a detailed discussion of the derivation of design loads are included in Volume III. The design loads used for each element are summarized in Table 1 below.

3.3.3 Static Analysis

In general, the design of the BFR magazine conforms to the proposed concept. The headwall and wingwalls are the 12-inch (300 mm) thick BFR wall section. The side and rear walls are the 10-inch (250 mm) thick BFR section. The roof is a conventional reinforced concrete element, 18-inches thick. The analysis of each element for the overpressure loads was preceded by analysis for static loads, primarily due to self weight and vertical and lateral loads imposed on the structure by the earth cover. The static design conforms to accepted design procedures of ACI 318-89 and related ACI handbooks. Each BFR element was assumed to perform under static loads as if it were an equivalent conventional reinforced concrete slab. The static analysis and design were performed to establish that the structure would support the conventional static loads and to determine residual capacity to resist blast loads. Conventional reinforced concrete foundations for the walls were designed based on the static loads.

3.3.4 Dynamic Analysis

The dynamic analysis of each element was performed using the computer programs CBARCS and SOLVER. CBARCS (version dated November 1987) analyzes concrete slabs and beams subjected to blast loads in accordance to the 1969 version on TM 5-1300. This program was used to quickly compute element moment capacities and resistance-deflection functions. The equations in CBARCS that perform these calculations are valid for the 1990 edition of TM 5-1300. SOLVER (Version 2.2, dated February 1989) is a single-degree-of-freedom dynamic analysis program. It computes velocity, acceleration, and displacement of a SDOF system over time. The results from CBARCS and the design overpressure loads were used as inputs to SOLVER to determine the maximum dynamic response of each element. CBARCS and SOLVER are available from the Waterways Experiment Station, US Army Corps of Engineers.

An iterative process was used wherein the effective strain rates were first assumed in order to estimate dynamic material strengths. CBARCS was run to compute the resistance-deflection function, followed by a run of SOLVER to determine maximum response. The time to elastic response was used to recompute strain rates and dynamic strengths for comparison to the original assumptions. This cycle was repeated until the dynamic strengths became more or less constant. Normally, closure was achieved after only two iterations.

In the original proposal, the BFR walls were analyzed using a single-degree of freedom model and assuming a damping ratio of 20%. This is an unusually high damping ratio to apply to reinforced concrete elements. A ratio of 3% to 5% is considered typical. To determine a usable, reliable damping ratio for design, explosive test results were compared to response predicted by the SDOF model method. The results showed that damping values of at least 20% were valid over the entire range of behavior, not just the elastic range. For design, 20% damping was used over the entire range of response.

During the review process, several reviewers notes that the 20% damping assumption might not be valid, even given the outstanding performance of the BFR system. Subsequently, a more realistic approach was implemented. The headwall and headwall pilasters were reanalyzed using only 5% damping for the elastic range and no damping for the plastic range. Both the headwall, and the pilasters met the support rotation limitations using this approach. Damping was neglected for the buried side and rear walls. Instead, these walls were analyzed to include soil-structure interaction effects. This analysis was performed using the computer program SDOF (version dated October 1992), written by the Omaha District, US Army Corps of Engineers. SDOF analyzes buried slabs using the concepts of interface stresses defined in US Army Technical Manual TM 5-855-1, "Fundamentals of Protective Design for Conventional Weapons," published November 1986. Using this approach, the walls again met the 12-degree support rotation limit. The roof slab is a buried element, but the 2-foot earth cover was assumed to be too thin, relative to the span, to provide significant attenuation of the blast loads. Therefore, reanalysis of the roof slab was performed using the same methods as for the headwall.

All walls were assumed to be one-way elements, spanning vertically, which is reasonable for the BFR system. The roof slab was also detailed to be a one-way element, spanning across the width of the magazine. The one-way spans make it possible to construct magazines in varying lengths with no changes in details. The effects of the earth cover and backfill were included in loads and mass. The live load surcharge was neglected for the dynamic analysis. For the roof slab, the total weight of the earth cover was included. For the side and rear walls, the ultimate resistance of each wall was reduced by the lateral loads imposed by the earth cover. The mass of soil acting with the walls was assumed to be a layer equal in thickness to one-half the span of the walls. Soils arching and any resulting attenuation of blast effects was neglected, which is conservative.

For design of the headwall, side and rear walls, and roof, support rotations were limited to 12 degrees. This was a design criteria limit. Computed support rotations due to the blast loads were computed to be much less than 12 degrees. The maximum support rotations are listed in Table 2 below.

3.3.5 Magazine Doors

The steel doors were adapted from existing standard magazine designs. Since these doors were designed for the headwall blast load, no analysis of the doors themselves was performed. The pilasters and header were also adapted from the existing standard magazines. The pilasters and header are conventional reinforced concrete beams. The BFR steel panels are discontinued at the edges of the header and pilasters. Since the existing standard reinforced concrete headwall is an two-way element and the BFR headwall is a one-way element, the new pilasters and header were analyzed in detail. All connections were assumed to be pinned, to reduce the ultimate resistance and shear requirements and eliminate the need for moment-resistant foundations. The pilaster spans vertically, as does the headwall, so the pilaster needs only to resist the dynamic reactions of the doors. The header spans horizontally across the span of the headwall, but the doors also primarily span horizontally. Therefore, the header needs only to resist blast loads from the area of the headwall above the door. The header and pilasters were analyzed using the same method as the walls, as described above. In order to prevent the door from flying into the magazine, support rotations of the pilasters and header were limited to 2 degrees.

3.3.6 Retaining Walls

The retaining walls, or wingwalls, supporting the earth cover at the sides of the magazine, are designed to resist active and passive earth pressures. A soil bearing capacity of 2500 pounds per square foot was assumed. Respectively, minimum safety factors of 1.5 against overturning and 2.0 against sliding were maintained. The 12-inch (300 mm) thick BFR wall section was used for the wingwalls. A conventional reinforced concrete foundation was provided. This foundation varies in width with the height of the wall. The wall and footing were designed as a typical cantilever retaining wall. Since the BFR steel panels do not extend into the foundation, additional reinforcement was provided at the base of the wall to provide moment continuity between the wall and the foundation. The design includes the positive drainage systems described above to reduce lateral earth pressures produced by a saturated backfill. Weepholes are provided in the wingwalls to provide adequate drainage.

Design soil conditions for the wingwalls and their foundations were as described in paragraph 3.1 above. If the actual soil backfill and/or bearing capacity are significantly different, the wingwalls must be checked and redesigned as required by the site adaptation agency.

3.4 Miscellaneous

The design of other components (louvers and ventilators) were adapted directly from the existing standard magazine designs. All lighting and lightning protection details are provided in accordance with the scope of work.

Table 1: Overpressure Loads

Structural Element	Peak Pressure (psi)	Impulse (psi-ms)	Duration (ms)
Headwall & Doors (primary)	100	1100	22
Headwall & Doors (secondary)	200	1100	10.0
Roof Slab	85	850	20.0
Side Walls	165	900	10.9
Rear Wall	432	1770	8.2

Table 2: Maximum Computed Support Rotations

Structural Element	Maximum Computed Support Rotation (degrees)
Headwall	9.3
Door Pilaster	3.0
Door Header	2.8
Roof Slab	1.8
Side Walls	3.0
Rear Wall	7.3

APPENDIX A

SCOPE OF WORK

CEMP-ET

28 November 1990

SCOPE-OF-WORK

EARTH-COVERED BOX MAGAZINE

1.0 SCOPE: This work is in two phases. The first phase involves analyzing a proprietary magazine design. The second phase involves the development of a standard magazine design.

2.0 PURPOSE: The purpose of this work is to provide designers an additional standard design option for those projects calling for magazine construction.

3.0 OBJECTIVE: The objective is to provide safe, secure storage magazines for ammunition and explosives.

4.0 REFERENCES: The following references will be used to the extent specified herein:

4.1 DOD 6055.9-STD "Ammunition and Explosives Safety Standards".

4.2 Std Dwg 33-15-74 "Magazine, Concrete, Oval-Arch, Earth-Covered" with accompanying technical specification, design analysis, and cost estimate.

4.3 ER 1110-345-710 "Drawings".

4.4 ER 1110-345-720 "Specifications".

4.5 ER 1110-345-700 "Design Analyses".

4.6 ER 1110-345-42 "Cost Estimates".

4.7 Documents provided by Trade and Finance Establishment (TAFI) (These will be furnished to work performer upon request.)

4.7.1 Punch-bound Volume of 3 Sections:

Section 1 - Tests and Reasoning of a Blast and Fragment Resistant (BFR) Standard Ammunition Magazine, TAFI, October 1990

Section 2 - Design and Cost Analysis of a Blast and Fragment Resistant Standard Ammunition Magazine, TAFI, May 1990

Section 3 - Technical Specification "SPECTEXT" Blast and Fragment Resistant System "ASP", August 1990

ENCL-17 (5 PAGES)

4.7.2. Appendices A through E of Ref 4.7.1 Section 1 above:

A - (In Hebrew) Israeli Defense Forces 1981 Test Report on the ASP and English translation of pages 1-3

B - The Structural Behavior of Two Systems Subjected to Above Ground Weapons Effects, South African Air Force, May 1983

C - Effect of Weapons on Blast Protection Doors and Acceleration Tests on Floor Systems, South African Air Force, May 1983

D - Test of BFR Walling Sections Against a MK 84, South African Defense Forces, February 1985

E - (In French) Comportement au souffle et aüx eclats de murs forts, Groupe Nucleaire Protection, November 1987

5.0 BACKGROUND: The Agan Steel Panel (ASP) is a patented blast- and fragment-resistant walling system developed in Israel. It consists of two parallel corrugated steel plates tied so they stand a desired distance apart. The space between the plates is then filled with concrete. It has had numerous applications as a blast barricade. The ASP creators have recently developed an earth-covered magazine with a rectangular cross-section using ASP components. A cost comparison of this box magazine with present standard designs was performed by the Protective Design Center at Omaha District. They concluded that the box magazine could provide substantial cost savings, assuming it was otherwise satisfactory. What is now needed is a technical evaluation of the design. If evaluation results are positive, usable design documents will then be needed.

6.0 REQUIREMENTS:

6.1 Phase I:

6.1.1 Present CE standard drawings of magazines are listed in Ref 4.1 as Standard Magazines. (Ref 4.1 is a publication sponsored by DoD Explosives Safety Board.) This means those magazines are permitted to store greater quantities of explosives and can be spaced closer together than magazines considered non-standard. Any new magazine design must become a Standard Magazine to be à fully useful structure. It must be demonstrated that the new design provides protection equal to or greater than that of present designs. The goal of Phase I is to determine whether or not the TAFI-designed magazine can qualify as a Standard Magazine.

6.1.2 Review Ref 4.7.1 (principally Sections 1 and 2). Evaluate approach taken, assumptions made, calculational procedures used, and results achieved.

6.1.3 Review Ref 4.7.2. Evaluate their applicability to the goal of Phase I.

6.1.4 Where appropriate, compare features of the box magazine with comparable features of Ref 4.2.

6.1.5 Prepare a brief report of evaluation performed and conclusions reached.

6.2 Phase II:

6.2.1 This phase shall not be started until authorized by HQUSACE. The goal of Phase II is a set of design documents similar to Ref 4.2.

6.2.2 Drawings. Prepare drawings entitled "Magazine, Steel and Concrete Box, Earth-Covered". Drawings will conform to Ref 4.3 and shall be modeled on Ref 4.2 as to style of presentation and degree of detail to be depicted. Required features not shown in Ref 4.7.1 Section 2 (e.g., vents, electrical system, door and its moving mechanism) should duplicate Ref 4.2 as much as possible. Place a note on the first sheet giving source information for the patented ASP walling system components.

6.2.3 Specifications. Prepare technical specifications conforming to Ref 4.4 and modeled on Ref 4.2 as much as possible. Incorporate Ref 4.7.1 Section 3.

6.2.4 Design Analysis. Prepare design analysis conforming to Ref 4.5. Material taken from Ref 4.7 shall be given proper attribution. The design analysis should begin with a short narrative outlining the rationale for the design. The report of para 6.1.5 above should be included.

6.2.5 Cost Estimate. Prepare a cost estimate conforming to Ref 4.6. Ref 4.2 can be used for guidance on items to be costed.

7.0 SUBMITTALS:

7.1 Furnish Phase I report to HQUSACE, ATTN: CEMP-ET, Washington, DC 20314-1000, with copy to DoD Explosives Safety Board, ATTN: DDESB-KT, 2461 Eisenhower Ave., Alexandria, VA 22331-0600.

7.2 Phase II submittals shall be distributed as follows. Drawings shall be half-size.

	Number of Copies		
	30% Review Material	90% Review Material	Final Design
USAED, Huntsville ATTN: CEHND-ED-PM PO Box 1600 Huntsville, AL 35807-4301	3	3	Original + 3
HQUSACE ATTN: CEMP-ES Wash., DC 20314-1000	1	1	
HQUSACE ATTN: CEMP-ET Wash., DC 20314-1000	2	2	
USAED, Omaha ATTN: CEMRO-ED-S 215 North 17 St. Omaha, NE 68102-4978	1	1	
USAEWES ATTN: CEWES-SS-R 3909 Halls Ferry Vicksburg, MS 39180-6199	1	1	
DoD Explosives Safety Board ATTN: DDESB-KT 2461 Eisenhower Ave. Alexandria, VA 22331-0600	1	1	
USA Defense Ammo Ctr & School ATTN: SMCAC-AV Savanna, IL 61074-9639	1	1	
TAFI (Address TBD)	1	1	

8.0 SCHEDULE:

8.1 Phase I. Submit the report described in para 6.1.5 within 90 calendar days after work commences.

8.1 Phase II. After authorization to commence work on Phase II, material shall be submitted for review and approval in accordance with the following schedule:

	Calendar Days
Submit 30%-completed design	90
Furnish comments (Govt)	135
Submit 90%-completed design	210
Furnish comments (Govt)	255
Submit final design	285