UFC 4-440-01A
01 March 2005

UNIFIED FACILITIES CRITERIA (UFC)

STORAGE DEPOTS

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UNIFIED FACILITIES CRITERIA (UFC)

STORAGE DEPOTS

U.S. ARMY CORPS OF ENGINEERS (Preparing Activity)

NAVAL FACILITIES ENGINEERING COMMAND

AIR FORCE CIVIL ENGINEER SUPPORT AGENCY

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

Change No.	Date	Location

This UFC supersedes TM 5-840-2, dated 7 October 1994. The format of this UFC does not conform to UFC 1-300-01; however, the format will be adjusted to conform at the next revision. The body of this UFC is the previous TM 5-840-2, dated 7 October 1994.

FOREWORD

\1\
The Unified Facilities Criteria (UFC) system is prescribed by MIL-STD 3007 and provides planning, design, construction, sustainment, restoration, and modernization criteria, and applies to the Military Departments, the Defense Agencies, and the DoD Field Activities in accordance with USD(AT&L) Memorandum dated 29 May 2002. UFC will be used for all DoD projects and work for other customers where appropriate. All construction outside of the United States is also governed by Status of forces Agreements (SOFA), Host Nation Funded Construction Agreements (HNFA), and in some instances, Bilateral Infrastructure Agreements (BIA.) Therefore, the acquisition team must ensure compliance with the more stringent of the UFC, the SOFA, the HNFA, and the BIA, as applicable.

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AUTHORIZED BY:

DONALD L. BASHAM, P.E.
Chief, Engineering and Construction
U.S. Army Corps of Engineers

DR. JAMES W WRIGHT, P.E.
Chief Engineer
Naval Facilities Engineering Command

KATHLEEN I. FERGUSON, P.E.
The Deputy Civil Engineer
DCS/Installations & Logistics
Department of the Air Force

Dr. GET W. MOY, P.E.
Director, Installations Requirements and Management
Office of the Deputy Under Secretary of Defense (Installations and Environment)

TECHNICAL MANUAL

STORAGE DEPOTS

HEADQUARTERS, DEPARTMENT OF THE ARMY
7 October 1994

REPRODUCTION AUTHORIZATION/RESTRICTIONS

TECHNICAL MANUAL
No. 5-840-2

HEADQUARTERS
DEPARTMENT OF THE ARMY
WASHINGTON, DC, *7 October 1994*

STORAGE DEPOTS

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CHAPTER 1

GENERAL

1-1. Purpose

This manual is intended to provide guidance in determining the general design requirements for constructing or modernizing storage depot facilities.

1-2. Scope.

The scope of this manual includes general information pertaining to requirements for general design of storage depot facilities. It is not a comprehensive structural design manual. This manual also does not include structural considerations for facilities suitable for storage of coal and ammunition.

1-3. References.

Appendix A contains a list of references used in this document.

CHAPTER 2

WAREHOUSES

2-1. General.

Warehouse design discussed in this manual is intended to provide a dry environment for the purpose of storing goods and material that require protection from the elements. Warehouses must be designed to accommodate the loads of the material to be stored, the associated handling equipment, and the needs of the operating personnel. The design of the warehouse space should be planned to best accommodate the physical dimensions of the material to be stored. The different types of warehouses generally associated with storage depots include heated and unheated warehouses, refrigerated warehouses, and controlled humidity (CH) warehouses.

2-2. Structural requirements.

Design of warehouse structures is to be based on the dead and live load requirements of the structure as it will be built. Snow, wind, and seismic loads shall be considered where they are applicable.

a. Dead load requirements. In general, the dead loads shall be calculated from the weights of all fixed components of the structure including fixed pieces of equipment. Refer to the values given in TM 5-809-1/AFM 88-3 Chap. 1, chapter 3, section 3 for weights of building materials.

b. Floor live load requirements. Live loads to be considered are concentrated wheel loads and uniformly distributed loads, as applicable.

(1) Concentrated loads pertain to any movable point load such as wheel loads from forklift trucks, wheel loads from trailers backed into the building, or any type of movable storage bin on legs. Truck loads within warehouses shall be taken as HS 20-44 loadings of the HB-13, Highway Bridges, published by the American Association of State Highway and Transportation Officials (AASHTO). Loads on railroad tracks within warehouses shall conform to American Railway Engineering Association (AREA) E-80 loading. Concentrated live loads due to forklift wheels can be calculated from mass (weight) data obtained from the forklift manufacturer plus an account of the loads this vehicle is expected to carry.

(2) Uniformly distributed live loads are determined from the type of occupancy expected for the floor. Masses (weights) of materials typically stored in warehouses are given in table 2-1. Live load pressures should be calculated for the maximum loading condition that the warehouse is expected to experience in its lifetime. Quite frequently the type of material stored in a warehouse will be different from that for which it was originally designed. If the material stored is beyond design loads, cracking and settlements can occur in the slab and foundation. As a precautionary measure, the maximum live load pressure for each building area in kilograms per square meter (pounds per square foot) should be displayed on plaques or walls. For design of floors due to heavy loads refer to TM 5-809-12/AFM 88-3, Chap. 15.

Table 2-1. Uniform live load, for storage warehouses.

Material	*Weight per cubic meter (foot) of space kg (lb)*	*Height of pile m (ft)*	*weight per square meter (foot) of floor kg (lb)*	*Live Load kg/m² (psf)*
Building materials:				
Asbestos	801 (50)	2 (6)	1465 (300)	
Bricks, building	721 (45)	2 (6)	1318 (270)	
Bricks, fire clay	1201 (75)	2 (6)	2197 (450)	
Cement, natural	945 (59)	2 (6)	1728 (354)	1465 (300)
Cement, portland	1153 (72) to 1682 (105)	2 (6)	2109 (432) to 3076 (630)	to
Gypsum	801 (50)	2 (6)	1465 (300)	1953 (400)
Lime and Plaster	849 (53)	1.5 (5)	1294 (265)	
Tiles	801 (50)	2 (6)	1465 (300)	
Woods, Bulk	721 (45)	2 (6)	1318 (270)	
Drugs, paints, oils:				
Alum, pearl, in barrels	529 (33)	2 (6)	967 (198)	
Glycerine, in cases	833 (52)	2 (6)	1523 (312)	
Linseed oil in barrels	577 (36)	2 (6)	1055 (216)	

Table 2-1. Uniform live load, for storage warehouses—continued.

Material	*Weight per cubic meter (foot) of space kg (lb)*	*Height of pile m (ft)*	*weight per square meter (foot) of floor kg (lb)*	*Live Load kg/m² (psf)*
Rosin, in barrels	769 (48)	2 (6)	1406 (288)	
Shellac, gum	609 (38)	2 (6)	1113 (228)	976 (200)
Soaps	801 (50)	2 (6)	1465 (300)	to
Soda ash, in hogsheads	993 (62)	0.8 (2¾)	815 (167)	1465 (300)
Sulphuric acid	961 (60)	0.5 (1⅝)	488 (100)	
Toilet articles	561 (35)	2 (6)	1025 (210)	
Varnishes	881 (55)	2 (6)	1611 (330)	
White lead, dry	1378 (86)	1.4 (4¾)	1992 (408)	
Dry goods, cotton, wool:				
Burlap, in bales	689 (43)	2 (6)	1260 (258)	
Carpets and rugs	481 (30)	2 (6)	879 (180)	
Coir yarn, in bales	529 (33)	2.5 (8)	1289 (264)	
Cotton yarn, in cases	400 (25)	2.5 (8)	976 (200)	
Jute, compressed	657 (41)	2.5 (8)	1601 (328)	
Linen damask, in cases	801 (50)	1.5 (5)	1221 (250)	
Linen goods, in cases	481 (30)	2.5 (8)	1172 (240)	
Linen Towels, in cases	641 (40)	2 (6)	1172 (240)	
Silk and silk goods	721 (45)	2.5 (8)	1758 (360)	
Sisal, compressed	326 (21)	2.5 (8)	820 (168)	
Tow, compressed	465 (29)	2.5 (8)	1133 (232)	
Groceries, wines, liquors:				
Beans, in bags	641 (40)	2.5 (8)	1562 (320)	
Beverages	641 (40)	2.5 (8)	1562 (320)	
Canned goods, in cases	929 (58)	2 (6)	1699 (348)	
Cereals	721 (45)	2.5 (8)	1758 (360)	
Cocoa	561 (35)	2.5 (8)	1367 (280)	
Coffee, green, in bags	625 (39)	2.5 (8)	1523 (312)	
Dates, in cases	881 (55)	2 (6)	1011 (330)	
Figs, in cases	1185 (74)	1.5 (5)	1806 (370)	
Flour, in barrels	641 (40)	1.5 (5)	976 (200)	1221 (250)
Fruits, fresh	561 (35)	2.5 (8)	1367 (280)	to
Meat and meat products	721 (45)	2 (6)	1318 (270)	1465 (300)
Milk condensed	80 (50)	2 (6)	1465 (300)	
Molasses, in barrels	769 (48)	1.5 (5)	1172 (240)	
Rice, in bags	929 (58)	2 (6)	1699 (348)	
Sal soda, in barrels	737 (46)	1.5 (5)	1123 (230)	
Salt, in bags	1121 (70)	1.5 (5)	1709 (350)	
Soap powder, in cases	609 (38)	2.5 (8)	1484 (304)	
Starch, in barrels	400 (25)	2 (6)	732 (150)	
Sugar, in barrels	689 (43)	1.5 (5)	1050 (215)	
Sugar, in cases	817 (51)	2 (6)	1494 (306)	
Tea, in chests	400 (25)	2.5 (8)	976 (200)	
Hardware:				
Automobile parts	641 (40)	2.5 (8)	1562 (320)	
Chain	1602 (100)	2 (6)	2929 (600)	
Cutlery	721 (45)	2.5 (8)	1758 (360)	
Door checks	721 (45)	2 (6)	1318 (270)	
Hinges	1025 (64)	2 (6)	1875 (384)	
Locks, in cases, packed	497 (31)	2 (6)	908 (186)	
Machinery, light	320 (20)	2.5 (8)	781 (160)	
Plumbing fixtures	481 (30)	2.5 (8)	1172 (240)	1465 (300)
Plumbing supplies	881 (55)	2 (6)	1611 (330)	to
Sash fasteners	769 (48)	2 (6)	1406 (288)	1953 (400)
Screws	1618 (101)	2 (6)	2959 (606)	
Shafting	2002 (125)			
Sheet tin, in boxes	4453 (278)	0.6 (2)	2715 (556)	
Tools, small, metal	1201 (75)	2 (6)	2197 (450)	
Wire cables, on reels			2075 (425)	
Wire, magnet, on spools	1201 (75)	2 (6)	2197 (450)	

Table 2–1. Uniform live load, for storage warehouses—continued.

Material	*Weight per cubic meter (foot) of space kg (lb)*	*Height of pile m (ft)*	*weight per square meter (foot) of floor kg (lb)*	*Live Load kg/m^2 (psf)*
Miscellaneous:				
Automobile tires	481 (30)	2 (6)	897 (180)	
Automobiles, uncrated	128 (8)		312 (64)	
Books (solidly packed)	1041 (65)	2 (6)	1904 (390)	
Furniture	320 (20)			
Rope, in coils	513 (32)	2 (6)	937 (192)	
Rubber, crude	801 (50)	2.5 (8)	1953 (400)	
Tobacco, bales	561 (35)	2.5 (8)	1367 (280)	

c. Roof live loads. Minimum roof live loads of 98kg/m (20 psf) will be considered for construction and maintenance load roof. Reduction of roof live loads will be permitted based on tributary loaded area and roof slope on any structural member in accordance with TM 5-809-1. This reduction will apply only to supporting structural members.

d. Overhead cranes. For maneuvering large items in storage warehouses, overhead cranes provide mobility without occupying excess storage space for material access. The beams and/or columns supporting the overhead crane must be designed to compensate the additional loads imposed.

(1) *Impact loads.* Increases in design loads for impact include a vertical force equal to 25 percent of the maximum wheel load, a lateral force equal to 20 percent of the mass (weight) of the trolley and lifted load only applied one half at the top of each rail, and a longitudinal force of 10 percent of the maximum wheel load of the crane, applied at the top of the crane rail (TM 5-809-1).

(2) *Moving loads.* Support increases for moving loads are beams-100 percent, columns 80 percent, and foundations, footings and piers — 40 percent (NAVFAC DM-2).

e. Snow loads. The snow load design requirements shall be in accordance with TM 5-809-1. Design considerations shall include the exposure and slope of the roof and its geometric and thermal features. For a roof with a slope less than 40 mm per meter (0.04:1) (½ inch per foot) a surcharge of 8 kg/m^2 (5 psf) as recommended by ANSI A58.1, should be added to the calculated snow load for rain on snow. Since warehouses in general have large roof areas, it is recommended to include this surcharge in the roof design. If the warehouse being designed is to be an unheated structure, the snow load will most likely be heavier than for a heated structure because of lack of snow melt. The aforementioned are uniform snow loads for flat roofs. If the roof is sloped, a reduction in the design uniform live snow load may be made.

f. Wind loads. Structures should be designed for wind loads in accordance with TM 5-809-1. Design factors shall assume that the wind can come from any direction and that negative pressures (suction forces) act on roofs, eaves, cornices, and walls facing the opposite to the direction of the wind. Exposure "A" should not be used in the design of warehouses in military installations.

g. Seismic loads. Seismic design of warehouses shall be in accordance with the provisions of TM 5-809-10/NAVFAC P-355/AFM 88-3, Chap. 13. Certain warehouse storage areas are considered high risk or essential facilities where damage to the structure could cause particular hardship or danger to life. These structures include flammable storage areas and chemical storage areas. In designing for horizontal seismic loads, these types of structures should be designed with appropriate occupancy importance coefficients as detailed in TM 5-809-10.

2-3. Floor types.

Warehouse floors are constantly subjected to heavy-duty usage; consequently proper floor types are an important consideration in design. Each type has its particular characteristics and is best suited for a particular type of traffic. General warehouse space should be floored with a concrete slab of proper design to carry the wheel loads and withstand the abrasion generated by the continual use of forklift trucks. The constant travel by forklift trucks can deteriorate an unprotected concrete surface, causing dusting and breakdown of the surface. Hardeners and dust proofers are recommended to alleviate this problem: they not only keep down the dust but they generally provide a reflective surface that will aid in more even distribution of lighting. Surfaces that are subject to wetting, such as outdoor docks, should not have a smooth finish to the concrete since this is a safety hazard and can cause slips and falls to personnel. Float finishing of the concrete or nonslip surface treatments should be used in these areas. Wooden floors are not recommended because of their low wear resistance to industrial traffic and their fire hazard. Office space can be covered with resilient tile or carpet to upgrade the floor slab to office conditions at relatively little expense.

2-4. Doors.

a. Obstructions. The area inside exterior doors leading to dock space is needed for maneuverability of forklift trucks. Building design should take this into account and columns should be planned such that they do not interfere with forklift mobility. Each exterior door should be protected by bumper guards to prevent damage from forklifts. Roll-up doors, or overhead type of doors, consume the least amount of usable warehouse space.

b. Fire doors. In buildings with fire resistance walls (one hour, two hour, or four hour), the properly rated fire doors shall be selected in accordance with the type of fire resistance wall openings.

2-5. Lighting.

Several types of classic designs make good use of natural lighting (fig 2-1). The monitor type of warehouse has windows on both sides and the ends of the raised central portions of the warehouse roof (fig 2-2). This provides good amounts of natural light to central portions of the warehouse. The bilateral building design is achieved by designing windows into the wall of the warehouse at heights just below the roof line (fig 2-3). This design allows light to enter the building above the storage height. Skylights are an additional method of getting natural light to interior areas of the warehouse. This method probably works best when the size of the warehouse is large because the skylights can be placed at any point on the roof of the structure. Artificial lighting in warehouses should be designed in accordance with TM 5-811-2/AFM 88-9.

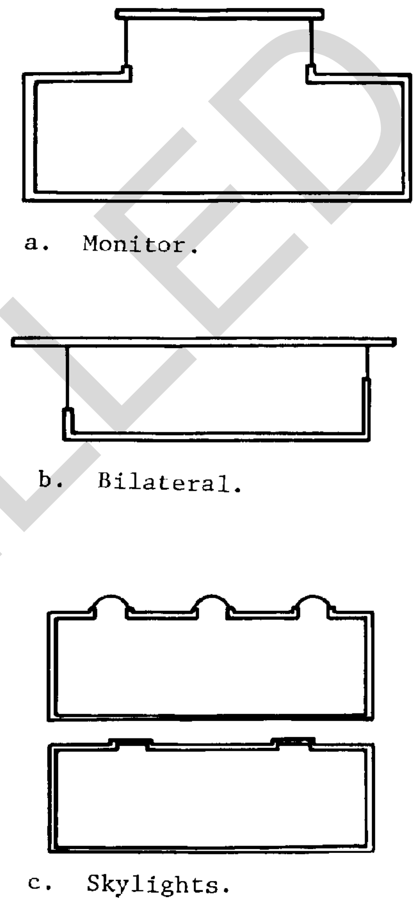


Figure 2-1. Examples of natural lighting designs.

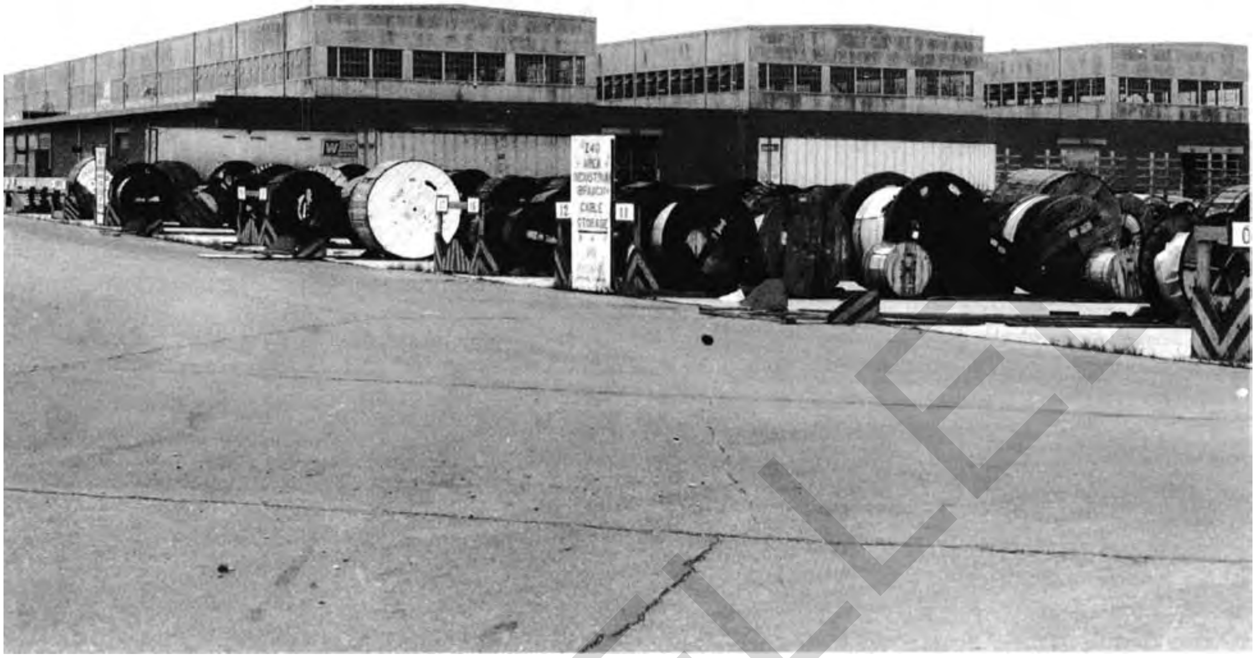


Figure 2-2. Example of monitor type warehouse window design.

Figure 2-3. Example of bilateral type warehouse window design.

CHAPTER 3

DOCKS

3-1. General.

Dock space for shipping and receiving terminals is the same as that for most general purpose warehouses. Dock heights on the truck side of the terminal should be approximately 1300 mm (4 ft 4 in) above the pavement, with hydraulic ramps (fig 3-1) at each truck berth to bring the height of truck bed in line with the dock height. An additional type of dock ramp is available, as shown in figure 3-2. This hooks to the truck bed and rests on the dock floor for transition of the height differential. On the rail side of the terminal, dock heights should be 1150 mm (3 ft 9 in) above the top of the rail. This will ensure that the rail car floor is even with dock floor, as shown in figure 3-3.

3-2. Column spacing.

Columns supporting the outer edge of the roof should be so spaced as not to interfere with the spacing of rail car doors or truck berths. Dock widths should be wide enough to allow efficient maneuvering of forklift trucks and other expected types of material handling equipment. A minimum width should be 3 m (10 ft). Forklift bumpers should be placed at both sides of all door jambs where forklift traffic will occur to prevent damage to the walls, door track and the door frame. Exterior dock space should be covered to protect workers and material from rain and snow accumulation (fig 3-4).

3-3. Truck docks.

Bumpers should be installed at the edge of the truck dock to protect the concrete from the impact of backing trucks. Wooden boards (fig 3-5) or rubber pads will serve this purpose. In addition there should be stairwells from ground level to dock height spaced along the dock if the dock runs the entire length of the building.

3-4. Interior dock space.

In colder climates, interior dock space may provide significant energy savings and more tolerable winter working conditions for dock workers. For this type of dock, doors should be designed to be slightly larger than the opening of a standard tractor trailer and should be fitted with hoods that fit around the trailer to prevent heat loss from the work space. This method of docking requires a door for every truck berth, which is an added first cost; but the protection and energy advantages make it a feasible alternative. Additionally, as shown in figure 3-6 receiving or shipping docks can be designed with recessed wells that contain the entire trailer within the warehouse. This method also prevents heat loss and eliminates the need for exterior berthing space, but it utilizes much of the heated space for truck parking.

Figure 3-1. Hydraulic dock leveler.

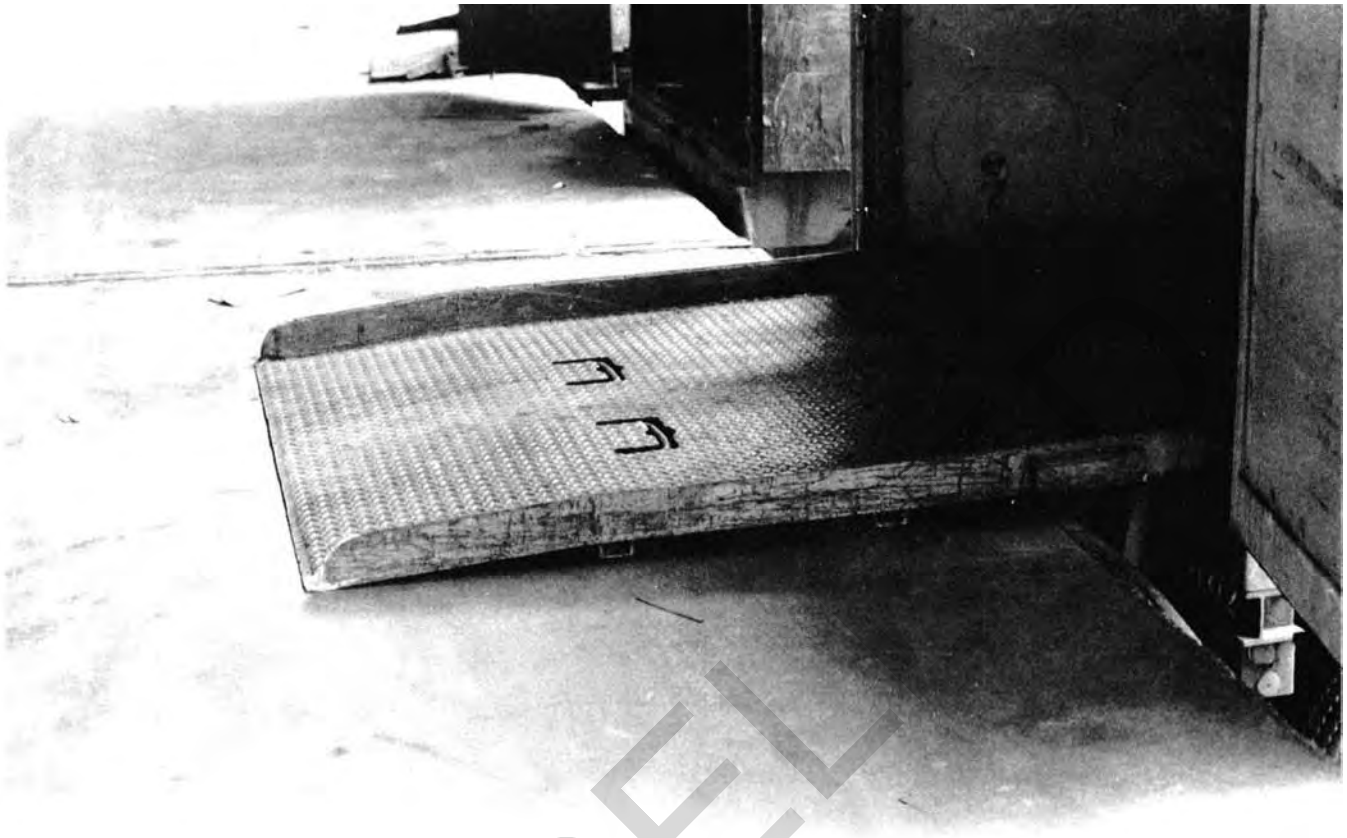


Figure 3-2. Portable dock ramp.

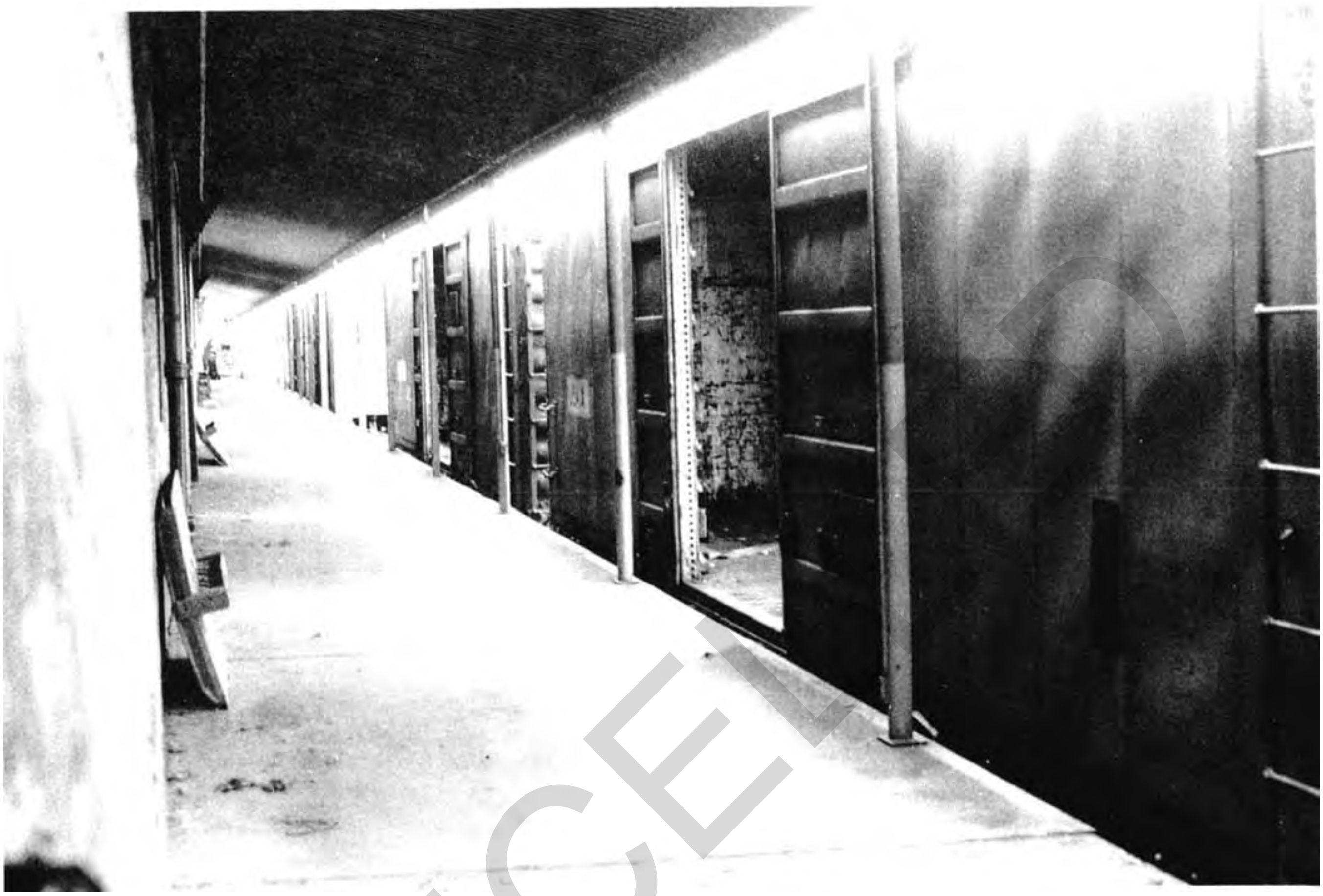


Figure 3-3.. Typical loading dock with height equal to rail car floor height.

Figure 3-4. Covered exterior dock space.

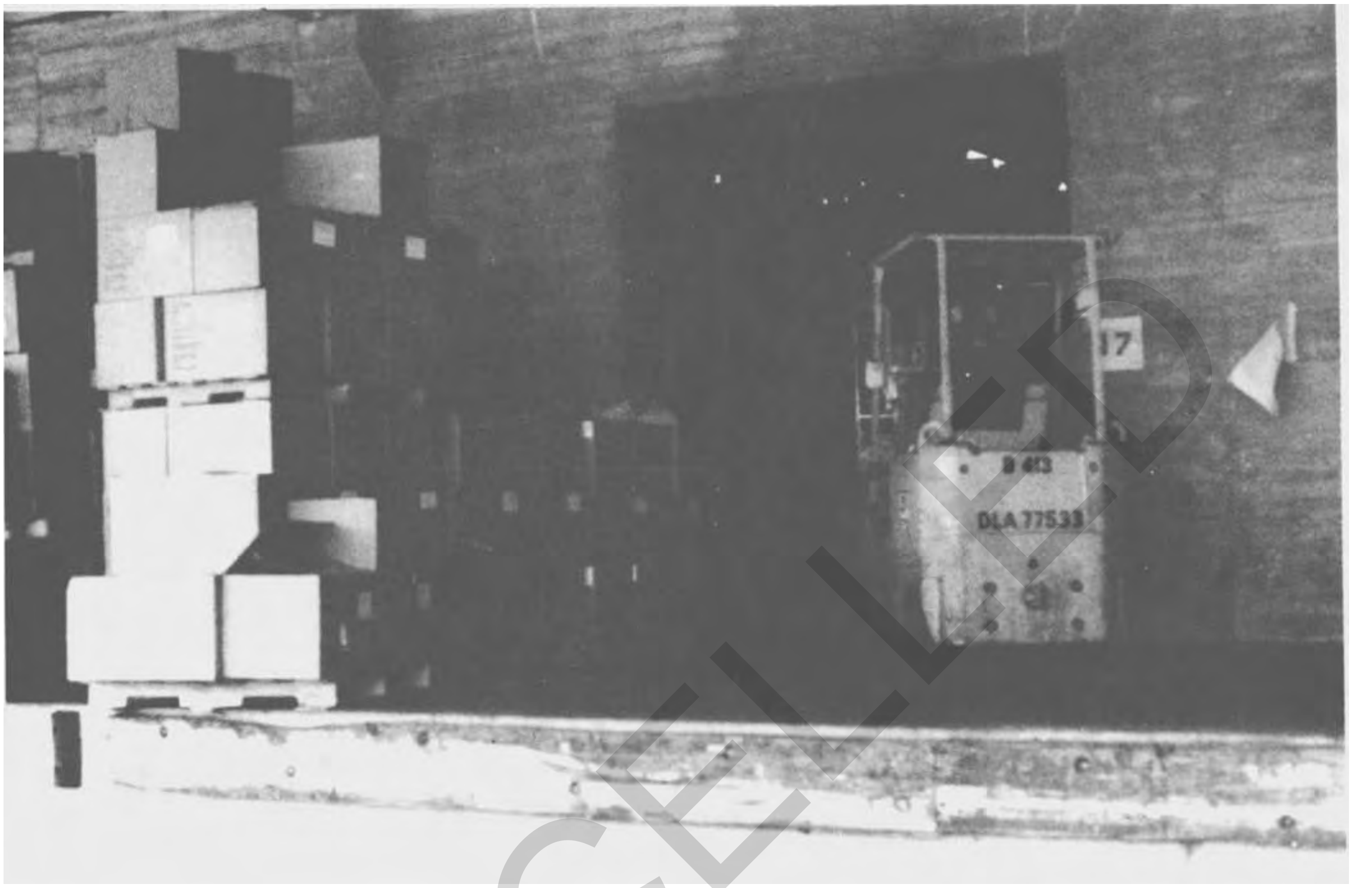


Figure 3-5. Loading dock showing wooden protective bumpers.

Figure 3-6. Interior dock space containing the entire trailer.

CHAPTER 4
STORAGE SHEDS

4-1. General.

Sheds are covered storage buildings either of the portable or permanent type, having incomplete exterior walls. Portable or transitory sheds are a prefabricated metal type of shelter that can be dismantled and moved to a more convenient location for reassembly. Due to their transitory nature, these types of sheds seldom have any utilities. Permanent sheds can be either wood, metal, concrete or masonry block, but are permanently anchored to the foundation. These types are more likely to have utilities such as lighting and fire sprinkler systems.

4-2. Location.

Sheds should be constructed on high ground, remote from water areas, and on terrain that is well drained to carry runoff away from the base of the structure. The ground should be level beneath the structure so that material stored on grade in a shed with unimproved base will not become unstable under high stacking loads. The grounds around the shed should be cleared of brush and low growth since these conditions reduce ventilation and provide cover for pests. They can be built with grade even with the road, such as in figure 4-1, or raised such that the slab occurs at truck or rail dock height, as in figure 4-2. Material that is in storage for a significantly long time can be stored out of the mainstream of depot activity in sheds that have a more limited accessibility.

4-3. Structural requirements.

a. Slabs. The type of shed storage determines the required bearing capacity of the structure, and the floor can range from graded earth to a concrete slab. Typical slab types are concrete, asphalt, and wood planks. The slab should be designed for the climate and type of load that is expected. Slabs should be sloped to drain water, but not so much that they would present a problem in stacking stored goods. Graded earth floors can be upgraded by concreting or laying down military landing mat, as shown in figure 4-3. Upgrading earth floors holds down dust and allows the use of heavy material handling equipment. Pavement thicknesses should be designed for heavy-duty traffic use. Compliance with design criteria given in the following manuals should provide adequate guidance for pavement and slab designs:

TM 5-822-5/AFM 88-7, Chap. 3
TM 5-822-7/AFM 88-6, Chap. 8
TM 5-809-12/AFM 88-3, Chap. 15

Storage items such as structural steel, steel bar stock, helicopter blades, airplane wings, and other large items require special storage and handling consideration. In addition these type storage items impose heavy and sometimes unusual loads on the floor which must be taken into consideration and accounted for in design of flooring.

b. Columns. Sheds are usually designed to have exterior columns only. This allows maximum storage flexibility within the shed area. Wider sheds can usually be accommodated with one interior column midway between the exterior columns; however, this arrangement is not practical if a central aisle is desired.

c. Walls. Most sheds do not have exterior walls- They may have no walls at all, or partial walls extending down from the eaves to protect the joists or trusses from deterioration from direct exposure. In cases where ventilation is important, walls are not desirable; where it is necessary to protect material, however, several methods of upgrading shed storage are available. Pallets stacked from floor to roof at the exterior of the shed provide excellent protection from the weather while eliminating the waste of interior space that would be used to store them. Alternatively, pelletized drum storage, as shown in figure 4-4, provides interior protection while using the exterior space for useful storage. Sheds can also be upgraded by closing off the sides with metal or wood siding. Metal upgrading is shown in figure 4-5. Sheds with open sides can be stocked from the center working outward using the sides of the shed as working aisles to access the goods, whereas sided sheds must have aisles within the shed to allow access to the goods.

4-4. Container storage.

a. General. One method which has evolved for material transfer is containerization of cargo. Handling of goods is reduced when a large container can be removed rather than smaller quantities of goods in repetitive movements. The general types of containers, employed in the containerization of goods are 6 m (20 ft) containers, 12 m (40 ft) containers, 6 m (20 ft) refrigerated containers, and the 12 m (40 ft) FLATRACK. Operations involved container storage often require the use of heavy container handling equipment (CHE).

Figure 4-1. Storage shed with floor at road level.

Figure 4-2. Storage shed with raised floor.

Figure 4-3. Flooring in shed area upgraded by use of steel military landing mats.

Figure 4-4. Palletized drum storage used as shed wall protection.

Figure 4-5. Open-sided storage shed upgraded with metal wall panels.

Figure 4-6. Containers stacked 3 high on concrete pavement.

CHAPTER 5
OPEN STORAGE

5-1. General.

Open storage areas are portions of the depot that are used for the storage of goods that do not require extensive protection from the elements. They are generally unimproved or semi-improved areas which do not provide any cover for the materials stored therein. These areas should be provided with the same access that is given to warehouses and sheds as well as shipping and receiving facilities that are necessary for open storage functioning. For planning purposes, a partial list of materials that may be stored in open storage can be found in Department of the Army Supply Bulletin SB 740-1.

a. Improved areas. Open storage areas which are the most flexible as storage sites are the improved areas. These sites are cleared of vegetation, graded, and provided adequate drainage, and then given some sort of hard treatment. This allows the storage of many items that would not be suitable on unimproved areas due to the increased bearing capacity of the surface and the high level of control of runoff. Typical materials used to surface the area are concrete slab and asphalt pavement. Less suitable materials would be steel mat and crushed and rolled stone. These latter methods of improving the surface will not allow maximum bearing capacities on the ground surface.

b. Semi-improved areas. These areas are similar to improved areas in that they are graded and drained, but they are not provided with a hard top surface. The bearing capacity of semi-improved areas will change with the moisture content of the soil and in wet conditions will not bear as heavy a load as in dry conditions.

c. Unimproved areas. Surfaces that have not been graded, drained, or hard-surfaced are classified as unimproved. Irregular surface contours do not allow uniform storage heights, and lack of grading and drainage tends to promote localized areas of water ponding and to reduce bearing capacity due to saturation of the soil. This is the least desirable form of open storage area since it does not promote dense storage practices nor does it provide for acceptable access to the storage area.

5-2. Surfacing requirements.

a. Choice of pavement type. The factors that affect the surfacing requirements of improved open storage areas include vehicle characteristics, traffic volume and flow patterns, material accessibility, and weight requirements of the stored material. Types of surfaces that are frequently used on improved storage areas: rigid pavements, flexible pavements and roller compacted concrete pavements (RCCP). The choice of type depends upon the usage requirements listed above. Rigid pavement applications such as concrete slabs are durable, long lasting, capable of resisting larger loads, and unaffected by the normal range of temperature fluctuation experienced throughout the year. They do require considerable labor in fabrication and are generally the more expensive method of providing improved surfacing. Flexible pavements are less durable, more sensitive to high temperatures, require greater base and subbase preparation, deflect more than rigid pavements under load, and in recent years have not provided much of a price advantage over rigid pavements. For flexible pavements, the mechanical handling equipment (MHE) wheel characteristics vary to such an extent that for similar load-carrying capacities, different vehicles may require different surfacing requirements. The wheel loads, number of wheels per vehicle and their arrangement on the vehicle, the tire contact pressure, and the tire contact area all determine the pavement loading and consequently its thickness. Because of this variation in pavement requirements, the engineering construction and maintenance effort may be several times greater for one vehicle than for another with equal load-carrying capability.

b. Traffic volume and flow patterns. Traffic volume is a primary consideration in the selection of the type of surfacing and its required thickness. It is essential that an adequate study be made to determine the number of passes and the operational flow patterns of each vehicle under consideration so that a reasonable design volume for a particular facility and vehicle can be selected. The material selectivity will also affect the type and thickness of the pavement. Selectivity involves the relative ease with which material can be located and removed from the storage area. Items stacked such that other items must be moved in order to access the needed item will require a number of vehicle passes dependent on the size and number of items to be moved. In this situation, the expected life of the pavement would be shortened due to the increased number of passes.

c. Weight requirements. The bearing capacity of the pavement will essentially determine the height to which open storage material can be stacked or the maximum weight of items in one area. The type and thickness of pavement will depend on these storage requirements. Summer heat affects most flexible pavement surfaces; and, subsequently, improper base and subbase construction can cause sinking and puncturing of the pavement surface under heavy loading.

5-3. Aisle and track layout.

Each open storage area will require specialized attention to provide the proper aisle and track layout for the particular material being stored on the area. The type of material will generally dictate the dimensions used and the proper MHE needed to accomplish transportation of the material. In general, though, efficient open storage layouts provide for straight-line flow of stock from loading and unloading areas to storage areas, ready access to each stock location, and both maximum and efficient utilization of road and track facilities. Aisles in open storage areas will be essentially roads since the dimensional requirements for MHE are large. Main aisles should be located in the longitudinal direction of the storage space, while cross aisles should be placed perpendicular to the main aisles. One efficient layout of main and cross aisles produces rectangular storage areas that are twice as long as they are wide. In large open storage areas, every alternating main aisle should be equipped with double track to accommodate cars to be loaded on one track while rail-mounted loading cranes occupy the other track to facilitate loading or unloading. Double-track layouts shall have crossovers at intervals of 300 to 1500 m (1,000 to 5,000 ft). Single-track layouts of more than 300 m (1,000 ft) should have rail connections at both ends. Figure 5-1 shows one example of open storage layout, and additional layout information can be found in DOD manual 4145.19-R-1.

5-4. Loading and unloading platforms.

a. Size. Within each open storage area there should be at least one rail car loading and unloading platform. Side-loading platforms should be at least 6 m (20 ft) wide and at least one car length long. The length is preferably two car lengths. The platform should be located such that the side face is 1880 mm (6 ft 2 in) from the center line of the track, and the elevation of the top of the platform should be 1150 mm (3 ft 9 in) above the top of the rail. Ramps up to the platform should have a slope no greater than 15 percent. If the platform is also to serve flat cars in which the cargo is to be unloaded from the end of the car, and end-loading platform should be constructed. The dimensions should be similar to the side-loading platform except that the width of the platform at the end-loading portion should be 10 m (32 ft) wide (fig 5-2).

b. Materials. The platforms can be constructed of concrete, wood, or earth-filled timbers. The type of construction should be based on the expected service loads and environmental conditions that the ramp and platform will experience.

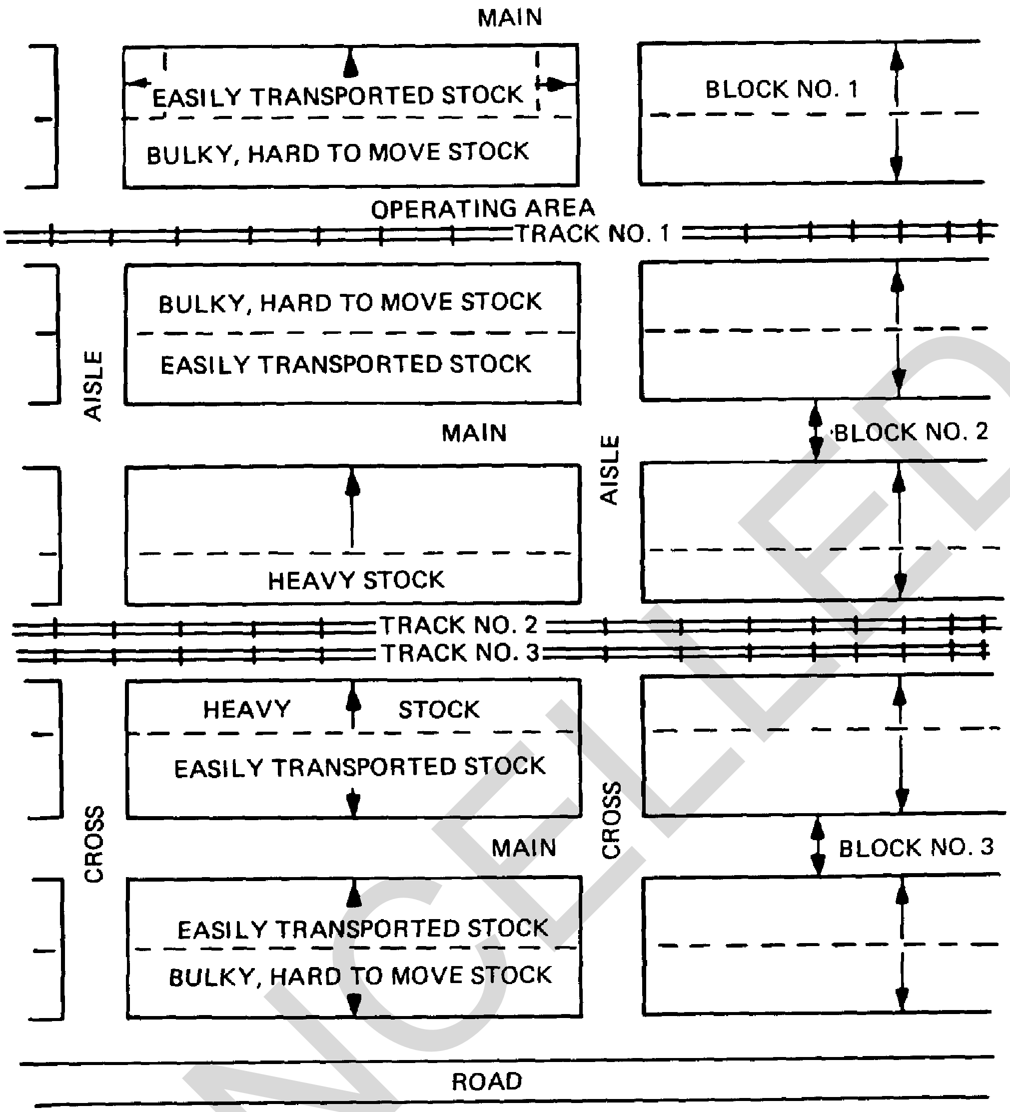


Figure 5-1. Example layout for open storage area.

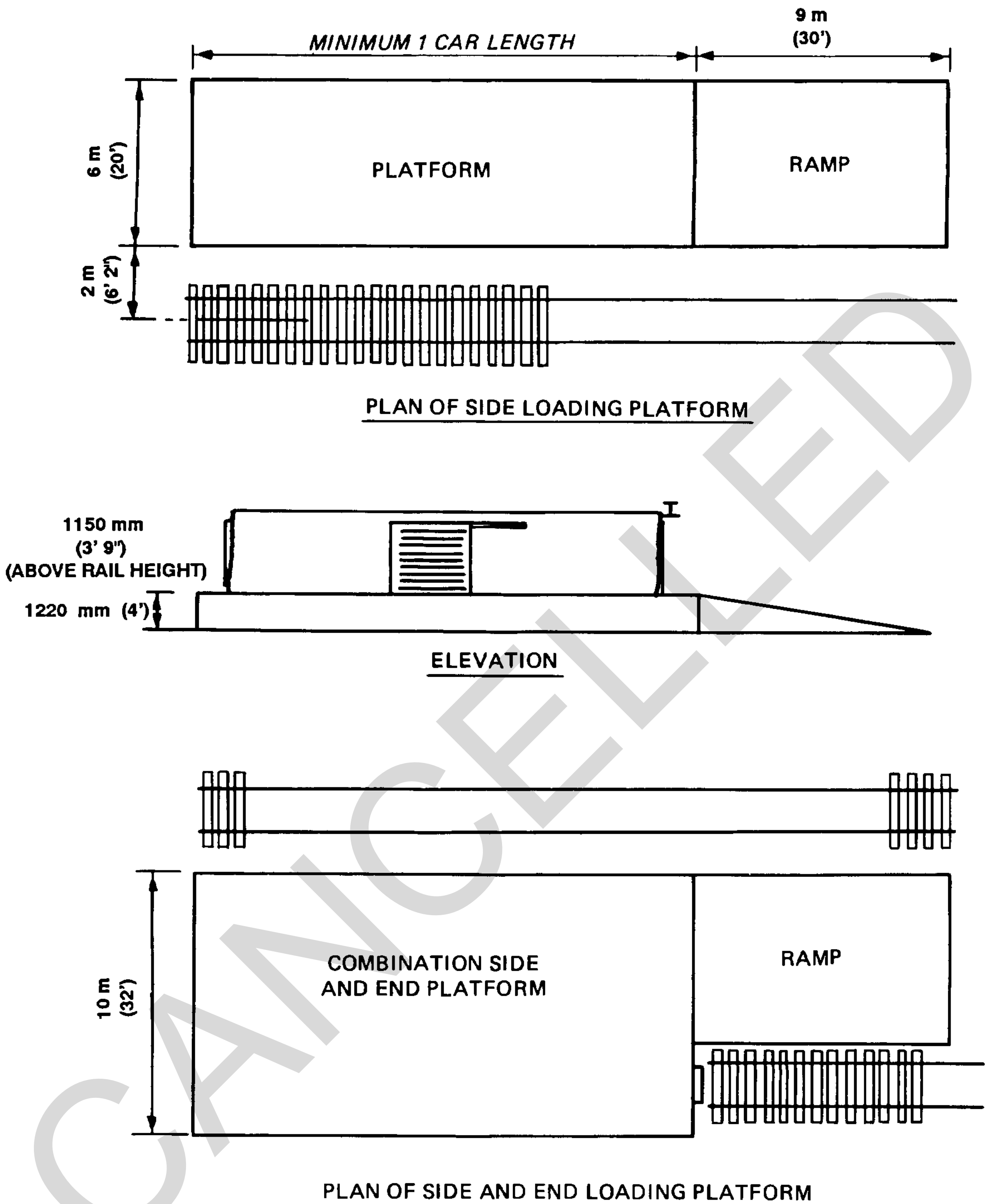


Figure 5–2. Sketch of end- and side-loading platforms.

CHAPTER 6
SPECIAL STORAGE AREAS

6-1. Flammable and combustible storage areas.

a. Size and location requirements. The size of flammable and combustible storage warehouses will be dependent upon the volume of stored material. Certain specifications will be followed in determining the shape. The warehouse will be single-story construction, built along a longitudinal axis (fig 6-1). It should not be longer than 300 m (1,000 ft) and it should have transverse fire walls constructed such that no interior space between fire walls is greater than 1850 m^2 (20,000 sf). The building will be detached from any other building and located away from any other building by at least 15 m (50 ft). When design considerations allow, the building should be located as far away from occupied buildings as possible and situated with respect to the prevailing wind direction such that toxic fumes or smoke do not drift over occupied areas.

b. Construction requirements. Buildings housing flammable or combustible material should be constructed from fire-resistive materials or noncombustible materials. Floors should be slab-on-grade-type construction made of structural concrete. Walls should be constructed of fire resistant materials of sufficient thickness, and designed to develop a 4-hour fire resistance rating. Fire walls should be constructed to limit internal areas to 1850 m^2 (20,000 sf) of clear storage space. Doors should be of the rolling steel type and where practicable should be eliminated in fire walls. All construction and control joints in the floor must be sealed to prevent spills from contaminating the subsurface soil or permeating to adjacent modules. A 100 mm (4 in) tall concrete curb will be required around the base of each storage area’s wall containment. Each personnel door within a storage module will have a 100 mm (4 in) set up. The elevation of storage area’s floors will be approximately 100 mm (4 in) below adjacent areas (hallways and shipping/receiving). Hallways and shipping/receiving areas will be the same elevation, but will be recessed approximately 50 mm (2 in) below the exterior grade. The discharge of fire water within a storage area will be contained to a certain extent by the internal spill containment curbs. Once the liquid level within the room reaches the top of the curbs, it should immediately be discharged to the exterior of the facility by means of overflow devices or scuppers. The elevation, size and number of scuppers within a storage module will be such to prevent the migration of fire water into adjoining building areas. Scuppers will be provided on exterior walls only, be as small as possible, provide automatic drainage, and prevent rain, snow, insects, or rodents from entering a facility. An emergency drainage system will be provided around the exterior of a HAZMAT facility in order to prevent contaminating nearby bodies of water (i.e. lakes, ponds, rivers streams, groundwater, etc.). The drainage system, if connected to public sewers or storm drains, will be equipped with traps or separators as applicable. The drainage system will be in accordance with all applicable Federal, State, and local regulations. If the capture and containment of discharged fire water is required, the preferred containment system would be via a remote imponding or ponding area. Imponding dike or berms surrounding a facility will be considered only as a secondary alternative. Below ground storage tanks will not be used in an emergency drainage system. Ramps within the warehouse will have a maximum grade of 10 percent. Electrical installations will be in accordance with Class I, Division 2, as defined in NFPA 70. When exterior wall panels are employed in areas where potential for explosion exists, the use of explosion fasteners should be considered. Should an explosion occur, these fasteners would allow the panels to "break away” upon absorbing the explosive impact, thereby, minimizing the damage to the structural members.

c. General considerations.

(1) Drum storage of combustible materials in open areas should be in an area with a concrete surface and a 150 mm (6 in) berm running entirely around the storage area.

(2) It is preferable that gas cylinders be stored in open-sided, concrete slab-type shells in order to minimize the possibility of harm due to build-up of a combustible, flammable, or toxic gas if the cylinder should leak.

(3) Construction of gas cylinder storage should conform to the requirements set forth in DOD 4145.19-R1 paragraph 5-405(d).

(4) Positive ventilation systems should be planned into the design of enclosed flammable and combustible storage areas to prevent the possibility of explosive vapor build-up.

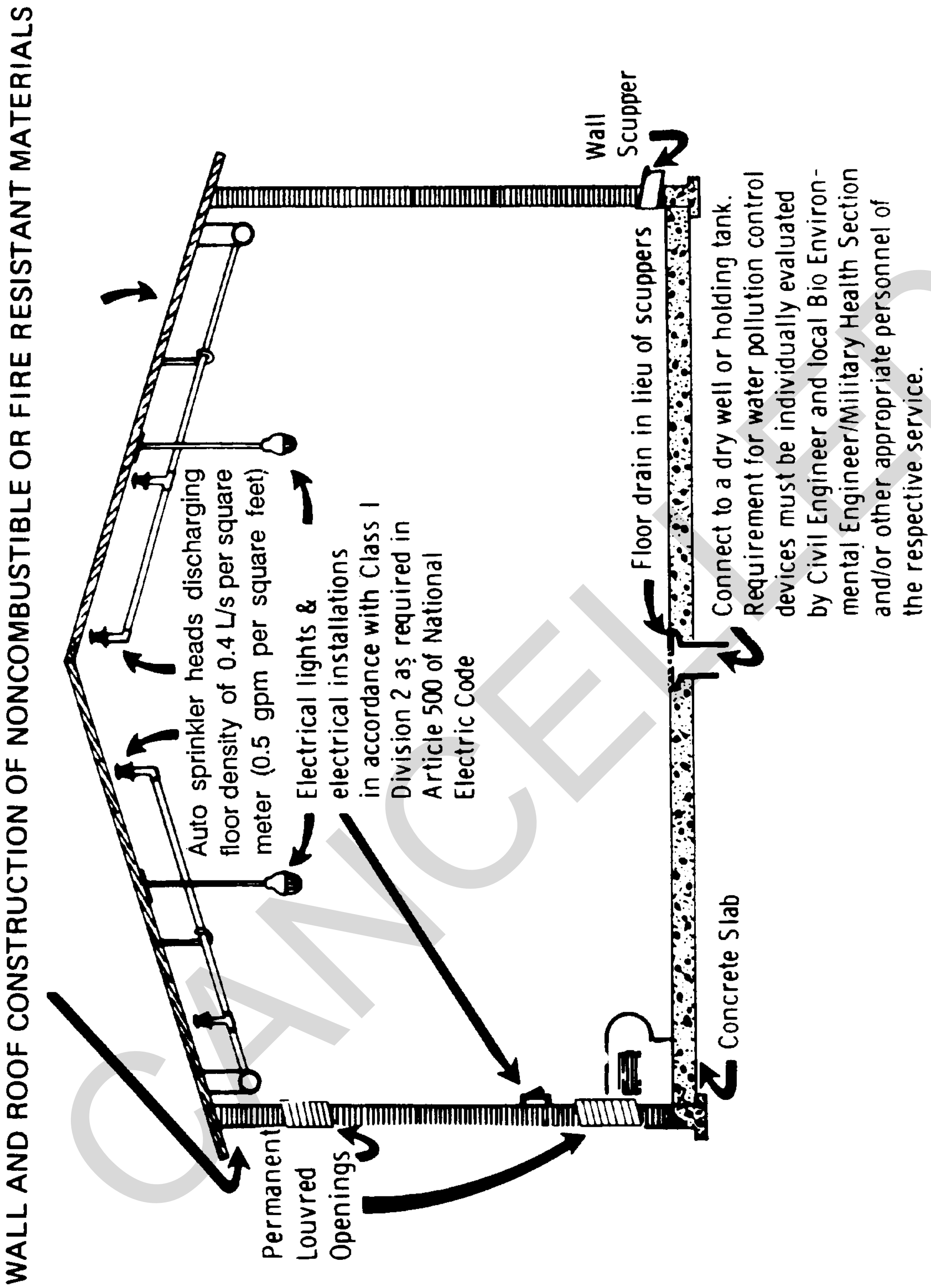


Figure 6–1. Cross section of a flammable storage warehouse.

(5) Flammable and combustible materials must be kept segregated from other storage items to prevent large-scale damage.

(6) AH hazardous materials storage areas should be identified as dangerous areas and warnings about smoking and other flammable items should be posted.

6-2. Radioactive storage areas.

a. General. The storage of radioactive material involves serious health-related hazards that are not readily apparent. Radioactive material gives off radioisotopes which emit several types of radiation that are damaging to human tissue. The hazard is complicated by the fact that the radiation is not detectable by any of the human senses.

b. Location and containment requirements. Buildings that are used to store radioactive material do not have to be separate facilities, although for purposes of safety in case of a fire, it is recommended that a separate building be constructed for the housing of all stored radioactive material. If the depot's radioactive storage mission is small and construction of an entire building is not justified, a portion of an existing building can be modified to provide the containment requirements necessary for safe storage.

c. Construction requirements. Buildings in which radioactive materials are to be stored should preferably be single story without basements or other below-grade spaces. Construction should be fire resistive or noncombustible, including interior finish, acoustical or insulating treatments, and partitions.

(1) *Floors.* Care should be taken to determine the load to be carried by the floor since the shielding material used to contain the radioactive materials can often be quite heavy. If the stored material is flammable in addition to being radioactive, the floor should be electrically conductive or nonsparking and should have a continuous surface to facilitate ease of cleaning and decontamination in case of spills of radioactive liquids and powdered solids. A concrete base covered with waterproof paper or metal foil and a top surface of impervious flooring materials in sheet or tile form is adequate. The floor should be waxed to fill the cracks in divisions and to provide the required surface continuity.

(2) *Walls and partitions.* Exterior walls of the building should be of a nonporous material and partitions within the building which separate high radiation areas from low radiation areas or secure areas should also be nonporous. These surfaces should also be smooth for ease of cleaning in case of a spill. Unprotected porous surfaces such as plaster walls are susceptible to contamination and in the removal of such a wall, plaster dust may spread contaminants throughout the building. Metal partitions, preferably with vitreous enamel surfaces, are probably the most easy to handle of the materials. A concrete block wall with a special smooth hard surface coating will generally reduce porosity to a satisfactory degree. Partition walls should be constructed so as to shield the stored radioactive material from personnel who must enter the building, and there should be baffle wall construction or positive interlocks at these entrances to prevent escape of radiation.

(3) *Ceilings.* Ceilings serve as the support for service pipes, heating and ventilating ducts, and light fixtures in addition to their normal functions. Structural framing, duct work, and piping runs should be planned to obviate the need for suspended ceilings. Where suspended ceilings are justifiable for providing certain conditions of cleanliness, lighting, and ventilation, gypsum board with taped joints or removable metal panels may be used. If the ceiling is merely the exposed lower side of the floor above, it should be given a smooth, nonporous finish. Pipes, ducts, and conduits leading out of the containment area should be baffled to prevent the escape of radiation.

(4) *Protective coatings.*

(a) Through the proper selection of materials the designer can economically facilitate decontamination efforts. Materials which are expensive but easily cleaned, or materials which are inexpensive and easily replaced may be used. Metal with a vitreous enamel coating is a good example of the first group; strippable paint is typical of the second. Ordinary paint is usually too porous to prevent contamination of the base material and it has been found that most of the organic paints tested under intense radiation tend to blister and check.

(b) Low-porosity surface coatings for application to various wall constructions can be obtained through the use of certain commercially prepared coatings including high gloss enamel and plastic paints. These materials have been found to provide satisfactory surfaces where spills are unlikely.

(c) Removable sheeting or strippable coatings can be used to cover surfaces directly exposed to contamination. These coatings are plastic solutions usually containing flammable solvents which can be applied with spray guns to specially prepared bases and removed without great difficulty. The use of spray guns for applying such materials may be hazardous, especially in small areas or rooms. Care should be taken to provide plenty of forced

ventilation in the area and to remove all sources of ignition to avoid a possible fire or explosion. Certain plastic adhesive tapes are also being used for this purpose.

(d) Care should also be used in removing and disposing of these coatings. Not only should their contaminated nature be considered, but some, when burned, liberate corrosive vapors which can cause extensive damage to sensitive equipment.

6-3. Hazardous chemicals.

a. There are two areas of safety consideration associated with hazardous chemical storage, chemical leakage and fire or combustion. Facilities to house these chemicals should be designed with both these considerations in mind. Among these chemicals are explosive chemicals, flammable chemicals, oxidizing chemicals, toxic and corrosive chemicals, and water-sensitive chemicals.

b. Construction requirements. Since most of the hazards associated with chemical storage involve combustion, fire, or explosion, the general requirements for construction should be similar to those outlined in paragraph 6-1. However, the nature of the type of chemical stored should dictate that special construction requirements be considered.

(1) *Special construction considerations.* Maintenance of cool surroundings is a condition suited to all chemical storage. Consequently, ventilation and exclusion of excess heat are important construction features. Natural ventilation can be utilized by designing louvers into the walls of the storage building. Openings placed under the eaves and just above the floor level will provide good movement of air in and around containers. Where a particularly hazardous situation may occur requiring a specific number of air changes per hour, forced ventilation can be achieved by mechanical means. Cool temperatures can be maintained by selecting materials that reflect the heat of the sun, and by limiting the number of windows allowed within the building.

(2) *Acid storage areas.* Figure 6-2 shows a cross section of an acid storage warehouse. Building construction should be single story without attic or basement and made of noncombustible or fire-resistant materials. Sprinkler systems are recommended as the method of automatic fire protection. Spill containment for these areas will be as defined in the construction requirements in paragraph 6-1. General purpose electrical installations are adequate. Noncombustible and corrosion-resistant partitions sealed to the floor to prevent spread of leaking acid are recommended. The building should have safety equipment such as eye wash fountains and deluge showers installed at easily accessible locations. Acid storage warehouses will contain enough heating equipment to prevent freezing of the acid during cold portions of the year.

(3) *Toxic chemical areas.* Floors and walls of areas used to store toxic chemicals will be made of smooth, nonporous materials that will not absorb the chemicals in case of a spill. Porous floors would make decontamination of a chemical spill difficult. Due to the nature of stored material, change areas and shower facilities should be installed for personnel required to work in these areas.

(4) *Oxidizing chemicals.* The NFPA categorizes liquid and solid oxidizing materials into four classes based on the burning property of the oxidize material when contacting a combustible material:

Class 1. An oxidizing material whose primary hazard is that it may increase the burning rate of combustible material with which it comes in contact.

Class 2. An oxidizing material that will moderately increase the burning rate or which may cause spontaneous ignition of combustible material with which it comes in contact.

Class 3. An oxidizing material that will cause a severe increase in the burning rate of combustible material with which it comes in contact or which will undergo vigorous self-sustained decomposition when catalyzed or exposed to heat.

Class 4. An oxidizing material that can undergo an explosive reaction when catalyzed or exposed to heat, shock, or friction.

Oxidizing chemicals should be kept separated from flammable materials since the chemicals provide their own oxygen and contribute to the combustion process. Fire protection systems in these areas should provide a specified water density according to classification in compliance with the provisions of NFPA Standard 43A and 43C.

6-4. Open chemical storage.

Certain chemicals are such that they can be stored in open storage areas. Chemicals stored in drums should be given layouts such that all drums are easily inspected for leakage and that ready access to these drums can be made. Storage of sealed drums lying on their sides is preferable to stacking drums on end. When drums are laid on their sides, they will shed water rapidly due to the geometry of the drums, and there will be no areas for water to collect and cause corrosion. Inspection of drums is made easier when they are laid on their sides since the tops are always visible.

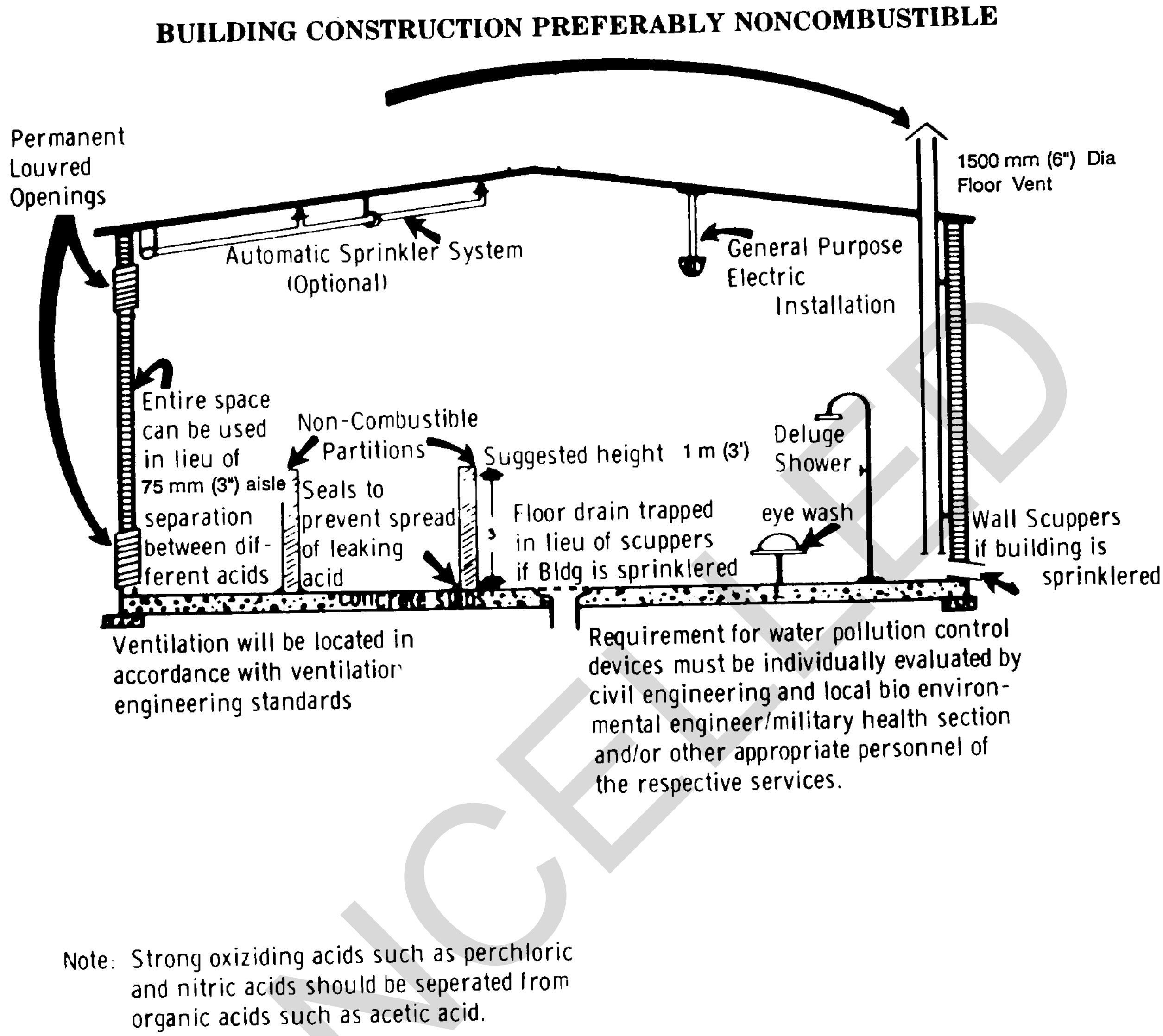


Figure 6–2. Cross section of typical acid storage building.

CHAPTER 7
TRANSPORTATION FACILITIES

7-1. General.

Railroad operations are an essential part of the operation of a storage depot; not only do they allow the efficient movement of large, bulky items, they also provide for economical movement of large quantities of goods by a minimum number of operating personnel. It will be necessary to design railroad facilities that will move freight from the main line of the serving railroad to warehouses and open storage locations within the depot. The design chosen will depend upon the size and purpose of the yard and the size and topography of available sites. Advantage should be taken of relatively level and well-drained sites in order to reduce the amount of earthwork.

7-2. Trackage requirements.

a. Access lines. Access lines will extend from the serving railroad to the boundary of the depot. Their construction will be either at the expense of the serving railroad, the Government, or both. If the expense is assumed by the serving railroad, the design will be approved by the Government. Construction of access lines during the early portion of the construction phase of a depot will provide a means of transporting construction materials to the site. If the length of the access track is greater than 8 km (5 miles), a decision should be made as to whether dual tracks or single track with passing siding should be constructed.

b. Receiving tracks. Receiving tracks are used to accept the rail shipment onto the depot and to separate cars for processing in the classification yard. The number of receiving tracks required is determined by the anticipated density of inbound traffic under worst-case conditions and the rate at which cars can be classified. The length of receiving tracks should be long enough to accommodate the maximum length train. These tracks should have direct access to the engine house. They may be connected to, or considered part of, the classification tracks. As a means of testing air brakes, compressed air lines should be installed in receiving tracks.

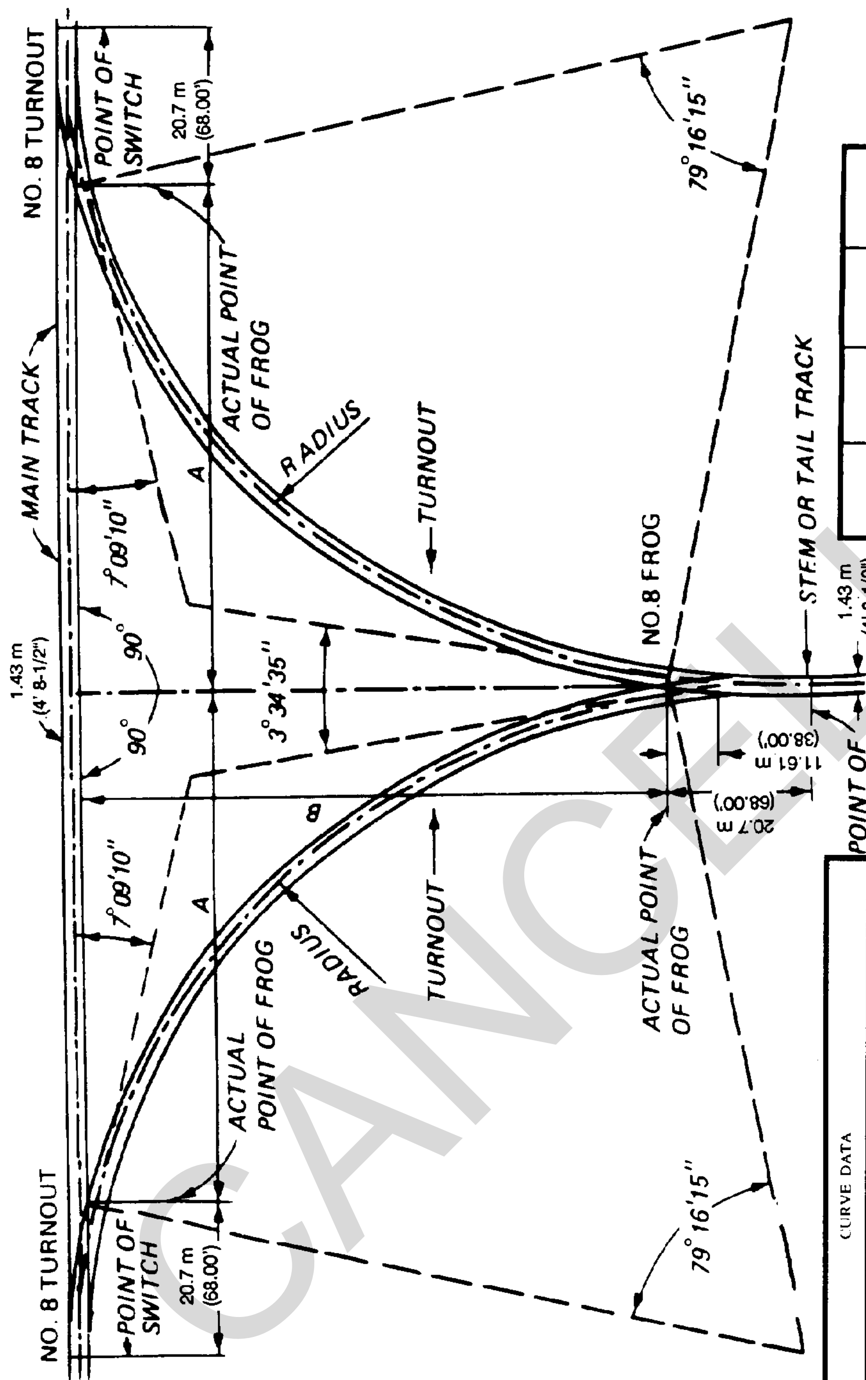
c. Classification tracks. Classification tracks are provided for sorting and forwarding of cars to storage areas and warehouses. They are also used to collect and assemble cars that are prepared for shipment from the depot. The length and number of tracks necessary for a classification yard are dependent upon the number of classifications and the rate of train departures from the yard. Several short classification tracks are more efficient than a few long ones. The classification yard should be double-ended wherever possible. Details of the track layouts necessary to construct a classification yard are found in TM 5-850-2/AFM 88-7, Chap. 2.

d. Departure tracks. Departure tracks are designed on the same principles as receiving tracks, and accommodate trains for inspection, air test, and attaching of locomotive and caboose prior to departure. Civilian practice calls for air lines to test the brakes before arrival of the locomotive. Military trains may be run directly from the classification tracks and the departure tracks omitted, or the receiving tracks can double as departure tracks. The number of tracks is based on rate of classification and train departures. The length is a function of train length and available space.

e. Track to warehouses and storage areas. Tracks to warehouse and storage areas should lead away from the classification yard and serve every warehouse and open storage area where goods carried by rail may go. When planning switches and curves for this type track, TM 5-850-2 should be consulted. The space between parallel warehouses (on the track side) will be sufficient for two house tracks, a third track to facilitate switching operations, and a 4 m (12 ft) wide single road. Track layouts between the warehouses will provide a connection at only one end of the warehouse area except where terrain or operating conditions require a double-end connection. At all single-end lines, bumpers will be constructed to prevent trains from leaving the end of the track. For open end storage areas, there will be at least one track running through the storage area with the required number of platforms to load and unload cars. See chapter 5 for greater platform details.

f. Wyes and tail track. Wyes are track layouts that are used in lieu of turntables for turning of cars and locomotives. They consist of the main track, two turnouts, and a stem or tail track, as shown in figure 7-1. In depot operations the tail track is made long enough to accommodate a locomotive and between 10 and 20 cars.

g. Engine shelter tracks. The engine shelter will be served by the number of tracks necessary to accommodate the number of locomotives utilized at the depot. The shelter will be close to the



CURVE DATA		
DEGREE OF CURVE	16° 00'	9° 30'
RADIUS	109.5 m (359.27)	184 m (603.81)
Δ	79° 16' 15"	79° 16' 15"
TANGENT	85.2 m (279.59')	152.4 m (500.14')
EXTERNAL	32.7 m (107.24')	54.9 m (180.24')
LENGTH	151 m (495.44')	254.3 m (823.43')

DEGREE OF CURVE	RADIUS	A	B
16° 00'	109.5 m (359.27)	96 m (315.55')	140.6 m (461.35')
9° 30'	184 m (603.81')	161.3 m (529.17')	171.7 m (563.31')

Figure 7–1. Typical design of wye trackage.

classification yard, and the tracks serving the shelter will lead from the classification yard.

7-3. Dimensions and clearances.

Dimensions of rail facilities for storage depots within CONUS will be based on the standard American track gage of 1.43 m (4 ft 8½ in). Overhead clearances and platform heights are measured from top of rail, and side clearances are measured from centerline of track. Any item that protrudes within the limits of these clearances is dangerous, and protection must be provided by appropriate warning signs or devices. For example, telltales must be used for overhead clearances ranging between 5.5 and 7 m (18 and 22 ft). The standard clearances are listed in table 7-1; local clearances or special conditions may require greater clearances. On curves, side clearances listed in table 7-1 will be increased 25 mm (1 in) per degree of curvature, with a maximum increase of 450 mm (18 in). When the fixed obstruction is on tangent track but the track is curved within 25 m (80 ft) of the obstruction, the lateral clearances shall be increased according to table 7-2. In a storage depot, train speeds should not be high enough to warrant superelevation of the track; however, if it is deemed necessary to superelevate any trackage, horizontal clearance on the inside rail shall be increased 3½ times the amount of superelevation of the outside rail in addition to the 25 mm (1 in) per degree of curvature.

7-4. Crossing.

Crossing surfaces must be as smooth as possible, and the materials selected for this purpose must be suitable for the type of traffic using the crossing. Although it may be desirable to match the material and texture of approach pavements, consideration must be given to a material and an installation that is economical to maintain and which will have a long service life. Materials such as portland cement concrete or bituminous concrete are economical to install, but are costly to remove and replace. Wood plank and prefabricated materials may be a little more costly to install, but are removable and reusable and therefore are more economical to use in the long run. Furthermore, they are easily removed and replaced, they facilitate the inspection of the track. Materials suitable for crossings are: bituminous concrete, portland cement concrete, precast concrete planks, wood planks, prefabricated rubber planks, modular plastic crossings, used rail, two-component epoxy and rubber. Details of these methods and their advantages can be found in TM 5-627/MO-103/AFM 91-33.

Table 7-1. Minimum safe overhead clearances.

Overhead Wires	
Primary, high voltage, high tension	10 m (35 ft)
Secondary, low voltage, telegraph, telephone, signal and low tension	7.5 m (25 ft)
Guys, messenger, communication, span, and lighting protection wire, and all voltage of effectively grounded continuous metal sheath cables	7.5 m (25 ft)
Miscellaneous Overhead Obstructions	
Building entrances (including engine houses)	5.5 m (18 ft)
Other than building entrances and wires	7 m (22 ft)
Underside of canopies a minimum of 1650 mm (5 ft 6 in) from track centerline	4.7 m (15 ft 6 in)
Side Clearances	
Building (other than for delivery)	2.5 m (8 ft 6 in)
Buildings, without platform (where delivery is required)	2.5 m (8 ft)
Canopies over platform, 4.7 m (15 ft 6 in) or less (delivery to platform required)	2.5 m (8 ft 6 in)
Canopies over platform 4.7 m (15 ft 6 in) or greater	1.7 m (5 ft 6 in)
Platforms between 100 mm (4 in) and 1150 mm (3 ft 9 in)	2 m (6 ft 2 in)
Platforms 100 mm (4 in) or lower	1.5 m (5 ft)
Refrigerator car platforms, between 1 m (3 ft 3 in) and 1.1 m (3 ft 7 in)	2.5 m (8 ft 6 in)
Refrigerator car platform 1 m (3 ft 3 in)	2 m (6 ft 2 in)
Engine house entrances	2 m (6 ft 6 in)
Building entrances (other than engine house)	2.5 m (8 ft)

Table 7-2. Lateral clearances for curved track.

Distance from Obstruction to Curved Track		*Increase per Degree of Curvature*	
m	*(feet)*	*mm*	*(inches)*
0–6	(0–20)	24	(1)
6.1–12	(21–40)	20	(¾)
12.1–18	(41–60)	13	(½)
18.1–25	(61–80)	6	(¼)

CHAPTER 8

ADMINISTRATIVE FACILITIES

8-1. General.

Efficient running of a military storage depot not only depends upon efficient layout of storage areas, but also upon adequate administrative facilities to absorb the personnel and recordkeeping activities that are inseparable from the storage mission. The design considerations associated with providing administrative facilities are perhaps the most straight-forward aspect of depot construction. It is, however, prudent to consult local and national building codes, as well as the following publications:

TM 5-809-1/AFM 88-3, Chap. 1
TM 5-809-2/AFM 88-3, Chap. 2
TM 5-809-3/AFM 88-3, Chap. 3

These manuals cover structural design for buildings, concrete, masonry, and structural steel, respectively; and TM 5-809-10, where seismic design may be applicable.

8-2. Parking facilities.

a. On-street parking. Parking can be considered to be either on-street or off-street. Each administrative building shall have its own parking facility. Where it is feasible, off-street parking is the recommended type. Where it is necessary to utilize on-street parking for a building, parallel parking is recommended over diagonal or perpendicular parking. Additional street width should be provided to accommodate any parking lane. A minimum of 2.5 m (8 ft) is required for parallel parking. Diagonal or perpendicular parking should be used for maximum parking capacity per length of road; however, widening of the street will be necessary to accommodate this type of parking.

b. Off-street parking. Parking lots, or off-street parking, are preferable to on-street parking. Lots should be designed for adequate parking spaces for personnel assigned to the building in question, plus additional spaces for visitors to the depot. Typical off-street parking is designed for perpendicular parking with two-way traffic lines. The required number of general purpose parking spaces can be determined from criteria found in Architectural and Engineering Instructions Design Criteria (AEI) or TM 5-803-5. Where massive parking lots are necessary, cross traffic connections should be planned every 110 m (360 ft) or 40 spaces. Requirements for roadway design leading to the parking facilities as well as through other storage depot facilities at military installations can be found in TM 5-822-2/AFM 88-7, Chap. 5.

8-3. Miscellaneous considerations.

a. Construction of administrative facilities should be of non-combustible materials which protect against loss by heat and weakening due to fire.

b. Should automatic data processing (ADP) facilities be necessary, consideration should be given to providing a false, raised floor such that electrical cables and cooling equipment can be run beneath this floor. If the raised floor portions are placed on a slab at elevation with surrounding offices, then access to the raised floor areas will be by stairs or ramps. All facilities can be placed on one level, eliminating the need for ramps or stairs, if the slab beneath the portion requiring the raised flooring is recessed and the false floor is installed to the surrounding floor elevations.

c. Doorways and areas housing computer equipment, mechanical equipment, etc. should allow adequate clearances for passage and storage of the equipment needed for operation.

d. In addition to providing adequate space the abovementioned equipment will generally exert heavy loads on the floor area. Design of floors that handle these loads should be accounted for during the preliminary stages.

APPENDIX A
REFERENCES

Government Publications.

Department of Defense

DOD 4145.19-R-1	Storage and Materials Handling
SB 740-1	Storage and Supply Activities Covered and Open Storage

Architectural and Engineering Instructions Design Criteria (AEI) issued 9 Dec 1991

Departments of the Army, Air Force, and Navy

TM 5-627/MO-103/AFM 91-33	Maintenance of Trackage
TM 5-803-5	Installation Design
TM 5-809-1/AFM 88-3, Chap. 1	Load Assumption for Buildings
TM 5-809-2/AFM 88-3, Chap. 2	Structural Design Criteria for Buildings
TM 5-809-3/AFM 88-3, Chap. 3/ NAVFAC DM 2.9	Masonry Structural Design for Buildings
TM 5-809-10/NAVFAC P-355.1/ AFM 88-3, Chap. 13, Sec. A	Seismic Design Guidelines for Essential Buildings
TM 5-809-12/AFM 88-3, Chap. 15	Concrete Floor Slabs on Grade Subjected to Heavy Loads
TM 5-811-2/AFM 88-9, Chap. 2	Electrical Design, Interior Electrical System
TM 5-822-2/AFM 88-7, Chap. 5	General Provisions and Geometric Design for Roads, Streets, Walks, and Open Storage Areas
TM 5-822-5/AFM 88-7, Chap. 3	Pavement Design for Roads, Streets, Walks, and Open Storage Areas
TM 5-822-7/AFM 88-6, Chap. 8	Standard Practice for Concrete Pavements
TM 5-850-2/AFM 88-7, Chap. 2	Railroad Design and Construction at Army and Air Force Installations
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General, United States Army
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Official:

MILTON H. HAMILTON
Administrative Assistant to the
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*U.S. G.P.O.:1994-300-723:39