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ARMY AMMUNITION AND EXPLOSIVES STORAGE DURING THE COLD WAR (1946-1989)

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U.S. ARMY ENVIRONMENTAL COMMAND
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14. ABSTRACT
This historic context discusses the development and construction of ammunition and explosives storage facilities during the Cold War. Ammunition storage falls into two major types: above-ground and below-ground, both of which are designed to minimize sympathetic destruction of nearby facilities; the layout and spacing of ammunition storage facilities on an installation also has been governed by strict distance standards based on the types of explosives stored in the structures. The report investigates the development of weapons technology during the Cold War era, modifications to existing ammunition storage facilities to accommodate changes in technology, and the design of buildings constructed during the Cold War for the storage of newly-developed ordnance.

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1.0 EXECUTIVE SUMMARY

This study was prepared by the Department of the Army to meet the compliance requirement associated with the *Program Comment for World War II and Cold War Era (1939-1974) Ammunition Storage Facilities*, issued by the Advisory Council on Historic Preservation on August 18, 2006. A programmatic treatment for the properties was developed in compliance with Section 106 of the National Historic Preservation Act of 1966 (NHPA), as amended, to take into consideration the effects of future management activities upon this class of Army resources constructed between 1939 and 1974, which might be historic.

Under 36 CFR 800.14(e) of the Advisory Council on Historic Preservation's regulations, the Army sought to develop an integrated and cost-effective approach to NHPA requirements that is consistent with the Army's need to provide munitions and ordnance in a rapidly changing and complex military environment. The programmatic treatment includes the preparation of a nationwide historic context on ammunition storage facilities constructed or modified during the Cold War Era (1947-1989) and site visits to nine World War II and Cold War era installations with representative examples of ammunition storage facilities. Currently, the Army inventory for ammunition storage facilities contains almost 22,000 buildings and structures constructed between 1939 and 1974.

The current project expands and complements an earlier historic context, *Army Ammunition and Explosives Storage in the United States, 1775-1945.* This effort was completed for the Ft. Worth District, U.S. Army Corps of Engineers (Murphey et al 2000). This earlier document provides background information on the evolution of ammunition storage facilities from the earliest stone buildings to the development of the earth-covered magazine commonly known as the igloo. The earlier *Army Ammunition and Explosives Storage* also details the organization of the Army depot system and the construction of new ammunition storage facilities during World War II. The current studies investigate the development of weapons technology during the Cold War Era, modifications to existing ammunition storage facilities, and the design of buildings constructed during the Cold War for the storage of newly-developed ordnance. The current project was completed on behalf of the United States Army Environmental Command (USAEC) through the United States Army Medical Research Acquisition Activity (USAMRAA).

The surrender of Japan on 2 September 1945 marked the end of hostilities in World War II and presented the U.S. military with the challenge of managing the conversion of real property constructed to support nationwide mobilization to support of a peacetime military. During the preceding six years, the Federal Government expended hundreds of millions of dollars in constructing 77 new military industrial facilities and 16 major ordnance depots. Ammunition plants, armor plate factories, vehicle assembly lines, and gun manufactories once needed to support the global war were now excess property. Numerous facilities were closed while others were placed in lay-away status should they be needed in the future. The tremendous amounts of ordnance and raw materials no longer needed for munitions production were transferred to storage depots or destroyed. The activity at Army depots declined, but none were closed due to the continued need to store ammunition.

The invasion of South Korea by Communist forces in June 1950 prompted the U.S. military to increase production at all active ammunition plants and reopen several plants closed at the end of World War II. Advances in weapons production were implemented at many locations, while some plants continued to load, assemble, and pack munitions using machinery and techniques developed during World War II. Communities that had experienced employment loss and depressed economic conditions due to plant closures in 1945 saw a marked, albeit brief, surge in new jobs. Many communities could not supply the needed labor, and recruitment brought new residents to areas—oftentimes with less than favorable reactions from long-time residents. As with the construction of new plants during World War II, the influx of employees strained local housing markets and community services.

During the late 1950s weapons technology became increasingly sophisticated. The perfection of extremely powerful explosives limited the amount of ammunition that was allowed to be stored in a single building. This created the need for enhanced logistical support at both depots and smaller installations. Guided missiles and rockets began to replace the artillery, anti-aircraft guns, and mortars that were the mainstay of munitions for the armed forces for the first half of the twentieth century. Ammunition storage facilities constructed during World War II, an era when most munitions were manually moved into and out of magazines, were used for the storage of these new and larger weapons. Forklifts and cranes replaced hand trucks and dollies in the movement of ammunition, and specialized lifting devices were developed to safely maneuver large missiles, such as the thirty-inch diameter HONEST JOHN, through the three-foot wide door of a standard igloo.

By the mid-1950s, the design of earth-covered magazines began to change. Newly constructed igloos differed slightly from those built during the preceding 15 years. Although the size and shape of the arched-roof structure was unchanged, wider openings with a set of double-leaf steel doors facilitated the movement of munitions. As budgets allowed, older magazines were modified with the installation of wider openings with double-leaf doors, and extending access ramps to allow the use of heavy equipment. Perhaps the most radical shift in igloo design also occurred during the 1950s. In 1954 the Chief of Ordnance recommended a new magazine referred to as the "yurt." Later renamed the Stradley after its designer, the yurt was engineered with vertical side walls and an elliptical arch for the roof. Large sliding doors opened the front of the magazine allowing easy access for heavy equipment. The vertical walls of the Stradley magazine created additional storage space as the constraints of the continuous arch of the igloo were eliminated, and munitions could be stacked vertically across the width of the structure. By 1960, nearly 500 Stradley magazines were constructed.

Large-scale construction of new ammunition storage facilities at Army depots was sharply curtailed after 1960; however, construction at other Army installations continued at a moderate pace. Many of the installation-level ammunition storage facilities were identical to those constructed at major ammunition depots: the standard 25 foot wide igloo. Others, such as those at proving grounds and missile ranges, were designed for a specific purpose and did not follow the standardized plans that guided construction for other facilities. Construction of installation-level ammunition storage facilities also included ready magazines and ammunition storehouses at Army ammunition plants. When new buildings were required, designs were characterized by uniformity, standardization in materials, and a lack of ornamentation. The critical criterion for new construction was safety—buildings generally were constructed of reinforced concrete in response to safety concerns.

The relative calm following the end of the Vietnam Conflict in 1975 and the end of the Cold War allowed the U.S. military to gradually reduce the number of ordnance related installations. Although none of the major ammunition depots was closed, smaller ordnance activities were consolidated and several ammunition plants closed.

Throughout the Cold War Era, ammunition depots continued to ship and receive munitions and the explosive components used in weapons manufacture. Unlike the World War II era, where short-term storage and distribution were the only activities, the Cold War brought added responsibilities to the Army ammunition depots. These included surveillance, renovation, and demilitarization. The development of new weapons influenced surveillance activities. Guided missiles powered by liquid propellants required special handling procedures, and the materials used in the propellant mix were highly volatile and toxic. The development of sensitive mines for aerial dispersion also added new surveillance responsibilities. Gravel mines were stored in liquid filled canisters. Once dispersed, the liquid would evaporate, sensitizing the explosive mix. Surveillance of this item included frequent checks to insure that the canisters remained sealed with no loss of the de-sensitizing fluid. Treaties crafted in the 1970s that resulted in elimination of chemical weapons added an additional burden to the depots. Rather than risk transporting the aging stockpile of chemical weapons, disposal facilities were designed and constructed at several depots to thermally or chemically render the agents harmless.

The Ordnance Corps did not have prescribed regulations on what types of weapons were stored in a particular facility. Generally, finished ammunition, such as artillery rounds or tank munitions, were stored in aboveground magazines governed by quantity and distance standards. Guided missiles, bulk high explosives, detonators and fuzes, or propellants were stored in earth-covered magazines. At the installation level, these same types of munitions were stored in smaller, aboveground, concrete or structural tile magazines near combat training ranges. Larger installations often had segregated yards for storing additional quantities of ammunition that were transported to training areas as needed. These ammunition storage areas were never used for the long-term storage of large quantities of ammunition, and only served the immediate needs of the installation.

Archival research and field investigations have shown that while this general guidance was followed whenever possible, extenuating circumstances often forced an installation to store ammunition in whatever empty space was available. Ammunition slated for transportation to an installation or for overseas shipment during times of conflict, could remain on an explosives transfer dock for extended periods. Small quantities of high explosives were infrequently stored in aboveground magazines if suitable earth-covered space was not available. Even when ammunition was moved to a magazine designed for another primary use, the same quantity distance standards dictated how it was stored. Safety of personnel was always of paramount importance.

Ammunition typically stored in aboveground magazines included ready armor and artillery shells. Storage of ammunition in earth-covered magazines was influenced by several factors. More sensitive explosives, including some types of artillery rounds and mines, were stored in earth-covered magazines to prevent sympathetic detonation of nearby magazines should an accident occur. Another consideration was temperature sensitivity. Earth-covered magazines maintained relatively stable interior temperatures throughout the year, and were ideal where temperature fluctuations might affect the explosive component, casing, or detonating element. The quantity of stored ammunition also influenced decisions to use earth-covered magazines. As they were considered safer than aboveground magazines for large quantities of ammunition, storage in earth-covered magazines made more efficient use of available space. The same amounts of explosive material could not be safely stored in a single aboveground magazine and required distribution among numerous buildings. Virtually all types of ammunition, including finished artillery and tank rounds, were placed in earth-covered magazines for long-term storage at depots.

This study examines Army ammunition storage facilities constructed during the Cold War Era and World-War-II era facilities used and modified between 1946 and 1989. This illustrated study is the result of an integrated program of archival research, site investigation, data analysis, and report preparation undertaken in 2007. The results of the study are presented in the following technical report, which is organized into the following chapters.

- Chapter 2, *Objectives and Methodology* details the project scope and the methods used in synthesizing data included in this report.
- Chapter 3, *Army Ammunition Storage Facilities Prior to the Cold War Era* offers background information on the types of ammunition storage facilities constructed before 1946.
- Chapter 4, *Cold War History* provides a brief synopsis of the significant military and political events of the Cold War.
- Chapter 5, *Army Ammunition and Explosives Storage During the Immediate Post World War II Era: 1946-1950* details the administrative organization of the Ordnance Corps, implementation of improved safety standards, and the types of ammunition storage facilities constructed between 1946 and 1950.
- Chapter 6, *Army Ammunition and Explosives Storage During the Korean Conflict: 1950-1953* describes the administrative organization of the Ordnance Corps, implementation of improved safety standards, and the types of ammunition storage facilities constructed between 1950 and 1953.
- Chapter 7, *Army Ammunition and Explosives Storage After Korea: 1954-1960* addresses the administrative organization of the Ordnance Corps, implementation of improved safety standards, and the types of ammunition storage facilities constructed between 1954 and 1960.
- Chapter 8, *Army Ammunition and Explosives Storage During the Vietnam Era: 1960-1974* covers similar topics including the administrative organization of the Ordnance Corps, the creation of the Army Materiel Command, standards, and the types of ammunition storage facilities constructed between 1960 and 1974.
- Chapter 9, *Army Ammunition and Explosives Storage During the Late Cold War Era: 1975-1989* examines the types of facilities constructed and discusses the organization of the Army Materiel Command between 1975 and 1989.

The report is accompanied by three technical appendices.

- Detailed breakdowns of the types, numbers, and locations of active ammunition storage facilities constructed between 1946 and 1989 are included in Appendix A.
- Appendix B includes historic summaries of architects and engineers known for their contributions to the construction of Cold War Era ammunition storage and ammunition production facilities.
- Appendix C contains information related to the funding of ammunition-related facilities between 1945 and 1989.

2.0 OBJECTIVES AND METHODOLOGY

2.1 Objectives

Currently, the Army manages 21,765 ammunition storage facilities constructed between 1939 and 1989 (U.S. Army Real Property Inventory 2007). The majority of these structures pre-date 1946; 18,203 were built between 1939 and 1945. These buildings have already reached the 50-year age generally required for consideration for listing in the National Register of Historic Places, and consideration under Section 106 of the National Historic Preservation Act. Ammunition storage facilities constructed during the Cold War also are approaching or have passed this 50-year threshold. To take into account the effects of management activities on ammunition storage facilities, the Army requested a Program Comment, which is a programmatic compliance alternative under the Advisory Council on Historic Preservation's regulations at 36 CFR 800.14. The programmatic treatment includes the preparation of a nationwide historic context on ammunition storage facilities constructed or modified during the Cold War Era (1946-1989) and site visits to nine World War II and Cold War era installations with representative examples of ammunition storage facilities.

2.2 Project Description

This illustrated technical report is the first component of this programmatic approach to treating ammunition storage facilities. This report explores post-World War II methods of storing weapons in a rapidly changing technological environment, and examines both ammunition storage facilities constructed during the Cold War, as well as modifications to the large number of facilities constructed during World War II. Architects, engineers, and contractors associated with the construction of World War II and Cold War Era ammunition-related facilities are also identified.

The U.S. Army places ammunition storage facilities primarily into two broad categories: depot level and installation level. Depot level, carrying the category code prefix of 421XX "consists of igloos, magazines (aboveground and earth covered), and storehouses for ammunition, explosives, and propellants in support of the bulk storage mission at depot/arsenal level. Bulk storage is defined as the mission to store ammunition for multiple sites/installations" (Department of the Army 2006:177). These are typically found only at large ammunition depots.

The second category, installation level with code 422XX, "consists of igloos, magazines (aboveground and earth covered), and storehouses for ammunition, explosives, and propellants for day-to-day storage in support of the installation mission. Also included are support storage for day-to-day use as specifically designated and determined by operational needs, basic load small arms storage for in-place and reinforcing units, and war reserve munitions for theater support based on war plans. Installation and ready issue storage is defined as the mission for storage of ammunition strictly for use at the installation level or for units assigned to the installation" (Department of the Army 2006:181). This second category of facilities, though more common at Army installations, were also constructed at large depots and arsenals for use by the individuals assigned to the installation.

The vast majority of ammunition storage facilities in the Army Real Property Inventory are located at major depots, and are standard 25-foot wide (interior dimension), earth-covered magazines popularly referred to as "igloos." The standard earth-covered magazines were constructed in lengths of 40 feet four inches, 60 feet eight inches, and 81 feet. The U.S. Navy pioneered the design of the earth-covered magazine in response to the devastating explosion at

Lake Denmark, New Jersey, in 1926. Igloos were constructed in large numbers at Army installations nationwide. Although the basic design of the igloo magazine remained unchanged from World War II until the end of the Cold War Era, variations did exist. The front walls used to retain the earthen bank were truncated a few feet from the ground in a magazine type referred to as the "Huntsville." Other magazines were used to store fuzes and detonators, and were often square and terminated in flat roofs. The Corbetta Beehive was another variant in igloo type. Designed to reduce the amount of reinforcing steel used during construction, the Corbetta was round with a hemispherical roof.

While most Army ammunition storage facilities were located at major depots, numerous buildings were constructed at other Army installations nationwide. Generally, these facilities were constructed to meet the short-term needs of the installation, and were not intended for storing large amounts of ammunition for extended periods. When units were deployed for military duty, ammunition was forwarded directly from depots to storage facilities near the combat zone rather than transported with the unit. The size of the installation and its primary mission dictated the size of the facilities. Army installations that trained large numbers of personnel required either more or larger facilities than those without this mission. Similar correlations are found where installations focused on training and support for armored or artillery units. The large size of the munitions for these weapons also required either more or larger storage facilities. In some instances, ammunition storage facilities served only for small arms ammunition used by military police or security personnel. For example, Fort Detrick, Maryland, retains a single 120 square foot ready magazine constructed for this purpose in 1951 (U.S. Army Real Property Inventory 2007).

Magazines constructed during the Cold War Era followed prototypes designed and built during the Second World War. The size of post-1946 ammunition storage facilities ranged from above ground magazines measuring three-feet square to depot-level ammunition storehouses of more than 46,000 square feet. By the end of the Cold War Era, the Army controlled ammunition storage facilities with over 48 million square feet of enclosed space; an area more than 1,100 acres in size.

2.3 Methodology

The research design for the current study incorporated four progressive tasks. These tasks were archival research, field investigation, data analysis, and report preparation. The collected data were analyzed to identify ammunition storage needs during the Cold War Era; policies impacting the construction of new facilities; the impact of rapidly evolving weapons systems on ammunition storage; and to identify engineers, architects, contractors, or builders associated with the construction of ammunition storage facilities.

2.3.1 Archival Research

A variety of sources were consulted during the preparation of this report. Previous studies reviewed included *Army Ammunition and Explosives Storage in the United States: 1775-1945* and *Historic Context for the World War II Ordnance Department's Government-Owned Contractor-Operated (GOCO) Industrial Facilities, 1939-1945* (Murphey et al. 2000; Kane 1995). These two reports provided general background information on the history of ammunition production and storage facilities of the World War II era. The current study expands on these earlier reports by discussing post-war trends and designs of ammunition storage facilities.

A review of secondary sources provided considerable information on military doctrine, planning, and the introduction of improved weapons systems, but little on the design or construction of ammunition storage facilities. Those sources that did discuss storage focused on the development of the igloo and the massive building campaigns of the World War II era.

Review of published primary sources included Congressional reports, hearings, and related government documents at the Library of Congress. These Congressional reports provided data on appropriations for construction of ordnance installations, but rarely specified the locations or types of ammunition storage facilities. The Library of Congress collections contain several pertinent reports completed in the 1980s including site documentation undertaken for the Historic American Buildings Survey/Historic American Engineering Record (HABS/HAER). These studies include a general history of the installation and large format photographic documentation.

Record groups reviewed at the National Archives and Records Administration, College Park, Maryland included Record Group 77—Army Corps of Engineers, Record Group 544—Army Materiel Command, Record Group 156—Office of the Chief of Ordnance, and Record Group 330—Office of the Secretary of Defense. These collections include files and correspondence of key agencies, safety and ammunition handling publications, and command histories for numerous installations. Cartographic and still images at the National Archives also were reviewed.

The large number and broad distribution of ammunition storage facilities created challenges in implementing the research design for this project. These challenges were compounded by the recent construction dates of many of the buildings. Studies on recent history grapple with a lack of historic perspective and the absence of associated scholarship. A similar challenge was the uniformity of design throughout the period. Ammunition storage facilities were constructed from standardized drawings or were designed by local architect/engineering firms to meet installation-specific needs. Project construction and administration was often at the installation level. This approach resulted in the retention of the majority of the plans and specifications at the installation level rather than in national repositories for indexing.

2.3.2 Field Investigations

The research design for this project included on-site investigations to capture installation-level information. The three Army installations were selected based on criteria of variety in design and numbers of Cold War Era ammunition storage facilities, the potential for unique structures, and for geographic distribution. Installations were selected based on information contained in the U.S. Army Real Property Inventory provided by the U.S. Army Environmental Command (USAEC). Criteria for site selection were developed in consultation with the USAEC and the Army Materiel Command (AMC). Field investigations included on-site architectural surveys, and a review of historic records and drawings held by the installation, and data from local repositories. The three Cold War Era sites selected for this study were:

Aberdeen Proving Ground, Aberdeen, Maryland
White Sands Missile Range, White Sands, New Mexico
Anniston Army Depot, Anniston, Alabama

Specific on-site research for each of these installations included review of architectural drawings, real property cards, previous cultural resource reports, historic photographs, and written histories. Collections at local museums, libraries, and historic societies also were reviewed to determine the impact ordnance depots imparted on local economies and demographics.

2.4 Definition of the Historic Context

The *Secretary of the Interior's Standards and Guidelines for Archeology and Historic Preservation* (48 FR 44716) and technical guidance provided by the National Register Program, the National Park Service, and the Department of the Army were consulted in the development of the historic context. The theoretical framework that allows the grouping of information on related properties is a historic context. Three elements comprise a historic context: theme, place, and time. For this study, the context was based on the following:

Time period:	1946 to 1989
Geographic Area:	United States
Theme:	Army Ammunition Storage

The time period covers the entire Cold War Era, defined as the emergence of the Soviet state in the immediate post-World War II period and ending with the fall of the Berlin Wall in 1989. The geographic area includes the 48 contiguous states, Alaska, and Hawaii.

Several sub-themes relating to the construction of ammunition storage facilities were developed as part of this study. They include:

1) weapons technology focusing on the impact that new weapons systems exerted on the design and construction of new ammunition storage facilities and the modification to existing facilities;

2) missions developed at ammunition depots after World War II, including the long-term surveillance of munitions and demilitarization; and

3) architecture/engineering emphasizing the development of new building types to house more advanced weapons systems and associations with significant architects, engineers, or builders.

2.5 Naval Construction of Ammunition Storage Facilities

In 1975, the Department of Defense consolidated all ammunition production under the guidance of the Army to reduce redundancy and improve efficiency. This action brought two ammunition plants constructed and operated by the Navy under Army control: Hawthorne, Nevada, and McAlester, Oklahoma. Unlike the Army, which created separate administrative structures for ammunition manufacturing and storage, the Navy constructed load lines for mines, torpedoes, and bombs within the ammunition depot. As a result, the Army acquired both the ammunition production facilities and a large number of Navy-built ammunition storage structures. The current study includes a discussion of ammunition storage facilities constructed by the Navy for that reason.

3.0 ARMY AMMUNITION STORAGE FACILITIES PRIOR TO THE COLD WAR ERA

3.1 Introduction

The ammunition storage buildings reflected in the U.S. Army Real Property Inventory were constructed on all types of installations built to service both the U.S. Army and Navy, and included buildings for virtually all the field services including the Ordnance Department, Chemical Warfare Service, and the Army Air Corps. At Army and Navy government-owned, government-operated, and government-owned, contractor-operated ordnance production plants, ammunition storage structures were constructed along loading lines for short-term storage of items required in manufacturing, and in larger depot areas prior to inspection and acceptance by the Ordnance Department. The U.S. Army and Navy operated a system of large and small depots for long-term storage of ammunition stores and short-term storage prior to distribution to end users. Army and Navy installations received ammunition shipments for use by military personnel in training or in routine military functions and also required on-site ammunition storage structures for safe short-term storage. The deployment of Army and Navy forces overseas required storage facilities at Ports of Embarkation to house ammunition prior to shipment. When overseas actions ended, ammunition was returned stateside; shipped to storage; and sorted for long-term storage, repair, or disposal, as required. This study focuses on the storage of explosive ammunition rather than the storage of artillery pieces and carriages, tanks, and trucks.

The Cold War-era system of ammunition storage, supply, and distribution had its antecedents in the system of ammunition supply, storage, and distribution that evolved following World War I and was expanded and revised during World War II, the two great wars of the twentieth century. The ammunition supply, storage, and distribution system tracked finished ammunition from the manufacturer into appropriate storage and then to final users.

Within the U.S. Army, the Field Service of the Ordnance Department was responsible for the production, maintenance and repair, testing, and storage of military weaponry and ammunition for the infantry, cavalry, and air corps. During World War II, the Ordnance Department materiel handling responsibilities were defined as the procurement, storage, maintenance, and issuance to the U.S. Army of weapons, ammunition, combat and transport vehicles, and spare parts. Materiel was handled by the Ordnance Department from the time it was transferred from the manufacturer until it was loaded onto ships for transport to the theaters of military operations (MacMoreland 1945:789). The Bureau of Ordnance was responsible for ordnance used by the U.S. Navy.

Both the Army and the Navy developed separate systems to distribute ordnance from point of production, to strategically located depots and finally, to the end users on installations or ships. In 1926, a permanent Joint Army-Navy Ammunition Storage Board was established to advise the Secretary of War and the Secretary of the Navy on the proper procedures to safely store ammunition. The work of this board resulted in the development of standardized designs for ammunition storage structures for defined classes of ammunition at ammunition production plants, ammunition storage depots, and at installations to support specific missions.

3.2 Early Army Ammunition Storage

The aftermath of World War I and the early years of the 1920s revealed the inadequacies of the Army and Navy ammunition supply systems. The Herculean efforts required to outfit the Army and Navy brought its own challenges after the Armistice in November 1918, when large shipments of ammunition was returned from overseas and storage sites were needed. Until that time, the focus of the Ordnance Department was on shipping ammunition produced in U.S. plants to troops fighting in Europe. As a result of this focus, five large ammunition storage installations were constructed in 1917-1918 on the East Coast near major shipping ports with rail access. The largest of the new depots was Raritan Arsenal in New Jersey. This installation was built on approximately 2,200 acres of salt marsh. The installation contained approximately 85 above-ground, terra-cotta tile magazines measuring 51 x 218 feet to store shell and black powder, and 12 magazines of sheet metal construction measuring 26 x 42 feet to store high explosives (Crowell 1919:551-552). In all, the Army concentrated ammunition storage at eight old line arsenals and five newly constructed ammunition depots. The Navy maintained eight ammunition storage areas generally located at, or nearby, major Navy yards. The storage capacity of these ammunition depots was soon overwhelmed by the large volume of ammunition and general ordnance stores returning to U.S. shores from Europe.

Following World War I, the Army reorganized its ammunition supply and distribution system to reflect new methods of supplying troops in the field. Depots were assigned one of these roles: reserve, intermediate, and installation, or area. Reserve depots were used to store vast stocks of ammunition received in bulk from factories for long-term storage until required by military emergencies. Intermediate depots were situated throughout the United States to supply installations within Army regions with three months of ammunition. Installation depots maintained one month's supply of ammunition for military activities. Between 1929 and 1940, the Ordnance Department operated 12 reserve depots, four intermediate depots, and small area depots on installations to support military training and missions (Thomson and Mayo 1991:353).

At the end of World War I, the Navy had eight ammunition depots located at, or within, a convenient distance from active Navy yards, since combat ships could not dock at Navy yards with ammunition on board. Six magazines, or ammunition storage depots, were located on the East Coast; two were located on the West Coast. The Navy used the term "magazine" to cover on-board ship storage of ammunition, as well as on-shore storage. Navy depots also assumed the task of overhauling ammunition periodically (U.S. Navy Department, Bureau of Yards and Docks 1947:323).

The event that most greatly influenced the evolution of the design of ammunition storage buildings during the twentieth century was a severe electrical storm on 10 July 1926 that ignited a fire in one storage magazine at Lake Denmark Naval Ammunition Depot, New Jersey. The fire caused a series of explosions that spread quickly throughout the depot. Fires burned for weeks at the installation, affecting every building and destroying many storage structures at Lake Denmark and at the Army's nearby Picatinny Arsenal (U.S. Navy Department, Bureau of Yards and Docks 1947:324; Murphey et al. 2000:22-24, B-3). A joint Navy and Army board conducted an investigation into the disaster and determined that storage procedures at Lake Denmark were recklessly inadequate. The investigation revealed that one magazine containing 1,691,000 pounds of TNT was located only 80 feet from another magazine containing 789,400 pounds of TNT. At the time of the explosion, Lake Denmark was one of several naval ammunition depots overcrowded with unused World War I munitions (Grandine and Cannan 1995:81-83).

As a result of an investigation, the Army and Navy adopted stringent new safety regulations for ammunition storage. A new type of ammunition magazine was designed along with new quantity and distance requirements for ordnance storage structures based on tables of distances. The new type of high-explosive magazine was a low, arched structure constructed of reinforced concrete and covered with earth. The arched design directed the force of an explosion up instead of out (U.S. Navy Department, Bureau of Yards and Docks 1947:324; U.S. Navy Department, Bureau of Yards and Docks 1938:O3-O12; Murphey et al. 2000:22-35, B-3). The new arched-type magazine was adopted by both the Navy and the Army. The Navy called the new design the "arched-type high-explosive magazine;" the Army called the new design the "igloo."

The amount of ammunition stored in a single storage unit was reduced considerably, while the distance between ammunition storage structures was increased. The revised Navy policy specified that single magazines contain less than 143,000 pounds of high explosives, and be located at least 500 feet apart (U.S. Navy Department, Bureau of Yards and Docks 1947:324; U.S. Navy Department, Bureau of Yards and Docks 1938:O3-O12). The Army recommended a minimum spacing between single igloos of 800 feet, while barricaded igloos could be spaced at 400 feet (National Archives and Records Administration [NARA] Record Group [RG] 156 Office of the Chief of Ordnance 1941:26-27). In addition, mandatory lightning rods and extensive grounding of all metal prevented lightning strikes from causing explosions. Standardized designs for aboveground ammunition storage structures were developed for each class of ammunition (see Table 3.1 for definitions of each class) (Murphey et al. 2000:24-25).

Table 3.1 Classifications of Ammunition for Aboveground Storage (Murphey et al. 2000:71)

Class	Type of Material
Class I	Finished Ammunition and loaded components
Class II	Smokeless powder
Class III	Ammunition, fuzes, and primers
Class IV	High Explosives
Class V	Ammonium nitrate and inert components
Class VI (Standard Warehouses)	Small Arms Ammunition

Implementation of these new standards for ammunition storage buildings occurred slowly during the late 1920s and most of the 1930s due to funding constraints. In 1928, the Navy constructed 77 arched, earth-covered magazines at Yorktown Mine Depot (currently, Yorktown Naval Weapons Station) in Virginia. The Navy also began construction of Hawthorne Naval Ammunition Depot, its ninth ammunition depot, and the first ammunition storage depot entirely planned and constructed after the Lake Denmark explosion. Located on 211 square miles in the middle of a desert near Hawthorne, Nevada, the installation served Mare Island and Puget Sound Navy Yards by rail. Construction began at Hawthorne in 1928. When commissioned in 1930, the installation contained 84 arched-type high-explosive magazines; 2 fuze and detonator magazines; a mine-filling plant; and a personnel support area. The construction and design of Hawthorne reflected the Navy's revised storage policy, as well as the Navy policy to include production areas at the depots. The magazines were designed according to the new capacity and spacing standards. Magazines were spaced 600 feet from one another, and groups of magazines were separated by larger areas (Building Technology Inc., 1984a:32; Grandine and Cannon 1995:83).

The Army completed its first igloos in 1929 at Savanna Ordnance Depot, Illinois; Benecia Arsenal, California; and Aberdeen Proving Ground, Maryland (Thomson and Mayo 1991:361). At Savanna Ordnance Depot, 24 igloos were arranged in parallel rows along six roads and were spaced 400 feet from each other to minimize the potential for the spread of explosions (Building Technology Inc., 1984b:38). Igloo storage also was constructed at Army Air Corps installations, including Selfridge Field, Michigan, and Langley Field, Virginia (U.S. Army Corps of Engineers, History Office, Box 110). From 1929 through World War II, the igloo was the Army's preferred structural design for high-explosive storage (NARA RG 156 Office of the Chief of Ordnance 1941:26-27; Grandine and Cannan 1995:120).

In 1936, the Ordnance Department requested $21 million for new construction and repair at various ordnance installations, including manufacturing arsenals and depots. Prior to funding the large monetary request, the War Department required a study to identify the ideal system of ammunition manufacturing and storage. The critical considerations in the plan submitted for review were: strategic location of new installations to avoid destruction by enemy attack; proximity to essential raw materials for production; distance from probable theaters of military operations; economy of operation; and climate. The board of officers reviewing the plan determined that the most critical criteria for the facilities were strategic location and proximity to potential theaters of operations. The location of new installations was decided by the Secretary of War, who directed that no further construction of permanent installations to store wartime reserves would occur east of the Appalachian Mountains or west of the Cascade and Sierra Nevada mountain ranges. Ordnance Department planners recommended that new installations be located at reasonable distances inland from the northern and southern U.S. borders for additional protection from enemy attack (Thomson and Mayo 1991:362). This area in the central portion of the U.S. became known as the "Zone of Interior."

During the late 1930s, Ordnance Department planners sought to counter the concentration of ammunition storage along the eastern seaboard. In 1937, the Ordnance Department proposed a policy to store 25 percent of ammunition along the East Coast, 65 percent in the central U.S., and 15 percent along the West Coast. The ammunition storage capacity, as reported during 1939, was approximately 65 percent along the East Coast, 27 percent in the central U.S., and 7 percent in the West (Thomson and Mayo 1991: 363).

U.S. Army and Navy planners were increasingly concerned over German expansion in Europe and Japanese aggression in the Pacific. In September 1939, Germany invaded Poland and in less than one year, both Poland and France fell. German forces occupied most of continental Europe. In the U.S., preparations began for possible war. The Munitions Program enacted in 30 June 1940 created a program for the production of $994,000,000 of ammunition (Thomson and Mayo 1991:365). This figure represented greater expansion in Ordnance operations over any previous war. Factory conversions to produce munitions and construction of new ammunition production plants and storage depots were mandated. Huge stocks of weapons and ammunition needed to be produced, stored, and distributed (Thomson and Mayo 1991: 7).

Initially, Ordnance Department planners proposed to expand ammunition storage capabilities through the construction of four new depots located in the four corners of the Zone of Interior, as well as expanding two existing installations located in the West (Thomson and Mayo 1991: 367). The siting of new installations was based on several criteria. The ideal site for an ammunition storage depot had access to a railroad line, was located at a safe distance from cities or towns, had topography and soils that could reduce construction and operation costs, was in a cool climate to promote safety, and was located in proximity to a loading plant to reduce shipping costs. The total amount of acreage needed for depots was between six and twelve thousand acres, dependent on the number of magazines planned for construction. The first four new ammunition storage depots constructed for the Ordnance Department were Portage Ordnance Depot at Ravenna, Ohio, in the northeast; Umatilla, Oregon, in the northwest; Fort Wingate, New Mexico, in the southwest; and Anniston, Alabama, in the southeast (Thomson and Mayo 1991: 367).

The Lend-Lease Act allowed Britain to acquire military supplies from the U.S., which President Franklin D. Roosevelt declared must become "an arsenal for democracy." After Germany invaded the Soviet Union in summer 1941, the lend-lease policy was extended to include the Soviet Union. The Ordnance Department realized that increased ammunition production required to fulfill the Lend-Lease program necessitated additional ammunition storage on the east coast to receive output from ammunition factories and to support transatlantic shipping to Great Britain. Ordnance Department planners were required to select four additional sites for ammunition storage depots with the passage of the Lend-Lease Act in March 1941. The selection of these sites in late 1941 brought the total of newly-designed depots to eight. The four additional depot sites were Milan, Tennessee; Seneca, New York; San Jacinto, Texas; and Red River, Texas. The original four geographically dispersed depots, and those constructed to support shipments to Europe, comprised the "A" program and contained all permanent construction for ammunition storage, warehouses, and support buildings (Whelan et al. 1997:30; Thomson and Mayo 1991:369-371, 378).

The United States entered World War II after the Japanese bombing of Pearl Harbor on 7 December 1941. Increased production of ammunition to support the American war effort required more new construction of ammunition storage facilities. Construction continued through 1942 at eight additional ammunition storage depots. In the construction of this group of depots, known as the "B" program, efforts were made to contain costs by constructing temporary mobilization-type buildings for administration and other non-critical buildings (Thomson and Mayo 1991: 378).

The new ammunition storage depots were among the largest installations constructed for the Army. The acreage contained in ammunition storage depots constructed at Ravenna, Ohio; Umatilla, Oregon; Fort Wingate, New Mexico; Anniston, Alabama; and Milan, Tennessee totaled 110,812 acres and included 3,504 ammunition storage igloos containing 5,775,512 square feet of explosives storage and an additional 413,139 square feet of storage in 38 large above-ground magazines (Fine and Remington 1989:340-341). The construction program for fiscal year 1942 added an additional 5,663,000 square feet of ammunition storage to the inventory. Six depots contained more than 20,000 acres each. In all, the construction of the 16 major Ordnance Department ammunition storage depots cost approximately $367 million (Thomson and Mayo 1991:369, 378, 377). In 1944, the Ordnance Department reported operations at 46 depots located all over the United States, plus sections in six Army Service Forces depots (NARA, RG 156, Office of the Chief of Ordnance 1944b:57). Of this number, 25 Ordnance Department installations were engaged in the receipt, storage, and issue of explosives (MacMorland 1945:791).

The Navy also increased ammunition storage capacity during the years leading to U.S. involvement in World War II. The Navy's largest ammunition depot at Hawthorne, Nevada, was expanded. By 1943, storage capacity at Hawthorne was 4,879,761 square feet in 1,678 buildings. In addition, the Navy constructed three vast inland storage depots: 98 square miles at Crane, Indiana; 70 square miles near McAlester, Oklahoma; and 75 square miles near Hastings, Nebraska. The inland storage depots were designed to supply regional coastal depots and transshipment points. The Navy also expanded older depots through land acquisition (Grandine and Cannan 1995:85). Many of these facilities were transferred to the Army in the 1970s.

Ammunition storage depots were designed and constructed by private architectural and engineering firms contracted through the Quartermaster Corps or the Corps of Engineers for the U.S. Army or through the Bureau of Yards and Docks for the Navy. The large ammunition storage depots constructed for both the Chemical Warfare Service and the Navy were generally government owned and operated. Six ammunition storage depots were operated by contractors; these depots were Anniston Ordnance Depot operated by Chrysler Corporation, Blue Grass Ordnance Depot operated by Firestone, Lordstown Ordnance Depot operated by Sears & Roebuck, Rossford Ordnance Depot operated by International Harvester, Portage Ordnance Depot operated by Atlas Powder Company, and Milan Ordnance Depot operated by Proctor and

Gamble (NARA RG 156 Office of the Chief of Ordnance 1945; NARA RG 156 Office of the Chief of Ordnance 1944a). In addition, contractors operated all depot divisions associated with the government-owned, contracted-operated ammunition production plants.

The Army's pre-World War II plans proposed that all depot work would be conducted by military enlisted personnel, particularly in the event of invasion, while the Navy planned on using civilian labor (Thomson and Mayo 1991:377). The Army quickly changed strategy to civilian government under the direction of the installation Commanding Officer. However, the remote locations of some of the ammunition depots, particularly those in the far west, resulted in a severe shortage of civilian manpower. In 1942, the Navy supplemented the civilian labor force at their inland depots with enlisted personnel (U.S. Navy Department, Bureau of Yards and Docks 1947:331-332).

In response to America's entry into World War II following the attack on Pearl Harbor, the War Department began a major reorganization in early 1942. Technical services, including the Ordnance Department, the Quartermaster Corps, the Signal Corps, Corps of Engineers, and the Medical Corps, were placed under the control of the Army Service Forces. Among the objectives of this organization on the home front was to provide consolidated planning among the technical services for coordinated procurement and distribution of supplies to support the mobilized Army Air and Ground Forces. In addition, the Army and the Navy collaborated on the production of shared munitions, specifically incendiary bombs and chemical weapons (Thomson and Mayo 1991:377).

Consolidated planning efforts undertaken by the Army Service Forces affected changes to Ordnance Department storage. In spring 1943, Army Service Forces planners determined that the Ordnance Department had overbuilt its storage capacity and reallocated a percentage of funding for storage construction within the Army Service Forces (Thomson and Mayo 1991:386ff). By the end of the war, the Ordnance Department operated 53 storage installations totaling 285,000 acres containing 65,000,000 square feet of covered storage in 15,000 separate covered storage points. Open storage added an additional 60,000,000 square feet to overall storage capacity (MacMorland 1945:789).

3.3 The Technology of Ammunition Storage

The Army's Ordnance Department stocked a total of 350,000 types of items. While no one depot stocked all the items, some depot inventories included over 100,000 different parts and assemblies of Ordnance materiel (MacMorland 1945:789). The internal handling requirements, the management challenges of the vast inventory of ordnance items, and the volume of materiel necessary to supply the military theaters of war required innovations in stock control and materials handling procedures. All aspects of receiving, inventorying, and shipping procedures were revised several times during the war. It was critical that the Ordnance Department maintain accurate records on stock on hand, manufactured stock, stock shipments, and projected needs to support troops in overseas operations. Mechanized stock control systems and IBM business machines to manage recordkeeping were introduced. Experiments were conducted to develop standardized practices to pack items efficiently and withstand transport so that materiel arrived overseas in serviceable condition. One major improvement in ammunition packaging was the introduction of pallets. Standardized storage procedures extended to drawings illustrating how different types of materiel were to be packed. New handling equipment, such as forklifts and cranes, were introduced to handle ammunition during receiving and shipping operations.

During the year 1 October 1943 to 30 September 1944, the Ordnance Department handled a total of 19,377,443 tons through their depots, representing 45 percent of the total tonnage handled by all depots in the Army Service Force. This figure excluded shipments made directly from the manufacturer to the user, which equaled 20 percent of the total tonnage (NARA RG 156 Office of the Chief of Ordnance 1944b:57). The remaining 35 percent represents non-ammunition shipments made by other Army Service Forces such as the Quartermaster Corps, Signal Corps, or Medical Corps.

As of 30 August 1944, 101,000 persons were employed at Army Ordnance Department depots. Ammunition handling equipment included 6,263 motor vehicles; 1,614 fork-lift trucks; 517 towing tractors; 238 cranes; and 160 locomotives (NARA RG 156 Office of the Chief of Ordnance 1944b:57-58). By 1945, mechanical handling equipment included over 2,000 forklifts of which one-third were battery operated to handle explosives, 250 cranes, 190 diesel-electric locomotives, and 7,500 motor vehicles ranging from five-passenger sedans to 15-ton tractor-trailers for hauling ammunition from rail heads to dispersed storage points (MacMorland 1945:791).

3.4 Industrial Design and Architecture of Ammunition Storage Facilities

At the beginning of World War II, the military had three broad classifications of ammunition materiel:

(1) most hazardous materials, including bulk high explosive, high explosive loaded in thin containers, such as aircraft bombs, and fuzes and detonators;

(2) less hazardous materials such as smokeless powder, loaded but unfuzed projectiles and small-arms ammunition, which are more stable than the materials in the preceding group; and

(3) inert materials, such as unloaded shells, cartridge cases, empty powder cans, and bag materials (U.S. Navy Department, Bureau of Yards and Docks 1947:328).

The Navy designed and constructed specific building types for each of the three classifications at its naval ammunition depots. The Army designed specific building types for the first two ordnance classifications. The Army used general storage building types to store inert ordnance materials. Ammunition storage building types constructed during World War II are summarized in Table 3.2 (Murphey et al. 2000:48-54; Grandine and Cannan 1995:81-127).

The earth-covered, arched magazine, or igloo, was the primary ammunition storage building type constructed during World War II. In fact, the Ordnance Department directed that all ammunition storage constructed after January 1941 be the arched concrete igloo magazine (NARA RG 156 Office of the Chief of Ordnance 1941:27). Igloo magazines were authorized for construction at manufacturing and ammunition loading plants, but not required (NARA RG 156 Office of the Chief of Ordnance 1941:27). The igloo magazines built by the Army were generally unbarricaded (NARA RG Office of the Chief of Ordnance 1941:53). In 1944, the Ordnance Department reported that it operated 28,705,000 square feet of igloo storage space, which represents 95 percent of the Army Service Forces total. Occupancy in October 1944 stood at 62 percent (NARA RG 156 Office of the Chief of Ordnance 1944b:57)

While the Navy also used the basic arched, earth-covered magazine, they also experimented with new designs for earth-covered magazines. The Bureau of Yards and Docks issued designs for a concrete rectangular box magazine that measured 50 x 100 with concrete

Table 3.2 World War II Ammunition Storage Building Types

Building Type	Army Construction	Navy Construction	Characteristics
Aboveground			
Fuze and detonator--depot level	No	Yes	Concrete frame, concrete walls, gable roof
Ready/small arms/pyrotechnic—installation level	No	Yes	Concrete frame, concrete walls, gable roof, small size
Shell magazine	No	Yes	Concrete frame, concrete walls, gable roof
Standard ammunition magazine	Yes	No	Structural clay tile walls, concrete floor, gable roof, 50 x 218 feet
Smokeless powder magazine	Yes	No	Structural clay tile walls, concrete floor, gable roof, 37 x 110 feet or 51 x 78 feet
Explosives/primer/fuze/post ordnance/smokeless powder—installation Level	Yes	No	Structural clay tile walls, concrete floor, gable roof, 26 x 42 feet
Richmond type	Yes	No	Brick or concrete block walls, shallow-pitch gable roof, earth berms on three sides
Earth-covered			
Arched concrete, not barricaded	Yes	Yes	Reinforced-concrete barrel arch, earth-covered, concrete front wall with or without extended wing walls
Arched concrete, with barricade	No	Yes	Same as above with barricade wall opposite door
Arched steel, temporary	Yes	Yes	Concrete floor, pre-fabricated steel arch
Arched fuze and detonator	Yes	Yes	Reinforced-concrete barrel arch, earth-covered, concrete front wall, 20 x 20 feet
Flat-roofed fuze and detonator	No	Yes	Reinforced-concrete with flat roof, earth-covered, concrete front wall
Rectangular box	No	Yes	Reinforced-concrete with flat roof, 50 x 100 feet
Triple arch	No	Yes	Three reinforced concrete barrel arches with common foundation
Corbetta Beehive	Yes	Yes	Circular, reinforced concrete dome, 52 foot diameter
Triple Corbetta Beehive	No	Yes	Same as above in groups of three with common loading dock
Specialized Storage			
Toxic gas yard	Yes	No	Open storage for canisters of toxic materials
Open storage	Yes	Yes	Paved or graveled open areas surrounded by earth barricades

loading platforms. Other designs were proposed to save critical construction materials. Designers developed triple-barrel vaulted magazines, which comprised three arched segments that shared common walls, foundations, and loading docks (Grandine and Cannan 1995:85). Another example of a design introduced to save critical materials was the Corbetta beehive magazine. Designed in 1942 by the Corbetta Construction Company of New York City, this structure was an elliptical, dome-shaped magazine. The Corbetta beehive equaled the arched, earth-covered magazine in structural strength, but required only half the steel, one-third the copper, and two-thirds the concrete required by the standard type of magazine (MacLeay 1942:74-75; Fine and Remington 1972:333-334, 530-531). The Corbetta beehive, rectangular box, and triple-arch magazine types were designed for use at Naval depots, but only the beehive was later adopted by the Corps of Engineers for use at Army ordnance installations (Murphey et al. 2000:49).

The typical Ordnance Department ammunition depot comprised 700 or 800 igloo magazines, 6 to 15 above-ground magazines, and/or open storage areas (MacMorland 1945:791-792). Warehouse space was usually in one story buildings at car or ground level loading access. In October 1944, the Ordnance Department had a total of 44,894,000 square feet of warehouse space which represented one-third of the total operated by all Technical Services depots. Occupancy of Ordnance Department warehouse space in October 1944 was about 65 percent. Shed storage space generally comprised structures constructed at ground level, with a roof, either concrete or dirt floor, and lacking side walls. In October 1944, the Ordnance Department operated 7,585,000 square feet of shed storage, which represented 56 percent of Army Service Forces total space. As reported in October 1944, the Ordnance Department had 67 percent occupancy of shed storage. Open space storage usually consisted of hardstand, which was concrete, macadam, or black top and was used to store items which could remain in the open, such as vehicles and heavy equipment. In October 1944, the Ordnance Department operated 42,770,000 square feet of open storage, which represented 24 percent of the Army Service Forces total. Occupancy as reported in October 1944 was 59 percent (NARA RG 156 Office of the Chief of Ordnance 1944b:57)

3.5 Social History of Ammunition Storage Facilities in the pre-Cold War Era

The Ordnance Department-operated depot system employed approximately 100,000 persons. Fourteen hundred officers were key managers and supervisors. Officers generally directed depot operations; some officers were detailed to the manufacturing plants to perform liaison functions and to monitor operations for the Ordnance Department. Approximately 2,200 enlisted personnel were assigned to operate specialized office equipment and to train prior to assignment at overseas depots. Approximately 86 percent of the employees were civilians; 35 percent were women. In addition, approximately 10,000 prisoners of war and Italian service troops worked in the depot system; this labor pool generally was assigned jobs in plant maintenance, salvage, and reclamation activities (MacMorland 1945:790).

The numbers employed at Ordnance Department-operated depots varied widely. Detachments of smaller than 100 persons might be assigned to the manufacturing plants or arsenals to handle products. At individual depots, the number of employees ranged from 500 to 6,000 (MacMorland 1945:790).

The impact of an individual depot on the local community varied with the size of the installation and number of employees. The impacts of depot divisions at large ammunition manufacturing plants were subsumed in the much larger impacts of the manufacturing plants. Construction of these ammunition storage installations generally required extensive numbers of employees for a short, intense time during the actual construction phase. Once the depots were operational, the numbers of employees stabilized at much lower levels than the numbers required for construction.

The large Ordnance Department and Navy depots generally became employment nodes for nearby local communities or became the basis for the establishment of a community in isolated regions. Depots in isolated areas required the creation of small towns to support civilian workers and their families. Labor forces, numbering between 500 to 3,500 persons, often moved to the vicinity to staff the depot. The depots were stand-alone installations with complete fire-fighting capabilities, and potable water treatment and sewage treatment capacity. Housing, community services, schools, nurseries, family shopping facilities, and hospital services were required to support employees in isolated depots (MacMorland 1945:791).

3.6 Demobilization

During mid-1943, Ordnance Department planners turned their attention to demobilization. All demobilization plans were based on the premise that the United States would emerge from the war as the "greatest military power in the world and would remain, for at least several postwar years, in a state of preparedness for action in widely dispersed areas…(and) that the United States would deploy troops in occupied areas for an extended period" (NARA RG 156 McMullen 1946:5).

For planning purposes, demobilization was divided into three phases. Period I began with Victory in Europe, and extended until Victory in Japan. It was predicted that Phase I would last about a year. During this phase, military operations would be concluded in Europe and men and materiel refocused on the war with Japan. Immediately upon the defeat of Germany, depot commanders would immediately cancel all shipments bound for Europe and be ready to receive redirected shipments of ammunition. It was important that ports not be clogged with materiel as was the case when Armistice was declared at the end of World War I, and that transportation channels be available to reroute necessary materiel to the Pacific Theater. It also was necessary to maintain accurate records of materiel on hand for redeployment to the Pacific. During this phase, Brig. Gen. E.E. MacMorland stated that implementation would include "huge cuts in the Ordnance production program with private facilities. Permanent termination of contracts will and must be effected promptly to permit manufacturers to turn to civilian pursuits without delay" (NARA RG 156 Office of the Chief of Ordnance 1944b:83-84).

Period II began with the cessation of hostilities with Japan and lasted for approximately six months. This period covered the return of men and materiel from the Pacific Theater and the implementation of peace plans. In this phase, the Ordnance Department anticipated that the depots would be flooded with returning ammunition that required overhaul, proper long-term storage, or disposal. The work load of the depots would increase, while the number of personnel available to perform the work would decrease. Period III began with the implementation of final peace plans and was estimated at about three years to span the time period between the final end of the war and the formation of the post-war military establishment (NARA RG 156 Office of the Chief of Ordnance 1944b:82-83).

As part of peace planning, the Ordnance Department anticipated retaining a nucleus of government-owned ammunition production plants and proving grounds "that would provide a reasonably balanced capacity for the production of all types of loading, explosives, and subsidiary materials, other than those readily available from commercial sources or other Government agencies" (NARA RG 156 Office of the Chief of Ordnance 1944c). The plan for ammunition storage was to retain all active Ordnance Department depots and to transfer all contractor-operated depots to the Ordnance Department. In addition, "igloo areas on plants and works declared surplus will be retained by the Ammunition Branch where of sufficient extent and properly located," particularly those magazine areas that could support port facilities (NARA RG 156 Office of the Chief of Ordnance 1944c).

3.7 Summary

Between 1940 and 1945, the United States produced $106 billion worth of munitions; in 1944, the peak year of production, over $42 billion was spent. This total represents the production of more ammunition than all the remaining Allied powers, and almost 50 percent more than the combined totals of Germany and Japan (Harrison 1988:171-192). The industrial mobilization effort of the United States during World War II was unparalleled in American and world history. Construction efforts included tens of thousands of buildings to house, train, equip, and supply an Army of over eight million men and women. This included 16 major ammunition depots at a cost of approximately $367 million.

The demobilization plans drafted during the summer of 1944 were needed the following year. The unconditional surrenders of Germany in May and Japan in September 1945 ended World War II. Demobilization plans drafted the preceding year were implemented, and the production of new ammunition was halted. Large quantities of ammunition began returning from Europe and the south Pacific, taxing existing storage facilities despite the ambitious building program undertaken during the war. With reduced resources and little time for planning or new construction, returning munitions were stored wherever room was available.

4.0 THE COLD WAR: 1946-1989

4.1 Origins of the Cold War: 1946-1950

4.1.1 Introduction

Ideological, military, and economic conflict between the United States and the USSR over Communist aggression characterized the Cold War. The Cold War was an unforeseen consequence of the post-World War II realignment of Europe negotiated among the primary victors: the United States, the United Kingdom, and the Soviet Union. The general policy adopted by the Allies was to occupy recently liberated territories until elections could be held. As a result, the Communist Soviet Union was able to exert pressure on the governments of Eastern European countries, thereby creating the division between east and west.

During WWII, the Allies held a series of meetings to discuss postwar Europe; the most significant of these occurred in February 1945 at Yalta, and was attended by Franklin Roosevelt, Winston Churchill, and Joseph Stalin. During the discussions, political and territorial questions that had been avoided in the effort to defeat Nazi Germany were addressed.

Roosevelt, Churchill, and Stalin reached agreement on several key issues in Yalta, including the future of Poland, Eastern Europe and Germany; the war in Asia; and the creation of a postwar international organization (Palmer and Colton 1978:821; Gaddis 2005:31). At that time all parties, including Stalin, pledged to establish freely-elected provisional governments representing all political parties in territories occupied by the Soviet army (Palmer and Colton 1978:821; Gaddis 2005:31). It was understood among the Allied powers that the country liberating a formerly German-occupied nation would exercise political control over that nation until final peace treaties were signed (Palmer and Colton 1978:850). As the liberating country, the Soviet Union was able to influence political outcomes in Eastern Europe.

Also at Yalta, Poland's eastern boundary was set at the Curzon line and its northern and western borders were extended at the expense of Germany. German disarmament and the partition of Germany by the Big Three powers and France also were discussed (Palmer and Colton 1978:821).

The third major issue discussed at Yalta concerned the creation of the United Nations (UN). Roosevelt was a strong proponent of cooperation among the world powers. He believed this cooperation could be achieved within the framework of the United Nations (Palmer and Colton 1978:824). He further believed that by acting as international policemen, the big powers could preserve future peace and security around the world. Roosevelt would never see the end of hostilities; on April 12, 1945 he passed away, leaving Harry S. Truman as President (Palmer and Colton 1978:824).

Immediately before the end of the war and right after the war the United States and the Soviet Union aggressively sought to appropriate German military secrets and the cooperation of German scientists. The Americans conducted their efforts under the name "Operation Paperclip." The purpose of the program was to "exploit German scientists for American research, and to deny these intellectual resources to the Soviet Union" (Advisory Committee Staff 1995:1; Walker 2005). Denying the Soviets the opportunity to recruit German scientists was the highest priority for Pentagon officials, regardless of whether or not the Germans were active members in the Nazi party (Advisory Committee Staff 1995:4). In March 1948, Captain Bosquet N. Wev outlined the government's position. He stated that "Nazism no longer should be a serious consideration from a viewpoint of national security when the far greater threat of Communism is now jeopardizing the entire world" (Advisory Committee Staff 1995:4).

As a result of the program, approximately 1,600 scientists and their families were brought to the United States (Advisory Committee Staff 1995:1). Scientists with backgrounds in aeromedicine, radiobiology, and ophthalmology were recruited to work at the Air Force's School of Aviation Medicine at Brooks Air Force Base, Texas; and other military installations, including the Army's Chemical Corps at Edgewood Arsenal, Maryland (Advisory Committee Staff 1995:2). Other scientists with backgrounds in radiation biology and physics also were recruited (Advisory Committee Staff 1995:3).

As part of this project, German engineer Wernher von Braun and a group of German scientists were recruited and transported to White Sands Missile Range in New Mexico, along with "enough captured rocket parts, equipment, and research data to build and launch 67 V-2s" (Library of Congress 2007:3). The group of scientists relocated in 1945, and agreed to work with the United States in order to develop and test the V-2. While in Germany, von Braun had worked on the early development of the V-2's predecessors, the A-1 thru the A-5, and the V-1. His experiments with the V-2 at White Sands were crucial to future rocket development in the United States.

4.1.2 The Truman Doctrine

Efforts to stop the spread of Communism guided much of the United States' foreign policy during the postwar years. In a 12 March 1947 speech before the joint houses of Congress, President Truman outlined his foreign policy, which became known as the Truman Doctrine. The Truman Doctrine evolved out of a desire by the American government to respond to perceived Soviet threats. Under the Truman Doctrine, the United States would provide political, economic, and military aid to any anti-Communist government threatened by "indigenous insurgents, foreign invasion, or even diplomatic pressure" (Ambrose 1971:150; Gaddis 1972:351, 352, 356). The Truman Doctrine governed American foreign policy for the next twenty years (Ambrose 1971:150). The first beneficiaries of the Truman Doctrine were Greece and Turkey, who received military aid to combat Communist insurgencies.

4.1.3 The Marshall Plan

Immediately following the Second World War, the United States undertook an ambitious plan to revitalize Europe's economy. Secretary of State George C. Marshall outlined his plan to revive Western Europe's economy in a 5 June 1947 speech at Harvard University. Marshall hoped that economic aid would discourage Europeans from electing Communist governments out of despair (Gaddis 2005:32). The plan initially met Congressional opposition. However, the Communist coup in Czechoslovakia and threat of Soviet Communist expansion into Europe prompted Congress to support Marshall's economic aid package. Economic aid was offered to all countries in Europe, including the countries in Eastern Europe; however, the Soviet Union prohibited its satellite countries of Eastern Europe from participating (Palmer and Colton 1978:845, 846).

The Marshall Plan sought to build European economic independence from American support. American financial aid was contingent upon European countries establishing individual economic policies, coordinating joint European economic policies to strengthen Europe's overall economy, and assuming a role in international trade (Palmer and Colton 1978:847). The American government encouraged European governments to reduce tariffs and currency controls and to create a European-wide internal market that would lead to mass production and lower costs (Palmer and Colton 1978:847). The Marshall Plan was an overwhelming success. By 1950, West German industrial production exceeded prewar levels, and by the early 1950s, the economic boom had spread to Italy and France (Palmer and Colton 1978:847). The Marshall Plan was, in part, responsible for the creation of the European Economic Community and eventually the European Union (Palmer and Colton 1978:847).

4.1.4 The Creation of Two Germanys

After World War II, Germany was divided into four occupation zones: Soviet to the east, American to the south, British to the northwest, and French to the southwest. The French, American, and British zones eventually combined to create West Germany (Federal Republic of Germany). West Germany became an independent country on 23 May 1949. East Germany (German Democratic Republic) was created 7 October 1949 with Soviet authorization. In addition, Berlin was divided into four sectors, similar to how Germany as a whole was partitioned (Gaddis 2005:105).

4.1.5 The Berlin Blockade

Tensions in Europe spiked during the late 1940s as the result of the Soviet blockade of Berlin. On 24 June 1948, the Soviets began a blockade of ground and water traffic into West Berlin. Stalin's reasons for imposing the blockade are unclear, but historians have speculated that the blockade was a response to the American introduction of a new currency in West Berlin, or efforts to unify the American, British, and French occupation zones under a newly created West Germany. Another theory posits that the Soviets were attempting to force the American, British, and French withdrawal from their respective sectors by taking advantage of their dependence on Soviet supply lines running through the Soviet zone (Gaddis 2005:33-34; Palmer and Colton 1978:846; Grathwol and Moorhus 1994:32).

The Berlin blockade threatened to launch a war-weary Europe into another armed conflict. The British and Americans retaliated to the blockade by imposing their own blockade on goods from the east to West Germany (Ambrose 1971:172). The Americans intensified their response to Soviet actions by conducting round-the-clock flying missions to Berlin. The airlift began on 26 June 1948 and supplied up to 13,000 tons of goods a day (Ambrose 1971:173). The Soviets lifted the blockade of West Berlin on 12 May 1949; however, the airlift continued until 30 September 1949. The airlift extended beyond the blockade because American military officials, suspicious that the Soviets would reinstate the blockade, wanted a stockpile of goods in West Berlin (Grathwol and Moorhus 1994:54).

4.1.6 The North Atlantic Treaty Organization (NATO)

While the West was supplying the citizens of West Berlin, the governments of Western Europe and the United States were creating a military organization to provide mutual defense to member nations. On 4 April 1949, Great Britain, France, Belgium, the Netherlands, Italy, Portugal, Denmark, Iceland, Norway, Canada, and the United States executed a treaty creating NATO. Greece, Turkey, and West Germany joined NATO in 1952 and 1955 (Ambrose 1971:174). The organization was created in an effort by countries assisted under the Marshall plan to provide for mutual military defense. After it was ratified by the Senate, President Truman signed the NATO treaty on 23 July 1949. The formation of NATO represented the first time the United States pledged defense of Western Europe during peacetime. Eastern European nations responded to the creation of NATO, and in particular the inclusion of West Germany in NATO, by forming the Warsaw Pact in May 1955 (Gaddis 2005:34).

4.1.7 China

Although the communist threat in Europe gained the most attention, communism was also a dominant force in Asian politics. The civil war in China was a flashpoint during the Cold War. Tensions between the Soviet Union and the United States were heightened as the threat of the most populous country in the world becoming Communist became a reality. The Nationalist (Kuomintang) and the Communist forces were fighting for control over China as early as 1927. In 1937, the Japanese invasion and occupation of China united competing Chinese forces in an uneasy alliance under Kuomintang leadership, helmed by Chiang Kai-shek. The Japanese defeat and withdrawal from China led to renewed hostilities between the Nationalists and the Communists. Open conflict broke out in the spring of 1946 and continued until September 1949. The Nationalists received aid from the United States while the Communists were given limited aid by the Soviet Union. Plagued by corruption, the Nationalists were unable to repel the Communist forces and fled in defeat to the island of Taiwan. Communist leader Mao Zedong proclaimed the creation of the People's Republic of China on 1 October 1949; the Soviet Union recognized the People's Republic of China the following day.

4.2 The Korean Conflict: 1950-1953

4.2.1 Introduction

The Cold War intensified during the 1950s through the 1970s. American foreign policy focused on limiting the spread of Communism, particularly to those nations previously unaffiliated with a Communist government. As a result of American foreign policy, the United States and the Soviet Union engaged in a series of proxy wars, whereby they fought each other indirectly, thus averting a nuclear war. Each Presidential administration attempted to address perceived Communist threats.

4.2.2 The Korean Conflict

Korea, which had been part of the Japanese empire since 1910, was jointly occupied by Soviet and American troops after World War II. Soviet troops occupied the northern half (above the 38th parallel) of the peninsula, while American forces occupied the southern half. The 38th parallel split the Korean peninsula in half and served as the line of demarcation until elections could be held and occupying forces withdrawn (Gaddis 2005:41). It was anticipated that a new government would unify the peninsula.

Although occupying forces left the Korean peninsula in 1948 and 1949, peninsula-wide elections did not take place. United Nations-sanctioned elections were held in the Republic of Korea (South Korea); the Democratic Republic of Korea (North Korea), which was supported by the Soviets, did not hold elections. Each government claimed legitimacy and threatened to cross the 38th parallel (Gaddis 2005:41). However, neither government could act without assistance from their respective supporters (Gaddis 2005:41).

Tensions came to a head when the North Koreans took decisive military action against the South. With Soviet approval, the North Koreans crossed the 38th parallel on 25 June 1950. The United States, with the support of the UN, came to the aid of the South Korean government. The hostilities on the Korean peninsula represented the first time that the recently-created United Nations (UN) intervened in military action. The Soviet Union, boycotting the UN for its failure to recognize the People's Republic of China, was absent from the Security Council during the vote to commit troops to South Korea.

A cease-fire was established in July 1951; however, fighting did not end until July 1953 when the Chinese, Americans, and the North and South Koreans agreed to an armistice. The

North Koreans, Chinese, and Soviets continued to refuse peninsula-wide elections. The conflict did not result in a clear victory for either the United States and its allies or the Soviet Union and its allies. The boundary between North and South Korea essentially was unchanged (Gaddis 2005:50).

United Nations assistance during the Korean Conflict was necessary as the United States was poorly prepared for combat, and an inadequate number of soldiers, heavy weapons, and supplies plagued military efforts (Betts 1995:17). The U.S. no longer maintained the large standing Army it created in WWII. Post war demobilization had been completed in June 1947, releasing approximately 1.2 million troops every month. The efforts decreased troop forces from approximately eight million to 685,458. Also as part of demobilization, the number of Army divisions had gone from 89 to 12. By the beginning of the Korean War the Army had 593,167 troops; however, by 1952, there were a total of approximately 1,596,419 Army personnel available for duty (Table 4.1) (Shrader 1995:10, 6; Epley 1993a; 4-5, 7).

Although the size of the Army more than doubled, the numbers deployed to Korea never surpassed 275,000. The need to maintain a strong force in the event of a Soviet strike was paramount to American policy during this period, and continued throughout the later years of the Cold War (Shrader 1995:10). The resultant decline in the number of troops after the Korean Conflict was less dramatic than after previous conflicts. Troop strength declined from 1,025,778 in June 1956, to 997,994 in June 1957, a reduction of only 27,784 troops (Table 4.2). The Cold War was a unique period in the Army's history, because the size of the regular Army remained consistently high compared to previous peacetime levels. The size of the Army leveled off around 900,000 in the late 1950s (Department of the Army 1956).

Table 4.1. Size of the Army during the Korean Conflict (Kuranda et al. 2003)

Year	Actual Size	Enlisted Men	Officers
1950	593,167	518,921	72,566
1951	1,531,774	1,399,362	130,540
1952	1,596,419	1,446,266	148,427
1953	1,533,815	1,386,500	145,633

Table 4.2. Size of the Army during the post-Korea Cold War (Kuranda et al. 2003)

Year	Actual Size	Enlisted Men	Officers
1954	1,404,598	1,274,803	128,208
1955	1,109,296	985,659	121,947
1956	1,025,778	905,711	118,364
1957	997,994	885,056	111,187
1958	898,925	792,508	104,716
1959	861,964	758,458	101,690
1960	873,078	770,112	101,236

4.3 Post-Korea Cold War: 1954-1960

4.3.1 The Domino Theory and Non-Alignment

Following the cessation of hostilities in Korea, countries non-aligned with the Soviet Union or the United States became a concern for American policymakers. These concerns were particularly acute in regards to countries newly declaring their independence from colonial powers. At a 7 April 1954 press conference, President Eisenhower voiced what became known as the "Domino Theory" regarding the political alignment of countries newly independent from

European colonial powers. Eisenhower stated that "'You have a row of dominos set up, you knock over the first one, and… the last one will go very quickly'" (Gaddis 2005:123). Many situations could create this domino effect, including outside pressures, or overthrows within a country (Gaddis 2005:123). Debate ensued over whom, the United States or the Soviet Union, would have influence over these countries. Non-aligned countries were those nations, particularly in the third world, that would commit to neither the Soviet Union nor the United States while leaving open the possibility of such a commitment (Gaddis 2005:124). Countries being pressured from either superpower would threaten to align with the other (Gaddis 2005:124).

4.3.2 The New Look and Massive Retaliation

President Eisenhower developed his own policy for addressing potential Soviet threats during the early 1950s. Termed the New Look, his policy was based on the assumption that American superiority in the numbers of nuclear weapons and American abilities to deliver those weapons would serve as a deterrent to Soviet hostilities. Eisenhower's reliance on nuclear weapons as a deterrent translated into reduced funding for conventional weapons. Indeed, nuclear firepower would be used to substitute for troops and aircraft (Betts 1995:20).

During the years immediately following the end of World War II, Congress was reluctant to appropriate funds for military spending. To achieve his policy goals, Eisenhower's budget priorities resulted in the Air Force receiving the bulk of military spending. Some political leaders advocated the elimination of the Army and Navy in favor of a strong Air Force (Ambrose 1971:162). The Air Force used its funding for long-range bombers and Intercontinental Ballistic Missiles (ICBM). The Navy also was a recipient of generous military budgets and used its funding to support the development of Submarine Launched Ballistic Missiles (U.S. Army Environmental Center [USAEC] 1997:23). President Eisenhower felt that weapons superiority was sufficient and refused to increase military manpower (Ambrose 1971:222).

Coupled with the New Look policy was the strategy of massive retaliation. This tactic threatened to destroy the Soviet Union. They would be able to retaliate, but would not have sufficient capabilities for defense (Ambrose 1971:222). As a deterrent, massive retaliation would make a nuclear war too destructive to fight, blurring the lines between winner and loser with the aim of eliminating war altogether (Shrader 1995:43-44). The New Look lasted until new policies for addressing potential Soviet threats were adopted under the Kennedy administration.

4.3.3 Hungary

Although the Unites States possessed the ability to retaliate against Soviet aggression, they were hesitant to use it. Soviet intervention in Hungary angered the Western powers, but did not result in Western retaliation. Riots in Budapest in October 1956 lead to a Soviet crackdown across the country. The moderate Imre Nagy sought political reforms, which led to a demand by students and workers for further liberalization of political freedom. After rioting broke out in Budapest, the Soviet Union responded by sending troops and quashing riots. A pro-Soviet government headed by János Kadár was installed. The incident demonstrated to Eastern and Western European leaders that the Soviet Union was willing to use force to preserve its influence (Gaddis 2005:240-241).

4.4 The Vietnam Era: 1960-1974

4.4.1 The Cuban Missile Crisis

The potential of nuclear war became a reality for most Americans in October 1962. The Soviet Union began constructing medium-range missile sites on Cuba in August 1962. Launch pads at the missile sites could fire missiles with a range of 1,000 miles. On 14 October 1962, an

American spy plane photographed the construction of the missile sites, proving months of rumors. In a 22 October 1962 televised statement, President Kennedy alerted the American public about the presence of the missile sites and warned the Soviet Union that the United States would consider a "nuclear missile launched from Cuba against any nation in the Western Hemisphere as an attack by the Soviet Union on the United States" (Ambrose 1971:289). President Kennedy directed the Navy to intercept Soviet ships headed towards Cuba. The crisis was resolved on 28 October 1962 when the United States promised not to invade the island and Soviet Leader Nikita Khrushchev announced the missiles would be removed.

4.4.2 Flexible Response

Increased military spending occurred during the Kennedy administration, bringing an end to fiscal conservatism, a hallmark of the Truman and Eisenhower administrations. By the second year of his administration, Kennedy had increased the Department of Defense budget to $56 billion and increased the size of the Armed Forces by 300,000 troops; this level of expansion in funding and troops was similar to the intensity of growth during the Korean War (Ambrose 1971:277, 283; Shrader 1995:116). The Kennedy administration reorganized the policies of the Truman and Eisenhower administrations of relying on nuclear weapons to deter Soviet aggression. President Kennedy wanted the ability to intervene in any crisis using either the threat of nuclear retaliation or using conventional weapons or troops (Ambrose 1971:278; USAEC 1997:36). The policy was known as Flexible Response. Flexible Response first was advocated by Army Chief of Staff Maxwell Taylor, who served under the Eisenhower administration. Regardless of his proposed reliance on troop strength, Kennedy did follow Eisenhower's role in continuing efforts toward missile development. The Soviets responded to changing U.S. policy by increasing their nuclear capabilities.

4.4.3 Mutual Assured Destruction (MAD)

President Kennedy's Secretary of Defense Robert McNamara developed the policy known as Mutual Assured Destruction that paralleled the paradigm of massive retaliation. Under this policy, the United States and the Soviet Union would target each other's major cities; the purpose of such targeting was to create the maximum number of casualties as possible. The rationale behind MAD was that if no one was assured of surviving a nuclear war, such a war would not occur (Gaddis 2005:80).

4.4.4 The Vietnam Conflict

The tensions between the Soviet Union and the United States intensified in Southeast Asia during the mid-1950s and early 1970s. The U.S. commitment to the government of South Vietnam began after the French left the country in 1954 and continued through 1973, when American troops pulled out. American intervention in the region, which began slowly under the Eisenhower administration and escalated after the Gulf of Tonkin incident in 1964, was predicated on efforts to stop the spread of Communism, specifically in Southeast Asia.

The American involvement in Southeast Asia began during the mid-1950s when the U.S. government provided assistance to the French. During the 1950s, the French were engaged in a conflict with Communist forces loyal to North Vietnamese leader Ho Chi Minh. After the French abandoned the outpost at Dien Bien Phu in May 1954, the United States sent military and economic advisors to Ho Chi Minh's opponents in South Vietnam (Gaddis 2005:132).

After the French defeat in 1954, the Americans, the British, the Soviets, and the Chinese agreed during the Geneva peace conference that the country should be divided at the 17th parallel. Ho Chi Minh established a Communist government in the north. Ngo Dinh Diem became the leader in South Vietnam. Elections in North and South Vietnam were scheduled to decide the fate of the country: continued division or unification. However, the elections were never held. The Viet Cong, guerrilla soldiers left behind in South Vietnam after the 1954 Geneva conference, began harassing South Vietnamese authorities. The South Vietnamese government appealed to the United States for additional aid (Palmer and Colton 1978:920).

American policy, from Eisenhower through Nixon, sought to check Communist expansion into South Vietnam and to fill the vacuum created by the French withdrawal from the region (Palmer and Colton 1978:920). This afforded American policy makers an opportunity to take action to prevent realization of the Domino Theory (Palmer and Colton 1978:920). Consequently, the U.S. sent substantial military forces to the region.

American participation in the conflict in Vietnam increased dramatically in 1964. Amid reports that American destroyers had been fired upon in the Gulf of Tonkin in August 1964, Congress passed the Gulf of Tonkin Resolution. The resolution gave the president broad powers to commit U.S. troops in Vietnam without prior consultation with Congress (Ambrose 1971:311). In effect, Congress enabled President Johnson to use "all necessary measures to repel any armed attack against American forces" (Ambrose 1971:311). In late 1964 and early 1965, President Johnson made the decision to initiate a bombing campaign against the North Vietnamese (Ambrose 1971:315). American military involvement in the conflict continued to escalate during the late 1960s. The Tonkin Gulf Resolution resulted in the deployment of 184,000 American soldiers to Vietnam by the end of 1965 (Tindall and Shi 1992:1358-1359). The number of Army personnel deployed to Vietnam climbed steadily for the next four years reaching a peak of over 500,000 in 1968.

President Richard Nixon initiated the steps that led to the United States withdrawal from Vietnam, despite seemingly contradictory policies. In the election of 1968, presidential candidate Richard M. Nixon promised to withdraw U.S. troops from Vietnam with "peace and honor." In June 1969, President Nixon announced the withdrawal of 25,000 troops. By May 1972, the regular Army had been reduced to 850,000 troops from its wartime peak of 1.5 million (Tindall and Shi 1992:1387).

Although the Nixon administration invigorated peace negotiations in the early 1970s and began turning over bases and equipment to the South Vietnamese, increased bombing of North Vietnam and the secret bombing of Cambodia contradicted Nixon's pledge of an early end to the war (Palmer and Colton 1978:923). Although an apparent escalation of military activity, progress toward a peaceful solution continued. The Nixon administration negotiated an agreement that returned American prisoners of war; the United States withdrew its forces in 1973 while the North and South Vietnamese governments remained in place (USAEC 1997:41). By 1974, the Army was reduced further to 783,000, a level that the Army maintained for the remainder of the Cold War era (Table 4.3) (Tindall and Shi 1992:1387). Two years later, North Vietnamese forces initiated a military offensive that resulted in the collapse of the South Vietnamese government. The country was reunified under a Communist government, and the People's Democratic Republic of Vietnam was declared in July 1976.

4.4.5 The Berlin Wall

After World War II, a divided Berlin became a way of life for its citizens. However, residents of the city could cross from east to west with relative ease, regardless of the political and military tensions. The city became physically divided after the East German government constructed a barrier to prohibit the movement of East Germans leaving the east for better opportunities and greater freedom in the west.

Highly educated, highly trained East Germans fled East Berlin for improved living standards in the west. Residents of East Germany were able to immigrate to West Germany via West Berlin. The annual number of immigrants leaving East Germany for West Germany exceeded 178,000 between 1952 and 1959; nearly half the immigrants were under 25 years of age (Grathwol and Moorhus 1994:76). Approximately twenty percent, or 4 million residents, of the East German population fled the country for West Germany by the end of the 1950s (Grathwol and Moorhus 1994:76). Immigration further increased during the early 1960s. During the first twelve days of August 1961, over 45,000 immigrants left the east (Grathwol and Moorhus 1994:84).

Table 4.3. Size of the Army during the late Cold War: 1960-1989 (Kuranda et al. 2003)

Year	Actual Size	Enlisted Men	Officers
1961	858,622	756,932	99,921
1962	1,066,404	948,597	116,050
1963	975,916	865,768	108,302
1964	973,238	860,514	110,870
1965	969,066	854,929	112,120
1966	1,199,784	1,079,682	117,786
1967	1,442,498	1,296,603	143,517
1968	1,570,343	1,401,727	166,173
1969	1,512,169	1,337,047	172,590
1970	1,322,548	1,153,013	166,721
1971	1,123,810	971,872	148,950
1972	810,960	686,695	121,290
1973	800,973	681,972	116,205
1974	783,330	674,466	105,998
1975	784,333	678,324	102,992
1976	779,417	677,725	98,647
1977	782,246	680,062	97,738
1978	771,624	669,515	97,785
1979	758,852	657,184	97,381
1980	777,036	673,944	98,717
1981	781,419	675,087	101,850
1982	780,391	672,699	103,109
1983	779,643	669,364	105,674
1984	780,180	667,711	107,883
1985	780,787	666,557	109,687
1986	780,980	666,668	109,757
1987	780,815	668,410	107,964
1988	771,847	660,445	106,963
1989	769,741	658,321	106,877

In an effort to staunch the flow of immigrants, the Soviet government constructed a wall cutting East Berlin off from West Berlin in August 1961. A barbed wire fence was constructed overnight on 12-13 August 1961. A more substantial and permanent concrete wall was constructed later. The twelve-foot tall concrete wall extended for 100 miles and was protected by guard towers, minefields, police dogs, and sentries ordered to shoot to kill anyone who tried to cross the wall (Gaddis 2005:115).

Construction of the Berlin Wall stabilized the political situation in Berlin between East and West. Khrushchev no longer needed to force Western powers out of Berlin because the wall separated West Berlin from East Berlin and East Germany (Gaddis 2005:115). The United States responded to the construction of the Berlin Wall by sending additional Army forces to West Berlin (USAEC 1997:40). The wall succeeded in halting the number of immigrants fleeing East Berlin for the west; the number of East Germans entering West Berlin nearly came to a halt (Grathwol and Moorhus 1994:107). The wall remained a physical reminder of Cold War tensions until it was opened in 1989.

4.4.6 Tensions Between China and the Soviet Union

Although the Soviet Union provided limited support to the Chinese Communists during the civil war with the Chinese Nationalists, relations between Mao and Stalin remained cool (Palmer and Colton 1978:863). During the early years of Communist rule, the Chinese government relied on economic and military aid from the Soviet Union. However, relations between China and the Soviet Union were measured, and at times hostile, by the late 1950s and early 1960s. The two countries disagreed over sharing nuclear technology, the construction of long-wave radio stations, and a joint fleet. The Chinese government declared its independence from Soviet influence after Stalin's death (Palmer and Colton 1978:864). Sino-Soviet relations remained restrained through the remainder of the Cold War. The Chinese relationship with the United States reached an important milestone when President Nixon paid a significant visit to China in February 1972, which reopened political and economic relations between the two nations (Gaddis 2005:151-152).

4.4.7 Détente and the Helsinki Conference

By the early 1970s, American foreign policy evolved yet again to respond to current world conditions. The Soviet Union and the United States sought ways to peacefully resolve their differences. Détente was the term used to describe Soviet and American efforts to reduce tensions (USAEC 1997:46; Palmer and Colton 1978:928).

President Nixon and Soviet leader Brezhnev signed an agreement on 29 May 1972 which, in addition to attempting to reduce tensions, recognized the spheres of Soviet and American influence and sought to improve economic, commercial, and cultural ties between the two countries (The American Presidency Project 1972). Under détente, 35 countries, including the United States, Canada, the Soviet Union, and NATO and Warsaw Pact countries, pledged to work towards peaceful cooperation and permanent peace in Europe at Helsinki in 1975 at the Conference on Security and Cooperation in Europe (Palmer and Colton 1978:928). The conference, which opened on 3 July 1973 and concluded on 1 August 1975, resulted in the adoption of the Helsinki Accords. Brezhnev encouraged the formation of the conference because he wanted western recognition of the Soviet Union's postwar borders (Gaddis 2005:187).

By signing the accords, the 35 countries agreed to accept the Oder-Neisse German-Polish boundary established at Potsdam in 1945 but never ratified in a treaty (Palmer and Colton 1978:928). The Helsinki Accords also stipulated that participating nations had to give prior notification of military maneuvers; outlined cooperation in the fields of economics, science, technology, and the environment; and recognized human rights and the fundamental freedoms in conformance with the "purposes and principles of the Charter of the United Nations and with the Universal Declaration of Human Rights" (Gaddis 2005:188; Conference on Security and Co-operation in Europe 1975:7). Détente came to an end during the Carter administration.

4.5 The Late Cold War: 1975-1989

The Cold War came to a virtually peaceful end in 1989 after a series of nearly simultaneous events. Soviet leader Mikhail Gorbachev played an influential role in the collapse of Communism in the Soviet Union and Eastern Europe. His programs of *perestroika*, the term he coined for restructuring the Soviet economy along western models, and *glasnost*, or opening issues to public debate and criticism, were partially responsible for the breakup of the Soviet Union. In addition, unlike previous Soviet leaders, Gorbachev did not respond militarily when Eastern block countries acted independently of Soviet authority (Gaddis 2005:253).

The end of the Cold War began in early 1989 when Hungarian Prime Minister Miklós Németh refused to approve funds for the maintenance of the barbed wire fences between the Austrian and Hungarian borders. Shortly thereafter, he ordered the fence to be dismantled. The result was Hungarians, East Germans, and other Eastern Europeans could now pass through Hungary to the West with relative ease. By fall 1989, the number of East Germans traveling to Hungary approached 130,000; the Hungarian government announced it would not stop their emigration to the West (Gaddis 2005:243-245).

The political situation in Poland throughout the 1980s contributed to the demise of Communism in that country. The trade union Solidarity was formed in 1980 in Gdańsk in response to growing economic and social crises, and advocated anti-communist ideals such as open trade and free elections. Although the Communist government of Poland initially recognized the union, Solidarity later suffered repression and had its leaders imprisoned. As economic conditions continued to deteriorate, however, the government invited Solidarity to put forth candidates to compete in a 1989 election for a newly created two-house legislature; they won all seats contested in the lower house and all but one seat in the upper house (Gaddis 2005:241; NSZZ Solidarność n.d.). On 24 August 1989, postwar Eastern Europe's first non–Communist government took power (Gaddis 2005:241, 242). The Communist Party of Poland dissolved in early 1990 (NSZZ Solidarność n.d.).

The Berlin Wall officially opened to allow East Germans to travel to the West on 9 November 1989. The East German government intended only to relax border crossings from the East to the West (Gaddis 2005:245). However, during a botched press conference, an East German official announced that travel through any of the border crossings would be unrestricted, effective immediately (Gaddis 2005:245). Within hours East Germans began gathering at crossing points; East German border guards, who had been given no previous instructions, opened the gates at Bornholmer Strasse, thereby allowing East Germans to cross into West Berlin unimpeded (Gaddis 2005:245).

Events in Eastern Europe did not leave the Soviet Union unaffected. A coup attempt in August 1991 destabilized the Soviet government. A politically weakened Gorbachev resigned as President of the Union of Soviet Socialist Republics on 25 December 1991, following a decree terminating the existence of the Soviet Union. The fall of Communism is antithetical to the Domino Theory put forward during the 1950s. Rather than continued communist aggression, it was the Soviet Union that collapsed.

4.6 The Nuclear Age

4.6.1 Introduction

Weapons became more deadly as the Cold War progressed. Larger and more powerful weapons than the atomic bombs dropped on Hiroshima and Nagasaki were developed. The governments of Soviet Union and the United States built large stockpiles of nuclear weapons in an effort to protect their respective countries. The growth of nuclear power became a defining characteristic of the Cold War.

4.6.2 Nuclear Weapons

The atomic bomb was seen as a tool that could effectively deter the Soviets from aggressive action towards its neighbors (Ambrose 1971:128). The United States could keep the Soviets in check without calling upon Americans to make sacrifices (Ambrose 1971:128). Increasing the nuclear arsenal was more cost effective than increasing the number of conventional weapons and increasing the size of the military to their World War II levels (Gaddis 2005:36). Four years after the bombing of Hiroshima and Nagasaki, President Truman announced on 22 September 1949 that the Soviet Union had exploded an atomic bomb.

The United States developed the hydrogen bomb, known at the time as a "super-bomb," during the early 1950s. A hydrogen bomb fused atoms as opposed to splitting them, as in the case of the atomic bomb. The Truman administration thought the hydrogen bomb, or thermonuclear bomb, was psychologically necessary in that Soviet possession of the hydrogen bomb would instill fear and panic in the West. American development and possession of the hydrogen bomb would negate any advantage the Soviet Union might gain from developing the atom bomb. The United States first tested the hydrogen bomb on 1 November 1952 on an island in the Pacific Ocean. Almost a year later, the Soviet Union tested its first hydrogen bomb in the Central Asian desert. Americans tested a more powerful thermonuclear weapon on 1 March 1954 in the Pacific Ocean. The weapon yielded fifteen megatons, or 750 times the size of the atomic bomb dropped on Hiroshima (Gaddis 2005:61-64).

The Soviet Union tested its first air-dropped thermonuclear bomb in November 1955, and in August 1957 tested the world's first intercontinental ballistic missile (Gaddis 2005:68). As early as 1958, the world's nuclear powers met in Geneva at the Conference on the Discontinuance of Nuclear Tests. At this conference, the Soviet Union and the United States agreed to a moratorium on nuclear testing while a formal treaty was under development. The parties expected to resolve certain issues at a summit in early 1961; however, the political scandal generated by the downing of an American U-2 spy plane overshadowed the nuclear treaty, and the summit was never held. The Soviet Union began testing nuclear weapons in August 1961, and the United States responded by detonating its own nuclear weapon the following month (Ambrose 1971:285).

4.6.3 The Army's Development of Nuclear Weapons

The Army developed a series of nuclear weapons to respond to potential Soviet threats. The Army sought to develop weapons that were distinct from strategic weapons such as intercontinental ballistic missiles (ICBMs) and submarine-launched ballistic missiles (SLBMs) (USAEC 1997:25). The Army developed several new weapons systems that had limited practical use. The 280mm "atomic cannon," presented in 1953 could deliver nuclear or high-explosive warheads a distance of approximately 17 miles. The weapon needed to be kept well behind friendly lines to protect it against enemy attack, thus limiting its use as a tactical weapon (USAEC 1997:25, 26). The "Davy Crockett" was another nuclear weapon with limited tactical applications. The low-yield weapon could be fired from a small rocket. Its 1.5-mile range and limited accuracy made its use difficult (USAEC 1997:26). NIKE missiles also were developed to provide air defense against a possible Soviet nuclear missile attack. NIKE missile stations were located throughout the United States. Other missile systems including the CORPORAL, the HONEST JOHN, and the LITTLE JOHN were developed at White Sands Proving Ground and Redstone Arsenal in an effort to create parity with numerically superior Warsaw Pact forces.

During the 1960s and 1970s, the Army gradually moved away from developing antiaircraft missiles to developing antiballistic missiles (ABMs) (USAEC 1997:46). The Army developed a couple of ABM systems, the SENTINEL in 1967 and the SAFEGUARD in 1975 (USAEC 1997:46).

4.6.4 Treaties Regulating Nuclear Weapons

Beginning in the 1960s, the Soviet Union and the United States signed a number of treaties and entered into agreements limiting the testing and number of nuclear weapons.

4.6.4.1 The Treaty Banning Nuclear Weapon Tests in the Atmosphere, Outer Space and Under Water (1963)

Popularly referred to as the Limited Test Ban Treaty, the Treaty Banning Nuclear Weapon Tests in the Atmosphere, Outer Space and Under Water, was signed on 5 August 1963 by the "Original Parties" that included the United States, the Soviet Union, and the United Kingdom. The Limited Test Ban Treaty abolished nuclear tests in the atmosphere, including outer space and under water by signatory states (Gaddis 2005:81).

4.6.4.2 The Treaty on the Non-Proliferation of Nuclear Weapons (1968)

The Treaty on the Non-Proliferation of Nuclear Weapons required signatory and acceding nations with nuclear weapons not to assist other nations with acquiring them. Non-nuclear-weapon participating countries agreed not to receive nuclear weapons or to seek assistance in the manufacture of nuclear weapons. The treaty was signed on 1 July 1968 by the United States, the Soviet Union, and the United Kingdom (Treaty on the Non-Proliferation of Nuclear Weapons 1968).

4.6.4.3 The Strategic Arms Limitation Talks (SALT I) and the Treaty on the Limitations of Anti-Ballistic Missile Systems Between the United States and the Soviet Union (1972)

Between 1969 and 1972, the United States and the Soviet Union were involved in a series of negotiations regarding ballistic missiles. Signed on 26 May 1972 by President Nixon and Soviet leader Leonid Brezhnev, the resulting Treaty on the Limitation of Anti-Ballistic Missile Systems restricted the number of land- and sea-based, long-range ballistic missiles. The treaty, popularly referred to as the Anti-Ballistic Missile (ABM) Treaty, limited the Soviet Union and the United States to two ABM sites each. Compliance would be verified through satellites. Anything other than symbolic defenses, including missiles, also was banned under the treaty (Gaddis 2005:200; Limitations of the Anti-Ballistic Missile-Defense Systems 1972). In 1973, Congress restricted the number of ABM sites to one, at Grand Forks, North Dakota. A protocol limiting each country to one ABM site was signed by the United States and the Soviet Union in 1974 (USAEC 1997:46).

Under the agreement, the Soviet Union would retain superiority in the number of ICBMs. A vocal opponent to the treaty, Senator Henry Jackson, proposed an amendment that would have required that "all subsequent arms control agreements provide for numerical equality in all weapons systems covered" (Gaddis 2005:200). This provision impacted the subsequent SALT II negotiations.

On-going negotiations between the Soviet Union and the United States regarding the number of nuclear of weapons continued under the Carter administration. This series of talks were referred to as SALT II. President Carter and Soviet leader Brezhnev signed the Treaty Between the United States of America and the Union of Soviet Socialist Republics on the Limitation of Strategic Offensive Arms, Together with Agreed Statements and Common

Understandings Regarding the Treaty on 18 June 1979. However, the United States Senate refused to ratify the agreement because senators thought it did little to reduce the nuclear danger and it allowed the Soviet Union improvements in capabilities (Gaddis 2005:202). World events, namely, the NATO decision to deploy Pershing II and cruise missiles and the Soviet invasion of Afghanistan, also contributed to the Senate's failure to act on the treaty (Gaddis 2005:203, 211). Consequently, President Carter withdrew the SALT II treaty from the Senate in January 1980.

4.6.4.4 Strategic Arms Reduction Treaties (START)

President Reagan proposed the Strategic Arms Reduction Talks (START) in May 1982. The talks aimed to reduce the number of ICBMs and the number of strategic nuclear weapons. The Soviet Union and the United States began developing agreements for reducing the risk of war (Department of Defense 1994:91). A number of treaties resulted from the START process.

4.6.4.5 Treaty on Elimination of Intermediate-Range and Shorter-Range Missiles-Between USA and USSR (1987)

Commonly referred to as the Intermediate-range Nuclear Forces (INF) Treaty, the Treaty on Elimination of Intermediate-Range and Shorter-Range Missiles-Between USA and USSR was signed by President Reagan and Mikhail Gorbachev on 8 December 1987. Prompted by START, the treaty stipulated the removal and destruction of 2,611 American and Soviet nuclear weapons. Verification of destruction of the missiles would be completed through inspections (Gaddis 2005:235).

4.6.5 Strategic Defense Initiative (SDI)

On 23 March 1983, President Reagan announced the Strategic Defense Initiative (SDI). The new program effectively signaled the end of MAD (USAEC 1997:60). SDI operated on the premise that a system could be developed that would be able to intercept and destroy strategic ballistic missiles before they reached the United States (Gaddis 2005:226). SDI was envisioned to be a space-based program that relied on x-ray lasers or other advanced technology (USAEC 1997:60). For the remainder of the Cold War, SDI continued in the research and the development phases, but was never made operational. Development of the SDI program enabled the United States to fulfill the terms of the 1972 ABM treaty, which limited operational systems but not research and development (USAEC 1997:60).

4.7 Summary

The Cold War began and ended rather peacefully. Although the Cold War was marked by a series of armed conflict and hostilities, nuclear annihilation was avoided. The fear of nuclear destruction meant that the two superpowers came close to nuclear war without actually deploying nuclear weapons. While the Soviet Union and the United States were engaged in indirect military conflicts around the world, they also were engaged in negotiations limiting the number and spread of nuclear weapons. In the late 1980s, a series of political events, particularly in Eastern Europe, heralded the end of the Cold War.

5.0 ARMY AMMUNITION AND EXPLOSIVES STORAGE DURING THE IMMEDIATE POST WORLD WAR II ERA: 1946-1950

5.1 Introduction

The intensification of tensions between the United States and the Soviet Union following the termination of World War II marked the beginning of the Cold War. At that time, the tasks of the Ordnance Field Service included providing long-term ammunition storage space for the War Department War Reserve in case of emergency and for the Peacetime Operating Reserve. The War Reserve comprised "items essential to the equipment and maintenance of the armed forces which cannot be obtained in sufficient quantities immediately upon mobilization" (NARA RG 156 McMullen 1946:62). The Peacetime Operating Reserve included storage of ammunition at regional depots for distribution to individual installations to support training and operations.

The maintenance and surveillance of ammunition became the primary mission of the Ordnance Corps in the years immediately after the end of World War II. Although limited amounts of new ammunition were produced, the quantities of surplus returning from the Pacific and Europe were considerable, taxing available storage facilities and prompting periods of construction for new ammunition storage facilities.

5.2 Ordnance Corps Operations

Although the Army disposed of much excess ammunition overseas, 801,457 tons of ammunition was returned to the continental United States following the ceasefire with Japan in 1945. To accommodate the incoming ammunition, the Field Service disposed of surplus ammunition stored in Ordnance depots. Inventories conducted at each depot determined the most suitable lots of ammunition for long-term storage, with the goal of maintaining enough "for war reserve and training requirements without having to draw upon ammunition lots needing renovation" (NARA RG 156 McMullen 1946:66). Overall, the Ordnance Department disposed of 25,014 tons of ammunition valued at $22,960,532 (NARA RG 156 McMullen 1946:65-66).

Ordnance depots accommodated 4,600,000 tons of ammunition in August 1945. By 31 December 1945, this amount had increased by 1,100,000 tons. Long-term storage contained 125,000 tons. In order to use space most efficiently, bombs and obsolete items occupying magazines were moved to open storage. Unserviceable ammunition that had been returned from overseas was identified and demilitarized, and serviceable ammunition was placed in magazines (NARA RG 156 McMullen 1946:67; NARA RG 156 Stephens 1959:17). Large amounts of materials were transferred among storage facilities throughout the 1940s. In 1949, each Ordnance depot re-warehoused an average of 140,645 tons of ammunition and toxics (NARA RG 156 Office of Ordnance Comptroller 1951).

On 31 December 1945, the Ordnance Field Service comprised 55 depots; these establishments included 10 ammunition depots, 16 depots that handled both ammunition and general supplies, 23 general supply depots, and 6 Ordnance sections located at Army Service Forces depots (NARA RG 156 McMullen 1946:57-59). The 10 ammunition depots were as follows:

Charleston Ordnance Depot, Charleston, South Carolina
Curtis Bay Ordnance Depot, Baltimore, Maryland
Delaware Ordnance Depot, Pedricktown, New Jersey
Milan Ordnance Depot, Milan, Tennessee

Nansemond Ordnance Depot, Portsmouth, Virginia
Portage Ordnance Depot, Apco, Ohio
San Jacinto Ordnance Depot, Houston, Texas
Susquehanna Ordnance Depot, Williamsport, Pennsylvania
Umatilla Ordnance Depot, Ordnance, Oregon
Wingate Ordnance Depot, Gallup, New Mexico

The following 16 depots stored both ammunition and general supplies:

Anniston Ordnance Depot, Anniston, Alabama
Benicia Ordnance Depot, Benicia, California
Black Hills Ordnance Depot, Igloo, South Dakota
Blue Grass Ordnance Depot, Richmond, Kentucky
Letterkenny Ordnance Depot, Chambersburg, Pennsylvania
Navajo Ordnance Depot, Bellemont, Arizona
Ogden Ordnance Depot, Ogden, Utah
Pueblo Ordnance Depot, Pueblo, Colorado
Raritan Ordnance Depot, Metuchen, New Jersey
Red River Ordnance Depot, Texarkana, Texas
San Antonio Ordnance Depot, San Antonio, Texas
Savanna Ordnance Depot, Proving Ground, Illinois
Seneca Ordnance Depot, Romulus, New York
Sierra Ordnance Depot, Herlong, California
Sioux Ordnance Depot, Sidney, Nebraska
Tooele Ordnance Depot, Tooele, Utah

In 1945, chemical warfare depots were under the command of the Chemical Warfare Service; on 2 August 1946, the Chemical Warfare Service was renamed the Chemical Corps (Sidell et al. 1997:45). The following four chemical warfare depots accommodated chemical ammunition (NARA RG 156 Army Service Forces 1945:Appendix F:50):

Eastern Chemical Warfare Depot, Maryland
Gulf Chemical Warfare Depot, Alabama
Midwest Chemical Warfare Depot, Arkansas
Deseret Chemical Warfare Depot, Utah

Eastern Chemical Depot, the first of its kind in existence in the United States at the beginning of World War II, became increasingly active following the end of the war. Materials continued to arrive at the depot before wartime production could be totally halted. In addition to the task of storing these materials, the depot faced the challenge of storing surplus items being returned from continental U.S. Army camps and installations that had terminated operations, as well as storing surplus materials from chemical depots and stations located overseas. This frantic pace continued for over a year; even after the activity lessened, the depot still required extensive personnel to maintain storage operations (Kennedy 1948:53-54).

The end of World War II cancelled the majority of Army construction projects. Ordnance installations and industrial facilities had undergone substantial expansion during World War II. Following the termination of fighting in Europe on 8 May 1945, new construction dramatically decreased (a complete discussion of appropriations for the construction of ammunition-related facilities is included in Appendix D). As a result, on 3 July 1945 the Office of the Chief of Ordnance issued revised policies that limited new construction to emergency situations only (NARA RG 156 Raaen 1945). On 25 January 1949, the Office of the Adjutant

General distributed a memorandum to the commanding generals and chiefs regarding master planning for emergency expansion. Under such circumstances, the Army advocated maximum use of existing facilities and directed that all new construction necessary for emergency expansion be temporary in nature and similar to that used towards the end of World War II (NARA RG 156 Lewis 1949). Available data illustrates the dramatic drop in the construction of new ammunition storage facilities; construction between 1946 and 1950 represented less than two percent of the numbers constructed in the previous five years (U.S. Army Real Property Inventory 2007).

The Office of the Chief of Ordnance monitored the status of long-term storage at Ordnance installations. An Ordnance Department technical instruction was initiated on 22 December 1948 requiring depots to submit quarterly reports that summarized quantities of stored ammunition and explosives. Data requested included the total amount of tonnage stored at the depot and the amounts currently in long-term storage, anticipated to be placed in long-term storage, and to be demilitarized. Information from these reports was integrated into Ordnance Department progress reports for the overall ammunition storage program (NARA RG 156 Office of the Chief of Ordnance 1948).

5.3 Ordnance Corps Organization

Previously independent of each other, the Ordnance Department, the Chemical Corps, and the Army's other technical services temporarily were placed under one department, the Services of Supply, renamed Army Service Forces, in 1942. This reorganization represented a substantive shift in Army administrative structure, from a decentralized model of independent bureaus that each focused on producing one commodity, called a commodity structure, to a centralized model in which similar functions were grouped under one organization, called a functional structure. The change represented another turn in a debate over Army structure that had begun during the early twentieth century, when presidents Theodore Roosevelt and William Howard Taft attempted to improve government efficiency by structuring it on a business model. At that time, the Dodge Commission recommended that the War Department reorganize supply functions under one department. Those who favored centralization wanted to eliminate inter-bureau competition and duplicative functions across bureaus, such as budget staffs (Kane 1995:64-5).

Reflecting the continuing debate, the Army Service Forces was eliminated in 1946, and the pre-World War II bureau structure was restored. Although the technical services had some level of collaboration with the Director of Service, Supply, and Procurement and the other five members of the Army General Staff, the technical services reported to the Chief of Staff (Hewes 1975:159). The bureau chiefs had resisted the organizational change because it reduced their authority and independence. However, steps were taken gradually to change the Army structure to a centralized form (Kane 1995:66).

Laws and Army rules passed during the immediate post-World War II period increased the centralization of the Army and the technical services. The National Security Act of 1947 shifted all of the country's military branches from independent organizations reporting directly to the president, as they had been since the country's beginnings, to coequal branches grouped under a central agency. The Act consolidated the Army, the Navy, and the newly independent Air Force under the National Military Establishment, headed by the Secretary of Defense (the Marines remained within the Navy structure). A 1949 amendment changed the agency's name to the Department of Defense. Each military branch was headed by a civilian secretary who reported to the Secretary of Defense. Previously, the War Department and the Navy operated autonomously from each other; the Army operated the air branch, and the Marines were located within the Navy.

Following the 1946 reorganization that restored the technical services, Army staff issued an organizational chart in March 1948 that reflected a merger between the Director of Service, Supply, and Procurement and the Director of Research and Development to form a Director of Logistics, but preserved the direct link between the technical services and the chief of staff. (Hewes 1975:173). In November 1948, another revised organizational chart indicated that the Director of Logistics had direct authority over the technical services and maintained a parallel link with the Assistant Secretary of the Army responsible for procurement. However, the technical services continued to function separately, and some of their functions were overseen by the other directors at the general staff level. The Director of Logistics informed the technical services they could continue to function autonomously (Hewes 1975:190-3). An Army special regulation issued in April 1950 preserved that structure, but changed some titles. The Director of Logistics was now Assistant Chief of Staff for Logistics, one of four assistant chiefs at the general staff level, and the procurement-focused Assistant Secretary of the Army now was the Assistant Secretary of the Army for Materiel (Hewes 1975:206).

The Army Organization Act of 1950 added real authority to the paper authority by changing the statutory basis for the technical services. The Act "gave the Secretary of the Army the authority to reassign duties of statutory agencies; in other words, the power to reorganize the technical services if he so wished" (Kane 1995:66). In 1952, indicating the short future for the technical services, the Secretary of Defense said that a reorganization of the technical services would be painful but was "long overdue" (Kane 1995:66).

5.4 Design and Construction of Ammunition Storage Facilities

The massive amounts of munitions returned from Europe and the Pacific strained ammunition storage capacity. Although more than 18,000 ammunition storage facilities had been constructed throughout the United States between 1939 and 1944, the space available proved inadequate. During 1945 and 1946, some additional storage facilities were constructed. Of this total, open storage pads accounted for the greatest numbers. Few open storage areas were constructed during the most active periods of World War II. These storage pads could hold up to 900 tons of munitions each and were simply dirt or gravel areas surrounded by an earthen berm (Plate 5.1). Poles with lightning rods frequently were placed at the corners of the storage areas (Plate 5.2). Storage pads were a temporary solution to the problem and held munitions only until additional space was created in more permanent facilities such as earth-covered magazines, or until the ammunition was slated for demilitarization. Storage pads were constructed in large numbers; over 100 were built at Blue Grass Army Depot, more than 250 were constructed at Fort Wingate Depot Activity, and both the Pueblo Chemical Depot and Sierra Army Depot were enlarged with over 600 storage pads (Plate 5.3) (U.S. Army Real Property Inventory 2007).

By early 1946, virtually all production of new ammunition ceased, and efforts turned to the long-term storage, surveillance, renovation and demilitarization of the vast quantities of munitions currently in storage. Permanent, depot-level storage facilities were constructed at few installations between 1945 and 1947; examples included 13 fuze and detonator and 78 high explosive magazines at Hawthorne Naval Depot, 12 fuze and detonator and 142 high explosive magazines at McAlester Naval Depot, and a single igloo storage building at Rocky Mountain Arsenal (Plate 5.4). The permanent buildings followed the identical plans used for construction during World War II (U.S. Army Real Property Inventory 2007).

Construction of new ammunition storage facilities dropped precipitously between 1947 and 1950. Few installation-level facilities were constructed in 1947 and 1948. Buildings constructed after 1947 included ready magazines for use in ammunition production areas. Ready magazines typically were flat-roofed, rectangular buildings built of reinforced concrete (Plate 5.5). The magazines were aboveground to facilitate movement of explosive components through the covered ramps that connected the individual buildings of the ammunition production line. Earth backfill generally surrounded the buildings on three sides to add additional protection in the event of an explosion.

5.5 Summary

With the end of combat in World War II, the Ordnance Corps faced the task of storing large amounts of ammunition returned from overseas theaters. With limited time to prepare, construction efforts focused on short-term storage of munitions in open areas until additional space was made available in earth-covered magazines. Compared to the periods of intense construction activity that took place during the war, few new facilities were constructed at either depots or installations between 1946 and 1950.

Plate 5.1 Typical open storage area (Courtesy U.S. Army, 2007)


Plate 5.2 Typical open storage area with lightning protection (Courtesy U.S. Army, 2007)

Plate 5.3 Typical open storage area (Courtesy U.S. Army, 2007)

Plate 5.4 Typical fuze and detonator magazine (Courtesy U.S. Army, 2007)

Plate 5.5 Typical earth-barricaded ready magazine, left (Courtesy U.S. Army, 2007)

6.0 ARMY AMMUNITION AND EXPLOSIVES STORAGE DURING THE KOREAN CONFLICT: 1950-1953

6.1 Introduction

American involvement in hostilities on the Korean peninsula began on 25 June 1950, and prompted a substantial mobilization effort that included accelerated defense production and the need for increased Army ammunition storage capacity. As a result, the Ordnance Corps experienced organizational and personnel problems due to the increased workload. Advance planning conducted during the peacetime period before the Korean Conflict enabled the Ordnance Corps to meet the challenges. The planning strategy focused on maintaining the ability to quickly expand production and supply under an emergency situation (NARA RG 544 Snodgrass 1951:ii, 1-2).

Although production of new ammunition increased, the Ordnance Corps continued its surveillance and renovation programs. The vast amounts of functional munitions already in storage were the first priority for shipment to the Korean peninsula. Inspections increased and viable ammunition was forwarded to combat zones. Renovation activities increased as the demand for ammunition grew. To clear storage space for newly-manufactured munitions, the destruction of unusable ammunition also escalated.

6.2 Ordnance Corps Operations

As of 1 January 1950, major Ordnance installations within the Zone of Interior stored 7,346,000 tons of ammunition valued at $7,346,000,000. This amount included 6,000,000 tons of serviceable ammunition and 1,243,000 tons of unserviceable ammunition that could be economically repaired. The remaining 103,000 tons of ammunition were unserviceable and uneconomically repairable; most of this stock had been returned from overseas at the end of World War II (NARA RG 156 Ammunition Task Force 1953b:162-1, Tab E). Funds had not been allocated during fiscal years 1947 to 1950 for the repair of unserviceable ammunition. Ammunition stocks were unbalanced with severe shortages or total lack of some types (NARA RG 156 Ammunition Task Force 1953a).

Prior to the Korean Conflict, the Field Service Ammunition Division of Raritan Arsenal in Metuchen, New Jersey, handled peacetime supply of ammunition for training purposes and operational supervision of ammunition maintenance and preservation. When fighting commenced in Korea, the Ammunition Division at Raritan controlled all overseas ammunition requisitions. Due to minimal staff, the division shifted personnel between installations to accommodate the increased activity in ammunition supply control. Within three months, Ordnance depots shipped approximately 493,200 tons of ammunition overseas to support the Far East Command (FECOM). As the fighting intensified, American troops met superior armor provided to North Korea by the Soviet Union. To counter this threat, FECOM requested the shipment of the newly-developed 3.5” HEAT (High Explosive Anti-Tank) rocket. The complete stock of this item at the time comprised only 1,409 rockets, all of which were stored at Letterkenny Ordnance Depot; however, 30,858 new HEAT rockets were assembled at Picatinny Arsenal between 3 July and 25 July 1950 (NARA RG 156 Snodgrass 1951:43-45; NARA RG 156 Ordnance Corps Survey 1952a:3-4). There is no record clarifying if the newly-assembled rockets were stored at Picatinny, or immediately shipped overseas.

The amount of ammunition expended between 1951 and 1953 is summarized in Table 6.1 (NARA RG 156 Hinrichs 1953).

Table 6.1. Tonnages of Ammunition Expended in Korea

Type of Ammunition	Tons Expended FY 1951	Tons Expended FY 1952	Tons Expended First Half of FY 1953	Total Tons Expended in Korea
Artillery	397,060	622,608	281,560	1,301,228
Mortar	62,083	38,007	45,610	190,700
Rocket	77,031	7,767	4,387	19,185
TOTAL	536,174	713,382	331,557	1,511,113

In addition to the supply missions for artillery, mortar, and rockets, the supply of atomic weapons raised new issues throughout the Korean Conflict. In early 1953, Pueblo Ordnance Depot in Colorado became operational as the initial Ordnance Special Weapons Depot to help fulfill the Ordnance Corps responsibility "for receipt, storage, and issue of all special design items of atomic weapons in the Army supply system" (NARA RG 156 Snodgrass 1953:21). This additional mission required the construction of 120 depot-level magazines. The magazines were standard, 25 by 80 foot igloos (U.S. Army Real Property Inventory 2007).

The Ordnance Corps maintained two categories of storage and supply systems: general supplies and ammunition. These two functions were organized separately and followed different regulatory practices. In 1952, 44 Ordnance field installations located within the Zone of Interior had an Ordnance supply assignment. As outlined in Plate 6.1, installations were assigned one or more of the following missions for general supplies and/or ammunition (NARA RG 156 Ordnance Corps Survey 1952a:1-4, Tab A):

(1) a distribution mission for storage and supply within a specific geographic area (assigned to depots or to depots titled "arsenals");

(2) a key mission for specific items of supply for overseas requisitions (assigned to depots or to manufacturing arsenals); and

(3) a reserve mission for bulk storage (assigned to depots, to depots titled "arsenals," or to manufacturing arsenals).

Within the continental United States, eight distribution areas existed for ammunition and seven for general supplies; one depot within each geographical area was assigned the distribution mission for the area. Ordnance depots regularly accounted for items stored and reported stock status to a designated National Stock Control Point, which consolidated data for supply control (NARA RG 156 Ordnance Corps Survey 1952a:1-4, Tab A).

Ordnance establishments closely monitored ammunition stocks. As a result of the outbreak of hostilities in Korea, ammunition and toxic materials frequently were re-warehoused and moved within the depot system (NARA RG 156 Field Service Division 1952). The quantity of ammunition in outside storage substantially decreased. By 1 June 1951, ammunition in outside storage dropped by 216,126 tons, most of which consisted of aircraft bombs (NARA RG 156 Snodgrass 1951:49-50). Ordnance installations submitted monthly Ammunition Storage Occupancy Reports and long-term storage reports to Raritan Arsenal. The figures in Table 6.2 were used in July 1950 to compute net usable storage space for the reports (NARA RG 156 Office of the Chief of Ordnance 1950b).

Table 6.2. Net Usable Area of Ammunition Magazines

Type of Magazine	Square Footage per Magazine
40-foot igloo, arch type	1,003
60-foot igloo, arch type	1,528
80-foot igloo, arch type	2,147
Standard magazine	10,335
44-foot 7-inch igloo, dome type	1,521
52-foot igloo, dome type	2,008
High-explosives magazine	960
Smokeless powder magazine	2,871
Primer and fuze magazine	2,840
8-foot 4-inch powder magazine	40

Table 6.3 shows net usable storage space for ammunition and toxic materials at Ordnance Corps installations as of 30 June 1951 (NARA RG 156 Ordnance Corps Survey 1952c:11). Warehouse space for general supply storage approached maximum capacity. As a result, some installations utilized ammunition storage space for general supplies. For example, low-ceiling magazines at Rock Island Arsenal, Illinois, and ammunition igloos at Benicia Arsenal, California, stored general supply items (NARA RG 156 Ordnance Corps Survey 1952c:12-13).

Table 6.3. Net Usable Storage Space for Ammunition and Toxics at All Ordnance Corps Installations, 30 June 1951

Type of Space	Net Usable Gross Space (thousands of square feet)	Occupied (thousands of square feet)	Actual Vacant (thousands of square feet)	Percent Occupied
Magazine	31,461	21,347	10,083	67.9
Open	25,394	12,082	13,312	47.6

Ammunition and explosives storage facilities located at Army installations during the Korean Conflict accommodated several types of materials: ammunition (including chemical ammunition/munitions), explosives, guided missiles, inert ammunition, JATOs (Jet Assisted Take-Off rockets), military pyrotechnics and pyrotechnic material, rockets, and solid propellants. The following terms were defined in the *Ordnance Safety Manual* (ORDM 7-224) published by the Department of the Army on 4 September 1951 to set forth Ordnance Corps safety regulations:

> *Ammunition*. "Types of munitions normally containing an explosive element and designed to inflict damage upon structures, personnel, materiel or military objectives. Ammunition includes shells, grenades, bombs, pyrotechnics and mines together with projectiles such as bullets, shot and their necessary primers, propellants, fuzes and detonators."
>
> *Chemical ammunition*. "Ammunition, the filler of which has the basic function of producing a toxic or irritant effect on the body, a screening or signaling smoke, or an incendiary action."
>
> *Chemical munitions*. "The term 'chemical munitions' is used to designate a variety of forms of artillery shell, mortar shell, spray tanks, airplane bombs, grenades, candles, rockets, and containers of chemical agents which are not high explosives or shrapnel. Chemical munitions are filled with war gases, smokes, or incendiaries."
>
> *Explosives*. "The term explosive, or explosives, includes any chemical compound or mechanical mixture which, when subjected to heat, impact, friction, detonation or other

suitable initiation, undergoes a very rapid chemical change with the evolution of large volumes of highly heated gases which exert pressures in the surrounding medium."

Inert ammunition. "Containing no explosives, active chemicals or pyrotechnics but not necessarily noncombustible."

JATO. "An auxiliary rocket device for applying thrust to some structure or apparatus."

Military pyrotechnics. "Ammunition manufactured specifically for use as signals, illuminants and like items."

Pyrotechnic material. "The explosive or chemical ingredients, including powdered metals, used in the manufacture of military pyrotechnics."

Rocket. "A complete missile which derives its thrust from ejection of hot gases generated from solid propellants carried in the missile."

Solid propellants. "Those substances whose rate of combustion is such as to permit their use for propelling projectiles. The greater portion of this material was originally termed 'smokeless powder.' This now includes the solid propellants used in JATOs, etc." (NARA RG 156 Ordnance Corps 1951:2-1 through 2-12).

A g*uided missile* was defined as "an unmanned vehicle moving above the earth's surface whose trajectory or flight path is capable of being altered by a mechanism within the vehicle" (NARA RG 156 Ordnance Corps 1954c:3,605). In April 1953, Ordnance Corps guided-missile policy designated the "complete rounds (missile as fired) or all separately packaged components required to assemble complete rounds" as ammunition items that would be stored as such. "Replacement parts for designated nonexplosive components of the missile" were considered normal general supply items (NARA RG 156 Office of the Chief of Ordnance 1953a).

During the Korean Conflict, ammunition and explosives were stored in various types of magazines at Army establishments. Existing magazine types were noted in the 1951 *Ordnance Safety Manual* (ORDM 7-224) (NARA RG 156 Ordnance Corps 1951:2-7 – 2-8):

(1) Igloo (barrel or arch) type (Plate 6.2)
(2) Corbetta (beehive or dome) type (Plate 6.3)
(3) Aboveground type (Plate 6.4)
(4) Hillside type (Plate 6.5)
(5) Subsurface type (all portions underground) (Plate 6.6)

The Ordnance Corps recommended the use of earth-covered, reinforced concrete igloos or Corbetta magazines for all types of ammunition and explosives (NARA RG 156 Ordnance Corps 1951:18-3). Earth-covered igloos offered many advantages over aboveground magazines. Igloos rarely experienced structural damage from nearby explosions, and the earth cover provided protection from missiles and blasts resulting from nearby explosions. The possibility of propagation of an explosion from one igloo to another was practically nonexistent; therefore, the construction of igloos required less land area, as they could be located closer together than aboveground magazines. The insulation furnished by concrete and earth materials generally maintained uniform temperatures within an igloo, resulting in less deterioration of ammunition and explosives. Igloos had low maintenance costs, provided greater security, and offered more flexibility in storage than aboveground magazines. Furthermore, igloos could not easily be seen from the air and afforded maximum protection from enemy bombing unless directly hit (NARA RG 156 Reed 1953b:1-2).

Aboveground magazines included those storage facilities originally categorized as standard ammunition magazines, black powder magazines, smokeless powder magazines, and primer and fuze magazines, all of which may or may not have been barricaded. A fifth type of aboveground magazine was the Richmond type, in which two sides and the rear were barricaded (Plate 6.7) (NARA RG 156 Ordnance Corps 1951:2-8). Standard ammunition magazines, which were designed for storing fixed or separate loading shell, typically rested on concrete foundation walls and piers and had steel frames, hollow-tile walls, and concrete floors. Measuring 51 feet 7 inches by 218 feet 8 inches, standard ammunition magazines generally were spaced 300 feet apart. Storage capacity of these facilities varied according to the specific materials stored (NARA RG 156 Ordnance Corps 1951:18-1 – 18-2).

Black powder and smokeless powder magazines were designed to store up to 250,000 pounds of high-explosive, bulk materials, although they usually contained a maximum of 100,000 pounds due to aisle space and limitations on stack heights required for inspection and shipping. Powder magazines typically rested on concrete foundation walls and piers; they had steel frames and hollow-tile walls filled with sand (Plate 6.8). The concrete floors usually were coated with spark-proof coatings. Generally, these magazines measured 27 feet 6 inches by 43 feet 4 inches and were spaced 800 feet apart. Primer and fuze magazines were the same size as powder magazines and were constructed with similar materials; however, primer and fuze magazines typically were spaced 300 to 400 feet apart (NARA RG 156 Ordnance Corps 1951:18-2 – 18-3). Hillside and subsurface magazines were utilized when underground storage was necessary. The Chief of Ordnance approved details for the proposed magazine, magazine area, and type of ground involved (NARA RG 156 Ordnance Corps 1951:17-50).

Storage facilities for ammunition and explosives were located in restricted magazine areas located separately from other facilities within the Army installation (NARA RG 156 Ordnance Corps 1951:2-8). Magazine areas also contained outdoor storage sites for ammunition stocks. These storage sites were either earth-revetted (on four sides, excluding entrances) or non-revetted (with or without roof covering). The earth-revetted sites sometimes were located between igloos (NARA RG 156 Ordnance Corps 1951:2-10 – 2-11).

In addition to facilities utilized for permanent storage of ammunition and explosives, Army installations also had temporary storage facilities for handling these materials during the production and shipping processes. There were several methods of temporary storage. Service magazines were auxiliary buildings used to store explosives in minimum quantities during the production process (NARA RG 156 Ordnance Corps 1951:2-14). Temporary storage yards comprised a group of railroad tracks for storing railroad cars containing ammunition and explosives for short periods ranging from 24 hours to 2 weeks (NARA RG 156 Ordnance Corps 1951:2-15). Groups of railroad tracks called holding yards stored these materials for indefinite periods (NARA RG 156 Ordnance Corps 1951:2-6). Loading docks were permanent facilities constructed at ground level or as elevated structures in magazine areas (Plate 6.9). Loading docks were "designed and installed for transferring explosives, ammunition and component parts thereof between automotive vehicles and railway cars" (NARA RG 156 Ordnance Corps 1951:2-7). Ammunition usually remained on the loading dock only for the period of time it took to load or unload a railcar, often less than 24 hours, although it could remain there for longer periods awaiting shipment or if other storage facilities were not available. An increased reliance on truck transport throughout the Cold War era, and the subsequent decline in rail traffic prompted many installations to use loading docks constructed for explosives transfer for other purposes.

Throughout the Korean Conflict, construction of ammunition and explosives storage facilities was initiated and/or completed at several Ordnance Corps installations. According to an

Ordnance Corps Construction Progress Report issued on 1 May 1952, construction of numerous ammunition storage magazines was completed at White Sands Proving Ground on 20 March 1952 under the FY 1951 program. The progress report also noted several projects approved under the FY 1952 construction program. Construction of 100 magazines at Blue Grass Ordnance Depot was 15 percent complete and was expected to be finished by 15 March 1953. Anniston, Tooele, and Letterkenny each were authorized for 100 new magazines. Work was scheduled to begin in the summer of 1952 at all three installations. The estimated cost for each group of 100 magazines at Blue Grass, Anniston, Tooele, and Letterkenny was $3,350,000 (NARA RG 156 Ordnance Corps 1952a).

Other ammunition and explosives construction projects in the FY 1952 program included facilities at Wingate, Sierra, and Pueblo Ordnance Depots. The final design for the construction of 80 igloo magazines at Wingate costing $2,680,000 was fixed for 21 July 1952; initial construction work was set for 22 September 1952, with a completion date established for the following year. Although the design for 120 magazines at Pueblo for $4,020,000 was completed by 1 May 1952, dates for beginning construction were not confirmed. Earth covering of 135 igloos at Sierra was implemented by Post Engineering at a cost of $10,000 (NARA RG 156 Ordnance Corps 1952a).

An Ordnance Corps Construction Progress Report prepared on 1 March 1953 indicated construction progress as of 31 January 1953. At that time, the 100 magazines under construction at Blue Grass were 88 percent complete, and the 100 igloo magazines underway at Anniston were 42 percent complete. The 100 igloos at Tooele were 9 percent complete; commencement of construction had been delayed until October 1952, resulting in a new estimated completion date of January 1954. Construction of the 100 magazines at Letterkenny was deferred and withdrawn from the FY 1952 construction program on 13 January 1953. The 100 magazines slated for construction at Pueblo were 52 percent complete; construction had begun in May 1952, with a completion date set for September 1953. The earth-covering project for 135 igloos at Sierra was completed in September 1952 (NARA RG 156 Ordnance Corps 1953).

The FY 1953 program included design directives for ammunition and explosives storage facilities at three installations. In August 1952, directives were issued for a missile propellant storage building at White Sands Proving Ground for $375,000, an explosives storage magazine for the training area at Aberdeen Proving Ground for $7,000, and magazines related to ammunition testing at Picatinny Arsenal for $30,000 (NARA RG 156 Ordnance Corps 1953). The propellant storage building at White Sands did not follow any standardized plan rather it was designed specifically for the application at the missile test range, and was one of a complex of buildings to support research into liquid-fueled guided missiles. The variety of missiles tested, and the use of different propellant mixes, mandated a design that differed from propellant storage buildings constructed for the maintenance of a single missile type which featured large, permanently-mounted storage tanks and extensive piping systems. Archival evidence suggests that at White Sands, propellants were stored in portable containers that were transported to the launch site where the rocket was fueled.

The inventory of guided missiles increased throughout the Korean Conflict, prompting the need for storage facilities for these weapons. Examples included guided missile magazines (Plate 6.10) and liquid propellant storage buildings (Plate 6.11). The components of liquid propellant stored included hydrazine, acid, hydrogen peroxide, and oxidants. Due to the explosive nature of the components, buildings were equipped with lightning protection such as grounding wires, and lightning rods (Plate 6.12). They featured cranes for lifting, and safety features such as emergency showers, and explosion proof interior lights and circuit breakers. The buildings were constructed using various materials such as panelized metal and concrete block. The foundations typically were constructed of poured concrete.

6.3 Introduction of New Safety Standards

Throughout the Korean Conflict, various safety publications aided Army personnel in matters relating to ammunition and explosives storage. The primary safety publication for ordnance activities was the *Ordnance Safety Manual* (ORDM 7-224). Prior to the outbreak of the Korean Conflict, Army personnel followed the mandatory requirements outlined in the 1945 safety manual. The Government Printing Office in Washington, D.C., published 45,000 copies of a rewritten version on 4 September 1951. The manual was bound in a loose-leaf binder for the insertion of replacement pages incorporating subsequent revisions. This manual contained significant revisions from the earlier document with added sections on handling of guided missiles, chemical and biological weapons, and expanded sections on surveillance and demilitarization (NARA RG 156 Intelligence, Safety and Security Office 1952:2-3).

The *Ordnance Safety Manual* provided guidance not only for Ordnance Corps personnel but also for other departments and agencies. For example, the Chemical Corps followed the manual's requirements for storing and processing "explosive, incendiary, poisonous, vesicant or irritant products" (NARA RG 156 Solomon 1949). Raritan Arsenal was responsible for the initial distribution of 15,000 copies of the 1951 safety manual throughout the Ordnance Corps; the Departments of the Army, Navy, and Air Force; other government agencies; and private industry. In February 1952, Army personnel expressed concern that adherence to the mandatory requirements of the safety manual impeded production at GOGO and GOCO installations. As a result, the Chief of Ordnance implemented contracts with these establishments as part of a waiver and exemption system (NARA RG 156 Holmes 1952; NARA RG 156 Reed 1953a). In addition to the safety manual, the Ordnance Corps issued safety regulations until 1945; after that time, they published the 100 series of Safety Bulletins (NARA RG 156 Intelligence, Safety and Security Office 1952:2-3).

During the Korean Conflict, the Department of the Army Assistant Chief of Staff maintained responsibility for overall Army safety. An appointed Director of Safety for the Army oversaw safety programs at all Army installations, including Ordnance Corps establishments. In addition, each of the six Army Commanders established a safety division at his headquarters. The Office of the Chief of Ordnance employed its own safety director; however, each technical service within the Office of the Chief of Ordnance also had a safety director. In 1952, five different safety offices operated within the Ordnance Corps: the Intelligence, Safety and Security Office; the Ordnance Field Safety Office; the Ordnance Ammunition Center; the Area Ammunition Inspectors; and the Ordnance District Safety Inspectors. The Armed Services Explosives Safety Board, appointed by the Secretary of the Army and the Secretary of the Navy, held separate responsibility for worldwide safety, primarily pertaining to explosives (NARA RG 156 Guest 1951:1-2).

Each of the safety offices within the Ordnance Corps performed specific tasks. As the primary safety office, Intelligence, Safety and Security established safety policies and standards. The Army created the Ordnance Field Safety Office on 6 February 1951 to conduct field inspections to ensure compliance with these safety policies and standards. Indiana Arsenal was selected as the location for the Ordnance Field Safety Office because it afforded convenient transportation for traveling safety inspectors; operations began on 6 March 1951. Area Ammunition Inspectors had responsibility for ammunition surveillance at Field Service installations (NARA RG 156 Ordnance Field Safety Office 1955:3-5; NARA RG 156 Guest 1951:4).

The Ordnance Ammunition Center located at Joliet, Illinois, performed safety inspections at installations that reported to the Chief of Industrial Service; most of these installations manufactured ammunition and explosives. Fourteen Ordnance Districts oversaw contractor-owned and contractor-operated plants; each district supervised safety inspections of these plants (NARA RG 156 Guest 1951:4-5). All Ordnance establishments followed a uniform procedure for reporting explosions and serious fires. An installation prepared a mandatory report upon the event of "an explosion, explosion followed by fire, or fire involving ammunition or other explosives" (NARA RG 156 Office of the Chief of Ordnance 1951b).

The concern for safety affected construction policies during the Korean Conflict. On 9 July 1951, the Office of the Chief of Ordnance ordered that the Armed Services Explosives Safety Board review safety features "of general plans for construction of new facilities or major modification of existing facilities for handling, transporting or storing military explosives or ammunition" (NARA RG 156 Office of the Chief of Ordnance 1951c). This order pertained to new construction and major modifications costing $10,000 or more. Heads of technical services were required to submit schematic sketches to the Chief of Ordnance at least one month prior to the completion of final plans or the commencement of construction work. These sketches included quantity-distance data, ammunition and explosives limits for the subject facility, type of ventilation and lightning protection, and explanation of any departure from standard safety regulations dictated by local conditions.

At the start of the Korean Conflict, serious accidents frequently occurred at Ordnance establishments. In response, the Office of the Chief of Ordnance ordered that safety surveys be conducted at all Ordnance establishments (NARA RG 156 Ford 1950). Due to the analysis of accidents and incidents, the observation of unsafe practices at Ordnance establishments during surveys, and the introduction of new explosives and weapons, the Ordnance Field Safety Office prepared a training curriculum for safety personnel. Known as the School for Ordnance Technical Safety, instruction began in April 1952 (NARA RG 156 Ordnance Field Safety Office 1955:14-16; NARA RG 156 School for Ordnance Technical Safety 1952).

The 80-hour curriculum had two phases. The University of Louisville conducted a two-week program of academic instruction, which was followed by two weeks of practical training at the Ordnance Field Safety Office. The practical instruction program focused on requirements outlined in the *Ordnance Safety Manual* and was presented in lecture format by Ordnance Corps personnel and guest speakers (NARA RG 156 Ordnance Field Safety Office 1955:14-16; NARA RG 156 School for Ordnance Technical Safety 1952). One part of the curriculum covered "safety standards in connection with ammunition depot operations, including receipt, storage, shipping, renovation and demilitarization of all types of ammunition and explosives." Classes included "Explosive Storage and Quantity Distance," "Lightning Protection," "Fire Protection," and "Industrial Safety" (NARA RG 156 School for Ordnance Technical Safety 1952).

In 1952, 182 students representing 79 installations and commands successfully completed the initial session of the School for Ordnance Technical Safety (NARA RG 156 School for Ordnance Technical Safety 1952). The program continued in full force until the end of the Korean Conflict, at which time the Army's production and work forces were reduced and the safety training requirements of the Ordnance Corps were reevaluated. The original curriculum ceased, and the School for Ordnance Technical Safety began offering a 40-hour Safety Directors Seminar in September 1954. Approximately 190 safety personnel received training during the initial seminar; the Safety Directors Seminar continued until June 1955. At that time, it was determined that safety training requirements could be met solely by the Ordnance Field Safety Office, with emphasis on long-term storage and maintenance. The Army's use of new and improved explosives and weapons necessitated continual safety training (NARA RG 156 School for Ordnance Technical Safety 1954; NARA RG 156 Ordnance Field Safety Office 1955:24-27).

6.3.1 Quantity Distance Standards

The safety of ammunition and explosives storage first became a priority following the disaster at the Naval Ammunition Depot at Lake Denmark, New Jersey, in 1926. Congressional inquiries into the cause of the explosion led to the creation of joint Army-Navy advisory group on ammunition storage. During the early Cold War era, the Army-Navy Explosives Safety Board (ANESB) fulfilled this advisory role until the Armed Services Explosives Safety Board (ASESB) was established in 1949 (NARA RG 156 Department of the Army 1949).

Ordnance Corps safety publications in the mid-1940s, such as the *Ordnance Safety Manual* issued on 3 May 1945 and Ordnance Corps Safety Bulletin Number 159 dated 6 September 1946, reflected safety standards based on the American Table of Distances (ATD) (NARA RG 156 Outland 1950:1). This table originally was developed in 1914 by a committee formed by the Association of Manufacturers of Powder and High Explosives for the purpose of determining safe distances between ammunition storage facilities and inhabited buildings, public railways, and public highways (Murphey et al. 2000:15). The table presented "inhabited building distances" that protected buildings and structures against substantial structural damage in the event of an explosion. The distances were calculated by correlating the quantity of explosives involved in an explosion with the recommended distance required for the protection of surrounding buildings and structures. Similar correlations were furnished for public railways and public highways (NARA RG 156 Ordnance Corps 1951:17-2). Ordnance Corps publications referred to these safety recommendations as "quantity-distance standards."

Following its inception, the ATD underwent minor revisions during the next three decades (NARA RG 156 Orsene 1951). Between 1945 and 1946, the ANESB conducted explosives safety tests that resulted in recommended modifications to the existing quantity-distance tables. These recommendations included increased spacing between magazines, a suggestion that required new construction, abandonment of some facilities, or reducing the quantities stored in each building (NARA RG 156 Connally 1947:6). In 1947, the ANESB presented these recommendations to the Army and the Navy (the two military services in existence at that time). After much discussion and consultation, ASESB (successor to ANESB) officially proposed new quantity-distance standards to the Secretaries of the Army, Navy, and newly-created Air Force on 1 April 1950. The Department of the Navy and the Department of the Air Force accepted the proposed safety standards; however, the Department of the Army objected to the recommendations (NARA RG 156 Orsene 1951).

The Army affirmed that the new standards did not provide increased safety. Furthermore, the Army believed that the new standards would be impractical and almost impossible to implement in conjunction with the Army's mission to meet national defense needs. The Army adhered to its position that the present standards, which conformed to the ATD, were adequate and under continual surveillance by the Institute of Makers of Explosives. A conference was held at the Pentagon on 8 May 1951 to address the controversy between the ASESB and the Army (NARA RG 156 Orsene 1951).

Following further review by a committee of consultants appointed by the Under Secretary of the Army, the quantity-distance standards proposed by the ASESB were not adopted. The committee determined that the proposed tables needed revision and clarification, claiming that "the experience derived from 23 years of operation under the existing Ordnance safety distance tables should be the primary guide in this revision" (NARA RG 156 Outland 1951). The Under Secretary of the Army advised the ASESB to re-examine the proposed standards. As a result, the Office of the Chief of Ordnance issued Ordnance Corps Technical Instruction 700-4-51 on 24 July 1951 ordering that the then-current standards would remain in effect.

As defined in the *Ordnance Safety Manual* published on 4 September 1951, the term "quantity-distance" referred to "the distance from a certain location such as an inhabited building, public railway, magazine or operating building, required to protect that location against substantial structural damage from the ignition or explosion of a definite quantity of a specific class of explosives as listed in Section 17 of this manual" (NARA RG 156 Ordnance Corps 1951:2-12). As outlined in Table 6.4, the manual identified twelve classes of ammunition and explosives stored at Ordnance establishments (NARA RG 156 Ordnance Corps 1951:17-35 – 17-50; Section 14). These classes were organized according to degree of damage resulting from possible ignition or explosion; however, the various items in a class could not necessarily be stored together safely. Storage compatibility of ammunition and explosives was outlined in a separate categorization (NARA RG 156 Ordnance Corps 1951:17-1).

Table 6.4. Classes of Ammunition and Explosives Stored at Ordnance Establishments

Class of Ammunition/Explosives	Typical Examples (not inclusive)
Class 1 Class 1 ammunition presented a minimal safety risk; adverse storage conditions could cause a fire hazard.	Small-arms ammunition, 20 mm caliber or less (excluding high explosive and incendiary rounds); firing devices; fuse lighters; safety fuses; ignition cartridges for trench mortar ammunition; and certain chemicals (such as aluminum powder, chlorates, magnesium powder, inorganic nitrates, and perchlorates) when packed and stored in original shipping containers.
Class 2 Class 2 solid propellants were an extreme fire hazard and could detonate; military pyrotechnics were sensitive to heat, flame, static electricity, and friction and also could be hazardous when moisture was present.	Solid propellants (smokeless powder); various pyrotechnic materials and military pyrotechnics, including flares, illuminants, signals, and incendiary ammunition (such as projectiles, bombs, and grenades) that are not high explosive; and illuminating projectiles, white phosphorous (WP)-loaded rocket heads, and certain types of chemical ammunition when not assembled with explosive components.
Class 2A The detonation risk of Class 2A double base propellant powders was dependent upon the amount of nitroglycerin used in the powder.	Double base propellant powders containing 20 percent or less nitroglycerin and various cannon, rifle, pistol, and shotgun powders.
Class 3 Class 3 fuzes without boosters and artillery primers typically would explode progressively but not more than one or two boxes at a time.	Fuzes without boosters; electric igniters for JATOs; practice grenades and mines with spotting charges; artillery and cannon primers; and primer detonators.

Class of Ammunition/Explosives	Typical Examples (not inclusive)
Class 4 Fires were not likely for Class 4 ammunition; however, if a fire occurred, ammunition would progressively detonate or explode a few boxes at a time.	Blank, fixed, and semi-fixed ammunition; high explosive ammunition, 20 mm caliber or less, including incendiary rounds; chemical-loaded bombs and certain types of chemical ammunition with explosive bursters; chemical rockets; rocket motors without heads; and illuminating and light-mortar shell. (All items must be packed in accordance with approved Ordnance drawings and specifications.)
Class 5 If a fire involving Class 5 ammunition was intense enough to ignite the explosives, detonation would occur immediately.	Separate loading shell containing Explosive D (a bursting charge explosive) and any other shell loaded with Explosive D not assembled to or packed with cartridge cases.
Class 6 A fire involving Class 6 boosters and fuzes could result in the progressive explosion of ammunition stacks.	Boosters, fuzes assembled with boosters, and certain chemically actuated fuzes.
Class 7 A fire involving Class 7 ammunition could result in high-order detonation resulting in severe structural damage.	Separate loading shell, fuzed or unfuzed, containing most high explosives.
Class 8 A fire involving Class 8 ammunition would result in en masse detonation.	Blasting caps, detonators, and percussion elements. (All items must be packed in accordance with approved Ordnance drawings and specifications.)
Class 9 Class 9 black powder was sensitive to friction, heat, and impact and was extremely dangerous to handle; initiating explosives would detonate without burning in the event of fire; bursting charge explosives presented a toxic hazard and could explode in the event of fire; solid propellants were an extreme fire hazard and could detonate.	Black powder in charges or containers; dynamite; various initiating explosives (such as lead azide, lead styphnate, and mercury fulminate); various bursting charge explosives, (such as Explosive D, pentolite, picric acid, RDX compositions, TNT, and tetryl); and various solid propellants, including those for JATOs and rockets.
Class 10 A fire involving Class 10 ammunition could result in high-order detonation; all ammunition stored in one magazine could simultaneously detonate en masse.	High-explosive, heavy-mortar shell; ammunition loaded with certain bursting charge explosives; bursters; JATOs; high-explosive rockets and rocket heads; and various bombs, grenades, and mines.
Class 11 Class 11 chemical ammunition was not considered an explosive hazard.	Certain types of chemical ammunition without explosive components and various chemically loaded rocket heads without explosive components.
Class 12 Class 12 chemicals were relatively insensitive and needed very strong initiation for detonation.	Certain chemicals (such as ammonium nitrate, DNT, nitrocellulose, and primacord).

For Classes 3, 4, 5, 6, and 7, inhabited building distances were represented by missile distance, which referred to "the limited range of a considerable number of missiles from the quantity and types of ammunition involved in the quantity-distance tables" (NARA RG 156 Ordnance Corps 1951:2-9). For Classes 8, 9, and 10, inhabited building distances were computed according to blast damage (NARA RG 156 Ordnance Corps 1951:17-6).

In addition to the classes listed in Table 6.4, the Ordnance Corps recognized the safety risks of substances related to long-range rockets and guided missiles. Research was underway in 1951 involving numerous liquids, gases, and solids to propel rockets and missiles. These fuels and oxidizers presented fire, explosion, and toxic hazards and were categorized into three classes to ensure storage safety: Classes 150, 950, and 1050. Materials in Class 150 often were used in industry and included nitric acid, gasoline, octane, kerosene, aniline, and liquid oxygen. Class 950 included materials such as hydrogen peroxide, hydrazine, diborane, liquid hydrogen, and nitromethane. Class 1050 comprised liquid nitrogen tetroxide, liquid fluorine, and metallic lithium (NARA RG 156 Ordnance Corps 1951:15-1 – 15-2; 15-14 – 15-16).

No Army publication, however, dictated what type of magazine should be used for a particular weapon or explosive. The governing factor was the volatility of the explosive, the quantity, and the distance to nearby magazines. Although the 1951 safety manual recommended the use of igloo and Corbetta magazines for storing all classes of ammunition and explosives, aboveground magazines could be utilized under certain circumstances. Standard ammunition magazines were permitted for storage of materials in Classes 1 and 2. Powder magazines could be used for high explosives when more desirable storage space was not available. In general, Class 1 materials could be stored in any weatherproof magazine or warehouse (NARA RG 156 Ordnance Corps 1951:18-1 – 18-3).

In addition to permanent magazines designed for ammunition and explosives, the Chief of Ordnance allowed temporary outdoor storage of certain types of these materials when necessary. Outdoor storage sites were placed to avoid exposure to power lines and were not located near reservoirs, underground water mains, electric cables, or sewer lines. Platforms supported the ammunition and explosives materials, which often were protected with nonflammable or waterproof covers. Outdoor storage sites sometimes were located midway between igloos that were placed 400 feet apart; however, such storage sites were not permitted within 1,600 feet of aboveground magazines (NARA RG 156 Ordnance Corps 1951:18-10 – 18-13). Due to the expansion of the Army during the Korean Conflict and the resulting shortage in storage space, the Ordnance Corps advocated maximum utilization of available facilities. Ordnance establishments were instructed to move certain types of small arms ammunition from aboveground magazines to open storage to conserve closed storage space for other materials (NARA RG 156 Office of the Chief of Ordnance 1952).

The quantity-distance tables presented in the 1951 safety manual followed the ATD and presented the minimum distances safely permitted between an ammunition or explosives location and an inhabited building, public railway, and public highway (Plates 6.13a-c). These distances were based on the quantity, as designated in pounds, of ammunition or explosives contained in a specific location (NARA RG 156 Ordnance Corps 1951:17-1 – 17-4). The 1951 tables also included the terms "magazine distance" and "intraline distance." Magazine distance referred to the "distance permitted between any two storage magazines within a magazine area dependent on type and quantity of explosives and ammunition involved" (NARA RG 156 Ordnance Corps 1951:17-6). Magazine distance was intended to prevent the explosion of one magazine from causing an explosion in a second magazine. Intraline distance identified the minimum distance safely permitted between two buildings located within a single ammunition production line.

Intraline distance also applied to temporary storage of ammunition and explosives utilized during the production process. For this purpose, intraline distances were used to determine the safe location of service magazines in relation to operating buildings and other service magazines (NARA RG 156 Ordnance Corps 1951:17-5).

Barricades often were used to protect buildings from explosives hazards. A barricade was defined in the 1951 safety manual as "an intervening approved barrier, natural or artificial, of such type, size and construction as to limit in a prescribed manner, the effect of an explosion on nearby buildings or exposures" (NARA RG 156 Ordnance Corps 1951:2-2). Natural barricades were earth mounds that had naturally sloping sides. Sometimes earth mounds were faced on one or both sides with wood or concrete, creating single-revetted or double-revetted barricades (Plate 6.14). Artificial, reinforced-concrete barricades containing earth fill also were constructed (Plate 6.15). For the manufacture and storage of the most sensitive materials, an entire building was encased with a barricade. This type, also called a rampauno barricade was often employed for handling initiating explosives such as tetryl, lead azide, or nitroglycerin (Plate 6.16). Natural or single-revetted barricades possessed the most strength and provided more protection than other types. Due to the possibility of settling and deterioration of materials, barricades were inspected regularly. The use of properly built barricades allowed quantity-distance standards to be reduced by one-half for some materials, such as bulk explosives and items loaded with explosives that could mass detonate. The Navy used barricades frequently at the entrance of depot-level earth-covered magazines. The Army, while not barricading igloo storage, made extensive use of various barricade designs at Army ammunition plants (Plate 6.17). For certain quantities of some types of ammunition and explosives, igloo, Corbetta, and Richmond magazines were considered barricaded in all directions except for the door ends (NARA RG 156 Ordnance Corps 1951:17-23 – 17-33).

Limitations on the number of magazines permitted in a block of facilities further enhanced safety. As many as 200 standard igloo magazines could be safely built within one magazine area as long as appropriate spacing distances were followed. No more than 100 magazines of other types were allowed in a single magazine block. A maximum of 50,000,000 pounds of ammunition or explosives was permitted within one magazine block (NARA RG 156 Ordnance Corps 1951:17-8 – 17-9). Safety distances within magazine areas also were established for auxiliary structures (such as guard shelters, ammunition surveillance buildings, and change houses), loading docks, holding yards, temporary storage yards, dams, underground utilities installations, and gasoline handling and storage facilities (NARA RG 156 Ordnance Corps 1951:17-11 – 17-15, 17-51).

The Ordnance Corps revised the 1951 safety manual three times between September 1951 and May 1954. The first set of changes, published on 15 August 1952, included slightly refined quantity-distance standards (NARA RG 156 Ordnance Corps 1952b:Section 17). For example, in 1951 inhabited building distances were to be used between ammunition and explosives locations and lands beyond the Ordnance establishment; the 1952 revisions instructed that the distances stop at the establishment's boundary (NARA RG 156 Ordnance Corps 1952b:17-3). The second set of updates, issued on 15 April 1954, contained minimal modifications to the organization of ammunition and explosives classes (NARA RG 156 Ordnance Corps 1954a:Section 17). The third set of changes, set forth on 14 May 1954, again included modest revisions to quantity-distance regulations (NARA RG 156 Ordnance Corps 1954b:Section 17). Eventually, the Department of Defense (DoD) issued quantity-distance standards in DoD Directive 4145.17, entitled *Quantity-Distance for Manufacturing, Handling, and Storage of Mass-Detonating Explosives and Ammunition.* These standards reached a compromise between those currently followed by the Army and the ANESB recommendations of

1947. The DoD published this directive on 7 December 1956 (DoD Explosives Safety Board 2004:8).

6.3.2 Additional Safety Standards for Ammunition Storage

In addition to quantity-distance standards, the Ordnance Corps followed a multitude of other safety regulations regarding the storage of ammunition and explosives. Although the commanding officer of an Ordnance Corps installation held ultimate responsibility for safety, a safety director administered the establishment's safety program in accordance with Army directives (NARA RG 156 Ordnance Corps 1951:1-2, 2-13). The Chief of Ordnance could grant short-term waivers if adherence to safety regulations prohibited the accomplishment of essential activities of storage, production, or shipment of critical Ordnance materiel or if there were extenuating circumstances. The Chief of Ordnance also could exempt existing buildings from following newly issued safety regulations; however, new construction and modifications to existing buildings were required to adhere to current safety standards (NARA RG 156 Ordnance Corps 1951:1-2, 1-4).

The 1951 *Ordnance Safety Manual* listed 17 storage-compatibility groups for ammunition and explosives; this categorization was separate from the hazard classifications used for quantity-distance standards. Items in Group A comprised materials that only could be stored alone, such as chemical ammunition, dynamite, and photoflash powder. Group A also included certain types of bombs, cartridges, fuzes, grenades, projectiles, rockets, pyrotechnic materials, and shell. Materials in Groups B through Q could be stored safely with other items within each individual group (NARA RG 156 Ordnance Corps 1951:Section 19). An Ordnance installation sought to avoid storing its complete stock of a certain type of ammunition or explosives in one magazine (NARA RG 156 Ordnance Corps 1951:18-9).

Chemical agents were organized into four storage categories according to types of fillings. Group A contained blister gases, such as mustard gases and lewisite, that required the use of complete protective clothing and gas masks. Group B comprised chemical toxins and smoke, including phosgene and tear gases, that necessitated the use of gas masks. Group C consisted of spontaneously flammable chemical agents, such as white phosphorus. Group D included incendiary and readily flammable chemical agents, including incendiary oil and thermite. If possible, each type of chemical agent was to be stored separately; however, chemical agents categorized in the same storage group could be stored together if necessary, with the exception of gas-filled munitions (NARA RG 156 Ordnance Corps 1951:29-1 – 29-4). Signs were posted outside doors of magazines containing chemical munitions. The signs designated the type of chemical munitions (Group A, B, C, or D) stored in the facility and warned personnel if they needed to wear gas masks or protective clothing upon entering the magazine (NARA RG 156 Ordnance Corps 1951:29-7 – 29-8).

The 1951 safety manual advised that chemical munitions in Groups A, B, and C be stored in igloo or Corbetta magazines. Class A chemical munitions posed the greatest hazards (NARA RG 156 Ordnance Corps 1951:29-9). Safety recommendations for storage facilities accommodating Class A chemical munitions included treating concrete magazine floors with sodium silicate for nonabsorbency. An authorized individual familiar with Class A chemical munitions had to be present when a magazine containing such munitions was opened. If leaking ammunition was suspected, a detector kit was used to determine the presence of toxic vapors. The authorized individual determined whether personnel entering the magazine should wear complete protective equipment, which consisted of gas masks, two layers of protective clothing, and protective footwear and gloves or mittens (NARA RG 156 Ordnance Corps 1951:29-13 – 29-46).

In addition to chemical munitions, other types of ammunition and explosives also required specialized care in handling and storage for safety purposes. For example, the 1951 safety manual directed that bulk initiating explosives could be stored in shipping containers temporarily, but not permanently, as long as the barrels were placed in frost-proof igloos or Corbetta magazines and stacked on end, only one tier high. Glazed earthenware crocks with plastic-capped covers were recommended to hold bags of bulk initiating explosives for regular storage purposes. Smokeless powder presented a hazard when exposed to direct sunlight. Separate loading projectiles could not be stored without fuze-well plugs. Complete rounds of rockets (comprising heads plus motors) were to be stored nose down in dry, cool magazines (NARA RG 156 Ordnance Corps 1951:18-14 – 18-17). Guided-missile liquid propellants were stored in containers with a maximum capacity of 55 gallons, which permitted storage of approximately 750 pounds (NARA RG 156 Redstone Arsenal 1952:8).

Ordnance Corps drawings and specifications provided instruction for packing, stacking, and arranging containers of ammunition and explosives in magazines. Regulations included grouping and identifying containers, allowing sufficient ventilation, and maintaining adequate aisles. For example, stacks in Richmond magazines were required to terminate a minimum of one foot lower than the eaves of the magazine. Open or damaged containers containing ammunition or explosives were not permitted in magazines (NARA RG 156 Ordnance Corps 1951:14-19, 18-7; NARA RG 156 Ordnance Corps 1954b:17-33).

Due to problems encountered during World War II, the Ordnance Department recognized the need for developing better methods of ammunition packing, taking into account the conservation of time and materials. As a result, a packing laboratory containing specialized testing equipment was established at Picatinny Arsenal in Dover, New Jersey. The laboratory expanded substantially by 1954. New types of ammunition "all brought with them special problems in packing, of protecting delicate mechanisms, housing unusual shapes, or sealing containers against leakage from within or contamination from without" (NARA RG 156 Picatinny Arsenal 1954:4). Between 1946 and 1954, the Picatinny laboratory developed and refined packing methods and materials for liquid explosives, fuzes, black powder, and rockets. The laboratory also simplified drawing requirements for ammunition packing, developed a new steel-conserving design for wooden ammunition box hardware, and investigated and solved problems in palletization. Palletization was a storage and handling technique involving the use of pallets, which were designed to temporarily group together boxes or cartons into larger units for the purpose of reducing handling costs (NARA RG 156 Picatinny Arsenal 1954:1-6, 16-19, 23-24).

The use of battery-powered equipment, as opposed to gasoline-powered equipment, was preferred for handling stored ammunition and explosives, as long as the materials were packed in approved containers with no evidence of visible exterior contamination by explosive material (Plate 6.18). Containers of explosives generally could not be transported on lift-truck forks without skids or pallets. Hand trucks used for transporting explosives needed four wheels, low centers of gravity, and brakes designed to automatically halt the vehicle upon disengagement of the operator. Also, hand trucks were painted brightly for easy visibility (NARA RG 156 Ordnance Corps 1951:24-3 – 24-13). A description of an ammunition-handling truck approved by the Safety and Security Branch, Ordnance Department for Handling Ammunition, emphasized the following safety features that met Industrial Truck Association requirements for spark-enclosed equipment (NARA RG 156 Facilities Section 1950):

> All motors, controls, wiring, switches and other sparking devices are encased in substantially dust and vapor tight housings. Battery compartment will accommodate 450

ampere hour, 32 volt battery. Compartment is provided with lock and keys and vent holes are covered with heavy gauge wire mesh shielded with expanded metal plate to prevent accidental shorting. Battery plug and receptacle are mounted within locked battery compartment. Safety line switch to break circuit is mounted accessible to operator. Trail tires are static conductor type.

These handling trucks were equipped with forks that could accommodate not only boxed ammunition on pallets, but also bombs of various sizes (Plates 6.19 through 6.23). When battery-operated equipment was not available, gasoline-powered equipment could be used but not in igloo, Corbetta, or Richmond magazines (NARA RG 156 Ordnance Corps 1951:24-3 – 24-13).

Ordnance installations strove to "limit the exposure of a minimum number of personnel, for a minimum time, to a minimum amount of the hazardous material consistent with safe and efficient operations" (NARA RG 156 Ordnance Corps 1951:16-1). Magazine areas were considered "restricted areas" that were off limits to unauthorized personnel; fences typically surrounded such areas (NARA RG 156 Ordnance Corps 1951:2-12, 16-6). Personnel entering munitions storage and handling areas were carefully regulated (Plate 6.24). Placards were posted on or near magazine doors indicating the maximum amounts of material, numbers of shift workers, and how many workers temporarily in an ammunition storage area, referred to as transients, were allowed in the building or structure at one time (Plate 6.25). Magazine doors were kept locked unless authorized to be open for operations. When personnel worked inside a magazine with more than one door, at least two doors remained unlocked and open. During the production process, if explosives were needed in an operating plant for more than a four-hour work requirement, they were stored in service magazines (Plate 6.26) (NARA RG 156 Ordnance Corps 1951:16-2 – 16-3, 16-6).

The presence of ammunition and explosives necessitated that fire safety be a priority at Ordnance establishments. Installations sought to control hunting, smoking, and the use of matches, lighters, and heat-producing equipment near ammunition and explosives (Plate 6.27). Establishments also enforced vehicle parking regulations to minimize risk of fire and explosion hazards (NARA RG 156 Ordnance Corps 1951:16-3 – 16-7).

Lightning during an electrical storm posed a significant fire hazard due to the possible ignition of ammunition or explosives. Personnel vacated magazines that did not feature approved lightning protection systems and moved to approved shelters, empty igloos, or Corbetta magazines (NARA RG 156 Ordnance Corps 1951:16-11 – 16-12). The 1951 safety manual directed the installation of lightning protection on all igloo or Corbetta magazines constructed after the publication of the manual. Existing igloo magazines were exempt from the lightning protection requirement as long as possible lightning damage would not inhibit essential military activities, and metal components such as doors and ventilators were bonded electrically and grounded properly (Plate 6.28). Lightning protection was provided for *groups* of aboveground magazines and included tall poles topped with grounded lightning rods at regular intervals within the group (Plate 6.29). Approved lightning protection systems comprised three types: the integrally mounted system, the separately mounted mast-type shielding system, and the separately mounted shielding system using an overhead ground wire (Plate 6.30). Temporary storage facilities were exempt from the regulation (NARA RG 156 Ordnance Corps 1951:8-1 – 8-2).

The commanding officer of each Ordnance establishment appointed a fire marshal to administer a fire-prevention and fire-fighting program. Firebreaks with a minimum width of 50 feet were required around aboveground magazines but were not necessary for igloos. Water barrels, pails, and fire extinguishers aided in combating minor fires. A fire-fighting force comprising guards, watchmen, firemen, and military personnel was available at all times. Assistance agreements sometimes were implemented with non-military fire departments from contiguous municipalities; however, outside firefighters were not allowed to combat fires involving explosives unless they had received specialized training (NARA RG 156 Ordnance Corps 1951:12-19 – 12-26).

Fire symbols displayed on aboveground magazines guided firefighters by denoting the general burning or explosive characteristics of materials stored in the buildings; such symbols were not required for igloos. The fire symbols had distinctive shapes to represent four groups according to degree of explosion hazards. For chemical munitions, fire symbols included four-inch diagonal stripes that identified toxic hazards (NARA RG 156 Ordnance Corps 1951:12-19 – 12-26). Fires involving chemical munitions stored in igloo or Corbetta magazines were not fought as the amount of explosive was small, minimizing the risk of a catastrophic explosion, and accessing the magazine exposed fire-fighters and other installation personnel to the toxic agent. (NARA RG 156 Ordnance Corps 1951:29-23 – 29-51). Each Ordnance establishment prepared a local disaster plan to be followed in the event of a serious fire, explosion, flood, or similar significant incident with the intent “to reduce injury to personnel and damage to property, to maintain wholesome public relations, and to preserve all evidence pertinent to cause and effect” (NARA RG 156 Ordnance Corps 1951:4-1).

For safety purposes, magazines typically did not feature heat or permanent electrical lighting; however, approved portable floodlight units were permitted inside and outside magazines when necessary for operations (Plate 6.31). Temperatures in ammunition storage facilities were carefully monitored. At Radford Army Ammunition Plant, for example, weekly temperature readings were taken at numerous locations including barricaded magazines, 80 foot igloos, and 60 foot mound-type magazines then compared to a reading taken outside in the shade (Radford Army Ammunition Plant 1949). Temperatures above 100 degrees inside a magazine posed a safety hazard. In such cases, the exterior of the magazine had to be cooled by water, or doors and ventilators had to be opened during the night. Certain types of ammunition and explosives were affected adversely by moisture; dunnage placed between layers of boxes could help by promoting free circulation of air. Excess vegetation on igloo magazines, as well as large nearby trees, had to be removed; igloo ventilators required a minimum of five feet of clear space around them. Regulations prohibited the storage of materials such as loose components or rounds of ammunition, lift trucks, conveyors, packing material, and empty boxes within magazines storing ammunition or explosives (NARA RG 156 Ordnance Corps 1951:18-4 – 18-5, 18-9; NARA RG 156 Ordnance Corps 1951:12-20, 6-14, 6-21).

The Ordnance Corps monitored the maintenance of ammunition storage facilities, and developed policies to establish when magazines required repair (NARA RG 156 Ordnance Corps 1951:16-7 – 16-8). For example, igloos exhibiting leaks required immediate attention; the presence of visible cracks without confirmed leaks did not necessitate repairs. The Ordnance Corps encouraged permanent correction rather than temporary repairs. Permanent repair entailed removing the earth cover and replacing the exterior membrane waterproofing that protected the concrete structure. Interior repairs to igloo magazines containing bulk explosives generally were prohibited; however, minor interior repairs could be performed under certain circumstances. In emergency situations, temporary interior repairs could be undertaken inside igloos containing complete rounds of boxed ammunition. Such interior work involved filling cracks and applying waterproofing treatment (NARA RG 156 Office of the Chief of Ordnance 1951a; NARA RG 156 Ordnance Corps 1951:18-10).

Normal maintenance, modification, renovation, or demilitarization of ammunition was not permitted in occupied magazines. When separate facilities were not available for these operations, empty magazines could be used. In addition, such operations could be performed in the open but within appropriate distances from ammunition and explosives storage areas (NARA RG 156 Ordnance Corps 1951:25-1 – 25-2). Under the order of the Chief of Ordnance, ammunition and explosives that could not be identified properly or that had deteriorated seriously could be destroyed by burning, detonation, or dumping at sea. Burning and detonation activities were located "at the maximum practicable distance available from all magazines," and natural barricades were utilized where possible (NARA RG 156 Ordnance Corps 1951:27-7 – 27-8).

6.4 Ammunition Surveillance and Inspection

The Ordnance Corps Field Service held responsibility for retaining ammunition in storage at depots and maintaining its serviceability. The Field Service conducted a program of ammunition surveillance, defined as "the observation, inspection, investigation, test, study, and classification of ammunition, ammunition components, and explosives in movement, storage, and use with respect to the degree of serviceability and the rate of deterioration" (NARA RG 156 Stephens 1959:13). The Chief of Field Service created the position of surveillance inspector in 1920, primarily to deal with smokeless powder and explosives left over from World War I. The ammunition surveillance program eventually encompassed all types of ammunition. The Chief of Ordnance oversaw the overall program in major ammunition depots, while the Chief of the Field Service Division provided staff supervision. The Ammunition Branch of the Field Service Division provided general supervision for surveillance activities. In 1947, Raritan Arsenal overtook most of the operational responsibility for the program. In 1952, these functions were transferred to the National Stock Control and Maintenance Point for Ammunition. In 1954, they were assigned to Joliet Arsenal, Illinois, which later became the Ordnance Ammunition Command (NARA RG 156 Stephens 1959:12-14; NARA RG 156 Ordnance Corps Survey 1952b:9-10).

During World War II, ammunition inspections occurred monthly for items in storage facilities. Between 1946 and 1950, ammunition inspectors focused on ammunition returned from overseas following World War II. Due to the enormous volume of work, inspectors performed only small percentage checks for safety before the ammunition was stored, whereas a larger inspection actually was warranted due to mislabeled and unidentified packages; however, this caused few problems as only small quantities of ammunition was actually shipped for use by Army personnel. Eventually, long-term storage plans were implemented. A routine percentage ammunition inspection generally occurred every twelve months. For chemical munitions, a semi-annual inspection was required, preferably following the seasonal period of highest temperature. Ammunition in open storage required frequent inspections due to possible damage from exposure to the elements (NARA RG 156 Stephens 1959:16-17, 19-20; NARA RG 156 Office of the Chief of Ordnance 1950a:17, 13-14).

Ammunition inspectors used a sampling process for examination of materials. The selection of samples adhered to the following guidelines:

> The sample should represent the entire quantity of the lot in storage, in the sense that the storage history of the sample should be similar to that of the lot. Not more than one container should be taken from any one box, and when several containers are required they should be selected from boxes stored in different portions of the stack. Selection of boxes (shipping containers) from which samples are to be taken should be so regulated that the sample will include conditions representative of the entire lot and in the

approximate percentages in which they occur (NARA RG 156 Office of the Chief of Ordnance 1950a:7).

For igloo magazines used for long-term storage, a three percent representative inspection sample was adequate except during the spring and fall months, when heavy condensation could occur. In such cases, a 100-percent inspection was necessary. Each Ordnance establishment submitted a Monthly Report of Surveillance Activities to the Office of the Chief of Ordnance on the last day of each month (NARA RG 156 Office of the Chief of Ordnance 1950a:17-18). In addition, installations maintained Depot Surveillance Record (DSR) cards on which inspection data for each lot of ammunition or explosives in storage were recorded. If the ammunition or explosives were transferred to another depot, the DSR card accompanied the shipment (NARA RG 156 Stephens 1959:21).

In 1953, the Ordnance Corps established an Area Program of Field Inspection of Ammunition Operations to ensure "the proper application of Ordnance Corps policies and regulations pertaining to the storage, surveillance, maintenance, movement, and handling of Ordnance ammunition, explosives, and propellants" (NARA RG 156 Office of the Chief of Ordnance 1953b). Under this policy, Ordnance establishments were grouped into four geographical areas.

One installation in each group was selected to station an Area Ammunition Inspector, who was responsible for inspecting ammunition operations at each establishment in his geographical area at least twice annually and for preparing reports for submission to the Chief of Ordnance. These four installations were as follows:

Area 1	Letterkenny Ordnance Depot, Pennsylvania
Area 2	Savanna Ordnance Depot, Illinois
Area 3	Red River Arsenal, Texas
Area 4	Ogden Arsenal, Utah

An Assistant Area Ammunition Inspector also was assigned to each geographical area; this individual was available to assume the duties of the Area Ammunition Inspector when necessary (NARA RG 156 Office of the Chief of Ordnance 1953b).

Each Ordnance establishment had an Ammunition Inspector-in-Charge who also served as the Chief of Surveillance Division. In addition, this individual could function as the Safety Director for the establishment. Besides ammunition and magazine inspection, the Ammunition Inspector-in-Charge performed numerous tasks, including technical advisement, approval of Standard Operating Procedures, maintenance of surveillance laboratories, retention of ammunition and storage drawings, and supervision of junior inspectors. All ammunition inspectors were experienced Ordnance Corps employees who underwent specialized training; they were assigned to Ordnance establishments by the Chief of Field Service (NARA RG 156 Office of the Chief of Ordnance 1950a:2-4; NARA RG 156 Guest 1951:18).

Ammunition inspectors examined magazines on a monthly basis and regularly tested lightning protection systems. The inspection of magazines containing chemical munitions was especially critical. Ammunition inspectors checked these magazines on a monthly basis for visual or olfactory evidence of leaks, deterioration, or unusual conditions; however, semi-monthly inspections were preferred. An ammunition inspector was not permitted to enter a chemical munitions magazine without having appropriate protective equipment available and a second person located outside the magazine to render aid if needed (NARA RG 156 Ordnance Corps 1951:29-5; NARA RG 156 Office of the Chief of Ordnance 1950a:3-4; 13).

Ammunition inspectors were monitored closely. On March 31 of each year, the Ammunition Inspector-in-Charge prepared an annual report of progress and development for each junior ammunition inspector under his supervision. After review by the Commanding Officer, this report was submitted to the Office of the Chief of Ordnance through the Area Ammunition Inspector. Junior inspectors were rotated to a different duty assignment every three months. Ammunition inspectors typically remained at an installation for a three-year period and then were subject to transfer to another establishment (NARA RG 156 Office of the Chief of Ordnance 1950a:5-7).

Formal training institutions for ammunition inspectors were established during World War II. Aberdeen Proving Ground sponsored the original Ammunition Inspectors School beginning in July 1941. The numbers of male trainees were limited because of Selective Service restrictions; therefore, female trainees were accepted beginning in September 1942 (NARA RG 156 Ordnance Department Field Service, Ammunition Supply Division 1945:Chapter IV:1-2). Delaware Ordnance Depot held inspector classes between 1941 and 1946. During those years, 250 trained ammunition inspectors actively performed surveillance duties. Due to the involvement of the United States in the Korean Conflict, the inspector training program resumed in 1950 at Savanna Ordnance Depot. The Ordnance Ammunition Surveillance and Maintenance School was established at Savanna in 1957 (NARA RG 156 Stevens 1959:22).

Beginning in July 1951, responsibility for storage surveillance training for atomic weapons fell under the newly-created Armed Forces Special Weapons Project (AFSWP). The AFSWP, located at Sandia Base in Albuquerque, New Mexico, provided technical training in the use of atomic weapons to officers, non-commissioned officers, and enlisted men from the Army, Navy, and Air Force. The Ordnance Corps assumed training responsibilities for topics such as storage, surveillance, maintenance, handling, and disposal. During 1954 and 1955, for example, the Ordnance School trained two officers and 400 enlisted men (NARA RG 156 Ordnance Training Command 1956).

In 1953, specialized training for the inspection of guided missiles began at the Ordnance Guided Missile School located at Redstone Arsenal in Huntsville, Alabama. Placed under the Ordnance Training Command at Aberdeen, Maryland, the school not only offered courses in inspection, repair, supply, and maintenance of guided missiles but also provided training for the handling, storage, issuance and inspection of guided-missile propellants and explosives. Guided-missile instruction continually changed in accordance with new developments in equipment. A section for CORPORAL missile training was created in 1953, closely followed by the establishment of the first NIKE ground station. By 1956, 5,203 Army personnel had successfully completed training in the Ordnance Guided Missile School (NARA RG 156 Ordnance Training Command 1956).

6.5 Ordnance Corps Organization

Having survived the reorganization efforts during the immediate postwar period, the Ordnance Corps structure retained the basic form that had been in place since post-World War I reorganizations reduced bureaucracy by consolidating similar functions (the Army Organization Act of 1950 changed the organization’s name from Ordnance Department to Ordnance Corps) (NARA RG 156 Ordnance Corps Survey 1952a:2-4; Sterling 1987:2, 5). According to this basic form, even though some departments merged or separated and some job titles changed, the main functions of the Ordnance Corps remained production, procurement, and storage of ordnance, and research and development on ordnance. The term “ordnance” included ammunition, explosives, bombs, rockets, and guided missiles, as well as weapons, artillery, and combat vehicles (NARA RG 156 Ordnance Corps Survey 1952a:6, 10; NARA RG 156 Ordnance Corps Survey 1952b:5).

The Industrial Division oversaw ordnance production and procurement. The Field Service Division oversaw ordnance storage, maintenance, and repair. The Research and Development Division, known before World War II as Technical Staff but renamed during the war, oversaw ordnance research and development. The division heads were Assistant Chiefs of Ordnance. The Personnel and Training Division represented a fourth division, but whether an Assistant Chief of Ordnance led it is not clear (NARA RG 156 Ordnance Corps Survey 1952c:Tab D).

Within the Industrial Division were the Ordnance Ammunition Center (OAC), the Ordnance Small Arms Ammunition Center (OSAAC), and the Ordnance Tank Automotive Center (OTAC), known as Commodity Centers; manufacturing arsenals and plants that produced missile components, tanks, and other ordnance, and participated in ordnance procurement; and fourteen ordnance districts, nationwide geographic divisions that oversaw ordnance procurement. These branches of the Industrial Division oversaw plants and facilities that pertained to their missions (NARA RG 156 Ordnance Corps Survey 1952c:Tab D; NARA RG 156 Ordnance Corps Survey 1952b:4-5).

Most ammunition production was overseen by the OAC, located in Joliet, Illinois. Established in 1951, the OAC was responsible for "mass production of standard Army ammunition other than small arms, including propellants, explosives and chemicals; supervision of renovation and demilitarization of all ammunition; supervision of certain ammunition modification;" and "the coordination and direction of procurement of components" (NARA RG 156 Ordnance Ammunition Center 1951; NARA RG 156 Snodgrass 1953:3-4). As of 1952, the OAC oversaw 23 ammunition production plants and related facilities. The OAC's mission also included procurement (NARA RG 156 Ordnance Corps Survey 1952c:Tab D; NARA RG 156 Ordnance Corps Survey 1952b:4). The OSAAC, located in St. Louis and also established in 1951, handled production of small-arms ammunition. As of 1952, it supervised three plants (NARA RG 156 Ordnance Corps Survey 1952c:Tab D; NARA RG 156 Ordnance Corps Survey 1952b:4; NARA RG 156 Snodgrass 1953:3-4).

The Field Service Division oversaw storage of ammunition and related components. It included 25 depots and shops and five sub-depots. The Chief of the Field Service Division controlled operation of the six national stock control points, regardless of their locations (NARA RG 156 Ordnance Corps Survey 1952c:Tab D). The ammunition supply branch was organized by commodity, while other supply branches were organized functionally, i.e. focused on supplying all parts to a product at the same time, such as a gun that included spare parts and fire control equipment (NARA RG 156 Snodgrass 1953:9). There were three types of depots: distribution depots serving a port or geographic area; commodity depots storing specified classes of supplies in support of distribution depots; and back-up or reserve depots supporting the commodity depots by storing equipment in bulk (NARA RG 156 Snodgrass 1953:9).

The Research and Development Division directed research and development of "new and improved ordnance materiel and materials" and coordinated the guided missiles program (NARA RG 156 Ordnance Corps Survey 1953b). It oversaw Aberdeen Proving Ground, White Sands Proving Ground, Redstone Arsenal, and the Office of Ordnance Research (NARA RG 156 Ordnance Corps Survey 1952c:Tab D).

The Ordnance Corps's focus during this period was on supplying ammunition and other ordnance to military forces in Korea. Other priorities were supplying ordnance to other countries as required under the Mutual Defense Assistance Program and maintaining a mobilization reserve (NARA RG 156 Snodgrass 1953:1). The Ordnance Corps faced the challenge of meeting these needs with reduced supplies and facilities as a result of post-World War II demobilization.

As a result of these demands, according to an events summary of fiscal year 1953, the Ordnance Corps faced "many challenging problems in the field of organization, personnel, and management" during this period. General James A. Van Fleet, former commander of the Eighth Army in Korea, told the Senate Subcommittee on Ammunition Shortages in 1953 that there were "serious and at times critical" ammunition shortages during his 22-month command (NARA RG 156 Snodgrass 1953:102). Of particular concern was whether the Ordnance Corps could serve its missions under its current structure in the event of full mobilization for a larger conflict (NARA RG 156 Snodgrass 1953:3).

Meanwhile, in the wake of the high cost of the Korean conflict, Department of Defense efficiency became an issue in the 1952 presidential campaign. The Secretary of the Army consulted businessmen who said the Ordnance Corps plan of partial decentralization resulted in "divided authority and responsibility," and recommended "true" decentralization. However, the Chief of Ordnance found only one instance of delay in ordnance procurement caused by divided authority. He argued that the organization and its procedures were not problematic but merely confusing to outsiders because of the vastness and complexity of its operations. Some changes were needed, he said, but substantial changes would paralyze operations (NARA RG 156 Snodgrass 1953:5, 11).

To solve these problems, the Chief of Ordnance had taken several actions during the conflict to improve efficiency. These actions centered around streamlining the structure and decentralizing some operations. The OAC and the SAAC were formed to decentralize ammunition production operations, and national stock control and maintenance points were established to decentralize depot and supply functions (NARA RG 156 Snodgrass 1953:4, 9). Personnel costs were reduced when contractors resumed operation of some plants and storage facilities, as in World War II, and the contractors absorbed the personnel costs (NARA RG 156 Snodgrass 1953:12). A Depot Realignment Plan begun in May 1952 distributed responsibilities more broadly across the depot system, particularly so distribution depots could accomplish their missions (NARA RG 156 Snodgrass 1953:27). A proposal to decentralize the Research and Development, Industrial, and Field Service divisions by moving them out of Washington was rejected (NARA RG 156 Snodgrass 1953:103-4).

Some military leaders disagreed with aligning the military with a business model because the military had goals that differed from business organizations, as summarized in the fiscal year 1953 summary of Ordnance Corps events and problems:

> "War is definitely an uneconomical operation, in which it would seem extremely difficult to achieve the economy possible when most factors are controllable. Hence, defense, and economy as defined in private industry, might not be compatible. In war, success is not measured in dollar profits, but rather by the speed and degree of effectiveness of supply in response to troop needs. Traditionally, American Army commanders have called for guns and ammunition to control the expenditure of lives. It would take time before the success of business concepts, as applied to defense management, could be determined" (NARA RG 156 Snodgrass 1953:5, 12).

Similarly, in 1952. Lt. Gen. L.B. Palmer, the Assistant Chief of Ordnance for Supply, praised the Ordnance Corps's mobilization and expansion effort for the Korean conflict despite reduced resources as a result of post-World War II demobilization. "Their machinery is running soundly and is in no danger of collapse," he said (NARA RG 156 Snodgrass 1953:103).

The Senate subcommittee investigating the allegations of ammunition shortages disagreed. In a preliminary report issued in May 1953, the subcommittee asserted that the ammunition procurement system "indicated unconscionable inefficiency, waste, and unbelievable red tape." Testimony indicated that some procurement documents traveled more than 10,000 miles and sat on 154 desks before a contract was let, and that the time between appropriation and ammunition delivery was 24 months. The ammunition shortage had caused "a needless loss of American lives" (NARA RG 156 Snodgrass 1953:50). However, in a second report in August, the subcommittee reported that "steady progress" had been made in increasing ammunition stockpiles (NARA RG 156 Snodgrass 1953:50).

6.6 Design and Construction of Ammunition Storage Facilities

Just prior to American's entry into the Korean Conflict, construction of ammunition storage facilities remained at the levels exhibited in the immediate post war period. Construction during 1949 paralleled that of the preceding two years with few new buildings. The number of new facilities rebounded slightly in 1950 with the construction of magazines; however, the majority of this new construction was at the installation level including new ready magazines at Fort Jackson, South Carolina; igloos and small arms magazines at Fort Campbell, Tennessee; and several igloos at the Youngstown, New York, National Guard Training Center. These buildings ranged dramatically in size. The largest magazine at Fort Jackson measured only 240 square feet, and four of the buildings were only ten-feet square. The magazines at Youngstown were classified as installation-level igloos measuring 25 feet by 60 feet (U.S. Army Real Property Inventory 2007). Construction again declined in 1951 with the majority of all new construction occurring at White Sands Missile Test Range where a few liquid propellant storage buildings and general-purpose magazines were built, and Fort Hunter Liggett, California, with several installation-level general-purpose magazines. The ammunition storage facilities at Fort Liggett included 9 small buildings: 3 measuring 420 square feet and 6 measuring 820 square feet (U.S. Army Real Property Inventory 2007).

American entry into the Korean Conflict prompted another period of intense construction for ammunition storage. In 1953, approximately twice as many new ammunition storage facilities were constructed than in the preceding seven years combined. This included 700 depot-level earth-covered magazines at seven installations: Tooele Army Depot, McAlester Army Ammunition Plant, Fort Wingate Depot Activity, Blue Grass Army Depot, Pueblo Chemical Depot, Pine Bluff Arsenal, and Anniston Army Depot. Archival information and field investigations suggest that all the depot-level earth-covered magazines constructed in 1953 were Army standard designs and approximately 25 feet in width by 80 feet long (Plates 6.32 and 6.33). The configuration of the wing walls varied among the installations. Some igloos featured the truncated walls of the Huntsville sub-type, while others had long wing walls (Plates 6.34 and 6.35). Almost all of the 700 igloos were built with double-leaf doors to facilitate movement of munitions with forklifts and other materials handling equipment (Plate 6.36). Rectangular smokeless powder and high explosives magazines were also constructed by the Navy in 1953 (Plate 6.37) (U.S. Army Real Property Inventory 2007).

Earth-covered magazines at Anniston were approved in 1952 and 100 were completed in 1953. The new magazines cost $15,130.52 each to construct and added 241,148 square feet of ammunition storage space. The total cost of completing the construction project at Anniston was $1,513,052.22 (Anniston Army Depot). At Blue Grass, the construction of 100 new igloos commenced in March 1952 (Blue Grass Ordnance Depot 1952:15). The main difference between the 1952 igloos and the 1942 igloos was the configuration of the wing walls. The 1952 igloos featured wing walls that were truncated much closer to grade. Backfill was incorporated, but much less earth wrapped around the façade of the wing walls in comparison to the 1942 versions. The 1952 igloos had a single entry with double-leaf steel doors. They featured a vent system similar to the 1942 igloos.

New magazines constructed at Army installations were located to take advantage of existing land and infrastructure and often were built between existing facilities in the igloo storage areas, or blocks (Plate 6.38). Although this reduced the magazine separation distance, the spacing was adequate for large amounts of less volatile materiel. Placing the magazines in this way saved money by reducing the amount of infrastructure, such as roads.

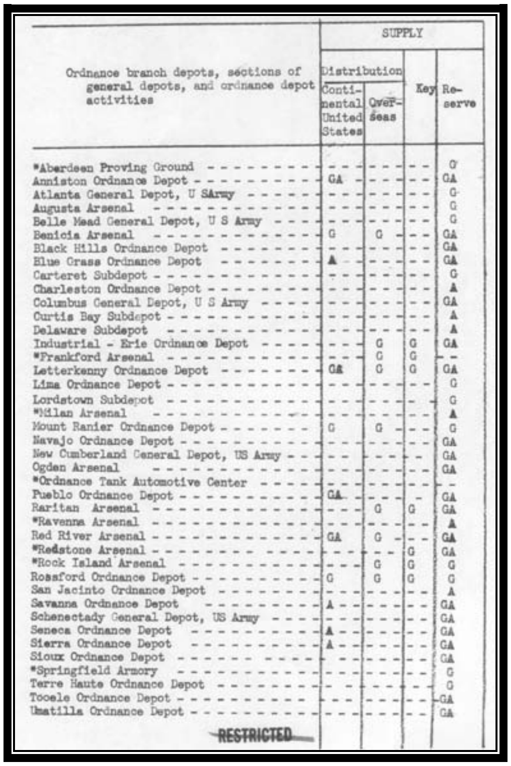
The Navy constructed few new ammunition storage buildings during this period. The largest number built at Hawthorne was in 1953 with the addition of numerous new high-explosive magazines. These were structurally identical to the rectangular box magazines of World War II. The only difference was the extension of the loading dock beyond the earth fill to facilitate the use of trucks and forklifts to handle ammunition (U.S. Army Real Property Inventory 2007). A major Naval construction project in the post-World War II era took place in 1953 at McAlester Navy Depot where over 300 buildings were constructed. This included 27 fuze and detonator magazines, 18 high explosive magazines, 83 earth-covered magazines, and 174 buildings for the storage of smokeless powder. All the buildings were classified as depot level and followed standard Navy plans (U.S. Army Real Property Inventory 2007).

In comparison to construction activity at depots, the Army only built approximately 100 new installation-level ammunition storage facilities nationwide. Many of these were small, reinforced-concrete service magazines, such as the 24 square foot examples at Lake City Army Ammunition Plant; however, new construction was active at selected installations. Fort Knox, Kentucky, for example, received several 2,420 square foot high-explosive magazines in 1953, and numerous fixed-ammunition magazines of similar size were built at Fort Lewis, Washington, the same year. These magazines complemented existing facilities in fulfilling the installation training mission; those at Fort Lewis were part of two new regimental areas constructed near the combat ranges (Fort Lewis 2007; U.S. Army Real Property Inventory 2007).

6.7 Summary

During the years of American involvement in the Korean Conflict, the Ordnance Corps faced many of the same challenges it confronted at the beginning of World War II. Although the massive building programs of World War II were not repeated, new construction did take place at selected installations; however, the influx of workers did not strain local economies and impact social institutions as it had during the war years. The Ordnance Corps responded to the demand for munitions with well-planned organization. Serviceable munitions were rapidly moved to combat areas, renovation activities quickly returned damaged or degraded ammunition to useable condition, and obsolete items were destroyed making additional storage space available.

In addition to servicing ammunition for the Korean Conflict, the Ordnance Corps also coped with new weapons systems. The numbers of guided missiles, both tactical and strategic, increased during the years of combat in Korea. Existing storage facilities were pressed into service, and new storage magazines constructed for these often large and sensitive munitions. Modifications to existing facilities took place to accommodate a heretofore unexpected type of ammunition.



Ordnance branch depots, sections of general depots, and ordnance depot activities	SUPPLY			
	Distribution		Key	Reserve
	Continental United States	Overseas		
*Aberdeen Proving Ground	-	-	-	G
Anniston Ordnance Depot	GA	-	-	GA
Atlanta General Depot, U SArmy	-	-	-	G
Augusta Arsenal	-	-	-	G
Belle Mead General Depot, U S Army	-	-	-	G
Benicia Arsenal	G	G	-	GA
Black Hills Ordnance Depot	-	-	-	GA
Blue Grass Ordnance Depot	A	-	-	GA
Carteret Subdepot	-	-	-	G
Charleston Ordnance Depot	-	-	-	A
Columbus General Depot, U S Army	-	-	-	GA
Curtis Bay Subdepot	-	-	-	A
Delaware Subdepot	-	-	-	A
Industrial - Erie Ordnance Depot	-	G	G	GA
*Frankford Arsenal	-	G	G	-
Letterkenny Ordnance Depot	GA	G	G	GA
Lima Ordnance Depot	-	-	-	G
Lordstown Subdepot	-	-	-	G
*Milan Arsenal	-	-	-	A
Mount Ranier Ordnance Depot	G	G	-	G
Navajo Ordnance Depot	-	-	-	GA
New Cumberland General Depot, US Army	-	-	-	GA
Ogden Arsenal	-	-	-	GA
*Ordnance Tank Automotive Center	-	-	-	-
Pueblo Ordnance Depot	GA	-	-	GA
Raritan Arsenal	-	G	G	GA
*Ravenna Arsenal	-	-	-	A
Red River Arsenal	GA	G	-	GA
*Redstone Arsenal	-	-	G	GA
*Rock Island Arsenal	-	G	G	G
Rossford Ordnance Depot	G	G	G	G
San Jacinto Ordnance Depot	-	-	-	A
Savanna Ordnance Depot	A	-	-	GA
Schenectady General Depot, US Army	-	-	-	GA
Seneca Ordnance Depot	A	-	-	GA
Sierra Ordnance Depot	A	-	-	GA
Sioux Ordnance Depot	-	-	-	GA
*Springfield Armory	-	-	-	G
Terre Haute Ordnance Depot	-	-	-	G
Tooele Ordnance Depot	-	-	-	GA
Umatilla Ordnance Depot	-	-	-	GA

RESTRICTED

Plate 6.1 Excerpt from General Staff Report. General supplies are indicated by a "G," and ammunition by an "A" (Ordnance Corps Survey 1952a)

Plate 6.2 Igloo construction, ca. 1953 (Courtesy U.S. Army, 2007)

Plate 6.3 Corbetta Beehive under construction (Courtesy U.S. Army)

Plate 6.4 Typical aboveground magazine (Courtesy U.S. Army, 2007)

Plate 6.5	Typical hillside magazine, also referred to as frost proof (Courtesy U.S. Army, 2007)

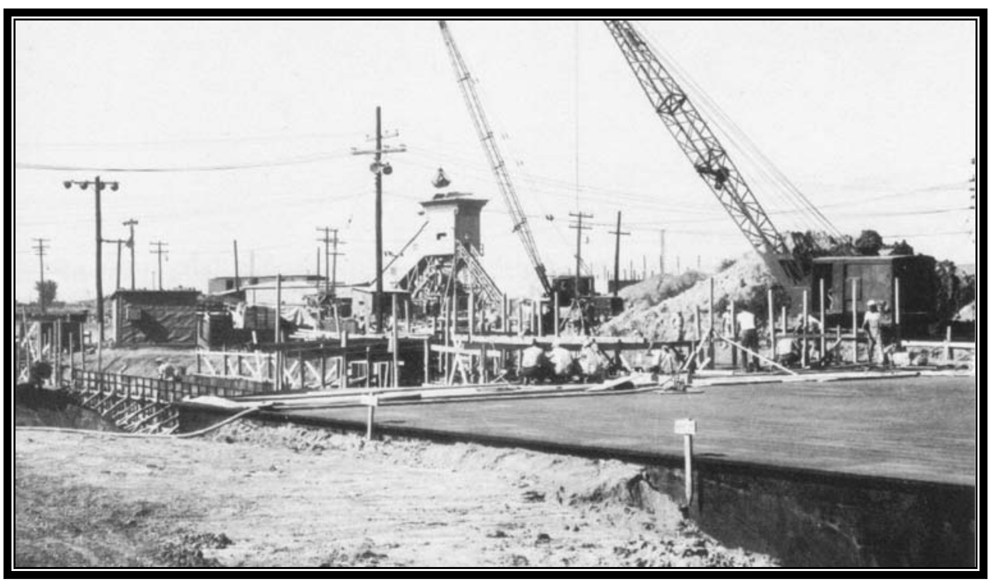


Plate 6.6	Construction of subterranean magazine (Courtesy U.S. Army)

Plate 6.7	Typical Richmond magazine (Courtesy U.S. Army, 2007)

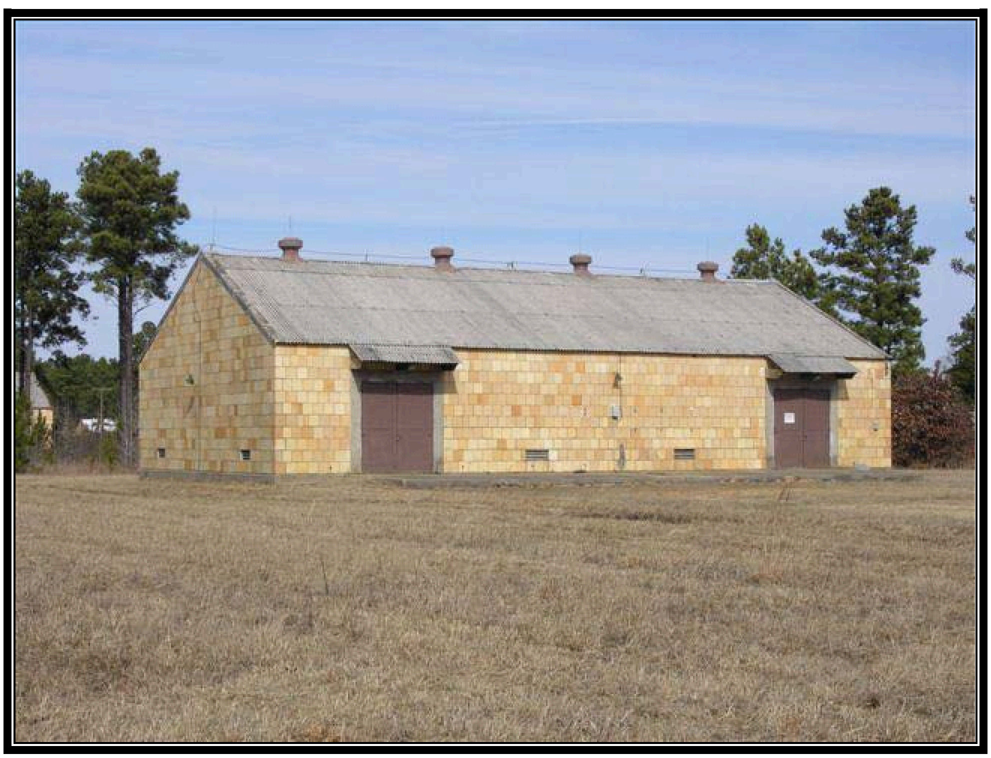


Plate 6.8	Typical powder magazine (Courtesy U.S. Army, 2007)

Plate 6.9 Typical loading dock (Courtesy U.S. Army, 2007)

Plate 6.10 Ammunition storage magazine (guided missiles) (Courtesy U.S. Army, 2007)

Plate 6.11 Liquid propellant storage building (Courtesy U.S. Army, 2007)

Plate 6.12 Liquid propellant storage building, note lightning rods (Courtesy U.S. Army, 2007)

Table No. 1739. Class 10.—Quantity-Distance

Quantity of explosives		Unbarricaded distance in feet [a]				
Pounds over—	Pounds not over—	Inhabited building distance	Public railway distance	Public highway distance	Magazine distance [b]	Intraline distance
--	10	145	90	45	60	--
10	25	145	90	45	60	40
25	50	145	90	45	60	60
50	100	240	140	70	80	80
100	200	360	220	110	100	100
200	300	520	310	150	120	120
300	400	640	380	190	130	130
400	500	720	430	220	140	140
500	600	800	480	240	150	150
600	700	860	520	260	160	160
700	800	920	550	280	165	170
800	900	980	590	300	170	180
900	1, 000	1, 020	610	310	190	190
1, 000	1, 500	1, 060	640	320	210	210
1, 500	2, 000	1, 200	720	360	230	230
2, 000	3, 000	1, 300	780	390	260	260
3, 000	4, 000	1, 420	850	420	280	280
4, 000	5, 000	1, 500	900	450	300	300
5, 000	6, 000	1, 560	940	470	300	320
6, 000	7, 000	1, 610	970	490	300	340
7, 000	8, 000	1, 660	1, 000	500	300	360
8, 000	9, 000	1, 700	1, 020	510	300	380
9, 000	[c] 10, 000	1, 740	1, 040	520	300	400

[a] These distances may be halved when requirements of paragraph No. 1725 are complied with.

[b] See paragraph No. 1710e for spacing if igloo type magazines.

[c] Maximum poundage of military pyrotechnics recommended at any one location in an operating line.

17–47

Plate 6.13a American Table of Distances (Ordnance Corps 1951:17-47)

Table No. 1739. Class 10.—Quantity-Distance—Continued

Quantity of explosives		Unbarricaded distance in feet [a]				
Pounds over—	Pounds not over—	Inhabited building distance	Public railway distance	Public highway distance	Magazine distance [b]	Intraline distance
10, 000	15, 000	1, 780	1, 070	530	300	450
15, 000	20, 000	1, 950	1, 170	580	300	490
20, 000	25, 000	2, 110	1, 270	630	300	530
25, 000	30, 000	2, 260	1, 360	680	300	560
30, 000	35, 000	2, 410	1, 450	720	300	590
35, 000	[d] 40, 000	2, 550	1, 530	760	300	620
40, 000	45, 000	2, 680	1, 610	800	300	640
45, 000	[e] 50, 000	2, 800	1, 680	840	300	660
50, 000	55, 000	2, 920	1, 750	880	400	680
55, 000	60, 000	3, 030	1, 820	910	400	700
60, 000	65, 000	3, 130	1, 880	940	400	720
65, 000	70, 000	3, 220	1, 940	970	400	740
70, 000	75, 000	3, 310	1, 990	1, 000	400	770
75, 000	80, 000	3, 390	2, 040	1, 020	400	780
80, 000	85, 000	3, 460	2, 080	1, 040	400	790
85, 000	90, 000	3, 520	2, 120	1, 060	400	800
90, 000	95, 000	3, 580	2, 150	1, 080	400	820
95, 000	100, 000	3, 630	2, 180	1, 090	400	830
100, 000	125, 000	3, 670	2, 200	1, 100	800	900
125, 000	150, 000	3, 800	2, 280	1, 140	800	950
150, 000	175, 000	3, 930	2, 360	1, 180	800	1, 000
175, 000	[f] 200, 000	4, 060	2, 440	1, 220	800	1, 050
200, 000	225, 000	4, 190	2, 520	1, 260	800	1, 100
225, 000	[g] 250, 000	4, 310	2, 590	1, 300	800	1, 150

[d] Maximum poundage of military pyrotechnics permitted at any one location in an operating line.
[e] Maximum poundage of military pyrotechnics recommended for storage at any one location.
[f] Maximum poundage of military pyrotechnics permitted for storage at any-one location.
[g] Maximum poundage permitted in any one magazine (exclusive of military pyrotechnics), without special authorization.

17—48

Plate 6.13b American Table of Distances (Ordnance Corps 1951:17-48)

Items Included in Class 10

1. Ammunition, composition B, and pentolite loaded.
2. Bangalore torpedoes.
3. Bombs, demolition.
4. Bombs, fragmentation.
5. Bombs, photoflash.
6. Boosters, auxiliary.
7. Bursters.
8. Cartridge, photoflash.
9. Demolition blocks.
10. Grenades, fragmentation.
11. Grenades, hand offensive.
12. Grenades, Rifle, AT.
13. JATOS, complete rounds.
14. Mines, antipersonnel (cast iron block).
15. Mines, HEAT.
16. Rockets, HE, complete rounds.
17. Rocket heads, HE loaded.
18. Shaped charges (Engineers).
19. Shell, HE, heavy mortar, over 81 mm. (including 81 mm. M56).

Plate 6.13c American Table of Distances (Ordnance Corps 1951:17-49)

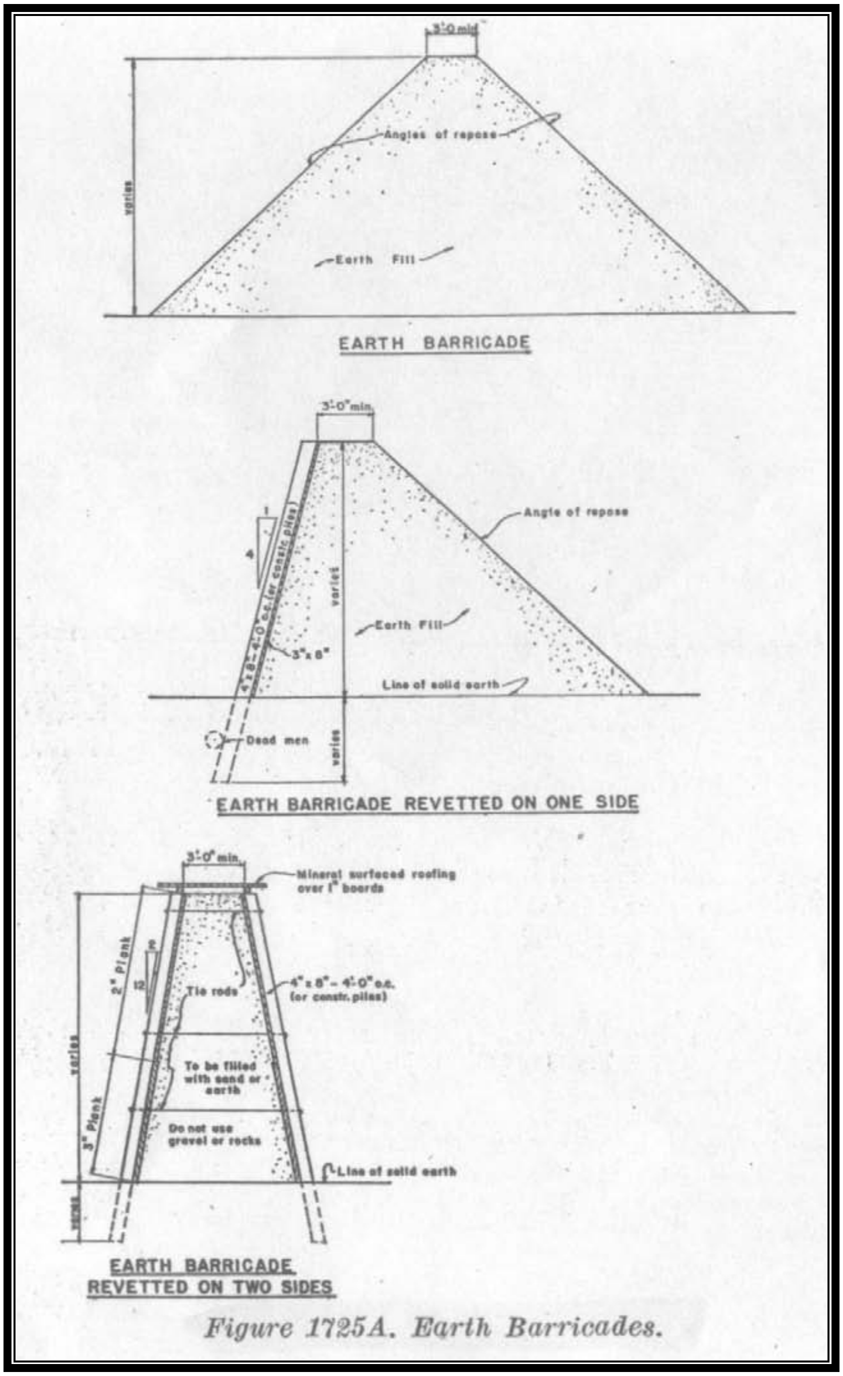


Figure 1725A. Earth Barricades.

Plate 6.14 Plans of various earth barricades (Ordnance Corps 1951:17-27)

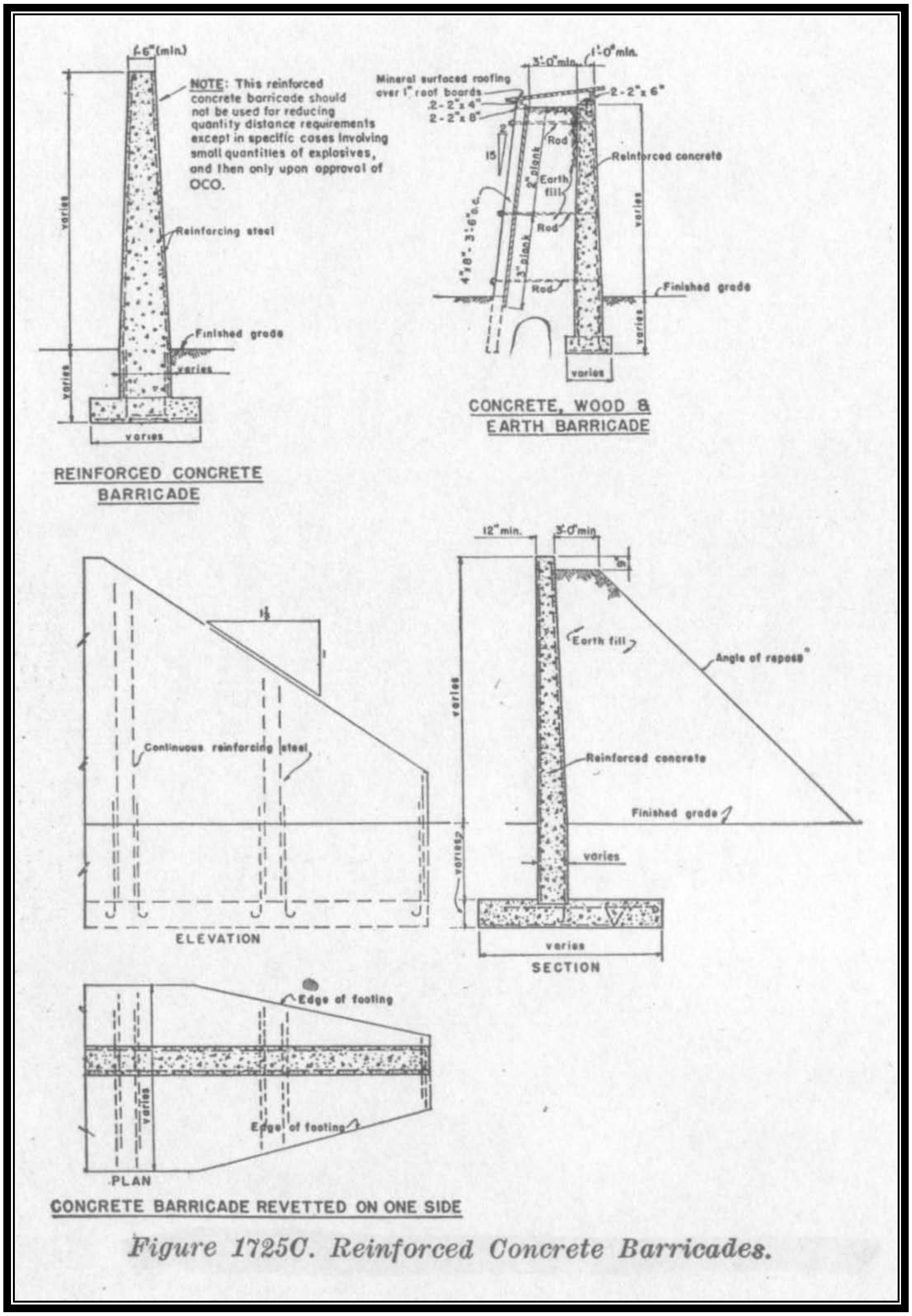


Figure 1725C. Reinforced Concrete Barricades.

Plate 6.15 Plans of various concrete barricades (Ordnance Corps 1951:17-31)


Plate 6.16 Typical smokeless powder storage building surrounded by rampauno barricade (Courtesy U.S. Army, 2007)


Plate 6.17 Typical concrete barricade opposite magazine entrance (Courtesy U.S. Army, 2007)

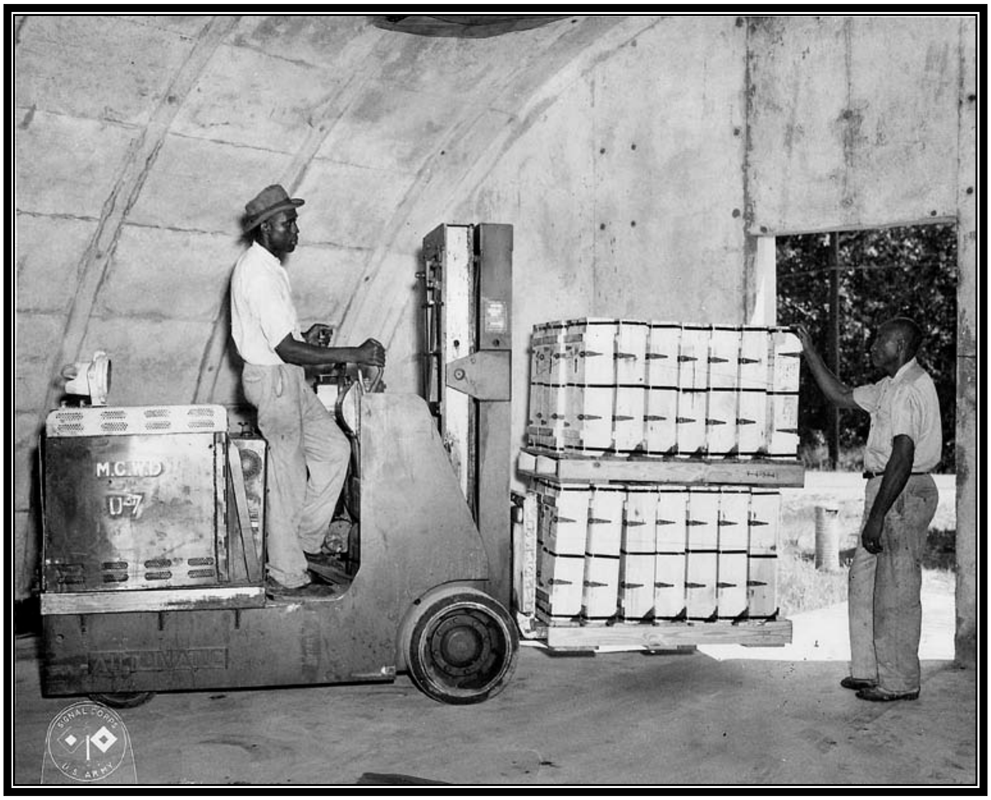


Plate 6.18 Handling palletized ammunition with electric forklift, ca. 1950 (Courtesy U.S. Army)

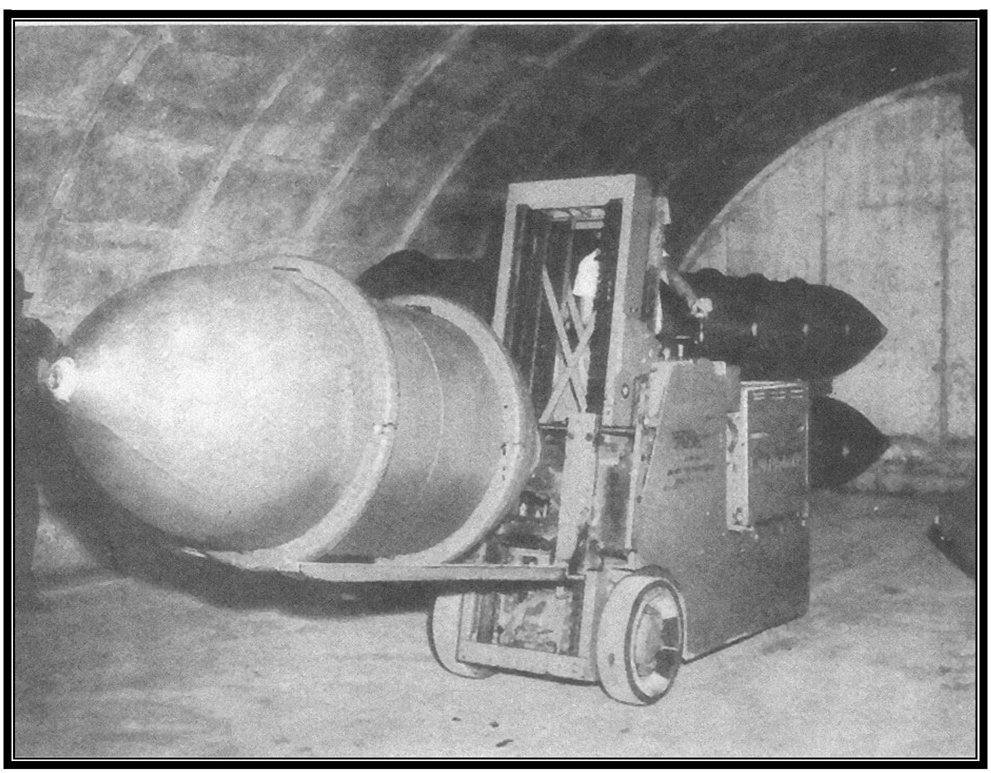


Plate 6.19 "Approved truck handling 4,000-pound bomb in igloo" (Facilities Section 1950:n.p.)

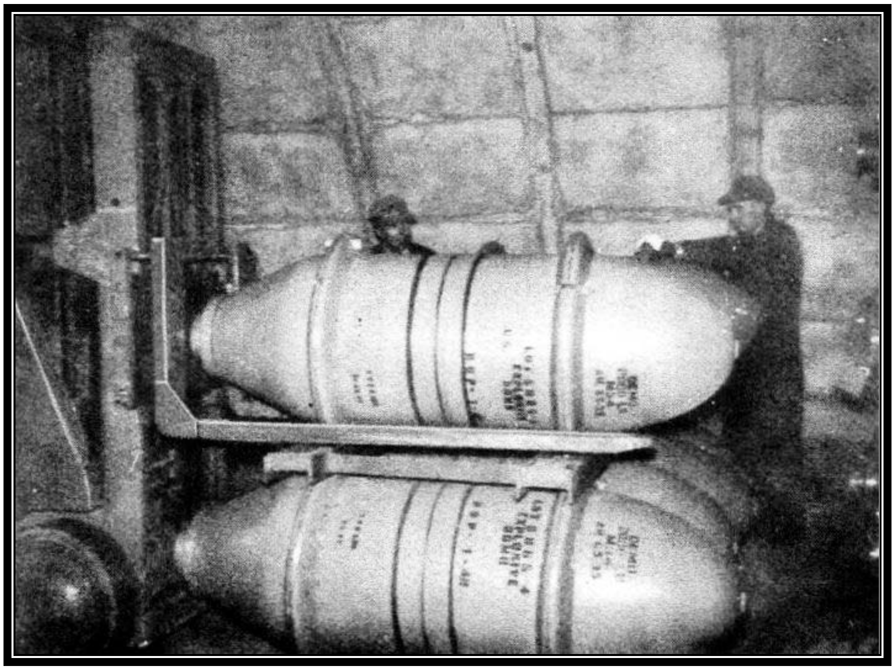


Plate 6.20 “Approved truck stacking 2,000-bomb in igloo” (Facilities Section 1950:n.p.)

Plate 6.21 “Bomb being placed on fourth tier on wooden dunnage” (Facilities Section 1950:n.p.)

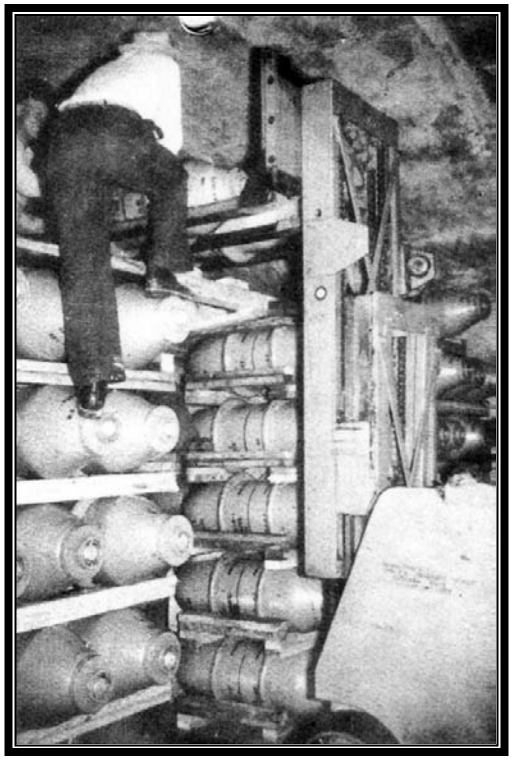


Plate 6.22 "Approved truck equipped with third center fork is stacking two 500-pound bombs in igloo on seventh tier on wooden dunnage" (Facilities Section 1950:n.p.)

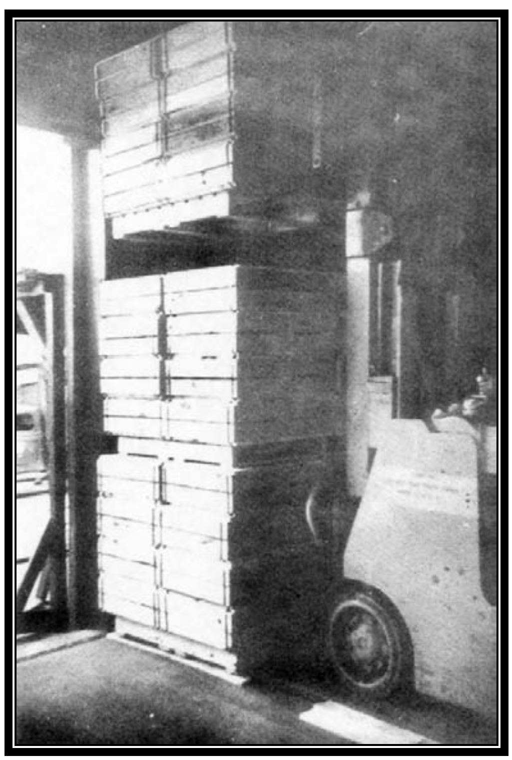


Plate 6.23 "Approved truck operating in magazine warehouse stacking 4,000-pound load of ammunition crates—16 cases per pallet" (Facilities Section 1950:n.p.)

Plate 6.24 Typical access control point at ammunition plant, ca. 1950 (Courtesy U.S. Army)

Plate 6.25 Typical signage indicating limits on numbers of operating personnel, transient personnel, and maximum amount of explosives allowed in an area (Courtesy U.S. Army, 2007)

Plate 6.26 Service magazine (World War II era with Cold War addition) at ammunition plant (Courtesy U.S. Army, 2007)

Plate 6.27 Typical access control point at ammunition plant, ca. 1950 (Photo courtesy Mason & Hanger Records, Eastern Kentucky University Archives, Richmond, KY)

Plate 6.28 Typical igloo door, note ground straps on both lower hinges (Courtesy U.S. Army, 2007)

Plate 6.29 Typical group lightning protection for aboveground magazines (Courtesy U.S. Army, 2007)

Plate 6.30 Typical shielding system of lightning protection at igloo storage (Courtesy U.S. Army, 2007)

Plate 6.31 Typical explosion-proof electrical connection on interior of igloo. A similar plug on the exterior was connected to a portable generator when electricity was needed inside the magazine (Courtesy U.S. Army, 2007)

Plate 6.32 Typical newly-constructed igloo storage, ca. 1953 (Courtesy U.S. Army)

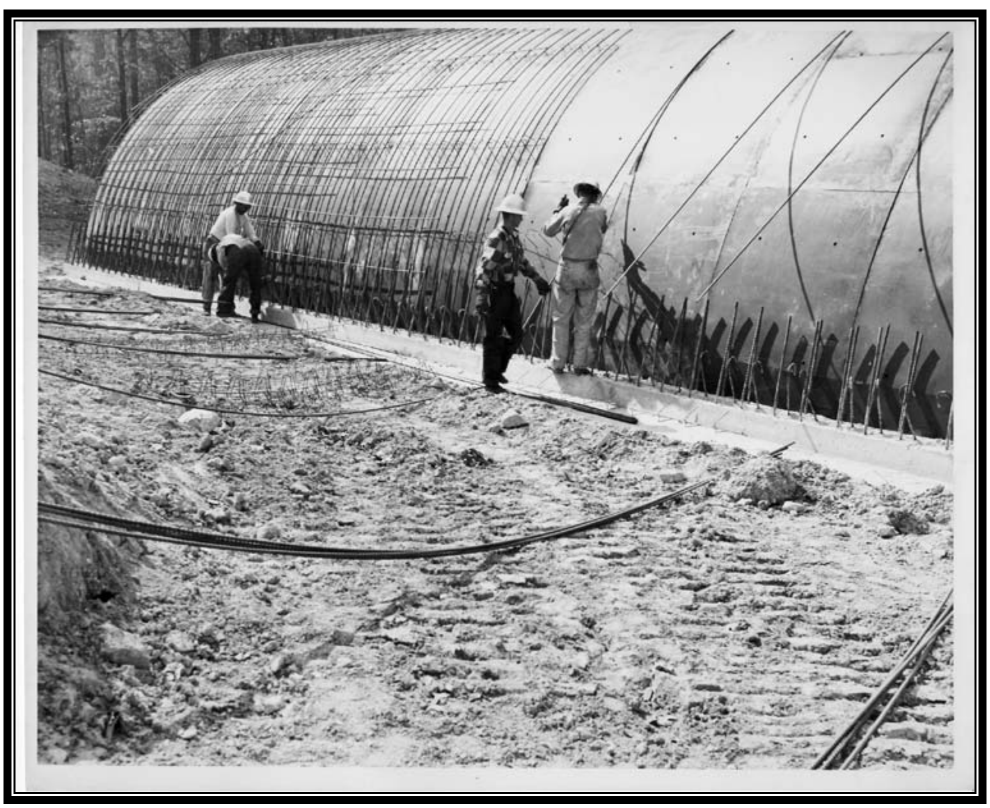


Plate 6.33 New igloo storage under construction with inner form in place and installation of reinforcing steel, ca. 1953 (Courtesy U.S. Army)

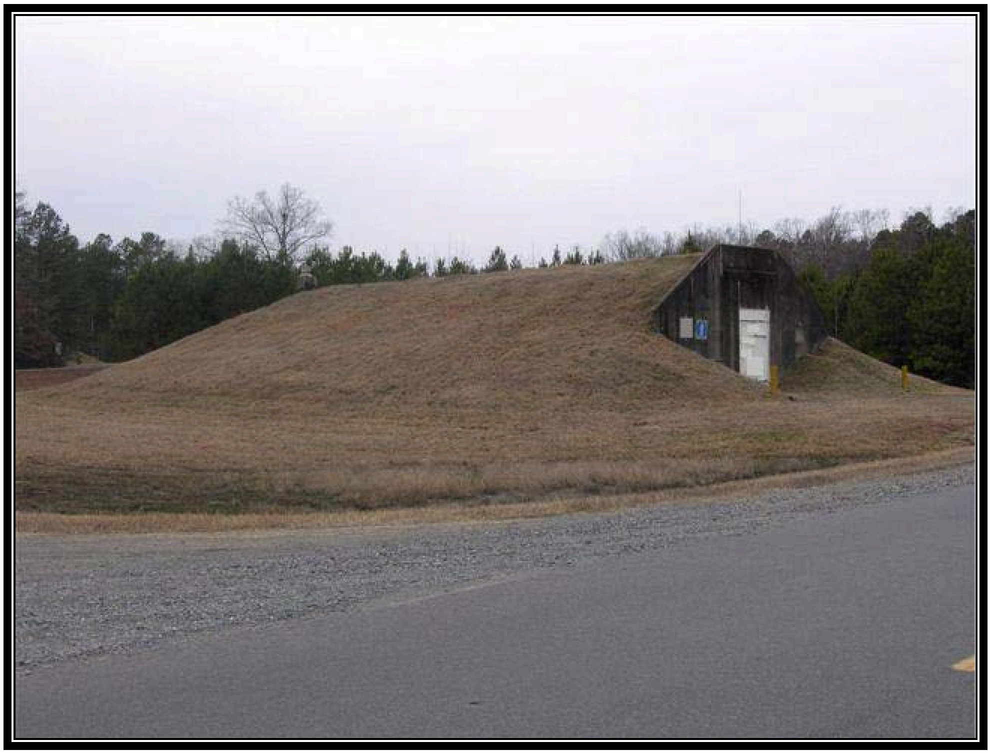


Plate 6.34 Typical igloo storage with truncated walls of the Huntsville type (Courtesy U.S. Army, 2007)

Plate 6.35 New igloo storage, ca. 1953 (Courtesy U.S. Army)

Plate 6.36	Typical igloo storage with long wing walls (Courtesy U.S. Army, 2007)

Plate 6.37	Typical earth-covered, rectangular smokeless powder magazines (Courtesy U.S. Army, 2007)

Plate 6.38 Typical igloo storage constructed during 1953 showing original, Huntsville types with new igloos built between (Courtesy U.S. Army, 2007)

7.0 ARMY AMMUNITION AND EXPLOSIVES STORAGE AFTER KOREA: 1954-1960

7.1 Introduction

Following the ceasefire in Korea on 27 July 1953, the Army once again transitioned to peacetime status, and ammunition and explosives storage policies were modified accordingly. During the post-Korea period, the Ordnance Corps maintained storage for all types of ammunition, rockets, guided missiles, bombs, mines, grenades, and pyrotechnic devices. The unstable international situation between Communist and democratic nations, as well as the transition from conventional weapons to guided missiles and atomic weapons, changed the nature of warfare and created new challenges within the Ordnance depot system. Although the Army recognized that conventional weapons remained important for contemporary warfare, lesser amounts of these weapons were produced as the focus shifted to developing a nuclear arsenal. Furthermore, some United States leaders promoted the idea of limited warfare, using conventional and low-yield atomic weapons, over the concept of massive retaliation. As a result, small atomic weapons were developed and produced concurrently with long-range guided missiles and rockets possessing nuclear warheads capable of massive destruction. These circumstances led to logistical problems for supply, distribution, and maintenance operations (NARA RG 544 Snodgrass 1957:1-3, 10,128-129).

The Ordnance Corps regularly analyzed supply operations in order to stay abreast of requirements for new weapons and changing warfare concepts, while taking into consideration the ongoing threat of atomic attack on the United States. For example, the Ordnance Corps initiated a project in 1953 for testing underground storage; however, a suitable storage site could not be located, and the project was canceled in 1957 (NARA RG 544 Snodgrass 1957:110, 123, 129). In May 1957 at Frankford Arsenal in Philadelphia, the Chief of Ordnance sponsored its first worldwide conference to enable Ordnance officers and essential civilian personnel to discuss improvements in "operations, policy guidance and procedures pertaining to supply, distribution, and maintenance in the United States and overseas" (NARA RG 544 Snodgrass 1957:120-121). The conference highlighted problems identified by various commands and sought solutions to those problems.

7.2 Ordnance Corps Operations

The threat of atomic attack on the United States increased the complexity of storage activities. Plans were proposed to replace the branch depot system with a general depot system wherein all Army depots would be designated general depots. In case of atomic attack, the same types of items would be stored at installations widely dispersed throughout the United States. This proposal was not adopted. The Army technical services maintained control over all depot stocks; however, the need for dispersal of supply facilities was recognized (NARA RG 544 Snodgrass 1957:112, 114-117, 129).

The Army streamlined operations by reducing the number of supply items. In addition, the number of depots decreased. In early 1954, an Army Depot Plan was formulated to select depots for inactivation, and the Ordnance Corps closed several depots each year. Despite the smaller number of depots, the Ordnance supply system retained the capability to support troops within the continental United States and overseas in the event of an atomic attack (NARA RG 544 Snodgrass 1957:112, 129; NARA RG 156 Baker 1956:40). By the end of June 1957, the following 20 Ordnance depots remained in operation, as shown in Plate 7.1 (NARA RG 544 Snodgrass 1957:4b; NARA RG 156 Department of the Army 1956:2-3):

Anniston Ordnance Depot, Anniston, Alabama
Benicia Arsenal, Benicia, California
Black Hills Ordnance Depot, Igloo, South Dakota
Blue Grass Ordnance Depot, Richmond, Kentucky
Erie Ordnance Depot, Port Clinton, Ohio
Letterkenny Ordnance Depot, Chambersburg, Pennsylvania
Mt. Rainier Ordnance Depot, Tacoma, Washington
Navajo Ordnance Depot, Flagstaff, Arizona
Pueblo Ordnance Depot (Army Special Weapons Depot), Pueblo, Colorado
Raritan Arsenal, Metuchen, New Jersey
Red River Arsenal, Texarkana, Texas
Rossford Ordnance Depot, Toledo, Ohio
San Jacinto Ordnance Depot, Channelview, Texas
Savanna Ordnance Depot, Savanna, Illinois
Seneca Ordnance Depot, Romulus, New York
Sierra Ordnance Depot, Herlong, California
Sioux Ordnance Depot, Sidney, Nebraska
Tooele Ordnance Depot, Tooele, Utah
Umatilla Ordnance Depot, Ordnance, Oregon
Wingate Ordnance Depot, Gallup, New Mexico

As of May 1956, most of these depots stored both ammunition and general supplies. San Jacinto and Wingate accommodated solely ammunition; Mt. Rainier and Rossford handled only general supplies. In addition, most depots had a guided missile mission. The exceptions were Navajo, Raritan, Red River, Rossford, San Jacinto, and Sioux. Pueblo Ordnance Depot was the only installation that dealt with special weapons (NARA RG 156 Department of the Army 1955a:7-8; NARA RG 156 Department of the Army 1956:3-5). By September 1958, Letterkenny Ordnance Depot also handled special weapons (NARA RG 156 Department of the Army 1958:6-7). In January 1959, Ordnance Corps Order 2-59 officially assigned special weapons missions to both Pueblo and Letterkenny Ordnance Depots and outlined the maintenance and supply responsibilities of each depot for atomic weapons and their non-nuclear components (NARA RG 156 Orzeck 1959b:36a).

Following the Korean Conflict, the Ordnance Corps Field Service Division maintained five main branches: Ammunition, Maintenance, General Supply, Requirements, and Operations. The Operations Branch handled the management program for the Field Service depot system. The Ammunition Branch held responsibility for stock control management, surveillance, maintenance, disposal, and packaging. By July 1957, the Ammunition and General Supply Branches of the Field Service Division were reorganized into the Ammunition Storage and Maintenance Branch and the Installations and General Supply Storage Branch. The Field Service Division continued to realign its branches along commodity lines rather than functional lines (NARA RG 544 Snodgrass 1957:113; NARA RG 156 Booz, Allen & Hamilton 1954:2).

The incorporation of special weapons into Ordnance Corps activities and the refinement of guided missiles systems led to the establishment of new units within the Field Service Division. As early as April 1953, Field Service branches were tasked with incorporating special weapons and materiel into their routine missions. In January 1955, the Ammunition Branch gained responsibility for non-nuclear atomic weapons, weapons components, and special design items of atomic weapons material. As a result, the Special Weapons Unit of the Technical Control Section, Ammunition Branch, Field Service Division, was established; a unit chief was assigned on 1 August 1955. The Ordnance Ammunition Command in Joliet, Illinois, assumed the

National Stock Control and Maintenance Point responsibilities for special weapons, while maintaining its regular duties of managing ammunition and explosives. In addition to the special weapons unit, the Guided Missile Unit of the Technical Control Section, Ammunition Branch, Field Service Division, was formed and a unit chief appointed on 15 July 1955. By November 1957, the Army Rocket and Guided Missile Agency at Redstone Arsenal, Huntsville, Alabama, served as the National Stock Control and Maintenance Point for guided missile ammunition (NARA RG 156 Matthews 1955:5; NARA RG 156 Baker 1956:4-6; NARA RG 156 Ordnance Corps 1954c:1,100, 2,100).

In December 1956, it was reported that the Ordnance Corps handled more than half of the total tonnage of all supplies shipped by the Army, and operated supply installations and activities in 21 states. By comparison, the volume of ammunition transported by the Ordnance Corps exceeded the amount of materiel in the Quartermaster Corps inventory, both shipments and in storage. The mission assignments comprised 31 storage sites, 19 conventional ammunition maintenance activities, 13 guided missile maintenance activities, one special weapons maintenance activity, 12 stock accounting locations, and 12 depot maintenance activities. Ammunition comprised over 50 percent of the total tonnage shipped by the Ordnance Corps, with other ordnance items such as trucks, tanks, and artillery making up the balance. The Ordnance Corps maintained 5,291,000 tons of ammunition worth approximately \$5.8 billion. Available storage space included more than 11,500 igloos and 750 aboveground magazines, as well as in open storage space equaling the length of a four-lane highway between Washington, D.C., and New York City (NARA RG 156 Office of the Chief of Ordnance 1956:9). In addition to Ordnance Corps depots, Chemical Corps depots also stored ammunition. In December 1956, Chemical Corps depots accommodated 228,000 tons of ammunition (NARA RG 156 Office of the Chief of Ordnance 1956:8-9; NARA RG 544 Snodgrass 1957:110, 115b, 117; NARA RG 156 Orzeck 1957b:26).

Ammunition storage installations were "directed to obligate quantities of conventional and guided missile ammunition for test purposes, surveillance programs, training use, national defense projects, foreign commitments, etc., prior to issuance of a shipping order (shipgo) or other disposition instructions" (NARA RG 156 Ordnance Corps 1954c:3,700). The Field Service Division monitored its ammunition supply from data recorded on monthly Ordnance Ammunition Stock Status Reports. In order to reduce supply accounting workloads, the form was modified in 1956 to reduce the frequency of assessments to a quarterly basis (NARA RG 156 Orzeck 1957a:72). Automatic data processing systems, which were designed to process stock accounting and accompanying financial records, began to be implemented in Field Service depots in 1957. Due to lengthy approval time, installation of these systems often did not occur until up to one year after the initial proposal (NARA RG 156 Orzeck 1959b:25-27).

The tonnage of ammunition stored and the available square footage of ammunition storage space at Ordnance Corps Field Service Depots during the years 1955 through 1959 are listed in Tables 7.1 and 7.2 (NARA RG 156 Baker 1956:35-36; NARA RG 156 Orzeck 1957a:45-46; NARA RG 156 Orzeck 1958:36-37; NARA RG 156 Orzeck 1959a:34-34; NARA RG 156 Orzeck 1960:51-52). The amount of ammunition stored decreased slightly in 1959. The ammunition storage space available in aboveground magazines and in igloos remained fairly constant; however, the amount of open space available for ammunition storage notably decreased in 1958 and 1959. This decrease was due to the elimination of vacant open space from the data used for computing the square footage of open ammunition storage (NARA RG 156 Orzeck 1959a:34-35).

Table 7.1. Ammunition Tonnage in Storage at Ordnance Corps Field Service Depots

Date	Ammunition Tonnage in Storage
31 December 1955	5,517,060
31 December 1956	5,765,272
31 December 1957	5,578,848
31 December 1958	5,354,472
31 December 1959	4,882,623

Table 7.2. Ammunition Storage Space Available at Ordnance Corps Field Service Depots

Date	Aboveground Magazine Space and Igloo Space (square feet)	Open Ammunition Space (square feet)
31 December 1955	30,473,000	26,492,000
31 December 1956	30,794,000	26,227,000
31 December 1957	30,424,000	24,505,000
31 December 1958	30,729,000	14,857,000
31 December 1959	30,670,000	11,888,000

By April 1959, Field Service depots stored a large backlog of ammunition slated for demilitarization. Insufficient funds and personnel prohibited timely demilitarization operations. On 1 April 1959, depots held 459,000 tons of unserviceable-uneconomically repairable or "otherwise non-required ammunition" (NARA RG 156 Orzeck 1959b:35). In July 1959, approximately 500,000 tons of ammunition awaited demilitarization. During the first quarter of FY 1960, $17 million was authorized for the demilitarization program. The Field Service Division anticipated a reduction in unserviceable ammunition and a more manageable backlog of approximately 100,000 tons by the end of FY 1961 (NARA RG 156 Orzeck 1960:42-43).

7.2.1 Space Utilization and Ammunition Storage

In the late 1950s, the types of ammunition storage facilities at Army installations basically remained the same as those utilized during the Korean Conflict. As described in *Ammunition Supply and Preservation* (ORDM 3-4) published on 3 May 1954 and revised up to 12 April 1957, ammunition and explosives were stored in igloo magazines, Corbetta magazines, standard aboveground magazines, or open storage sites. A new magazine, originally called a yurt but later named a Stradley, was introduced by October 1954. Yurts (Stradleys) were designed to accommodate large and/or heavy items, such as bombs or new series, rockets, JATOs and solid propellants for guided missiles, guided missile warheads, and conventional ammunition. Small arms ammunition sometimes was stored in warehouses (NARA RG 156 Ordnance Corps 1954d:5,200; NARA RG 156 Office of the Chief of Ordnance 1954:11-12).

Due to safety hazards, the Ordnance Corps did not advocate open ammunition storage sites except for certain types of bombs or for emergency situations, as authorized by the National Stock Control and Maintenance Point for Ammunition at the Ordnance Ammunition Command in Joliet, Illinois. Following the Korean ceasefire, a multitude of explosive-filled bombs, projectiles, and shells required storage; however, existing storage capacity could not accommodate the large quantity. As a result, numerous installations were granted permission to build standard covered unrevetted X sites and revetted Y sites for outside storage. X sites were unbarricaded and had temporary covers; they were used for the storage of ammunition in Classes 1, 3, 4, and 5. Y sites had six-foot-high earth barricades on four sides and either were covered or uncovered (Plate 7.2). Ammunition in Classes 5, 6, 7, 8, and 10 were stored in Y sites. Open sites were not considered permanent storage except when utilized for bombs (NARA RG 156 Ordnance Corps 1954d:5,200-5,200a, 5,255).

Permanent storage was "used for serviceable ammunition on which all necessary inspection has been completed, utilizing maximum density of storage space" (NARA RG 156 Ordnance Corps 1954d:5,200a). To avoid the costly transfer of munitions between installations, igloos, standard magazines, and warehouses sometimes were used for temporary storage of ammunition awaiting shipment. In such cases, the goal was to occupy 75 percent of the magazine in terms of tonnage; ammunition could be stored on pallets or hand stacked. In addition, the Army used concrete box service magazines for temporary storage (NARA RG 156 Ordnance Corps 1954d:5,200-5,200a).

During the post-Korea period, Ordnance depots continued to file monthly Ammunition Storage Occupancy Reports as they had done during wartime. These reports were forwarded to the appropriate National Stock Control and Maintenance Point, represented by either the Ordnance Ammunition Command for conventional ammunition or Redstone Arsenal for guided missile ammunition. In 1957, net usable storage space was computed as shown in Table 7.3 (NARA RG 156 Ordnance Corps 1954c:4,105).

Since 1950, net usable storage space had increased 66 square feet for a 40-foot arch-type igloo, 80 square feet for a 60-foot arch-type igloo, and 80 square feet for a 52-foot dome-type igloo. (See Table 5.2 for comparison.) This increase in storage space resulted from revised storage methods that sacrificed ease of handling to obtain a maximum amount of storage space (NARA RG 156 Ordnance Corps 1954d:5, 235).

Table 7.3. Net Usable Area of Ammunition Magazines

Type of Magazine	Square Footage per Magazine
40-foot igloo, arch type	1,069
60-foot igloo, arch type	1,608
80-foot igloo, arch type	2,147
Standard magazine	10,335
44-foot 7-inch igloo, dome type	1,521
52-foot igloo, dome type	2,088
High-explosives magazine	960
Smokeless powder magazine	2,871
8-foot 4-inch powder magazine	40

In order to utilize magazine space most efficiently, depot officials were advised to carefully pre-plan each storage operation. The largest ammunition lot was stored in the rear of the magazine, while the small lots were placed in the front. All lots were placed so that ammunition from one lot could be removed from the magazine without rearranging other lots. If a lot of ammunition was large enough to require storage in more than one magazine, the lot locations were preferably in the same block of magazines to facilitate storage and surveillance operations. Complete stocks of an item, however, were distributed among numerous magazine blocks (NARA RG 156 Ordnance Corps 1954d:5,220). Each lot of ammunition was identified by a Magazine Data Card visibly placed on an end stack. The card identified quantity, nomenclature, and lot number and recorded all activity involving the ammunition. Alphabetical suffixes were assigned to original lot numbers when ammunition components were modified or added. Magazine Data Cards were cross-referenced when numerous portions of the same lot were stored separately (Plate 7.3) (NARA RG 156 Ordnance Corps 1954d:5,235, 5, 240, 7, 325).

Procedures for permanent ammunition storage in any type of facility followed drawings periodically published in the "List of Current Storage and Outloading Drawings" produced by Savanna Ordnance Depot (NARA RG 156 Ordnance Corps 1954d:5,200-5,200a). By 1957, the Ordnance Corps issued peacetime storage drawings in the 19-48-3000 and 19-48-4000 series to replace wartime drawings in the 19-48-1000 series. The new drawings increased storage volume in igloo magazines by approximately 18 to 30 percent. The 3000 series drawings depicted a side-aisle arrangement. Most types of ammunition were stored in accordance with the 3000 series drawings. The 4000 series drawings utilized a modified center aisle and pertained only to boxed ammunition in igloo magazines, standard magazines, and warehouses. In contrast, the 1000 series drawings for boxed ammunition stored in igloos utilized a block side-aisle or a full center-aisle configuration. Transition to the new modified center-aisle method was not authorized immediately and was to be performed only during normal maintenance, modification, renovation, or storage of tonnage receipts (NARA RG 156 Ordnance Corps 1954d:5,215).

The Ordnance Corps determined specific regulations for storing boxed ammunition in igloo magazines utilizing the new modified center-aisle configuration. Small and large lots of ammunition often occupied the same igloo. The center aisle was approximately 30 inches wide and ran from the front door to the first large lot, which filled the entire width of the igloo. Small lots were placed on one side of the center aisle to be readily accessible. Boxes were stored without touching the side walls and close to, but not over, the drains that ran along the base of the longitudinal walls. Boxes were stacked three to six inches from the end walls and as near to the front door as possible. Dunnage was placed under the bottom row of ammunition boxes and was required between layers of cleated boxes, but not between layers of uncleated boxes unless moisture content was high (NARA RG 156 Ordnance Corps 1954d:5,215-5,215a). For some types of ammunition, the Ordnance Corps continued to advocate the use of palletization for maximum efficiency in storage and handling, and drawings were issued for the construction of pallets (NARA RG 156 Ordnance Corps 1954d:5,290).

Peacetime storage regulations designated the type of magazine to be used for various classes of ammunition. Certain magazines and warehouses accommodated Class 1 small arms ammunition and/or inert ammunition items; both materials could be stored together in warehouses as long as they were separated by firewalls. General supplies were not permitted to be stored in warehouses containing Class 1 ammunition. Warehouses storing Class 1 ammunition preferably had masonry or metal walls, utilized noncombustible building materials, and contained up to 44,000 square feet of space (NARA RG 156 Ordnance Corps 1954d:5,235, 5,245).

Igloo magazines typically were used for most other types of ammunition; however, in order to provide maximum storage capacity, standard unrestricted magazines were utilized for fast-moving Class 4 artillery ammunition. Storage in igloo magazines was dictated by igloo size and how effectively the ammunition could fill the entire space. Boxed Class 4 ammunition, separate-loading shell, and propelling charges occupied 80-foot igloos; bombs were stored in 60-foot igloos; and demolition materiel and bulk explosives were placed in 40-foot igloos (NARA RG 156 Ordnance Corps 1954d:5,235).

Various storage details pertained to different types of munitions. Bombs occupying igloos were supported by steel or wood dunnage, had shipping bands in place, and were configured with inspection aisles on both ends (Plate 7.4). Two 6,000-pound-capacity electric forklifts were recommended for handling 10,000- or 12,000-pound bombs (NARA RG 156 Ordnance Corps 1954d: 5,105, 5,235a, 5,250). Pyrotechnic materials required storage in dry and well-ventilated igloos (NARA RG 156 Ordnance Corps 1954d:5,260, 5,270). If igloo magazines met certain requirements, the limit of 250,000 pounds for Class 9 or 10 explosives could be increased to 500,000 pounds with the approval of the Office, Chief of Ordnance (NARA RG 156 Ordnance Corps 1954d:5,230). Igloos, aboveground magazines, and warehouses containing gas grenades, shotgun shells, and certain types of small arms ammunition featured special door locks; Ordnance personnel centrally controlled the keys, which could be signed out only by authorized individuals (NARA RG 156 Ordnance Corps 1954d:5,210).

Certain types of ammunition and ammunition components were classified as top secret, secret, or confidential and had to be stored accordingly. For example, ammunition and most components, as well as inert items, typically were unclassified items. Proximity (VT) fuzes generally were designated as classified materiel for storage, handling, and transportation purposes. Classified ammunition items were stored separately from unclassified items in magazines that met quantity-distance standards. Classified bulky inert materiel was placed in warehouses or standard aboveground magazines. Storage locations accommodating top secret items were identified as "Exclusion Areas," while those containing secret or confidential materiel were known as "Limited Areas." Personnel periodically conducted security checks of the locks on storage facilities containing classified ammunition (NARA RG 156 Ordnance Corps 1954d:5,205).

In addition to recommended storage methods, the Ordnance Corps also provided regulations for the loading of ammunition onto rail cars. Ammunition shipments were carloaded and braced in accordance with Ordnance Corps drawings or pamphlets published by the Bureau of Explosives. Ammunition and explosives were loaded in rail cars in "tight loads," meaning that items were hand tight or braced-wedge tight with no free spaces between items in rows; this arrangement prevented lengthwise movement. (NARA RG 156 Ordnance Corps 1954d:5, 300, 5,305).

7.3 Ammunition Surveillance and Inspection

During the post-Korea period, ammunition surveillance procedures basically remained the same as those used during the Korean Conflict. The Chief, National Stock Control and Maintenance Point for Ammunition at the Ordnance Ammunition Command maintained operational control for ammunition surveillance at major Ordnance Corps installations (NARA RG 156 Ordnance Corps 1954d:6, 105). Ordnance drawings and specifications provided standards for inspections, atmospheric data was recorded daily, and Depot Surveillance Record (DSR) cards were maintained. Igloos, standard aboveground magazines, and warehouses storing ammunition were inspected on a monthly basis; chemical ammunition magazines were examined at least once per month (NARA RG 156 Ordnance Corps 6,125-6,125m, 6,140, 6,110, 6,145).

Percentage inspections of ammunition samples were performed for incoming shipments of newly manufactured ammunition and for outgoing shipments if an annual inspection had not been conducted within the previous 12 months. The sample range varied from one percent to 100 percent, depending upon conditions. Most types of stored ammunition required annual percentage inspections; however, chemical ammunition underwent semi-annual inspections. The condition of packing and packaging containers in closed storage facilities also was noted (NARA RG 156 Ordnance Corps 1954d:6,115, 6,120, 6,125). Ammunition packages used in open storage were inspected regularly for damage; in addition, the packaged ammunition in open storage underwent a percentage inspection every 90 days. For bombs in open storage, a percentage inspection of closing plugs was conducted semi-annually, and fuze cavities were assessed for moisture, rust, or corrosion. In addition, open storage sites were examined following unusual weather events (NARA RG 156 Ordnance Corps 1954d:6,150-6,150a).

The Ordnance Ammunition Command, Aberdeen Proving Ground, Frankford Arsenal, and Savanna Ordnance Depot worked together to finalize a new surveillance plan for conventional ammunition in February 1959. The Ordnance Corps distributed the new plan to Field Service ammunition depots in March 1959 (NARA RG 156 Orzeck 1959b:35). By December 1959, Frankford Arsenal had proposed a new surveillance plan for small arms ammunition. After final approval and pre-trial testing at two establishments, the small arms ammunition plan was incorporated into the new surveillance plan for conventional ammunition (NARA RG 156 Orzeck 1960:43).

7.3.1 Guided Missile Storage

Following the Korean Conflict, the Ordnance Corps Field Service Division instituted policies for guided missile ammunition support depots. On 30 March 1954, technical and supply support for guided missiles was assigned to various Field Service depots (see Table 7.4) (NARA RG 156 Sierra Ordnance Depot 1955:Appendix A). Installations receiving guided missiles for the first time underwent extensive preparations. For example, Sierra Ordnance Depot had three months to learn how to handle guided missiles prior to their arrival in March 1954. Sierra sent three representatives to Pueblo Ordnance Depot to observe guided missile operations. After this training, they designed new Standard Operating Procedures (SOPs) and flow charts, developed special firefighting procedures, and directed modifications to igloos for storage (NARA RG 156 Sierra Ordnance Depot 1955:2).

Table 7.4. Guided Missile Support Assignments on 30 March 1954

Guided Missile Assignment	Field Service Depot
NIKE Storage and Issue	Seneca Ordnance Depot Letterkenny Ordnance Depot Savanna Ordnance Depot Pueblo Ordnance Depot Sierra Ordnance Depot
CORPORAL Storage and Issue	Letterkenny Ordnance Depot Sierra Ordnance Depot Pueblo Ordnance Depot
HONEST JOHN Storage and Issue	Blue Grass Ordnance Depot Tooele Ordnance Depot

The first NIKE missiles to arrive via boxcar at Sierra Ordnance Depot were bundled in groups of three and transported to standard magazines using forklifts. A short cable secured each top-heavy bundle to the mast of the fork (Plate 7.5). Sierra personnel expended 64 manhours per car to unload the first four carloads of guided missiles. As they became more experienced, the workmen performed the task in about five manhours. Due to an accident involving a bundle that tipped over before being secured to the forklift mast, a stabilizer was designed for attachment to the NIKE missile (NARA RG 156 Sierra Ordnance Depot 1955:2).

The early NIKE missile, known as the NIKE AJAX, used liquid propellants known as inhibited red fuming nitric acid (IRFNA) and unsymmetrical dimethylhydrazine (UDMH). These fuel components were stored at Sierra in four 60-foot igloo magazines modified with ventilator systems. Individual drums of IRFNA were transported from cars to vans using aluminum dollies; the vans then were transported and unloaded into the igloos. Workmen expended 80 manhours unloading the first car. Revised methods in handling, such as the design of a two-wheeled cart, significantly reduced unloading time (Plate 7.6). Storage of batteries for the NIKE missiles also presented problems at Sierra. The shape of battery boxes prohibited them from being stacked; therefore, the first shipment of batteries was placed on the magazine floor, consuming substantial space. To increase storage efficiency while protecting the batteries from damage, racks with shelves were constructed for the magazines (Plate 7.7) (NARA RG 156 Sierra Ordnance Depot 1955:5-7).

In November 1954, the Office of the Chief of Ordnance revised guided missile assignments. Blue Grass, Letterkenny, Pueblo, Savanna, Seneca, and Tooele Ordnance Depots retained their guided missile missions as assigned in March 1954. Sierra Ordnance Depot lost its CORPORAL mission, but retained responsibility for NIKE missiles. Anniston Ordnance Depot received a CORPORAL mission. Benecia Arsenal and Black Hills, Mount Rainier, and Umatilla Ordnance Depots gained NIKE missions. Erie Ordnance Depot was assigned both a CORPORAL and NIKE mission. All new missions involved reserve storage for the missiles, components, or propellants. Some missions entailed only the routine inspection and maintenance afforded to other types of ammunition, while others included the complete renovation of guided missiles that required the disassembly, inspection, repair, or refueling of the missile (NARA RG 156 Hinrichs 1954:2-4).

The Department of the Army issued an Ordnance Support Plan for Guided Missiles and Associated Equipment on 15 July 1955. The “complete rounds (missiles as fired) and all separately packaged components required to assemble complete rounds” were considered ammunition items for supply purposes (NARA RG 156 Department of the Army 1955b:1). The non-explosive parts of a guided missile were designated general supply items, as well as the associated guidance, launching, and handling equipment. Guided missiles, their explosive components, and fuels generally were stored separately. Benecia Arsenal and Erie, Letterkenny, Mount Rainer, and Pueblo Ordnance Depots were tasked with the storage and issue of guided missiles without explosive components and fuels. These establishments performed depot pre-storage inspection, in-storage inspection, depot pre-issue inspection, and repair and rebuild operations as necessary. Anniston, Black Hills, Letterkenny, Pueblo, Savanna, Seneca, and Sierra Ordnance Depots handled storage and issue of explosive components, fuels, and oxidizers except for JP-4 and liquid oxygen. Depot maintenance and renovation of NIKE and CORPORAL explosive components occurred only at Anniston, Letterkenny, and Pueblo Ordnance Depots (NARA RG 156 Department of the Army 1955b:11-12, Annex 1, Annex 2).

Due to the size of guided missile ammunition items and the desire to efficiently utilize space, depot personnel pre-planned storage operations in accordance with Ordnance Corps drawings and policies. In general, regulations pertaining to conventional ammunition were followed for guided missile ammunition with the exception that inspection aisles were required for guided missile items. Furthermore, guided missile ammunition used the same handling equipment as conventional ammunition, with the addition of “slings, strongbacks, sisterhooks, winches, cranes, plane loaders, and other heavy equipment” for large and heavy guided missile ammunition items (Ordnance Corps 1955:8, 210, 215).

As outlined in *Ammunition Supply and Preservation* (ORDM 3-4) in September 1959, guided missile ammunition components occupied general purpose warehouses, standard aboveground magazines, and igloo magazines. In all circumstances, maximum storage quantities were dictated by quantity-distance tables. Warehouses and restricted aboveground magazines were only used for inert components. Rocket motors, warheads, and other explosives typically were stored in 80-foot igloos. Special-purpose storage shelters accommodated liquid fuels and oxidizers; storage of these materials in igloos required the authorization of the Army Rocket and Guided Missile Agency at Redstone Arsenal (Plate 7.8). With the exception of igloo magazines, storage facilities containing liquid oxidizers required a surrounding 50-foot firebreak with no vegetation or combustible material present. Outdoor storage was permitted for empty guided missile containers and for unserviceable inert missile bodies slated for repair or rebuilding (Plate 7.9) (Ordnance Corps 1955:8,200, 2,225, 8,240).

Earth-covered magazines were the preferred location for the storage of guided missiles. The reinforced concrete of the magazine combined with the earthen covering offered advantages. For example the inside temperature of the magazine remained relatively stable throughout the year minimizing possible damage from extreme heat or cold.

Guided missile ammunition items were packed in metal containers designed for re-use or in wooden boxes. Ammunition boxes were strapped prior to storage or shipping, preferably using flat, galvanized steel strapping. Strapping could be performed inside the magazine or immediately outside on the magazine apron or at a nearby location. Metal containers or wooden boxes containing rocket motors for guided missiles and large rockets were marked with temperature limits. When stored, these ammunition items were pointed in the same direction within the storage facility except when an igloo was utilized. Items in igloo storage were pointed towards a barricaded wall of the igloo. Rocket motors could be stored with installed igniters, which generally contained over two pounds of double base propellant and/or black powder. Igniters also could be stored separately in boxes placed in igloos (Ordnance Corps 1955:8,230, 8,235, 8,270, 8,275). Metal drums filled with guided missile liquid propellants could be stored safely using metal pallets such as those utilized by the Bureau of Ordnance, Department of the Navy (NARA RG 156 Orzeck 1957b:60).

Wooden boxes containing guided missile ammunition were carefully examined for moisture, mold, mildew, fungi, or rot. If personnel observed moisture on a box, dunnage was used to expose all surfaces to the air, and the magazine was kept well ventilated. The discovery of wet or moldy boxes necessitated a temperature check of the magazine. The confirmation of high temperatures prompted the magazine to be placed under close surveillance with daily temperature readings; personnel reported abnormally high temperatures to Redstone Arsenal. The presence of boxes with fungi, mildew, or rot also was communicated to Redstone Arsenal; such boxes were marked for priority issue (Ordnance Corps 1955:8,270.)

Storage facilities containing guided missile ammunition items underwent formal monthly inspections by a team of two people. For safety purposes, one person remained immediately outside the entrance in case help was needed. Complete protective clothing comprising a suit, hood, mask, gloves, and boots was available during all operations involving liquid propellants; however, this clothing only was used when personnel detected odors or exposed propellants (Plate 7.10) (Ordnance Corps 1955:9,140, Appendix A9,300).

7.4 Design and Construction of Ammunition Storage Facilities

During 1952, the Ordnance Corps began planning the construction program for FY 1954. The Chief of Ordnance desired that installation expansion only occur at those major Ordnance establishments slated for permanent retention (NARA RG 156 Baldwin 1952a:Inclosure 1). The construction of new ammunition and explosives storage facilities was influenced by requirements for approved production schedules. The need for these storage facilities depended upon "justification statements depicting quantities and dates of production, computation of service-wide requirements and use of existing facilities" (NARA RG 156 Baldwin 1952b:Inclosure 1). If standard drawings did not exist for proposed construction projects, the Office of the Chief of Engineers prepared new drawings using design criteria furnished by Ordnance installation commanders (NARA RG 156 Baldwin 1952c:Inclosure 1). Delays in the obligation of construction funds appropriated during the Korean Conflict continued to impact the entire program after the ceasefire (NARA RG 156 Ford 1953). Nevertheless, on 7 August 1953, Public Law 209 of the FY Construction Authorization Act appropriated $133,671,000 in new funds for the Army's military construction program (NARA RG 156 Bergin 1953). Details of selected Ordnance Corps projects are summarized in Table 7.5. Most of these projects were for the construction of igloos (Plate 7.11).

Table 7.5. Construction at Selected Installations (NARA RG 156 Ordnance Corps 1954e, 1955)

Location	FY Authorized	Year Completed	Type	Cost
White Sands	1950	1954	One Igloo Storage	148,000
White Sands	1952	1954	Eight Igloo Storage	160,000
Wingate	1952	1954	80 Igloo Storage	
Tooele	1952	1954	100 Igloo Storage	
Redstone	1954	1955	One storage magazine	3,000
Letterkenny	1954	1956	100 Igloo storage	3,350,000
Picatinny	1955	1956	Four installation level magazines	30,000
White Sands	1955	1955	Liquid propellant storage	375,000

In addition to the ammunition storage facilities depicted in Table 7.5, the Act authorized the construction of 478 Stradley magazines at one installation in FY 1955. The Stradleys were completed in 1958 at a cost of $14,400, 000 (NARA RG 156 Ordnance Corps 1954e, 1955).

Other activity in the FY 1954 program included a design directive issued in December 1952 for three concrete igloo magazines at Aberdeen Proving Ground. The Ordnance Corps required the igloos for training military personnel in storing, handling, renovating, and transporting ammunition; current facilities were described as "crude, makeshift arrangements which hamper[ed] instruction programs" (NARA RG 156 Department of the Army 1952). The new igloos were to follow standard designs—measuring 26 feet 6 inches by 60 feet 8 inches, encompassing 1,620 square feet each, and having concrete floors. The projected cost for each igloo was $26,500; a total appropriation of $80,000 was requested. Construction of the three igloos at Aberdeen was approved by the Secretary of the Army, and the request was forwarded to the Secretary of Defense for clearance in February 1953 (NARA RG 156 Department of the Army 1952; NARA RG 156 Ordnance Corps 1953).

These construction projects followed plans that in many cases were more than 15 years old. Between the end of World War II and the Korean Conflict, the Army had not revised its standards for magazine construction. Most of the ammunition storage facilities constructed in the late 1940s and early 1950s comported with plans developed in 1941 with minor variations to suit a particular site. In many cases, the older plans simply were traced and a new title block created. Other storage buildings, such as those for liquid propellants, were specially designed to suit a research or testing purpose (Plate 7.12). As the number of requests for standardized plans increased, the Chief of Ordnance drafted new guidelines for "For Construction and Operation of Ammunition Magazine Areas" in 1954. Nine factors for selecting the type of magazine were established: 1) protection from dampness and extreme temperatures; 2) local climate; 3) character and magnitude of explosive hazards for ammunition type; 4) degree of isolation of storage site and available land; 5) similarities and differences of the stored ammunition as it relates to sympathetic explosions; 6) quantity, area required per unit of quantity, and degree of separation for the type of ammunition; 7) dimensions of ammunition types, stacking methods, and scale of storage operation; 8) need for protection from enemy action; and 9) comparative cost and availability of materials and skilled labor. The Chief of Ordnance defined seven general types of magazines based on construction method, size, and use (NARA RG 156 Office of the Chief of Ordnance 1954:1-4).

Subterranean Magazines: "These are completely underground and are usually accessible only by elevator. They are built where protection from enemy action is highly important . . . or where aboveground structures would constitute flight hazards (as at air strips) or would interfere with the field of fire of a weapon. They provide uniform cool temperatures, are dry if properly constructed, are suitable for all types of ammunition and explosives require lesser safety distances than any other type of magazine. They are not built where other types of magazines will suffice since the construction cost is very high."

Hillside Magazines: "These are tunneled into a hillside so as to be completely underground except at the front end" (NARA RG 156 Office of the Chief of Ordnance 1954:2). Like the subterranean magazine, hillside construction was considered acceptable for all ammunition types, and provided good protection from enemy actions. The only limitation was finding areas with suitable terrain (Plate 7.13).

Mounded Magazines (High Type): "High-type mounded magazines have shells of reinforced-concrete with arched roofs, and incorporate complete safety features" (NARA RG 156 Office of the Chief of Ordnance 1954:2). Mounded magazines were the standard type for all large depots and the most secure magazine type that could be constructed in large numbers. All types of ammunition could be stored in the high-type mounded magazine. This magazine form followed closely on the earth-covered barrel-vaulted igloo of World War II. Mounded magazines were moderately expensive to build.

Mounded Magazines (Intermediate Type): Similar to the high-type mounded magazines, the intermediate type could take two forms: reinforced-concrete walls with a concrete roof, or prefabricated steel arches set on a concrete foundation. Both types were earth covered. Intermediate types held smaller quantities of ammunition and required greater safety distances than the high type. Another disadvantage was that the steel arch variant was difficult to waterproof. They were, however, suitable for the same types of ammunition and bulk explosives as the high type, and were considerably less expensive to construct.

Ammunition Shelters: Ammunition shelters were arched-roof, prefabricated-steel, smaller buildings intended for field or garrison use as an alternative to open dumps or other shelters. Generally, ammunition shelters were not earth-covered, but if it was it could be considered a low type mounded magazine. Ammunition shelters were not acceptable where a high degree of safety was needed, or where multiple types of ammunition were stored in the same area.

Ammunition Storehouses: Ammunition storehouses are the standard above-ground magazine of the World War II era, generally constructed of brick or hollow tile and topped by a gable roof. Wood, sheet-metal, and asbestos sided buildings were also constructed as ammunition storehouses during World War II, but were considered substandard by the Chief of Ordnance by 1954. Originally used to store a variety of completed ammunition, they were now recommended only for small arms and inert materials. They were not recommended for other munitions types as they would not prevent sympathetic explosions, experienced wide seasonal temperature fluctuations, needed extreme separation for safety, and provided no protection from enemy actions (Plate 7.14).

Ammunition Open Storage Sites: These were cleared areas used to store ammunition in the open. They were sometimes paved and frequently surrounded by an earth barricade. They were recommended only when other magazine types could not be constructed, or for short-term storage.

Special Magazines: The Chief of Ordnance also defined a category of magazines designed and constructed for specific functions. These included:

- "anti-aircraft artillery battery magazines and ready boxes have been designed to prevent the escape of missiles in the event of an explosion of a limited quantity of artillery ammunition, and are intended for use at anti-aircraft battery positions in metropolitan areas where the magazine cannot be separated from habitations, etc., by the normal safety distances; that were designed to prevent the escape of guided missiles and were intended for use in metropolitan areas where safe separation could not be achieved;
- constant temperature magazines have thermostatically controlled heating for keeping propelling charges at the prescribed temperature for proof-firing (Plate 7.15);
- heated magazines and ready boxes have been built for underwater storage of bulk initiating explosives storage of proximity fuzes, etc;
- field ammunition shelters and improvised bunkers are used in combat storage;
- liquid propellant storehouses are built for storage of liquid fuels and oxidizers for guided missiles;
- casemate magazines are shell and powder storage rooms in fortifications" (NARA RG 156 Office of the Chief of Ordnance 1954:1-15).

All other magazine types were considered obsolete or sub-standard and were no longer considered for new construction. These included the Corbetta Beehive, Huntsville, pre-war types of igloos, Richmond magazines, and virtually all above ground types other than those listed above (NARA RG 156 Office of the Chief of Ordnance 1954:15).

These guidelines applied to construction at both installations and depots. The main difference in construction was in the size and number of magazines. Ammunition storage at the installation-level was only needed for immediate training and operating needs. Installation-level storage was generally smaller, and fewer were required. The same quantity distance standards applied, but the amount of ammunition was less, and magazines were typically closer together. Ease of construction, cost, and the reduced chance of damage from enemy actions allowed installations to construct greater numbers of intermediate-type mounded magazines than were constructed at depots.

The Ordnance Department provided standardized drawings for all the recommended ammunition storage facilities and general guidance on construction methods. The exception to this was non-standard, custom designs for special needs such as at proving grounds and test ranges. The greatest attention was given to the high type of mounded magazine as it was envisioned as the standard design that would be constructed in the greatest numbers. The philosophy behind the design was that in the event the contents exploded, the main force of the blast would be directed upward through the roof of the magazine (Plate 7.16). For this reason, the concrete was thick at the foundation and thin at the crown of the vault. A heavier coating of earth along the sides of the shell helped prevent the force of the explosion from extending laterally. Should an explosion occur, there was little doubt that the individual magazine would be completely destroyed, but by controlling the direction of the blast, it would not lead to a chain-reaction with the explosion of nearby magazines. The mounded magazine was designed to withstand the force of an explosion equivalent to 500,000 pounds of explosives in another magazine 185 feet away. The weakest point of the structure was the exposed front wall which was constructed to survive the same explosion at a distance of 360 feet. If necessary, an earth and concrete barricade was constructed opposite the door for added protection. The earth covering helped prevent heavy pieces of reinforced concrete from an exploding magazine from penetrating the shell of another (NARA RG 156 Office of the Chief of Ordnance 1954:8-12).

The mounded magazine also incorporated protection from lightning, static discharge, and fire. The individual pieces of reinforcing bar used in the construction of the shell were welded to each other forming a “Faraday cage” (Plate 7.17). The cage was then grounded or connected to an underground wire that encircled the magazine, also known as a “counterpoise.” The entire assembly created a uniform field integral to the shell that efficiently grounded any electrical charge. Fire was also a concern. The majority of the ammunition depots were located in rural areas, oftentimes heavily wooded or on open grassland. Wildfires were a constant threat. While a fire would not damage the concrete shell, or penetrate the steel doors of the magazine, ventilation was required to remove fumes and any water that seeped into the storage area. The only acceptable method of ventilation was the natural flow of air through open vents in the front wall or door, and an exhaust stack at the rear of the magazine. If fire approached the magazine, fusible links holding open the front and rear dampers would melt and counterweights automatically closed the dampers and sealed the magazine (Plate 7.18) (NARA RG 156 Office of the Chief of Ordnance 1954:10).

In its draft on the construction and operation of ammunition storage areas, the Ordnance Corps identified two, high type mounded magazines: the igloo and the yurt. The igloo was the standard magazine type constructed in great numbers during the World War II era. While the igloo satisfied many of the objectives for ammunition storage established by the Ordnance Corps, such as security and safety, they had one disadvantage: the curvature of the barrel vault limited the volume of the magazine available for storage. As the size and weight of munitions increased with the rapid development of weapons systems such as guided missiles, it became apparent that the ideal magazine shape would have vertical side walls with a flat roof. This however ran counter to the explosion containment philosophy of the barrel vault. The solution was a magazine design with vertical walls topped by an elliptical arch. The new magazine was named the yurt for its visual similarities to the portable housing of nomadic Asians (Plate 7.19). Like the barrel-vaulted igloo, the concrete of the yurt was thinnest at the crown of the arch, and only the front wall was not earth covered. Access to the yurt was through an eight-foot wide by nine-foot high doorway that allowed efficient handling of large objects with forklifts. The Ordnance Corps planned on three sizes of yurt: 285, 433, and 582 cubic meters; however, no evidence suggests these sizes were ever built. Although the barrel-vaulted magazine would still be an option for smaller installations, they would not be constructed at any major depot. When the draft standards were developed in 1954, plans for the yurt were under development and not available for distribution. The yurt was later renamed for its designer, Earl B. Stradley (NARA RG 156 Office of the Chief of Ordnance 1954:12).

General guidelines for auxiliary buildings and depot layout were also addressed in the draft prepared in 1954. Shipping and receiving facilities for rail traffic required an inbound interchange track where Army locomotives received railcars from the serving railway. After passing over a pit where individual cars were inspected for defects or evidence of tampering, the train was broken up in a classification yard for distribution to centrally located ammunition transfer platforms at the installation. Ammunition was then moved by truck to the various storage facilities. The Army felt it too expensive to construct rail sidings to individual magazines. Trucks delivering explosives were also carefully inspected when entering or leaving a depot. Other facilities for the movement of ammunition included the less than carload (LCL) building. These buildings, served by both highway and rail, housed inspection, classification, reconditioning, repacking, and shipment of small lots of miscellaneous ammunition (NARA RG 156 Office of the Chief of Ordnance 1954:4-5).

As the mission of many depots shifted from the hectic pace of shipping and receiving hundreds of tons of munitions during World War II, to one of long-term storage and monitoring, additional ammunition handling facilities were needed. Surveillance buildings were used for the periodic inspection of munitions to determine if they were serviceable, needed reconditioning, or should be destroyed. Normal maintenance such as repainting or minor repair was completed in ammunition maintenance or cleaning and painting buildings (Plate 7.20). Many depots included facilities for ammunition renovation or demilitarization. Many of the operations paralleled those for the manufacture of new munitions and included several, widely-spaced buildings connected by ramps. The disassembly building used remote control equipment to remove the nose and base closures. Closed circuit television allowed an operator in a remote bombproof building to operate the equipment. Various components of the ammunition could be recovered for re-use including the explosives and brass casings. A "popping furnace" burned out any residual explosives prior to re-using or scrapping the brass (Plate 7.21). Ammunition that could not be safely or easily demilitarized was transported to a demolition area where it was buried and exploded. Loose propellants or explosives resulting from demilitarization activities were placed in metal trays at a burning ground and ignited. Service magazines and safety shelters were associated with each of these activities. Safety shelters (also referred to as bombproofs, fallout shelters, or foxholes) were scattered throughout the magazine areas where personnel could seek shelter in the event of an accident (Plate 7.22) (NARA RG 156 Office of the Chief of Ordnance 1954:5-7).

In addition to buildings directly related to the storage and handling of explosives, depots had numerous support buildings. A typical collection included an administrative area containing the headquarters, fire house, guard house, dispensary, and housing; an industrial area with carpenter and mechanic shops, a heavy equipment repair shop, a locomotive storage and repair facility, a boiler house and steam plant, and several warehouses; and a warehouse area for the storage of inert materials. Many of these dated from the World War II era (Plates 7.23 and 7.24).

The ultimate effect of the 1954 draft report is unclear. Many of the recommendations in the report were not implemented, as the numbers of newly-constructed magazines continued to decline throughout the second half of the twentieth century, and the Army did not plan on building additional depots. The prohibition on igloo-type mounded magazines did have some effect. One hundred of this type was completed at Letterkenny Arsenal in 1955, but it is likely these were in the design and construction phase prior to the Chief of Ordnance's report. After construction of the depot-level igloos at Letterkenny, few of this type were constructed; however, this magazine form continued in use at the installation level, and was constructed at active Army installations, airfields, proving grounds, and ammunition plants.

Between 1955 and 1960, installation-level igloo magazines were built ranging in size from only 360 square feet at Aberdeen Proving Ground, Maryland, and Fort Lee, Virginia, to over 2,400 square feet at Hunter Army Airfield, Georgia. One-thousand square foot installation-level igloos were also built at the Lake City Army Ammunition Plant (U.S. Army Real Property

Inventory 2007). Installations with a mission of training large numbers of troops saw the greatest activity. At least 30 high-explosives magazines were constructed at Fort Bragg, North Carolina, in 1956, and a similar number were built at Fort Lewis, Washington, the following year.

Examples of the common types of ammunition storage facilities constructed during the mid-1950s are depicted in Plates 7.25 through 7.31. Plate 7.25 shows an installation level magazine, measuring only 131 square feet, that was constructed in 1954 at a demolition area. This earth-covered magazine for storing explosives and detonators was used in the disposal of munitions. The building is a square, reinforced-concrete box with a flat roof. The magazine is accessed through double-leaf steel doors and a single ventilator is located on the roof. Demolition areas also featured personnel safety facilities (Plate 7.26).

Explosives transfer buildings constructed in 1956 closely followed the design of explosives loading docks built during World War II with a concrete platform and ramp, shed-roofed canopy, and office area. The buildings constructed during the Cold War substituted less-expensive concrete block for the office rather than the reinforced concrete used during the 1940s. Many transfer buildings underwent extensive renovations in the 1990s; others were converted to loading docks for non-munitions related materiel (Plate 7.27) (U.S. Army Real Property Inventory 2007).

A second time that the number of newly-constructed magazines exceeded 100 was in 1958. That year, 478 yurt/Stradley magazines were constructed at an Army depot. These magazines followed the recommendations made by the Chief of Ordnance in 1954 with vertical side walls and an elliptical arch. Exterior dimensions were 81 feet 8 inches in length and 30 feet in width. The interior measured 25 feet by 80 feet (Plate 7.28). The concrete walls were wide at the base and narrow at the crown of the arch. The Stradley magazines were 14 feet high from the top of the slab to the bottom of the crown. These magazines enclosed 792 cubic meters of space, roughly 50 percent more than the largest yurt planned by the Ordnance Corps in 1954. Door openings were either eight feet wide by nine-feet-six-inches in height or 12 feet in width with a ten foot height. The openings were closed by double-leaf sliding doors contained in an upper and lower track (Plate 7.29). A roller chain and gear assembly operated the door. Metal ramps were dropped in place over the lower track when the doors were open to allow forklifts to enter the building (Plate 7.30). Ventilators were located in the front wall on both sides of the door and an exhaust vent was centered on the rear wall (Plate 7.31). All the ventilators had the counterweighted damper and fusible link system in the event of a wildfire (U.S. Army Real Property Inventory 2007).

The 478 Stradley magazines and supporting infrastructure were estimated to cost slightly less than $11 million, but the final cost exceeded this by nearly 50 percent. The magazines alone cost $12,585,597 to construct. Other costs associated with the construction effort included electric lines ($2,039), communication lines ($22,117), fences ($148,260), roads ($1,623,349), and over $426,000 in light bulbs. The Army recognized the designer of the yurt, Earl B. Stradley, when they placed a plaque on one magazine officially declaring this magazine type as the "Stradley" (Plate 7.32) (U.S. Army Real Property Inventory 2007).

7.5 Ordnance Corps Organization

The Army's ammunition production and storage structure continued to receive attention in response to supply problems identified during the Korean conflict. The Army continued attempts to control the Ordnance Corps and the other technical services as part of its effort to increase the efficiency of its supply system. Reflecting several years of reorganization proposals and committee studies, the Army staff was reorganized during the mid-1950s. The reorganizations were the strongest move yet toward increased authority over the technical services. In addition, to make use of advances in weapons technology and update the Army's World War II-era weapons and tactical doctrines, a need identified during the Korean conflict, the reorganizations removed research and development functions from the procurement and supply services (Hewes 1975:217).

In September 1954, a change to the 1950 special regulation removed the rest of the general staff from direct responsibility over the technical services, and appointed a Deputy Chief of Staff for Logistics with direct command over the technical services that was more strongly articulated than in previous reorganizations. John Slezak, Secretary of the Army, stated that the purpose of the reorganization

> is to combine the seven technical services into an integrated logistical system, subordinating the Chiefs of Technical Services to the head of this system and giving him authority to modify the respective Technical Service missions in order to achieve one integrated system in place of seven autonomies. Accordingly, it is intended that wherever the authority granted the Deputy Chief of Staff for Logistics involves transfer to him of authority heretofore exercised by other parts of the Army staff, the extent of the transfer shall be interpreted so as to insure that the Deputy Chief of Staff for Logistics can carry out the objectives set forth [above] (Hewes 1975:233-4).

A 1955 revision more clearly stated the comprehensive authority of the Deputy Chief of Staff for Logistics position. The officeholder possessed Department of the Army staff responsibility for "development and supervision of an integrated Army logistics organization and system, including all controls over policies, procedures, and personnel which are essential to the discharge of this responsibility" (Hewes 1975:235).

Subsequent reorganization proposals reflected a debate over whether the Deputy Chief of Staff for Logistics should stay involved in operations or focus on logistics planning, and whether an entirely new organization should be formed that eliminated the technical services altogether. The next Army reorganization, effective 3 January 1956, retained a Deputy Chief of Staff with authority over the technical services, reporting to the Assistant Secretary of the Army for Logistics (Hewes 1975:239-40). No further reorganization of the Army occurred until Robert F. McNamara was appointed Secretary of Defense in 1961 (Hewes 1975:241).

The Ordnance Corps, however, continued to examine its structure to ensure optimum efficiency, particularly as it faced the prospect of declining budgets and fewer employees following the Korean conflict. During fiscal year 1957, it completed "a Corps-wide integrated system of programming, budgeting, and analysis known as the Ordnance Command Management System" (NARA RG 544 Snodgrass 1957:3-4). Ordnance Corps procurement and supply procedures and policies also were scrutinized from the outside, by Congressional committees, the Bureau of the Budget, and Defense and Army agencies (NARA RG 544 Snodgrass 1957:3-4).

During the late 1950s, the Ordnance Corps structure included three Assistant Chiefs of Ordnance who oversaw the organization's largely unchanged major functions: the Research and Development, Industrial, and Field Service divisions. Two other department heads – Chief, Office of Manpower, and Chief, Office of Program Coordination – were given Assistant Chief status in 1956. Its approximately 125 installations and activities included: 3 commodity commands, renamed from commodity centers and including the Ordnance Ammunition Command, the Ordnance Tank-Automotive Command, and the Ordnance Weapons Command; 4 proving grounds; 14 ordnance districts; 8 manufacturing arsenals; 20 depots; 26 active plants and works; 25 inactive plants and works, and 20 other facilities and activities (NARA RG 544 Snodgrass 1957:4b, 5-6).

Various internal reorganizations occurred during this period to place a new focus on guided missiles and other special weapons and continue improving efficiency. For example, at the end of fiscal year 1957, there were plans for the Industrial Division to eliminate its three civilian executives and appoint two special consultants, one for artillery, vehicles, and infantry systems, and the other for guided missile and aircraft armament systems (NARA RG 544 Snodgrass 1957:7). North Storage Activity at Seneca Ordnance Depot was established in 1956 to meet storage needs for special weapons (NARA RG 544 Snodgrass 1957:9).

Another significant efficiency-related event, resulting from the post-Korea slowdown in ammunition procurement and supply, was the closure of several ordnance installations and development of plans to close additional facilities. Lordstown Ordnance Depot was redesignated Lordstown Storage Activity and then closed; Volunteer and Wabash River Ordnance Works also were closed. Inactivation plans were approved for Aberdeen Ordnance Depot, Delaware Storage Activity, Curtis Bay Storage Activity, and Camp Stanley Storage Activity. Gopher, Cactus, and Morgantown Ordnance Works, Gulf Ordnance Plant, and Maynard Test Station were declared excess; Burlington, Cornhusker, and Kansas Ordnance plants and Volunteer and Wabash River Ordnance works were placed on standby (NARA RG 544 Snodgrass 1957:8-9).

The Chief of Ordnance focused during this period on "centralized control and decentralized operations." The Ordnance Board conducted a study of an organizational structure for the future. It favored extending the command structure to include an Ordnance Missile Command, a Research and Development Command, and a Procurement Command, and removing control functions from the Office of the Chief of Ordnance staff, leaving it to handle planning, monitoring, and appraising (NARA RG 544 Snodgrass 1957:11). However, a new emphasis also was placed on contact between Office of the Chief of Ordnance personnel and field personnel regarding procurement and production, "toward an effort to better acquaint field personnel with current policies and objectives, and to acquaint OCO personnel with current field operating problems" (NARA RG 544 Snodgrass 1957:75).

7.6 Summary

The latter years of the 1950s marked the first time since before World War II that a new type of ammunition storage facility was constructed in large numbers. The design of the Stradley magazine was a direct result of new weapons systems: the guided missile. The size of many of the guided missiles hampered efficient storage in the arched-roof magazine constructed in great numbers before and during the World War II era. The elliptical roof form, vertical side walls, and large doors of the Stradley magazine provided ample space to maneuver and stack even the largest missile in the Army inventory. The storage of large numbers of missiles also required that the Ordnance Corps establish additional training programs for personnel and a command structure to insure the proper handling and surveillance of this ammunition type.

To insure that any new construction not only provided maximum flexibility in weapons storage, but also maintained the highest level of safety, the Ordnance Corps revised its safety program. Quantity distance standards, munitions surveillance and handling, the recommended types of facilities, and the general layout of the installation were all visited and new policies issued. This coincided with reorganizations that created centralized ammunition inspection offices to insure that all facilities and weapons in storage were properly monitored.

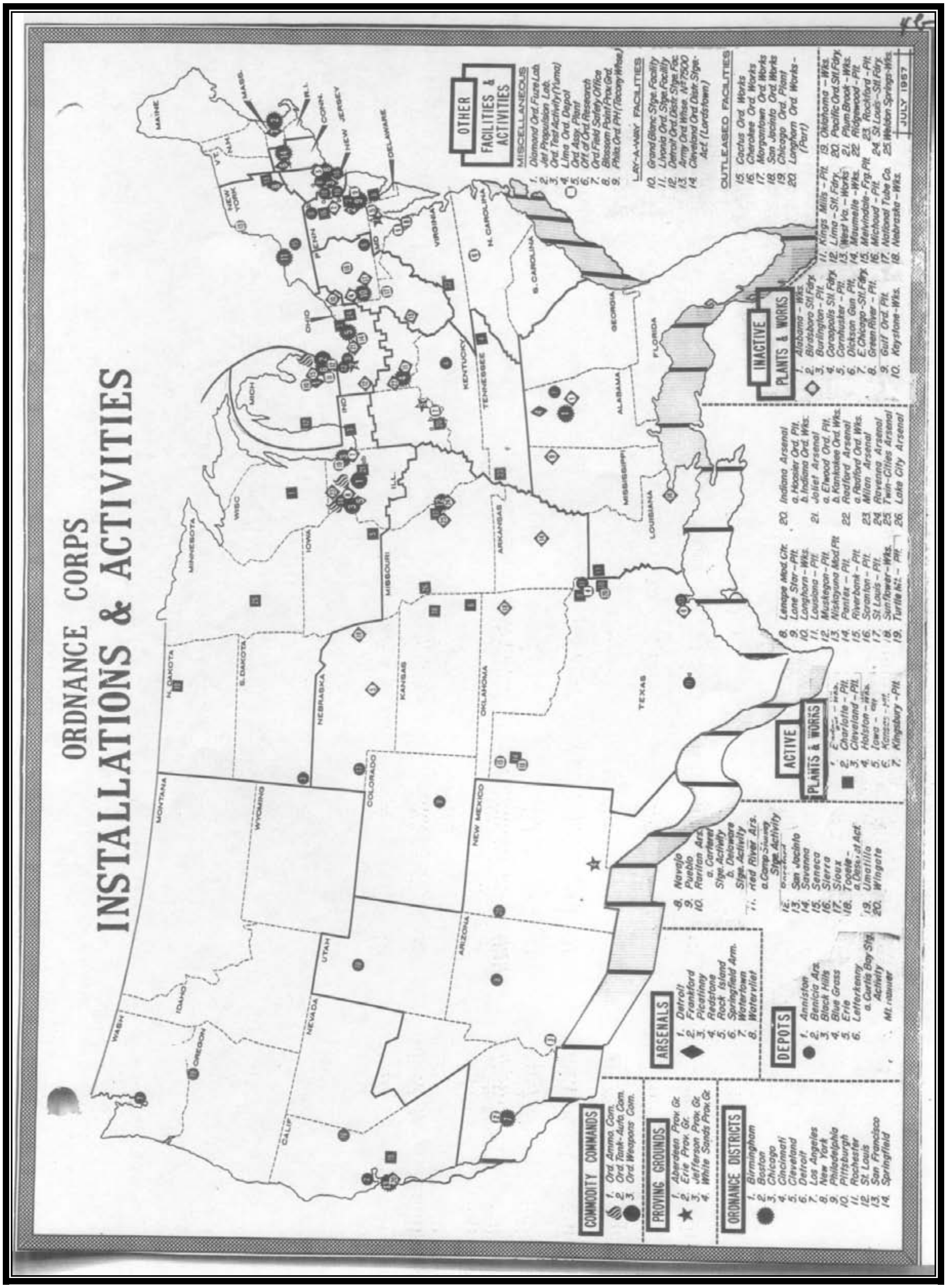


Plate 7.1 Ordnance Corps installations and activities, 1957 (Snodgrass 1957:4b)

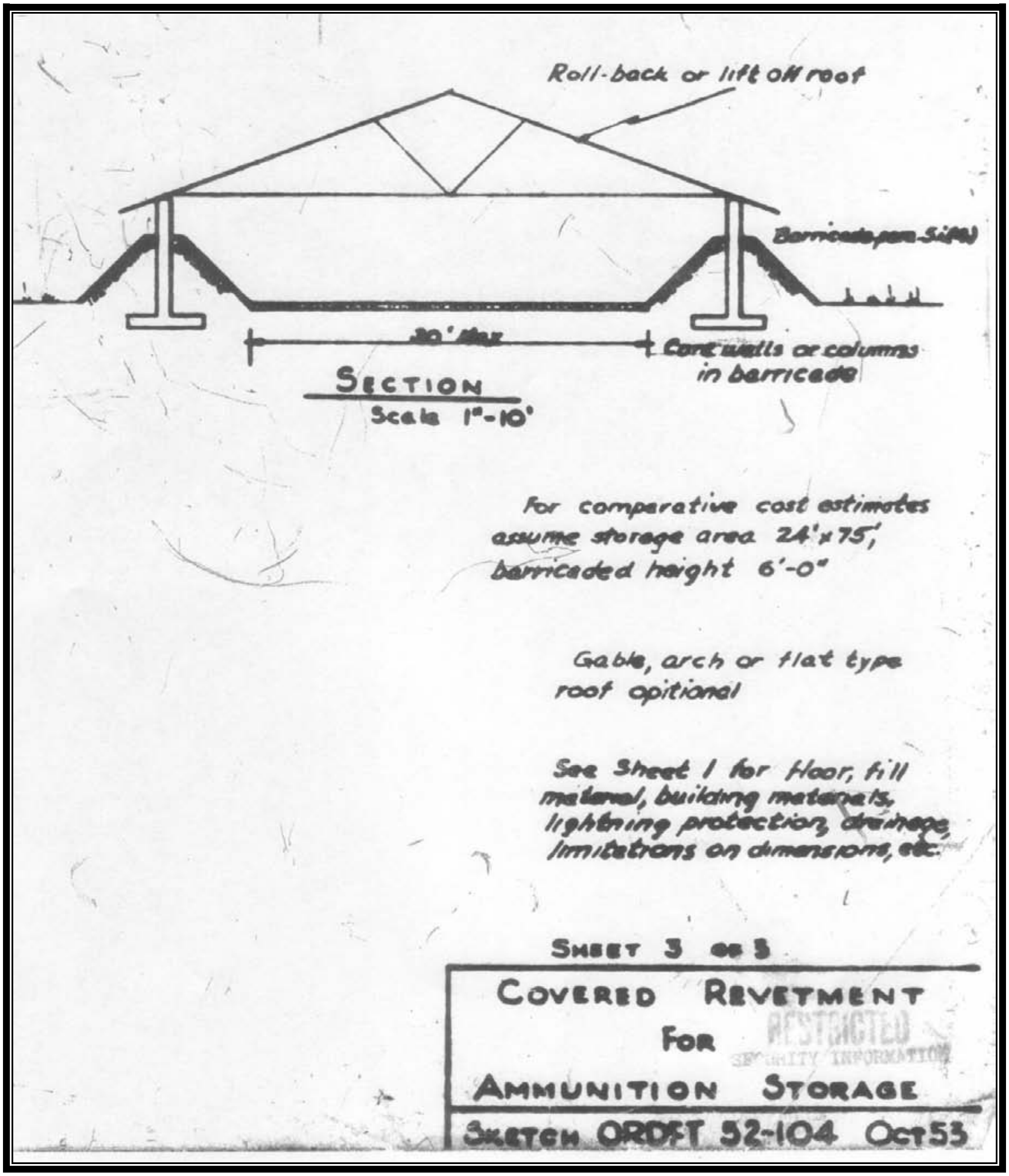
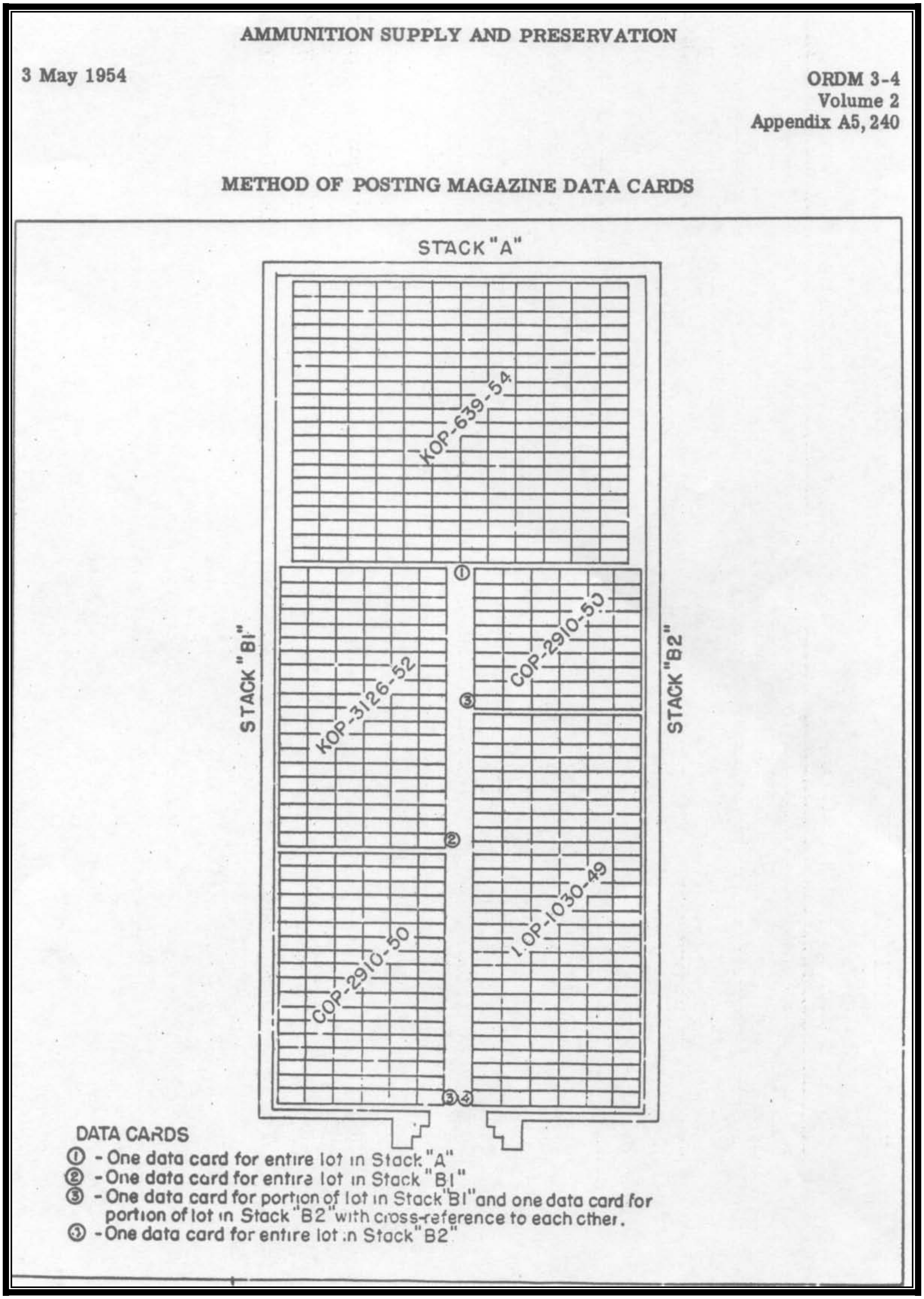


Plate 7.2 Plan for erecting coverings over open storage areas (Reed 1953a:n.p.)


AMMUNITION SUPPLY AND PRESERVATION

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METHOD OF POSTING MAGAZINE DATA CARDS

DATA CARDS

① - One data card for entire lot in Stack "A"
② - One data card for entire lot in Stack "B1"
③ - One data card for portion of lot in Stack "B1" and one data card for portion of lot in Stack "B2" with cross-reference to each other.
④ - One data card for entire lot in Stack "B2"

Plate 7.3 Method of controlling inventory through the use of Magazine Data Cards (Ordnance Corps 1954d:A5, 240)

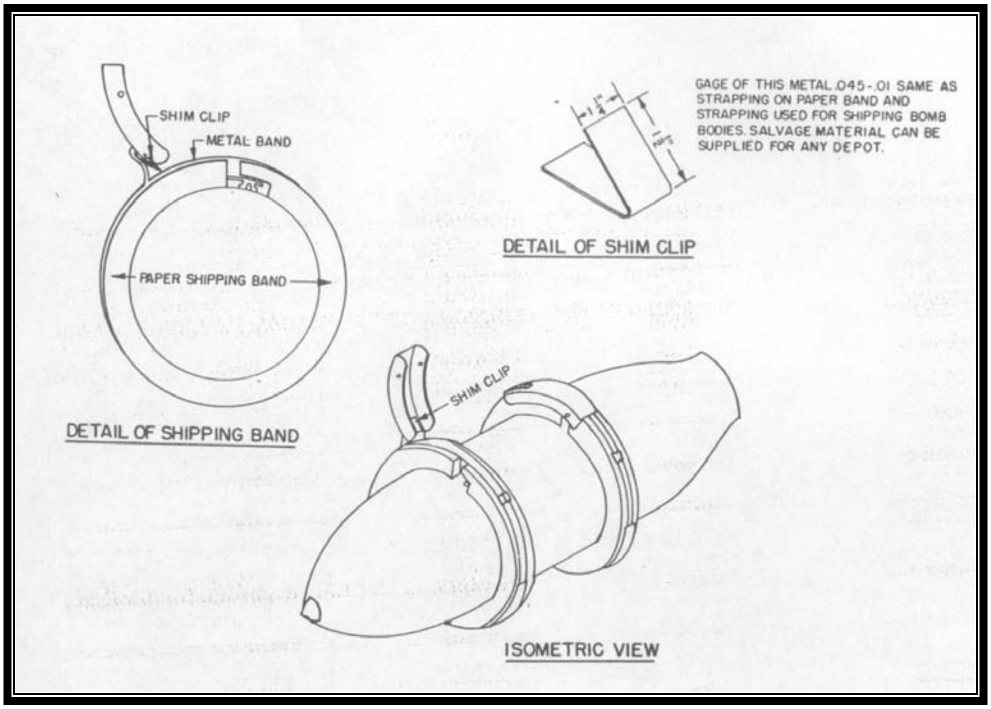

Plate 7.4 Detail of shipping bands used for handling bombs (Ordnance Corps 1957d:A7, 300)

Plate 7.5 Bundle of three NIKE missiles. Note steel cables on forklift frame and stabilizers attached to center missile container (Sierra Ordnance Depot 1955:n.p.)

Plate 7.6 Container of inhibited red fuming nitric acid and specially designed handling cart (Sierra Ordnance Depot 1955:n.p.)

Plate 7.7 Rack designed for storage of NIKE missile batteries (Sierra Ordnance Depot 1955:n.p.)

Plate 7.8 Typical storage tank and shelter for inhibited red fuming nitric acid (Courtesy U.S. Army, 2007)

Plate 7.9 Typical outdoor storage area for empty LANCE missile containers (Courtesy U.S. Army, 2007)

Plate 7.10 Typical fueling operation of liquid-propelled guided missiles ca. 1970. Note full protective gear (Courtesy U.S. Army)

Plate 7.11 Typical igloo storage (Courtesy U.S. Army, 2007)

Plate 7.12 Typical liquid propellant storage building. The tanks are replacements (Courtesy U.S. Army, 2007)

Plate 7.13 Typical hillside, or frost-proof magazine (Courtesy U.S. Army, 2007)

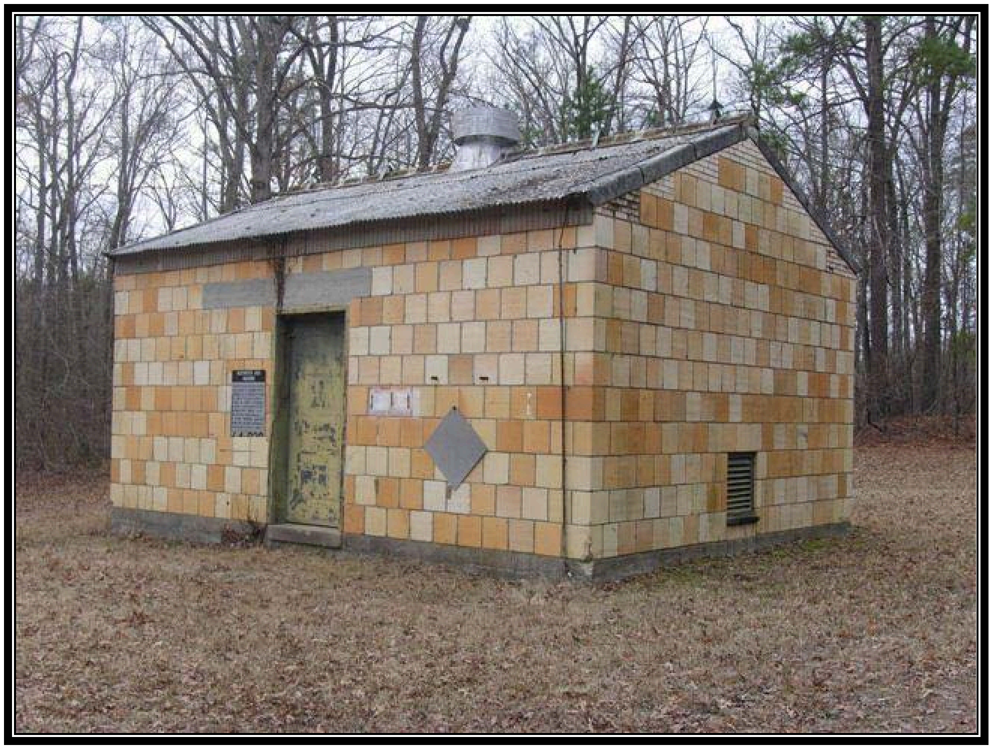

Plate 7.14 Typical aboveground ammunition storehouse (Courtesy U.S. Army, 2007)

Plate 7.15 Typical earth-covered magazine modified with heating plant to create a constant temperature magazine (Courtesy U.S. Army, 2007)

Plate 7.16 Igloo destroyed by detonation of contents, ca. 1955. Note how the force was directed upwards, even though the magazine was totally destroyed (Courtesy U.S. Army)

Plate 7.17 Construction of igloo magazines, ca. 1953. Note welder moving across top of arch (Courtesy U.S. Army)

Plate 7.18 Detail of typical igloo ventilator. Note counterweight and flag that would pop-up if ventilator closed (Courtesy U.S. Army, 2007)

Plate 7.19 Typical Stradley magazine (Courtesy U.S. Army, 2007)

Plate 7.20 Typical ammunition maintenance building constructed during World War II (Courtesy U.S. Army, 2007)

Plate 7.21 Typical conveyor leading to popping plant where brass casings were heated to remove any residual explosive, ca. 1945. Note large volume of ammunition boxes to right of image (Courtesy U.S. Army)

Plate 7.22 Typical safety shelter, or foxhole (Courtesy U.S. Army, 2007)

Plate 7.23 Typical World War II era administration building (Courtesy U.S. Army, 2007)

Plate 7.24 Typical World War II era dispensary, guard house, and fire station (Courtesy U.S. Army, 2007)

Plate 7.25 Typical installation-level magazine for fuze and detonator storage (Courtesy U.S. Army, 2007)

Plate 7.26 Typical personnel safety area at demolition area (Courtesy U.S. Army, 2007)

Plate 7.27 Typical explosives transfer building and loading dock showing enlarged office building and modified canopy over dock (Courtesy U.S. Army, 2007)

Plate 7.28 Typical interior of Stradley magazine (Courtesy U.S. Army, 2007)

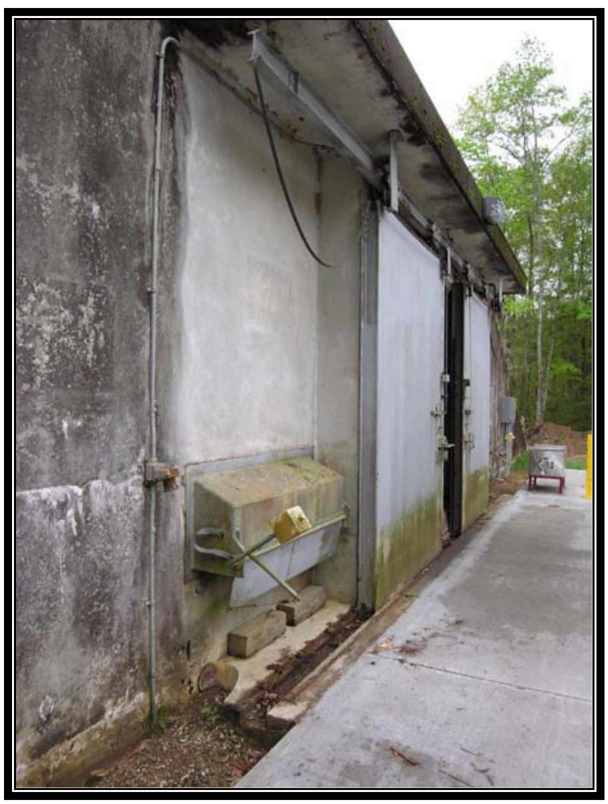

Plate 7.29 Sliding doors of typical Stradley magazine (Courtesy U.S. Army, 2007)

Plate 7.30 Ramps used to cover lower door track for forklift access to typical Stradley magazine (Courtesy U.S. Army, 2007)

Plate 7.31 Ventilator at rear of typical Stradley magazine (Courtesy U.S. Army, 2007)

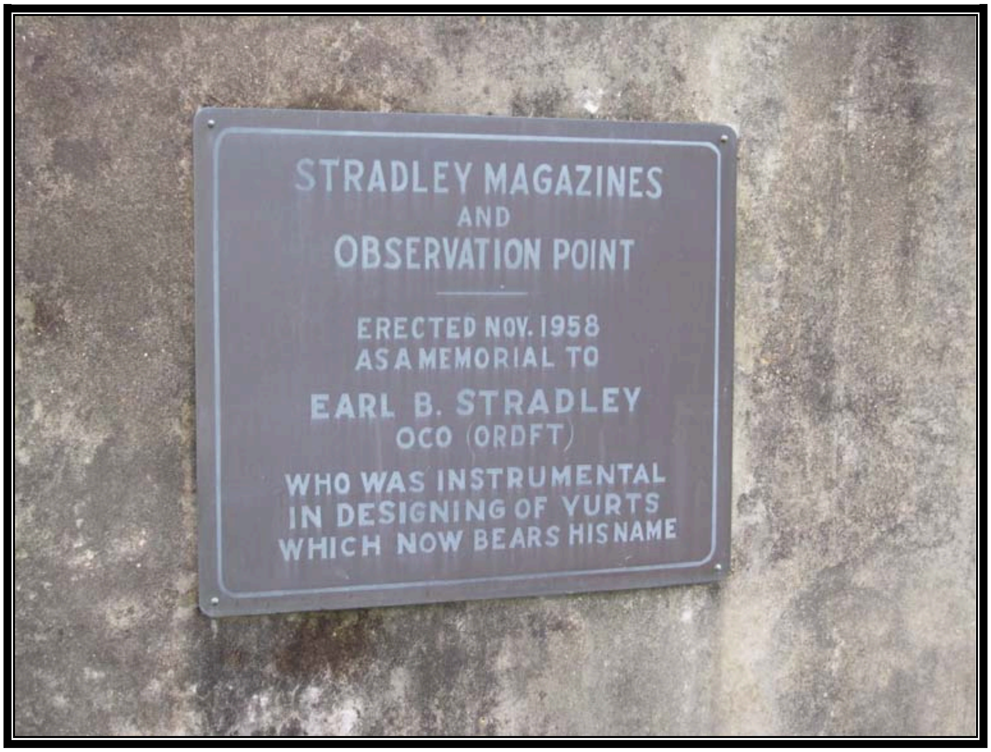

Plate 7.32 Plaque dedicating the yurt magazine to Earl B. Stradley (Courtesy U.S. Army, 2007)

8.0 ARMY AMMUNITION AND EXPLOSIVES STORAGE DURING THE VIETNAM ERA: 1960-1974

8.1 Introduction

The unstable international situation continued in the early 1960s. The threat of an atomic/nuclear attack upon the United States by the Soviet Union persisted. The decade was highlighted by two notable events that had the potential to prompt another world war: the Cuban Missile Crisis in 1962 and the escalation of the Vietnam Conflict.

These two events illustrated differing positions on the composition of the armed forces. Many military leaders advocated the continued role of nuclear weapons as both a deterrent to global conflict and as a retaliatory weapon in the event of an attack by Communist forces. The growth of the nuclear arsenal that took place throughout the 1950s reflected this position. Attempts by the USSR to place intermediate-range missiles in Cuba emphasized the need to maintain nuclear capabilities. Troop increases in Vietnam, however, pointed out the need to increase the numbers of conventional weapons and place additional emphasis on improving or developing new systems.

Although a massive retaliation concept had been adopted by the United States following World War II, the idea of limited warfare had become a more rational approach by 1960 (NARA RG 156 Snodgrass 1961:163). While General Maxwell Taylor, former Chief of Staff of the U.S. Army, recognized that "the primary goal of national defense was to protect the nation from the danger of general atomic war," he told Congress in 1959 that "the United States was developing too great a nuclear retaliatory force—an 'overkill' capacity against possible enemy military targets" (NARA RG 156 Snodgrass 1961:164).

General John H. Hinrichs, Chief of Ordnance, apparently agreed with General Taylor's viewpoint. In 1960, General Hinrichs believed that full-scale nuclear war was possible but improbable; therefore, he advocated that the Ordnance Corps fund weapons for both general war and limited war (NARA RG 156 Snodgrass 1961:164). Although challenged by budgetary and manpower restrictions throughout FY 1960, the Corps sought to develop, procure, supply, and store powerful weapons for use in a general nuclear war while improving other weapons for limited war. For inventory purposes, the emphasis on weapons for atomic war declined after FY 1960. Between FY 1960 and FY 1964, inventory objectives, or the ratio of various weapons types in storage decreased for guided missiles and special weapons and increased for conventional weapons. This change is illustrated by Table 8.1 (NARA RG 156 Snodgrass 1961:151, 163-166).

Table 8.1. Change in Weapons Inventory Objectives between FY 1960 and FY 1964

Type of Weapons	Inventory Objective Percentage FY 1960	Inventory Objective Percentage FY 1964
Guided missiles and special weapons	67 percent	20 percent
Conventional weapons (including tanks, self-propelled weapons, and ammunition)	33 percent	80 percent

In addition to the atomic threat, a Soviet chemical and biological menace loomed over the United States. In 1960, Major General Marshall Stubbs, Chief Chemical Officer of the Chemical Corps, actively advocated greater chemical and biological preparedness. Major General Stubbs "quoted a Soviet source who, in 1958, had described the next war as being distinguished from all past wars in the mass employment of military air force devices, rockets, weapons; and various means of destruction such as nuclear, chemical, and bacteriological weapons" (Sidell et al. 1997:58). Stubbs reported that the Soviet Union possessed powerful chemical munitions, which comprised approximately one-sixth of their total munitions stock. Stubbs also claimed that Soviet experts were pursuing extensive research and development activity in biological warfare agents (Sidell et al. 1997:57).

8.2 Ordnance Corps Organization and the Creation of Army Materiel Command

The 1960s were marked by organizational changes not only within the Ordnance Corps but also within the overall Army. In March 1960, ammunition storage remained under the Ammunition Storage and Maintenance Branch of the Field Service Division, where it had been placed in 1957 (Plate 8.1). In September 1960, the Field Service Division created a "director" concept for more efficient execution of depot operating programs (NARA RG 156 Walker 1960:26-27). Field Service depots were reorganized so that all activities fell under one of four directorates, each run by a director who reported to the depot commander. The four directorates were as follows: Comptroller, Directorate for Administration, Directorate for Services, and Directorate for Supply Operations. A depot with a national mission, such as National Stock Control and Maintenance Point, had a fifth Directorate for National Activities (Plate 8.2). Ammunition and explosives storage was administered by the Directorate for Supply Operations, which held the tasks of "stock control, storage, depot maintenance, in-process inspection, station liaison, and technical assistance" (NARA RG 156 Ordnance Corps 1960:320). Another improvement addressed by the Field Service Division in the early 1960s was the need to demilitarize lethal surplus materiel in a manner that prohibited reconstitution of the items (NARA RG 156 Snodgrass 1961:131).

During FY 1960, the Ordnance Corps transferred most responsibility for ammunition supply control in the field from the Major Items Supply Management Agency (MISMA) at Chambersburg, Pennsylvania, to the Ordnance Ammunition Command at Joliet, Illinois. Under the new arrangement, MISMA continued to calculate gross ammunition figures, while the Ordnance Ammunition Command determined new requirements on a troop basis (NARA RG 156 Snodgrass 1961:131-132). In 1962, a massive realignment of tasks occurred as a result of an Army reorganization. Functions of the Ordnance Corps, the Chemical Corps, and other technical services were reassigned to newly established Army commands. The Army Materiel Command (AMC) became responsible for logistical functions previously performed by the Ordnance Corps and the Chemical Corps.

The technical services were eliminated in 1962 as the result of a study of the Department of the Army instigated by Secretary of Defense Robert S. McNamara, called Project 80 or Study of the Functions, Organization, and Procedures of the Department of the Army (Kane 1995:66; Hewes 1975:316). A result of the study was the creation of the Army Materiel Command (AMC), assigned the mission of "the life cycle management of materiel from concept through research and development, procurement and production, supply, distribution and maintenance, and finally, into disposal" (Kane 1995:66). Materiel included not only conventional and chemical ammunition, but also other commodities such as weapons and general supplies. The offices of most technical services chiefs were eliminated, including the chief of ordnance and the chief chemical officer. Responsibility for their various functions – both primary functions and auxiliary functions such as personnel management – was distributed among the Army Materiel Command and other Army departments and commands (Kane 1995:66).

The AMC used both functional and commodity forms of organization. Functional commands within AMC were the Supply and Maintenance Command and the Test and Evaluation Command; commodity commands were the Electronics Command, Missile Command, Munitions Command, Mobility Command, and Weapons Command (Kane 1995:66).

The Army Materiel Command assumed responsibility from the chief of ordnance for 8 arsenals, 4 proving grounds, 19 depots, 5 depot activities, 1 laboratory, 11 procurement district offices, 17 active plants and works, 21 inactive plants and works, 9 excess plants and works 3 industrial equipment storage sites, 4 commodity commands, 1 tank modification center, and 10 other activities (Kane 1995:66). Appropriation and construction authorization laws passed during this period indicated that ammunition-related facilities were located within the Missile Command, the Munitions Command, and the Test and Evaluations Command.

AMC was reorganized during the early 1970s to accommodate cutbacks in the number of Army civilian employees and the reduction in the Army as the country's involvement in Vietnam wound down. Several commodity commands within the Army Materiel Command were consolidated in 1973 as part of the Army reorganization of that year and two reorganization projects, Total Optimum Army Materiel Command (TOMAC) and the Department of the Army's Baseline Development and Utilization Planning Project (CONCISE). As part of this reorganization, the Munitions Command and the Weapons Command were consolidated into the Armament Command (Army Materiel Command Historical Office 2007a).

During the initial transition to AMC control, many of the Ordnance depot, supply, and maintenance tasks were performed by the Supply and Maintenance Command (SMC), a subordinate command of AMC. At the completion of the Army reorganization in 1966, SMC was abolished (Sidell 1997 et al. 1997:58; U.S. Army DARCOM 1984:27).

8.3 Ordnance Corps Operations

8.3.1 Ammunition Storage and Supply Control

In the early 1960s, General Hinrichs presented Ordnance Corps guidelines supporting a long-range supply program that included "the geographical dispersion of reserve stocks, planned reduction of covered storage space in the depots, development of new maintenance concepts, reduction in rebuild activities, and the reduction in major items" (NARA RG 156 Snodgrass 1961:131). This philosophy was reflected in the amount of ammunition tonnages stored at Ordnance Corps Field Service Depots during FY 1961 and in the available storage space. These figures are listed in Tables 8.2 and 8.3 (NARA RG 156 Snodgrass 1960:29-30; NARA RG 156 Snodgrass 1961:31-32).

Table 8.2. Ammunition Tonnage in Storage at Ordnance Corps Field Service Depots during FY 1961

Date	Ammunition Tonnage in Storage
30 June 1960	4,607,391
31 December 1960	4,465,249
30 June 1961	4,282,788

Table 8.3. Ammunition Storage Space Available at Ordnance Corps Field Service Depots during FY 1961

Date	Aboveground Magazine Space and Igloo Space (square feet)	Open Ammunition Space (square feet)
30 June 1960	30,674,000	10,940,000
31 December 1960	29,310,000	10,940,000
30 June 1961	28,852,000	9,823,000

Ammunition inventory and gross storage space began to decrease throughout FY 1961, primarily as a result of the closure of San Jacinto Ordnance Depot. The decline was expected to continue due to the planned inactivation of Ordnance establishments over the next several years (NARA RG 156 Walker 1960:29; NARA RG 156 Walker 1961:31).

The use of automatic data processing systems for supply control gained popularity in the 1960s. After reviewing the efficiency of electronic systems installed at Anniston Depot and Frankford Arsenal, the Office of the Secretary of Defense concluded that monetary savings were less than expected but "accuracy and timeliness of reporting and control were fully achieved" (NARA RG 156 Snodgrass 1961:143). The Ordnance Corps experimented with both RCA and IBM electronic data processing systems. In 1959, Rock Island Arsenal received an RCA system for installation at the Ordnance Weapons Command; however, the use of an IBM system at Benicia Arsenal proved more favorable for the maintenance of supply and financial accounts. As a result, IBM electronic data processing systems were installed at Erie, Letterkenny, Mount Rainier, and Pueblo Ordnance Depots, as well as at Raritan and Red River Arsenals (NARA RG 156 Snodgrass 1961:143-144).

8.3.2 Reassignment of Depot Missions

A reassignment of depot missions occurred in the early 1960s. Although the assignment of new missions coincided with broad reorganizations within the Army, they were not directly related. The Field Service Division prepared Change No. 1 to *Depot Missions – Ordnance Corps* (AR 780-970) on 14 October 1960 and forwarded the document to the Army's Deputy Chief of Staff for Logistics (DCSLOG) on 23 March 1961 for approval and publication. Changes affected numerous ammunition and explosives storage activities. An ammunition demilitarization mission was assigned to Sioux and Wingate Ordnance Depots, which already had ammunition supply reserve missions. Letterkenny and Pueblo Ordnance Depots gained surveillance missions for special weapons. Savanna Ordnance Depot received a mission for the preparation of drawings for palletization, outload, and storage of guided missiles. To provide better control over the guided missiles program, the national mission for radio-controlled aerial targets was transferred from Raritan Arsenal to the U.S. Army Ordnance Missile Command; however, Raritan retained responsibility for maintenance and inventory control for target missile systems (NARA RG 156 Walker 1960:23-25; NARA RG 156 Walker 1961:37-38).

Chemical Corps toxic ammunition stored at Black Hills Ordnance Depot, Navajo Ordnance Depot, and Deseret Depot Activity at Tooele Ordnance Depot was redefined as either Chemical Corps toxics or Chemical Corps ammunition. Chemical Corps toxics stored in bulk at the three establishments were the responsibility of the Chemical Corps; however, Chemical Corps toxics used as ammunition fillers were categorized as Ordnance Corps ammunition. Black Hills, Navajo, and Deseret also received surveillance missions for Chemical Corps toxics and Chemical Corps ammunition (NARA RG 156 Walker 1960:23-25). Furthermore, Anniston, Blue Grass, and Umatilla Ordnance Depots received missions for storage of "certain chemical ammunition" (NARA RG 156 Walker 1961:38).

Congress enacted a law in 1958 ordering the transfer of San Jacinto Ordnance Depot in Channelview, Texas, to the General Services Administration (GSA) for sale by 20 August 1960. The Secretary of Defense determined that there was no need to replace the outloading ammunition depot. The Ordnance Corps finalized closure plans for San Jacinto by April 1959; estimated costs, including decontamination, were approximately $3.68 million. On 1 January 1960, San Jacinto was placed under the command of Red River Arsenal in Texarkana. All ammunition stocks were removed by the end of April 1960. Approximately 28,000 tons of ammunition were issued for use, 26,000 tons were relocated to other depots, and 14,000 tons were discarded at sea. San Jacinto was decontaminated by May 1960; a staff of 18 custodians remained at the depot under the direction of Red River Arsenal (NARA RG 156 Snodgrass 1961:153-155).

On 1 June 1960, the GSA requested bids for the sale of San Jacinto, which had been divided into 40 parcels of land ranging from 36 acres to 289 acres, a railroad right-of-way, and a pipeline easement. Bids were due on 1 August 1960; however, response was poor. A bid from Smith Douglas Company for the ammonia plant and a bid from the Missouri Pacific Railroad for a portion of the railroad right-of-way were the only offers accepted. Following a second unsuccessful bid invitation on 22 August 1960, the Army anticipated a lengthy disposal period and directed the Chief of Engineers to relieve the Chief of Ordnance from custody of San Jacinto on 7 January 1961 (NARA RG 156 Walker 1960:30-32; NARA RG 156 Snodgrass 1961:155).

In addition to the closure of San Jacinto, other Ordnance Corps establishments that stored ammunition and explosives were inactivated. On 30 March 1961, the Secretary of Defense approved the phased-out closure of Benicia Arsenal, Raritan Arsenal, and Redstone Depot Activity between 31 March 1961 and 31 March 1964. These establishments all had reserve ammunition storage missions. Following close-out and mission transfer, Benicia and Raritan Arsenals became excess property. With assistance from the GSA on 28 June 1961, the Field Service Division presented a pictorial tour to non-defense government agencies to promote the availability of the two arsenals for other government uses. Redstone Depot Activity was to become part of the Army Ordnance Missile Command following close-out. Employees from the inactivated establishments were considered for placement in other Ordnance Corps jobs; Ordnance Storage Interns received priority for job placement because of the cost expended on their training (NARA RG 156 Walker 1961:41-45).

8.3.3 Storage Space Utilization

As U.S. involvement in the Vietnam Conflict declined, AMC began to analyze storage operations. In March 1974, the Commanding General, AMC, directed Brigadier General Leslie R. Sears, Jr., Comptroller, to review AMC's management of storage space, including utilization and occupancy. The Comptroller compared storage status in FY 1969 with data from FY 1974 and presented his findings to the Commanding General on 9 October 1974 (NARA RG 544 Sears 1974a; NARA RG 544 Sears 1974b). In FY 1974, AMC managed 67 percent, or 79 million square feet, of the Army's storage space including nearly 40 million square feet in igloos and magazines. This space was divided among depots, ammunition plants, arsenals, and other establishments (Plate 8.3) (NARA RG 544 Sears 1974a:Chart 8). Approximately 90 percent of AMC igloo and magazine storage space was located at depots and ammunition plants (NARA RG 544 Sears 1974a:Chart 7). Of the 16 AMC depots and activities, 6 establishments stored only ammunition and 6 stored ammunition and general supplies (NARA RG 544 Sears 1974a:2, Charts 7 and 8).

Of the AMC depots and activities, Sierra experienced the greatest increase in net storage occupancy between FY 1969 and FY 1974; in addition, occupancy levels at Anniston and Tooele grew. Net storage occupancy at the remaining AMC ammunition depots and activities basically remained the same or decreased slightly during the five-year period (NARA RG 544 Sears 1974a:Chart 11). Although most stocks of ammunition and explosives were stored at the depots and activities, AMC ammunition plants and arsenals also accommodated these materials. Between FY 1969 and FY 1974, ammunition storage occupancy increased slightly at Pine Bluff and Ravenna. Occupancy levels decreased at Joliet and Lone Star and remained approximately the same at Indiana, Iowa, Kansas, Milan, and Redstone (NARA RG 544 Sears 1974a:Chart 12).

Between FY 1969 and FY 1974, none of the active AMC ammunition storage establishments were utilized to full capacity. A substantial portion of igloo and magazine space at AMC depots and activities had been out-leased or converted to standby status, particularly at Savanna, Umatilla, Fort Wingate, and Navajo (Plate 8.4) (NARA RG 544 Sears 1974a:Chart 11). Slow-moving stocks of ammunition were stored at the two latter establishments (NARA RG 544 Sears 1974a:3-4, 7, Chart 11). Although depots and activities leased empty igloo and magazine space or placed it on standby status, AMC ammunition plants and arsenals rarely did so. For example, almost half of ammunition and explosives storage space available at Milan was not occupied in 1974, although 1.7 million square feet of such space was available. The Comptroller attributed this under-utilization to lack of management; apparently no AMC staff claimed responsibility for monitoring the availability of storage space at the ammunition plants and arsenals (NARA RG 544 Sears 1974a:4).

The Comptroller determined that approximately 60 percent of igloo and magazine storage space at active AMC ammunition storage installations was vacant (NARA RG 544 Sears 1974a:Chart 21). He attributed the substantial amount of empty igloo and magazine space to the current ARMCOM ammunition storage plan, which directed that all the active AMC storage establishments be utilized and that all ammunition workloads be evenly distributed throughout the facilities, whether depots, ammunition plants, or arsenals. The Comptroller recommended the implementation of a new distribution plan for ammunition storage that would provide "maximum utilization and cost effectiveness . . . taking into account strategic considerations" (NARA RG 544 Sears 1974a:7). He advocated a long-term plan that concentrated ammunition storage in certain areas so that empty storage space could be converted to standby status and closed off if possible. Under the plan, active AMC installations accommodating ammunition and explosives were to maximally use each storage area before beginning to utilize other storage areas (NARA RG 544 Sears 1974a:7, Chart 22).

8.4 Ammunition Surveillance and Inspection

During FY 1961, the Field Service Division requested that Picatinny Arsenal prepare an ammunition packaging manual for Ordnance employees involved in package design and development. The manual outlined packaging requirements in regards to package size, type, and weight (NARA RG 156 Walker 1961:57). During the same fiscal year, the container for the T317E1 eight-inch atomic projectile was modified to prolong the time the projectile could be stored without undergoing inspection or other maintenance operations. The goal was to minimize movement and handling and thus improve reliability of the projectile (NARA RG 156 Walker 1961:59).

In December 1961, the Ordnance Corps published a pamphlet entitled *Ordnance Engineering Design Handbook: Maintenance Engineering Guide for Ordnance Design* (ORDP 20-134). The chapter devoted to missile and rocket materiel explained the design of cradles and storage pallets for missiles. Cradles were used to support a missile during lifting, positioning, or storage. Cradles made for a particular missile were marked with guidelines to facilitate proper positioning of the missile. Guidelines were placed on the cradles so that they remained visible once the missile was placed in the cradle, thus ensuring perfect positioning. Cradles featured bumper guards around the edges and retaining straps with handy fasteners that could be disconnected easily. Storage pallets for missiles were designed to be lifted by fork-lift trucks from all four sides. Skids on the bottom of pallets were at least three inches high (Plate 8.5) (Ordnance Corps 1961:135-136).

The handling and surveillance of guided missiles required the construction of additional facilities. Although technically not ammunition storage, these facilities directly supported the surveillance mission. For example, guided missiles required fueling facilities. The liquid-fueled LANCE missile used highly toxic fuel and sensitive components (Redstone Arsenal 2007). These materials were pumped into the fuel cells and the ready missiles were stored in magazines. A typical LANCE fueling facility contained widely separated areas for the storage of the fuel and the oxidant, cells for loading the fuel into the missile, a welding shop where the fuel tanks were sealed to prevent leakage, gaseous nitrogen storage, an administration building, a shipping and receiving building, and a shop building (Plate 8.6).

When Rocketdyne developed the LANCE missile, it estimated a shelf life of five years (Redstone Arsenal 2007). After that time the fuel components would deteriorate; the most significant problem lay in crystallization of the oxidant. To insure that missiles in storage were suitable for deployment, surveillance activities escalated. New facilities were constructed to carefully remove the fuel components from the rocket, perform laboratory tests to determine the viability of the materials, adjust the chemical composition of the propellants, inspect the rocket combustion chamber for corrosion, and then re-fuel the LANCE prior to returning it to storage (Plate 8.7).

Storage and operations involving chemical rockets required additional training. In the early 1960s, instructors from the Ordnance Ammunition Surveillance and Maintenance School (OASMS) were trained at Rocky Mountain Arsenal in the storage and surveillance of chemical rockets. Following the completion of their training, the instructors developed a course at OASMS for Ammunition Inspectors who worked with chemical rockets at Ordnance Field Service establishments. Attendance for the newly created course began during the last quarter of FY 1962; personnel were assigned to training based upon their installation's priority for receipt of chemical rockets (NARA RG 156 Walker 1961:12).

8.5 Design and Construction of Ammunition Storage Facilities

As the 1960s began, the depots constructed during World War II were nearly 20 years old and in need of repair; however, the Ordnance Corps had limited funds for facilities construction and maintenance. During FY 1960, Ordnance Corps priorities for construction, repairs, and utilities were categorized in six areas: ammunition storage, ammunition maintenance, general supply storage, headquarters and community facilities, support facilities, and depot maintenance. Support facilities, including utility work, and general supply storage received the most funding (NARA RG 156 Snodgrass 1961:141-142). Ammunition storage facilities received $700,000 for improvements throughout the Army; work performed included "repair of leaking igloos, loading ramps, and roads and railroads in the ammunition areas" (NARA RG 156 Snodgrass 1961:141). In addition, existing igloo doors were widened to accommodate new types of weapons. The new doors also provided substantial resistance to the external heat and pressure wave of an atmospheric atomic explosion (NARA RG 156 Snodgrass 1961:143).

As the 1960s progressed, the military reexamined quantity-distance standards. Research was underway “to establish procedures which are adequate for current and future protective design” of explosives storage and manufacturing facilities (Cohen and Dobbs 1967:400). The effect of detonation on reinforced concrete used in explosives buildings and barriers was explored under the Supporting Studies Program for the Armed Services Explosives Safety Board. Blast, high-velocity fragments, and secondary effects such as heat and electromagnetic emissions were identified as notable factors. Since the results of various tests proved the limitations of conventional structures in providing protection from detonation, a new technique in the reinforcement used in standard concrete walls was developed and published in *The Military Engineer* in 1967. The new technique utilized an increased quantity of straight flexural steel reinforcement, which was interlaced “with well anchored, continuous bent diagonal bars (Plate 8.8). Tests demonstrated that a structure built using the new technique could withstand a detonation of at least 7,000 pounds of TNT (Cohen and Dobbs 1967:400-402).

Construction of ammunition storage facilities during the Vietnam era concentrated on installation-level facilities. Between 1960 and 1974, more than ten times the number of ammunition storage facilities were constructed at installations than at depots. This corresponds with an increase in the size of the Army during this period, and likely correlates with additional training demands. More than 17 installations received new facilities, including Fort A.P. Hill and Fort Belvoir, Virginia; Fort Sill, Oklahoma; Fort Campbell, Tennessee; Dugway Proving Ground, Utah; and Aberdeen Proving Ground, Maryland. The types of installation-level storage facilities included ammunition huts, ammunition storehouses, igloos, and high-explosive magazines. Generally, installation-level magazines were smaller in size than similar facilities constructed at depots, but examples of large storage buildings included a 10,000 square foot small arms magazine at Fort Bragg, North Carolina, and a 6,400 square foot guided missile magazine at Redstone Arsenal, Alabama.

Many of the installation-level magazines were custom designed for special needs at research and development facilities, testing ranges, and proving grounds. For example, numerous magazines were constructed for a variety of purposes at one testing range during the 1960s and 1970s, ranging from nine-square-foot, aboveground fuze and detonator magazines to guided missile magazines of 2-3,000 square feet (Plates 8.9 and 8.10). Constructed as earth-covered magazines, the area’s high winds caused severe erosion of the covering, and a concrete membrane was later installed over the missile magazines (Plate 8.11). The variety of buildings at the range also included liquid propellant storage, ammunition storehouses, and high explosive magazines (U.S. Army Real Property Inventory 2007).

Generally, Army installations in the continental United States did not store nuclear weapons. The Army fielded few tactical weapons during the Cold War, such as the LANCE missile and Davy Crocket. These weapons systems were designed for the defense of Western Europe, and activities within the United States were limited to training using inert or dummy warheads. The exception to this was Fort Hood, Texas, where one of the largest construction projects of the Vietnam era took place in 1969. The Army constructed over 100 special-weapons magazines at that time. All these magazines exceeded 2,000 square feet in size, and the majority measured 2,362 square feet (U.S. Army Real Property Inventory 2007). This construction coincides with the addition of two areas, historically known as North and West Fort Hood, to the main post in 1969. Between 1952 and 1969, the Army ran North and West Fort Hood under the Defense Atomic Support Agency (DHSA). The DHSA was the direct successor of the Manhattan Project and the Armed Forces Special Weapons Project (created in 1947). DHSA was responsible for carrying out research on nuclear weapons, conducting stockpile support, and was the lead DoD agency in stockpile stewardship. The consolidation of these three parts under direct

Army control brought the mission of surveillance and storage of nuclear weapons to Fort Hood. The DHSA remained at Fort Hood throughout the Cold War and was renamed the Defense Nuclear Agency in 1971 (Global Security 2007; Department of Defense 2007).

8.6 Inter-Service Cooperation for Ammunition and Explosives Storage

During the 1960s, Army, Navy, and Air Force commanders recognized the need for a formal, inter-service arrangement for ammunition logistics. On 11 February 1969, the three departments published a *Joint Interservice Logistic Support Agreement for Ammunition*. The intent of the agreement was "to define policies and establish procedures pertinent to the CONUS logistical support that may be provided by one military service to another military service for ammunition" (NARA RG 544 Departments of the Army, Navy, and Air Force 1969:I-1). The agreement covered the following items identified under the Federal Supply Classes (NARA RG 544 Departments of the Army, Navy, and Air Force 1969:I-1 – I-3):

1040: Chemical Weapons and Equipment
1055: Launchers, Rocket and Pyrotechnic
1305: Ammunition, through 30mm
1310: Ammunition, over 30mm up to 75mm
1315: Ammunition, 75mm through 125mm
1320: Ammunition, over 125mm
1325: Bombs
1330: Grenades
1336: Guided Missile Warheads and Explosive Components
1337: Guided Missile and Space Vehicle Explosive Propulsion Units, Solid Fuel, and Components
1338: Guided Missile and Space Vehicle Inert Propulsion Units, Solid Fuel, and Components
1340: Rockets and Rocket Ammunition
1345: Land Mines
1350: Underwater Mine Inert Components
1351: Underwater Mine Explosive Components
1355: Torpedo Inert Components
1356: Torpedo Explosive Components
1360: Depth Charge Inert Components
1361: Depth Charge Explosive Components
1365: Military Chemical Agents
1370: Pyrotechnics
1375: Demolition Materials
1376: Bulk Explosives
1377: Cartridge and Propellant Actuated Devices and Components
1380: Military Biological Agents
1385: Explosive Ordnance Disposal Tools, Surface
1386: Explosive Ordnance Disposal Tools, Underwater
1390: Fuses and Primers
1395: Miscellaneous Ammunition
1398: Specialized Ammunition Handling and Service Equipment
1410: Guided Missiles
1420: Guided Missile Components
1425: Guided Missile Systems, Complete
1427: Guided Missile Subsystems

4925: Ammunition Maintenance and Repair Shop Specialized Equipment
8140: Ammunition Boxes, Packages, and Special Containers

The policies and procedures of the agreement were coordinated by representatives of each service. The Army was represented by Headquarters, U.S. Army Materiel Command, Washington, D.C.; the Navy by the Naval Supply Systems Command, Washington, D.C.; the Air Force by Headquarters, Air Force Logistics Command, Wright-Patterson Air Force Base, Ohio; and the Marine Corps by the Commandant of the Marine Corps, Washington, D.C. These coordination representatives functioned as the central point of contact regarding the agreement and ensured that the agreement was reviewed jointly by the military services on an annual basis (NARA RG 544 Departments of the Army, Navy, and Air Force 1969:I-4 – I-5).

When ammunition storage space was desired by any particular service, the military service needing space forwarded a letter to the agent representative for the establishment at which storage was requested. The letter included the square footage and type of space required, such as igloo, aboveground magazine, etc.; the type and quantity of ammunition to be stored; special storage considerations, such as security issues or interim storage; and the date for which the space was needed. The agent representative was required to respond to the requesting service within 30 days of receipt of the letter (NARA RG 544 Departments of the Army, Navy, and Air Force 1969:V-1 – V-2).

The service owning the ammunition and the service storing the ammunition shared responsibilities. Prior to delivery of the ammunition, the owning service submitted technical data to the storing service, such as manuals, storage drawings, packaging requirements, and handling requirements. If needed, the owning service also supplied special equipment for ammunition handling. For ammunition common to both services, the storing service followed its own storage and surveillance procedures in order to maintain standardization unless otherwise directed by the owning service. For ammunition and explosives peculiar to the owning service, the storing service followed surveillance procedures furnished by the owning service (NARA RG 544 Departments of the Army, Navy, and Air Force 1969:V-3 – V-5).

The inter-service agreement dictated that stored ammunition and explosives be identified by specific ownership and segregated accordingly by Federal stock number, lot number, and condition code. The storing service rotated stock by its own procedures, maintained records identifying ownership of ammunition, and had authority to suspend ammunition presenting defects or hazards. Cooperation among the various military services was imperative. When day-to-day storage problems arose, depots sought to resolve them directly with the owning service. A Joint Service Committee regularly reviewed workload requirements and resolved conflicts regarding storage space. For long-range storage planning, the committee prepared annual updates outlining storage requirements as compared to actual storage capacity. The updates were based upon munitions data obtained from the Secretary of Defense and the five-year defense program. Munitions requirements were converted into storage requirements (NARA RG 544 Departments of the Army, Navy, and Air Force 1969:V-3 – V-7).

8.7 Summary

Surveillance of existing ammunition stockpiles remained a key component of Ordnance Corps activities during the Vietnam era. The development of additional guided missile systems created new responsibilities for some installations as refueling and inspection were added to their mission. Growing production of new ammunition brought about by the escalation of American involvement in Southeast Asia called for increased activity at most installations with more numerous shipments of munitions and the need for additional installation-level magazines to support training missions. Plans developed during the post-Korea period aided depot staff in efficiently storing and transporting ammunition. The existing depot system sufficed for ammunition storage and few new facilities of this level were constructed. The majority of buildings were constructed for individual installations and at Army ammunition plants.

Sweeping changes in Army organization also took place during the Vietnam era. The Field Services were eliminated in 1962. Except for a short period in the early 1940s, this organizational structure had existed since before World War II. The Army Materiel Command assumed responsibility for numerous Army activities including proving grounds, arsenals, depots, and ammunition plants. Although additional reorganization of AMC took place in the mid-1970s, it remained in control of ordnance activities throughout the remaining Cold War period.

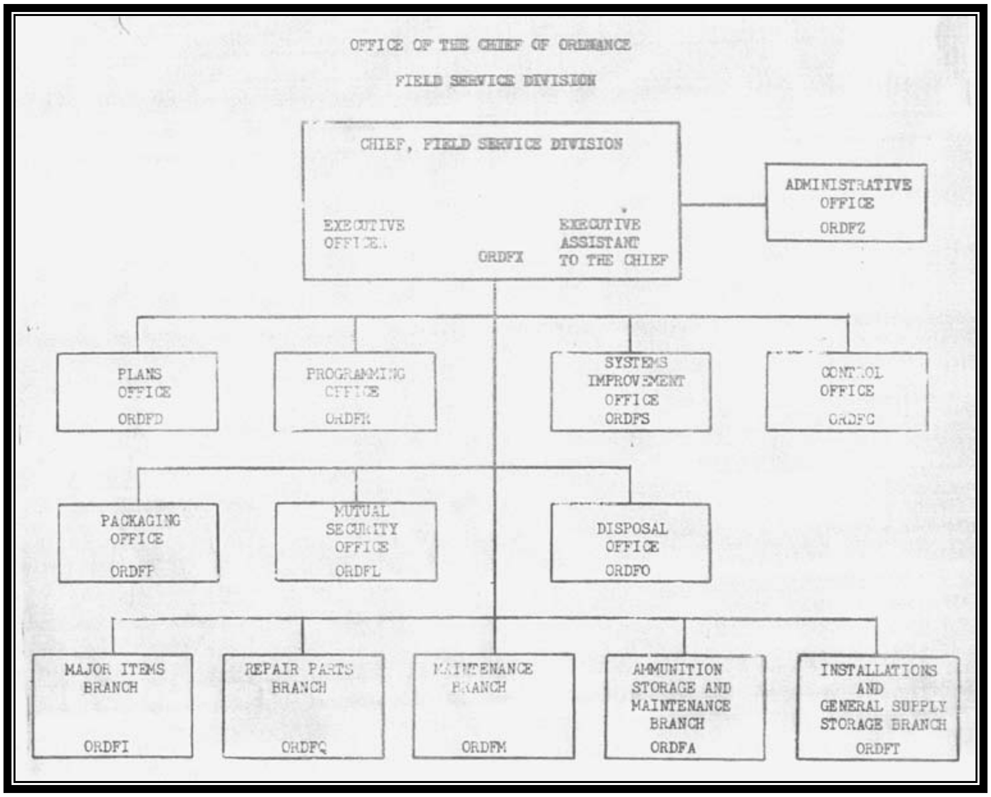

Plate 8.1 Organizational chart of the Field Service Division of the Ordnance Corps (NARA RG 156 Snodgrass 1961:n.p.)

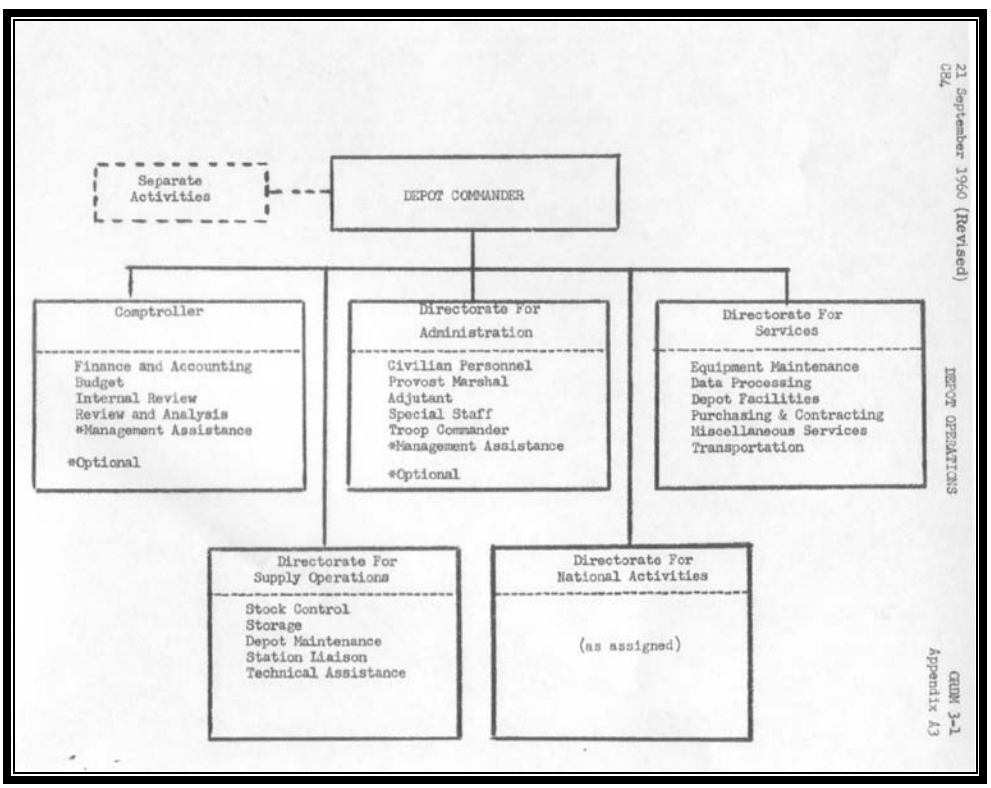

Plate 8.2 Organizational chart for depot activities (NARA RG 156 Ordnance Corps 1960:A3)

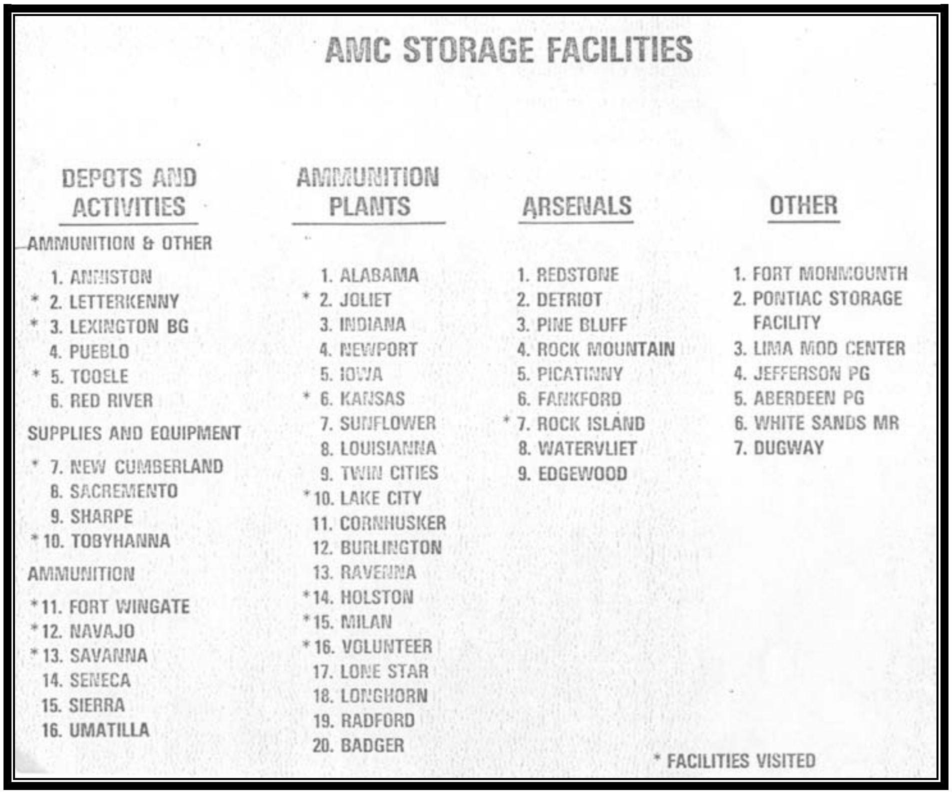

Plate 8.3 Army Materiel Command storage facilities, 1974 (NARA RG 544 Sears 1974a:Chart 8)

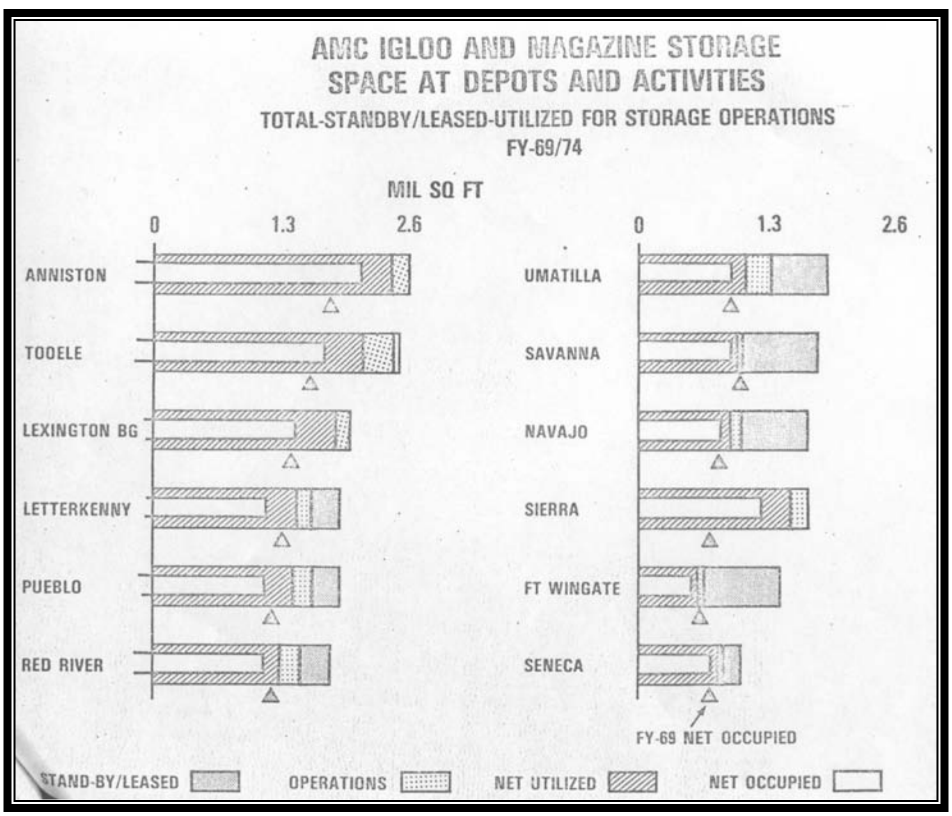

Plate 8.4 Space utilization of AMC igloo and magazine storage (NARA RG 544 Sears 1974a:Chart 11)

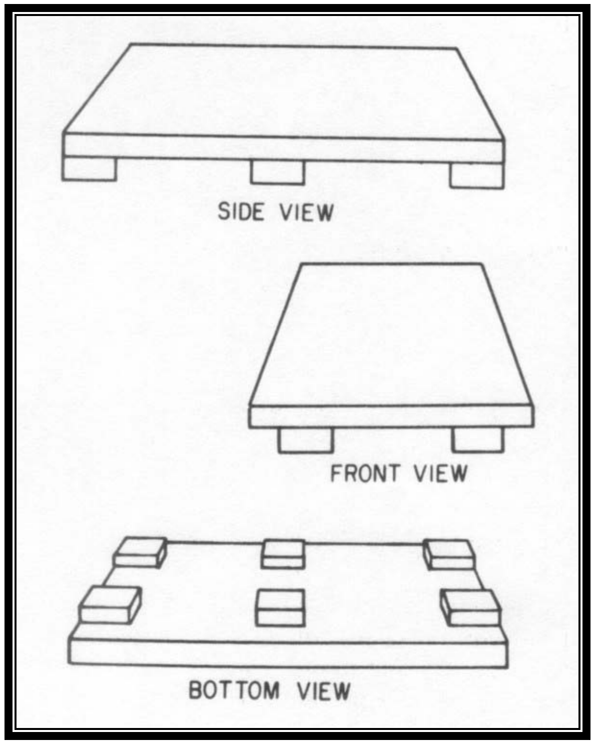

Plate 8.5 Pallets designed for four-sided lifting for efficient handling (Ordnance Corps 1961:136)

Plate 8.6 Typical refueling cell for LANCE missile, ca. 1970 (Courtesy U.S. Army)

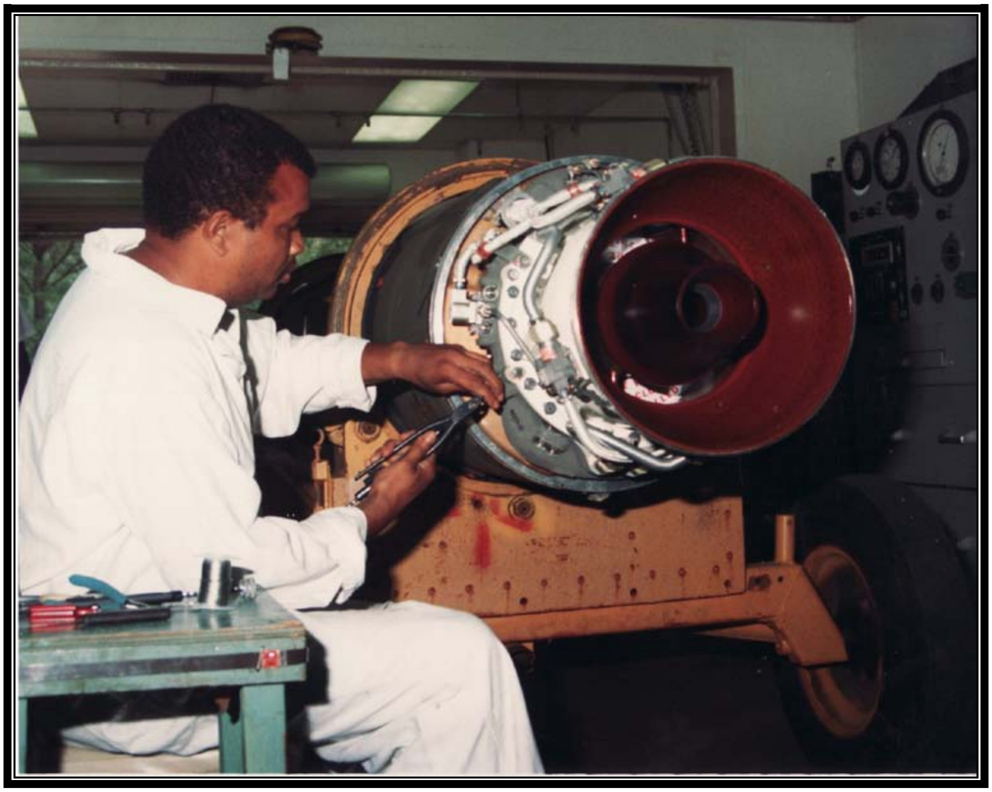

Plate 8.7 Inspection of LANCE missile as part of surveillance program (Courtesy U.S. Army)

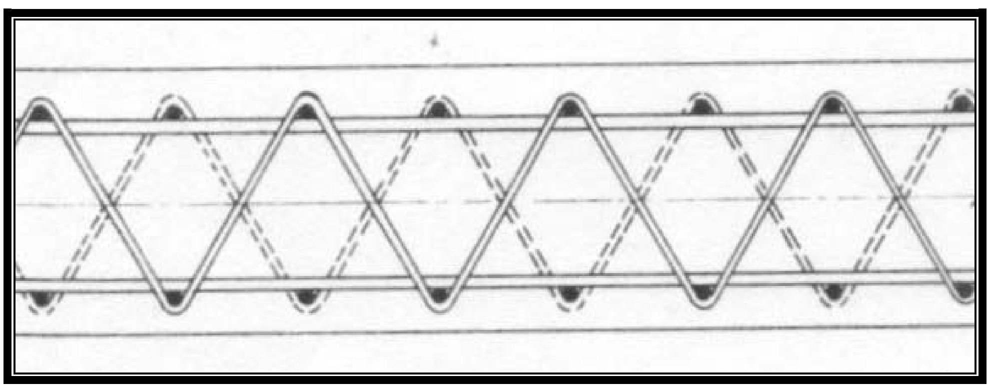

Plate 8.8 New method for interlacing reinforcing steel used in magazine construction (Cohen and Dobbs 1967:401)

Plate 8.9 The large structure is a climatic test chamber for various munitions. The small structure to the left is a nine square foot magazine (Courtesy U.S. Army, 2007)

Plate 8.10 Guided missile magazine completed in 1959 (Courtesy U.S. Army, 2007)

Plate 8.11 Rear of guided missile magazines showing concrete laid over earth fill (Courtesy U.S. Army, 2007)

9.0 ARMY AMMUNITION AND EXPLOSIVES STORAGE DURING THE LATE COLD WAR ERA: 1975-1989

9.1 Introduction

The end of the war in Southeast Asia marked a turning point in the Cold War. Although the United States was involved in military actions in the later Cold War, such as in Panama and Granada, the mobilization of large numbers of troops did not take place from 1974 to 1989. The abolishment of Selective Service in the mid-1970s converted the Army to an all volunteer organization. Although the Army decreased in size from a high during the Vietnam Conflict of over 1.5 million, it remained fairly constant from 1975 to 1985 with about 780,000 officers and enlisted personnel.

Although President Ronald Reagan oversaw the development of new weapons in the 1980s, these efforts focused on technologically sophisticated systems; the volume of conventional weapons declined, and it was estimated that more than half of the storage space at active AMC installations was unused. Vacant igloo storage was leased wherever possible or placed on standby status to minimize the expense of maintenance.

9.2 Army Materiel Command Operations and Organization

The Army revised several ammunition-related depot commands during the 1970s. For example, Tooele Army Depot in Tooele, Utah, assumed responsibility for the following depot activities between 1973 and 1976:

Umatilla Depot Activity, Hermiston, Oregon (August 1973)
Fort Wingate Depot Activity, Gallup, New Mexico (September 1975)
Navajo Depot Activity, Flagstaff, Arizona (September 1975)
Pueblo Depot Activity, Pueblo, Colorado (July 1976)

Tooele Army Depot served as a supply depot for ammunition and general supplies. Major functions included storage, stock distribution, returned-materiel processing, and ammunition surveillance and demilitarization. Tooele also was responsible for the "design, manufacture, procurement, storage, and testing of ammunition equipment for demilitarization, renovation, modification, modernization, and normal maintenance of conventional-type ammunition" (NARA RG 544 Tooele Army Depot 1976:2). Umatilla, Fort Wingate, and Navajo were reserve supply depots, while Pueblo had limited maintenance, receiving, and shipping assignments (NARA RG 544 Tooele Army Depot 1976:1-2).

Another establishment that stored both ammunition and general supplies was Red River Army Depot in Texarkana, Texas. The mission of Red River was similar to that of Tooele Army Depot. The Directorate for Supply at Red River was responsible for "the receipt, storage, care and preservation, and issue of general supplies and ammunition (conventional, guided missiles, and selected ammunition)" and the "maintenance of ammunition (conventional guided missiles, and selected ammunition)" (NARA RG 544 Red River Army Depot 1977:65). The Directorate of Supply comprised six divisions: Ammunition, General Supply, Inventory Control, Materiel Management, Production Planning and Control, and Transportation. At the end of 1976, the Ammunition Division included 290 personnel, including 32 supervisors and 17 leaders (NARA RG 544 Red River Army Depot 1977:66).

The Army Materiel Acquisition Review Committee (AMARC) was charged to study ways to further improve AMC's efficiency as federal cutbacks, consolidations, and base closures continued. The industry-heavy committee's recommendations focused on decentralization by reducing the number of managers and aligning the organization more closely with a business structure, so that managers throughout the organization had more individual freedom. One result was that AMC was renamed the U.S. Army Development and Readiness Command (DARCOM) on 23 January 1976, a name retained until 1 August 1984 (Kane 1995:67; Army Materiel Command Historical Office 2007a; Army Materiel Command Historical Office 2007b). The name change was intended to "symbolize the change to a more corporate structure" (Army Materiel Command Historical Office 2007b).

Another result was an increase in commands. Depot functions were decentralized through the establishment of the U.S. Army Depot System Command (DESCOM) on 1 September 1976 (Army Materiel Command Historical Office 2007b). The following depots with ammunition missions were assigned to DESCOM, effective 1 September 1976:

U.S. Army Depot Anniston, Anniston, Alabama
U.S. Army Depot Letterkenny, Chambersburg, Pennsylvania
U.S. Army Depot Lexington-Bluegrass, Lexington, Kentucky
U.S. Army Depot Red River, Texarkana, Texas
U.S. Army Depot Seneca, Romulus, New York
U.S. Army Depot Sierra, Herlong, California
U.S. Army Tooele, Tooele, Utah

The organizational changes recommended by AMARC had mixed results. Although its emphasis on development caused an increase in development of weapons and other equipment, the decentralization of and increase in commands "split responsibilities, resources, and facilities; required greater coordination of projects; prevented the smooth transition of projects from the R&D to the test and fielding phases; and caused animosity between R&D and logistics support personnel within the DARCOM community" (Army Materiel Command 2007a). Between 1979 and 1984, through two efforts, AMARC Revisited and the Resource Self-Help Affordability Planning Effort, commodity commands were reconsolidated and other improvements were made (Army Materiel Command 2007a; Army Materiel Command 2007b).

During the 1980s, Army ammunition depot operations within the continental United States remained under the centralized management of DESCOM. As of 31 December 1981, DESCOM controlled installations that stored ammunition for all military services and contained 22,387,000 net square feet of storage space. Optimal storage capacity totaled 3,198,143 tons (Department of the Army Headquarters 1982:22). Plate 9.1 indicates the net square footage and storage capacity of each DESCOM ammunition depot and activity as of 31 December 1981. Plate 9.2 shows the location of DESCOM installations, as well as storage facilities at Army ammunition plants and arsenals managed by the U.S. Army Armament Materiel Readiness Command (ARRCOM) (Department of the Army Headquarters 1982:24). DESCOM, which was headquartered in Chambersburg, Pennsylvania, had an annual budget of more than $2.7 billion and supported 43,000 civilian and military personnel in 1984 (U.S. Army DARCOM 1984:24).

By 1984, DARCOM oversaw ten subordinate commands with 64 installations and 26 sub-installations located on a total of 4.4 million acres. They included the Armament, Munitions and Chemical Command (AMCCOM), which oversaw four arsenals, 29 ammunition plants (15 active and 14 on standby or inactive), and two research and development centers; DESCOM, which oversaw eleven depots and six depot activities; and the Missile Command (MICOM), "which manage(d) the Army's air defense, field artillery and antitank missile systems programs." The other commands included: Aviation Systems Command, Communications-Electronics Command, Tank-Automotive Command, the Troop Support Command, Electronics Research and

Development Command, and Test and Evaluation Command. The annual DARCOM budget amounted to more than $27 billion. Ninety percent of the work force was civilian with the balance made up of military personnel (Babers 1984:18-22).

Further changes were made to return DARCOM to a military structure and away from a corporate structure. In 1984, directorates were renamed deputy chiefs of staff, and the command's name was returned to Army Materiel Command (Army Materiel Command 2007b). Other changes were made throughout the remainder of the decade as AMC responded to declining resources, functional changes, structural reviews and evaluations, and Base Realignment and Closure Commission recommendations. One planned change included "consolidation of all AMC industrial activities – depots, ammunition plants, and arsenals – in a new Industrial Operations Command (IOC) at Rock Island Arsenal" (Army Materiel Command 2007b). It is unclear whether this change was made.

As of 1993, AMC consisted of six commodity commands and five functional commands and elements. The six commodity commands were: Missile Command; Armament, Munitions, and Chemical Command; Tank-Automotive Command; Aviation and Troop Command; Chemical and Biological Defense Command; and Communications-Electronics Command. The five functional commands were: Test and Evaluation Command; Depot Systems Command; U.S. Army Security Assistance Command; Army Research Laboratory; and Simulation, Training, and Instrumentation Command (Kane 1995:67).

9.2.1 Ammunition Logistics

During the 1980s, the Army became aware of the need for improvements in ammunition logistics. In April 1984, a new office known as the Project Manager for Ammunition Logistics (PM, AMMOLOG) was created within the U.S. Army Armament, Munitions and Chemical Command. The PM, AMMOLOG, which was located at the Armament Research and Development Center in Dover, New Jersey, was tasked with developing an overall plan for improvement of the ammunition logistics system. The PM, AMMOLOG sought to minimize the logistics involved in ammunition storage, handling, and transportation (Bentzley 1985:6).

One goal of the PM, AMMOLOG, was to advance ammunition to the field in original packaging; therefore, new packaging was developed for some types of ammunition. For example, the 155mm Field Artillery Projectile Container (FAPC) was created to replace the eight-projectile wood and strap pallet currently in use. The FAPC could be stored and handled in the supply system and then transferred to supply vehicles for immediate transport to the field. Projectiles could be placed in the FAPC either fuzed or with intact lifting plugs. Individual projectiles could be removed for use while others remained in the container. The FAPC also afforded nuclear, biological, and chemical protection for the projectiles (Bentzley 1985:7).

9.3 Ammunition Surveillance and Inspection

Following production, end items of ammunition typically were stored at Army ammunition plants as long as possible in order to minimize transportation handling costs at depots. Once ammunition was shipped to Army depots for long-term storage, the munitions sometimes remained there for decades. Lengthy storage periods and protection from moisture and temperature extremes were important factors for packaging materials, and the designs for ammunition storage facilities, plans, and aids (Department of the Army Headquarters 1982:7).

Throughout the 1980s, the Army preferred the use of earth-covered magazines for long-term storage. *The Army Ammunition Management System*, Department of the Army Pamphlet 700-16 published on 1 December 1982, presented the following storage recommendations:

> Earth-covered magazine storage should be used wherever possible. In comparison with other methods, it provides a higher degree of protection and safety for the ammunition and surrounding targets, greater physical security, and reduced maintenance of the ammunition. The Board supports open revetted pad storage only under emergency or temporary conditions, not for permanent, long-term use. An example of an approved use for open storage is for bombs slated for demilitarization stored on revetted pads between magazines (Department of the Army Headquarters 1982:8).

This policy adhered to standards outlined in a letter dated 18 December 1974 from the DoD Explosive Safety Board (DDESB) to all military services.

Ammunition in long-term storage was monitored regularly. The Army operated an Ammunition Stockpile Reliability Program (ASRP) for "evaluating the operational readiness, serviceability, safety, reliability, and performance of ammunition in the stockpile and/or deployed for use in combat or training and to provide information necessary for decision making in the overall logistic management of ammunition—retention, maintenance, modification, or replacement" (Department of the Army Headquarters 1982:8). Representative samples of ammunition were selected for visual inspection and/or testing to eliminate unsafe munitions from the stockpile. Army depots performed ammunition maintenance and renovation when necessary. Funding constraints contributed to a backlog of conventional ammunition slated for renovation. The Army planned to eliminate this backlog by the mid-1980s (Department of the Army Headquarters 1982:8).

The Army disposed of ammunition that "became obsolete, excess, unserviceable, uneconomical to repair, and/or condemned/hazardous for continued storage, maintenance, and/or use" (Department of the Army Headquarters 1982:8). When ammunition demilitarization in large quantities was warranted, the Army considered four options:

(1) sales to foreign governments,
(2) demilitarization by a commercial contractor,
(3) disassembly and reuse of components, or
(4) detonation or burning.

Personnel conducting demilitarization received specialized training. The Army used demilitarization equipment supplied by the Ammunition Peculiar Equipment (APE) program, which designed and produced APE for depot operations. APE commodity centers were located at Savanna Army Depot Activity and at Tooele Army Depot (Department of the Army Headquarters 1982:8-9).

9.4 Nuclear, Chemical, and Biological Weapons

Although the end of the Vietnam Conflict in April 1975 was a significant event of the 1970s, other issues also captured attention. By the early 1970s, the Soviet Union had attained nuclear weapons capability nearly equal to that of the United States. In 1972, Colonel Ray H. Smith, Chief, U.S. Army Nuclear and Chemical Surety Group, perceived the possibility that the United States soon might fall inferior to the Soviet Union in the area of nuclear weaponry. Colonel Smith affirmed the need for the United States to maintain strategic nuclear weapons systems for full-force nuclear war as well as tactical nuclear weapons systems for conventional war (Sidell 1997:66; Smith 1972:161). He also believed that “because of their tremendous destructive power, these weapon systems must be sufficiently safe, secure, and reliable to give our leaders and the public at large great confidence that there is small risk of accident or of unauthorized use” (Smith 1972:161). To address this topic, the Army operated a nuclear surety program that set forth procedures to ensure the “safety, security, and reliability” of nuclear weapons (Smith 1972:161). The program sought to avoid accidents and unauthorized use, while maintaining the readiness capability of the weapons. Important considerations included the storage and handling of nuclear weapons.

In addition to the Soviet nuclear threat, the 1970s were characterized by public concern in the United States regarding the use of chemical and biological weapons. In addition to the nuclear surety program, the Army conducted a chemical and biological weapons (CB) surety program, which was implemented within the AMC on 6 October 1967 (NARA RG 544 U.S. Army Materiel Command 1967:1). The Special Assistant for Nuclear, Chemical, and Biological Affairs, Headquarters, AMC served as the CB surety officer and managed the program. In addition, each AMC arsenal and depot executing a chemical and biological mission had a surety officer accompanied by a small staff “to continually monitor, survey, advise, and recommend on surety matters” (NARA RG 544 U.S. Army Materiel Command 1967:3).

The establishment of the CB surety program did not alleviate the concerns of political leaders and the U.S. public. In November 1969, President Nixon restated the U.S. policy of not being the first to use lethal chemical weapons against an enemy, adding that he also prohibited the use of incapacitating chemical weapons; however, the U.S. remained open to using chemical weapons for retaliation if necessary. Also in November 1969, President Nixon banned the use of biological weapons for any reason and ordered the disposal of all existing stocks. In February 1970, the president renounced the use of toxins and ordered the destruction of all such agents (Sidell 1997:68-69; Smith 1972:162). In 1973, the Army made plans to disestablish the Chemical Corps; however, indications that the Soviet Union was intensifying its chemical warfare program prompted the Secretary of the Army to maintain the organization (Sidell 1997:70-71).

Nixon’s orders added additional responsibilities to those installations storing biological and chemical weapons. The remaining stockpiles of biological agents at Pine Bluff Arsenal, Rocky Mountain Arsenal, and Fort Detrick, Maryland were destroyed between 1971 and 1973 (Sidell 1997:69). Demilitarization of chemical weapons increased during the 1970s. Rather than transport chemical agents to centralized detoxification facilities, a move unpopular with the public due to concerns about accidental releases, new buildings designed to safely dispose of chemical agents were constructed at the storage. One of the first was constructed in early 1972 at Rocky Mountain Arsenal for the disposal of more than 579,000 gallons of mustard gas (*Ordnance* 1972:277).

Chemical demilitarization projects completed within the continental United States by the end of FY 1977 are summarized in Table 9.1 (NARA RG 544 Office of the DA Project Manager for Chemical Demilitarization and Installation Restoration 1977:7).

Table 9.1. Chemical Demilitarization Projects Completed by 30 September 1977

Task	Location	Actual Completion
Biological stockpile	Multiple	October 1972
Bulk mustard	Rocky Mountain Arsenal, Colorado	March 1974
Nerve agent GB in underground tanks	Rocky Mountain Arsenal, Colorado	November 1974
Agents in concrete drums (Phase I)	Edgewood Arsenal, Maryland; Aberdeen Proving Ground, Maryland	August 1975
Nerve agent GB in ton containers	Rocky Mountain Arsenal, Colorado	February 1976
Honest John warhead/M139 bomblets (nerve agent GB)	Rocky Mountain Arsenal, Colorado	August 1976
M34 cluster bombs/M125 bomblets (nerve agent GB)	Rocky Mountain Arsenal, Colorado	September 1976
M55 rocket—nerve agent GB (Phase I)	Dugway Proving Ground, Utah	September 1976
M139 bomblets—nerve agent GB (Phase II)	Dugway Proving Ground, Utah	September 1977

Due to the Army's need for an installation restoration program to decontaminate facilities exposed to chemical, biological, and radiological material, including ammunition storage, facilities, the Army created the Project Manager for Chemical Demilitarization and Installation on 22 August 1975 (NARA RG 544 Office of the DA Project Manager for Chemical Demilitarization and Installation Restoration 1977:1-4). The Project Manager was responsible for the demilitarization of "hazardous chemical substances and munitions, including lethal, incapacitating, and other chemicals which are designated for disposal," and oversee the "design, development, and acquisition of special equipment and facilities" (NARA RG 544 Office of the DA Project Manager for Chemical Demilitarization and Installation Restoration 1977:4). By the end of FY 1977, projects also were underway at the following establishments:

Anniston Army Depot, Alabama
Lexington-Blue Grass Army Depot, Kentucky
Pine Bluff Arsenal, Arkansas
Pueblo Army Depot, Colorado
Tooele Army Depot, Utah
Umatilla Army Depot, Oregon

Although the production of chemical weapons had halted, binary weapons were under development in the 1970s. These weapons solved many of the complications related to the storage and transport of chemical munitions. A binary weapon differed from the usual unitary chemical weapon, which was filled with a highly toxic chemical agent and then stored. A binary weapon contained two non-lethal agents that would mix within the weapon upon firing and form a lethal agent at that point. This process facilitated safe storage and handling of the weapon. Despite their advantages, binary weapons were not authorized for production until the 1980s (Sidell 1997:71, 78; Smith 1972:162).

Throughout the last decade of the Cold War, concern escalated over the use of chemical weapons by the Soviet Union and other countries. The Haig Report, which was presented by the U.S. Secretary of State to the U.S. Congress in 1982, documented the use of lethal chemical warfare agents in Afghanistan by the Soviet Union and in Southeast Asia by Laos and Vietnam under Soviet supervision. This report confirmed the chemical weapons capabilities of the Soviet Union. In addition, the use of chemical agents by Iraq during its invasion of Iran in the 1980s caused further apprehension regarding the possible risk of chemical warfare in future military engagements throughout the world. The U.S. Army proactively initiated a chemical program in the 1980s that reinstituted the production of chemical weapons (Sidell 1997:74-76).

Quantities of chemical weapons stored within the continental United States fluctuated during the 1980s. The U.S. Army debated methods of demilitarization. In 1982, incineration was chosen as the preferred means of demilitarizing chemical agents (Sidell 1997:80). The Army commenced construction of the BZ Agent/Munition Demilitarization Facility at Pine Bluff Arsenal in 1984 (Panamerican Consultants, Inc. 2001:2-29). The next year, construction began for a chemical-agent incineration disposal facility on Johnston Atoll. Known as the Johnston Atoll Chemical Agent Disposal System (JACADS), the incinerators did not become operational until 1990. Meanwhile, Public Law 99-145 ordered in 1986 that the U.S. stockpile of chemical weapons be destroyed by 1994. The U.S. Congress extended the deadline twice, first to 1997 and later to 2004. The Army began construction of another incineration disposal facility at Tooele, Utah, in 1989; this facility became operational in 1996. The Army held responsibility for protecting the environment and public health throughout all demilitarization activities (Sidell 1997:80).

The use of chemical weapons remained a critical issue throughout the 1980s and continued into the 1990s. In 1987, the Soviet Union admitted possession of chemical warfare agents and declared a production halt. In September 1989, the United States and the Soviet Union executed the Wyoming Memorandum of Agreement (MOU), which led to discussions regarding the prohibition of chemical weapons (Sidell 1997:80). On 1 June 1990, the United States and the Soviet Union executed a bilateral agreement for the destruction of chemical weapons. However, the launch of Operation Desert Storm in January 1991 "escalated fears of a new chemical war to levels not seen since World War I" (Sidell 1997:81). In 1993, the United States, Russia, and other nations signed the Chemical Weapons Convention treaty that prohibited development, production, stockpiling, and use of chemical weapons (Sidell 1997:83). Nevertheless, the U.S. Army became concerned about the use of chemical and biological weapons by terrorists (Sidell 1997:84).

9.5 Design and Construction of Ammunition Storage Facilities

Although DESCOM managed Army ammunition storage facilities, the Army Corps of Engineers maintained responsibility for construction, major modification, and rehabilitation of magazines (Department of the Army Headquarters 1982:10). The Army planned to build approximately 1,700 new ammunition storage facilities in the continental United States and in Europe between 1981 and 1986. Due to an estimated project expenditure of $200 to $300 million, cost effectiveness was a priority. A huge concern was the amount of land required to site magazines according to safety distance standards. In anticipation of the upcoming construction project, the U.S. Army Construction Engineering Research Lab (CERL) in Champaign, Illinois, conducted a study of ammunition storage facilities and published the results in March 1981. The CERL report, *Functional Requirements and New Concepts for Ammunition Storage Facilities*, identified "innovative ammunition storage facilities that are functional, life-cycle cost effective, and have substantially fewer real estate requirements than existing designs" (Howdyshell 1981). The CERL study examined four categories of functional requirements for existing magazines: shelter, safety, security, and operations. The investigation concluded that while safety had taken priority in the past, shelter and operations also needed attention. The study not only determined that smaller capacity magazines could reduce real estate costs, it identified a new design concept (Howdyshell 1981).

Many of the existing standard magazines had earth-covered circular or oval arches; the arch barrels were constructed with reinforced concrete or corrugated steel. The CERL report claimed that these arches leaked and required expensive repairs. In addition, the arches created space inefficiencies. Furthermore, the report noted condensation problems, magazine doors that were too small to accommodate forklifts, and the absence of hard surfaces outside doors for proper loading and unloading. To address these problems, the CERL report applauded a magazine designed by the Navy. This earth-covered, rectangular magazine had a flat roof, thus providing more efficient storage space. In turn, fewer magazines and less land would be needed, resulting in lower costs. Expense also could be reduced by using pre-cast concrete, as opposed to form work, for the roof and front wall. The Army took the Navy's design under consideration (Murphey et al. 2000:54).

Meanwhile, the Army rehabilitated existing earth-covered magazines as necessary to meet current ammunition storage requirements. For example, refrigerators were installed in magazines at Pine Bluff Arsenal that stored chemicals for biological warfare (Murphey et al. 2000:54). In addition, existing magazines sometimes were converted to training facilities. In 1984, the Army planned to transform sixteen overgrown, surplus magazines at Redstone Arsenal, Alabama, to a model corps storage area to provide authentic training for troops (Benson 1984:53).

The terms "standard" and "non-standard" continued to be used for earth-covered magazines throughout the 1980s and into the 1990s. Of the two types, standard magazines possessed the greater structural strength, offered more protection for ammunition, and could be built with lesser distance between magazines. Standard magazines also had larger storage capacity. In 1997, the term "standard" was replaced with "7-bar," and the term "non-standard" was changed to "undefined." A new term, "3-bar," was introduced to describe designs for intermediate-strength, earth-covered magazines. The term acknowledged magazine designs with greater strength and protection than undefined magazines but less strength and protection than 7-bar magazines. Groups of 3-bar magazines could be constructed using less inter-magazine separation distance than that required for undefined magazines (Department of Defense Explosives Safety Board 2004:39).

Despite the Army's plans to building 1,700 new ammunition storage facilities, the construction of new ammunition storage facilities remained low in the years following the Vietnam Conflict until the end of the Cold War Era. As with the preceding years, the majority of the construction was of installation-level facilities. These facilities ranged in size from a 25 square foot fixed ammunition magazine at Camp Bonneville, Washington, to a 20,000 square foot high-explosive magazine at Fort Knox, Kentucky. General trends indicate that smaller ready magazines and ammunition huts were completed at numerous Army installations. Between 1976 and 1982, Fort Benning, Georgia, received 26 installation-level ready magazines measuring 96 square feet each. Construction at Fort Dix, New Jersey, between 1984 and 1987 included 28 installation-level ammunition huts with 120 square feet of floor area. Twelve ammunition huts, either 120 or 240 square feet, were built during 1988 and 1989 at Fort Knox, Kentucky. Some of the greatest construction activity of the late Cold War was at Fort Polk, Louisiana. In 1987, 2 ammunition storehouses, 5 special weapons magazines, 6 ammunition huts, and 22 general purpose magazines were among those constructed; all were classified as installation level (U.S. Army Real Property Inventory 2007).

Although installation-level ammunition storage facilities account for the largest numbers built during the latter years of the Cold War, depot-level buildings were also constructed. Twelve igloos were constructed at Fort Jackson, South Carolina, in 1977. This was followed five years later by the construction of 68 igloo magazines and two ammunition storehouses at the Deseret Chemical Depot. In addition to these depot-level facilities, explosives transfer facilities were built at Louisiana, Milan, and Lone Star Army ammunition plants and Tooele Ammunition Depot. After taking control of Hawthorne Naval Depot in 1975, the Army constructed two ammunition storage facilities in 1978. These earth-covered magazines were composed of separate arched sections with a common front wall. Ammunition was stored in these buildings prior to demilitarization at the Western Area Demilitarization Facility (U.S. Army Real Property Inventory 2007). Although construction of new facilities was low, many modifications were made to existing igloos. The most common was to enlarge the opening to improve the efficient movement of ammunition with heavy equipment. In some cases, this included removing additional concrete, and constructing a new surround for double doors (Plate 9.3). More extensive modifications to World War II era magazines included extending one wing wall of Huntsville-type igloos, and installing large sliding doors similar to those used in Stradley magazines (Plate 9.4).

The most abundant facility type constructed after the Vietnam Conflict was the ammunition storage pad. Storage pads of varying size were constructed at numerous installations across the country including Fort Benning, Georgia; Fort Bliss, Texas; Fort Greeley, Alaska; Fort Knox, Kentucky; Fort Leonard Wood, Missouri; and Fort McCoy, Wisconsin. Sixty-six storage pads were built at the Sunny Point, North Carolina, Military Ocean Terminal in 1981. The largest two covered over 32,000 square yards: roughly six acres each.

Table 9.2 provides data on the numbers, locations, and types of ammunition storage facilities constructed during the late Cold War.

9.6 Summary

From the late 1970s to the end of the Cold War, Army Materiel Command focused on increasing efficiency and space utilization of ammunition storage facilities at installations nationwide. Construction of new ammunition storage facilities was limited with the majority of activity taking place at installations rather than depots. Although some facilities exceeded 20,000 square feet in size, the newly-constructed magazines were generally small. Construction activities at depots included modifications of front doors to facilitate the use of forklifts and heavy equipment for the handling of munitions.

Demilitarization and surveillance remained a major effort at Army's ammunition depots. As new weapon systems were developed, obsolete munitions were disassembled to recover useable components or destroyed. Agreements on abolishing the use of chemical and biological weapons lead the Army to construct facilities for the safe disposal of these agents. Rather than transport an aging stockpile of chemical-agent filled munitions, disposal facilities were constructed at the depots.

Table 9.2 Ammunition and explosive storage facilities currently managed by the U.S. Army that were constructed during the late Cold War (U.S. Army Real Property Inventory)

	Installation Level													Special Types			Depot Level			
Location	General Purpose Cat.Code 42283	Igloo Cat.Code 42280	Ammunition Hut Cat.Code 42281	Small Arms Cat. Code 42230	Fixed Ammunition Cat.Code 42240	Unit Ammunition Cat.Code 42285	Ammunition Storehouse Cat.Code 42231	Fuze and Detonator Cat.Code 42210	High-Explosive Magazine Cat.Code 42215	Ready Magazine Cat.Code 42235	Ammunition Structure Cat.Code 42286	Guided Missile Magazine Cat.Code 42260	Special Weapons Cat.Code 42250	Smokedrum Storehouse Cat.Code 42225	Ammunition Storage Pad Cat.Code 42510	Battery Storage Cat.Code 42410	General Purpose Cat.Code 42183	Explosives Transfer Cat.Code 42104	Igloo Cat. Code 42180	Ammunition Storehouse Cat.Code 42181
Aberdeen Proving Ground, MD	1	1	1	1																
Camp Bonneville, WA					3															
Camp Swift, TX						2														
Charles Melvin Price Support Center, IL	1																			
Fort Custer Training Center, MI		2																		
Dahlonega, GA		1				1														
Deseret Chemical Depot, UT																			68	2
Dugway Proving Ground, UT		4													1					
Florence Military Reserve Center, AZ		1							1											
Fort A.P. Hill, VA															1					
Fort Benning, GA										29	2									
Fort Bliss AAA Ranges, TX	1								1						3					
Fort Bragg, NC	4	2		3		2	2					2			1					
Fort Carson, CO		8	2																	
Fort Dix, NJ			31											1						
Fort Drum, NY	20								1											
Fort Greeley, AK															13					
Fort Hunter Liggett, CA							1													
Fort Indiantown Gap, PA							2													
Fort Jackson, SC					2										1				12	
Fort Knox, KY			10			1	1		11						1					
Fort Lee, VA			2																	
Fort Leonard Wood, MO	8			1									1		1					
Fort Lewis, WA															2					
Fort McClellan, AL		2	5				2													
Fort McCoy, WI	10														2					
Fort Ord, CA					1															
Fort Pickett, VA				1	12										4					
Fort Polk, LA	22		6				1						2							
Fort Riley, KS		6				1	2								3					
Fort Sill, OK																1				
Fort Stewart, GA					30															
Fort Wingate Depot Activity, NM	2																			
Fort Campbell, TN							3													
Hawthorne Army Depot, NV									2											
Indiana Army Ammunition Plant, IN									1											
Iowa Army Ammunition Plant, IA	3														1					
Kansas Army Ammunition Plant, KS	1						7			1										
Letterkenny, Army Depot, PA																				1
Lone Star Army Ammunition Plant, TX																		1		
McAlester Army Ammunition Plant, OK							1		1						1					
Milan Army Ammunition Plant, TN									4	9								1		
Military Ocean Terminal Sunny Point, NC															61					
Mississippi Army Ammunition Plant, MS		15					1		1											
MTA Camp Clark, NV										1										
MTA Fort Wm. Henry Harrison, MT		3																		
MTC Camp Roberts, CA		3																		
NG Ethan Allen AFB, VT				1																
TTC Fort Irwin, CA									22											
Pine Bluff Arsenal, AR							1										3		1	1
Pahakuloa, HI		8				1	1													
Red River Army Depot, TX															2					1
Tooele Army Depot, UT															2			1		
Umatilla Chemical Depot, OR																				1
USA Adelphi Laboratory Center, MD	2																			
VTS Catoosa, GA			2																	
VTS Milan, TN			2																	
West Point Military Reservation, NY				1			1													
White Sands Missile Range, NM								4	1				2		4					
Yakima Training Center, WA					1															
Yuma Proving Ground, AZ		14							1						1					

10.0 BIBLIOGRAPHY

Advisory Committee Staff

1995 "Memorandum to the Members of the Advisory Committee on Human Radiation Experiments." 5 April. Electronic Document. Available at http://www.gwu.edu/~nsarchiv/radiation/dir/mstreet/commeet/meet13/brief13/tab_f/br13f3.txt. Viewed on 27 March 2007.

Anniston Army Depot

2007 Personal Communication with Clifton Tolbert. Held at Anniston Army Depot, Anniston, Alabama. 3 April 2007.

Various Base Engineer. Construction drawings on file at the Base Engineer's Office, Anniston Army Depot, Anniston, Alabama.

Various Real property records on file at the Real Property Manager's Office, Anniston Army Depot, Anniston, Alabama.

Ambrose, Stephen E.

1971 Rise to Globalism. American Foreign Policy 1938-1970. Penguin Books, Inc., Baltimore, Maryland.

American Presidency Project

1972 "Text of the 'Basic Principles of Relations Between the United States of America and the Union of Soviet Socialist Republics.'" Electronic Document. Available at http://www.presidency.ucsb.edu/ws/index.php?pid=3438. Viewed on 30 March 2007.

Army Materiel Command Historical Office

2007a "U.S. Army Materiel Command, A Brief History." Accessed 4 April at www.amc.army.mil/amc/ho/studies/brief_amc_history.html.

2007b "A Brief History of AMC, 1962-2000." Accessed 4 April at www.amc.army.mil/amc/ho/brief_history.htm.

Babers, Lt. Gen. Donald M.

1984 "The DARCOM Story." *The Ordnance Magazine* 2, no. 2:1827.

Benson, Sigrid

1984 Facilities Upgrade USAOMMCS. *The Ordnance Magazine*. Fall 1984:52-53.

Bentzley, Charles M.

1985 Project Manager Ammunition Logistics. *The Ordnance Magazine*. Fall 1985:6-8.

Bernstein, Carl

1992 "Cover Story: The Holy Alliance." *Time*, 24 February. Electronic Document. Available at http://www.time.com/time/printout/0,8816,974931,00.html. Viewed on 26 March 2007.

Betts, Richard K.

1995 *Military Readiness: Concepts, Choices, Consequences*. The Brookings Institution, Washington, DC.

Blue Grass Ordnance Depot

1952 "Historical Summary Blue Grass Ordnance Depot Richmond, Kentucky 1 January – 30 June 1952." National Archives and Records Administration II, College Park, Maryland. Record Group 156, Office of the Chief of Ordnance. NARA Finding Aid A-1; Entry 1023B; General Administration Files, 1946-1954; Box 34C.

Building Technology Incorporated

1984a *Historic Properties Report: Hawthorne Army Ammunition Plant, Hawthorne, Nevada*. Prepared by Building Technology Incorporated, Silver Spring, Maryland, under Contract No. CX-0001-2-0033 to HABS/HAER, National Park Service, U.S. Department of the Interior.

1984b *Historic Properties Report: Savanna Army Depot Activity, Savanna, Illinois.* Prepared by MacDonald and Mack Partnership, Minneapolis, Minnesota under Contract No. CX-0001-2-0033 to HABS/HAER, National Park Service, U.S. Department of the Interior.

Christensen, John

n.d. "Pope John Paul II: Cold Warrior with a Cross." CNN Interactive. Electronic Document. Available at http://www.cnn.com/SPECIALS/cold.war/episodes/19/spotlight/. Viewed on 26 March 2007.

1999 "John Paul II: Conscience of the World." CNN. Electronic Document. Available at http://www.cnn.com/SPECIALS/1999/pope/legacy/. Viewed on 26 March 2007.

Cohen, E., and N. Dobbs

1967 Structural Protection against Explosives. *The Military Engineer*. November-December 1967:400-403.

Conference on Security and Co-operation in Europe

1975 *Final Act*. Helsinki, Finland. Electronic Document. Electronic Document. Available at http://www.osce.org/documents/mcs/1975/08/4044_en.pdf. Viewed on 26 March 2007.

Crowell, Benedict

1919 *America's Munitions 1917-1918*. Government Printing Office, Washington, D.C.

Department of the Army

1956 *Progress. United States Army Reports.* Department of the Army, Washington, D.C.

2006 "Guide Army Real Property Category Codes, Pamphlet 415-28." Department of the Army, Washington, D.C.

Department of the Army Headquarters

1982 *The Army Ammunition Management System*. Department of the Army Pamphlet 700-16. 1 December 1982. Electronic document. Available at http://www.army.mil/usapa/epubs/pdf/p700_16.pdf. Viewed June 2007.

Department of Defense

1994 *Coming in from the Cold. Military Heritage in the Cold War*. Report on the Department of Defense Legacy Cold War Project.

2007 "Defense Nuclear Agency Changes Name." Electronic document. Available at http://www.defenselink.mil/releases/release.aspx?releaseid=946. Viewed on 7 August 2007.

Department of Defense Explosives Safety Board

2004 *Approved Protective Construction (Version 2.0), Technical Paper No. 15*. Alexandria, Va. June 2004. Electronic document. Available at http://www.ddesb.pentagon.mil/TP%2015/TP%2015.htm. Viewed on 14 March 2007.

Epley, William W.

1993 *America's First Cold War Army, 1945-1950*. The Land Warfare Papers No. 15, The Institute of Land Warfare, Association of the United States Army, Arlington, Virginia.

Fine, Lenore, and Jesse A. Remington

1989 *The Corps of Engineers: Construction in the United States*. Reprint of 1972 edition. Government Printing Office, Washington, D.C.

Fort Lewis

2007 "Fort Lewis Internet, Korea 1949-1955." Electronic document. Available at http://www.lewis.army.mil/lewis-korea.asp. View 7 August 2007.

Gaddis, John Lewis

1972 *The United States and the Origins of the Cold War: 1941-1947*. Columbia University Press, New York, New York.

2005 *The Cold War. A New History*. The Penguin Press, New York, New York.

Global Security

2007 "Fort Hood." Electronic document. Available at http://www.globalsecurity.org/military/facility/fort-hood.htm. Viewed 7 August 2007.

Grandine, Katherine, and Deborah Cannan

1995 *Support and Utility Structures and Facilities (1917-1945): Overview, Inventory, and Treatment Plan*. Prepared by R. Christopher Goodwin & Associates, Inc., for U.S. Army Corps of Engineers, Baltimore District.

Grathwol, Robert P. and Donita M. Moorhus

1994 *American Forces in Berlin: Cold War Outpost*. Department of Defense, Legacy Resource Management Program, Cold War Project. Government Printing Office, Washington, DC.

Harrison, Mark
1988 "Resource Mobilization for World War II: The U.S.A., U.K., U.S.S.R. and Germany 1938-1945." *Economic History Review.*

Hawthorne Army Depot
1926 Memorandum from the Chief of Ordnance and the Chief of the Bureau of Yards and Docks to the Secretary of the Navy on the Ammunition Depot to serve the Pacific Coast. 13 December 1926. On file at Hawthorne Army Depot, Real Property Office, Hawthorne, Nevada.

1930 Construction report: The Navy's Storage Depot for High Explosives at Hawthorne, Nevada. Prepared by Lieutenant Commander, C. H. Cotter (CEC) USN, Officer in Charge of Construction. 17 January 1930. On file at Hawthorne Army Depot, Real Property Office, Hawthorne, Nevada.

1945 Wartime History of Ordnance Activities. 15 December 1945. On file at Hawthorne Army Depot, Real Property Office, Hawthorne, Nevada.

1978 "U.S. Army Armament Materiel Readiness Command, Hawthorne Army Ammunition Plant, Annual Historical Review, Fiscal Year 1978." National Archives and Records Administration II, RG 544, Entry 1203/ACC 81-0070, Box 1.

Various Base Civil Engineer. Construction drawings on file at the Base Civil Engineers Office, Hawthorne Army Depot, Hawthorne, Nevada.

Hewes, James E., Jr.
1975 *From Root to McNamara: Army Organization and Administration.* Center of Military History, Washington, D.C.

Hix, W. Michael, Ellen M. Pint, John R. Bondanella, Bruce Held, Michael V. Hynes, David Johnson, Art Pregler, Mike Stollenwerk, Jerry Sollinger
2003 *Rethinking Governance of the Army's Arsenals and Ammunition Plants.* Prepared for the U.S. Army by RAND, Arlington, Virginia.

Howdyshell, P.A.
1981 *Functional Requirements and New Concepts for Ammunition Storage Facilities.* Prepared by U.S. Army Construction Engineering Research Lab, Champaign, Illinois. March 1981. Electronic abstract available at http://stinet.dtic.mil/oai/oai?&verb=getRecord&metadataPrefix=html&identifier=ADA097938. Viewed on 7 June 2007.

Kane, Kimberly L.
1995 *Historic Context for the World War II Ordnance Department's Government-Owned Contractor-Operated (GOCO) Industrial Facilities, 1939-1945.* U.S. Army Materiel Command Historic Context Series, Report of Investigations, Number 1. Prepared for U.S. Army Corps of Engineers, Ft. Worth District. Contract No. DACA63-93-D-0014, Delivery Order No. 0014. Prepared by Geo-Marine, Inc., Plano, Texas.

Kennedy, Robert H.
1948 Eastern Chemical Depot – 1921-1947. *Chemical Corps Journal*. January 1948:53-55.

Kuranda, Kathryn M, Brian Cleven, Nathaniel Patch, Katherine Grandine, and Christine Heidenrich
2003 "Unaccompanied Personnel Housing (UPH) During the Cold War (1946-1989)." Prepared for U.S. Army Environmental Center, Aberdeen Proving Ground, Maryland.

Library of Congress
2007 "Historic American Buildings Survey/Historic American Engineering Record, 1933-Present (HAER No. NM-1-B), White Sands Missile Range, V-2 Rocket Facilities." Electronic document. Available at http://memory.locgov/ ammem/collections/habs_haer Viewed on 7 May 2007.

Limitations of the Anti-Ballistic Missile-Defense Systems
1972 Limitations of the Anti-Ballistic Missile-Defense Systems. Electronic Document. Available at http://www.nuclearfiles.org/menu/library/ treaties/ missile-defense/trty_missile-defense_limitations_1972-05-26.htm. Viewed on 2 April 2007.

MacLeay, Francis R.
1942 Concrete Beehive for Munitions Storage. *Engineering News-Record* (March) 26:74-76.

MacMorland, E.E.
1945 "Ordnance Supply System." *Mechanical Engineering*. December 1945, pp. 789-797.

Murphey, Joseph, Dwight Packer, Cynthia Savage, Duane E. Peter, and Marsha Prior
2000 *Army Ammunition and Explosives Storage in the United States: 1775-1945*. Geo-Marine, Inc., Special Publications No. 7. Prepared for the U.S. Army Corps of Engineers, Fort Worth District. July 2000.

National Archives and Records Administration II, College Park, Maryland. Record Group 156, Office of the Chief of Ordnance.

Ammunition Task Force
1953a *Ordnance Ammunition Program, 1 July 1950 – 31 December 1952. Volume I: Programming within Office, Chief of Ordnance. Book 1: Narrative*. NARA Finding Aid A-1; Entry 1339; Field Service Division, Administrative Office, Ammunition Task Force Files, 1950-1952; Box H2.

1953b *Ordnance Ammunition Program, 1 July 1950 – 31 December 1952. Volume I: Programming within Office, Chief of Ordnance. Book 5: Ammunition (Preservation and Stock Status).* NARA Finding Aid A-1; Entry 1339; Field Service Division, Administrative Office, Ammunition Task Force Files, 1950-1952; Box H2.

Army Service Forces, War Department
1945 *Postwar Installation Study*. For Planning Purposes Only. 28 September 1945. NARA Finding Aid NM-26; Entry 645; Executive Division, Special Planning Branch, Records Relating to Industrial Demobilization Planning, 1944-1945; Box A13AE.

Baker, M.P.
1956 *Historical Summary of Field Service Division Activities, 1 July 1955 – 31 December 1955*. 18 May 1956. NARA Finding Aid A-1; Executive Office; Historical Branch; Historical Summaries of the Field Service Division, 1955-1961; Box 1.

Baldwin, Russell J.
1952a Annual Construction Policy Statement, FY 1954. Memorandum to Ordnance Corps Division Chiefs from Lt. Colonel Russell J. Baldwin, Deputy Executive Officer, Office of the Chief of Ordnance, Department of the Army, Washington, D.C. 26 June 1952. NARA Finding Aid A-1; Entry 1243; Industrial Division, Staff and Management Office, Facilities and Resources Section, Budget Justification and Supporting Papers Pertaining to the Ordnance Military Construction Program, FY 1951-1954, 1950-1954; Box I217.

1952b Submission of FY 1954 Construction Program. Memorandum to Ordnance Corps Division Chiefs from Lt. Colonel Russell J. Baldwin, Deputy Executive Officer, Office of the Chief of Ordnance, Department of the Army, Washington, D.C. 27 June 1952. NARA Finding Aid A-1; Entry 1243; Industrial Division, Staff and Management Office, Facilities and Resources Section, Budget Justification and Supporting Papers Pertaining to the Ordnance Military Construction Program, FY 1951-1954, 1950-1954; Box I217.

1952c Advance Planning, FY 1954 Military Construction, Army, Program. Memorandum to various Ordnance Corps installations from Lt. Colonel Russell J. Baldwin, Deputy Executive Officer, Office of the Chief of Ordnance, Department of the Army, Washington, D.C. 17 December 1952. NARA Finding Aid A-1; Entry 1243; Industrial Division, Staff and Management Office, Facilities and Resources Section, Budget Justification and Supporting Papers Pertaining to the Ordnance Military Construction Program, FY 1951-1954, 1950-1954; Box I217.

Bergin, William E.
1953 FY 1954 Construction Program. Memorandum to various Army officials from Major General William E. Bergin, Adjutant General, Department of the Army, Washington, D.C. 20 August 1953. NARA Finding Aid A-1; Entry 1243; Industrial Division, Staff and Management Office, Facilities and Resources Section, Budget Justification and Supporting Papers Pertaining to the Ordnance Military Construction Program, FY 1951-1954, 1950-1954; Box I217.

Booz, Allen & Hamilton

1954 *Stock Control of Major End Items*. Prepared for the Ordnance Corps, Department of the Army, by Booz, Allen & Hamilton, Management Consultants. 27 July 1954. NARA Finding Aid A-1; Entry 1043; Executive Office, Office of Executive Management, Management Engineering Services Contract Files, 1951-1960; Box 5.

Connally, William P., Jr.

1947 Recommended Changes in Army and Navy Safety Standards for the Storage of Explosives and Ammunition. Memorandum for the Judge Advocate General from Colonel William P. Connally, Jr., Chief of Military Affairs Group. 13 June 1947. NARA Finding Aid A-1; Entry 1111; Intelligence, Safety, and Security Office, Safety Branch, General Administrative Files, 1950-1055; Box E13.

Department of the Army

1949 Safety. Special Regulation No. 385-15-1. Washington, D.C. 4 October 1949. NARA Finding Aid A-1; Entry 1111; Intelligence, Safety, and Security Office, Safety Branch, General Administrative Files, 1950-1955; Box E13.

1952 Construction Project Justification Data FY 1954 for Aberdeen Proving Ground. 3 October 1952. NARA Finding Aid A-1; Entry 1243; Industrial Division, Staff and Management Office, Facilities and Resources Section, Budget Justification and Supporting Papers Pertaining to the Ordnance Military Construction Program, FY 1951-1954, 1950-1954; Box I218.

1955a *Depots Missions, Ordnance Corps*. Army Regulations No. 780. Washington, D.C. NARA Finding Aid A-1; Entry 1342; Field Service Division, Operations Branch, Correspondence and Other Records Relating to Missions and Organization of Ordnance Installations, 1952-1956; Box 3.

1955b *Ordnance Support Plan for Guided Missiles and Associated Equipment*. 15 July 1955. NARA Finding Aid A-1; Entry 1342; Field Service Division, Operations Branch, Correspondence and Other Records Relating to Missions and Organization of Ordnance Installations, 1952-1956; Box 3.

1956 *Supply and Service Installations and Activities: Depot Missions, Ordnance Corps*. Army Regulations No. 780-970. Washington, D.C. 23 May 1956. NARA Finding Aid A-1; Entry 1022; Executive Office; Historical Branch; Historical Summaries of the Field Service Division, 1955-1961; Box 1.

1958 *Supply and Service Installations and Activities: Depot Missions, Ordnance Corps*. Army Regulations No. 780-970. Washington, D.C. 9 September 1958. NARA Finding Aid A-1; Entry 1022; Executive Office; Historical Branch; Historical Summaries of the Field Service Division, 1955-1961; Box 2.

Facilities Section, Plans and Operation Branch, Field Service Division, Office of the Chief of Ordnance

1950 Brochure for approved ammunition handling truck. NARA Finding Aid A-1; Entry 1111; Intelligence, Safety, and Security Office, Safety Branch, General Administrative Files, 1950-1955; Box E5.

Field Service Division

1952 Depot Operations Report DA 808, Tonnage Handled. NARA Finding Aid A-1; Entry 1104; Office of the Ordnance Comptroller, Background Data for Chief of Ordnance Handbook, 1950-1958; Box 13.

Ford, E.L.

1950 Accidents. Memorandum to Commanding Officers, All Ordnance Establishments, from Major General E.L. Ford, Chief of Ordnance, Department of the Army, Washington, D.C. 25 April 1950. NARA Finding Aid A-1; Entry 1111; Intelligence, Safety, and Security Office, Safety Branch, General Administrative Files, 1950-1955; Box E3.

1953 Implementation of Construction Program. Memorandum to various Ordnance Corps installations from Major General E.L. Ford, Chief of Ordnance, Department of the Army, Washington, D.C. 23 January 1953. NARA Finding Aid A-1; Entry 1243; Industrial Division, Staff and Management Office, Facilities and Resources Section, Budget Justification and Supporting Papers Pertaining to the Ordnance Military Construction Program, FY 1951-1954, 1950-1954; Box I217.

Guest, Harry

1951 *Safety and the Ammunition Inspector*. Lecture given by Mr. Harry Guest at the Ammunition Inspectors School, 9 November 1951. Edited by E.W. Olsen, AIS. NARA Finding Aid A-1; Entry 1111; Intelligence, Safety, and Security Office, Safety Branch, General Administrative Files, 1950-1955; Box E6.

Hinrichs, J.H.

1953 Ammunition Expenditure Data. Memorandum to Mr. Jerry E. Bush, Comptroller, Progress Reports and Statistics Division, OSD, from Brigadier General J.H. Hinrichs, Assistant Chief of Ordnance, Office of the Chief of Ordnance, Department of the Army, Washington, D.C. NARA Finding Aid A-1; Entry 1339; Field Service Division, Administrative Office, Ammunition Task Force Files, 1950-1952; Box H8.

1954 Storage and Maintenance of Guided Missiles and Rockets. Memorandum to various Field Service installations from Major General J. H. Hinrichs, Assistant Chief of Ordnance, Office of the Chief of Ordnance, Department of the Army, Washington, D.C. 2 November 1954. NARA Finding Aid A-1; Entry 1342; Field Service Division, Operations Branch, Correspondence and Other Records Relating to Missions and Organization of Ordnance Installations, 1952-1956; Box 3.

Holmes, Joel G.

1952 Ordnance Safety Manual. Memorandum from Brigadier General Joel G. Holmes to Chief of Ordnance, Department of the Army, Washington, D.C. 25 February 1952. NARA Finding Aid A-1; Entry 1025; Executive Office, Historical Branch, Historical Studies, 1942-1962; Box 2.

Intelligence, Safety, and Security Office

1952 History of Safety Branch, IS&S Office, July thru December 1951. Ordnance Corps. 25 April 1952. NARA Finding Aid A-1; Entry 1111; Intelligence, Safety, and Security Office, Safety Branch, General Administrative Files, 1950-1955; Box E10.

Lewis, H.B.

1949 Master Planning for Emergency Expansion. Memorandum from Major General H.B. Lewis, Acting Adjutant General, Department of the Army, Washington, D.C., to Commanding Generals and Chiefs. 25 January 1949. NARA Finding Aid A-1; Entry 1242; Industrial Division, Staff and Management Office, Facilities and Resource Section, Records Relating to Ordnance Installations and Facilities in the National Industrial Plant Reserve, 1948; Box I214.

Matthews, M.A.

1955 *Historical Summary of Field Service Division Activities, 1 January 1955 – 30 June 1955*. 29 July 1955. NARA Finding Aid A-1; Entry 1022; Executive Office; Historical Branch; Historical Summaries of the Field Service Division, 1955-1961; Box 1.

McMullen, Richard F.

1946 *Ordnance Demobilization: September-December 1945*. Historical Section, Office of Technical Information, Office of the Chief of Ordnance, Army Service Forces, Washington, D.C. 31 March 1946. NARA Finding Aid UD; Entry 654J; Executive Division, Historical Branch, Publications and Reports, 1941-1945; Box 26.

Office of the Chief of Ordnance

1941 *Ordnance Safety Manual*. Government Printing Office, Washington, D.C.

1944a Heileman Memorandum “Contractor Operated Ordnance Depots,” Finding Aid NM-26, Entry 646A, Executive Division, Historical Branch, Military Historical Files, June 1941-June 1945, Box A-772, 24 March 1944.

1944b “Conference on Supply Control, Redistribution and Disposition of Military and Industrial Property 5-6 October 1944,” Finding Aid UD, Entry 654J, Executive Division, Historical Branch, Publications and Reports, Box 26.

1944c Hardy Memorandum: Demobilization Planning, Finding Aid UD, Entry 654J, Executive Division, Historical Branch, Publications and Reports, Box 26, 17 February 1944.

1945 Project Supporting Papers on Project 56, Finding Aid NM-26, Entry 648 Executive Division, Historical Branch, Supporting Papers to Various Topics of Ordnance Responsibility and Accomplishment, Box A-685, 2 July 1945.

1948 Status of Long Term Ammunition, Explosives, Loaded and Inert, and Packing Materials Storage Operations. Ordnance Department Technical Instruction Number 300-55-48. 22 December 1948. NARA Finding Aid A-1; Entry 1014A; Executive Office, Publications Branch, Publications Record Set, 1946-1954; Box B15.

1950a Surveillance of Ammunition. Ordnance Department Technical Instruction Number 380-1-50. 31 January 1950. NARA Finding Aid A-1; Entry 1014A; Executive Office, Publications Branch, Publications Record Set, 1946-1954; Box B15.

1950b Ammunition Storage Occupancy Report (Reports Control Symbol ORDFA-2). Ordnance Department Technical Instruction Number 380-2-50. 12 July 1950. NARA Finding Aid A-1; Entry 1014A; Executive Office, Publications Branch, Publications Record Set, 1946-1954; Box B15.

1951a Repair of Igloo Magazines. Ordnance Corps Technical Instruction Number 140-1-51. 26 February 1951. NARA Finding Aid A-1; Entry1014A; Executive Office, Publications Branch, Publications Record Set, 1946-1954; Box B16.

1951b Reports of Incidents at Ordnance Installations. Ordnance Corps Order Number 19-51. 27 March 1951. NARA Finding Aid A-1; Entry 1014A; Executive Office, Publications Branch, Publications Record Set, 1946-1954; Box B10.

1951c Safety Review of Construction Plans. Ordnance Corps Order Number 39-51. 9 July 1951. NARA Finding Aid A-1; Entry 1014A; Executive Office, Publications Branch, Publications Record Set, 1946-1954; Box B10.

1952 Ordnance Corps Technical Instruction Number 320-1-52. Inclosure 1: Conservation of Covered Storage Space as copied from Ordnance Corps Manual 3-1, *Depot Operations*. 16 June 1952. NARA Finding Aid A-1; Entry 1025; Executive Office, Historical Branch, Historical Studies, 1942-1962; Box 7.

1953a Ordnance Corps Guided Missile Policy. Ordnance Corps Order Number 46-52: Change 2. 24 April 1953. NARA Finding Aid A-1; Entry 1014A; Executive Office, Publications Branch, Publications Record Set, 1946-1954; Box B10.

1953b Program of Field Inspection of Ammunition Operations. Ordnance Corps Order Number 35-53. 8 October 1953. NARA Finding Aid A-1; Entry 1014A; Executive Office, Publications Branch, Publications Record Set, 1946-1954; Box B10.

1954 *Construction and Operation of Ammunition Magazine Areas*. Preliminary Incomplete Draft. 29 October 1954. NARA Finding Aid A-1; Entry 1343; Field Service Division, Plans Office, Administrative Files, 1951-1954; Box 14.

1956 Study of the Branch Depot Concept. 20 December 1956. NARA Finding Aid A-1; Entry 1022; Executive Office; Historical Branch; Historical Summaries of the Field Service Division, 1955-1961; Box 1.

Office of Ordnance Comptroller

1951 Depot Operations Report DA 808, Tonnage Handled. NARA Finding Aid A-1; Entry 1104; Office of the Ordnance Comptroller, Background Data for Chief of Ordnance Handbook, 1950-1958; Box 13.

Ordnance Ammunition Center

1951 "Ordnance Ammunition Center." Finding Aid A1, Entry 1111, Intelligence, Safety, and Security Office; Safety Branch; General Administrative Files. 1950-55. Box E6.

Ordnance Corps, Department of the Army

1951 *Ordnance Safety Manual*. Ordnance Corps Manual ORDM 7-224. 4 September 1951. NARA Finding Aid A1; Entry 1014A; Executive Office, Publications Branch, Publications Record Set, 1946-1954; Box B7.

1952a Ordnance Corps Construction Progress Report. 1 May 1952. NARA Finding Aid A-1; Entry 1243; Industrial Division, Staff and Management Office, Facilities and Resources Section, Budget Justification and Supporting Papers Pertaining to the Ordnance Military Construction Program, FY 1951-1954, 1950-1954; Box I215.

1952b *Ordnance Safety Manual: Changes No. 1*. Ordnance Corps Manual ORDM 7-224. 15 August 1952. NARA Finding Aid A-1; Entry 1014A; Executive Office, Publications Branch, Publications Record Set, 1946-1954; Box B7.

1953 Ordnance Corps Construction Progress Report. 1 March 1953. NARA Finding Aid A-1; Entry 1243; Industrial Division, Staff and Management Office, Facilities and Resources Section, Budget Justification and Supporting Papers Pertaining to the Ordnance Military Construction Program, FY 1951-1954, 1950-1954; Box I215.

1954a *Ordnance Safety Manual: Changes No. 2*. Ordnance Corps Manual ORDM 7-224. 15 April 1954. NARA Finding Aid A-1; Entry 1014A; Executive Office, Publications Branch, Publications Record Set, 1946-1954; Box B7.

1954b *Ordnance Safety Manual: Changes No. 3*. Ordnance Corps Manual ORDM 7-224. 14 May 1954. NARA Finding Aid A-1; Entry 1014A; Executive Office, Publications Branch, Publications Record Set, 1946-1954; Box B7.

1954c *Ammunition Supply and Preservation. Volume 1: General Instructions*. Ordnance Corps Manual ORDM 3-4. 3 May 1954. Revised up to and including Change 11, 7 November 1957. NARA Finding Aid A-1; Entry 1025; Executive Office, Historical Branch, Historical Studies, 1942-1962; Box 3.

1954d *Ammunition Supply and Preservation. Volume II: Technical Instructions Pertaining to Types of Ammunition Other than Guided Missiles*. Ordnance Corps Manual ORDM 3-4. 3 May 1954. Revised up to and including Change 9, 12 April 1957. NARA Finding Aid A-1; Entry 1025; Executive Office, Historical Branch, Historical Studies, 1942-1962; Box 3.

1954e Ordnance Corps Construction Progress Report. 1 May 1954. NARA Finding Aid A-1; Entry 1243; Industrial Division, Staff and Management Office, Facilities and Resources Section, Budget Justification and Supporting Papers Pertaining to the Ordnance Military Construction Program, FY 1951-1954, 1950-1954; Box I218.

1955 Ordnance Corps Construction Progress Report. 1 June 1955. NARA Finding Aid A-1; Entry 1243; Industrial Division, Staff and Management Office, Facilities and Resources Section, Budget Justification and Supporting Papers Pertaining to the Ordnance Military Construction Program, FY 1951-1954, 1950-1954; Box I218.

1960 *Depot Organization*. Ordnance Corps Manual ORDM 3-1, Change 84. 21 September 1960. Attachment to *Historical Summary of Field Service Division Activities, 1 July 1960-31 December 1960*. 15 June 1960. NARA Finding Aid A-1; Entry 1022; Executive Office; Historical Branch; Historical Summaries of the Field Service Division, 1955-1961; Box 3.

Ordnance Corps Survey

1952a *General Staff Report, Ordnance Corps Survey, Procurement and Supply Chapter, Section XI, The Depot System*. NARA Finding Aid A1; Entry 1044; Executive Office, Office of Executive Management, Management Surveys and Service Reports, 1949-1957; Box 3.

1952b *General Staff Report, Ordnance Corps Survey, Procurement and Supply Chapter, Section XII, Inspection*. NARA Finding Aid A1; Entry 1044; Executive Office, Office of Executive Management, Management Surveys and Service Reports, 1949-1957; Box 3.

1952c *General Staff Report, Ordnance Corps Survey, Procurement and Supply Chapter, Section XII, Inspection*. NARA Finding Aid A1; Entry 1044;

Executive Office, Office of Executive Management, Management Surveys and Service Reports, 1949-1957; Box 1.

Ordnance Department Field Service, Ammunition Supply Division

1945 *Project No. 64: Ammunition Supply*. 26 June 1945. NARA Finding Aid NM-26; Entry 648; Executive Division, Historical Branch, Supporting Papers Relating to Various Topics of Ordnance Responsibility and Accomplishment, 1939-1945; Box A688.

Ordnance Field Safety Office

1955 *Monograph: Ordnance Corps Safety Inspection and Training, 1950 – 1955*. November 1955. Edited by Safety Branch, OCO, January 1956. NARA Finding Aid A-1; Entry 1025; Executive Office, Historical Branch, Historical Studies, 1942-1962; Box 6.

Ordnance Training Command

1956 *Ordnance Military Training, 1945 – 1955*. Prepared by Ordnance Training Command, Aberdeen Proving Ground, Maryland. 19 July 1956. NARA Finding Aid A-1; Entry 1025; Executive Office, Historical Branch, Historical Studies, 1942-1962; Box 7.

Orsene, F. W.

1951 Armed Services Explosives Safety Board Proposed Quantity-Distance Standards. Memorandum for Record from Colonel F. W. Orsene, Chief, Facilities and Supply Branch. 17 May 1951. NARA Finding Aid A-1; Entry 1111; Intelligence, Safety, and Security Office, Safety Branch, General Administrative Files, 1950-1955; Box E12.

Orzeck, Rita R.

1957a *Historical Summary of Field Service Division Activities, 1 July 1956 – 31 December 1956*. 29 May 1957. NARA Finding Aid A-1; Entry 1022; Executive Office; Historical Branch; Historical Summaries of the Field Service Division, 1955-1961; Box 3.

1957b *Historical Summary of Field Service Division Activities, 1 January 1957 – 30 June 1957*. 2 August 1957. NARA Finding Aid A-1; Entry 1022; Executive Office; Historical Branch; Historical Summaries of the Field Service Division, 1955-1961; Box 2.

1958 *Historical Summary of Field Service Division Activities, 1 July 1957 – 31 December 1957*. 6 June 1958. NARA Finding Aid A-1; Entry 1022; Executive Office; Historical Branch; Historical Summaries of the Field Service Division, 1955-1961; Box 2.

1959a *Historical Summary of Field Service Division Activities, 1 July 1958 – 31 December 1958*. 25 May 1959. NARA Finding Aid A-1; Entry 1022; Executive Office; Historical Branch; Historical Summaries of the Field Service Division, 1955-1961; Box 2.

1959b *Historical Summary of Field Service Division Activities, 1 January 1959 – 30 June 1959*. 7 August 1959. NARA Finding Aid A-1; Entry 1022;

Executive Office; Historical Branch; Historical Summaries of the Field Service Division, 1955-1961; Box 3.

1960 *Historical Summary of Field Service Division Activities, 1 July 1959 – 31 December 1959*. 2 June 1960. NARA Finding Aid A-1; Entry 1022; Executive Office; Historical Branch; Historical Summaries of the Field Service Division, 1955-1961; Box 3.

Outland, G. W.

1950 Application of Attached Quantity-Distance Tables Proposed by Armed Services Explosives Safety Board. Memorandum from Colonel G. W. Outland, Assistant, Office of the Chief of Ordnance, Department of the Army, Washington, D.C., to Commanding Officers at various Ordnance Corps installations. 1 December 1950. NARA Finding Aid A-1; Entry 1111; Intelligence, Safety, and Security Office, Safety Branch, General Administrative Files, 1950-1955; Box E12.

Picatinny Arsenal

1954 *Packing and Packaging of Ammunition and Related Materiel at Picatinny Arsenal, 1946 – 1954*. Dover, New Jersey. October 1954. NARA Finding Aid A-1; Entry 1025; Executive Office, Historical Branch, Historical Studies, 1942-1962; Box 4.

Raaen, J.C.

1945 Initiation and Approval of Requests for New Construction. Memorandum from Colonel J.C. Raaen, Executive Officer, Office of the Chief of Ordnance, Army Service Forces, Washington, D.C., to All Ordnance Installations (including Districts). 3 July 1945. NARA Finding Aid A-1; Entry 1049; Unclassified General Correspondence, 1945-1954; Box A711.

Redstone Arsenal

1952 Tentative Estimates of Ordnance Personnel Requirements to Handle World Wide Procurement, Inspection, Storage, Maintenance, and Distribution of Guided Missile Liquid Propellants Thru FY 54. 5 July 1952. NARA Finding Aid A-1; Entry 1014A; Executive Office, Publications Branch, Publications Record Set, 1946-1954; Box B10.

Reed, C.S.

1953a Mandatory Requirements of the Ordnance Safety Manual. Memorandum from Colonel C.S. Reed, Ordnance Corps. 13 July 1953. NARA Finding Aid A-1; Entry 1025; Executive Office, Historical Branch, Historical Studies, 1942-1962; Box 2.

1953b Study of Requirements for Design and Siting of Covered Revetment for Ammunition. Memorandum from Colonel C.S. Reed, Ordnance Corps, to Chief, Field Service Division. 27 October 1953. NARA Finding Aid A-1; Entry 1111; Intelligence, Safety, and Security Office, Safety Branch, General Administrative Files, 1950-1955; Box E5.

School for Ordnance Technical Safety

1952 *School for Ordnance Technical Safety: Master Brochure*. Ordnance Field Safety Office, Indiana Arsenal, Charlestown, Indiana. NARA Finding Aid A-1; Entry 1111; Intelligence, Safety, and Security Office, Safety Branch, General Administrative Files, 1950-1955; Box E6.

1954 *School for Ordnance Technical Safety: Safety Directors Seminar*. Ordnance Field Safety Office, Indiana Arsenal, Charlestown, Indiana. NARA Finding Aid A-1; Entry 1111; Intelligence, Safety, and Security Office, Safety Branch, General Administrative Files, 1950-1955; Box E6.

Sierra Ordnance Depot

1955 *Historical Monograph of Sierra Ordnance Depot on Receipt, Storage and Shipment of Guided Missiles Material*, 1 January 1954 – 1 December 1955. Sierra Ordnance Depot, Herlong, California. 7 December 1955. NARA Finding Aid A-1; Entry 1025; Executive Office, Historical Branch, Historical Studies, 1942-1962; Box 4.

Snodgrass, Raymond J.

1953 *Summary of Major Events and Problems of the Ordnance Corps, July 1952 – June 1953*. Historical Branch, Executive Office, Office of the Chief of Ordnance, August 1953. NARA Finding Aid A-1; Entry 1020; Executive Office, Historical Branch, Summaries of Major Events and problems, 1952-1961; Box 1.

1961 *Summary of Major Events and Problems of the Ordnance Corps, July 1959 – June 1960*. Historical Branch, Executive Office, Office of the Chief of Ordnance, January 1961. NARA Finding Aid A-1; Entry 1020; Executive Office, Historical Branch, Summaries of Major Events and problems, 1952-1961; Box 1.

Solomon, Morton

1949 Minutes of Department of the Army Fire Prevention and Protection Conference. Memorandum to Chief of Ordnance from Lt. Colonel Morton Solomon, Corps of Engineers, Office of the Chief of Engineers. 13 June 1949. NARA Finding Aid A-1; Entry 1111; Intelligence, Safety, and Security Office, Safety Branch, General Administrative Files, 1950-1955; Box E2.

Stephens, Clifford W.

1959 *Ordnance Corps: Inspection of Ammunition in Movement, Storage, and Use 1946-1958. Volume I: Narrative*. Headquarters, Ordnance Ammunition Command, U.S. Army, Joliet, Illinois. February 1959. NARA Finding Aid A-1; Entry 1025; Executive Office, Historical Branch, Historical Studies, 1942-1962; Box 3.

Walker, I.B.

1960 *Historical Summary of Field Service Division Activities, 1 July 1960 – 31 December 1960*. 15 June 1960. NARA Finding Aid A-1; Entry 1022;

Executive Office; Historical Branch; Historical Summaries of the Field Service Division, 1955-1961; Box 3.

1961 *Historical Summary of Field Service Division Activities, 1 January 1961 – 30 June 1961*. 28 September 1961. NARA Finding Aid A-1; Entry 1022; Executive Office; Historical Branch; Historical Summaries of the Field Service Division, 1955-1961; Box 3.

National Archives and Records Administration II, College Park, Maryland. Record Group 544, Army Materiel Command.

Departments of the Army, Navy, and Air Force

1969 *Joint Interservice Logistic Support Agreement for Ammunition*. 11 February 1969. NARA Finding Aid XXXX; Entry 565; Communication Files, 1970; Box 2.

Letterkenny Army Depot

1976 *Unit History Report: Supplement for Fiscal Year 1976*. 1 July 1975-30 September 1976. NARA Finding Aid WW; Entry 1220; Annual Historical Summaries; 1970; Box 1.

Office of the DA Project Manager for Chemical Demilitarization and Installation Restoration

1977 *Annual Historical Review (RCS CSHIS-6(R3))*. 1 October 1976 – 30 September 1977. NARA Finding Aid WW; Entry 1238; Annual Historical Summaries, 1962-1978; Box 1.

Red River Army Depot

1977 *Annual Historical Summary (RCS CSHIS-6(R2)) of Red River Army Depot, Texarkana, Texas 75501*. 1 January 1976-1 January 1977. NARA Finding Aid WW; Entry 1220; Annual Historical Summaries; 1970; Box 1.

Sears, Leslie R., Jr.

1974a Storage Space Utilization and Occupancy. Presentation to Commanding General, AMC, by Brigadier General Leslie R. Sears, Jr., Comptroller. 9 October 1974. NARA Finding Aid XXXX; Entry 561; Communication Files, 1974; Box 2.

1974b Storage Space Utilization and Occupancy CAMERA 4-75. Memorandum for Record from Brigadier General Leslie R. Sears, Jr., Comptroller. 16 October 1974. NARA Finding Aid XXXX; Entry 561; Communication Files, 1974; Box 2.

Snodgrass, Raymond J.

1951 *History of Ordnance Activities Relating to the Korean Conflict, June 1950 – September 1951*. Historical Branch, Executive Office, Office of the Chief of Ordnance, October 1951. NARA Finding Aid WW; Entry 1231; Historical Summaries, 1945-1976; Box 2.

1957 *Summary of Major Events and Problems of the Ordnance Corps, July 1956 – June 1957*. Historical Branch, Executive Office, Office of the

Chief of Ordnance, December 1957. NARA Finding Aid WW; Entry 1217; Organizational History, 1973; Box 2.

Tooele Army Depot

1976 *Tooele Army Depot: Organizational History*. 1 July 1975-30 September 1976. NARA Finding Aid WW; Entry 1231; Historical Summaries, 1945-1976; Box 2.

U.S. Army Depot System Command

1977 *Annual Historical Review (RCS CSHIS-6 (R3))*. 1 October 1976 – 30 September 1977. NARA Finding Aid WW; Entry 1238; Annual Historical Summaries, 1962-1978; Box 1.

U.S. Army Materiel Command

1967 Army Programs: AMC Chemical and Biological Weapons Surety Program. AMC Regulation No. 11-33. 6 October 1967. NARA Finding Aid XXXX; Entry 562; Communication Files, 1963-1967; Box 1.

NSZZ Solidarność

n.d. "History and Political Changes." Electronic Document. Available at http://www.solidarnosc.org.pl/english/about/eng_about_02.htm. Viewed on 26 March 2007

Ordnance

1972 Disposal of Mustard Gas. *Ordnance*. January-February 1972:277.

Ordnance Corps, Department of the Army

1955 *Ammunition Supply and Preservation. Volume 3: Technical Instructions Pertaining to Guided Missile Ammunition and Large Rockets*. Ordnance Corps Manual ORDM 3-4. 1 July 1955. Revised up to and including Change 10, 23 February 1960. On file at Library of Congress, Washington, D.C.

1961 *Ordnance Engineering Design Handbook: Maintenance Engineering Guide for Ordnance Design*. Ordnance Corps Pamphlet ORDP 20-134. 31 December 1961. On file at Library of Congress, Washington, D.C.

Palmer, R.R. and Joel Colton

1978 *A History of the Modern World*. Alfred A. Knopf, New York, New York.

Panamerican Consultants, Inc.

2001 *Installation Cold War Inventory and Assessment: Pine Bluff Arsenal, Pine Bluff, Jefferson County, Arkansas*. Draft 18 July 2001. Prepared for U.S. Army Corps of Engineers, Southwest Division, Fort Worth District, Fort Worth, Texas.

Radford Army Ammunition Plant

1949 "Monthly Report of Surveillance Activities, 1 July 1949." National Archives and Records Administration II, College Park, Maryland. Record Group 156, Office of the Chief of Ordnance. NARA Finding Aid A-1; Entry 1049; General Administration Files, 1946-1954; Box A268.

Redstone Arsenal

2007 "Historical Summary of the Lance Missile System." Electronic document. http://www.redstone.army.mil/history/lance/chronology.html. Viewed on 5 May 2007.

Shrader, Charles Reginald (Ed)

1995 *Reference Guide to United States Military History, 1945 to the Present*. Facts on File, Inc., New York, New York.

Sidell, Frederick R., Ernest T. Takafuji, and David R. Franz, specialty editors

1997 *Medical Aspects of Chemical and Biological Warfare*. Chapter 2. History of Chemical and Biological Warfare: An American Perspective. By Jeffery K. Smart, Command Historian, U.S. Army Chemical and Biological Defense Command, Aberdeen Proving Ground, Maryland.

Smith, Ray H.

1972 Army Nuclear and Chemical Surety. *Ordnance*. September-October 1972:161-162.

Sterling, Keir B.

1987 *Serving the Line with Excellence: The Development of the U.S. Army Ordnance Corps*. U.S. Army Ordnance Center and School, Aberdeen Proving Ground, Maryland. Viewed on 2 April 2007.

Thomson, Harry C., and Linda Mayo

1991 *The Ordnance Department: Procurement and Supply*. U.S. Army in World War II: The Technical Services. Center of Military History, U.S. Army, Washington, D.C. Reprint of 1960 edition.

Tindall, George Brown and David E. Shi

1992 *America, A Narrative History*. W.W. Norton and Company, New York, New York.

Treaty on the Non-Proliferation of Nuclear Weapons

1968 "Treaty on the Non-Proliferation of Nuclear Weapons." Electronic Document. Available at http://www.nuclearfiles.org/menu/library/treaties/non-proliferation-treaty/trty_npt_1970-03-05.htm#.

U.S. Army Corps of Engineers, History Office

n.d. Quartermaster and Corps of Engineers drawings on 105mm negatives. Fort Belvoir, Virginia.

U.S. Army DARCOM

1984 The DARCOM Story. *The Ordnance Magazine*. Volume 2, Number 2. Spring 1984:18-27.

U.S. Army Environmental Center

1997 *Thematic Study and Guidelines: Identification and Evaluation of U.S. Army Cold War Era Military-Industrial Historic Properties*. U.S. Army Environmental Center, Aberdeen Proving Ground, Maryland.

U.S. Army Real Property Inventory

2007 U.S. Army Real Property Inventory provided by the U.S. Army Environmental Command, Aberdeen, Maryland.

U.S. Navy Department, Bureau of Yards and Docks

1938 *Design Data*. Government Printing Office, Washington, D.C.

1947 *Building the Navy's Bases in World War II*. 2 volumes. Government Printing Office, Washington, D.C.

Walker, Andrew

2005 "Project Paperclip: Dark Side of the Moon." BBC News. Electronic Document. Available at http://news.bbc.co.uk/1/hi/magazine/4443934.stm. Viewed on 27 March 2007.

Whelan, Deborah, Leo Hirrel, William T. Dod, J. Hampton Tucker, and Katherine Grandine

1997 *Historic Context for Department of Defense World War II Permanent Construction*. Prepared by R. Christopher Goodwin & Associates, Inc., Frederick, Maryland, for the U.S. Army Corps of Engineers, Baltimore District, Baltimore, Maryland.

APPENDIX A

APPENDIX A. AMMUNITION STORAGE FACILITIES AT ACTIVE ARMY INSTALLATIONS (1939-1989)

1.0 Ammunition Storage

The following tables provide details on the types of ammunition storage facilities currently managed by the U.S. Army. The data was obtained from the U.S. Army Real Property Inventory and is current as of June 2007. The three tables are broken down by the types of facilities at each installation, the number constructed at each installation by year, and the number constructed at all Army installations by year. The facility types are referenced by the Category Code for that particular building type.

1.1 Depot-Level Facilities

The majority of depot-level facilities were constructed at major depots and arsenals, although some were built at individual installations. Generally, magazines with Category Codes 42107 through 42180 were earth-covered; the remaining were constructed above ground. Depot-level facilities were designed for bulk storage of explosives, ammunition, and propellants for distribution to numerous sites or installations.

Category Code	Description
42104	Explosive Transfer Building, or Explosive Loading Dock
42107	Stradley, Non-Atomic Blast Resistant Earth-Covered Magazine
42110	Fuze and Detonator Magazine
42120	High Explosive Magazine
42150	Smokeless Powder Magazine
42160	Special Weapons Magazine
42170	Guided Missile Magazine
42180	Igloo Storage
42181	Ammunition Storehouse
42182	Small Arms Ammunition Magazine
42183	General Purpose Magazine
42184	Ammunition Hut
42186	Ammunition Storage Structure

1.2 Installation-Level and Ready-Issue Facilities

The majority of installation-level facilities were constructed at individual Army installations; however, these types were constructed at depots and arsenals. Installation-level magazines were designed for the day-to-day storage of explosives, ammunition, and propellants for use by the installation and usually in small quantities. This type was only for use by the installation and the units assigned there. These types included both earth-covered and aboveground storage depending on the mission and needs of the installation.

Category Code	Description
42210	Fuze and Detonator Magazine
42215	High Explosive Magazine
42225	Smokedrum Storehouse
42228	Ammunition Storage other than depot or unit
42230	Small Arms Ammunition and Pyrotechnics Magazine
42231	Ammunition Storehouse
42235	Ready Magazine
42240	Fixed Ammunition Magazine
42250	Special Weapons Magazine
42260	Guided Missile Magazine
42280	Igloo Storage
42281	Ammunition Hut
42283	General Purpose Magazine
42285	Unit Small Arms Ammunition Storage
42286	Ammunition Storage Structure

1.3 Special Types of Magazines

These include liquid propellant storage facilities, refrigerated storage for batteries associated with weapons, and open storage pads. These facilities were constructed at depots, arsenals, and installations depending on individual needs and missions.

Category Code	Description
42310	Liquid Propellant Storage Building
42311	Liquid Propellant Storage Facility
42312	Liquid Propellant Storage Structure
42410	Battery Cold Storage Building
42510	Ammunition Storage Pad

Table A.1 Numbers and Types of Ammunition Storage Facilities at Active Army Installations (1939-1989)

	Depot Level by Category Code													Installation Level by Category Code															Special Types by Category Code					
Location	42104	42107	42110	42120	42150	42160	42170	42180	42181	42182	42183	42184	42186	42210	42215	42225	42230	42231	42235	42240	42250	42260	42280	42281	42283	42285	42286	42288	42310	42311	42312	42410	42510	**Total**
1st Lt. Robert L. Poxon USARC, MI																													1					**1**
Aberdeen Proving Ground, MD														1	16	1	2	9	23	1			49	2	6								1	**111**
Anniston Army Depot, AL	18	478						800	1	6	2								5															**1310**
Atchison Caves, KS										1																								**1**
Badger AAP, WI														1	22				5				3	6	87									**124**
Blossom Point Research Facility, MD														1	2																			**3**
Blue Grass Army Depot, KY	8			1	12			901	1	2		1			4		1																104	**1035**
Camp Bonneville, WA																			3															**3**
Camp Bullis, TX																			1															**1**
Camp Navajo, AZ				1				783		12									5				1											**802**
Camp Stanley Storage Activity, TX								122		3	5																							**130**
Camp Swift, TX												1														2								**3**
Charles Melvin Price Support Center, IL																									1									**1**
Combat Support Training Center, CA																	3																	**3**
CTC Fort Custer Training Center, MI																							2											**2**
Dahlonega, GA																							1		5	1								**7**
Defense Distribution Depot Susq., PA																				2														**2**
Deseret Chemical Depot, UT	209								2						2									1										**214**
Donnelly Training Area, AK															1																			**1**
Dugway Proving Ground, UT																		4					12										1	**17**
Finleyville NIKE-PI-43, PA																													1					**1**
Florence Military Reserve Center, AZ															1								1											**2**
Fort A.P. Hill, VA																							11		1								1	**13**
Fort Belvoir, VA															10				1	4														**15**
Fort Benning, GA															2			1	29				24				2							**58**
Fort Bliss, TX																							10	2	2									**14**
Fort Bliss AAA Ranges, TX														3	1							4	8		1				1				3	**21**
Fort Bragg, NC															30		5	2			2	2	2		6	2		1					1	**53**
Fort Carson, CO														1			1						20	2										**24**
Fort Chaffee MTC,															23																			**23**
Fort Detrick, MD																			1															**1**
Fort Dix, NJ														1	2	2				7	1			44					1					**57**
Fort Drum, NY														20									1											**33**
Fort Eustis, VA																	7																	**7**
Fort Gillem, GA																							6											**6**
Fort Gordon, GA																		1					20											**21**
Fort Greeley, AK															9																		13	**22**
Fort Hamilton, NY														1																				**1**
Fort Hood, TX																				6	104													**110**
Fort Huachuca, AZ															13		6								6									**25**
Fort Hunter Liggett, CA																		1							14									**15**
Fort Indiantown Gap, PA																		2							4									**6**
Fort Jackson, SC								12									1		5	2													1	**21**
Fort Knox, KY														4	41		6	1					1	10		1							1	**65**
Fort Leavenworth, KS																	3						1											**4**
Fort Lee, VA																							11	2										**13**
Fort Leonard Wood, MO																	1				1				8								1	**11**
Fort Lewis, WA																				36			3										3	**41**
Fort McClellan ARNG Training Ctr., AL																		2			2		2	5										**9**
Fort McCoy, WI																		1	2				10										5	**18**
Fort Meyer, VA																			4															**4**
Fort Ord, CA														1	1		1	1		11				3	1									**19**
Fort Pickett ARNG MTC, VA																	1			24													4	**29**
Fort Polk, LA																		3		1	6			6	22								1	**39**
Fort Richardson, AK							4							1	1							1	50		2								1	**60**
Fort Riley, KS																	2	2					15										3	**23**
Fort Ritchie Raven Rock Site, PA																		1	1															**2**
Fort Sam Houston, TX																		1								3								**4**
Fort Shafter, HI																												1						**1**
Fort Sill, OK																							17	6								1	2	**26**
Fort Stewart, GA																				30														**30**
Fort Wainwright, AK																					6		27											**33**
Fort Wingate Depot Activity, NM	1							730				1							1						14								254	**1001**
Fort Campbell, TN																	2	3					119											**124**
Green River Test Complex, UT																	1					5			3									**9**
Greenlief TS/UTES 01, NE										4														4										**8**
Hampton (Marcella Rd), VA																													1					**1**
Hawthorne Army Depot, NV	5		87	1448	238				2	4	1			31	4				3													1		**1824**
HMO3 (Snake Creek Test Site), FL														2																				**2**
Holston AAP, TN															130																			**130**
Hunter Army Airfield, GA																																		**21**

Table A.1 Numbers and Types of Ammunition Storage Facilities at Active Army Installations (1939-1989)

	Depot Level by Category Code													Installation Level by Category Code															Special Types by Category Code					
Location	42104	42107	42110	42120	42150	42160	42170	42180	42181	42182	42183	42184	42186	42210	42215	42225	42230	42231	42235	42240	42250	42260	42280	42281	42283	42285	42286	42288	42310	42311	42312	42410	42510	Total
Indiana AAP, IN															21			1					173		149									344
Iowa AAP, IA	1										30				33				42				278		3								1	388
Jefferson Proving Ground, IN														4	5			1					31		1									42
Joliet AAP Elwood, IL														8	6			7					2		4									27
Kalaeloa, HI																			1															1
Kansas AAP, KS														2	3			11	16	25	7		192		3									252
Lake City AAP, MO														19	71			2					14		20									126
Letterkenny, Army Depot, PA							1	902	11	1	20																						1	939
Lone Star AAPt, TX	1																			38			200											239
Longhorn AAP, TX														1	60										11									72
Louisiana AAP, LA	3													1				4	45				173											226
LTA Keystone																			1															1
McAlester AAP, OK	3		140	169	175			1120		3								1	2		1		1							1			1	1614
Milan AAP, TN	1			22				874							10				69				4	9									1	976
Military Ocean Terminal Sunny Point, NC																																	66	66
Mississippi AAP, MS															1			1					15											17
MTA Camp Clark, NV																			1				6											7
MTA Camp Edwards, MA																							7											7
MTA Camp Santiago, PR															1								16											17
MTA Fort Wm. Henry Harrison, MT																							4											4
MTC Camp Roberts, CA																							15											15
Newport Chemical Depot, IN																52								2										54
NG Ethan Allen AFB, VT																	1						5											6
NG Youngstown Training Site, NY																							41											41
NTC Fort Irwin, CA															22																			22
Papago Military Reservation, AZ															1				4															5
Picatinny Arsenal														3	16		2		5	1			14	1	19			2						63
Pine Bluff Arsenal, AR			74	6	5			268	2	1	56							23							1					30	2			468
Pahakuloa, HI																		1					8			1								10
Pueblo Chemical Depot, CO					2			920	3						1														4				619	1549
Radford AAP, VA					133			92											1															226
Ravenna AAP, OH								2			1							1	34															38
Ravenna Training and Logistics Site, OH								674			2								9				2							1				688
Red River Army Depot, TX	3			14	1		2	701	1			2		1																			2	727
Redstone Arsenal, AL															21				4			1	393		1				1				2	423
River Road Training Site, DE															2		2						1											5
Rock Island Arsenal																									4									4
Rocky Mountain Arsenal, CO								1			1																							2
Roswell WETS, NM															3																			3
Savanna Depot Activity, GA					26	26		393			32							1																478
Sierra Army Depot, CA								804			12			1	1			1	1														664	1484
Tobyhanna Army Depot, PA																			2															2
Tooele Army Depot, UT	4							907											4						8								2	925
TS AFRC Los Alamitos, CA																									6									6
Twin Cities AAP, MN															29		8		16															53
Umatilla Chemical Depot, OR	39				1			1001	1		14				2				5														2	1065
USA Adelphi Laboratory Center, MD																									2									2
VTS Catoosa, GA																								2										2
VTS Milan, TN																								2										2
West Point Military Reservation, NY																	1	1																2
Wheeler Army Airfield, HI																							18											18
White Sands Missile Range, NM														32	10		2	1	1		2	16			2				11				4	81
Yakima Training Center, WA																	1			12													3	16
Yuma Proving Ground, AZ														2	1			1	4	1			22		1								1	33
Total	**87**	**478**	**301**	**1661**	**593**	**26**	**10**	**12216**	**24**	**37**	**176**	**5**	**0**	**123**	**697**	**3**	**60**	**94**	**353**	**204**	**122**	**33**	**2077**	**98**	**446**	**11**	**2**	**4**	**20**	**31**	**2**	**2**	**1769**	**21765**

Table A.2 Numbers and Types of Ammunition Storage Facilities at Active Army Installations by Year of Construction (1939-1989).

	Depot Level by Category Code													Installation Level by Category Code															Special Types by Category Code					
Year	42104	42107	42110	42120	42150	42160	42170	42180	42181	42182	42183	42184	42186	42210	42215	42225	42230	42231	42235	42240	42250	42260	42280	42281	42283	42285	42286	42288	42310	42311	42312	42410	42510	**Total**
1939					30			116		3	5																							**154**
1940				22	48			79			1												5											**155**
1941	16			189	22	23		2748		4	66			29	135	1	5	6	108	36	1		658		175					1			2	**4225**
1942	16		61	48	203		6	6620	5	8	58	1		9	181		16	27	118	53			782	4	121	3							1	**8341**
1943	17		144	1105	116			1823	5	17	9	1		3	154	1	1	3	7				62	2	5					30	2			**3507**
1944	11		44	2				6	4	4					26		2	8	3			1	2	6	5							1		**125**
1945	1		13	93				1			3	2		26				3	2				7	1	5								1539	**1696**
1946	1		12	127										1				1	1						1								104	**248**
1947															1		1																	**2**
1948	1								1		1			1	6				13	3			2		2			1						**31**
1949											3								1															**4**
1950		1							1						3		3		5	1		2	45		2									**63**
1951	1								2					1	4			2	6				6		10				4					**36**
1952											12			4	6		4	2	3			4	140						2				1	**178**
1953	1		27	73	174			629			1			6	24		2		8	20			27		4									**996**
1954														2	6		2	3	3	6		3	49	1	6								1	**82**
1955				1				100						1	22		7		6			4	32		8				4					**185**
1956	6			1										3	29		1		12	2	2		6		5			1	3					**71**
1957														3	1		3	1	2	20	2	1	15		1				4					**53**
1958		477					4							2	5			1			4	1	3	1	1								3	**502**
1959	1													10	5			2	1			3	12		1			1	1					**37**
1960														7	3		1	1	1				2	1	2									**18**
1961	6					3					5			1	3				1			2	9	6	5								1	**42**
1962														1	1			1	2				1		1								1	**8**
1963	3									1	1				2		1					7	7	3										**25**
1964															4			1					15	1					1					**22**
1965														5	3			1		1			18		9				1					**38**
1966															3		1			6	1		4	2	1									**18**
1967											1				13				2														2	**18**
1968								5						1	1		1			4			12	4	1									**29**
1969	1										7				1			1	3		104		5	3	1								3	**129**
1970								5						2	4		1			2			2	2	2									**20**
1971														1	3								12		1								1	**18**
1972															1			1	3			3			2									**10**
1973	1							2															27		8									**38**
1974															1								23											**24**
1975																		3	1						10									**14**
1976	1																	2	1	3			21		2								4	**34**
1977								12						1			1	1	13	14			3										2	**47**
1978									2						2		1		10		1		3		8								2	**29**
1979																		2		1	2			3		1							14	**23**
1980	1							1			3				1		1	1	4				2		2	1							1	**18**
1981									1						1				3							1							70	**76**
1982	1							68	2						1				6				10	1									1	**90**
1983																	2	1		30			2		1		2						1	**39**
1984	1														2			1					6	1	2								1	**14**
1985															22			1	1					7	4								2	**37**
1986																		2					12	23		1							3	**41**
1987																1	1	10		1	5	2	21	13	28			1					2	**85**
1988								1							12		2	1	2				4	9	4	3							3	**41**
1989									1			1		3	5			4	1	1			3	4		1						1	4	**29**
Total	**87**	**478**	**301**	**1661**	**593**	**26**	**10**	**12216**	**24**	**37**	**176**	**5**		**123**	**697**	**3**	**60**	**94**	**353**	**204**	**122**	**33**	**2077**	**98**	**446**	**11**	**2**	**4**	**20**	**31**	**2**	**2**	**1769**	**21765**

Table A.3 Numbers of Ammunition Storage Facilities at Active Army Installations by Year of Construction (1939-1989)

Location	1939	1940	1941	1942	1943	1944	1945	1946	1947	1948	1949	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
1st Lt. Robert L. Poxon USARC, MI																	1															
Aberdeen Proving Ground, MD			20	10	30		1			3			2	13	8	1	5	2	2	1	1	1				1	1	1			1	
Anniston Army Depot, AL				716						1		1			101	1		10		477					3							
Atchison Caves, KS																									1							
Badger AAP, WI				95		24										5																
Blossom Point Research Facility, MD				2									1																			
Blue Grass Army Depot, KY				802	15			104				1	3		100		3				1		6									
Camp Bonneville, WA																																
Camp Bullis, TX			1																													
Camp Navajo, AZ					795					5								1												1		
Camp Stanley Storage Activity, TX	49	79																														
Camp Swift, TX																																
Charles Melvin Price Support Center, IL																																
Combat Support Training Center, CA						2																1										
CTC Fort Custer Training Center, MI																																
Dahlonega, GA																											5					
Defense Distribution Depot Susq., PA																														2		
Deseret Chemical Depot, UT				140			1													2												
Donnelly Training Area, AK																						1										
Dugway Proving Ground, UT					2	3	2					1												1			3					
Finleyville NIKE-PI-43, PA																			1													
Florence Military Reserve Center, AZ																																
Fort A.P. Hill, VA																																
Fort Belvoir, VA				2	1					3						2									2				3	2		
Fort Benning, GA					11		4							2		6	2	1														
Fort Bliss, TX					3									4				6	1													
Fort Bliss AAA Ranges, TX						1													1		5		7								1	
Fort Bragg, NC																		33							1				2			
Fort Carson, CO																										6	4					4
Fort Chaffee MTC,			23																													
Fort Detrick, MD													1																			
Fort Dix, NJ			9	3																1		1			3	1		1		4		2
Fort Drum, NY			3																					1								
Fort Eustis, VA																	7															
Fort Gillem, GA				6																												
Fort Gordon, GA				20				1																								
Fort Greeley, AK																	9															
Fort Hamilton, NY																		1														
Fort Hood, TX																												6			104	
Fort Huachuca, AZ				11	8									4								2										
Fort Hunter Liggett, CA													9										5									
Fort Indiantown Gap, PA																											4					
Fort Jackson, SC												6																				
Fort Knox, KY				21	8										12																	
Fort Leavenworth, KS													1						3													
Fort Lee, VA																					11											
Fort Leonard Wood, MO																																
Fort Lewis, WA															10	6			23													
Fort McClellan ARNG Training Ctr., AL																																
Fort McCoy, WI				2																3							1					
Fort Meyer, VA			4																													
Fort Ord, CA			12									1																			3	2
Fort Pickett ARNG MTC, VA				12																												
Fort Polk, LA																							1					1				
Fort Richardson, AK				10												43				6				1								
Fort Riley, KS			4										1	1					2												3	
Fort Ritchie Raven Rock Site, PA																1							1									
Fort Sam Houston, TX				4																												
Fort Shafter, HI																					1											
Fort Sill, OK			2																				6		7		10					
Fort Stewart, GA																																
Fort Wainwright, AK																	27		2	4												
Fort Wingate Depot Activity, NM			654	8	2		254			2					79																	
Fort Campbell, TN												5		106		1	1									8						
Green River Test Complex, UT																									5			1			1	2
Greenlief TS/UTES 01, NE						8																										
Hampton (Marcella Rd), VA																	1															
Hawthorne Army Depot, NV	4	70	193	129	1241	6	119								59		1															
HMO3 (Snake Creek Test Site), FL																											2					
Holston AAP, TN					130																											
Hunter Army Airfield, GA					1									10					10													
Indiana AAP, IN			338												4																	
Iowa AAP, IA			340	14	2	1				10			6		2														1		6	

Table A.3 Numbers of Ammunition Storage Facilities at Active Army Installations by Year of Construction (1939-1989)

Location	1939	1940	1941	1942	1943	1944	1945	1946	1947	1948	1949	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
Jefferson Proving Ground, IN			11		3		1							11	14	2																
Joliet AAP Elwood, IL			7	15			2	1				1				1																
Kalaeloa, HI						1																										
Kansas AAP, KS			225	5									2		1															7	1	
Lake City AAP, MO			74	8										2	15		12	1										6	8			
Letterkenny, Army Depot, PA				809	5	7	1				3		2				100						5		1						5	
Lone Star AAPt, TX				238																												
Longhorn AAP, TX				58											3	3	8															
Louisiana AAP, LA				192	1		2	1						1																2		
LTA Keystone																																
McAlester AAP, OK					1108	46	15	140							302																	
Milan AAP, TN			955										1	1									1	1		2			1			
Military Ocean Terminal Sunny Point, NC																																
Mississippi AAP, MS																																
MTA Camp Clark, NV																																
MTA Camp Edwards, MA																				2	1									4		
MTA Camp Santiago, PR																																
MTA Fort Wm. Henry Harrison, MT																																
MTC Camp Roberts, CA			12																													
Newport Chemical Depot, IN				52																			2									
NG Ethan Allen AFB, VT		5																														
NG Youngstown Training Site, NY												41																				
NTC Fort Irwin, CA																																
Papago Military Reservation, AZ											1		2			1																
Picatinny Arsenal			9	8	13	6	3	1	2	7						1		4		2	1					1	2	2		1		
Pine Bluff Arsenal, AR				345	55	6	1							12	43																	
Pahakuloa, HI																																
Pueblo Chemical Depot, CO				806			619								120			3	1													
Radford AAP, VA				189	37																											
Ravenna AAP, OH			8	28			1																							1		
Ravenna Training and Logistics Site, OH			54	634																												
Red River Army Depot, TX				720	1		2																									1
Redstone Arsenal, AL				405	6										2		1	1				3		1	1		1		2			
River Road Training Site, DE			2																										1	1		
Rock Island Arsenal						3	1																									
Rocky Mountain Arsenal, CO							2																									
Roswell WETS, NM																					3											
Savanna Depot Activity, GA	101	1	236	136															1				3									
Sierra Army Depot, CA				812			664					1									2					1				4		
Tobyhanna Army Depot, PA																								2								
Tooele Army Depot, UT				814											103																	5
TS AFRC Los Alamitos, CA				6																												
Twin Cities AAP, MN				50											1																	2
Umatilla Chemical Depot, OR			1029	4	11	11	1								6		1			1												
USA Adelphi Laboratory Center, MD																																
VTS Catoosa, GA																																
VTS Milan, TN																																
West Point Military Reservation, NY																																
Wheeler Army Airfield, HI					18																											
White Sands Missile Range, NM												2	5	10		8	6		6	2	11	9	1		1	1	4					2
Yakima Training Center, WA															11												1				3	
Yuma Proving Ground, AZ																		8		1				1							1	

Table A.3 Numbers of Ammunition Storage Facilities at Active Army Installations by Year of Construction (1939-1989)

Location	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
1st Lt. Robert L. Poxon USARC, MI																			
Aberdeen Proving Ground, MD	2	1								1		1				1		1	
Anniston Army Depot, AL																			
Atchison Caves, KS																			
Badger AAP, WI																			
Blossom Point Research Facility, MD																			
Blue Grass Army Depot, KY																			
Camp Bonneville, WA						3													
Camp Bullis, TX																			
Camp Navajo, AZ																			
Camp Stanley Storage Activity, TX			2																
Camp Swift, TX																		2	1
Charles Melvin Price Support Center, IL										1									
Combat Support Training Center, CA																			
CTC Fort Custer Training Center, MI										2									
Dahlonega, GA							1											1	
Defense Distribution Depot Susq., PA																			
Deseret Chemical Depot, UT										1		70							
Donnelly Training Area, AK																			
Dugway Proving Ground, UT																		5	
Finleyville NIKE-PI-43, PA																			
Florence Military Reserve Center, AZ														2					
Fort A.P. Hill, VA	12						1												
Fort Belvoir, VA																			
Fort Benning, GA	1					1	11	10				6	2		1				
Fort Bliss, TX																			
Fort Bliss AAA Ranges, TX		1								1			1		2	1			
Fort Bragg, NC					1				3	1	1		2				9		
Fort Carson, CO							2		2							6			
Fort Chaffee MTC,																			
Fort Detrick, MD																			
Fort Dix, NJ														1	4	21	6		
Fort Drum, NY			8		8										4		3	5	1
Fort Eustis, VA																			
Fort Gillem, GA																			
Fort Gordon, GA																			
Fort Greeley, AK									13										
Fort Hamilton, NY																			
Fort Hood, TX																			
Fort Huachuca, AZ																			
Fort Hunter Liggett, CA																	1		
Fort Indiantown Gap, PA						1									1				
Fort Jackson, SC							15												
Fort Knox, KY								1	1									20	2
Fort Leavenworth, KS																			
Fort Lee, VA									1									1	
Fort Leonard Wood, MO								11											
Fort Lewis, WA						2													
Fort McClellan ARNG Training Ctr., AL												1	2		1	2	3		
Fort McCoy, WI						8							1				3		
Fort Meyer, VA																			
Fort Ord, CA																			1
Fort Pickett ARNG MTC, VA							13				4								
Fort Polk, LA																	36		1
Fort Richardson, AK																			
Fort Riley, KS												1				10			1
Fort Ritchie Raven Rock Site, PA																			
Fort Sam Houston, TX																			
Fort Shafter, HI																			
Fort Sill, OK																			1
Fort Stewart, GA													30						
Fort Wainwright, AK																			
Fort Wingate Depot Activity, NM														2					
Fort Campbell, TN					3														
Green River Test Complex, UT																			
Greenlief TS/UTES 01, NE																			
Hampton (Marcella Rd), VA																			
Hawthorne Army Depot, NV								2											
HMO3 (Snake Creek Test Site), FL																			
Holston AAP, TN																			
Hunter Army Airfield, GA																			
Indiana AAP, IN		1																	1
Iowa AAP, IA		2												3			1		

Table A.3 Numbers of Ammunition Storage Facilities at Active Army Installations by Year of Construction (1939-1989)

Location	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
Jefferson Proving Ground, IN																			
Joliet AAP Elwood, IL																			
Kalaeloa, HI																			
Kansas AAP, KS		2			1	1	2										5		
Lake City AAP, MO																			
Letterkenny, Army Depot, PA											1								
Lone Star AAPt, TX														1					
Longhorn AAP, TX																			
Louisiana AAP, LA		1	21			1											4		
LTA Keystone																			1
McAlester AAP, OK					1	1													1
Milan AAP, TN										5	3							2	4
Military Ocean Terminal Sunny Point, NC											66								
Mississippi AAP, MS												10	1	3					3
MTA Camp Clark, NV				6			1												
MTA Camp Edwards, MA																			
MTA Camp Santiago, PR				17															
MTA Fort Wm. Henry Harrison, MT			1					3											
MTC Camp Roberts, CA																	3		
Newport Chemical Depot, IN																			
NG Ethan Allen AFB, VT																		1	
NG Youngstown Training Site, NY																			
NTC Fort Irwin, CA															22				
Papago Military Reservation, AZ	1																		
Picatinny Arsenal																			
Pine Bluff Arsenal, AR										3				1				1	1
Pahakuloa, HI																	9		1
Pueblo Chemical Depot, CO																			
Radford AAP, VA																			
Ravenna AAP, OH																			
Ravenna Training and Logistics Site, OH																			
Red River Army Depot, TX								1									2		
Redstone Arsenal, AL																			
River Road Training Site, DE				1															
Rock Island Arsenal																			
Rocky Mountain Arsenal, CO																			
Roswell WETS, NM																			
Savanna Depot Activity, GA																			
Sierra Army Depot, CA																			
Tobyhanna Army Depot, PA																			
Tooele Army Depot, UT												1						2	
TS AFRC Los Alamitos, CA																			
Twin Cities AAP, MN																			
Umatilla Chemical Depot, OR								1											
USA Adelphi Laboratory Center, MD						2													
VTS Catoosa, GA															2				
VTS Milan, TN																			2
West Point Military Reservation, NY										2									
Wheeler Army Airfield, HI																			
White Sands Missile Range, NM		2					1		2		1								7
Yakima Training Center, WA									1										
Yuma Proving Ground, AZ			6			14				1				1					

APPENDIX B

APPENDIX B: WORLD WAR II AND COLD WAR AMMUNITION STORAGE ARCHITECTS, ENGINEERS AND CONTRACTORS

1.0 Summary

This section presents the results of archival research completed in regards to information on the architects, engineers, and contractors that were involved in the planning and construction of Army ammunition storage and production facilities during WWII and the Cold War. Archival research was conducted at the National Archives and Records Administration (NARA), College Park, Maryland; Library of Congress, Washington, DC; and the American Institute of Architects (AIA). A repository dedicated to the field of professional engineering was not located. As a result, information on engineers and contractors was located at NARA and the Library of Congress, but is somewhat limited. Background information on architects is typically gathered through the AIA's *American Architects Directory*; however, these directories only date to 1955, 1962, and 1970. Architectural firms or architects involved with construction during WWII are only included in the directory if they remained active through 1955. If a firm changed names, or merged with another firm, it may be impossible to trace this change. As a result, even though a repository of information on architects exists, the information can be limited.

In cases where a significant amount of information was located in regards to a particular architectural or engineering firm or company, a brief history was developed to chronicle the creation and activities of the business. Companies with extensive information include: Black & Veatch, Day & Zimmerman, The Hunkin-Conkey Construction Company, Mason & Hanger, and Wilbur Watson & Associates. These firms demonstrated considerable expertise in large construction projects including many dams and bridges that gained them experience with reinforced concrete, a material widely used in ammunition storage facilities. Many of these firms also constructed Army ammunition plants that included large numbers of ammunition storage buildings. The remaining firms and companies are included in a chart outlining information such as firm location, previous work, associations, or accomplishments.

2.0 Black & Veatch

Black & Veatch was formed in 1915 by Ernest Bateman Black and Nathan Thomas Veatch in Kansas City, Missouri. Some of their first work included utility projects, such as power plants and water systems. Only two years after the firm was founded, the War Department contacted the company asking them to oversee the creation of WWI war camps in Arkansas, New Mexico, and Oklahoma. Following the war, the company returned to utility work and successfully formed relationships with city governments in Topeka, Kansas and Kansas City, Missouri (Black & Veatch 2005:2-3).

In 1942, Ernest Black was named president of the American Society of Civil Engineers. During his acceptance speech he designated WWII as the "engineer's war" (Black & Veatch 2005:7). Though military work kept the company busy, Black & Veatch continued to work in Kansas and Missouri on water treatment facilities. They also provided financial assessments for companies, primarily in the western United States. After the war ended the company remained busy, despite the lack of military work (Black & Veatch 2005:7).

In 1947, the company served as designers for construction and rehabilitation at the Iowa Army Ammunition Plant, working for the Atomic Energy Commission once again. In 1949, Ernest Black died, leaving Veatch as the only owner of the firm. During the 1950s, Veatch restructured the company by creating a civil division, a power division, and an appraisals department" (Black & Veatch 2005:9). Work during this period included the construction of a dam in Colorado and a large power plant in Iowa.

During the late 1940s and early 1950s, Black & Veatch designed the Loring Air Force Base Weapons Storage Area. This portion of the facility was used for the storage of nuclear weapons. The buildings designed by Black & Veatch were in what was considered the "Q Area," where security was at a maximum (Lemert 1979:164; Earth Tech, Inc. 1999:3; Global Security 2000-2007:n.p.). As of 2007, the company is still in existence, with a worldwide clientele (Black & Veatch 2006).

3.0 Day & Zimmermann

Dodge & Day, the precursor to Day & Zimmermann, was originally formed in 1901 when Charles Day and Kern Dodge formed a partnership. Charles Day graduated as an electrical engineer from the University of Pennsylvania in 1899. Kern Dodge had graduated the same year with a degree in engineering from the Drexel Institute in Philadelphia. Day and Dodge had known each other as neighbors. Both were associated with the Link-Belt Manufacturing Company in Philadelphia; Day was an employee, and Dodge was the son of the company's owner, James Mapes Dodge (Rodengen 2001:11-14).

Day first joined Link-Belt in 1899, and was quickly made "superintendent of installation of power plant equipment" (Rodengen 2001:11-14). Day worked with another associate of Link-Belt, Conrad Lauer. Lauer and Day specifically worked on exposing the company to what was known as the Taylor Method, a scientific or manufacturing management process developed by Frederick Winslow Taylor. According to the Taylor Method, manufacturing could be streamlined if it was assessed as an entire process rather than individual tasks. Though he did not necessarily center his theories on improved technology, many people influenced by Taylor implemented new technology as a means of improving efficiency based on his teachings. Taylor brought this assembly line idea to Henry Ford, and also influenced others, such as Day, Lauer, and Dodge. As a result, Day and Lauer created what was is considered the country's first entirely electric plant at Link-Belt. They incorporated new pulley systems and new machinery including steel cutting machines that saved the company time and money (Rodengen 2001:11, 14; Stross 1989:59).

In 1907, the firm began work in electrical railway engineering and construction (Rodengen 2001:18). Their first two projects in this new area of engineering and construction were located in Pennsylvania and North Carolina. The following year, Dodge & Day was hired to assist in the construction of the Panama Canal. This was a significant project because it gave them nationwide exposure, and experience with monumental concrete works. The firm proved it was adequate for the job, and even broke the world record for hauling concrete (Rodengen 2001:19). With a system of cables and lifts, constructed by Dodge & Day, the firm was able to move "2,000 cubic yards of concrete per 10-hour day" (Rodengen 2001:19).

Directly after the passage of the National Defense Act of 1916, Day enlisted in the Army and was assigned to an infantry company. He soon was asked to assist in organizing the country's industrial mobilization during WWI. He served on boards for the military, assessing ammunition storage plans as well as the organization of moving troops and supplies throughout the country overseas. During this same time, the firm, now known as Day & Zimmermann after John Zimmerman who joined the firm in 1907, thrived due to contracts related to the war. Much of their work was associated with transforming industrial companies into war materiel producers. Zimmermann managed the company while Day remained in the Army (Rodengen 2001:26-27). Day & Zimmerman continued their relationship with military departments after the Armistice. In fall of 1917, Day was asked to assist in the assessment of England's abilities to accept war materiel and troops, and in 1918 the firm was contracted to perform design, site planning, and construction management of the U.S. Philadelphia Quartermaster Terminal.

In November 1940, the company was hired for the design and construction of the Iowa Ordnance Plant (Jerabek-Wuellner 2005:3-83). The firm was also contracted to operate the plant after its completion late 1941. The contract was worth an estimated $30,000. During construction, Day & Zimmermann had as many as 1,938 employees working at the plant. In addition to the manufacturing and munitions storage buildings, the facility included a full complement of support buildings such as a fire department and hospital (Rodengen 2001:48-49). Day & Zimmermann grew significantly as a result of war related contracts. By 1943 they employed 18,000 people (Rodengen 2001:55, 61).

In the late 1950s, Day & Zimmermann was hired to complete a feasibility study for construction of Lincoln Square in Manhattan. The project was significant, because it was unlike any city events center ever proposed, which gather numerous cultural institutions in a central downtown location. Although Day & Zimmerman would not participate in actual construction, the report completed by the firm illustrated that the proposed center was feasible from all perspectives. The company was praised for going to such an extent to complete a thorough study (Rodengen 2001:59-60).

During the 1960s, H.L. Yoh, who joined the firm in 1962, worked on a contract with McDonnell Aircraft to create the Mercury and Gemini capsules for the National Aeronautics and Space Administration. Also during this time, the company designed a monorail system for the 1964 World's Fair in New York. Day & Zimmerman maintained a diverse client base. They worked for the Hershey Chocolate Company providing design and management services for candy production (Rodengen 2001:73-76). In 1999, Day & Zimmermann acquired Mason & Hanger (Rodengen 2001:132).

4.0 The Hunkin-Conkey Construction Company

Samuel Hunkin and William Hunkin both worked in construction in Cleveland during the late nineteenth century. In 1900 the brothers joined to form Hunkin Brothers Construction Company. Shortly after creation of the company, Guy E. Conkey joined the firm; Conkey was a nephew of the Hunkins. In 1903 Samuel Hunkin died, leaving the firm with William Hunkin as president and Conkey as vice-president. Four years later, the firm was renamed Hunkin-Conkey Construction Company. In 1906, following the San Francisco earthquake, the firm traveled west to aid in reconstruction efforts. After returning to Cleveland, the firm worked on projects in Ohio, Michigan, Maryland, and New York. Projects included harbors, docks, and bridges, but also included major manufacturing plants such as Firestone Tire & Rubber's facilities in Akron and Goodyear Tire & Rubber in Akron and California (U.S. Ordnance Department 1940:n.p.; Case Western Reserve University 2007:n.p.).

Hunkin-Conkey's work also included dam construction. By the late 1930s and early 1940s, they were involved in the construction of Shasta Dam in California and Confluence Dam in Pennsylvania. With experience in a variety of projects, Hunkin-Conkey was a natural choice for constructing the Ravenna Ordnance Plant and Depot. The firm's familiarity with Ohio likely gave them an advantage as well (U.S. Ordnance Department 1940; Case Western Reserve University 2007:n.p.).

Following WWII, Hunkin-Conkey constructed bridges, hospitals, plants, and turnpikes. By 1970 the company was considered the nation's 11th largest construction firm (Case Western Reserve University 2007:n.p.). The firm closed down only two years later (Case Western Reserve University 2007:n.p.).

5.0 Mason & Hanger

Around 1827, Claiborne R. Mason of Virginia established Mason Syndicate. The company worked on the early stages of the Chesapeake & Ohio Railroad, and by the mid-nineteenth century the Mason name became synonymous with railroad construction, including bridge and tunnel building . Around 1870, the name of the firm was changed to Mason and Hoge (Lemert 1979:3-4, 22). By the late 1800s, the company won a contract to build part of the Chicago Drainage Canal. The project was significant because it was considered the world's largest construction project at the time (Lemert 1979:27). During the late nineteenth and early twentieth century, the company worked on heavy construction projects including additional canals, as well as river locks and dams. In 1907, the company was renamed Mason & Hanger, with Harry Baylor Hanger as president, Silas B. Mason II as treasurer, and John J. Watts as secretary. The company took on several large projects prior to WWI, but once the war began some projects were suspended and the company turned toward military construction (Lemert 1979:29-34).

Silas Mason was made president of Mason & Hanger in 1925, after the death of Harry Hanger. The following year, the company was awarded contracts to work on construction of the Independent Subway Line in New York. A branch of the company, Silas Mason Company, was created during this time and began construction on the subway tunnels. This subsidiary company also won a contract to construct piers for the George Washington Bridge over the Hudson River. In 1927, Mason & Hanger was awarded a large subway contract to build tunnels between Manhattan and Brooklyn. Other projects included subway tunnels in Boston, portions of the Lincoln Tunnel in New York, tunnels associated with Fort Peck Dam in Montana, Rays Hill Tunnel in Pennsylvania, the Brooklyn-Battery Tunnel, and the Merriman Dam in Delaware. Through these projects, the company proved to be dependable, efficient, and inventive. The projects also allowed the company to technologically advance, with the use of new machinery and new construction methods (Lemert 1979:45, 49, 52-64).

During the 1930s, Mason & Hanger bid on their largest project since the company's creation, the Grand Coulee Dam. The company joined Guy F. Atkinson Company and E. L. and W. E. Kier, forming Mason, Walsh, Atkinsin & Kier (MWAK) in order to bid on the initial phase of construction for the dam on the Columbia River in Washington state. MWAK won the bid, and in May 1937 completed the foundation for the dam. The following December MWAK joined with another company, Interior Construction, and won the contract for the second phase of construction. By January 1942, MWAK and Interior Construction completed the Grand Coulee Dam and its associated powerhouse (Lemert 1979:92-107). According to a history of the company, titled *First You Take a Pick & A Shovel*, the dam was considered the largest masonry structure in the world, occupying 35 acres and using over 15 million cubic yards of concrete (Lemert 1979:92). The company's official history placed the dam in historical perspective, saying that "eclips(ed) the Great Pyramid of Cheops, celebrated for 4,500 years as the largest masonry structure in the world" (Lemert 1979:92).

Upon completion of the Grand Coulee Dam, Mason & Hanger was awarded several military contracts in preparation for WWII. These included: Radford Ordnance Works, Virginia; New River Ordnance Plant, Virginia; Louisiana Ordnance Plant; and Badger Ordnance Works, Wisconsin. Mason & Hanger would serve as the operator of the Louisiana facility near Minden, east of Shreveport. (War Department 1941:1).

After the conclusion of WWII, the company resumed work on the Brooklyn-Battery tunnel, while also constructing tunnels for a reservoir in South Dakota. Silas Mason Company and Mason & Hanger Company maintained their relationships with the Federal government when they contracted to produce fertilizer at several idle ammunition plants including Louisiana, Lone Star, Milan, Illinois, and Ravenna (Mason & Hanger-Silas Mason Co., Inc. 1950:82, 88). In 1947, Mason & Hanger was awarded a contract to rehabilitate an ordnance plant for the US Atomic Energy Commission. The contract included adapting the plant from medium caliber loading to high explosive production (Mason & Hanger-Silas Mason Co., Inc. n.d.:21-22).

This plant was an unusual project because it was the first facility to utilize atomic energy for the routine production of bombs. This production was a continuation of the Manhattan Project of WWII. The Atomic Energy Commission planned one additional facility during this time, the Pantex Ordnance Plant, near Amarillo, Texas (Lemert 1979:160-161).

During this time, the company began designing a new structure that would avoid the release of radioactive material in the event of an explosion. In 1957, Mason & Hanger was awarded a design and engineering contract for supervising tests of a new structure termed the "Gravel Gertie" (Lemert 1979:170). The Gravel Gertie was a concrete tube with a thirty foot diameter. The roof of the structure was constructed of wire screen and tar paper covered by eighteen feet of gravel (Lemert 1979:170). This design allowed the gravel to serve as a filter, eliminating the risk of a large release of radioactive particles. The experiments were completed at the Nevada Test Site. After completing three tests, one with 120 pounds of explosives and two with 550 pounds of explosives, Mason & Hanger was confident in the design of the Gravel Gertie, and began construction of the structures (Lemert 1979:170; U.S. Department of Energy 2004:n.p.). The company ran a variety of blast resistance experiments at the Nevada Test Site between 1951 and 1954 (Mason & Hanger-Silas Mason Co., Inc. n.d.:4).

The company headed in quite the opposite direction after the close of the Cold War. With the United States disarmament program in motion, Chairman and CEO of the company in 1992, Dwight E. Heffelbower, remarked in an interview that the company's "biggest challenge is to divert away from the Department of Defense work. Conventional ammunition obviously is going down in volume" (Petros 1992:D3). During this time, the company joined into agreements with the Department of Defense for ammunition clean up. This process included testing for hazardous waste, as well as the demilitarization of all types of weapons including chemical, nuclear, and conventional (Liem 1992:B5). In 1994, Mason & Hanger was included in the Forbes 500 list. This list of top earning privately owned companies placed Mason & Hanger at 429th place with a value of $420 million (Lexington Herald Leader 1994:A13).

Mason & Hanger-Silas Mason Company was purchased by the company Day & Zimmermann, Inc. in 1999. At this time, several of Mason & Hanger's subsidiary company's merged under Day & Zimmermann as well (Jordan 1999:D1). When the merger occurred, Mason & Hanger employed 5,000 workers, while Day & Zimmermann employed 17,000 (Jordan 1999:D1). Today, as a company of Day & Zimmermann, Mason & Hanger provides services related to architecture, interior design, civil engineering, structural engineering, mechanical engineering, electrical engineering, and chemical engineering.

6.0 Wilbur Watson & Associates

Wilbur J. Watson and Company was formed in 1907. Watson attended Case School of Applied Science, where he received an undergraduate degree in civil engineering. He worked as an engineer for one of the oldest engineering firms in Ohio, Osborn Engineering Company in Cleveland (Case Western Reserve University 2007:n.p.). Watson gravitated toward bridge design, designing bridges while at Osborn, and continuing to do so once he created his own firm. Watson & Company constructed numerous bridges in Ohio, including the Third Avenue Bridge and King Avenue Bridge, both in Columbus, and the Howard Street Bridge in Akron. A number of the bridges were constructed as part of the "City Beautiful" movement. Watson introduced new theories in bridge design throughout his career, including the use of pre-cast concrete beams (Case Western Reserve University 2007:n.p.). He also wrote essays and books on creative options in bridge design.

In 1917, the firm became The Watson Engineering Company; the name once again was changed in 1924 when the firm became Wilbur Watson and Associates. During this time, civil engineer Ralph Harding and architect Carl Nau were included in the firm (US Ordnance Department 1940:21).

In 1928, the firm was granted the daunting task of designing the largest uninterrupted enclosed space in the world (Case Western Reserve University 2007:n.p.). The Goodyear Airdock, located in Akron, Ohio, was designed to house the construction of Navy zeppelins. The structure was over 1,100 feet long and 300 feet wide; an area equal to eight football fields (American Society of Civil Engineers 2007a:n.p.). The need for such a large open interior was a challenge that Watson remedied with the use of steel arches. The building, still extant, is distinctive for its size and design, but also for its mound shape. This allowed the 211 foot tall massive structure to avoid being heavily affected by wind (American Society of Civil Engineers 2007a:n.p.). The building was designated a Civil Engineering Landmark in 1980 (American Society of Civil Engineers 2007b:n.p.).

Wilbur Watson died in 1939, leaving Harding and Nau to continue operation of the firm. When granted the contract to construct the Ravenna Ordnance Plant, Harding agreed to stay in Cleveland and manage the firm; Nau traveled to Ravenna where he served as architect-engineer on construction of the Ordnance Plant along with the Hunkin-Conkey Construction Company (US Ordnance Department 1940:21-22).

Firm/Company Name	Location of Firm/Company	Year Established	Army Ammunition Related Projects	Previous Work
A.C. Polk	Birmingham, AL	No information	Anniston Army Depot (contract 1940/41 as architectural and engineering firm)	No information
Armstrong and Armstrong	Roswell, NM	No information	Fort Wingate (1940/41 construction contract)	No information
A. Smith Construction Co.	Houston, TX	No information	Fort Wingate (1940/41 construction contract)	No information
Austin Willmott Earl (spelling in HABS Willmott and Wilmott)	San Francisco, CA	ca 1940	Hawthorne Army Depot (1942)	United Engineering Company Shipyard Electrical Services and Switching Station, California (1945-HAER)
Blanchard & Maher Architects	San Francisco, CA	No information	Hawthorne Army Depot (1942)	Designs for state parks during the 1930s
C.F. Haglin & Sons, Inc.	Minneapolis, MN	C.F. Haglin established in 1873, Sons joined firm in early 1900s	Lone Star AAP; Shumaker/Camden, AZ (HE mags and smokeless powder mags); Indiana AAP (1941)	Minneapolis Grain Exchange, Minnesota (1902, 1909, 1928-NRHP); Androy Hotel, Minnesota (1919-NRHP); Graybar Electric Company building, Michigan (1926-NRHP); Rand Tower, Minnesota (1929-NRHP);
C.G. Kershaw Contracting Co.	Birmingham, AL	1909	Redstone Arsenal (1941)	No information
Charles Ramsey and Co.	Lubbock, TX	No information	McAlester AAP; Lone Star (1941)	No information
Dinwiddie Construction Co.	San Francisco, CA	No information	Hawthorne Army Depot (1942)	Columbia Gorge Hotel, Oregon (1921–NRHP)
Engineers Limited	San Francisco, CA	No information	Redstone Arsenal	No information
Engstrom and Wynn	Wheeling, WV	No information	Blue Grass Army Depot (1942)	No information
Ford J. Twaits	Los Angeles, CA	No information	Tooele Army Depot (1942 as part of “Inter-Mountain Contractors”)	No information
Gieb, LaRoche, Dahl and Chappel	Dallas, TX	No information	Red River ASF (architects/engineers 1941)	No information
Gilboy, O’Malley & Stopper	Philadelphia, PA	No information	Tobyhanna Army Depot (architects/engineers design 1951/54)	No information
Griffith Co.	Los Angeles, CA	No information	Tooele Army Depot (1942 as part of “Inter-Mountain Contractors”)	No information
Hart, Freeland and Roberts	Nashville, TN	1920	Blue Grass Army Depot (Contract for survey and design 1942)	Banks, schools, and churches throughout Nashville; Tennessee Executive Residence, Nashville (1930s)
J.A. Terteling & Sons	Boise, ID	No information	Umatilla Army Depot (1941 construction contractors)	No information
J.B. Converse & Co.	Mobile, AL	No information	Anniston Army Depot (contract 1940/41 as architectural and engineering firm)	No information
Mittry Brothers Construction Co.	No information	No information	Hawthorne Army Depot	First Street Bridge Spanning Los Angeles River, California (1926/28-HAER)
Morrison-Knudson	Boise, ID	ca 1912	Tooele Army Depot (1942 as part of “Inter-Mountain Contractors”)	Stanley R. Mickelson Safeguard Complex (ca 1970-HAER); Hoover Dam, NV (1933-1935 NRHP and HAER);
M.T. Reed	No information	No information	Anniston Army Depot (CWE)	No information
Peter Kiewit & Sons Co.	Omaha, NE	1884	Kansas AAP; Tooele Army Depot (1942 as part of “Inter-Mountain Contractors”)	Life Stock Exchange Building, Nebraska (ca 1920-HAER); Union Passenger Terminal, Nebraska (NRHP); Plum Bush Creek Bridges, Colorado (NRHP)
P. Odegard & Associates	Portland, OR	No information	Umatilla Army Depot (1942 construction contract)	No information

Firm/Company Name	Location of Firm/Company	Year Established	Army Ammunition Related Projects	Previous Work
Ruby Construction	No information	No information	Anniston Army Depot (CWE)	No information
Sanderson & Porter	New York, NY	1894	Joliet AAP Elwood (1941); Pine Bluff Arsenal (1941)	US Rubber Company, Charlotte, NC (1942); Nine Mile Hydroelectric Power Plant, Washington (1906/08-NRHP and HAER)
Stevens & Koon	Portland, OR	No information	Umatilla Army Depot (1940 engineers)	No information
Tankersley Construction Co.	Oklahoma City	No information	McAlester AAP	McIntosh County Courthouse, Oklahoma (ca 1930-NRHP); Cleveland County Courthouse, Oklahoma (ca 1930-NRHP)
Valley Construction	Columbus, MS	No information	Anniston Army Depot (CWE)	
William Lozier, Inc.	Rochester, NY	No information	Letterkenny Army Depot (architect/engineer 1941)	No information
Winston Brothers, Co.	No information	No information	Lone Star AAP; Indiana AAP (1941)	Skagit Power Development, Diablo Dam and Powerhouse, Washington (ca 1935-NRHP and HAER)

CWE = Cold War Era; NRHP=National Register of Historic Places; HABS=Historic American Buildings Survey; HAER=Historic American Engineering Record

7.0 Bibliography

American Society of Civil Engineers

2007a "The Construction Zone." Electronic document. Available at http://www.constructioninst.org/files/pdf/enews/hyperlinksept04.pdf Viewed 26 March 2007.

2007b "History and Heritage of Civil Engineering." Electronic document. Available at http://live.asce.org/hh/index.mxml?lid=80 Viewed 26 March 2007.

Black & Veatch Holding Company

2005 "Black & Veatch, 90 Years of Building a World of Difference." Electronic document. Available at www.bv.com/resources/pubs_90_anniversary_history_booklet.pdf Viewed on 22 March 2007.

2006 "Black & Veatch" Electronic document. Available at http://www.bv.com Viewed on 23 March 2007.

Case Western Reserve University

2007 "The Encyclopedia of Cleveland History." Electronic document. Available at http://ech.case.edu/ech-cgi/search.pl Viewed 26 March 2007.

Earth Tech, Inc.

1999 "Historic American Engineering Record, Loring Air Force Base, Weapons Storage Area." Electronic document. Available at http://memory.loc.gov Viewed on 23 March 2007.

GlobalSecurity.org

2000-2007 "Weapons Storage Sites/Q Area." Electronic document. Available at www.globalsecurity.org/wmd/facility/q_area-intro.htm Viewed on 23 March 2007.

Jerabek-Wuellner, Margarita

2005 *Historic Property Evaluation of the Built Environment for the Iowa Army Ammunition Plant, Middletown, Des Moines County, Iowa.* Prepared for U.S. Army Installation Management Agency, Northwest Region (IMNW-PWD-E), Rock Island, Illinois. Contract No. DAAA09-01-D-3003, Delivery Order No. 18. Prepared by Parsons, Fairfax, Virginia.

Jordan, Jim

1999 "Mason & Hanger Parent Being Sold." Herald Leader 23 April: D1.

Lemert, Ann Arnold

1979 *First You Take A Pick & Shovel: The Story of The Mason Companies*. John Bradford Press, Lexington, Kentucky.

Lexington Herald Leader

1994 "Mason & Hanger among Forbes 500." 1 December:A13. *Lexington, Kentucky*.

Liem, Robert

1992 "Engineering Firm Resets Sites On Site Cleanup." *Herald Leader* 27 February:B5.

Mason & Hangar-Silas Mason Co., Inc.

n.d. Specialized Engineering Service for Industry and Defense Agencies. Mason & Hangar-Silas Mason Co., Lexington, Kentucky and New York, New York. On file at University of Kentucky, Special Collections Library (620.6M381).

Petros, Liz Caras

1992 "Career Reflects Ways Arms Industry Evolved Dwight E. Heffelbower Rose to Chairmanship of Mason & Hanger." *Herald Leader* 24 February:D3.

Rodengen, Jeffrey L.

2001 *The Legend of Day & Zimmermann, A Century of Service 1901 – 2001*. Write Stuff Enterprises, Inc., Fort Lauderdale, Florida.

Stross, Randal E. (editor)

1989 *Technology and Society in Twentieth Century America an Anthology*. Wadsworth Publishing Co., Belmont, California.

U.S. Department of Energy

2004 "Nevada Test Site, Gravel Gertie." Electronic document. Available at www.nv.doe.gov/library/factsheets/doenv_710.pdf

U.S. Ordnance Department

1940 "Building the Ravenna Ordnance Plant: A Job History." On file at Ravenna Army Ammunition Plant, Ravenna Ohio.

War Department

1941 "Cost Plus-A-Fixed-Fee, New Ordnance Facility, Construction and Operation Contract with Silas Mason Company, New York, NY." On file at Eastern Kentucky University, Special Collections Library "Mason & Hanger Historical Records, 1914-1999" (Box 42, f.03).

APPENDIX C

APPENDIX C. FUNDING THE CONSTRUCTION OF AMMUNITION-RELATED FACILITIES

1.0 Introduction: Austerity During the Immediate Post-World War II Period (1946-1950)

Congressional appropriations for ammunition production and storage during the immediate post-World War II period reflected a transition from an immense military budget required to meet emergency needs to a peacetime budget designed to meet minimum defense requirements during a period of spending austerity. By 1950, however, Congress was increasing ammunition-related spending to finance the development of new ammunition technology. Many appropriations made during the Cold War era are not installation specific, referring only to general Ordnance Corps funding for new facilities.

Ammunition-related appropriations for fiscal years 1946 to 1948 indicated that Congress was shifting to peacetime funding of the Army and was hesitant to expand the Army's infrastructure through land acquisition or building construction. While World War II appropriations for the Ordnance Department and the Chemical Warfare Service reflected the wartime buildup of the military, appropriations for these two departments were drastically reduced shortly after the war. The Ordnance Department's appropriation declined to $327.7 million for fiscal year 1947 and then to $245.5 million for 1948. The Chemical Warfare Service appropriation dropped to $25.9 million for fiscal year 1947, and then to $19.9 million for 1948.

The Army Corps of Engineers, which oversaw construction on military installations, was appropriated $115.5 million for Army construction for fiscal year 1947. The appropriation did not identify construction projects to be funded, and no separate authorization listing authorized Army construction projects was located. The appropriation did indicate that Congress wanted to limit new Army construction. Two conditions of the appropriation were that the Secretary of War approve all land purchases, and that land be acquired through purchase only if that was cheaper than leasing it (United States Code Congressional Service 1946:528). The Army Corps of Engineers received no military construction appropriation during fiscal year 1948 (United States Code Congressional Service 1947:561-2).

Meanwhile, the Military Appropriation Act of 1948 reduced portions of appropriations made available between fiscal years 1942 and 1946. The Army Corps of Engineers had to return $13 million intended for construction at military posts, while the Ordnance Department returned $363 million and the Chemical Warfare Service returned $30 million (United States Code Congressional Service 1947:562). However, the following year's appropriation provided the Ordnance Department $10 million to pay expenses on contracts executed before July 1, 1946 (United States Code Congressional Service 1948:672).

Appropriations for the Ordnance Department and the Chemical Service increased for fiscal years 1949 and 1950. The Ordnance Department's fiscal year 1949 appropriation nearly tripled to $610 million, and then increased to $730 million for fiscal year 1950. The Chemical Service appropriation increased approximately one-third in fiscal year 1949, to $26 million, and then by an additional one-third in fiscal year 1950, to $35 million (United States Code Congressional Service 1948a:671-2; United States Code Congressional Service 1949:1008-9).

For military construction, Congress appropriated $76 million to the Army Corps of Engineers for fiscal year 1949 and $85.7 million for fiscal year 1950 (United States Code Congressional Service 1948a:671; United States Code Congressional Service 1949:1008). These appropriations were directed to finance construction authorized in June 1948. This authorization included approximately $7 million in construction at seven ammunition-related installations.

Construction directly related to ammunition housed research and development on ammunition-related materials. It included chemical laboratory facilities at Edgewood Arsenal, Maryland; research and development facilities for high explosives, completed bombs, rockets, and rocket powders at Picatinny Arsenal, New Jersey; and laboratory, storage, and testing facilities for rocket development at White Sands Proving Ground, New Mexico. Other construction financed at these installations under this appropriation consisted of support structures such as utilities, family quarters, and administration buildings (United States Code Congressional Service 1948:390-92).

2.0 Increase in Appropriations During the Korean Conflict

Ammunition-related military spending increased dramatically when the United States became involved in military action in Korea in fall 1950. Equipment and supplies was one of three areas of the military the Department of Defense targeted for expansion at the start of the Korean conflict (United States Code Congressional and Administrative Service 1951a:2213). As a result, multiple appropriations during fiscal year 1951 dramatically increased that year's funding for the Ordnance Department, the Chemical Corps, and construction. Four appropriations provided the Ordnance Department a total of $7 billion, and the Chemical Corps received $120.2 million spread over three appropriations (United States Code Congressional Service 1950a:1052; United States Code Congressional Service 1950b:801-2; United States Code Congressional Service 1950c:1246; United States Code Congressional Service 1951a:48).

Appropriations for ammunition-related spending remained elevated through fiscal year 1954, although not as high as at the beginning of the Korean conflict. The Ordnance Corps received $8 billion in fiscal year 1952, $2.7 billion in 1953, and $3.2 billion in 1954. The Chemical Corps received $122.5 million in 1952, slightly higher than its 1951 total appropriation, but was not financed under a separate line item in 1953 and 1954 (United States Code Congressional and Administrative Service 1951b:571-2; United States Code Congressional and Administrative News 1952a:498-9; United States Code Congressional and Administrative News 1953a:380).

Ammunition-related construction during the early 1950s focused on ammunition storage facilities as well as research and development. During fiscal year 1951, three appropriations provided the Army Corps of Engineers a total of $500 million for Army construction, the first substantial Army construction appropriation since the end of World War II. The majority of the money was appropriated in the second supplemental appropriation halfway through the fiscal year, after the United States became involved in Korea (United States Code Congressional Service 1950a:1052; United States Code Congressional Service 1950b:801; United States Code Congressional Service 1950c:1246).

These funds were directed to finance two construction authorizations. The first two appropriations financed an authorization that included $11.6 million in construction at ten ammunition-related installations. The significant construction projects at these installations focused on research and development and included: rocket development and test facilities at Picatinny Arsenal; chemical laboratories and testing facilities, cluster and firebomb assembly facilities, and an experimental loading and filling building at the Army Chemical Center, Maryland; and laboratories, rocket motor test stands, and a nitroglycerin plant at Redstone Arsenal, Alabama (United States Code Congressional Service 1950d:240-1). The third appropriation funded an authorization that included $38 million in construction for the Ordnance Corps and $21.1 million for the Chemical Corps, for unspecified installations (United States Code Congressional Service 1950e:1238).

Army construction appropriations during fiscal year 1952 were even greater than in the previous year. This growth reflected attention to another aspect of the military expansion program: "namely, the provision for adequate airfields, forts, camps, stations, depots, bases, and other facilities needed to meet the operational requirements of the approved forces and to permit the utilization of the newer types of equipment now coming off the production lines" (United States Code Congressional and Administrative Service 1951a:2213-4).

The first appropriation of $48.3 million was directed to finance construction authorized during previous years. A supplemental appropriation of $1 billion financed previous authorizations and a new authorization that included $160 million in ammunition-related construction, the first substantial outlay under this category during the postwar period. For the Ordnance Corps, $123 million in construction was authorized at 34 installations, including storage buildings at 22 installations and research and development buildings at eight installations. The Chemical Corps was authorized to spend $37 million at six installations; all were slated to receive storage buildings. Research and development buildings were authorized at two installations (United States Code Congressional and Administrative Service 1951c:485-7; United States Code Congressional and Administrative Service 1951b:571; United States Code Congressional and Administrative Service 1951d:772).

Authorized ammunition-related construction for fiscal year 1953 focused on research and development buildings, but returned to storage buildings in 1954. Of the overall Army construction appropriation, nearly $50 million was authorized for ammunition-related construction during 1953, divided roughly equally between the Ordnance Corps and the Chemical Corps. Research and development buildings were authorized for six of the nine Ordnance Corps installations and all four authorized Chemical Corps installations (United States Code Congressional and Administrative News 1952b:579-80). Of the overall Army construction appropriation for 1954, $10.5 million was authorized for 10 Ordnance Corps installations, including storage buildings at five installations and research and development buildings at two installations (United States Code Congressional and Administrative News 1953b:486-7). No military construction line items were contained in appropriations for either year, but the line item that funded ammunition procurement and production permitted the use of funds in that category for construction (United States Code Congressional and Administrative News 1952a:498-9; United States Code Congressional and Administrative News 1953a:380).

3.0 Reduced Spending During the Mid- to Late-1950s

Reflecting a return to a peacetime budget, ammunition-related spending on operations and construction declined during the mid- and late 1950s. Unlike appropriations for previous fiscal years, appropriations for fiscal years 1955 to 1958 contained no ammunition-related line items. The fiscal year 1955 appropriation even contained a provision requiring the Army to return $500 million previously appropriated for ammunition procurement and production (United States Congressional and Administrative News 1954a:401-3; United States Code Congressional and Administrative News 1955a:334-6; United States Code Congressional and Administrative News 1956a:518-20; United States Code Congressional and Administrative News 1957a:329-31). This absence indicated that wartime production of ammunition had ceased. Peacetime production likely was drastically reduced, and few new munitions were manufactured. Activity at most ammunition plants and depots focused on demilitarization and surveillance. Ammunition production and storage costs might have been financed through other appropriation line items, such as "Military Personnel" or "Maintenance and Operations."

Spending on Army construction was reduced during the mid- and late 1950s too. No construction line items were contained in fiscal year 1955 appropriations. For fiscal year 1956, $485 million was appropriated, but it was intended to fund five prior construction authorizations as well as the current authorization, which only authorized $20 million in ammunition-related construction at 22 installations. The majority of the construction related to support buildings, such as utilities, administration, maintenance, and housing. Research and development buildings were authorized for two installations, and storage buildings were authorized at one installation, although the specific installations were not named (United States Code Congressional and Administrative News 1954a:401-3; United States Code Congressional and Administrative News 1954b:955-6; United States Code Congressional and Administrative News 1955b:502-3; United States Code Congressional and Administrative News 1955c:534-5).

Congress appropriated $202 million for Army construction during fiscal year 1957. However, as with the 1956 appropriation, the money was directed to fund construction authorized for several prior years, in addition to the current authorization, which included $12.3 million for ten ammunition-related installations. As in the previous authorization, most of the construction consisted of utility, maintenance, administrative, and housing buildings. Research and development buildings were authorized at two installations, and storage buildings were authorized at three installations (United States Code Congressional and Administrative News 1956b:1174; United States Code Congressional and Administrative News 1956c:795).

For fiscal year 1958, $310 million was appropriated for Army construction to finance authorizations from several prior years, as well as the current authorization, which included $22.6 million at eight ammunition-related installations. Most of the authorized construction consisted of utility, maintenance, housing, and administrative buildings; White Sands Proving Ground was authorized to receive buildings for research and development, and storage (United States Code Congressional and Administrative News 1957b:583-4; United States Code Congressional and Administrative News 1957c:457-8).

4.0 Slow Escalation in Ammunition Spending 1959-1966

Appropriations for ammunition-related spending resumed in fiscal year 1959, but were lower than appropriations earlier in the decade. For the first time, ammunition-related appropriations included funding for missiles, reflecting increased interest in the development of guided missile systems. Through fiscal year 1966, ammunition spending hovered between $1.2 billion and $1.7 billion (United States Code Congressional and Administrative News 1958a:842; United States Code Congressional and Administrative News 1959a:408; United States Code Congressional and Administrative News 1960a:401; United States Code Congressional and Administrative News 1964a:544; United States Code and Administrative News 1965a:836).

Ammunition-related construction authorizations during this period ranged from $8.5 million in fiscal year 1960 to $28.2 million in fiscal year 1959, and relied on appropriations as low as $20 million in fiscal year 1961 and as high as $323.4 million for fiscal year 1966 (United States Code Congressional and Administrative News 1958b:744; United States Code Congressional and Administrative News 1958c:1288-9; United States Code Congressional and Administrative News 1959b:333; United States Code Congressional and Administrative News 1959c:617; United States Code Congressional and Administrative News 1960b:188-9; United States Code Congressional and Administrative News 1960c:527-8; United States Code Congressional and Administrative News 1961a:112; United States Code Congressional and Administrative News 1961b:740; United States Code Congressional and Administrative News 1962a:276; United States Code Congressional and Administrative News 1962b:677-8; United

States Code Congressional and Administrative News 1963a:339-40; United States Code Congressional and Administrative News 1963b:508; United States Code Congressional and Administrative News 1964b:401; United States Code Congressional and Administrative News 1964c:1010; United States Code Congressional and Administrative News 1965b:759-60; United States Code Congressional and Administrative News 1965c:799).

The majority of funding was authorized for support buildings, such as utility, maintenance, administration, and housing buildings. Funding for buildings more specifically related to ammunition production financed research and development buildings. Production facilities were authorized for fiscal year 1965 at Picatinny Arsenal, New Jersey (United States Code Congressional and Administrative News 1964b:401). No ammunition storage buildings were authorized during this period.

5.0 Vietnam-Era Ammunition Appropriations

Corresponding with the nation's increasing involvement in the Vietnam conflict, ammunition-related spending grew during the late 1960s and early 1970s. Ammunition appropriations grew to $2.1 billion for fiscal year 1967 and $5.5 billion in 1968. For the first time, the 1968 appropriation specified that $269 million be used for the NIKE-X anti-ballistic missile system (United States Code Congressional and Administrative News 1967a:9; United States Code Congressional and Administrative News 1967b:267). Fiscal year 1969 appropriations included $5.6 billion and an additional $510 million, the largest ammunition appropriation of this period and the first time additional funding was provided (United States Code Congressional and Administrative News 1968a:1299). This practice continued through fiscal year 1974.

While still high, appropriations declined to $4.3 billion plus $50 million for 1970, to $2.9 billion plus $50 million for 1971, and to $2.3 billion plus $300 million for 1972, but rose to $3 billion plus $90 million for fiscal year 1973. Beginning in fiscal year 1972, appropriations were listed separately for ammunition and missiles (United States Code Congressional and Administrative News 1969a:498; United States Code Congressional and Administrative News 1970a:2366-7; United States Code Congressional and Administrative News 1971a:815; United States Code Congressional and Administrative News 1972a:1383).

For the first time during the postwar period, spending on ammunition-related construction included buildings for ammunition production facilities as well as arsenals and depots. This spending coincided with the peak in ammunition-related construction spending during this period, fiscal years 1968 to 1971.

During fiscal year 1967, seven installations were authorized to receive $10.5 million in new buildings, financed by two Army construction appropriations totaling $402 million. Five of the installations were to receive research, development, and test buildings, while the other two installations were authorized utilities and supply facilities (United States Code Congressional and Administrative News 1966a:874; United States Code Congressional and Administrative News 1966b:1373; United States Code Congressional and Administrative News 1967a:10). The 1968 authorization – financed by a $372 million Army construction appropriation – grew to $22.9 million at 17 installations, including research, development, and test buildings at six installations and production facilities at Pine Bluff Arsenal, Arkansas. The other buildings included utilities, maintenance buildings, housing, administration buildings, and supply buildings (United States Code Congressional and Administrative News 1967c:314; United States Code Congressional and Administrative News 1967d:596-7).

The 1969 ammunition-related construction authorization declined slightly to $22 million but listed 19 facilities, including four ammunition plants. The authorization was financed by a $548 million Army construction appropriation (United States Code Congressional and Administrative News 1968b:1004). Although the buildings authorized at the plants were only utilities, the authorization is significant for being the first during the post-World War II period that provided buildings for plants. The four facilities were Burlington Army Ammunition Plant, New Jersey; Joliet Army Ammunition Plant, Illinois; Lake City Army Ammunition Plant, Missouri; and Sunflower Army Ammunition Plant, Kansas. Other authorized construction included production facilities at Rock Island Arsenal; research, development, and test facilities at four other installations; and several types of support buildings (United States Code Congressional and Administrative News 1968c:436-7).

The 1970 construction authorization, the largest of this period, permitted $26.7 million in construction at 21 facilities, financed by a $287 million Army construction appropriation. Included were utilities at five plants: Badger Army Ammunition Plant, Wisconsin; Holston Army Ammunition Plant, Tennessee; Iowa Army Ammunition Plant; Joliet; and Sunflower. Also included were research, development, and test buildings at four installations and utilities and other support buildings at various installations (United States Code Congressional and Administrative News 1969b:323; United States Code Congressional and Administrative News 1969c:490). The 1971 construction authorization of $15 million at 15 facilities included unspecified buildings at six ammunition plants: Alabama Army Ammunition Plant, Badger; Burlington; Cornhusker Army Ammunition Plant, Nebraska; Iowa; and Radford Army Ammunition Plant, Virginia. The authorization was funded by a $647 million Army construction appropriation (United States Code Congressional and Administrative News 1970b:1407-8; United States Code Congressional and Administrative News 1970c:1643). Beginning with this authorization, the types of buildings authorized for each installation were no longer specified.

The 1972 authorization was considerably lower, authorizing $7.4 million at five installations: Aberdeen Proving Ground, Maryland; Letterkenny Army Depot, Pennsylvania; Redstone Arsenal, Alabama; White Sands Missile Range, New Mexico; and Yuma Proving Ground, Arizona. The authorization was financed by a $438.3 million Army construction appropriation (United States Code Congressional and Administrative News 1971b:422; United States Code Congressional and Administrative News 1971c:527). For fiscal year 1973, $10.2 million in construction was authorized at eight installations. As with the prior year, no plants were included; all authorizations were for arsenals, depots, and proving grounds. The authorization was financed by a $413.9 million Army construction appropriation (United States Code Congressional and Administrative News 1972b:1325; United States Code Congressional and Administrative News 1972c:1344).

6.0 Appropriations during the Post-Vietnam Conflict Period

Ammunition spending declined through the mid-1970s as the Army budget transitioned to a peacetime focus. Fiscal years 1974 through 1976 represented declines in spending on both ammunition and missiles. Spending increased during the late 1970s, but there was a greater increase in spending on missiles than on ammunition. For fiscal year 1974, ammunition spending declined to $784.3 million plus $146.1 million, while missile spending declined to $602 million plus $22 million (United States Code Congressional and Administrative News 1973a:1158-9). Ammunition spending for fiscal year 1976 declined to $637.2 million, and missile spending declined to $422.6 million (United States Code Congressional and Administrative News 1976a:161-2).

Spending on ammunition-related construction increased, although the number of installations authorized for construction funds did not increase substantially. For example, $27.6 million was authorized at 10 facilities for fiscal year 1974, and $35.4 million was authorized at 12 facilities in 1975. A comparison of the authorizations' lists of installations and funding levels during this period and the prior one indicates that more funds were allocated to each installation than in previous years. This suggests that either a greater number of buildings or more-substantial buildings were authorized (United States Code Congressional and Administrative News 1974b:727; United States Code Congressional and Administrative News 1974a:2011-12).

Ammunition-related spending increased during the late 1970s, both in ammunition and missile production and in building construction, particularly at ammunition plants. For fiscal year 1977, the ammunition appropriation totaled $903 million and the missile appropriation totaled $497 million. Appropriations increased again in 1978, to $1.2 billion for ammunition and $537 million for missiles. The ammunition appropriation remained at $1.2 billion for fiscal years 1979 and 1980, but the missile appropriation increased to $737 million for 1979 and $1.1 billion in 1980 (United States Code Congressional and Administrative News 1976c:1285-6; United States Code Congressional and Administrative News 1977a:892-3; United States Code Congressional and Administrative News 1978a:1237-8; United States Code Congressional and Administrative News 1979a:1145-6).

Spending on ammunition-related construction increased dramatically during the late 1970s, notably because a number of plants were authorized to receive new buildings. For fiscal year 1977, $81.6 million was authorized, a 130 percent increase over the previous year. Of 24 installations authorized for new construction, 11 were ammunition plants (Radford Army Ammunition Plant was listed twice, authorized to receive two different funding amounts). For the first time, the authorization listed some of these plants separately, for unknown reasons (United States Code Congressional and Administrative News 1976b:1350). The fiscal year 1978 construction authorization increased even more dramatically, to $571.3 million for 28 named installations and one "unspecified" ammunition facility that was authorized for construction totaling $334.7 million, representing the majority of the authorized funds. The named installations included 14 plants (two ammunition plants, Iowa and Indiana, were listed twice) (United States Code Congressional and Administrative News 1977b:359).

While still elevated compared with earlier in the decade, the fiscal year 1979 authorization was lower than in the previous year, $106 million for 27 installations. Seventeen were plants, but six of them were listed twice: Holston, Iowa, Kansas, Longhorn, Milan, and Sunflower (United States code Congressional and Administrative News 1978b:566). The construction authorization increased again for fiscal year 1980, to $188 million for 38 installations. Eighteen were plants; five of them were listed twice: Indiana, Lake City, Radford, Riverbank, and Scranton (United States Code Congressional and Administrative News 1979b:929).

7.0 Bibliography

United States Code Congressional Service

1946 Military Appropriation Act, 1947
1947 Military Appropriation Act, 1948
1948a Military Functions Appropriation Act, 1949
1948b Military Installations – Army and Air Force – Construction
1949 National Military Establishment Appropriation Act, 1950
1950a Supplemental Appropriation Act, 1951
1950b General Appropriation Act, 1951
1950c Second Supplemental Appropriation Act, 1951
1950d Military and Naval Installations – Development
1950e Military and Naval Installations – Construction, etc.
1951a Fourth Supplemental Appropriation Act, 1951

United States Code Congressional and Administrative News

1952a Department of Defense Appropriation Act, 1953
1952b Military and Naval Installations – Construction
1953a Department of Defense Appropriation Act, 1954
1953b Military and Naval Installations – Alaska Communication System – Construction
1954a Department of Defense Appropriation Act, 1955
1954b Supplemental Appropriations Act, 1955
1955a Department of Defense Appropriation Act, 1956
1955b Supplemental Appropriation Act, 1956
1955c Military, Naval, and Air Force Installations – Construction, Etc.
1956a Department of Defense Appropriation Act, 1957
1956b Construction of Military Installations
1956c Supplemental Appropriation Act, 1957
1957a Department of Defense Appropriation Act, 1958
1957b Military Installations – Construction
1957c Supplemental Appropriation Act, 1958
1958a Department of Defense Appropriation Act, 1959
1958b Military Construction Act of 1958
1958c Military Construction Appropriation Act, 1959
1959a Department of Defense Appropriation Act, 1960
1959b Military Installations and Facilities
1959c Military Construction Appropriation Act, 1960
1960a Department of Defense Appropriation Act, 1961
1960b Reserve Forces Facilities Act of 1960
1960c Military Construction Appropriation Act, 1961
1961a Reserve Forces Facilities Act of 1961
1961b Military Construction Appropriation Act, 1962
1962a Armed Forces – Construction at Military Installations
1962b Military Construction Appropriation Act, 1963
1963a Military Construction, Etc.
1963b Military Construction Appropriation Act, 1964
1964a Military Construction, Etc.
1964b Department of Defense Appropriation Act, 1965
1964c Military Construction Appropriation Act, 1965
1965a Department of Defense Appropriation Act, 1966
1965b Military Construction, Etc.

1965c Military Construction Appropriation Act, 1966
1966a Armed Forces – Military Installations – Construction
1966b Military Construction Appropriation Act, 1967
1967a Supplemental Defense Appropriation Act, 1967
1967b Department of Defense Appropriation Act, 1968
1967c Military Installations – Construction
1967d Military Construction Appropriation Act, 1968
1968a Department of Defense Appropriation Act, 1969
1968b Reserve Forces Facilities Authorization Act, 1969
1968c Military Construction Appropriation Act, 1969
1969a Department of Defense Appropriation Act, 1970
1969b Military Construction and Reserve Forces Facilities – Appropriations
1969c Military Construction Appropriation Act, 1970
1970a Department of Defense Appropriation Act, 1971
1970b Military Construction – Reserve Forces Facilities
1970c Military Construction Appropriations Act, 1971
1971a Department of Defense Appropriation Act, 1972
1971b Military Construction – Reserve Forces Facilities
1971c Military Construction Appropriation Act, 1972
1972a Department of Defense Appropriation Act, 1973
1972b Military Construction – Reserve Forces Facilities
1972c Military Construction Appropriation Act, 1973
1973a Department of Defense Appropriation Act, 1974
1973b Reserve Forces Facilities Authorization Act, 1974
1974a Military Construction Authorization Act, 1975
1976a Department of Defense Appropriation Act, 1976
1976b Military Construction Authorization Act, 1977
1976c Department of Defense Appropriation Act, 1977
1977a Department of Defense Appropriation Act, 1978
1977b Military Construction Authorization Act, 1978
1978a Department of Defense Appropriation Act, 1979
1978b Military Construction Authorization Act, 1979
1979a Department of Defense Appropriation Act, 1980
1979b Military Construction Authorization Act, 1980

United States Code Congressional and Administrative Service

1951a Military and Naval Installations – Construction. Legislative History
1951b Department of Defense Appropriation Act, 1952
1951c Military and Naval Installations – Construction
1951d Second Supplemental Appropriation Act, 1952