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PROJECT REPORT

PROCESS DETERMINATION AND PLANT LAYOUT

FOR

WESTERN DEMILITARIZATION FACILITY

HAWTHORNE, NEVADA

SEPTEMBER 1974

PREPARED BY

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553
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1974

NAVAL AMMUNITION PRODUCTION ENGINEERING CENTER
NAVAL AMMUNITION DEPOT
CRANE, INDIANA

UF 553 .W4 G7 1974

Groh, Dale L.

Process determination and
plant layout for Western
... #32632518

DEMILITARIZATION FACILITY - NAVAL AMMUNITION DEPOT - HAWTHORNE, NEVADA

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The findings of this report are not to be construed as an official position of the Department of the Navy.

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Forward

This report, prepared by the Naval Ammunition Production Engineering Center, is the second of a series of reports concerning the investigation, testing, and designing of ammunition facilities, equipment, and processes in support of the Naval Ammunition Facilities' Modernization Program.

The techniques, systems, and methods used do not necessarily make them acceptable for other ammunition systems. However, it is hoped that this report will be of value to others whose tasks may require the same or similar equipment systems.

A demilitarization facility of this type has never before been developed or built. To establish feasibility, site layout, and general arrangement, a contract for a brief study (30 days) was awarded to Mason and Hanger - Silas Mason, Incorporated. The contract did not require extensive safety, economic, or pollution control analysis, but generally required a suggested layout, method of operation, site area size, estimated cost, and square footage that might be required, should this project be approved. This report, which was nearly two years in preparation, utilizes the study as a base line and no criticism of the Mason and Hanger - Silas Mason, Incorporated study is intended or should be implied. As a matter of fact, fully 70 percent of the study was used with little or no changes. This included such items as: utility requirements, personnel requirements, basic demilitarization processes, pollution control techniques, general site plan, first

generation equipment concepts, the use of ready magazines, the type of plant transportation system, the separate off-loading dock technique, and many other more detailed parameters.

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I. INTRODUCTION & DEFINITION OF THE PROBLEM

To effectively meet the threat of aggression posed by other nations of the world, the United States has, since the second world war, maintained an extensive armament capability. The weapons of modern warfare (both nuclear and conventional) are kept in readiness for use as a deterrent as well as an applied force as demonstrated in the recent Vietnam involvement.

This arsenal of armament consists of a multitude of different components including conventional ammunition items. Considering just the conventional ammunition items, the list of different and unique characteristics of each is extensive.

Maintenance of this vast store of ammunition requires expenditure of funds for storage, periodic renovation, and disposal. Disposal is required because ammunition design is evolutionary which causes older designs to become obsolete and long-stored items to become physically obsolete leaving large numbers of individual items without the possibility of consumption. It is this process of gleaning obsolete, unserviceable ammunition known as demilitarization/disposal that is the focus of attention for the Department of the Navy, Naval Sea Systems Command (formerly Naval Ordnance Systems Command). The object of the program is to modernize the demilitarization/disopsal capabilities of the Western United States' ammunition activities which include: WPNSTA Concord, WPNSTA Seal Beach, NAD Bangor Annex of NAVTORPSTA Keyport, and NAD Hawthorne. Toward this end,

NAVSEASYSCOMHQ directed NAPEC (Naval Ammunition Production Engineering Center)(SEA-9926) to proceed with the development of a plan for the demilitarization/disposal of unserviceable ammunition. The task assignment stated that the study plan would consist of developing a recommended prototype building(s) configuration, with alternatives, for demilitarization.

The building(s) must have the capability and capacity to:

a. Demilitarize the various types of conventional ammunition slated for disposal by the West Coast inventory listings.

b. Eliminate/reduce air-water-noise pollution to meet federal, state, and local standards, consistent with current technology.

c. Utilize state-of-the-art designs for equipment.

d. Utilize existing specifications for unpacking, handling, and processing the materials.

e. Eliminate/reduce human handling and processing.

f. Reclaim and process saleable scrap, explosives, and usable components.

g. Dispose of unwanted scrap, surplus excesses, and pollutants.

h. Provide safety devices to preclude or prevent human errors.

II. SCOPE & ASSUMPTIONS

This study was conducted under the following assumptions:

a. Equipment costs to be based on current catalog price.

b. Installation cost to be based on NAPEC estimates.

c. Number of people required to be determined by standard industrial engineering practices.

d. The production rates for all items would be equal to or greater than any attained at existing facilities.

e. Standard production to be based on one eight-hour shift, five days each week.

Preliminary study and investigation of the task was conducted by the engineering firm of Mason & Hanger - Silas Mason Company, Incorporated under contract with NAPEC's Manufacturing Technology Development Staff (now Modernization Staff). This study led to the prototype configuration illustrated by Figure 1. Military construction funding for the facility project was for the number of structures evenly divided per increment. Section IV will discuss at length the application of this initial feasibility study.

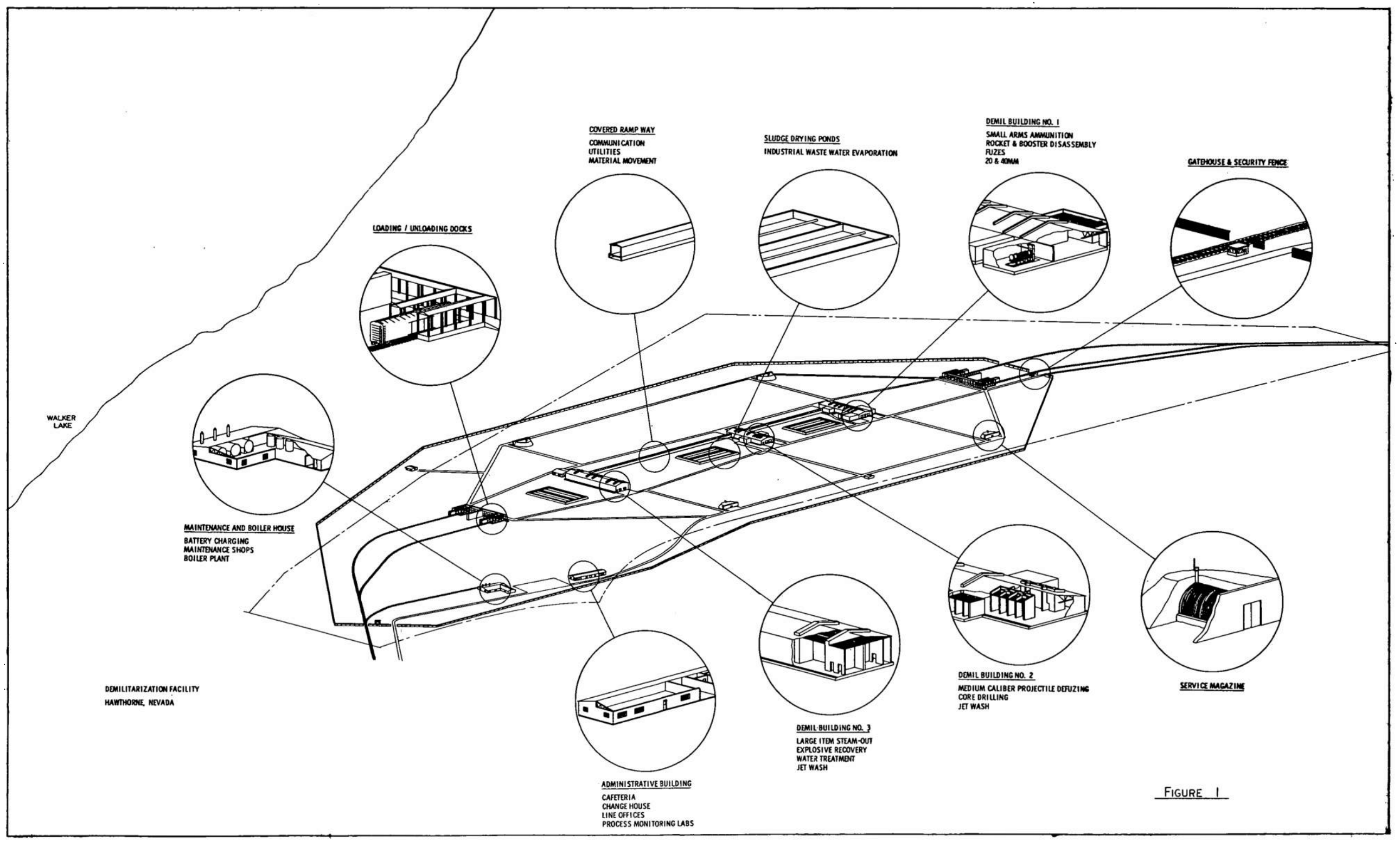
WALKER LAKE
LOADING / UNLOADING DOCKS
COVERED RAMP WAY
COMMUNICATION
UTILITIES
MATERIAL MOVEMENT
SLUDGE DRYING PONDS
INDUSTRIAL WASTE WATER EVAPORATION
DEMIL BUILDING NO. 1
SMALL ARMS AMMUNITION
ROCKET & BOOSTER DISASSEMBLY
FUZES
20 & 40MM
GATEHOUSE & SECURITY FENCE
MAINTENANCE AND BOILER HOUSE
BATTERY CHARGING
MAINTENANCE SHOPS
BOILER PLANT
DEMILITARIZATION FACILITY
HAWTHORNE, NEVADA
ADMINISTRATIVE BUILDING
CAFETERIA
CHANGE HOUSE
LINE OFFICES
PROCESS MONITORING LABS
DEMIL BUILDING NO. 3
LARGE ITEM STEAM-OUT
EXPLOSIVE RECOVERY
WATER TREATMENT
JET WASH
DEMIL BUILDING NO. 2
MEDIUM CALIBER PROJECTILE DEFUZING
CORE DRILLING
JET WASH
SERVICE MAGAZINE

FIGURE 1

III. HISTORY OF NAVAL AMMUNITION DEMILITARIZATION

At the end of World War II, the naval ammunition production base was valued at 1.25 billion dollars and included 20 NADs and 11 ordnance depots. These facilities were commissioned prior to 1945 for World War I and World War II type explosive loading and assembly operations. No facilities were designed or built in this period for the down-loading and demilitarization of ammunition. Today, NAVSEASYSCOMHQ manages eight NADs/WPNSTAs, two Naval Ordnance Stations, and one Naval Torpedo Station with a present day investment of over 2.25 billion dollars.[1]

Little has been done between the periods of conflict to establish a complete demilitarization capability. During periods of inactiveness, the Navy is traditionally plagued with lack of funds for plant improvement or for process engineering development. Demilitarization in the past has been conducted on a "pay-as-you-go" basis, that is, money for design, development, and operation of demilitiarization processes was being derived from monetary returns from scrap metal, explosive propellants, and other components. While this practice reduced substantially the cost of eliminating the stocks of unserviceable ammunition, it in turn slowed the rate of stock reduction because of the absence of adequate capital to provide effective demilitarization processes for all but the simplest items. It is this reduced demilitarization capability

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[1]BUFORD, POLAND LCDR, USNRI; BOYD, WILLIAM LT., The U. S. Navy Bureau of Ordnance in World War II (U. S. Government Printing Office) 1953

that allowed magazines to remain filled with unserviceable ammunition when the space could have been put to better use for the storage of serviceable ammunition. Reduced capital and the resultant "slimmed" processes also have hindered the maximizing of returns on the scrap components by not allowing flexibility in the downloading steps to coincide with the scrap market climate. Furthermore, much of the obsolete items were disposed of by deep-water dumping; a process whereby ammunition was prepared by removing the fuze and boosters, encasing the rounds in concrete or with other material to achieve a negative buoyancy, then placing these ammunition items aboard an obsolete ship hull, towing it to a preplanned location and sinking the ship. This method was thought to be cost effective; however, recent EPA (Environmental Protection Agency) rulings have almost eliminated this method because of possible pollution to the oceans.[2] A recent study shows that there is not enough ships to handle all the ammunition items and that this method of disposal is extremely costly; approximately one million dollars per ship with no salvage value.[3]

Existing facilities were constructed utilizing the structural design technology of the time and the parameters required by the production of individual ammunition items. Recent

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[2]EPA Regulation on Transportation, Dumping, and Dumping of Material in Ocean Waters (40CFR, Section 220-226) 38 FR 28610 of 15 Oct 1973

[3]Report; NAVORDSYSCOM, Economic Feasibility of Munitions Disposal by Ocean Dumping, 14 Feb 1974

advancements in structural design technology, an ever increasing inventory with hundreds of different items and their individual demilitarization requirements, new air and water pollution restrictions, and a rapidly changing scrap market have prompted an intensive and exhaustive study to be considered in the area of demilitarization.

The object of the modernized demilitarization project is to improve the current "pay-as-you-go" plan with its limited inventory reduction rate.

IV. INITIAL FEASIBILITY STUDY AND ITS APPLICATION

The engineering firm of Mason & Hanger - Silas Mason Company, Incorporated completed the feasibility study and issued a final report 10 December 1971.[4] The following is a summary of that report and the subsequent use made of the findings for the final design of the Western Demilitarization Facility. NAD Hawthorne was selected for the site by NAVSEASYSCOMHQ and Mason & Hanger - Silas Mason Company, Incorporated was directed to utilize this parameter in the study. The analysis used for the site selection is outlined in Section V.

a. General description of the facility layout. Figure 1 shows that the prototype plant could consist of three demil buildings; Number 1: for small-arms ammunition, rocket, and booster disassembly and 20 and 40MM; Number 2: for medium-caliber projectile defuzing, core drilling, jet wash; and Number 3: for large item steam-out explosive recovery and jet wash. The basis for this number of separate process buildings was the inventory which, after cursory analysis, was found to consist of items with general sizes that readily fell into these three defined categories.

In addition to these three primary structures, the configuration also includes four ready-service magazines and two rail/truck off-loading docks with nonpropagation features. All structures and magazines are positioned on the site according

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[4]Final Report, NAD Hawthorne, Nevada, A Prototype Facility for Renovation/Demilitarization at Naval Ammunition Depot, Hawthorne, Nevada, 10 November 1971

to intraline separation criteria identified by NAVORD Publication OP 5, "Ammunition and Explosives Ashore."

Each primary structure was designed utilizing separation walls of reinforced concrete specified in the NAVFAC Design Manual P-397, "Structures to Resist the Effects of Accidental Explosions." The separation walls were used to divide the structure into a number of chambers, each capable of handling a certain explosive charge without allowing sympathetic detonation to occur between chambers.

Movement of material within the complex was to be by hand-operated ammunition carts and driverless tow tractors which connected each primary structure, the off-loading dock, and the ready service magazines.

b. Facility layout verification. Before the criteria outlined by the Mason & Hanger final report could be implemented into a fixed design, each area of consideration, assumptions, etc., required verification to insure adherence to the safety and economic practices of the Navy system.

The first area requiring analysis was the inventory which, was assumed, could be separated into three categories:

(1) Small items - Small-arms ammunition, rockets and booster disassembly, fuzes, and 20 and 40MM.

(2) Medium sized items - Medium-caliber projectiles, etc.

(3) Large items - Mines, depth charges, bombs, etc.

At first glance, the assumption seems justified, since sufficient numbers of items appear in each category to balance the workload between the three buildings. However, after examining the required operations in each building, the following safety problems were discovered:

(1) Items arrived at each of the buildings with the fuze-booster/main-charge configuration intact.

(2) Operations with high accidental detonation probabilities were included in the same structure with high concentrations of explosives.

(3) Almost no personnel protection existed from overpressure in a given operation building from an accidental detonation in that building at the specified charge weights.

The following economic problems were inherent with the three building arrangement:

(1) Since items appeared at each of the three structures in "packed" form, each building would require a dunnage removal system.

(2) Since operations involving a high probability of accidental detonation were to take place in each structure, each structure would require "heavy" wall design to prevent sympathetic detonation.

(3) Since two of the three inventory categories contained items with smokeless powder propellant, separate smokeless powder handling areas would need to be provided for the respective structures.

(4) Since two of the three structures would house operations requiring wet processing, either duplicate waste water treatment areas would be required or the effluent piped great distances to a common plant.

The second area of analysis was the docks. Two off-loading docks were used, one at each end of the facility. The use of two docks allows a higher charge weight to be placed at the site, however, movement of explosive-laden items from two directions would complicate the transportation flow and add to the problem of in-process material control within the plant and this type of control is required to keep explosive charge weights within the specified limits.

The third area for analysis was ready-service magazines which are positioned as shown by Figure 1. Magazines in these locations provide flexibility to the plant but positioned as shown require lengthy transportation lines and additional personnel to work in them.

The fourth and final area of analysis was the placement of the Administration Building and boiler plant near the transportation routes and off-loading areas of "all-up" rounds of ammunition. This positioning would either place these nonproduction type structures and personnel in a potentially hazardous area or would require extensive hardening of the structure to ease the hazard.

The areas discussed above were analyzed critically enough to initiate a "new look" at the demil/disposal problem. This "new look" would use as a guide much of the Mason & Hanger prototype design since the scope and funding for the facility construction were based on their final report. Section V outlines the approach taken to achieve this "new look" at the demil/disposal problem.

V. REANALYSIS OF THE DEMIL/DISPOSAL PROBLEM

The word demilitarization as it is used in this report is defined as any and all process steps required to alter an item so that its original military potential is destroyed.

The reasons for demilitarization are many and varied, but basically involve:

a. Ammunition that is obsolete according to recent standards.

b. Ammunition that is unserviceable due to prolonged storage.

c. Ammunition that has been rejected during production.

Selection of Site

To dispose of the ammunition items listed for disposal by the West Coast Inventory in an efficient, safe, and ecologically acceptable manner, a facility of a new design would seem to be in order as current facilities lack at least one of these parameters. Requirements for the site of the Western Demilitarization Facility are as follows:

a. A large unobstructed site with adequate area for the location of the various buildings without explosive quantity distance problems between the buildings or the new facility and existing facilities.

b. A substantial distance between the site and non-government areas to eliminate noise problems.

c. A site in close proximity to the major storage area for the ammunition items.

d. A site with a high evaporation rate to reduce the cost of pollution controls for disposing of waste water by concentrating wastes.

e. A site near a labor force that is familiar with ammunition production.

Table 1 was used to select the site by matching the requirements with the characteristics of the West Coast activities.

TABLE 1

NO.	SITE REQUIREMENTS	ACTIVITIES			
		NAD Hawthorne Nevada	WPNSTA Seal Beach, Calif.	WPNSTA Con-cord, Calif.	NAD Bangor Wash (Incl. Bangor Annex)
1	Large unobstructed site	X			
2	Substantial separation distance for nongovernment areas	X			
3	Close proximity to large amounts of items	X		X	
4	High evaporation rate for pollution control	X			
5	A source of ammunition oriented personnel	X	X	X	X

After considering the site requirements and the characteristics of each existing activity, NAD Hawthorne, Nevada, seemed to meet most of the requirements.

Plant Layout and Building Concepts

In order to outline the design parameters for the facility, it is first necessary to outline the general characteristics of the ammunition items requiring demilitarization. The weight per item varies from under one pound to over one ton, the quantity of explosive material varies from a few grains to hundreds of pounds, and the quantity of individual items varies from a few hundred to several million.

a. Conventional ammunition items generally consist of the following components:

(1) Packing materials, shipping containers, or crates.

(2) Fuze or initiator.

(3) Booster or auxiliary detonating fuze.

(4) Main charge explosive material.

(5) Inert hardware components either contaminated by contact with the explosive material or noncontaminated.

In the case of gun ammunition, mortar rounds, and other projected items, they consist of propellant and a primer or propellant initiator.

b. The guidelines that have been established for the design of the facility are as follows:

(1) The square footage of the required structures should be within the limits set forth by the feasibility study.

(2) The facility is to be capable of demilitarizing all of the current West Coast inventory and those to be listed in the forseeable future.

(3) The facility is to be designed according to state-of-the-art and near state-of-the-art processing methods (for a definition of state-of-the-art as it applies to this project, see Process Systems and Equipment, Page 32).

(4) Processes are to be used that will release saleable or reuseable items from the facility.

(5) The facility is to comply with the pollutant emission criteria projected for the forseeable future.

(6) The facility is to be designed so it can be operated with a minimum number of highly trained personnel.

(7) The facility is to be designed to minimize the need for utilities and maximize the amount of material output per unit of time.

c. Demilitarization of isolated items has been performed at existing production facilities throughout the Navy system. The processes utilized were analyzed and the following major processes were selected to be considered for the facility as state-of-the-art:

(1) Demil ("popping") furnaces used for detonating the explosive contained in small items such as fuzes, boosters, and small caliber projectiles. There are two types of furnaces available for this purpose. It was decided to include both designs since each has advantages for different items.

(2) Breakdown and defuzing equipment for gun ammunition and small caliber ammunition. This equipment is used to separate the projectile from the cartridge case and defuze the rounds.

(3) Steamout of pure TNT loaded items including the operation to recover the molten explosive; the washout of explosives containing TNT, RDX, wax, and aluminum powder.

(4) Disposal of bulk explosives and propellants utilizing the technology derived from pilot plants designed and operated by Army and Navy agencies.

(5) Removal of bulk main charge explosives from hardware by mechanical means. Contour drills and lathes have been utilized to remove this explosive in a dry condition.

(6) Collection and containerization of bulk dry explosives derived from the mechanical removal processes.

(7) Collection and containerization of bulk propellant; mainly smokeless powder.

(8) Reprocessing of certain explosives for resale or reuse.

Other processes that are now in various stages of concept and development were considered for inclusion in the facility under the heading of near state-of-the-art. They are: (a) Cut-up and punching of hardware to expose the explosive inside for more efficient detonation or deflagration (slow burning); (b) Decontamination of hardware by flashing the residue left on the surfaces;

(c) Reprocessing of explosives other than those considered in the state-of-the-art category.

The requirements of these near state-of-the-art processes were given the same weight as the state-of-the-art processes.

d. Using state-of-the-art and near state-of-the-art processes as a basis for continued analysis, problems with the degree of pollution, the quantity of explosive involved, and the degree of hazard with respect to accidental detonation were examined and the following data listed:

(1) The process and the degree of potential pollution problems experienced are listed below in order of magnitude from largest to smallest:

(a) Washout and recovery of bulk explosives - large amounts of water released as effluent requiring treatment.

(b) Reprocessing of bulk explosives for resale or reuse - moderate amounts of water released as effluent requiring treatment.

(c) "Popping furnaces" - pollution control of high temperature stack gases released from many different explosives.

(d) Bulk explosives disposal - pollution control of stack gases released from different explosives.

(e) Breakdown of components, mechanical removal of explosives, punching, and sawing, etc. - washdown and clean-up water.

(2) The process and the quantity of explosive that can be expected in that process is listed below in the order from

large to very small using the following quantity criteria: (a) Large, 5,000 to 10,000 pounds; (b) Moderate, 1,000 to 2,500 pounds; (c) Small, 1 to 300 pounds; (d) Very small, less than one pound.

(a) Washout and recovery of bulk explosives - large quantities both in process and in the items applicable to this method of processing.

(b) Reprocessing of bulk explosives for reuse or resale - large quantities of explosives in process.

(c) Disposing of bulk explosives - moderate quantities of explosives in various stages of preparation for disposal.

(d) Removal of bulk dry explosives from hardware - small quantities of explosives involved in the removal area; moderate quantities in the area of collection and containerization.

(e) Breakdown of components - small quantities of explosives in process at any one time.

(f) "Popping furnace" - very small amount of explosive involved at the furnace with small amounts in the feeder mechanisms.

(3) The process and the relative degree of hazard with respect to accidental detonation as determined by the use of remote control procedures in existing facilities in order from largest to smallest are:

(a) Breakdown of components (fuze-booster main-charge separation).

(b) "Popping furnace" for small items.

(c) Mechanical removal of dry bulk explosives from hardware.

(d) Disposal of bulk explosives.

(e) Reprocessing of bulk explosives for reuse or resale.

(f) Washout and recovery of bulk explosives.

e. Demilitarization of items generally follows a patterned sequence. The following sequence is used for the components listed in paragraph 1 of this section:

(1) Remove all packing material, shipping crates, and dunnage.

(2) Remove all available inert noncontaminated components.

(3) If applicable, remove the propellant materials and the related primer.

(4) Remove the primary detonating fuze or fuzes.

(5) Remove the booster or auxuliary detonating fuze.

(6) Remove the main explosive charge.

(7) Either reprocess or dispose of the main explosive charge.

(8) Decontaminate the main charge explosive-laden hardware and detonate/deflagrate the fuze/booster components.

(9) Perform any processes necessary to segregate salvageable scrap materials.

f. In general, the following considerations should be made in the design of the demilitarization facility to reduce the magnitude of incidents involving accidental detonation of explosives:

(1) The greater the degree of hazard associated with a particular process, the smaller the quantity of explosive should be allowed in an exposed condition (subject to sympathetic detonation).

(2) Separation of the fuze-booster/main explosive charge should be accomplished as early in the demilitarization sequence as possible. This will reduce the chance of a high yield detonation. Utilizing these two considerations, it is believed that personnel safety will be increased while the need for sophisticated blast resistant structures will be decreased. Using this same line of reasoning, in the area of pollution, it is considered advantageous to group the high quantity effluent producing processes either together or as close as possible in order to share and thus reduce the waste treatment facilities.

g. Recognizing the characteristics of the state-of-the-art processes listed in paragraph c, the general demilitarization sequence of paragraph e, and the considerations for safety and structural economics in paragraph f, it is possible to: (a) Determine individual processing areas; (b) Group similar areas together into separate structures; and (c) Roughly arrange the structures in an efficient manner. The following is a closer analysis of these three steps:

(1) Individual areas identified for the state-of-the-art and near-state-of-the-art processes included:

(a) An area for receiving material, removal of dunnage, etc.

(b) An area for the separation of the fuze-booster/main charge and the removal of the propellant and primer from applicable items.

(c) An area for the removal and recovery of main explosive charges utilizing washout processes.

(d) An area for the removal of dry, bulk, main explosive charges utilizing mechanical processes.

(e) An area for the collection and containerization of the bulk, dry explosives removed as described above.

(f) An area for the preparation of bulk, dry explosives prior to disposal.

(g) An area for reprocessing explosives for resale or reuse.

(h) An area for the operation of the "popping" furnaces for small items.

(i) An area for additional work on small items such as fuzes and boosters to aid in their disposal.

(j) An area for additional work on large items to aid further demilitarization processes.

(k) An area for the decontamination of explosive laden hardware.

(2) After analysis of the individual areas, it was determined that the following groupings should be made and adequate structures provided to best satisfy the safety, structural economic, and pollution economic considerations:

(a) The area required to receive material, remove dunnage, shipping material, etc., should be combined with the area required for the separation of the fuze-booster/main-charge and the removal of loose propellant and primer. These operations should be combined because they are applicable to almost all of the ammunition items regardless of size, the quantity of explosive in process is small, and the degree of hazard is relatively high. The name "Preparation Building" should be assigned to the structure to generally describe its function.

(b) The area to washout and recover bulk main explosive charges should be allowed to remain separate because of the high quantities of exposed explosive involved both in process and in the ammunition items. By providing a separate structure named "Washout Building" for this process, more potential for locating the building on the facility layout is provided to comply with the safety, structural economic, and pollution economic considerations that will be made during the detailed building design phase.

(c) The area to remove dry, bulk, main explosive charges by mechanical methods, the area for additional work on small items, and the area for work on large items to aid further processing should be combined with the area for collection and containerization

of bulk explosive because the first three processing methods require the collection capability to some degree. The structure should be given the name "Mechanical Removal Building."

(d) The area to dispose of bulk, dry explosive should be left separate because it has no direct connection with individual ammunition items, because of the degree of hazard involved, and because of the quantity of explosive in preparation for disposal. The name "Bulk Explosives Disposal Building" should be given to this structure.

(e) The area to reprocess bulk explosives for reuse or resale should be housed in a structure named "Refining Building." This building also has flexibility to comply with safety, structural economic, and pollution economic considerations that will be made during the detailed building design phase.

(f) The area for the operation of the "popping" furnaces should be combined with the area required for decontamination of hardware and located in a structure named "Decontamination and Small Items' Furnace Building." This should be done because of the similar nature of the pollution emissions and because these processes would be the last to be performed before the material leaves the facility.

(3) The arrangement of the buildings on the provided site can be made utilizing the patterned sequence outlined in paragraph e. Since conveyance mechanisms between processes can be simplified if the movement of material is more or less in a single direction, the layout shown in Figure 2 illustrates the single directional flow and the basic processes previously outlined.

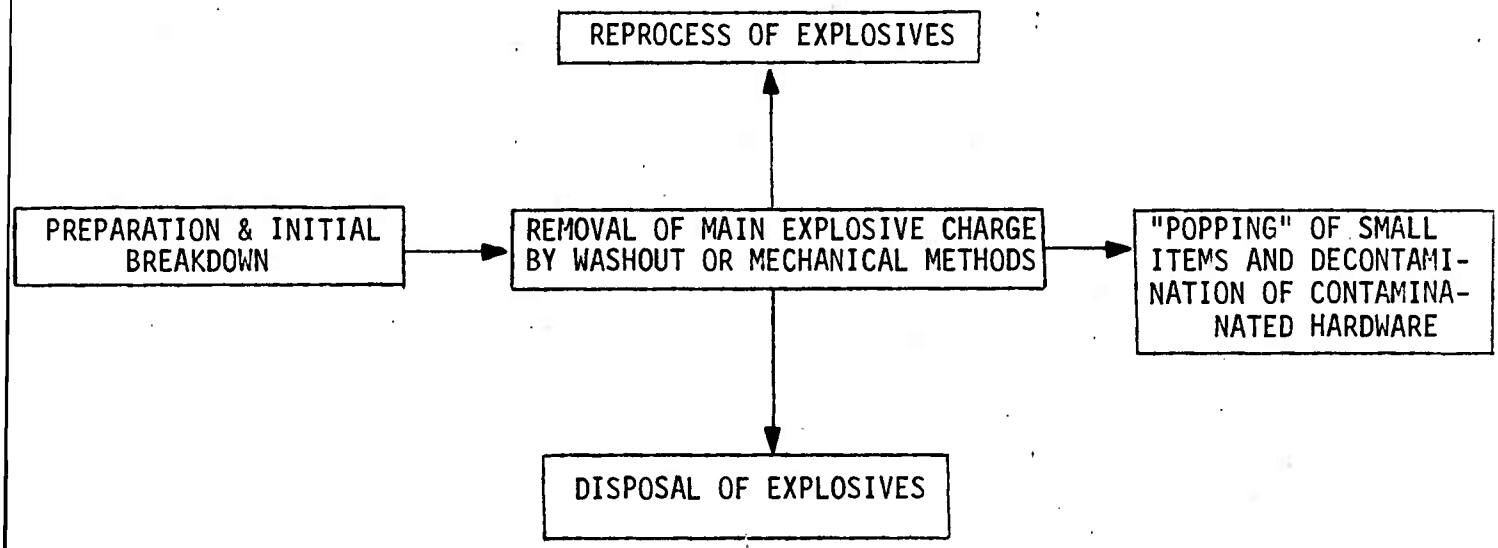

FIGURE 2

Separating the processes as previously defined and identifying them by the structure name previously given to each, but retaining the same flow pattern, the layout shown in Figure 3, can be devised.

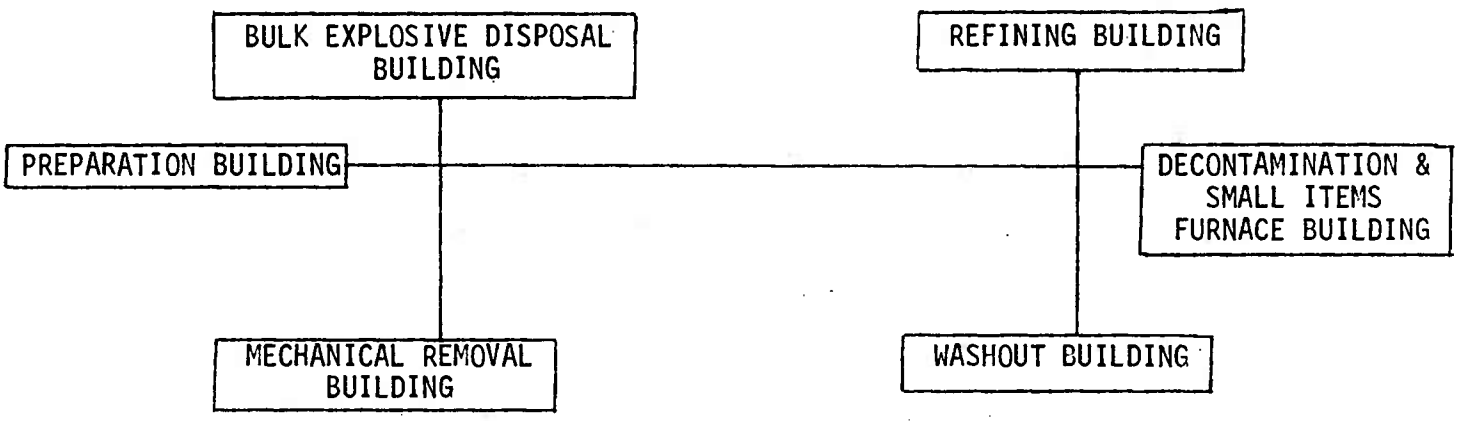

FIGURE 3

h. Additional flexibility is added to the plant by placing five earth covered steel arch magazines between the individual process buildings. These magazines allow material to be delayed between process steps in case of surges or conflicts with concurrent operations. To be able to efficiently supply ammunition items to the facility, those ammunition items containing large quantities of explosives (50,000 pounds or more) require temporary storage as they arrive. This large quantity of explosives will create both personnel safety and structural problems unless proper storage provisions are made. To prevent these problems from occurring, an off-loading dock of a new design should be utilized.

i. Having determined the processes to be included, the number of individual process buildings required, and the basic arrangement of those structures, it then is necessary to establish the basic requirements for each structure in order to proceed to a more complete layout. An approach taken to establish the basic requirements in two stages: (a) Establishing the various building concept designs; and (b) analyzing each building type to establish the required design parameters.

(1) After analyzing the state-of-the-art processes, it was determined that two basic structural concepts will be required. They are:

(a) A structure containing a number of individual rooms or cells connected by doors and ports (doors not extending to

the floor) and with walls designed to resist the effects of an accidental detonation inside and to offer protection to personnel involved in the process. These cells would be utilized for the processes that are considered to be a high safety hazard and involve a low quantity of explosive.

(b) A structure containing a large volume of space, in particular height, to house the washout and refining processes that require equipment interconnected to form a system.

(2) After the two concepts were outlined, each structure was examined independently and desired capabilities listed. For buildings with individual cells:

(a) A sufficient number of cells should be provided to allow several independent operations to take place simultaneously.

(b) The cells should be arranged to allow material and personnel movement with little or no restrictions due to concurrent operations.

(c) An interconnection capability between the individual cells should be provided for material movement in a multi-step process.

(d) Sufficient utilities and ready access to them should be provided to reduce the cost of installing new processes at a later date.

(e) Ready access to the cells for the installation of new equipment should be provided.

(f) A centralized point of control should be provided for all remote processes (no personnel allowed to be exposed

to the explosive during the operation). This point of control would be isolated from any explosive, thus eliminating the strict electrical codes that normally increase the cost of control equipment.

(g) Cells should be provided which are large enough to allow a majority of processes and equipment to be utilized.

(h) An allowable explosive charge weight to cover a majority of ammunition items requiring cell-type processes should be used for the cell design.

(i) Sufficient area for nonhazardous work adjacent to the cells should be provided. The enclosure of this area would offer protection to personnel from the effects of an accidental detonation in a cell.

(3) For buildings requiring a large volume of space:

(a) They should be tall enough to allow gravity flow of explosive-laden process water through the various stages of recovery or reprocessing.

(b) A lifting capability should be provided for installation of equipment and for use in locating the ammunition items.

(c) An attachment capability and structural support should be provided for lateral loads due to seismic effects on equipment in order to reduce heavy bracing of equipment decks.

j. A method of conveying materials between buildings, which has not been previously discussed, is required. It should allow flexibility in the plant and extensive use of structural economics. Table 2 lists the parameters used in determining the type of conveyance.

TABLE 2

Rating System

The five systems are rated from best to worst by the numbers 1 to 5

		Overhead monorail, power & free type	Live roller/belt conveyor	Floor mounted/overhead mounted tow of carts	Electric tractors w/ carts, personnel guided	Electric tractors w/ carts, driverless
1.	Flexibility for the different sized and weighted items	4	5	3	1	2
2.	Resistance to exterior environment without building protection	3	4	5	2	1
3.	Ability to divert, hold, and transfer items according to changes in alternatives	4	5	3	1	2
4.	Ability to maintain quantity distances between items	4	5	3	2	1
5.	Amount of initial investment required (lowest is #1)	3	5	4	1	2
6.	Ability to operate in and around congested areas	4	5	3	1	2
7.	Number of personnel to operate/control (lowest is #1)	3	4	2	5	1
8.	Availability of off-the-shelf components with explosive rating	2	1	3	4	5
	TOTALS	27	34	26	17	16

The results of this tabulation indicate two related conveyance systems to be the most feasible for the facility. The driverless tractor/component cart system is the better of the two finalists; however, operations inside the various process buildings demand flexibility that only a driver can provide. For this reason, a driver/driverless configuration should be adopted. The system would require a pavement path between buildings and would be controlled by the latest

guidance mechanisms. Changes in process steps would be handled by changes to the tractor's control program similar to those made in warehouse systems. The use of this type of system will allow the individual process buildings to be arranged on the provided site free from the constraints inherent with other conveyance systems.

Process Systems and Equipment

Now that the size and characteristics of the facility have been identified for a plant intended to be totally flexible in the area of demilitarization according to the parameters previously outlined, it is necessary to develop the "first generation" of process equipment beyond the original concept. The term "first generation" is given to those process systems and related equipment that will perform the state-of-the-art and near-state-of-the-art processes identified at the start of the project. As new processes are developed, new generations of equipment will evolve for use in the plant. The following design approach is recommended for identifying: the desired interface with the process buildings, the process systems required, and the desired capabilities of individual pieces of process system equipment.

a. The design approach taken to establish a process plant with building envelopes to adequately house various equipment systems has already been discussed. The parameters covering the points of interface between the building and the equipment and the desired design considerations are:

(1) Utilities - The buildings should have electricity, water, steam, and compressed air readily available near the point

where process equipment would be installed. The equipment designs would utilize the availability and characteristics of the utilities (voltage, steam, and compressed air line pressure, etc.) to preclude extensive changes to the building after construction.

(2) Lighting - The buildings should have sufficient lighting for installation and maintenance work. Any special lighting for spot use in particular areas should be supplied with the equipment.

(3) Equipment control - It is necessary to analyze the two major types of buildings and processes in order to outline the control concepts.

(a) The celled buildings should utilize a central control area for monitoring and controlling critical steps of an operation which are performed remotely. Standard modules containing several closed circuit television monitors and areas for switches should be available for connection to the applicable equipment.

(b) In noncelled buildings, the process controls should be placed at a convenient point or points determined during the system design by the design agency.

(4) Equipment mobility - As in the previous area, two different concepts are involved according to the building type.

(a) Celled buildings would have equipment that could be installed and removed at periodic intervals (several months). The frangible walls of each cell should be removable for this function.

(b) The large one room processing buildings should utilize equipment, decks, stairs, etc. that could stay in place for long periods of time (several years).

(5) Door and port usage in celled buildings - The corridors which link all of the cells together should be designed for easy movement of material and personnel. The ports connecting the corridor with the cells should be designated as the primary paths for material entering the cell processes. The doors connecting the corridor with the cells are intended for personnel movement primarily, but could be used for moving material through, if required. The ports located in the wing walls between the cells should be designed for material movement if more than one cell is required for a process.

b. The design approach to the facility which has already been discussed outlined some of the parameters that should be followed. Those same parameters plus several more should be followed in order to establish process systems for the plant. These parameters are:

(1) Process systems should be established to demilitarize all of the items listed by the West Coast inventory data.

(2) Systems should be designed utilizing state-of-the-art processes.

(3) Systems should be designed that will release salable or reusable components.

(4) Systems should be designed that will comply with the pollution criteria projected to the time frame of the facility's operation period.

(5) Systems should be designed that will economize the usage of personnel and maximize the monetary return.

(6) Systems should be designed to economize the use of utilities (water, electricity, fuel, etc.).

(7) Systems should be designed considering items similar to, but not yet listed by, the West Coast inventory data.

Before proceeding further in the process system analysis, the term state-of-the-art should be defined. The term state-of-the-art denotes the existing processes available for consideration and possible inclusion. The term is not to be considered synonomous with the term "as previously constructed" which covers the detailed design and make-up of the existing equipment. The equipment that would perform the selected state-of-the-art processes would be detail designed and constructed to conform to the seven parameters just mentioned and the various constraints of the new facility.

After analysis of the governing parameters, it was discovered that:

(a) Not all of the items listed by the West Coast inventory have existing state-of-the-art processes available for implementation.

(b) In some cases, the existing state-of-the-art processes will not comply with the seven required parameters.

(c) Some state-of-the-art processes could be applied to items not having utilized the process previously or not listed by the West Coast inventory data.

It was decided to approach the process design phase utilizing a "generation" concept. Processes that have a solid basis for consideration would be utilized in the "first generation" of capability. Subsequent development of processes would be utilized in "second, third, fourth, generations, etc." of capability. The plant would thus be evolutionary in its development.

c. After establishment of the desired processes, it is necessary to develop the detailed design of the individual items of equipment. The following approach should be taken to determine the parameters for each item of equipment used to make up a system.

(1) Analyze the characteristics of each item requiring a given process or process step.

(2) Group the items with similar characteristics.

(3) Design a piece or pieces of equipment to perform the required process or process steps with as much flexibility as possible to accept the similar items.

(4) Automate the system to a degree that complies with the given parameters.

(5) Provide detailed designs for equipment to accept all of the items designated and listed by the West Coast inventory for the "first generation" of capability.

(6) Consider all of the items designated but not specifically listed by the West Coast inventory for the design of the equipment that may appear as "second, third, and fourth generation" capability.

It is believed that this approach to design in conjunction with the facility design approach previously outlined will provide a demilitarization facility capable of handling old, current, and new conventional ammunition in an efficient, cost saving, and pollution free manner.

A final report[5] was issued in January 1973 with the site as illustrated by Figure 4 and the process plant, with related process descriptions, which are shown in Figure 5.

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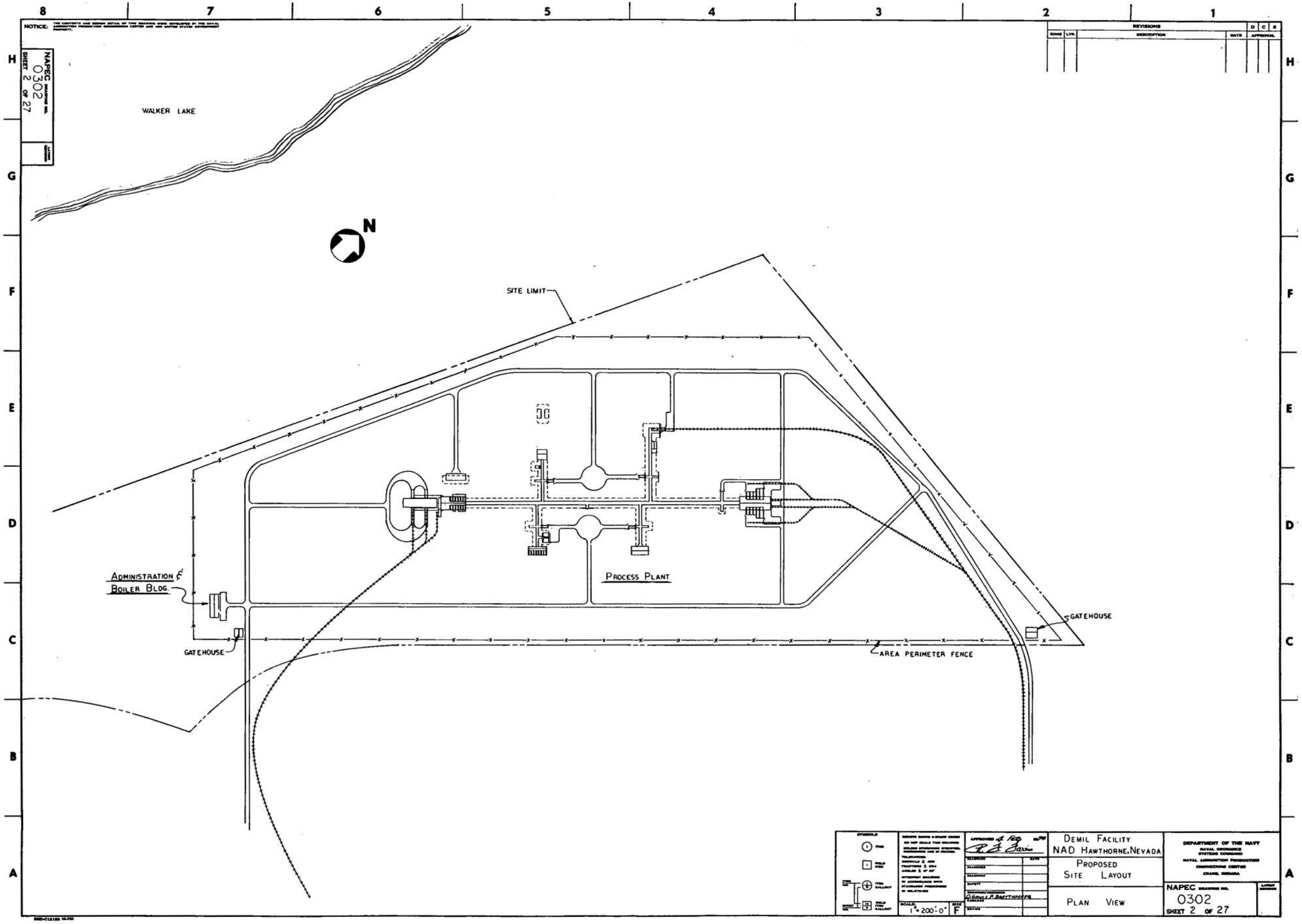
[5]Proposed Demilitarization Facility at NAD Hawthorne, Nevada, Preliminary Design Criteria and Layout Sheets 1 thru 22, 1 Jan 1973


NOTICE:
NAPEC DRAWING NO. 0302
SHEET 2 OF 27
WALKER LAKE
N
SITE LIMIT
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GATEHOUSE
PROCESS PLANT
GATEHOUSE
AREA PERIMETER FENCE
REVISIONS
DEMIL FACILITY
NAD HAWTHORNE, NEVADA
PROPOSED SITE LAYOUT
PLAN VIEW
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DEPARTMENT OF THE NAVY
NAVAL ORDNANCE SYSTEMS COMMAND
NAVAL AMMUNITION PRODUCTION ENGINEERING CENTER
CRANE, INDIANA
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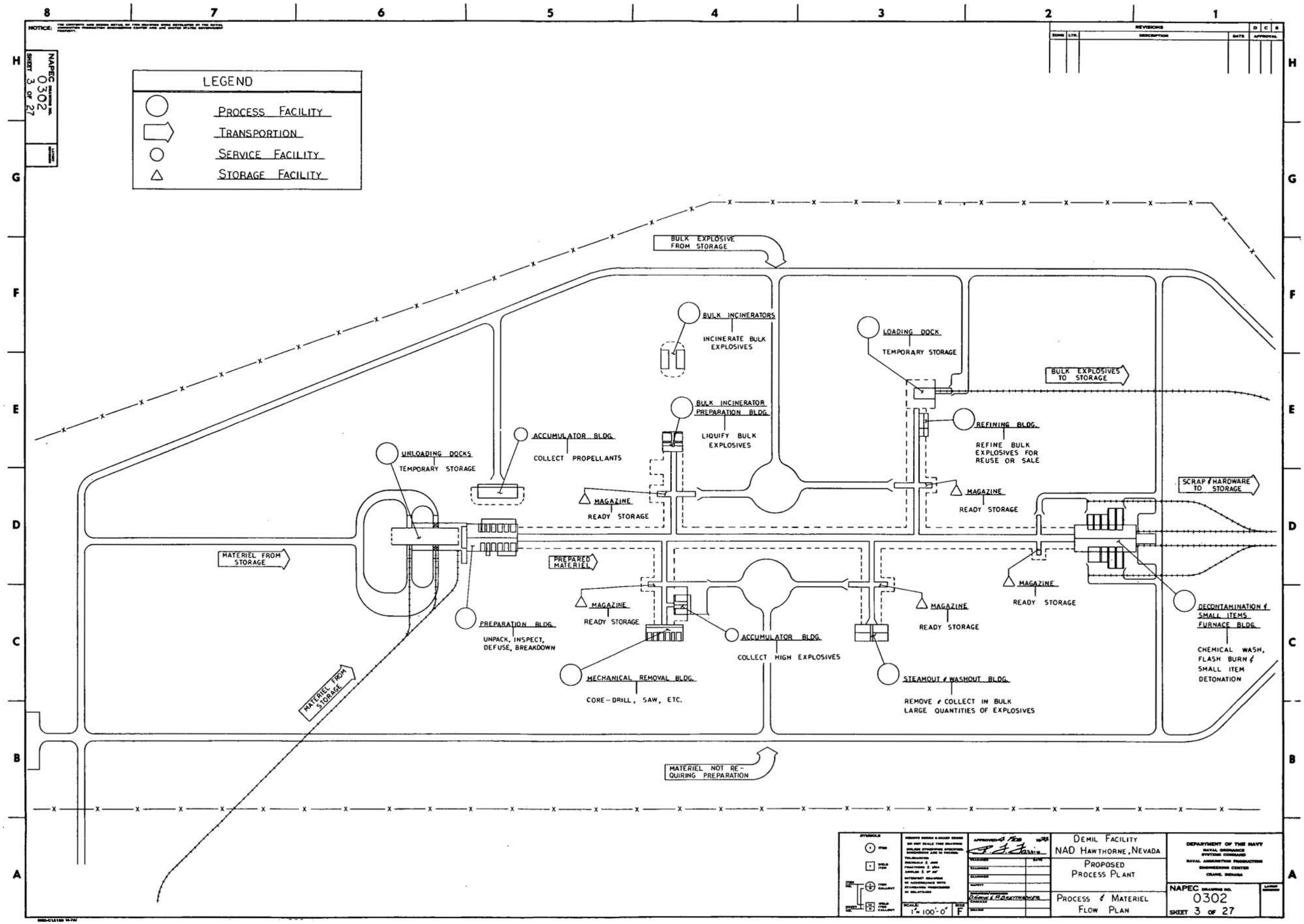
FIGURE 4


NAPEC 0302 SHEET 3 OF 27
LEGEND
PROCESS FACILITY
TRANSPORTION
SERVICE FACILITY
STORAGE FACILITY
BULK EXPLOSIVE FROM STORAGE
BULK INCINERATORS
INCINERATE BULK EXPLOSIVES
LOADING DOCK
TEMPORARY STORAGE
BULK EXPLOSIVES TO STORAGE
BULK INCINERATOR PREPARATION BLDG.
LIQUIFY BULK EXPLOSIVES
REFINING BLDG.
REFINE BULK EXPLOSIVES FOR REUSE OR SALE
ACCUMULATOR BLDG.
COLLECT PROPELLANTS
UNLOADING DOCKS
TEMPORARY STORAGE
MAGAZINE
READY STORAGE
SCRAP & HARDWARE TO STORAGE
MATERIEL FROM STORAGE
PREPARED MATERIEL
PREPARATION BLDG.
UNPACK, INSPECT, DEFUSE, BREAKDOWN
ACCUMULATOR BLDG.
COLLECT HIGH EXPLOSIVES
MECHANICAL REMOVAL BLDG.
CORE-DRILL, SAW, ETC.
STEAMOUT & WASHOUT BLDG.
REMOVE & COLLECT IN BULK LARGE QUANTITIES OF EXPLOSIVES
DECONTAMINATION & SMALL ITEMS FURNACE BLDG.
CHEMICAL WASH, FLASH BURN & SMALL ITEM DETONATION
MATERIEL NOT REQUIRING PREPARATION
DEMIL FACILITY
NAD HAWTHORNE, NEVADA
PROPOSED PROCESS PLANT
PROCESS & MATERIEL FLOW PLAN
DEPARTMENT OF THE NAVY
NAVAL ORDNANCE SYSTEMS COMMAND
NAVAL AMMUNITION PRODUCTION ENGINEERING CENTER
CRANE, INDIANA
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SHEET 3 OF 27
SCALE: 1" = 100'-0"
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FIGURE 5

VI. DEVELOPMENT OF THE FINALIZED FACILITY SCHEME

Naval Facilities Engineering Command, Western Division, selected the firm of Tudor Engineering, Keller & Gannon to perform the architectural and engineering work on the facility.[6]

Personnel from NAVSEASYSCOMHQ, including NAPEC, NAD Hawthorne, NEDED (Naval Explosives Development Engineering Department) Yorktown, and CEL (Civil Engineering Laboratory) Port Hueneme, formed the project team and they presented the Navy's requirements to the A&E firm for the development of the site plan and the design of individual process buildings.

At this point, it becomes necessary to outline the various tools, techniques, etc., that would be utilized to design and equip the final approved facility.

A primary safety consideration of the explosives industry is permitting only a minimal accumulation of explosive quantities, whenever possible, based upon the proposition: "The bigger the amount of explosive, the bigger the boom." Similarly, to prevent damage and possible detonation of adjacently stored explosives by blast or shrapnel, explosives are stored in nominal quantities in magazines or production buildings at specific separation distances from one another. The standard defining permissable quantities and required separation distances is NAVORD Publication, OP5, "Ammunition and Explosives Ashore," which lists empirically tabulated distances

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[6]NAVFAC Contracts; No. N62474-73-C-5695, No. N62474-73-C-5243, and No. N62474-73-C-5696

required to forestall a "chain reaction" of explosions in the event of a single accident.

Today, the effort to maintain safety is a vital concern of any current modernization program and goes beyond the requirement to protect explosives, in that it insures the maximum possible safety for the human operators. Consequently, current design standards involve building protection practices that limit building damage and minimize personnel injury. Increased protection is made possible through the application of knowledge gained about the nature of explosion shock waves, construction design, and building techniques. Structures can be designed to resist the shock wave (or overpressure) created by an explosion by using extensively reinforced concrete; exposure of personnel can be reduced by the use of blast doors, interlocked doors, elimination of openings and windows, etc.

The Western Demilitarization Facility, unlike other modernization projects such as "A" Plant at McAlester, Oklahoma,[7] did not have the constraint of having to utilize existing structures at fixed locations. The economic analysis in this case would use a major guideline, building separation distance vs. structural hardening per given quantity of explosive. Building separation in a plant of this nature is an attractive feature until normal utility runs, increased interbuilding conveyance, and site

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[7]Project Report; Cast High Explosives Fill Plant, NAD McAlester, 18 Dec 1973

constraints begin to approach parity in cost with structural hardening of selected buildings.

a. Initial Layout of the Site

The information provided initially to the A&E firm by the Navy agencies outlined only the number, type, and general arrangement of process buildings required according to the industrial engineering study.[8] As a starting point, the process buildings were arranged according to the requirements at distances corresponding to the Safety Manual OP5, Volume 1, Table 7-7c, Safety Distances-Intraline Separations, Unbarricaded. Explosive quantities permitted in each cell of the celled buildings, work bays of the large area buildings, and maximum building explosive limits were provided as part of the industrial engineering information. During this initial layout, problems developed in the following four areas:

(1) Off-Loading Dock. The off-loading dock, by nature, would require the largest allowable explosive limit because of the rail car capacities normally utilized. It has been the general safety practice, in existing production facilities, to include the loading or off-loading docks with the adjacent building, thus combining the allowable charge weights to form the one used for the placement of the complex within the given facility. This practice is based on the theory that loading and unloading of new ammunition

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[8]NAD Hawthorne, pg. 34

are not hazardous operations. In the case of demilitarization, however, the integrety of the ammunition is often below that of new ammunition. In many cases this is the reason for its required disposal. Recognizing this higher degree of hazard, it was decided to treat the act of off-loading as a separate function from preparation; therefore, the dock would need to be relocated at some distance from the preparation building. In order to minimize the distance from the off-loading area to the preparation building, the dock was barricaded and the distance of separation reduced to that given in the barricaded column of Table 7-7c in OP 5.

(2) Large Charge Weight Cells. Many items found in the inventory have main explosive charge weights ranging from 500 pounds to a maximum of 3000 pounds. Although the number of hazardous breakdown operations required for items in this category are few, an area for this type of work had been outlined in the industrial engineering data. This area originally was to be located in the Preparation Building adjacent to cells with limits below the 500 pound figure.

After analysis of the structural problems involved, not with the high charge weight cell walls but with the remaining areas of the Preparation Building, it was decided to relocate the large cells as a separate unit to a new location. Since large charge weight cells had been envisioned originally in the Mechanical Removal Building, the requirements were combined and the new complex moved near the Mechanical Removal Building. The complex is treated

as part of the Mechanical Removal Building, separated by a distance calculated to prevent heavy structural damage to its parent building upon which it depends for utilities.

(3) Rearrangement of Process Buildings. After initial analysis by the A&E firm, it was discovered that rearrangement of the Washout, Mechanical Removal, and Bulk Explosive Disposal Buildings would realign the QD (Quantity Distance) arcs and make better use of the available site. This change in arrangement at first appeared to impair the original process flow; however, after considering the flexibility of the driverless tractor system, it was decided to arrange the facility as suggested and shown in the final scheme illustrated by Figure 6.

(4) Ready Magazine Location. According to the industrial engineering analysis, the best location for ready magazines was in the direct material flow path between process buildings. Therefore, as shown by Figure 5, the desired location of the magazines was in the feeder path leading to each of the process buildings; however, this location proved to be economically unfeasible. The overpressure design for each process building was more expensive than could be justified on the returns from increased efficiency. The five ready magazines were then assembled into two groups and relocated as shown in Figure 6. The magazines are located beyond the QD arcs of barricaded distances from each process building.

The final calculated values of overpressure that will be seen at each process building due to a maximum charge incident

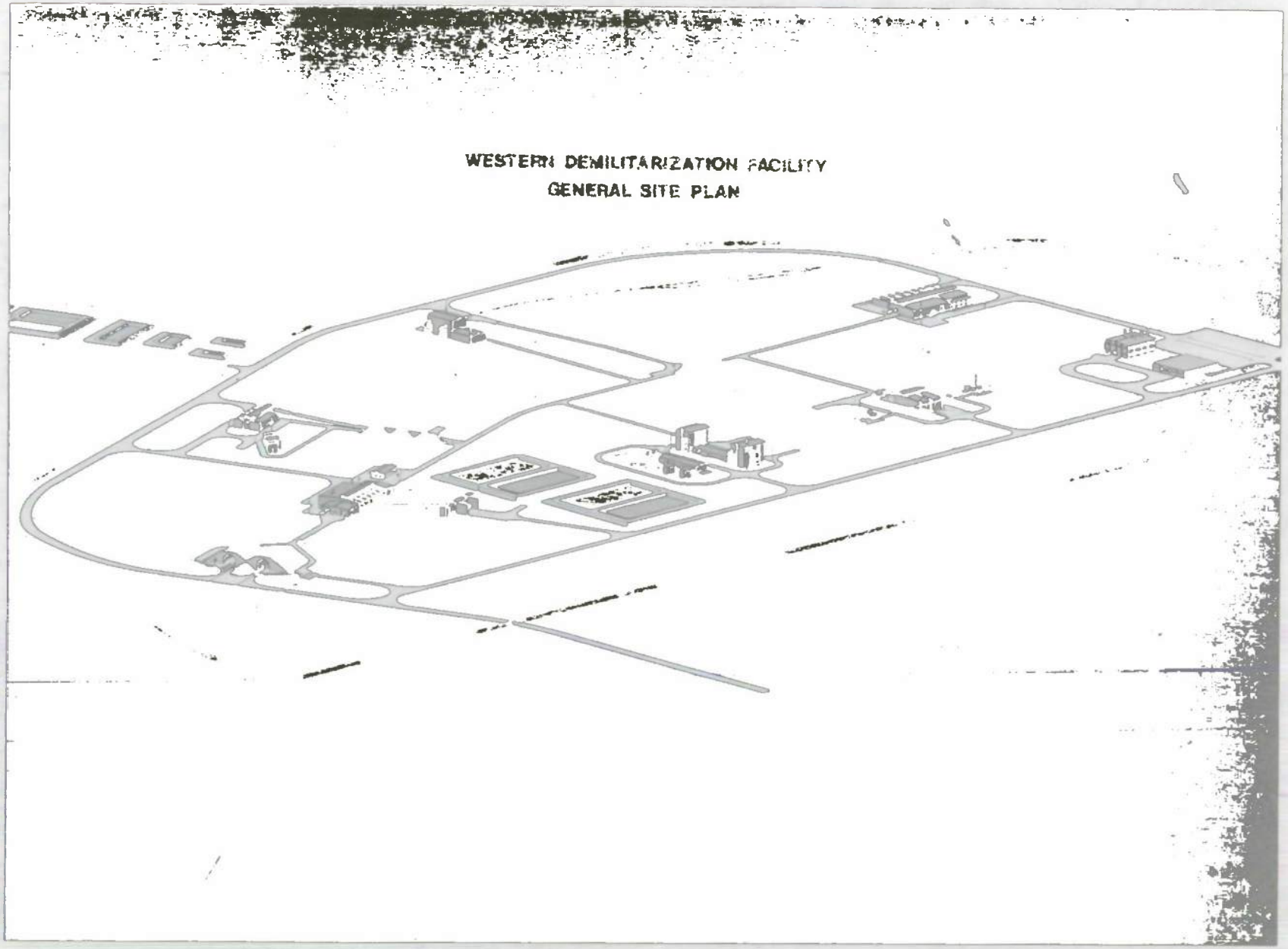

Fig 6

at any given building are shown for the near corner on Table 3 and for the far corner on Table 4.[9] For a given structure, the highest pressure value anticipated was used as the guideline for the design.

b. Structural Considerations and Problems

The Western Demilitarization Facility is the first large scale multi-structure plant to be constructed using the design criteria outlined in the NAVFAC Manual P-397. The manual generally covers cell wall construction with respect to definite charge weights and locations. The celled buildings, such as the Preparation Building, and the large workroom buildings, such as the Washout Building, however, presented some slightly different problems that are not clearly answered in the design manual. Tudor Engineering structural engineers, working closely with research structural engineers from CEL, Port Hueneme, California, applied the manual's criteria in addition to more recent data and some conventional design techniques to solve the individual problems.[10] The problems encountered typify those that can be expected when a manual based on tests with simplified structural designs is applied to complex requirements derived from an industrial engineering analysis. For this reason, some of the major problems encountered and the solutions used are discussed here.

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[9]Tudor-Keller & Gannon, 30% Submittal, Basis for Design for Demilitarization Facility, Naval Ammunition Depot, Hawthorne, Nevada, 30 Apr 1973

[10]Civil Engineering Laboratories, Port Hueneme, California; W. Keenan and J. Tancreto; Blast Environment from Fully and Partially Vented Explosions in Cubicles; Technical Report

TABLE 3

OVERPRESSURES AT NEAR CORNER FROM DONOR SOURCES

DONOR SOURCE		RECEIVER BUILDING										
		Offload Dock	Prep. Bldg.	Large Cells	Mech. Rem.	Steam Out	Refin. Bldg.	Bulk Incin	Decon-tam.	Accum.	Boiler	Admin.
Offload	R		435	852	987	1,222	1,778	1,832	2,354	522	2,410	2,387
Dock	Z		11.1	21.8	25.3	31.3	45.5	46.8	60.2	13.4	61.6	61.1
1.2W=60,000	Pso		4.3	2.6	2.1	1.6	1.0	1.0	0.7	5.6	0.7	0.7
Prep.Bldg.	R	410		342	470	660	1,153	1,258	1,733	168	1,846	1,840
1.2W=7,200	Z	21.2		17.7	24.3	34.2	59.8	65.2	89.8	8.7	95.6	95.3
	Pso	2.6		3.5	2.2	1.4	0.7	0.6	0.4	13.0	0.4	0.4
Large Cells	R	817	342		67	806	884	1,307	1,643	552	1,877	1,898
1.2W=3,600	Z	53.4	22.3		4.4	52.7	57.7	85.5	107.3	36.1	123.0	124.0
	Pso	0.8	2.3		30.0	0.8	0.7	0.4	0.3	1.3	0.3	0.3
Mech.Rem.	R	973	492	82		837	722	1,254	1,523	690	1,797	1,836
1.2W=4,320	Z	59.7	30.2	5.0		51.3	44.3	77.0	93.5	42.3	110.0	113.0
	Pso	0.7	1.6	42.0		0.8	1.0	0.5	0.4	1.1	0.3	0.3
Steam Out	R	1,187	658	807	815		880	394	952	596	980	960
1.2W=21,600	Z	42.5	23.6	28.9	29.2		31.5	14.1	34.1	21.3	35.1	34.4
	Pso	1.1	2.3	1.7	1.7		1.6	5.0	1.4	2.7	1.3	1.4
Refining	R	1,766	1,186	896	738	935		970	884	1,282	1,328	1,410
1.2W=60,000	Z	45.1	30.3	23.9	19.1	23.9		24.8	22.6	32.8	34.0	35.0
	Pso	1.0	1.6	2.3	3.2	2.3		2.2	2.5	1.5	1.4	1.4
Bulk Incin.	R	1,800	1,277	1,350	1,300	402	1,000		632	1,208	530	516
1.2W=3,000	Z	125.0	88.7	93.8	90.2	27.9	69.5		43.9	83.9	36.8	35.8
	Pso	0.3	0.4	0.4	0.4	1.7	0.6		1.0	0.5	1.3	1.3
Decontam.	R	2,327	1,740	1,640	1,522	972	870	603		1,732	518	650
1.2W=3,600	Z	152.0	114.0	107.0	99.5	63.5	56.8	39.4		113.0	33.9	42.5
	Pso	0.2	0.3	0.8	0.4	0.6	0.7	1.2		0.3	1.4	1.1
Accum.	R	498	167	555	695	605	1,258	1,216	1,735		1,800	1,780
1.2W=180	Z	89.1	29.8	99.0	124.0	108.0	225.0	217.0	310.0		321.0	317.0
	Pso	0.4	1.3	0.4	0.3	0.3	0.1	0.1	0.1		0.1	0.1
Mag A	R	956	358	203	204	500	763	1,010	1,410	453	1,587	1,603
1.2W=10,800	Z	43.2	16.2	9.2	9.2	22.6	34.5	45.7	63.7	20.5	71.8	72.5
	Pso	1.0	2.7	6.7	8.7	3.7	1.4	1.0	0.6	2.1	0.5	0.5
Mag B	R	1,707	1,113	1,027	928	490	495	398	562	1,118	820	880
1.2W=6,000	Z	92.8	61.2	56.5	51.0	26.9	27.2	21.9	30.9	61.5	45.0	48.3
	Pso	0.4	0.7	0.8	0.9	1.7	1.9	1.9	1.6	0.7	1.0	0.9

LEGEND: W = Explosive Charge Weight in Pounds of TNT

Z = Scaled Distance, $ft/lb^{1/3}$

Pso = Peak Positive Incident Pressure, lb/in^2

TABLE 4

OVERPRESSURES AT FAR CORNER FROM DONOR SOURCES

DONOR SOURCE		RECEIVER BUILDING										
		Offload Dock	Prep. Bldg.	Large Cells	Mech. Rem.	Steam Out	Refin. Bldg.	Bulk Incin	Decon-tam.	Accum.	Boiler	Admin.
Offload Dock 1.2W=60,000	R		652	942	1,132	1,448	1,888	1,900	2,525	650	2,493	2,496
	Z		16.7	24.1	29.0	37.0	48.3	48.6	64.6	16.6	63.8	63.8
	Pso		3.9	2.3	1.7	1.3	0.9	0.9	0.6	3.9	0.6	0.6
Prep. Bldg. 1.2W=7,200	R	495		432	620	892	1,274	1,346	1,914	238	1,936	1,960
	Z	25.7		22.4	32.1	46.2	66.0	69.8	99.2	12.3	100.0	101.5
	Pso	2.1		2.5	1.5	1.0	0.6	0.6	0.4	6.5	0.4	0.4
Large cells 1.2W=3,600	R	945	525		202	1,013	982	1,420	1,820	625	1,974	2,032
	Z	61.7	34.3		13.2	66.3	64.2	92.8	119.0	40.8	129.0	133.0
	Pso	0.7	1.4		5.0	0.6	0.6	0.4	0.3	1.1	0.3	0.2
Mech.Rem. 1.2W=4,320	R	1,100	695	172		1,014	812	1,376	1,704	767	1,900	1,974
	Z	67.5	42.6	10.5		62.2	49.8	84.5	104.6	47.1	116.0	121.0
	Pso	0.6	1.1	8.7		0.7	0.9	0.4	0.3	1.0	0.3	0.3
Steam Out 1.2W=21,600	R	1,308	870	850	903		1,007	468	1,150	717	1,096	1,080
	Z	46.8	31.2	30.5	32.3		36.1	16.8	41.2	25.7	39.3	38.7
	Pso	1.0	1.6	1.6	1.5		1.3	3.9	1.1	2.0	1.2	1.2
Refining 1.2W=60,000	R	1,858	1,408	984	850	1,040		1,097	1,060	1,407	1,427	1,550
	Z	47.5	36.0	25.2	21.7	26.6		28.0	27.1	36.0	36.5	39.7
	Pso	1.0	1.3	2.1	2.6	2.0		1.8	1.9	1.3	1.3	1.2
Bulk Incin. 1.2W=3,000	R	1,910	1,490	1,396	1,407	632	1,132		812	1,330	613	640
	Z	133.0	103.0	97.0	98.0	43.9	78.7		56.4	92.5	42.6	44.5
	Pso	0.2	0.3	0.4	0.4	1.0	0.5		0.8	0.4	1.0	1.0
Decontam. 1.2W=3,600	R	2,415	1,960	1,708	1,644	1,203	976	730		1,860	590	750
	Z	158.0	128.0	111.7	107.5	78.7	63.8	47.7		121.7	38.6	49.0
	Pso	0.2	0.3	0.3	0.3	0.5	0.6	0.9		0.3	1.2	0.9
Accum. 1.2W=180	R	592	293	640	795	832	1,385	1,288	1,920		1,882	1,893
	Z	106.0	52.3	114.0	142.0	148.0	247.0	230.0	343.0		336.0	338.0
	Pso	0.3	0.8	0.3	0.2	0.2	0.1	0.1	0.1		0.1	0.1
Mag. A 1.2W=10,800	R	1,042	576	254	282	707	880	1,118	1,584	573	1,684	1,734
	Z	47.1	26.1	11.5	12.8	32.0	39.8	50.5	71.7	25.9	76.2	78.5
	Pso	1.0	2.0	4.8	5.2	1.5	1.2	0.9	0.6	2.0	0.5	0.5
Mag. B 1.2W=6,000	R	1,793	1,333	1,088	1,044	690	625	522	737	1,847	924	1,020
	Z	98.6	73.3	59.8	57.4	37.9	34.3	28.7	40.5	68.5	50.7	56.0
	Pso	0.4	0.5	0.7	0.8	1.2	1.4	1.7	1.1	0.6	0.9	0.8

LEGEND: W = Explosive Charge Weight in Pounds of TNT

Z = Scaled Distance, $ft/lb^{1/3}$

Pso = Peak Positive Incident Pressure, lb/in^2

(1) Openings in Cell Backwalls

The industrial engineering analysis indicated the need for openings through the backwall of each cell for the movement of material and personnel. This layout would allow concurrent operations to be performed in adjacent cells. NAVFAC Manual P-397 does not mention this type of condition. All cell wall configurations with related design criteria included in the manual are continuous sections free from openings. The practice with conventional design in the past has been to close this type opening from the connecting corridor by suspending a steel plate in front of the opening on the cell side. During pressurization of the cell due to an incident, the plate would be propelled against the wall, thus sealing the opening. This practice had been used for charge weights that were smaller than the desired 300 pound limit and for walls of greater mass than that indicated by preliminary estimates using NAVFAC Manual P-397. The problem in this case was of a two-fold nature in that the opening was a discontinuity in the wall subject to high stresses and the mass of the steel plate propelled against the wall would produce additional loads to be considered. The problem was solved by balancing the size (thickness) of the steel plate and the wall in order to produce the desired wall rotation of 5° with the smallest wall section practical.

(2) Concrete Wall Spalling in Inhabited Areas

The basic theory behind the technical data supplied by NAVFAC Manual P-397 is that during an incident involving a

given amount of high explosive, a thin wall section can be designed to "ride out" the effects of the blast if it can remain intact at the critical points. "Riding out" in some cases means sustaining permanent wall deformation to some degree. A degree of "rotation" allowed is usually specified for each wall size developed. In the case of the corridor/cell separation wall, 5° was used as the design requirement. Figure 7 illustrates the problems associated with this rotation factor.

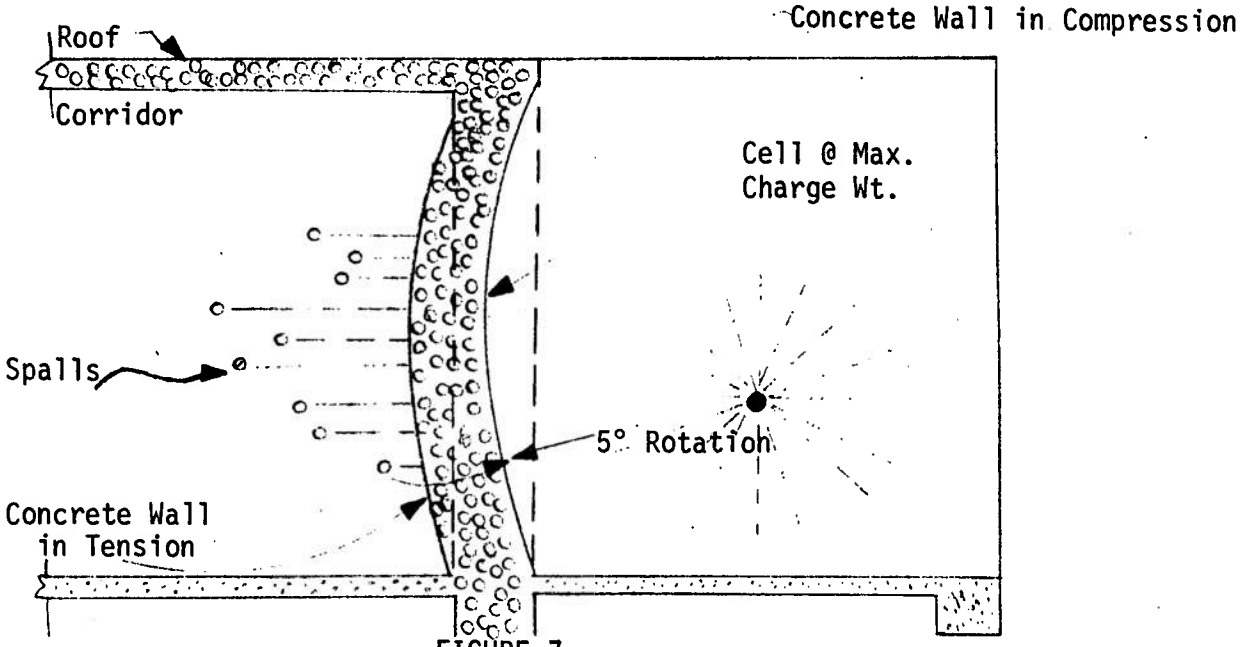


FIGURE 7

A rotation factor of less than 5°, say 2°, would reduce but not prevent spalling or the breaking away of pieces of the wall and would call for a greatly increased wall section. Instead, it was decided to use steel plates bolted a sufficient distance from the corridor wall to prevent spalls from entering the inhabited area. The plates are installed to remain in place should sudden translation of the concrete occur.

(3) Exterior Door Pressure Levels

The large explosive charge weights required for an efficient plant not only called for hardened walls, roofs, etc., but also created a phenomenon around exterior openings. It was found, after calculations, that the overpressure levels at exterior doors of most of the structures were above those able to be resisted by standard door design. Results of a typical analysis based on the P-397 design manual for one of the celled buildings, the Preparation Building, appear in Table 5. From the Table, which gives the design load pressure level in psi and duration in milliseconds, it can be seen that for this structure peak pressures are generated from:

(a) Individual preparation cells at a design load of 300 pounds each.

(b) Off-loading dock at a design load of 50,000 pounds.

(c) Magazine Group A at a design load of 9000 pounds.

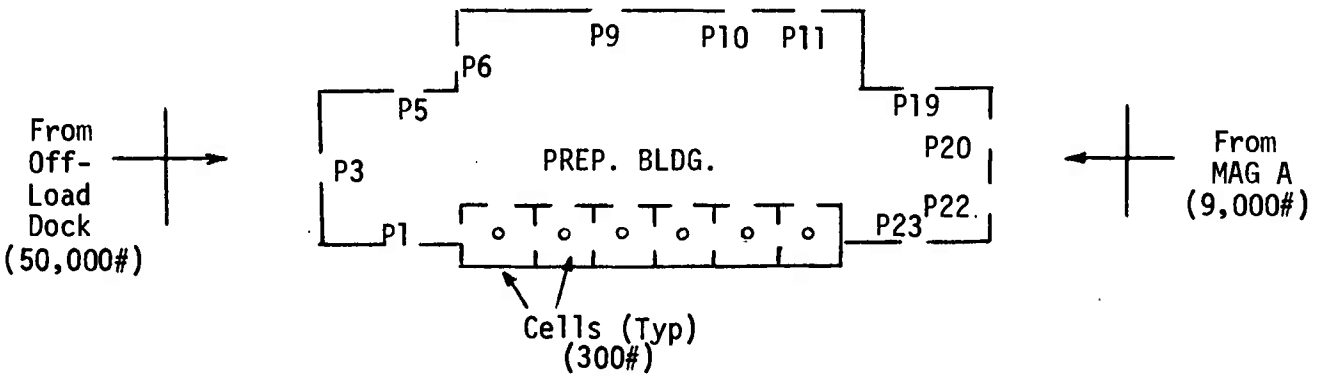
Each pressure level and its corresponding duration was analyzed for its effect on the particular opening to determine the peak design condition. Before design of these doors could be initiated, the use of the door, both for normal plant operation and for emergencies, was determined. As labeled on the building plan associated with Table 4, doors P3, P20, and P22 are 10' x 10' openings used for material movement during processing. Doors P9

Table 5

DESIGN LOADINGS FOR DOORS IN PREPARATION BUILDING

DOOR OR WINDOW NUMBER	DONOR SOURCE	DESIGN LOAD	
		P (psi)	t_o (msec)
P1	Prep Cell	19	11.2
	Off-Load Dock	4.4	94
P3	Prep Cell	16	8.4
	Off-Load Dock	12.0	54.2
P5	Prep Cell	16	8.4
	Off-Load Dock	4.4	94
P6	Prep Cell	10.0	11.3
	Off-Load Dock	10.0	60.6
P9	Prep Cell	7.6	12.9
	Off-Load Dock	3.5	99.4
P10 & P11	Prep Cell	7.6	12.9
	Off-Load Dock	3.1	98.1
P19	Prep Cell	17	8.4
	Off-Load Dock	2.9	99.9
P20	Prep Cell	16	8.4
	MAG A	6.5	44.0
P22	Prep Cell	16.0	9.8
	MAG A	6.5	44.0
P23	Prep Cell	19	11.2
	Off-Load Dock	2.9	99.9
*P30, 31, 43, 32, 44, 33, 45, 34, 46, 35, 47	Prep Cell	472	7.8
*P42, 41, 40, 39, 38, 37, 36	Prep Cell	594	6.1

*Not indicated on drawing, but represent blast doors and ports in the cells



Legend: P = Peak pressure in lb/in^2

t_o = Time duration of peak pressure in milliseconds

and P10 are 10' x 10' openings for equipment installation and maintenance. The remaining openings are 3' x 7' personnel doors which will be used for normal access and emergency egress. Initially, it was decided to design all doors to resist the peak conditions. However, after analysis of the required doors, it was discovered that the 10' x 10' openings would require a substantial and potentially expensive unit. The cost of such a door can be justified if the personnel protection is significant. In this case, however, it was considered that the operating characteristics for doors of this design under normal processing conditions would discourage their use and would probably result in their being left in the open position for long periods of time. Since the interior environment (temperature, humidity, etc.) depends on a closed door condition, it was decided to provide standard, easily operated roll-up doors for these openings and allow the door to fail under peak loads as long as the pressure leakage into the building did not exceed personnel safety limits.[11] In all cases the leakage was below the limit. The 3' x 7' doors were designed to resist the peak loads and remain operable for use in emergency egress.

c. Individual Structures and their Intended Functions

The final form of each of the structures was made after all the structural analysis had been completed, economic trade-offs made, and safety considerations given. The following

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[11]Table 3-1, NAVFAC Design Manual P-397, Structures to Resist the Effects of Accidental Explosions

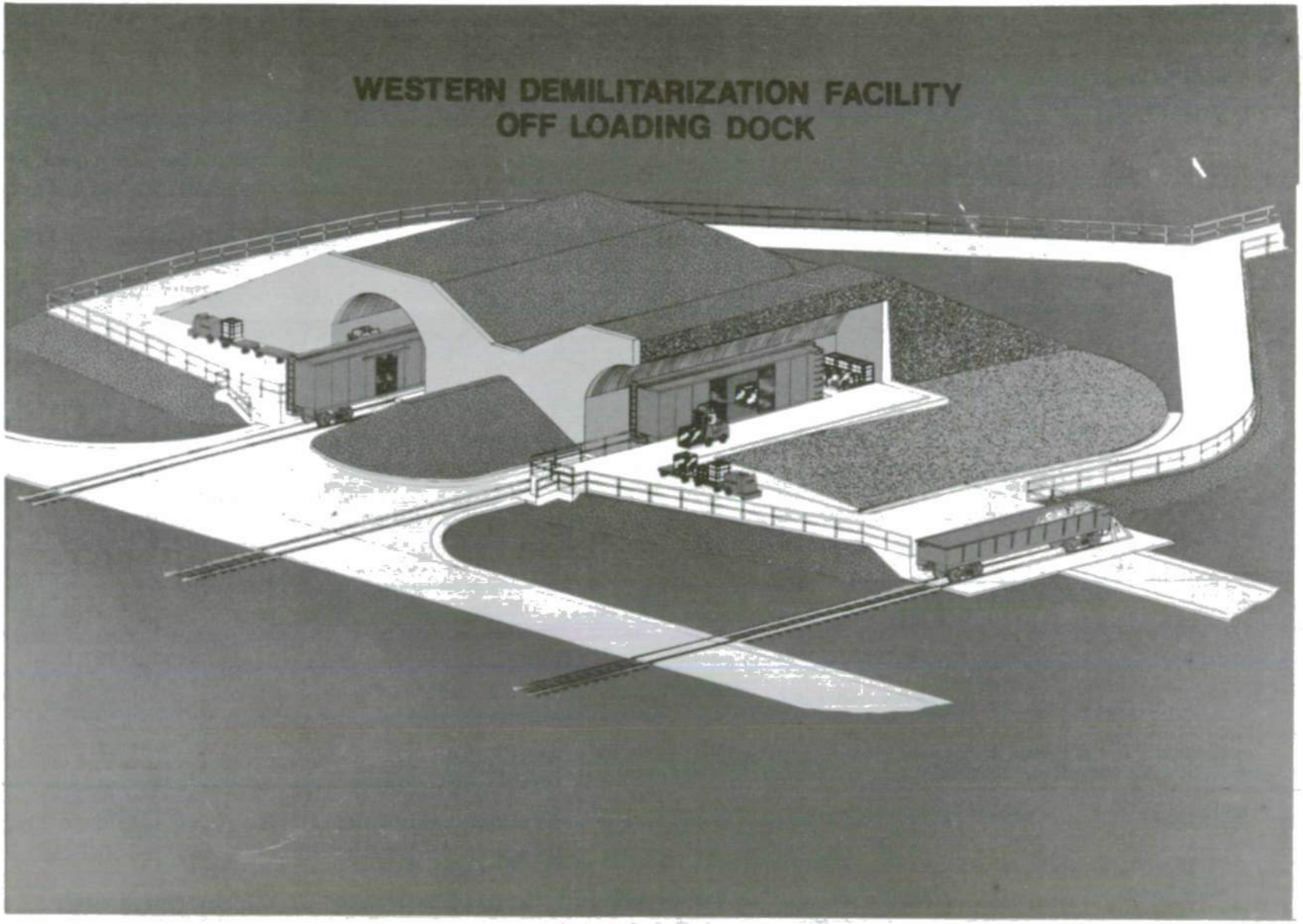


FIGURE 8

text describes each structure and its intended use with references made to included processes and locations of critical equipment.

(1) Off-Loading Dock. Most material entering the plant will begin its journey at this location. Figure 8 illustrates the layout of the two-chambered dock. An earth-covered steel arch will provide protection from propagation between chambers as well as thermal protection for the in-coming ammunition components. It will be possible to conduct normal unloading operations in all but the severest of weather. The spur line and dock located at the right of the off-loading dock will be used for outgoing dunnage derived from the preparation of the ammunition.

The driverless tractor transportation system will service the dock area by picking up ammunition and returning dunnage. Truck service as well as the rail type shown in the illustration will be utilized.

(2) Preparation Building. As is the case with the off-loading dock, most material entering the plant will have some preparation performed at this building. Figure 9 illustrates the structure looking at the celled side with two cells sectioned and process equipment depicted. Material will enter the building by driverless tractor through the large room on the left. Shipping containers, banding, pallets, and all easily removable components will be removed from the ammunition in this room. The material will then move down the central corridor, enter a cell if a particular process is required, and end up in the large room to the right.

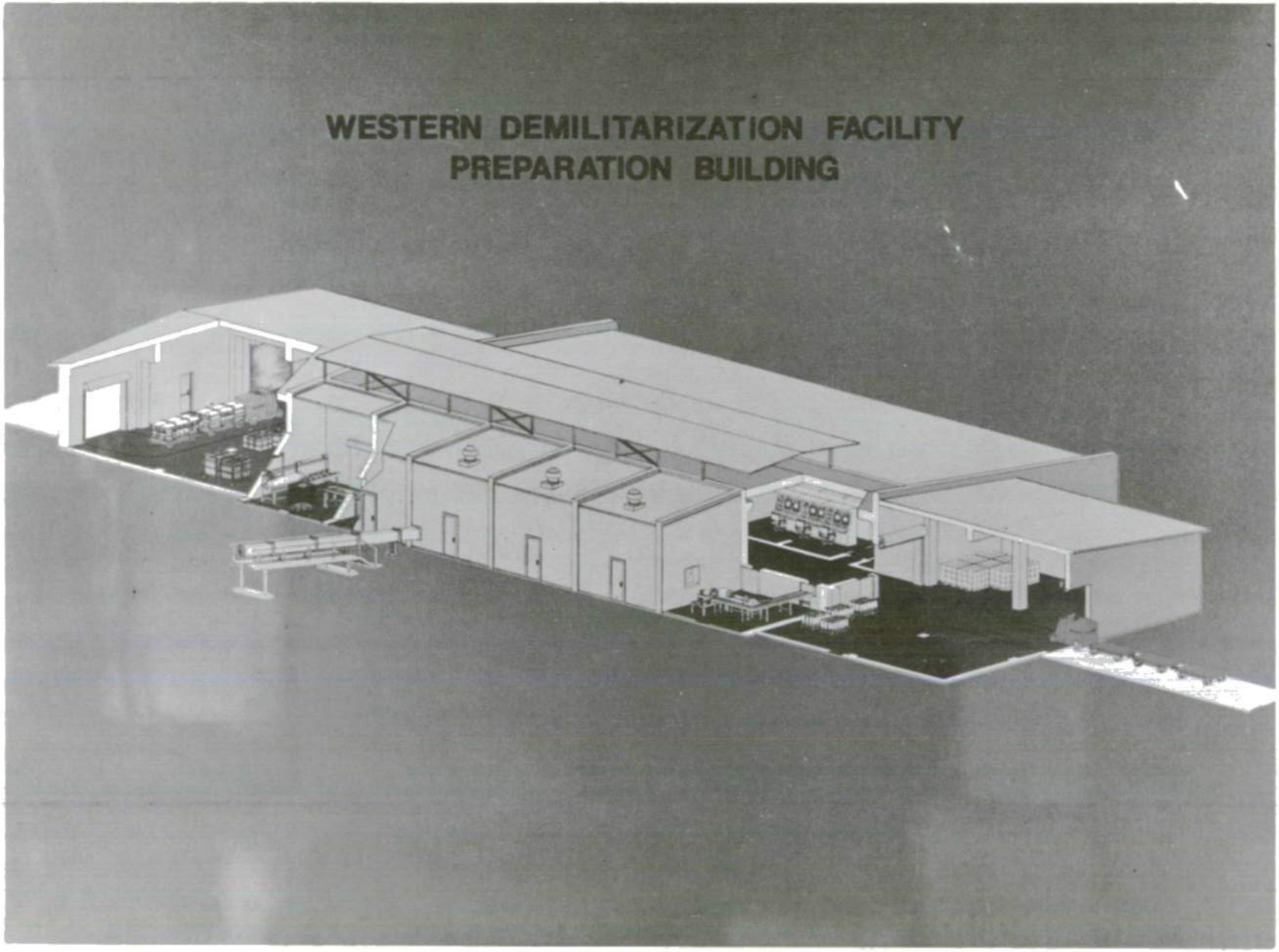

WESTERN DEMILITARIZATION FACILITY
PREPARATION BUILDING

FIGURE 9

From here, the components, now segregated and containerized, will be dispatched to appropriate buildings within the plant for further processing. Again transportation will be by driverless tractor. Control of hazardous operations and interlocking of cells, equipment, etc., will be performed in the control room shown deep in the interior of the building. Since the control room is isolated from any explosive atmosphere, standard electrical components can be utilized. All utilities to the cell side of the building will run through the utilities' deck shown above the corridor. Mechanical equipment for the interior climate as well as support equipment for process equipment will be located on the opposite side of the building from the cells.

(3) Smokeless Powder Accumulator Building. Many of the ammunition items have smokeless powder propellant charges. Since the separation processes performed in the Preparation Building will involve the release of large quantities of smokeless powder and there is a fire danger related to this material, a separate structure was positioned on the cell side of the preparation building. Figure 10 illustrates the building with half of the operating equipment shown. The equipment located in the right half of the building will be utilized for collecting small-grained propellant by vacuum methods. The equipment on the left side of the building will be utilized for collecting grain propellant that is too large to be transported by vacuum. In this case, a conveyor which enters the building from above will be used. In all cases, propellant will be transferred

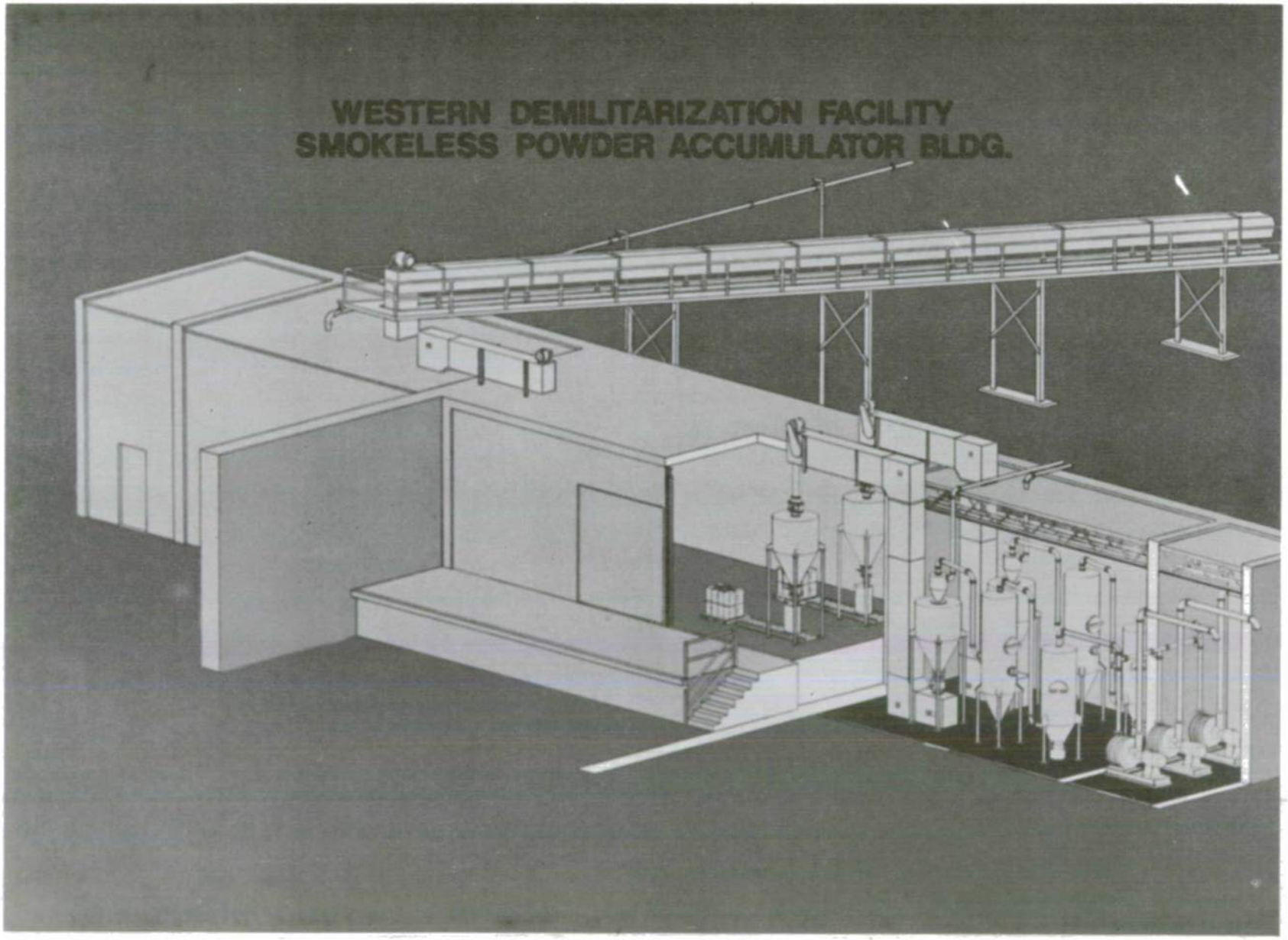

WESTERN DEMILITARIZATION FACILITY
SMOKELESS POWDER ACCUMULATOR BLDG.

FIGURE 10

to the boxing room in the center of the building for containerization and off-loading.

(4) Steamout Building. A major processing method for the removal of bulk main charge explosives utilizes steam, warm water, or both in conjunction with recovery equipment. Figure 11 illustrates the facility complex that will be used for the removal and recovery operation. In each of the two work bays, the operation will involve hoisting the explosive-loading item to the washout/steamout deck by means of an overhead crane. From this point, the explosive will flow through various recovery steps by means of gravity and will end its journey in a solidified condition.

The building will be serviced by the driverless tractor system operating on the process roadway.

The center section between the two work bays houses mechanical equipment, offices, and a laboratory for the explosive waste treatment plant to be discussed in Section VII. As can be seen from the illustration, the work bay structure represents a free standing envelope in which the work levels are constructed. A change of the process and the related changes in the equipment can be accomplished by disassembly and relocation of the platforms to suit the new requirements. Emergency egress capability is included for all equipment platform configurations by providing openings at fixed levels and locations within a short walkway spanning the distance from probable equipment platforms.

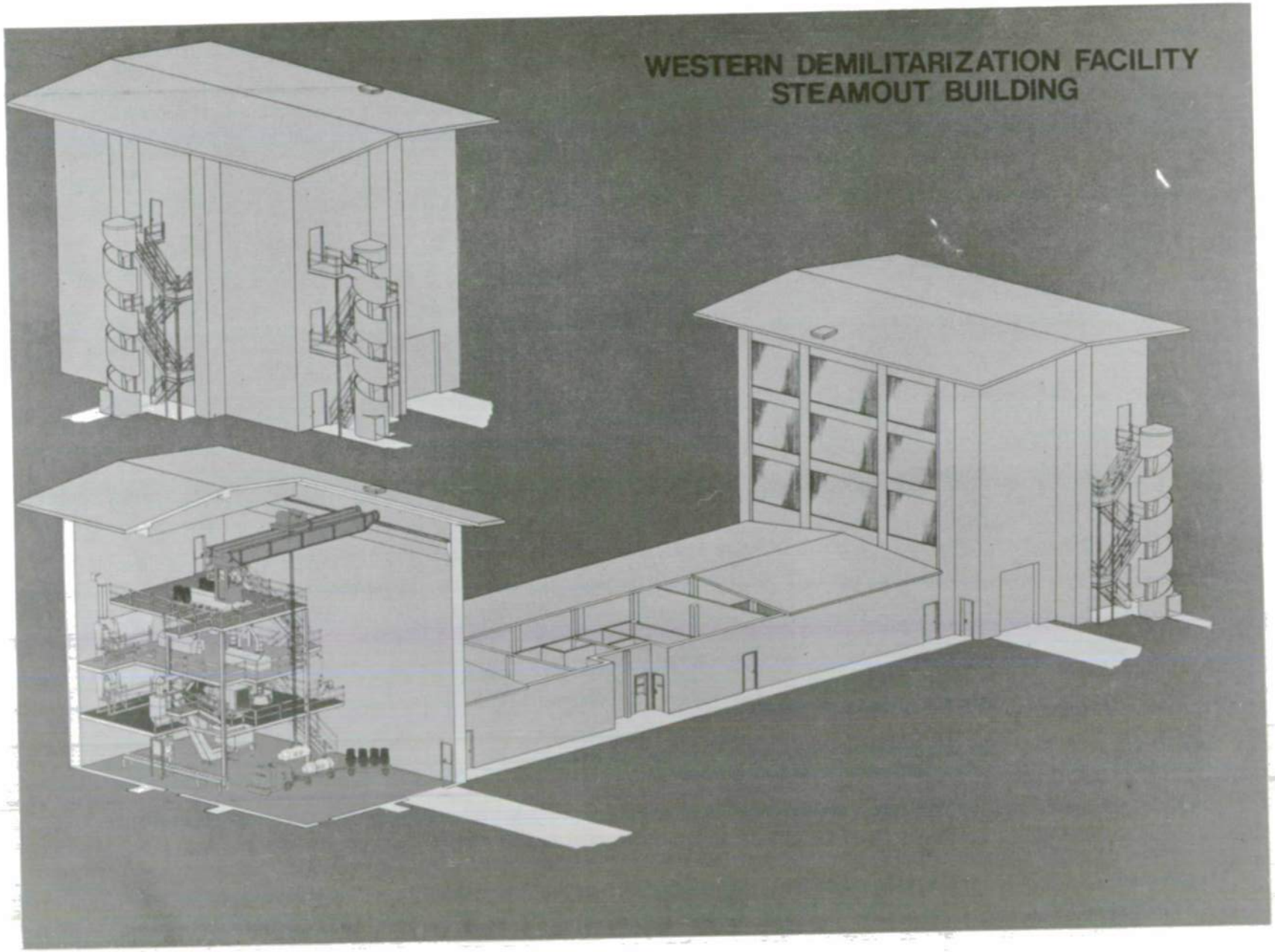
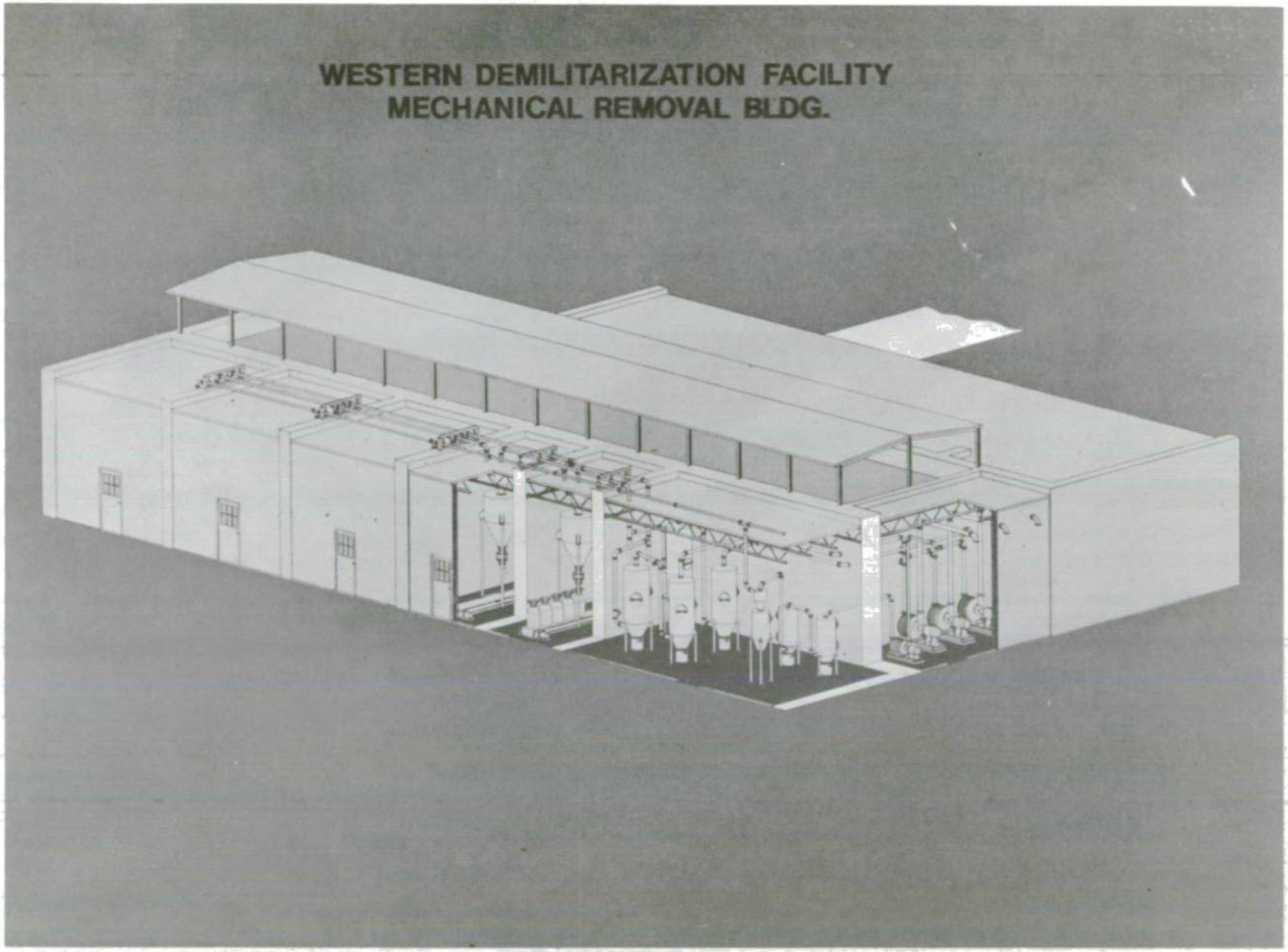


FIGURE 11

(5) Mechanical Removal Building. Another major processing method involves removing the main explosive charge without the use of fluids. This process, called mechanical removal, is mostly applicable to hardware that is symmetrical about an axis running through an opening available for extraction of explosives. This covers the majority of gun ammunition projectiles from 40MM through 175MM. The explosive is machined from the projectile cavity by a contour lathe and transported to collectors by vacuum. Figure 12 illustrates the building with the sectioned portion at the right showing the explosive recovery and containerization equipment; the unsectioned portion to the left contains the removal cells. Removal equipment will not occupy all of the cells simultaneously. Sawing and punching equipment for small items will also be installed in this building to aid reduction processes found in the remaining buildings of the plant. The driverless tractor system will be the primary means of transporting material to and from the building. Remote control of cell operations will be from a control room located, as in the Preparation Building, deep inside the structure.

(6) Large Cell Complex. Several types of ammunition such as torpedo warheads, mines, etc., require sawing or cutting to permit explosive removal processes in other buildings. In many cases, the quantity of explosive in the main charge is too great to be handled in the cells of buildings previously described. Three cells are provided in the Mechanical Removal Building for handling these items. Figure 13 illustrates the three cells and a bandsaw, one of the major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MECHANICAL REMOVAL BLDG.

FIGURE 12

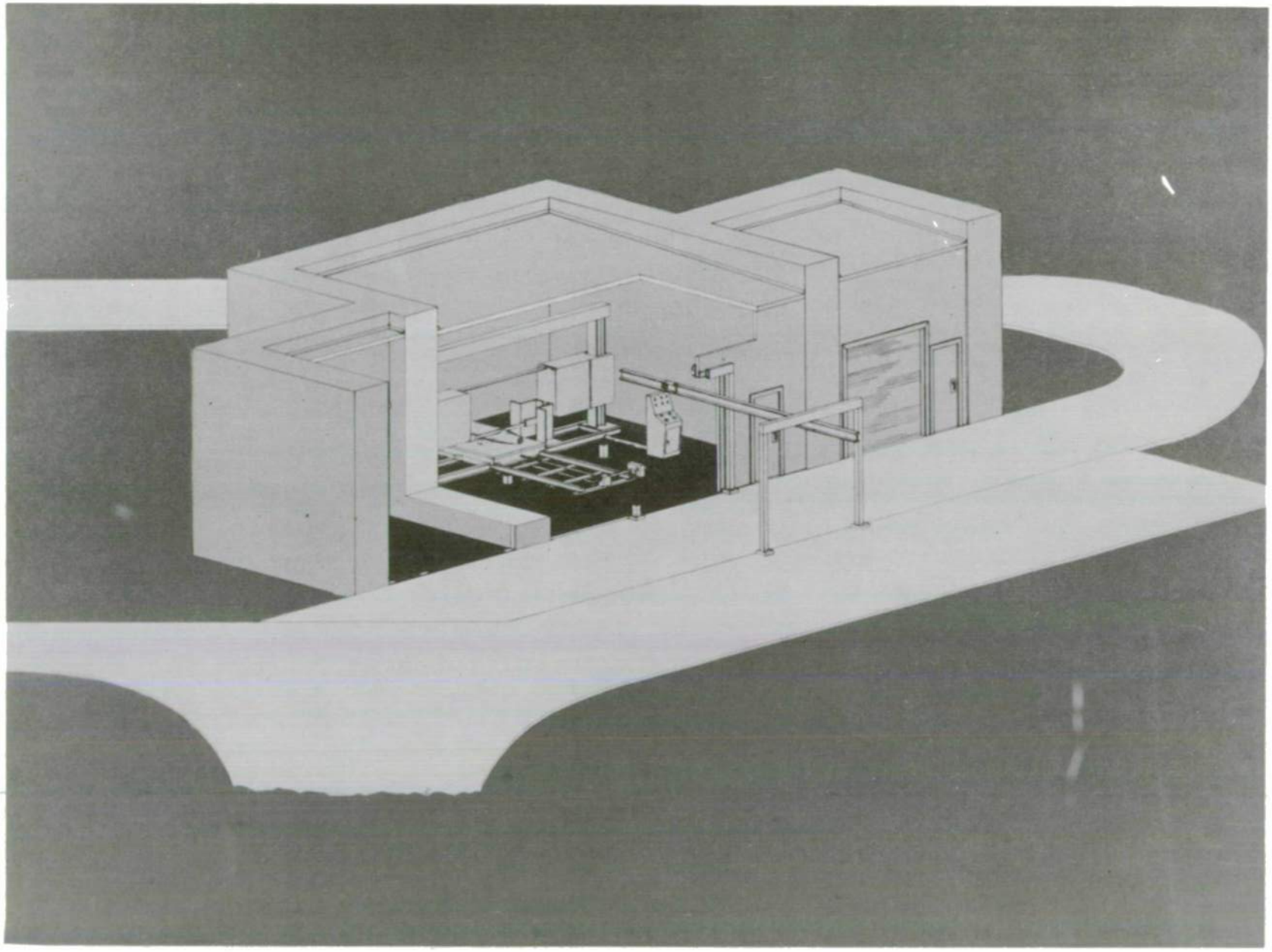


FIGURE 13

equipment items that will be utilized. Material can enter these cells from the frangible wall side only since the charge weight used for the design (3000 pounds) prevents the use of doors in the backwall. Control of the operation will be from the parent Mechanical Removal Building. No personnel will be allowed outside of the Mechanical Removal Building when any of these three cells are operating. Material will be delivered to the cells by the driverless tractor system on the process roadway shown in front of the structure.

(7) Bulk Explosive Disposal Building. Large quantities of energetic material (explosives and propellants) will not be suitable for salvage or reuse. Also, the process waste treatment plant will produce quantities of explosive in the form of sludge. Figure 14 illustrates the two-chambered building that will be used to reduce these influents to a slurry form for further reduction to more stable compounds by incineration or some other related process. The equipment shown on the two pads outside the building operates on the tumble burner incineration technique utilized by Radford Army Ammunition Plant. Material to be reduced will enter the building by way of the process roadway and will be off-loaded in the corridor area. From here, the material will be transferred to the preparation room where it will be ground and mixed with water and pumped to the furnace by remote control. The control room for both processing areas is below ground as shown. The two-chambered building will allow different materials to be processed concurrently.

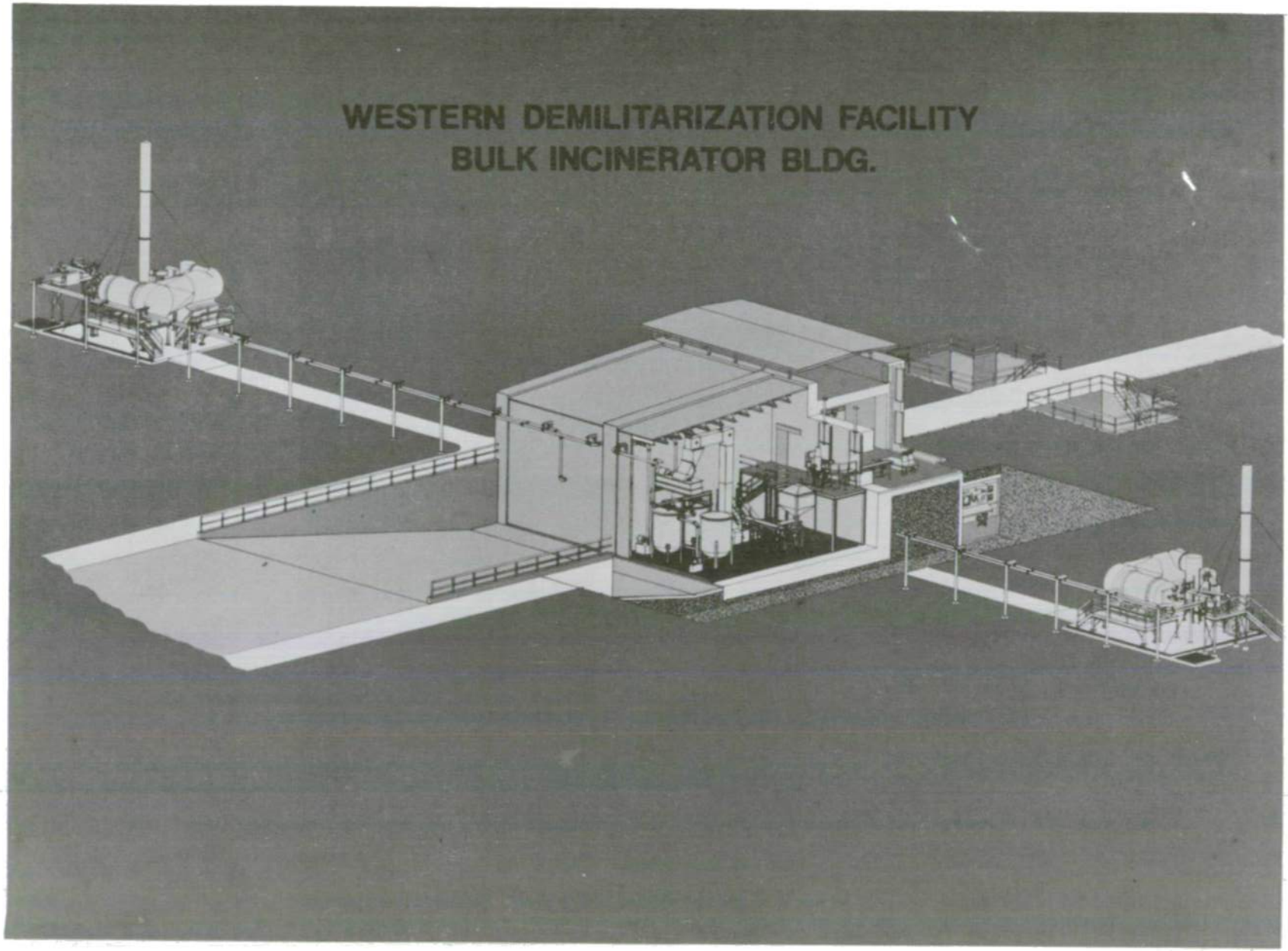
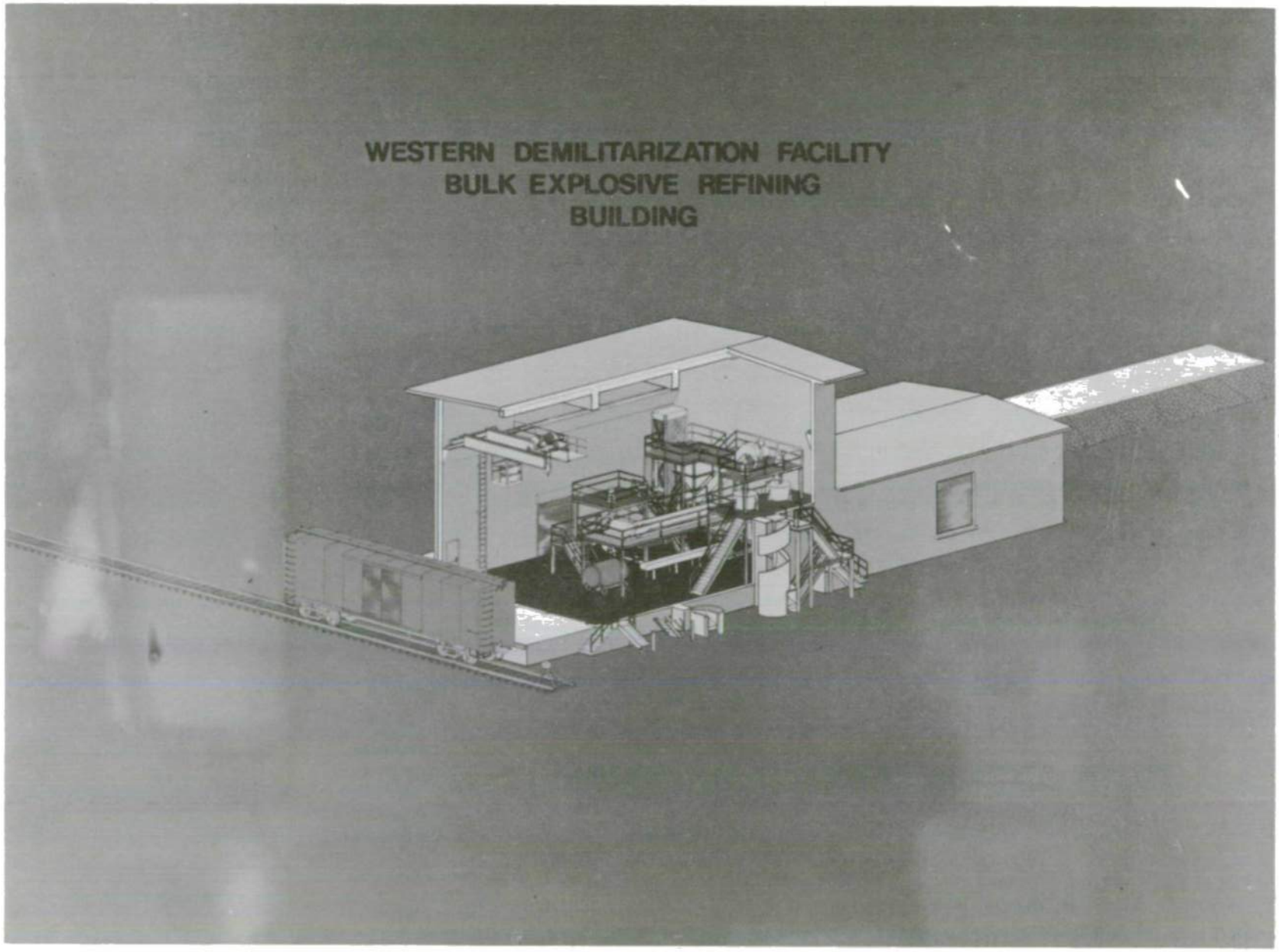

WESTERN DEMILITARIZATION FACILITY
BULK INCINERATOR BLDG.

FIGURE 14

(8) Bulk Explosive Refining Building. In some cases, it will be necessary to subject material removed at either the washout complex or the Mechanical Removal Building to additional processing operations to end up with a marketable product. Figure 15 illustrates the structure provided for this function. The structural aspects of the building represent a scaled down version of one washout building workroom. Bulk quantities of the material will enter the building to be processed, packaged, and off-loaded.

(9) Decontamination and Small Items Furnace Building. Like the Preparation Building, the Decontamination Building will be a stop for all components except the main explosive charge and some propellants. A major requirement for the facility is to release scrap materials free from explosive contamination. This scrap will bring higher salvage returns and be able to be turned over to private concerns directly after leaving the site. Figure 16 illustrates the building and some of the major equipment systems that will be utilized. Material will enter the structure via the process roadway and will be subjected to one of several furnace operations. Material will leave the structure either from the furnace discharge area shown with the spur line and gondola cars or from the area designated for further scrap separation processes shown with the spur line and boxcar. Since most of the operations require remote control, a control room layout similar to that in the Preparation Building will be used. It can be seen located deep within the structure.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BULK EXPLOSIVE REFINING
BUILDING

FIGURE 15

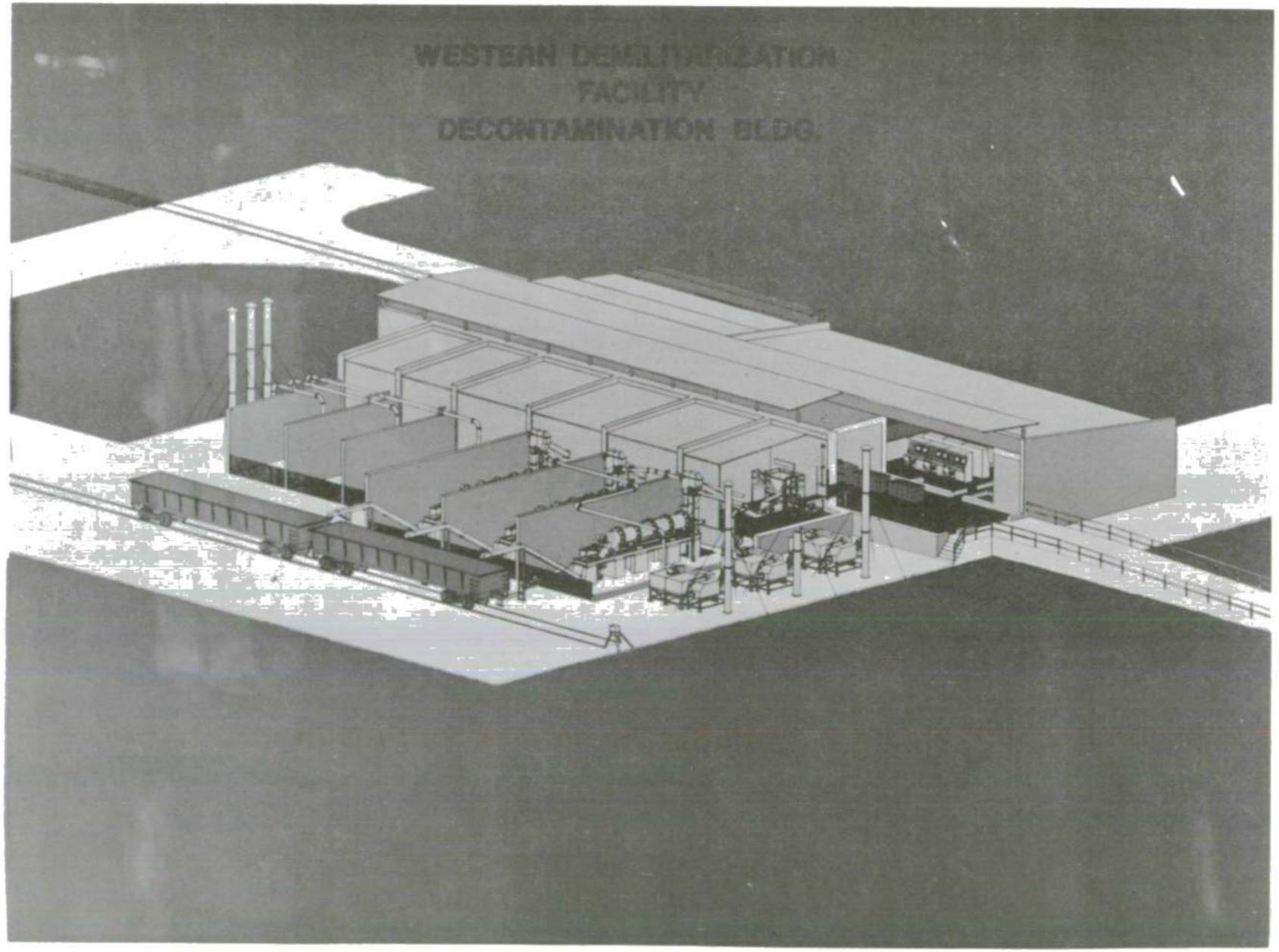
WESTERN DEMILITARIZATION
FACILITY
DECONTAMINATION BLDG.

FIGURE 16

(10) Magazine Group A. In order to provide flexibility to the plant, insure compliance with quantity distance criteria, and improve efficiency in processing, temporary storage magazines are provided in two locations along the process roadway. Figure 17 illustrates the larger of the two groups which is made up of three separate earth-covered, steel-arch magazines. The driverless tractor will be programmed to stop at this complex either for withdrawl of material from storage or for deposit of material until the next process step is readied.

(11) Administration Building and Boiler Building. Since the demilitarization facility is required to be located far enough from existing structures to comply with explosive safety criteria, a lunch and locker area was required. Figure 18 illustrates both the lunch and locker/administration building and the boiler building which allows this facility to be self-sufficient. Employee parking will be at the administration building only and not at the individual process buildings. The administration building will also house a quality assurance laboratory.

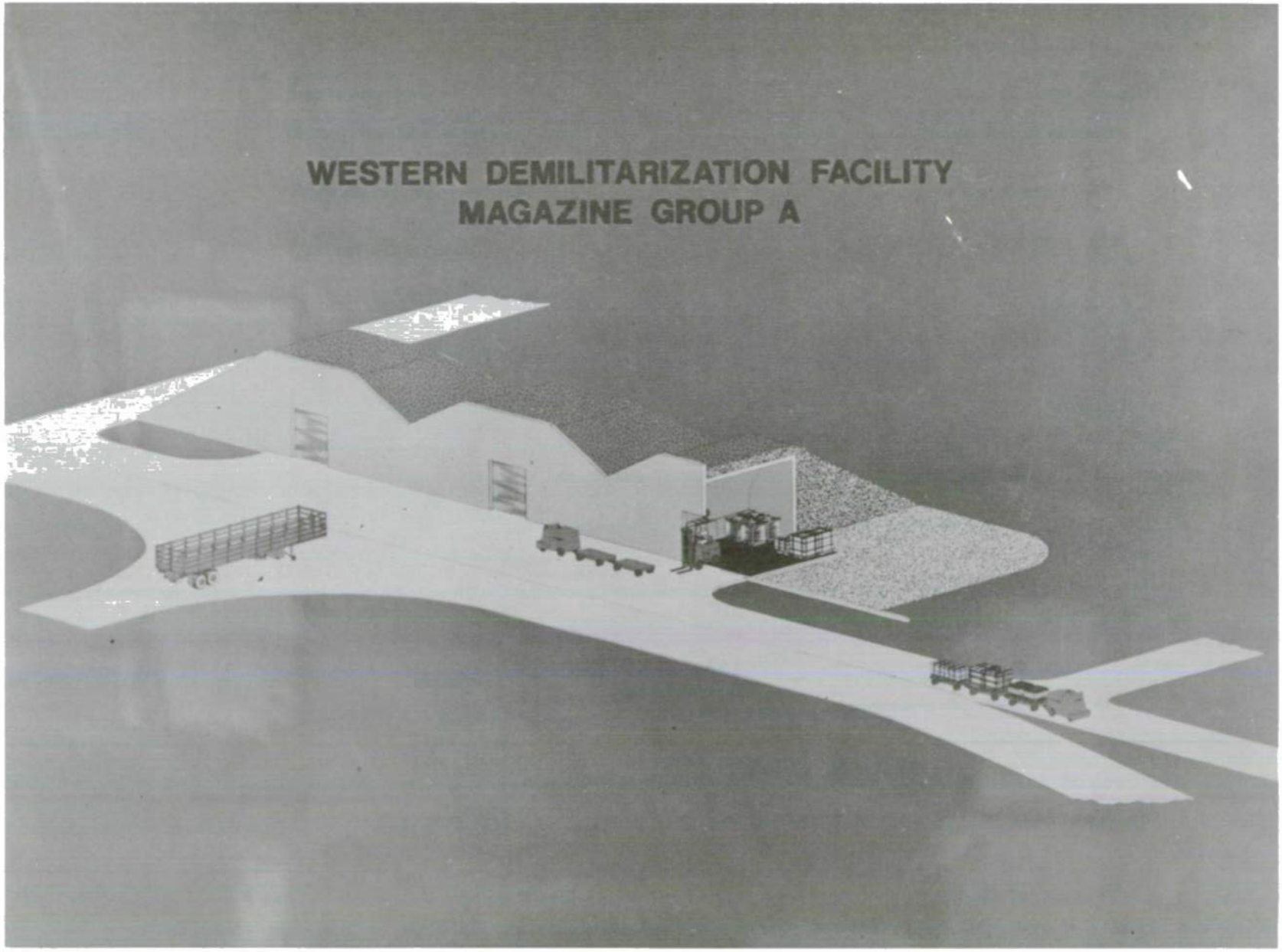

FIGURE 17

WESTERN DEMILITARIZATION FACILITY
ADMINISTRATION BUILDING
& BOILER BUILDING

FIGURE 18

VII. DEVELOPMENT OF THE FIRST GENERATION OF PROCESS EQUIPMENT

Naval Facilities Engineering Command, Western Division, on 19 July 1974, selected the firm of Battelle Columbus Laboratories[12] to perform the engineering work on the first generation of process equipment.

NAVSEASYSCOMHQ, including NAPEC and NAD Hawthorne, formed the project team and they presented the Navy's requirements to Battelle for the development of Phase I of the design effort.[13,14]

Phase I of the design effort will include an investigation of state-of-the-art demilitarization processes within the Department of Defense, processing techniques used in nonexplosive oriented manufacturing, and a report identifying possible design paths to follow. A final report for Phase I will be issued by 1 January 1975.

Phase II will involve Battelle's following the selected design path or paths to the establishment of design information suitable for equipment fabrication.

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[12]NAVFAC Contract No. N62474-74-C-3913

[13]Equipment Design Procurement Process Description; Addendum A; Western Demilitarization Facility, NAD Hawthorne, available from Naval Ammunition Production Engineering Center, Crane, Indiana

[14]Equipment Procurement Outline of General Requirements, Increment II, Western Demilitarization Facility, NAD Hawthorne, available from Naval Ammunition Production Engineering Center, Crane, Indiana

VIII. PROCESS WASTE TREATMENT

A major concern which led to the establishment of the Western Demilitarization Facility is the environmental impact of the explosive-laden effluent that has been released from existing demilitarization sites. This effluent has been in the form of both liquid and gaseous emissions.

The cost of adequate pollution controls is an added burden to any process, cutting into profits of private corporations as well as increasing the cost of production for government institutions. The release of potentially hazardous material from the demilitarization processes, however, cannot be tolerated for prolonged periods of time; therefore, the price of adequate controls must be paid. This price for adequate controls can be reduced if the controls are applied efficiently to the various process techniques available. The following text identifies the pollution problems involved in demilitarization and the techniques used to solve them.

a. Nature of effluents. State-of-the-art demilitarization processes basically involve (1) explosive mixed with water and (2) gaseous compounds emitted from furnace stacks.

The washout process represents the first type of emission in that quantities of explosive from hardware are mixed in water which is used as a carrying agent for the explosive through several steps of the recovery process. In addition, buildings that have cells require periodic "wash down" with steam and hot water.

Residual explosive in this case is mixed with water in various concentrations.

The large rotary furnaces used for detonation of small items represents the major source of gaseous emission. This emission, while not a major source for contamination from explosive material, contains high concentrations of particulate matter.

b. Allowable emission criteria. The original task assignment stated "eliminate/reduce air-water-noise pollution to meet federal, state, and local standards consistent with current technology." This statement was further defined by NAVMATINST 6240.1B of 10 October 1972 which stated:

> "Navy shore activities will conform to air and water quality standards and related implementation, including emission standards, adopted pursuant to the Clean Air Act, as amended (42 U.S.C. 1857), and the Federal Water Pollution Control Act, as amended (33 U.S.C. 466). In those cases where no such air or water quality standards are in force for a particular geographical area, Navy shore facilities in that area shall conform to the standards established pursuant to state or local laws."

c. Water pollution abatement. Two different problem areas that required solution were quickly identified in the area of

water pollution. First, there was no state or local emission criteria on which to base a design. Second, the nature of the emissions involved in demilitarization were unknown because of the possible combinations of explosives that could be expected and that are not encountered in any other type of explosive industry. For these reasons, as well as the high evaporation rate in the Nevada desert, a new approach to the water pollution problem was investigated. This approach called for "zero discharge to ground" of water used in the plant.

The plant for treatment of the process waste water would be placed adjacent to the washout complex recognizing that the processes located in those work bays would require the greatest amount of water and, therefore, would produce the greatest amount of explosive contaminated effluent. The treatment plant would consist of:

(1) Primary treatment plant very similar to a municipal raw water treatment plant to remove suspended and dissolved solids allowing the effluent to be utilized again in the process building.

(2) Waste water ponds that would accept effluent from the first stage of the treatment plant and utilize 100% evaporation.

The solids derived from the various stages of the treatment plant would be transported to the bulk explosive disposal building for reduction. This approach appears to be the most feasible and is the one presently being pursued.

d. Air pollution abatement. Air emissions are mainly in the form of furnace stack gases that contain mostly particulate matter. Because of the high gas temperatures involved, bag-house filters will be used to the greatest extent possible with little or no use made of wet scrubbers.

IX. SUMMARY

The preceding report has attempted to present the nature of the investigations that comprise the total program for the modernization of the demilitarization capability of the West Coast activities. Many of the detailed aspects of the total program either have not been discussed or have been given only cursory mention since detailed analysis and design are on-going. The ultimate goal of the program is to reduce the cost of advancing weapon technology by efficiently eliminating the ammunition which has been made obsolete. Only time and dedicated effort to this program will bring about the achievement of this goal.

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NAVMAT-02	1
Office of the Chief, Naval Operations, Washington, DC	
NOP-04	1
NOP-41	1
NOP-411C1	1
Commanding Officer, Naval Missile Center, Point Mugu, California 93042	
Code 5704.3	1
Western Division, Naval Facilities Engineering Command, San Bruno, California 94066	
Code 405	1
Naval Facilities Engineering Command, Alexandria, Va. 22332	
NAVFAC-051PH	1
Department of Defense Explosive Safety Board, Forrestal Building, Washington, DC 20301	1

Naval Explosives Development Engineering Department Naval Weapons Station, Yorktown, Virginia 23491	4
Defense Documentation Center, Defense Supply Agency, Cameron Station, Alexandria, Va. 22314	2
Naval Supply Systems Command, Washington, DC	
NAVSUP-0523	1
Tooele Army Depot, Tooele, Utah	
Frank Crist	1
Commander, US Army Armament Command Rock Island, Illinois 61201	1
Project Manager for Munition Production Base Modernization and Expansion, Picatinny Arsenal, Dover, New Jersey 07801	
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NAD Hawthorne Hawthorne, Nevada	6
Executive Director, JCAP/CG, US Army Armament Command Rock Island, Ill. 61201	3
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Commanding Officer, China Lake, California	2
Commander, Picatinny Arsenal, Dover, New Jersey	
SMUPA-MT	1
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Tudor Engineering, 149 New Montgomery St. San Francisco, California 94105	1