
ENGINEERING AND DESIGN

STORAGE DEPOTS

MOBILIZATION CONSTRUCTION



DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
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No. 1110-3-150

9 April 1984

Engineering and Design
STORAGE DEPOTS
Mobilization Construction

1. Purpose. This manual provides guidance for the design and layout of railroads, roadways, storage yards and warehouse site planning for U.S. Army mobilization facilities.
2. Applicability. This manual is applicable to all field operating activities having mobilization construction responsibilities.
3. Discussion. Criteria and standards presented herein apply to construction considered crucial to a mobilization effort. These requirements may be altered when necessary to satisfy special conditions on the basis of good engineering practice consistent with the nature of the construction. Design and construction of mobilization facilities must be completed within 180 days from the date notice to proceed is given with the projected life expectancy of five years. Hence, rapid construction of a facility should be reflected in its design. Time-consuming methods and procedures, normally preferred over quicker methods for better quality, should be de-emphasized. Lesser grade materials should be substituted for higher grade materials when the lesser grade materials would provide satisfactory service and when use of higher grade materials would extend construction time. Work items not immediately necessary for the adequate functioning of the facility should be deferred until such time as they can be completed without delaying the mobilization effort.

FOR THE COMMANDER:


PAUL F. KAVANAUGH
Colonel, Corps of Engineers
Chief of Staff

Engineer Manual
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	<u>Paragraph</u>	<u>Page</u>
CHAPTER 1.	GENERAL CONSIDERATIONS	
	Purpose and scope	1-1 1-1
	Depot function	1-2 1-1
	Depot types	1-3 1-1
	Location	1-4 1-1
	Overall requirements	1-5 1-1
	General arrangements	1-6 1-2
	Access requirements	1-7 1-4
	Staging of construction	1-8 1-5
CHAPTER 2.	WAREHOUSES	
	Functions	2-1 2-1
	General	2-2 2-1
	Centralized shipping and receiving terminals	2-3 2-1
	Dock space	2-4 2-2
	Shipping and receiving areas in individual warehouses	2-5 2-2
	Storage sheds.....	2-6 2-3
	Sprinkler systems.....	2-7 2-3
CHAPTER 3.	OPEN STORAGE	
	Description	3-1 3-1
	Types of open storage areas ...	3-2 3-1
	Locations and layouts	3-3 3-1
	Loading and unloading platforms	3-4 3-2
	Storage Areas	
	Aisle and track layout	3-5 3-2
	Material handling equipment ...	3-6 3-6
	Surfacing requirements	3-7 3-6
	Personnel facilities	3-8 3-6
	Lighting	3-9 3-7
	Fire protection requirements ..	3-10 3-7

	<u>Paragraph</u>	<u>Page</u>
CHAPTER 4.	CONTAINER STORAGE	
	General	4-1 4-1
	Types of containers	4-2 4-1
	Storage requirements	4-3 4-2
	Proximity to truck and rail access	4-4 4-10
	Surface requirements	4-5 4-10
	Container handling equipment ..	4-6 4-11
	Loading/unloading facilities ..	4-7 4-13
	Lighting	4-8 4-14
CHAPTER 5.	SPECIAL STORAGE AREAS	
	Flammable and combustible materials.....	5-1 5-1
	Radioactive hazards.....	5-2 5-2
	Chemicals.....	5-3 5-5
	Signs and safety markings.....	5-4 5-5
CHAPTER 6.	TRANSPORTATION FACILITIES	
	General	6-1 6-1
	Planning requirements	6-2 6-1
	Trackage requirements	6-3 6-1
	Signals and crossings	6-4 6-2
	Engine shelter	6-5 6-4
	Service facilities	6-6 6-4
	Yardmaster's office	6-7 6-7
	Truck facilities	6-8 6-9
CHAPTER 7.	ADMINISTRATIVE SUPPORT FACILITIES	
	General	7-1 7-1
	Parking facilities	7-2 7-1
	Cafeterias	7-3 7-1
	Dispensary	7-4 7-1
	Facilities engineering organization	7-5 7-1
	Security	7-6 7-3
	Depot utility lines	7-7 7-4
APPENDIX A.	REFERENCES	A-1

LIST OF FIGURES

Figure 3-1. Open storage area layout showing street and track access.

9 Apr 84

- Figure 3-2. Sketch of end and side-loading platform.
- 3-3. Example layout for open storage area.
- 4-1. Basic container configuration for side loader CHE.
- 4-2. Basic container configuration for front-loading CHE.
- 4-3. Basic container configuration for straddle carrier that can only operate between its legs.
- 4-4. Basic container configuration for straddle carrier that can operate outside the confines of its legs.
- 4-5. Layout of yard gantry crane showing five container rows plus one truck lane beneath gantry.
- 4-6. Container layout for trailer chassis.
- 6-1. Typical design of wye trackage.
- 6-2. Service facilities for diesel locomotives.
- 6-3. Diesel locomotive water facility.
- 6-4. Concrete inspection pit.

9 Apr 84

CHAPTER 1

GENERAL CONSIDERATIONS

1-1. Purpose and scope. This manual covers new storage depots for Army mobilization facilities. Guidance is given for the design and layout of railroads, roadways, storage yards, and warehouse site planning. The manual does not cover the requirements for storage of coal or ammunition or for building design and construction.

1-2. Depot function. The function of an Army storage depot is to acquire, accumulate, identify, prepare for storage, store under satisfactory conditions, process, prepare for shipment, distribute, and regulate the flow of supplies, equipment, and goods necessary for the efficient support of the using Army agency under mobilization constraints.

1-3. Depot types. Storage depots are used for storage in conjunction with the supply of Army agencies within the conterminous United States and for supplying installations in other countries. In-transit depots are primarily used for the temporary storage of supplies, equipment, and material intended for export to other countries.

1-4. Location. In general, the location of the depot will have been previously determined.

a. Storage depots. When a site has not been previously determined and in order to facilitate construction and reduce costs, site planning should work with the level areas and the natural drainage characteristics. It should be near major truck routes and close to at least one rail line. The site may also have access to an airport. The depot site should be centrally located with respect to all the Army agencies that will use it as a means of supply.

b. In-transit depots. In-transit depots may be located at or near the port of export to facilitate use of storage-in-transit freight rules. The site should provide for both covered and open storage, protection, accessibility to and from road and rail lines, means of access to ship berths, and security measures. Much of the export and retrograde materials will be containerized; therefore, provisions need to be made for storage and marshaling areas to accommodate containers moving through the in-transit depot.

1-5. Overall requirements.

a. Minimum criteria. The designer will be furnished the requirements for the facilities based on the following factors:

9 Apr 84

- (1) Gross area requirements for:
 - warehouse storage
 - shed storage
 - open storage
 - administrative areas (if separate)
 - support facilities
- (2) Gross area and special requirements for:
 - flammable material storage
 - hazardous chemical storage
 - radioactive material storage
- (3) Volume flow requirements for:
 - average and maximum volumes received
 - average and maximum volumes shipped
- (4) Personnel and equipment numbers for:
 - officer personnel and equipment
 - material handling equipment
 - support equipment

b. Storage area definitions. Gross storage area requirements refer to the entire square foot area of the storage warehouse, shed, or open storage area. Gross space for storage operations is gross storage area less unusable space, standby space, and space not allocated to DOD use (rented space). Net storage areas refer to areas on which material may be stored. Net storage space is gross space for storage operations less aisle space, space lost to structural obstructions, and administrative space (work space and offices).

1-6. General arrangements. Depot layouts will be designed for both rail and truck service. The following principles should apply to general layouts.

a. Warehouse layouts. Warehouses will be laid out in rows of buildings with tracks and roads alternating between building rows such that each warehouse is served by both truck and freight car loading and unloading accesses. The lengths of rows should be governed by efficiency of road and track operation and the amount of necessary interwarehouse movement. Single-story warehouses should be planned for rather than multistory units. Space between individual warehouses will be sufficient to establish minimum fire protection and adequate access to other parts of the depot.

9 Apr 84

b. Shed layouts. Shed storage should be adjacent to warehouse storage and laid out in longitudinal rows similar to warehouses. They may be open on the sides and ends or closed on the sides and open on the ends, but always fully covered to protect the goods from the elements. Each shed should have concrete slabs surrounding the shed area such that wheeled vehicles such as forklift trucks can supply the sheds without difficulty.

c. Open storage. Open storage areas are preferably located adjacent to and parallel with both warehouse and shed areas. These areas will be designed for supply and distribution by both rail and truck vehicles. Storage areas in open storage will be designed to accommodate oversized material, material that can weather the elements, and containerized cargo. Since much of Army cargo will be shipped and stored in containers, open storage areas should be designed for their convenience.

d. Material handling equipment.

(1) General. Material handling equipment (MHE) is any piece of equipment or machinery designed to facilitate the lifting, moving, and stacking of material in any of the areas of the storage mission.

(2) Cranes and hoists. Large and heavy storage items require specialized storage areas and heavy lift equipment to move them. In particular at Army storage depots, such material as jeeps, aircraft wings, helicopter blades, trucks, lumber, and steel are some of the large, bulky, heavy materials that cannot be economically lifted by forklift trucks or similar equipment. Most of the above mentioned material and the great majority of other bulky items require outside storage and are most easily moved by cranes or hoists.

(a) Yard gantry cranes. Rubber-tired gantry cranes can move about on paved surfaces and have a limited turning radius. They are very flexible and due to their height off the ground, they are well adapted to placing loadings at great boom distance beyond highly stacked material close to the crane.

(b) Truck-mounted cranes. The truck-mounted crane is slightly more versatile than the gantry cranes in its mobility around the depot; however, it cannot handle as high-capacity loads as the gantry cranes, and it is more limited in reach when maneuvering near stacking material. Truck-mounted cranes come in capacities from 5 tons up to 300 tons.

(c) Locomotive cranes. These cranes are mounted on rail cars and operate from trackage on the depot. They are well suited to loading and unloading of open rail cars containing material of moderate weight. They are restricted to moving material close to the track on which they are riding.

(d) Crawler-mounted cranes. Crawler-mounted cranes are similar to truck-mounted cranes, but their crawler treads spread the weight more evenly over the surface and they can track over weaker soil areas. They have about the same handling capacities as the truck-mounted cranes.

(e) Straddle carrier hoists. For moving lumber, or steel, or elongated items that are stored outside and stored in long rows spaced closely together, a straddle carrier hoist is an efficient means of accessing the material. This type of hoist generally travels on rubber tires and runs in narrow aisles between the piles of materials. These vehicles can also be used to unload open rail cars where the track is embedded in a wearing surface that allows the hoist to maneuver across them.

(f) Overhead hoists. For indoor storage of large, bulky items, the use of overhead hoists provides the mobility that is necessary without taking up expensive storage space for material handling access. The columns flanking a hoist-served bay need to be designed for the additional loads imposed by the hoist. Additionally, widths of the bay between columns will be restricted by the physical dimensions of the hoist.

1-7. Access requirements.

a. Truck access. The size of access roads to supply the depot facility will depend upon the size of the facility and the daily volume flow of truck vehicles. One two-lane access road branching from the main highway will fill requirements for small to moderate facilities. Additional lanes or provisions for multiple access roads to handle large volumes of traffic may be necessary for large facilities. Heavy loads, such as heavy-lift cranes, will in most cases require an improved road surface. For example, the gantry crane and the straddle carrier hoists cannot operate on unimproved soil when it becomes wet. If the hauler-mounted crane is used in place of the gantry crane or the straddle carrier hoists, the track should be flat so that the crane does not damage the pavement. Details of road construction requirements may be found in EM 1110-3-130, EM 1110-3-131, and EM 1110-3-132.

b. Traffic flow. Ideally, access roads should be designed to funnel truck traffic into a reporting yard from which it could be directed to its ultimate destination. Traffic would flow easily along loop-type roads where a vehicle could approach its assigned berth from one direction, load or unload its cargo, and continue away from the storage area around a loop or out of the storage facility on a different access road to avoid congestion of vehicles reversing direction. In the warehouse platform areas a sufficient paved area should be provided along the platforms to maneuver truck traffic for

9 Apr 84

loading or unloading the trailer from either the tail or side. Truck access should be provided to sheds and open storage areas.

c. Rail traffic. The depot should be located as near as possible to main line railroads to avoid having to lay long access track to the facility. The ends of tracks that are used for rail-mounted cranes should be fitted with stops, unless the crane is traveling on a main line track within the depot. Tracks that are placed within storage areas should be recessed into the pavement so that wheeled vehicles such as forklift trucks can operate within the area without having to negotiate the elevated track. Crossovers for locomotive cranes, which generally travel on standard gage track, should be provided every 2,000 feet to allow for easy access to all parts of the storage area.

d. In-transit depots. Requirements for access to in-transit depots should be similar to those for storage depots; however, major emphasis should be placed on truck and container vehicle access.

1-8. Staging of construction. Due to the shortened time, material, and manpower constraints, construction may have to be staged. Initially all construction should be kept as austere as possible. The use of expedient surfaces such as landing mats are appropriate at the early stages of the logistics support operation. The type of mat employed must be capable of withstanding sustained container handling operations over a several-month period without a major maintenance effort. After demand for engineer troop units becomes less critical and sources of aggregate and construction material become available, the mat can be replaced with either flexible or rigid pavement.

CHAPTER 2

WAREHOUSES

2-1. Functions. This chapter covers site-planning requirements for general-purpose warehouses. Not included in this chapter are special storage areas such as chemical, radiological, or flammable materials that have special requirements.

2-2. General.

a. Large depots. A centralized shipping and receiving terminal within the depot is efficient for large depots. Centralization allows for the receipt of all less-than-carload-lot material at one area, thereby consolidating movement of commercial carriers to one terminal and dispatch yard while also allowing yard carriers efficient movement of goods to storage warehouses once the material has been sorted at the receiving terminal. This concept also reduces the need for sophisticated MHE in remote warehouses; similarly, efficient movement of goods from warehouse to shipping terminal to commercial carrier is utilized.

b. Location. The location of the shipping and receiving terminal should be central to the warehouses that it must serve. It should also be located close to a depot entrance in order to simplify interaction with commercial carriers. Area should be provided for a dispatching yard, commercial truck parking, and trailer storage. Access to rail shipping and receiving yards should also be convenient.

c. Small depots. If the depot is small or has a mission of mainly storage, a centralized shipping and receiving terminal may not be economical. In these cases the area of each warehouse that is set up to receive or ship goods can act in this capacity.

2-3. Centralized shipping and receiving terminals.

a. Factors in design. Centralized shipping and receiving terminals are designed for efficient flow of material, rather than for efficient storage as is the case for general storage warehouses.

b. Dispatch yard. The most efficient method of truck dispatching uses a dispatch yard with a dispatch office to organize incoming and outgoing trucks. The yard should be close to the receiving and shipping terminal so that the dispatch officer can have visual as well as audio communication with the terminal. The size of the dispatch yard will depend upon the shipping and receiving requirements of the depot but should contain enough parking area to store trailers after they have been unloaded and before they are reloaded, as well as

9 Apr 84

acreage for trucks to wait while they are in line for a dock space. The storage area should be marked to designate parking areas and travel lanes. Sufficient roadway width should be provided to allow easy movement of trailers by either commercial or yard cabs. Pavement thicknesses should be designed for heavy-duty traffic use and should comply with the criteria of EM 1110-3-131 for flexible pavements, and EM 1110-3-132 for rigid pavements. If site conditions allow, both the central shipping and receiving terminal and its dispatch yard should be close to an entrance to the depot to reduce commercial truck traffic throughout the depot and to minimize confusion of drivers as to their depot destination.

c. Commercial carrier access. Both the shipping and receiving portions of the terminal should have access to truck and rail transportation. The most efficient design would allow trucks on one side to park side by side and open their tail doors onto the loading dock. The rail side of the building should be designed according to the spacing of doors on rail cars. On the rail side of the building, the area between the rails can be paved so that this side of the building can be used for truck access when not being used by rail cars. Additional accessible dock space may be necessary to utilize the maximum number of trucks on this side. Concrete pads should be provided where the dolly wheels rest to prevent the trailer from sinking into the asphalt.

2-4. Dock space. Dock space for shipping and receiving terminals is the same as that for most general purpose warehouses. Heights and alignment capabilities of docks will be a part of the warehouse design. Dock widths should be wide enough to allow efficient maneuvering of forklift trucks and other expected types of MHE. Lighting should be installed on outside docks to allow nighttime operations. At the ends of the building, all docks should terminate in ramps to the street in order to facilitate interwarehouse movement of goods for forklift or cart.

2-5. Shipping and receiving areas in individual warehouses. Since the activity of shipping and receiving in individual warehouses is less than at central terminals, the size of the dock space can be reduced proportionally. If it is anticipated that the storage mission of the warehouse under design will be long-term storage with only minor shipping and receiving activities, truck berthing space can be reduced to several berths adjacent to the shipping and receiving area. If more active movement of goods is anticipated and it would be more efficient to unload trucks directly outside of the area of the warehouse in which they will be stored, full-length loading docks can be maintained along the entire length of the building. On the rail side of the warehouse it will generally be more efficient to use docks the entire length of the building because of the orientation of the cars for unloading and loading purposes.

9 Apr 84

2-6. Storage sheds.

a. Types. Sheds are covered storage buildings either of the portable or permanent types, 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 are permanently anchored to the foundation and more likely to have utilities such as lighting and fire sprinkler systems.

b. 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. Sheds should be oriented in a manner similar to warehouses, with access to rail on one side and truck on the opposite.

2-7. Sprinkler systems.

a. Requirements. Sprinklers are required in warehouses, sheds (including transit and pier sheds), and similar types of storage buildings containing supplies of a critical nature, of severe fire hazard, of high monetary value, or of vital importance. Sprinkler requirements will follow the guidance of the National Fire Code standards for sprinkler systems. Generally warehouse buildings will fall in the category of ordinary hazard, Group 3, based on NFPA 13.

b. Additional fire fighting requirements. Additional fire fighting protection will be supplied by small hose and fire extinguishers. Fire hydrants should be located at entrances to the warehouse, especially in warehouses that do not have any windows in the walls. Detailed reference to fire hydrants can be found in EM 1110-3-164.

CHAPTER 3

OPEN STORAGE

3-1. Description. 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 improved 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 warehouse and sheds as well as shipping and receiving facilities that are necessary for open storage functioning.

3-2. Types of open storage areas.

a. Improved areas. These sites are cleared of vegetation, graded, and provided adequate drainage, and then given some sort of hard surface 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.

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 loads as in dry.

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.

d. Control of vegetation. For semi-improved and unimproved areas, control of vegetation is an important consideration. Protection of the area by application of weed killers or the spreading of some cover material such as shells or salt that prohibits unwanted growth will improve the usefulness of the storage space and retard the deterioration of material stored there.

3-3. Locations and layouts. Each open storage area should be equipped to load and unload both truck and rail cars by either forklift or crane. Rail siding platforms will serve both rail cars and trucks by means of a forklift truck. Open rail cars or flat bed trucks can also be on- or off-loaded by means of mobile crane or rail crane. Receiving and shipping areas should be located such that MHE does not have to transport goods long distances to or from their storage location; access between rows of storage should be provided for wheeled vehicles,

9 Apr 84

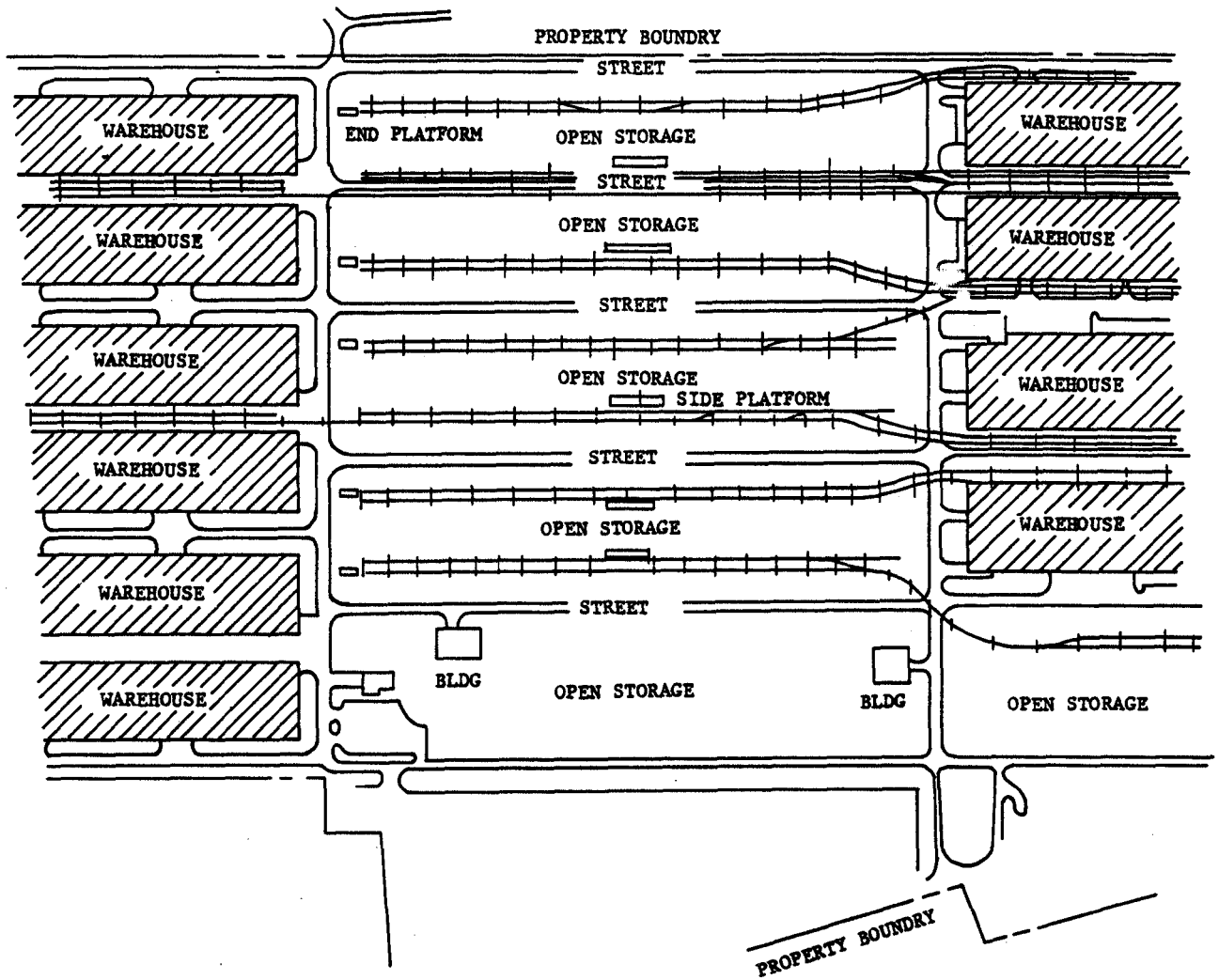
and rail platforms should be centrally located. Figure 3-1 gives a layout for open storage that provides for both rail and truck access to open storage areas.

3-4. Loading and unloading platforms.

a. Size. Within each open storage area there should be at least one rail car loading and unloading platform. Ideally, there should be a platform located on each run of track within the storage area, but in order to adequately serve the storage area, platforms should be at least close enough that MHE carrying goods to and from the platform do not have to travel more than 700 feet from loading platform to storage. Side-loading platforms should be a minimum of 20 feet wide and one car length long. The length is preferably two car lengths. The platform should be located such that the side face is 6 feet 2 inches from the center line of track, and the elevation of the top of the platform should be 3 feet 9 inches 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, an 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 32 feet wide (fig 3-2).

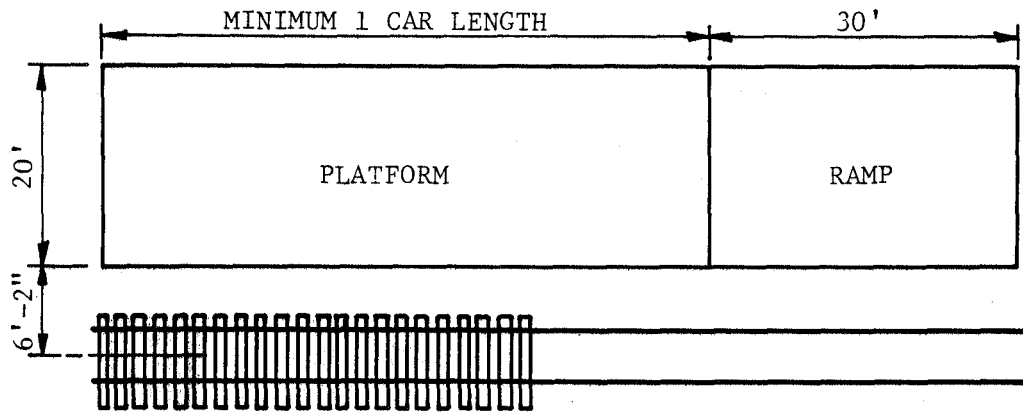
b. Materials. The platforms can be constructed of concrete, wood, or earth-filled timbers. The type of construction should be based on the expected service loads and environmental conditions that the ramp and platform will experience.

3-5. Aisle and track layout. 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. Double-track layouts should have crossovers at intervals of 1,000 to 5,000 feet. Single-track layouts of more than 1,000 feet should have rail connections at both ends. Figure 3-3 shows one example of open storage layout.

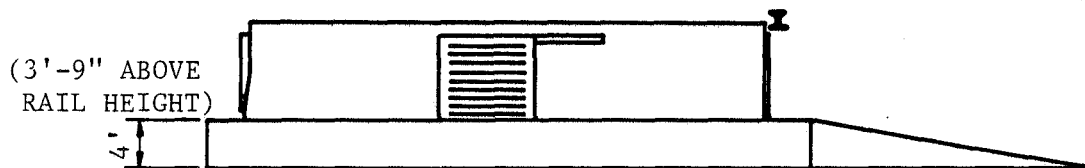


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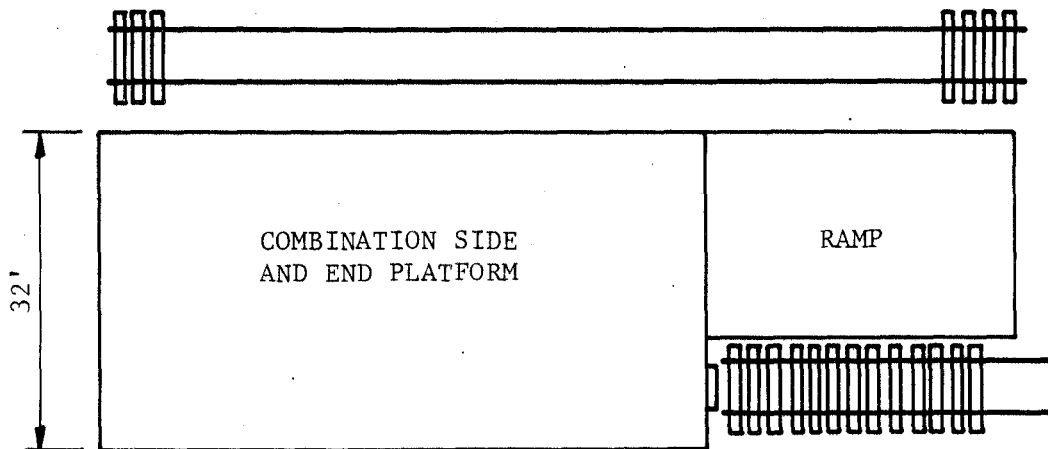
FIGURE 3-1. OPEN STORAGE AREA LAYOUT SHOWING STREET AND TRACK ACCESS



PLAN OF SIDE LOADING PLATFORM



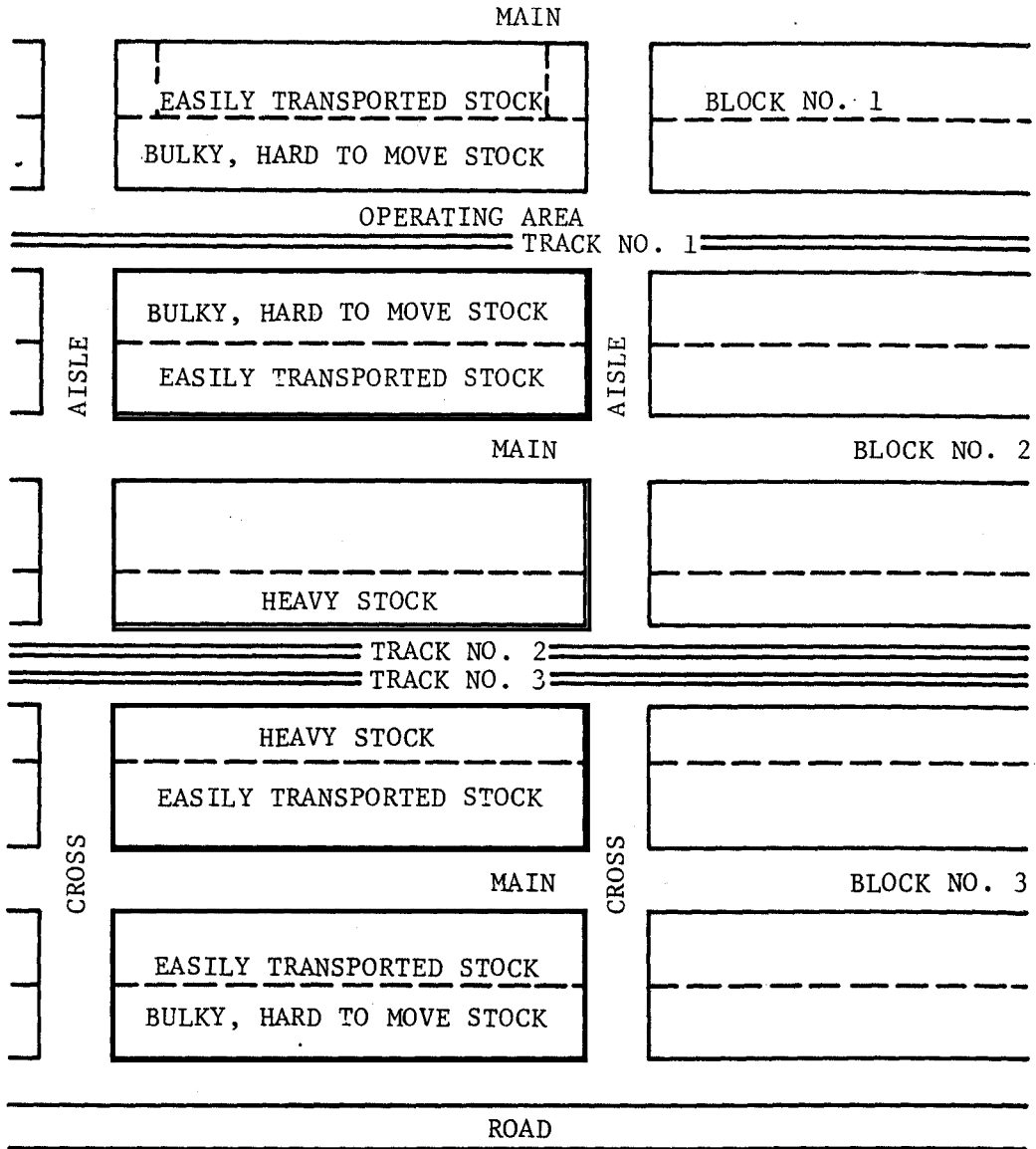
ELEVATION



PLAN OF SIDE AND END LOADING PLATFORM

U. S. Army Corps of Engineers

FIGURE 3-2. SKETCH OF END - AND SIDE-LOADING PLATFORM



U. S. Army Corps of Engineers

FIGURE 3-3. EXAMPLE LAYOUT FOR OPEN STORAGE AREA

9 Apr 84

3-6. Material handling equipment.

a. Major types and uses. Forklift trucks are the chief means of transferring goods in open storage. Their load capacity ranges from 2,000 to 15,000 pounds, and they must have access to the entire open storage area. In addition, in order to be able to move in and out of rail cars, forklifts should have rail side ramps to allow forklift access to the interior of the car. Crawler or truck-mounted cranes are also typically used to handle material in open storage. Crawler and truck-mounted cranes usually operate from roadways alongside of the storage block but can be utilized in other areas.

b. Special purpose MHE. Special purpose MHE such as straddle carriers or side-loading forklift trucks may be economical for storage of long, bulky objects such as pipe, wood, or structural steel. The details of these and other MHE are covered later in this manual.

3-7. 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. There are two types of surfaces that are frequently used on improved storage areas: rigid pavements (EM 1110-3-132) and flexible pavements (EM 1110-3-131). Rigid pavement applications should only be used in areas where temperature fluctuations are extreme. They require considerable labor in fabrication and are generally the more expensive method of providing improved surfacing. Flexible pavements will normally be used. Steel mat may be selected for short term use as an expedient surfacing method.

b. Traffic volume and flow patterns. Traffic volume is a primary consideration in the design of the type of surfacing and its required thickness. The operation flow patterns and the number of passes of each vehicle under consideration will determine the design volume for a particular facility. For more information EM 1110-3-130 should be consulted.

c. Weight requirements. The type and thickness of pavement will depend on stack height and material weight storage requirements.

d. Area requirements. It is extremely important that the total surface area be limited in order to minimize construction and maintenance efforts. Area requirements vary with vehicle characteristics, operational patterns, container sizes and weights, driver skill, number of vehicles, and protective measures taken.

3-8. Personnel facilities. Shelter, restrooms, offices, and other personnel facilities necessary for the operating personnel of an open

9 Apr 84

storage area should be located in the warehouse nearest to the open storage area. If the storage site is remote from all surrounding warehouses, then the personnel facilities must be constructed on site.

3-9. Lighting.

a. Type. Satisfactory illumination should be provided for night operations. Lighting units should consist of adjustable-type floodlights mounted on buildings, poles, or towers as required to provide a uniform distribution of light over the area to be lighted. Floodlight towers, where required, should be made of steel and should be grounded at the base. The number, size, location, mounting height, and beam characteristics of floodlights should be designed to provide a uniform distribution of light, avoiding objectionable glare, over the entire area with a minimum of waste light against buildings and in unused areas. Open storage areas subject to night operation should be provided with approximately 1/2 to 1 foot-candle at the working level. Loading platforms subject to night operations should be provided with approximately 5 foot-candles of light at the working level.

b. Wiring systems. Multiple systems should be utilized for floodlighting. Where the number and size of floodlights will permit, the wiring should be connected to the interior system of an adjacent building or to an exterior secondary distribution circuit. Where a substantial quantity of power is involved, a primary distribution system circuit may be extended to the area and transformers provided at suitable locations. Control should be by means of low-voltage switches or circuit breakers. Switches should be of the fused type unless the wiring is connected to a fused circuit. Primary wiring should be of the same type as the primary system to which it is connected, unless material handling, flying hazards, or other local conditions indicate that a change in the type of system is necessary or is desirable to affect economy. Aerial and underground circuits should comply with the requirements of EM 1110-3-190.

3-10. Fire protection requirements. While open storage areas are not as combustible as conventional warehouse buildings, the materials stored at the area may present a fire hazard. Requirements for outside storage should follow the NFPA Standards, with particular reference to NFPA 30, NFPA 46, and NFPA 231A. In general, there should be an adequate alarm system installed either on the open storage site or in an adjacent building within 200 feet of the storage site. The open storage area should also have adequate fire hydrants located around the area (guidance can be found in EM 1110-3-164), and goods and material should not be stored so close together that access to an area of the storage cannot be obtained in the event of a fire.

CHAPTER 4

CONTAINER STORAGE

4-1. General. Operations that need consideration when planning for a container storage area are: receiving and shipping administration, loading (stuffing) and unloading areas, storage area layout, surfacing requirements, and container handling equipment (CHE).

4-2. Types of containers.

a. Twenty-foot containers. The Army presently bases its fleet of containers on the standard 8- by 8- by 20-foot container. This container is similar to the commercial industry standard but has been given the name MILVAN. It functions as both a storage container and a shipping container. It fits on flat bed trucks for transportation purposes, and can be stacked and lifted by CHE as described later in this chapter. As a storage container, it has a 1,060-cubic foot storage capacity. It is made of steel with plywood interior sides and hardwood floor, so it will protect stored material in open storage situations. In its empty state, it weighs 4,770 pounds and is designed for a full capacity of 44,800 pounds.

b. Forty-foot containers. Available commercially but not yet part of the Army container fleet are 8- by 8- by 40-foot containers that are similar to the MILVAN but hold twice the volumetric capacity. These may show up in the storage inventory from time to time as a result of having goods shipped in commercial containers. The weight capacity of these containers is about 67,200 pounds.

c. Twenty-foot refrigerated container. For storage and transportation of perishable goods, the Army has in its inventory a 20-foot refrigerated container. This container measures 8 by 8 by 20 feet and weighs approximately 8,500 pounds empty. Due to the inclusion of its 10-kW engine generator, its storage capacity is less than the standard MILVAN. It is stackable with other refrigerated or standard MILVANS.

d. Transport. For over-the-road hauling of MILVANS, two containers can be secured to a special tractor trailer designed to carry these containers, and the result is similar to a standard 40-foot tractor trailer.

e. Forty-foot FLATRACK. For handling breakbulk cargo and items that are long or not adaptable to MILVANS, such as vehicles or tall items, the Army has developed the 40-foot platform container name FLATRACK. It can be used as a conventional 40-foot container or it can be equipped with trailer wheels and landing gear for use as an over-the-road trailer. As a storage container, the FLATRACK has adjustable corner posts which allow a variable height to the container.

9 Apr 84

This allows additional FLATRACK containers to be stacked on top of it without damage to the stored goods. Since it is built to industry dimensional standards, it is compatible with commercial 40-foot containers for stacking purposes and can be lifted by any commercial CHE. The container has an empty weight of 15,000 pounds and a gross capacity of 67,200 pounds. As an over-the-road trailer, it is compatible with tractors and can haul one 20-foot container or 67,200 pounds of cargo.

4-3. Storage requirements.

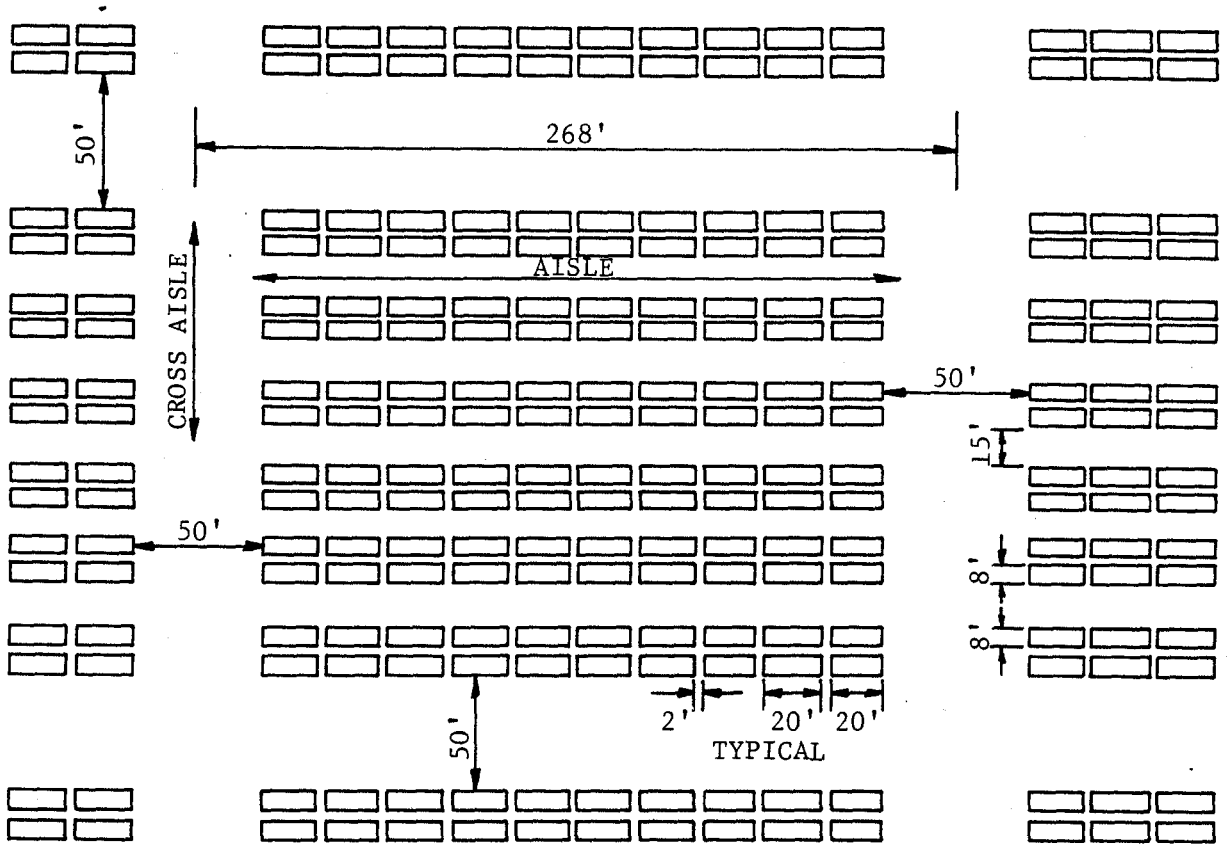
a. Shipping and receiving facilities. Material in containers received in the storage depot will fall into two categories. Either the container will contain one stock item and be destined to be used as a storage container, in which case it can be stored immediately, or it will contain multiple stock items, in which case it will be necessary to separate the items for distribution to their logical storage locations. In the latter case, a shipping and receiving section will be necessary. As containers loaded with multiple stock items will most likely arrive by truck, a truck dock should be provided. Should containers loaded with multiple stock items arrive by rail, the containers can be transferred to yard tractor trailers for transportation within the depot to the receiving area.

b. Container stuffing area for shipping. Quite often depots ship stock items for distribution to overseas bases via containerized freight. By present procedures, containers will be stuffed according to location of delivery overseas and then distributed to the various bases within one locale once they have arrived at the distribution depot. This will require an enclosed item assembly area in conjunction with the loading dock area.

c. Storage in containers. Since containers are, in themselves, shelter for the goods contained within them, they may be stored in open, outdoor storage areas.

d. Storage layouts. The density of the storage will depend upon the surfacing conditions and the CHE used. There are five basic types of CHE discussed below that can efficiently access containers from storage: side loaders, front loaders, straddle carriers, yard gantry cranes, and trailer chassis.

(1) Side loaders. Side loaders carry the container over the body of the loader and deposit it into its storage location from the loader's side. Since it loads from the side and can only load directly adjacent to itself, the most efficient layout for containers is as shown in figure 4-1. In this configuration, a density of 172 20-foot-long MILVANS per acre can be achieved when containers are stacked two high. Cross aisles should be spaced at approximately



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FIGURE 4-1. BASIC CONTAINER CONFIGURATION FOR SIDE LOADER CHE

9 Apr 84

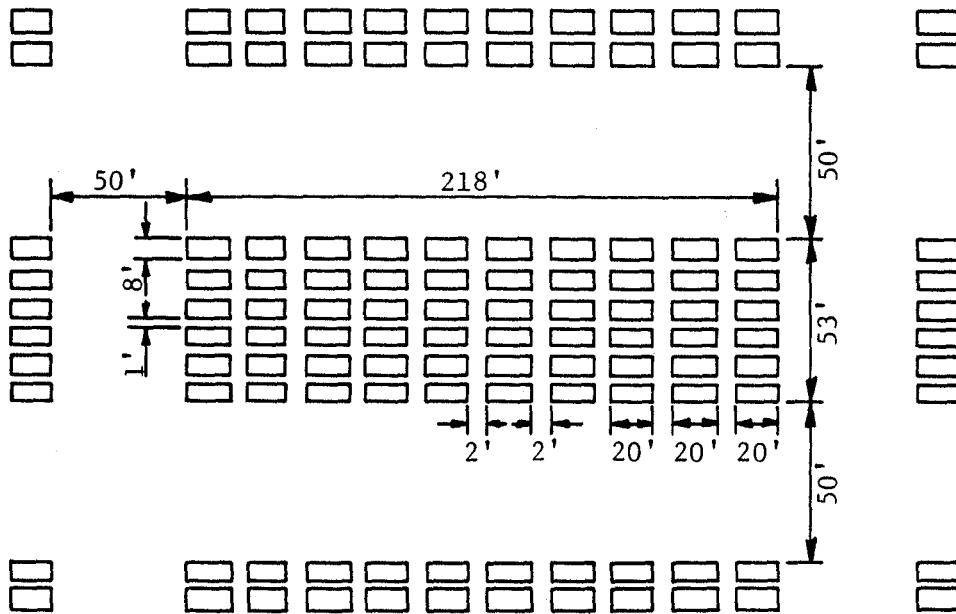
268-foot intervals or after a row of 10 MILVANS, as shown in figure 4-1.

(2) Front loaders. A front loader handles containers at its front and requires a larger access aisle to maneuver into position to pick up a container. However, containers can be stacked in groups where there is not direct access to every container, since the front-end loaders can move containers and easily maneuver into the center of the group. Also, there are several front loader-type vehicles that have been designed to reach over other containers to access top containers without moving ones that would otherwise be in the way. The layout shown in figure 4-2 provides for a density of 190 20-foot MILVANS per acre when stacked two high.

(3) Straddle carriers. Straddle carriers straddle the container and lift it from above. This type of carrier requires aisles between each row of containers, but the aisles are narrow, having only to accommodate the legs of the carrier. The layout shown in figure 4-3 will provide for 224 20-foot containers per acre when stacked two high. Rows of containers should not be longer than four 40-foot containers or eight 20-foot containers in order to minimize the difficulty of maneuvering the straddle carrier along the aisles. The configuration shown in figure 4-3 is for a straddle carrier that cannot operate outside the confines of its legs; therefore, there must be an aisle between each row of containers. If the straddle carrier can operate on either side of its body, then a configuration as shown in figure 4-4 may be used and a density of 250 20-foot containers per acre can be achieved.

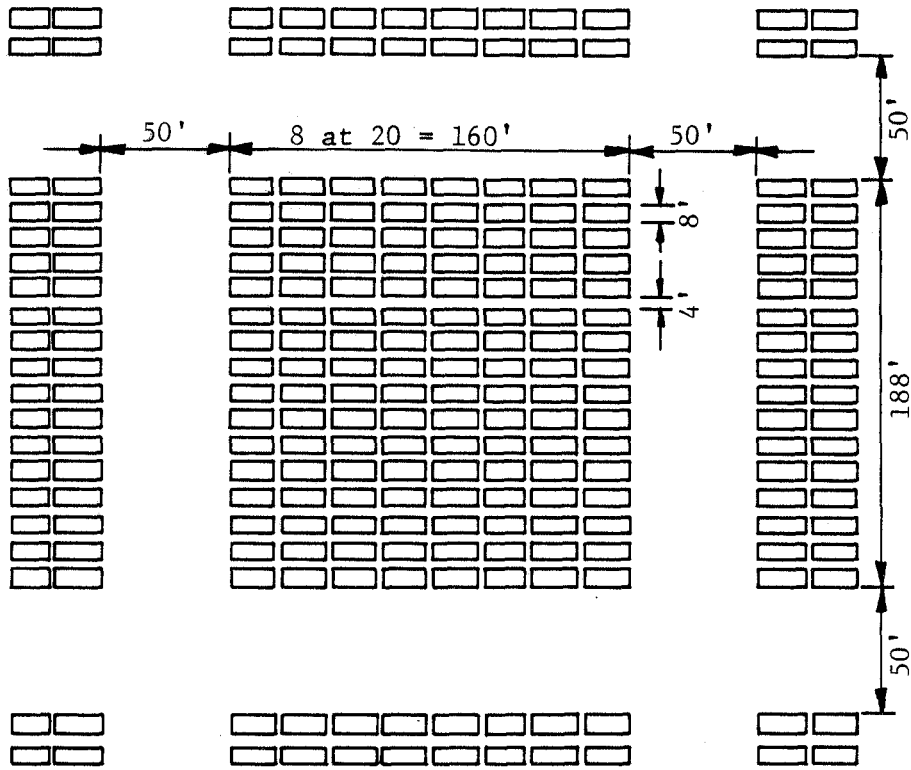
(4) Yard gantry cranes. Yard gantries are like straddle carriers in that they straddle the containers, but they generally straddle from three to five rows of containers and are much more limited in their maneuverability. This lack of maneuverability is compensated by the compactness of container storage and flexibility of the gantry crane on its frame. For most layouts, the yard gantry will need only to move back and forth along one long row of containers, or it may need to get from one row to the next by an occasional cross aisle. The layout shown in figure 4-5 will provide for 260 20-foot containers per acre stacked two high in arrays 5 by 10. There is room for a truck lane beneath the gantry in this setup in order to remove the accessed container without using the gantry as a container transporter.

(5) Trailer chassis. The requirements of trailer chassis when equipped with containers are that they only be stacked one high and that there be access for a yard tractor to pick up any trailer without moving another trailer. The suggested layout for this type of container configuration is shown in figure 4-6. Using this layout, 74 20-foot MILVANS, two per 40-foot trailer chassis, can be stored per acre. One of the advantages of this type of container storage is



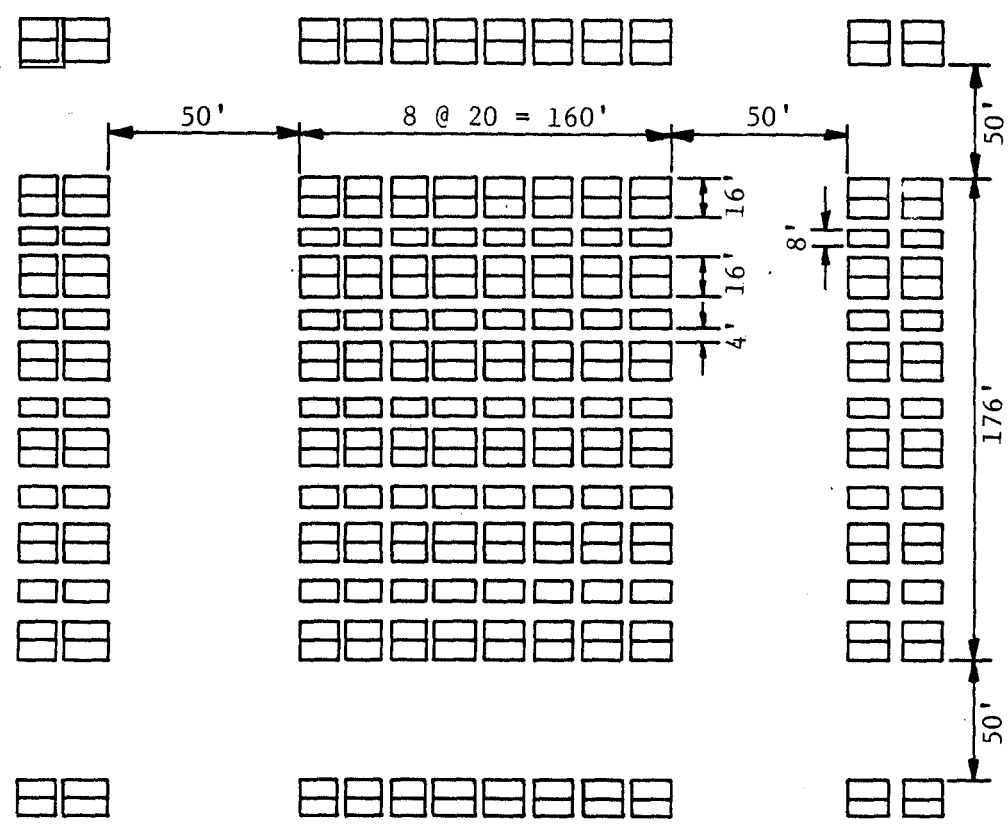
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FIGURE 4-2. BASIC CONTAINER CONFIGURATION FOR FRONT-LOADING CHE



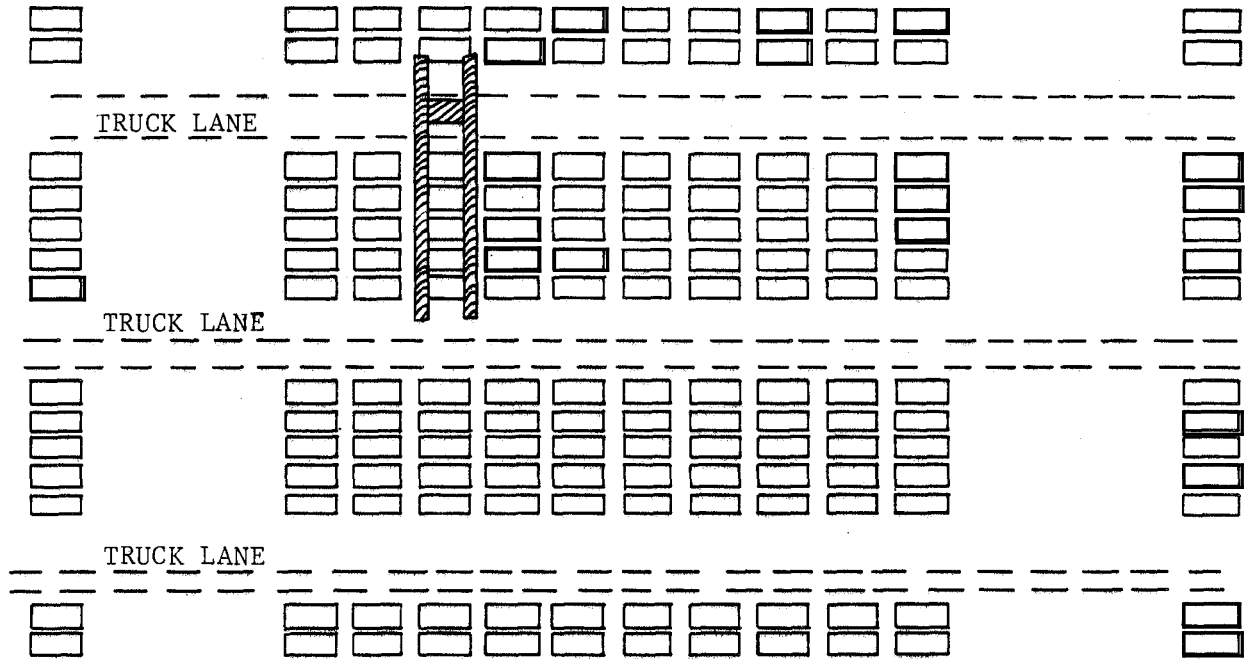
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FIGURE 4-3. BASIC CONTAINER CONFIGURATION FOR STRADDLE CARRIER THAT CAN ONLY OPERATE BETWEEN ITS LEGS



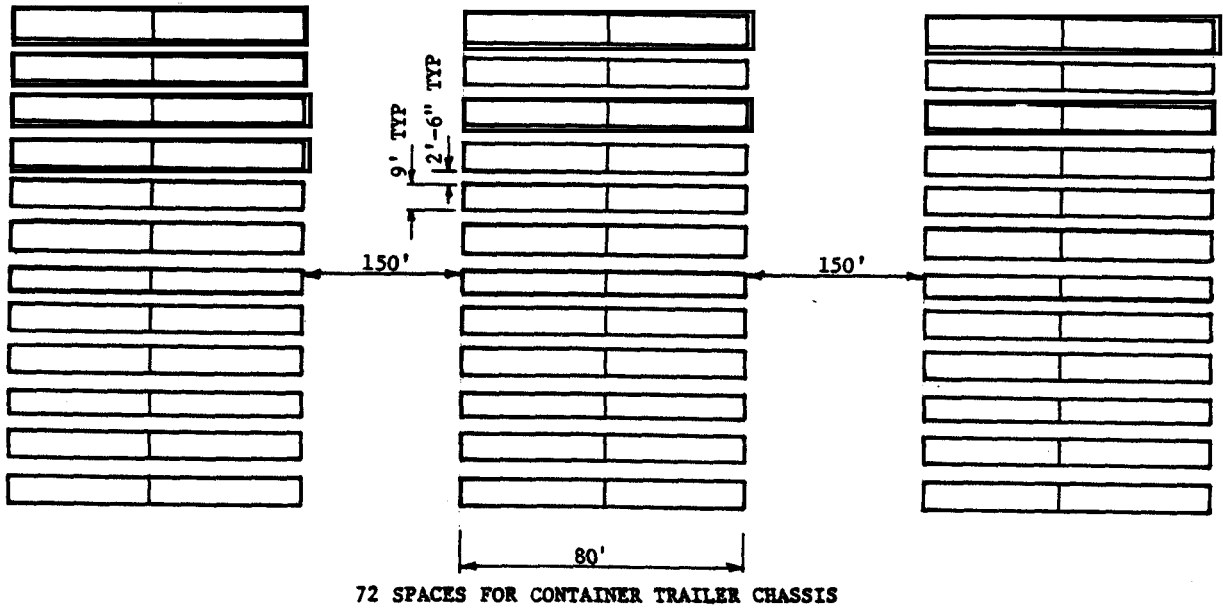
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FIGURE 4-4. BASIC CONTAINER CONFIGURATION FOR STRADDLE CARRIER THAT CAN OPERATE OUTSIDE THE CONFINES OF ITS LEGS



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FIGURE 4-5. LAYOUT OF YARD GANTRY CRANE SHOWING FIVE CONTAINER ROWS PLUS ONE TRUCK LANE BENEATH GANTRY



U. S. Army Corps of Engineers

FIGURE 4-6. CONTAINER LAYOUT FOR TRAILER CHASSIS

elimination of the need for sophisticated CHE. All that is necessary to move container and chassis is a yard tractor.

e. Empty containers. At each depot installation there will be a need to store empty containers. Area for empty containers should be set aside to store at least 10 percent of the inventory of containers. This area should be located near the container stuffing building such that containers will be easily available to personnel stuffing containers for shipment. The type of container layout will depend upon the type of container and the type of CHE expected to handle the containers from storage to stuffing point. Since access will most likely be to the first available container, the containers can be stored in a closer storage pattern than if they are stored full.

4-4. Proximity to truck and rail access. Containers will arrive and depart from the storage facility both by truck and by rail. Most of the containers will travel at least part of the time by some means of truck transportation. The container storage area should have direct access to portions of the rail track system, as well as a large open area where the containers can be transferred to or from the CHE for purposes of storage or shipment. The CHE can load the containers on or off trailers, or into or out of railway cars. In some instances, it may be necessary to utilize a mobile crane to load or unload containers from rail cars. The storage area should be served by double track sidings from a train makeup yard. These sidings should run the length of the container storage area with numerous crossovers so that empty or reloaded cars can be switched onto the outgoing track. A railway siding will also run down one of the aisles in the storage yard so that a yard gantry crane, straddle truck, or forklift truck can transfer containers to and from the flatbed railway cars.

4-5. Surface requirements.

a. General. The heavy loads imposed on the container storage surface due to container weight and CHE require special consideration in the design of the surface. Containers that are fully loaded may be stacked two and three high in the storage area exerting tremendous pressures on the pavement and subgrade, and CHE can have gross weights greater than 100,000 pounds producing large axle loads even in the unloaded condition.

b. Basic considerations. The basic considerations regarding the alternatives between flexible and rigid pavements have been outlined in paragraphs 3-1 and 3-2. In order to make the proper choice of pavement type, consideration must be given to the soil properties in the area, the expected life and degree of maintenance life of the pavement, the number of passes of CHE vehicles, and the type of CHE vehicle to be used at the storage site. Refer to the following manuals for design criteria of both rigid and flexible pavement: EM 1110-3-130, EM 1110-3-131, and EM 1110-3-132.

4-6. Container handling equipment.

a. Equipment scope. Efficient operation of container storage areas requires specialized handling equipment to move the containers from one location to another. This equipment falls into the category of MHE, but since it has such a specialized function of moving containers, it will be covered separately under CHE. This section will deal with CHE of the type used to load and unload truck and rail cars, and to store and move containers within the container storage area.

b. Considerations in choosing CHE. The choice of CHE depends upon the mission of the storage facility, the surface conditions of the storage area, the types of containers it is expected will be handled at the depot, and the volume of traffic anticipated within the lifetime of the depot. A short description of the available types of CHE and their technical capabilities will be presented here, such that the user can tailor his choice of CHE to the specific depot needs.

c. Types of CHE. It is anticipated that the majority of the containers that will be received at Conterminous United States depots will either be 8- by 8- by 20-foot MILVANS or the commercial 8- by 8- by 40-foot containers. These containers will arrive and depart the depot by either truck or rail. The types of CHE that best fill the needs of loading or unloading these containers are front loaders, straddle carriers, yard gantry cranes, and mobile cranes. The most efficient CHE for storing and transferring containers within the depot are the front loaders, side loaders, straddle carriers, and yard gantries. Equipment manufacturer's are noted with the various types of CHE. The manufacturers mentioned are not intended to be a complete list of those producing that type of CHE, nor is the list a recommendation by the Army. The manufacturers are mentioned only to give examples of the type of CHE described.

d. Front loaders. The front loading container handler is the larger capacity relative of the forklift truck. It handles the containers from the front of the vehicle. It is either a hydraulic or manual lift-type truck with lift capacity from 40,000 to 87,000 pounds. It is designed to lift containers by placing forks beneath the container, but it can be adapted to lift containers from above through the use of a special container adapter. Some manufacturers are Belotti, Caterpillar, Clark, Hyster, and Lancer Boss.

e. Side loaders. Side loaders access their containers from the side. One manufacturer is Lancer Boss.

f. Straddle carriers. Straddle carriers load and unload their cargo by straddling it. This means that there must be an access road on each side of a row of containers to accommodate the legs of the carrier; however, these rows are relatively narrow and the number of

9 Apr 84

containers per unit area is still high. Belotti and Clark/Ferranti are two manufacturers.

g. Yard gantry cranes. These handlers are gantry-type cranes that span several rows of containers and run on tracks or rubber tires. They are able to access containers in any particular row by means of a hoist that travels along the gantry to position itself over the proper container. They can access containers in stacks, from trucks/to trucks, or from rail cars/to rail cars. Some manufacturers are Drott, Marathon Le Tourneau, and Paceco.

h. Mobile cranes. The mobile crane, while basically thought of as a bulk cargo piece of handling equipment, can be used to good advantage as a container handler. It has the advantage of good mobility by being able to move exactly where needed, and once in place, it has a decided advantage of extended reach without moving. It is a piece of equipment that would be in the inventory of a storage depot whether or not the depot had a container storage mission. Also to its advantage is the fact that there are a number of mobile cranes already in the Army inventory. Listed here are some of those that are adaptable as container handlers.

(1) 40,000-pound truck-mounted crane. This crane is one of the smaller in the Army inventory that can handle less-than-full-loaded 20-foot containers. Its Federal stock number is 3810-554-4103. It can lift 40,000 pounds at a radius of 10 feet and has a 30-foot boom.

(2) 80,000-pound crawler-mounted crane. This crane, FSN 3810-230-2819, has principal characteristics which include 80,000-pound capacity at 12-foot radius and a 50-foot boom. It weighs 135,000 pounds without load.

(3) Other manufacturers. Some additional manufacturers are Marathon Le Tourneau, Harnischfeger Corporation, and FMC Corporation.

i. Tractors and trailers. For purposes of moving containers from depot to depot or for moving commercial trailers deposited on the depot property, linehaul tractors and yard tractors are needed in the depot inventory.

(1) M 52 linehaul tractor truck. This tractor is one of the smaller ones in the Army inventory. It is, however, capable of hauling container transporters on paved improved surfaces. It is a three-axle vehicle having a tractive capacity of approximately 30,000 pounds which would indicate that it cannot carry a fully loaded 20-foot container on a trailer; but it has carried such a load on improved surfaces. It is compatible with all the trailers mentioned in this subparagraph.

(2) M 818 linehaul tractor truck. This tractor is also a three-axle vehicle with a road tractive capacity in the vicinity of

9 Apr 84

30,000 pounds. Its capabilities are similar to the M 52, and it is compatible with the trailers mentioned here.

(3) M 915 linehaul tractor truck. The M 915 is an Army adaption of a commercial 6 by 4 tractor used for linehaul operations over primary roads. It is a three-axle vehicle with drive wheels on the rear two axles. It is capable of transporting fully loaded 40-foot containers on chassis or greater than 68,000 pounds of breakbulk cargo over primary roads. This tractor is intended to be the Army's primary container mover. It is primarily meant to haul the M 872-34 ton container/breakbulk transporter, but it is compatible with the majority of commercial trailers with which it may come in contact.

(4) M 878, yard type tractor truck. The yard tractor is primarily used to haul trailers around the depot. It is a highly maneuverable tractor which has a cab that is restricted to the operator only. It has an automatically locking, hydraulic-lift fifth wheel (trailer coupler). It is compatible with commercial trailers as well as the M 871 and M 872.

(5) Coupleable, MILVAN container transporter. This container chassis is the primary Army-owned container-mover for usage on primary, hard surface roads in the Conterminous United States. The chassis consists of a 20-foot frame, landing gear, and single-axle bogie. The bogie is movable along the length of the frame. The frame has provisions for coupling two 20-foot units to form a 40-foot chassis, with the bogies under the rear frame to form a tandem-axle configuration. Each frame has twist locks to accept International Standards Organization (ISO) containers. There is a provision for lowering the twist locks flush with the top of the frame so that 40-foot containers can be transported on a coupled chassis.

(6) M 871 22-1/2-ton dual purpose container/breakbulk transporter. It is designed as a tactical semitrailer to be hauled by the M 818, M 915, or M 52. It is primarily a mover of 20-foot, 44,600-pound containers, or breakbulk goods of this weight. It is meant to be used in the linehaul mission, but will serve in the capacity of a depot trailer. It has container locks on the chassis for 5-foot, 6-2/3-foot, 10-foot, and 20-foot containers. For breakbulk cargo it has 48-inch high side panels.

(7) M 872 34-ton container/breakbulk transporter. This semi-trailer is the heavy-duty chassis in the Army inventory. It is a tri-axle, commercial design semitrailer capable of hauling fully loaded 40-foot containers, or 67,200 pounds of breakbulk cargo. Its prime mover is the M 915 linehaul tractor or the M 878 yard tractor.

4-7. Loading/unloading facilities.

a. Roads. Rail cars and over-the-road trailers carrying containers will be loaded and unloaded from one central location within the container storage area. The facilities necessary include drive on/drive off flatcar ramps and the CHE described above. Loading and unloading should be accomplished in a large flat area adjacent to both the rail lines and the container storage area. CHE can load empty containers on trailers to ready them for stuffing or shipment; or CHE can unload full containers from rail cars or truck trailers in preparation for stripping or storage. Adequate road access to the loading/unloading area should be provided to allow fully loaded trailers pulled by yard tractors to pass one another without either having to yield way. As a safe minimum, such a two-way road should have at least 24 feet of pavement width. Sufficient turn-around area should be provided for trailer trucks that have been loaded or unloaded to easily maneuver out of the loading area. It would be preferable to have a loop type road where entering traffic exited by a different road. Requirements for roadway design at Army installations can be found in EM 1110-3-130.

b. Platforms. Flatcar platforms for drive on/drive off containers or vehicles transported by rail car should be built as near as possible to rail car height such that bridges from the car to the platform will be horizontal. Access ramp slopes should be less than 10 percent. Access from the ramp to where the CHE is operating should be provided to allow the CHE to on- or off-load the containers.

4-8. Lighting.

a. General considerations. In connection with container storage, all areas associated with the storage, handling, processing, and transportation of containers should be lighted to permit work during the hours of darkness, promote safety, and provide security to the stored goods.

b. Lighting intensity. Lighting intensity depends upon the task to be performed. Illumination intensities in the vicinity of 5 foot-candles are necessary for work around loading and unloading areas; illumination between 0.2 and 0.5 foot-candles is required for open storage areas. Roadway illumination levels fall in between these two extremes.

c. Lighting units. Most recent trends in lighting large open areas have been to use specialized lighting units called high mast overhead lighting. In this type of lighting, high-penetration luminaries are mounted on tapered poles or triangular steel towers that may range in height from 50 to 150 feet. The luminaries may be lowered to within 3 feet of the ground for inspection and servicing. Each mast contains from four to as many as 12 lamps aimed so as to spread the light over the desired area. Lamps may be 1,000-watt mercury vapor, metal halide, or high-pressure sodium vapor.

CHAPTER 5

SPECIAL STORAGE AREAS

5-1. Flammable and combustible materials.

a. Purpose and sources. The storage of flammable and combustible materials constitutes a storage condition that needs a higher degree of safety consideration than conventional storage. Specifications governing construction practices for combustibles not outlined in this publication can be obtained from NFPA 30. One source for much of the information relating to material covered here can be found in the NFPA Fire Protection Handbook.

b. Segregation. Flammable and combustible materials must be kept segregated from other storage items to prevent large-scale fire damage to conventional storage items should the combustible material catch fire or ignite spontaneously. Design consideration should be given to maintaining this segregation throughout the entire storage operation.

(1) Shipping and receiving. Where facilities permit, special shipping and receiving areas and temporary storage areas should be maintained to prevent the volatile materials from coming in contact with other material.

(2) Location requirements. The building will be detached from any other building and located away from any other building by at least 50 feet. 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.

c. Firefighting equipment.

(1) Automatic sprinklers. Utility connections will be required where automatic sprinkler systems are to be installed within combustible and flammable storage warehouses. Sprinkler systems should provide a discharge density of greater than 0.5 gpm/square foot of floor area. A dry well or holding tank may be required. Water from sprinkler systems or spilled liquids must not be allowed to enter the ground water.

(2) Extinguishers. Outside, at least one portable fire extinguisher of rating not less than 12-B units as defined by NFPA 10 should be located within 10 feet of the door.

(3) Alarm systems. Combustible and flammable storage areas should be equipped with automatic alarm systems. Since these storage buildings are generally unoccupied, the alarm system must be automatic. The alarm system should be connected to an audible alarm device located

on the outside of the building, if the building is located near occupied buildings, for purposes of early warning. It should also be part of a system that automatically notifies the depot fire station or security office.

d. Open storage of flammable and combustible materials.

(1) Container types. Open storage of flammable and combustible materials can range from automotive fuel tank farms to drum storage of fuel oils and combustible chemicals. This discussion will be confined to design criteria for drum storage in open areas and small facilities for tank storage.

(2) Drum storage in open areas. Open storage areas for flammable and combustible materials will be away from occupied buildings and kept segregated from open storage areas for conventional material. The area to be used will be concrete surfaced with a 6-inch high berm running entirely around the storage area. Access to the interior of this special area will be provided for firefighting equipment by means of a concrete ramp that bridges the 6-inch-high curb. The slope of the ramp will be less than 10 percent. This ramp will also provide the needed access for forklift trucks and MHE. Pumps or other provisions should be made for removal of rainwater from the bermed area.

(3) Bulk storage. Bulk storage of flammable or combustible materials should be in tanks. These tanks should be constructed to conform to requirements in NFPA 30. They should be kept away from public ways and buildings, as shown in table 5-1. All storage sites will be sloped away from the tanks and the areas will be cleared of brush.

5-2. Radioactive hazards.

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. As a result, artificial warning and safeguards should be provided to prevent contamination by these materials.

(1) Fire hazard. The problems of providing safe storage of radioactive material are complicated by the possibility of fire hazard. Materials that emit radiation can become vaporized or turned to ash during a fire. These particles then become airborne radiation and can easily spread to other areas and contaminate all that they touch. Firefighting efforts are also hampered when radioactive material is concerned. Due to the possibility of leaking radiation, firefighters

Table 5-1. Safety Distances for Tank Storage

Capacity Tank Gallons	Minimum Distance In Feet from Property Line Which Is or Can Be Built Upon, Including the Opposite Side of a Public Way	Minimum Distance In Feet From Nearest Side of any Public Way or From Nearest Important Building on the Same Property
275 or Less	5	5
276 to 750	10	5
751 to 12,000	15	5
12,001 to 30,000	20	5
30,001 to 50,000	30	10
50,001 to 100,000	50	15
100,001 to 500,000	80	25
500,001 to 1,000,000	100	35
1,000,001 to 2,000,000	135	45
2,000,001 to 3,000,000	165	55
3,000,001 or more	175	60

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9 Apr 84

cannot get close enough for a period of time long enough to fight the fire.

(2) Radiation levels. The level of measurable radiation is usually the indicator used to classify the type of radiation area. As defined by the Occupational Safety and Health Administration, a radiation area is any area accessible to personnel where the level of radiation over the major portion of the body is such that in a 1-hour period the radiation dose would be in excess of 5 millirems, or in any 5 consecutive days a dose in excess of 100 millirems would be recorded. A high radiation area is classified as any area where the level of radiation over the major portion of the body is greater than 100 millirems per hour. Greater detail on levels of radiation and their classifications can be found in OSHA 1910.96.

b. Location and containment requirements.

(1) Facilities within other buildings. 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.

(2) Separate buildings. The location of separate facilities should be chosen so that the building is sufficiently distant from occupied buildings to preclude any danger of exposure to personnel not connected with movement or transportation of the material and to prevent contamination in case of an explosive accident. There should be sufficient access to the building such that fire equipment can get to the building in case of a fire or explosion, and the location should be chosen to minimize the possibility of human contact with airborne radiation that would result from any fire or explosion.

c. Site requirements. Selection of a radiation facility site will include consideration of the following factors.

(1) Surrounding operations considerations. The impact of surrounding operations upon the proposed facility will be included with respect to:

- Radiation background
- Effluents from nearby operations
- Fire and explosive hazard
- Capability of controlling access

9 Apr 84

(2) Relative location of facility. Impact of proposed facility is to consider operations in surrounding areas and in areas downwind and downstream of the proposed site, i.e., increased radiation background, effect of effluent discharge, and impact of most severe plausible radiation incident.

(3) Possibility of flood or land movement. Buildings in which radioactive materials are to be stored should preferably be single story without basements or other below-grade spaces.

5-3. Chemicals. There are two areas of safety consideration associated with hazardous chemical storage, chemical leakage, and fire or combustion.

a. Special construction. The drainage system should be provided with a central dry well or holding tank. Drains are not to be tied into the general waste water return lines.

b. Open chemical storage. Certain chemicals are such that they can be stored in open storage areas. The construction requirements of such open storage areas are similar to the requirements described for open storage of flammable and combustible materials. 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 also made easier when they are laid on their sides since the tops are always visible.

c. Gas cylinder storage. Gas cylinders should be treated as if they were always full and storage conditions designed to reflect this rule. It is preferable that gas cylinders be stored in open-sided sheds in order to minimize the possibility of harm due to build-up of a combustible, flammable, or toxic gas if a cylinder leaks. If a storage shed or building is necessary to confine the gas, at least 50 feet clear space should be allowed between it and any surrounding building to prevent injury in the case of an explosion.

5-4. Signs and safety markings. All hazardous materials storage areas should be identified as dangerous areas and warnings about smoking or carrying other flaming materials should be posted.

CHAPTER 6

TRANSPORTATION FACILITIES

6-1. General. Railroad operations allow for the efficient movement of large, bulky items and provide for economical movement of large quantities of goods by a minimum number of operating personnel. During times of mobilization, the majority of breakbulk cargo will travel to and from depots by rail. Therefore, depots must contain adequate provisions for movement of material by rail. Design of railroads will be in conformance with EM 1110-3-152.

6-2. Planning requirements.

a. Components. 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. These facilities should include: access lines, sidings and spur tracks, receiving tracks, classification tracks, departure tracks, tracks to warehouse, open storage areas, and material loading/unloading areas, as well as tail tracks, wyes when required, and tracks to engine house and maintenance facilities. Advantage should be taken of relatively level and well-drained sites in order to reduce the amount of earthwork.

b. Traffic. The planning of a yard or terminal layout involves an evaluation of traffic, operating, and strategic considerations. Terrain and traffic govern yard layouts to such an extent that there can be no standard layout. The operational parts of yards are used for receiving, storing, classification, and departure purposes, but setting aside separate areas (as distinguished from separate tracks) for these functions is the exception rather than the rule. (It is normal in very large yards only, and usually only in yards employing humps and complex switching and retarding equipment.) In addition to facilities necessary for repair of rolling stock and leads adequate to permit continuous switching without delaying other traffic, most yards need only one arrangement of ladders and parallel yard tracks.

6-3. Trackage requirements.

a. Access lines. Access lines will extend from the serving railroad to the boundary of the depot. 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 5 miles, either 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

9 Apr 84

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 breaks, compressed air lines should be installed in receiving tracks.

c. Classification tracks. Classification tracks are provided for the 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.

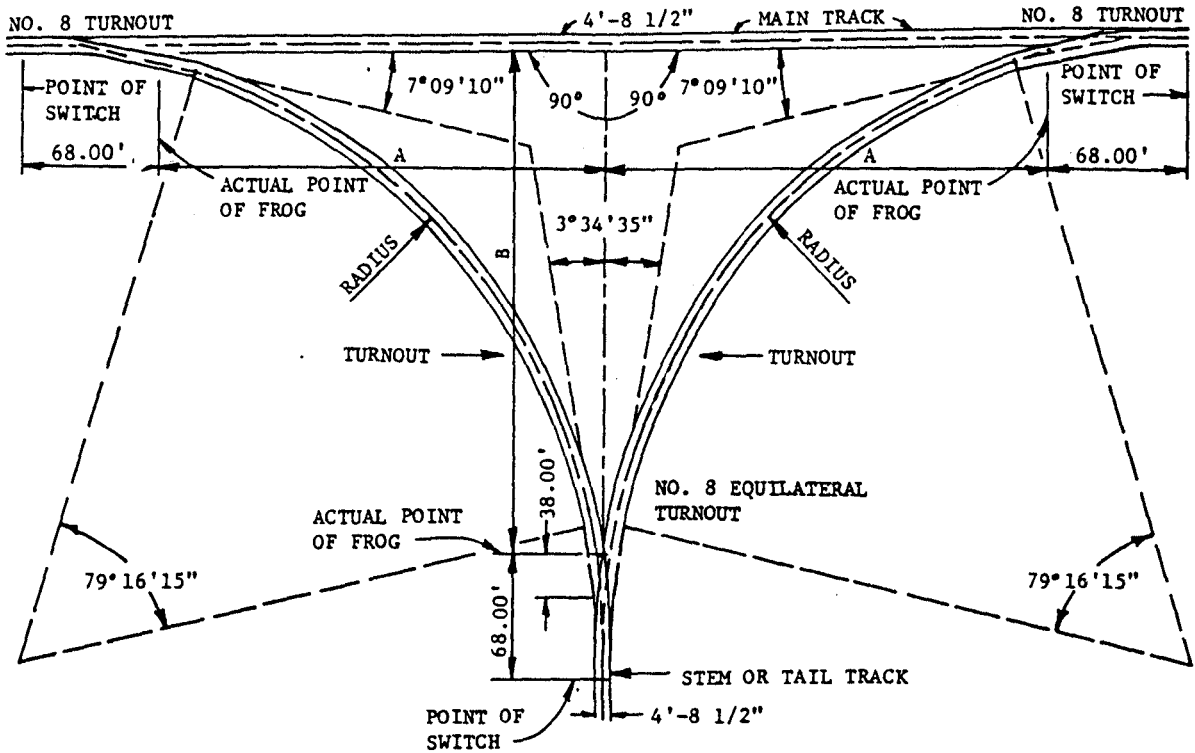
d. Departure tracks. Departure tracks are designed on the same principles as receiving tracks, and accommodate trains for inspection, air test, and attaching of locomotive and caboose prior to departure. Army trains may be run directly from the classification tracks, omitting departure tracks if provisions are made for car break testing. The receiving tracks can also 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. 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 12-foot-wide single road. Track layouts between the warehouse 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 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.

f. Wyes and rail 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 rail track, as shown in figure 6-1. In depot operations the tail track is made long enough to accommodate a locomotive and between 10 and 20 cars.

6-4. Signals and crossings.

a. Signals. Signal location should stress safety in high hazard areas. Design layouts should attempt to separate all rail traffic from civilian or Army vehicular or pedestrian traffic wherever it is possible. For example, administrative areas of the depot should be



CURVE DATA		
DEGREE OF CURVE	16° 00'	9° 30'
RADIUS	359.27	603.81
Δ	79° 16' 15"	79° 16' 15"
TANGENT	297.59'	500.14'
EXTERNAL	107.24'	180.24'
LENGTH	497.06'	834.23'

DEGREE OF CURVE	RADIUS	A	B
16° 00'	359.27'	321.30'	342.01'
9° 30'	603.81	534.92	569.40

U. S. Army Corps of Engineers

FIGURE 6-1. TYPICAL DESIGN OF WYE TRACKAGE

9 Apr 84

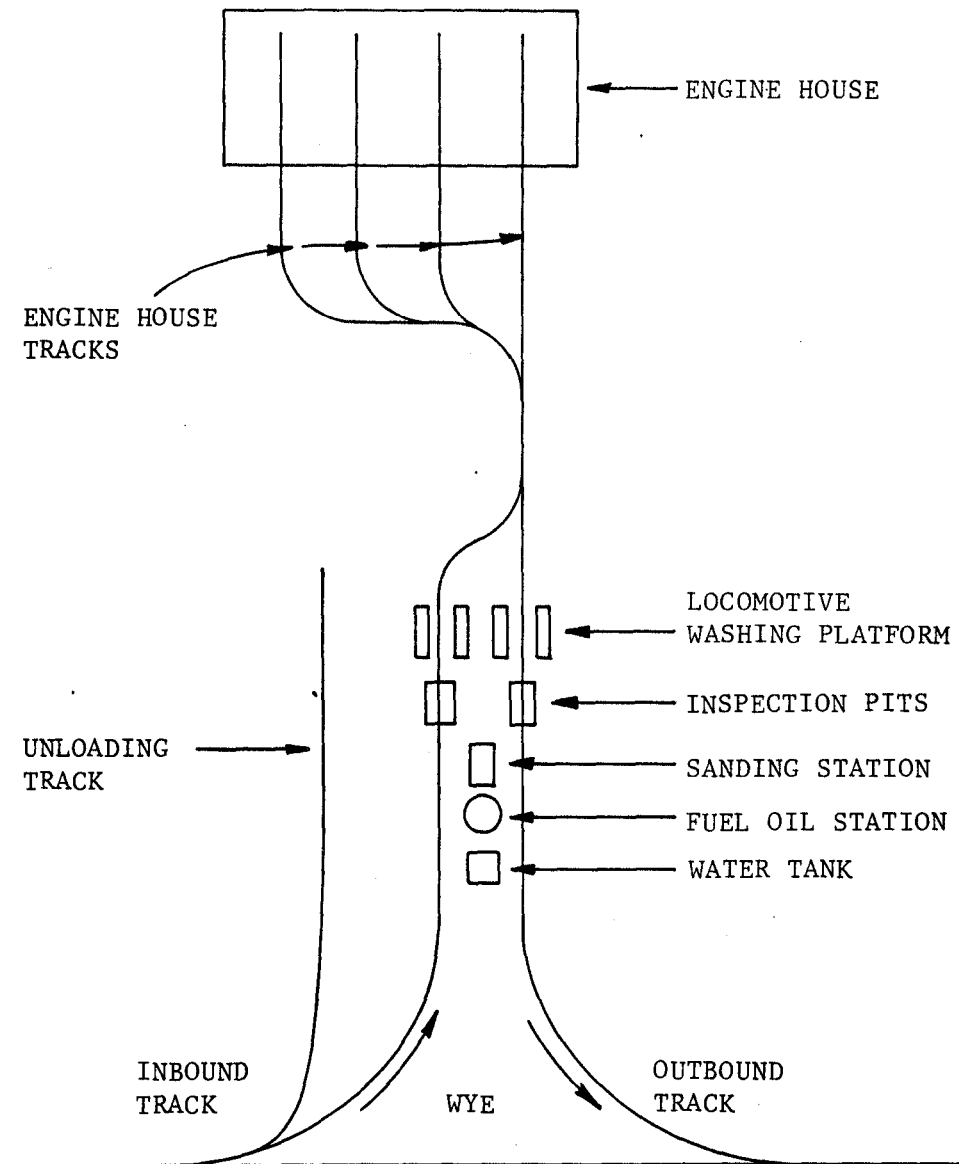
planned such that there are no rail lines crossing roads between the vehicular entrances to the depot and the final destination of these vehicles at administrative parking lots. This will eliminate the need for warning signals for daily traffic to and from the depot. If such a design cannot be planned, use of signals may be considered necessary. Within the warehouse area where rail lines cross roads between warehouses, signals are not considered necessary since it is a normal hazard to watch for moving freight cars, and yard speed limits will provide ample time for a potentially dangerous crossing to be avoided.

b. 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 5-year 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 cost more to install, but are removable and reusable and therefore are more economical to use in the long run. Further, because 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.

6-5. Engine shelter. The engine shelter should be a building designed for the purpose of housing and for conducting repair and maintenance to the depot locomotives. The engine shelter should be located close to the classification yard. This facilitates movement of the engine to and from the yard where most of its daily activity occurs. The engine shelter will be served by the number of tracks necessary to accommodate the number of locomotives utilized at the depot. The service facilities described below should line the engine shelter tracks.

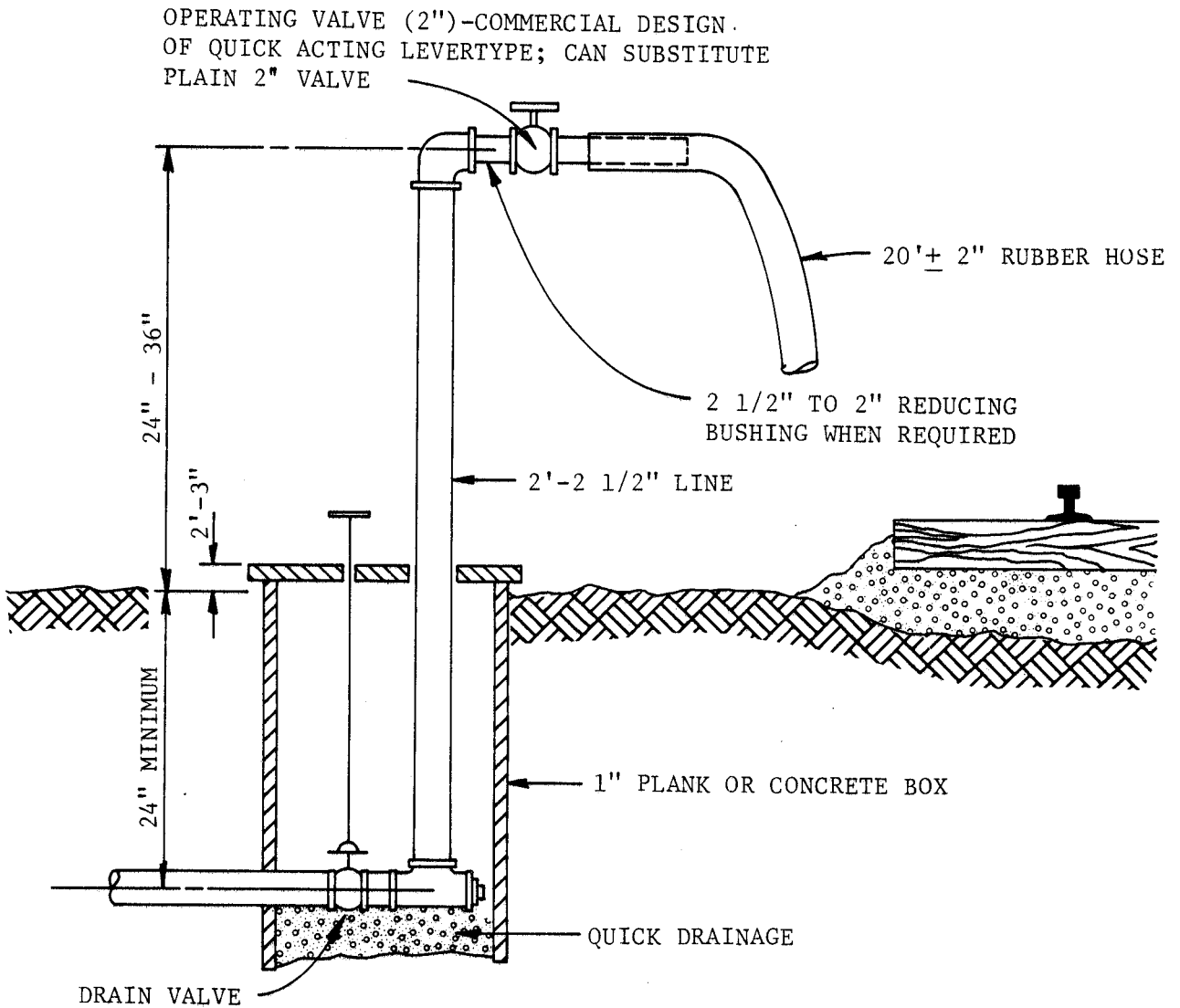
6-6. Service facilities. Service facilities should be laid out so the servicing operations can be performed in proper sequence as the locomotive moves through the terminal. The usual relation of operations and facilities is: (a) inspection at inspection pits or platforms; (b) lubrication (oil and grease service during inspection); (c) sand, diesel oil, and water at appropriate facilities; (d) running repairs at engine house; (e) outbound movement at the ready track and wye. All facilities used before entering the engine shelter should be placed on the inbound lead, as in figure 6-2.

a. Water requirements. Diesel locomotives require engine-cooling water and water to supply steam heating systems, if used. This facility should be provided at the engine terminal. The quantity required per locomotive will be between 100 and 200 gallons. A supply facility is shown in figure 6-3.



U. S. Army Corps of Engineers

FIGURE 6-2. SERVICE FACILITIES FOR DIESEL LOCOMOTIVES



NOTE: HOSE CONNECTION CAN BE TAKEN FROM
ELEVATED STORAGE TANK, INSTEAD OF FROM
UNDERGROUND SUPPLY LINE.

U. S. Army Corps of Engineers

FIGURE 6-3. DIESEL LOCOMOTIVE WATER FACILITY

9 Apr 84

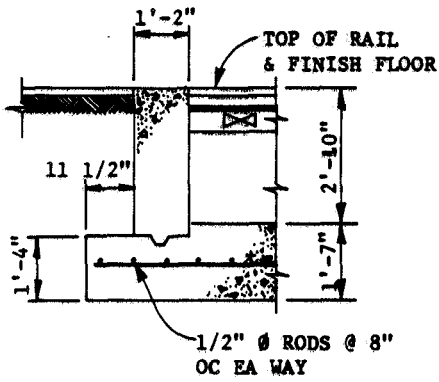
b. Fuel oil station. Diesel fuel oil should be stored in tanks placed high enough to permit fueling by gravity. If elevated tracks are available, the tank can be gravity filled from a tank car; otherwise, the oil must be pumped into the storage tank or forced out by compressed air. An earth dike should be built around the tank to form an impounding reservoir with a capacity greater than that of the tank. This earth-dike reservoir contains the oil and prevents fire or spread of fire in case the tank is damaged or destroyed. For fueling diesel engines, the nozzle on the fuel hose should be of a size and type that will not fit a water-intake opening, and vice versa, to avoid the accidental placing of water in the fuel tank or fuel in the water tank.

c. Sanding facilities. Sanding facilities are placed adjacent to the fueling station so that sand and fuel may be taken at the same time. Each terminal must be able to provide sufficient sand for all locomotives serviced there. Facilities must provide for unloading, storing, and drying of green sand and for the storage and delivery of dry sand. A fine, sharp, dry sand is required for locomotive traction or breaking ability. Sand may be placed in the locomotive by hand or by gravity from a tank placed at a higher level than the locomotive itself. The tank is filled by hand, clamshell, or compressed air. Where low temperatures are anticipated, steam coils are placed in the tank to improve flowability. Diesel locomotives have a capacity for 16 cubic feet. The rate of use and spacing of sand stations will be a function of gradients, train load, and number of stops made.

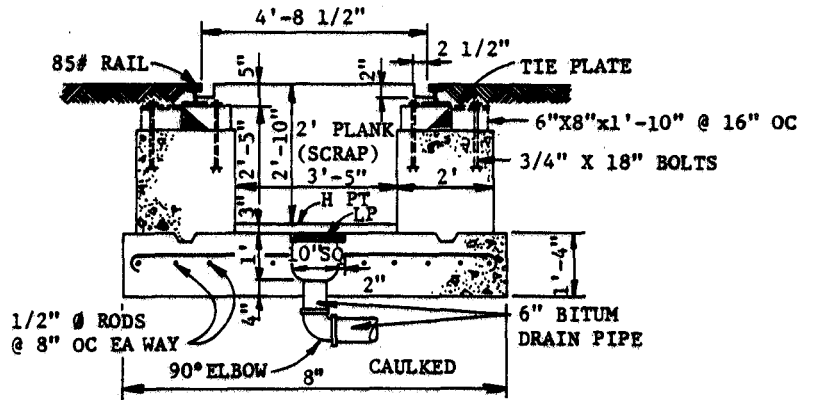
d. Inspection pits. For purposes of inspecting the underside of locomotives, an inspection pit is needed on the inbound track to the engine shelter. Figure 6-4 shows details of a concrete inspection pit; the drain is for removing collecting water from the pit.

e. Rail car facilities. The car shop, when required, will consist of a series of tracks designed to facilitate light repairs to cars. Tracks are laid in pairs spaced 18 feet center to center, with each pair separated 24 feet between adjacent track centers to provide material handling and storage space. The length and number of tracks will depend upon the anticipated amount of rail car repair. A machine shop may also be considered necessary to facilitate repairs to rail cars. The rail car shop and machine shop should be located close to the engine shelter so that the machine shop can be used for that facility also.

6-7. Yardmaster's office. Direction of rail activities for the depot occurs at the yardmaster's office. The yardmaster's office should be located on or close to the classification yard and may be a one- or two-story building, depending upon the size of the depot classification yard. If the structure is a two-story building, the top story should contain the operations room (block station) where direction of yard activities can be controlled from a better vantage point. This



SECTION OF END WALLS



CROSS SECTION

U. S. Army Corps of Engineers

FIGURE 6-4. CONCRETE INSPECTION PIT

9 Apr 84

facility may contain automatic switching equipment, signal controls, and radio equipment for directing remote operations.

6-8. Truck facilities. While railroad operations require more support facilities for efficient depot operation, most movement of goods around the depot will be by commercial and yard-type trucks. A fueling point, very similar to a gasoline station, will be required. They will need to be maintained and repaired by the depot motor pool, which is a post engineer facility. The yard cab storage area should be located near the maintenance and repair shops. It should be at minimum a covered, improved surface where cabs not being used can be stored.

CHAPTER 7

ADMINISTRATIVE SUPPORT FACILITIES

7-1. General. The administrative facilities of depot operations range from separate office structures to administrative offices located in the storage area. The size of these facilities will be given to the designer.

7-2. Parking facilities.

a. On-street parking. Each administrative building should have its own parking facility. Where it is necessary to utilize on-street 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. Typical off-street parking is designed for perpendicular parking with two-way traffic lanes. The required number of general purpose parking spaces can be determined from criteria found in table 7-1. Typical parking layouts and dimensions can be found in "Architectural Graphic Standards." Where massive parking lots are necessary, cross traffic connections should be planned every 360 feet or 40 spaces.

7-3. Cafeterias. Large depot facilities should have an administrative cafeteria for depot-operating personnel. The administrative cafeteria may be located in the administration building or in a separate facility within close walking distance to the administration building, while the operating personnel cafeteria should be centrally located to the area where most of the depot-operating personnel work. Access to the cafeterias should provide for parking and food delivery services. In small depot facilities, a single cafeteria may be provided.

7-4. Dispensary. Each depot will have a facility for the routine daily health care of its employees and to administer first aid in the case of emergency accidents. The dispensary should be in a separate building centrally located with respect to warehouse areas, open work areas, and administrative areas in order to minimize the time needed to get to medical help when an emergency occurs. In addition, access to the facility for emergency vehicles such as ambulances should be simple and direct.

7-5. Facilities engineering organization.

a. General. Every depot must have the support of a facilities engineering operation to carry on the day-to-day tasks of maintenance and repair of the depot. This support facility should be structured to reflect the size and needs of the depot mission.

Table 7-1. Parking Spaces Authorized for
Non-organizational Vehicles

<u>Facility</u>	<u>Number of Parking Spaces</u>
Administration, Headquarters and Office Buildings	50 percent of assigned personnel
Maintenance Shops	38 percent of assigned personnel, largest shift
Dispensaries, up to 5,000 sq. ft.	10 spaces
Security Offices (at gates) for installations of 110-2,000	5 spaces
Warehouses	One space for each 500 sq. ft. of office area, plus 1 space for each 4 persons assigned to storage activ- ities.
Enlisted Personnel Dining Facilities	30 percent of assigned military personnel and 38 percent of civilian employees.
Central food preparation facilities	50 percent of assigned military personnel and 38 percent of civilian employees.

Table from DOD 4270.1-M, Oct. 1, 1972 Department of Defense
Construction Criteria Manual.

9 Apr 84

b. In-house facilities. The designer will be given the applicable components from table 7-2 that are to be included in the depot layout. The layout should be compact, with storehouse and covered areas close to the vicinity of the shops. Main stores of lumber that can be exposed to the weather and the majority of steel stock should be housed in covered storage areas close to the using shops. All shops should have adequate parking area for vehicle parking and should have at least one large truck access for large pieces of stock. If fire station facilities are to be constructed, their location should be central to the depot and located on a main access road that will allow quick access to all parts of the depot.

Table 7-2. Components of the Facilities Engineering Group

- Administrative building to include space for:

- Administrative offices
- Administrative general office area
- Engineering offices
- Engineering drafting rooms
- Construction inspection office

- Plumbing shop
- HVAC shop
- Electric shop
- Motor pool
- Machine shop
- Welding shop
- Paint shop
- Road and ground maintenance shop
- Fire station
- Covered storage for equipment and stock
- Lumber yard

7-6. Security.

a. General. Depot security depends a great deal upon the type of material stored and the location of the depot. Normally, the mission of the depot will be to store material that does not require extreme security measures. Therefore, the purposes of securing the facility will be to prevent theft and pilferage. Where classified material and material that could be hazardous to personnel not familiar with its dangers will be stored, special security measures will be required.

b. Fencing. The degree of fencing security will be a function of the locale and the sensitivity of the stored material. As a minimum, perimeter fencing will be installed around all depots to prevent entry by unauthorized personnel and to eliminate loss of stored material due to theft. Chain link fencing will be the first choice of material to be used; different gages can be used to provide varying amounts of

9 Apr 84

security. For secure applications, no. 6-gage wire should be used; for lower security applications, no. 9 or no. 11 gage may be used. In high security areas, chain link fence at least 8 feet high should be topped off with three-strand barbed wire on outriggers facing outward. Wooden security fence should only be used where chain link is not available. Where privacy of operations is required, wooden fencing can be used, or chain link woven with metal flats to provide a visual barrier.

c. Gates. Gates and entrances should all be designed to have as high a degree of security as the total barrier. Provide all gates with hinges and padlocked bolt or plunger arrangements that cannot be easily tampered with from the outside of the installation. If the facility is not manned at all times, provide the main gate with a double lock system.

d. Security lighting. Security lighting such as street lights and flood lights on warehouses should be installed to discourage unauthorized entry at night.

7-7. Depot utility lines. All water, gas, and steam lines will be buried underground to make surface traffic movement more efficient. In storage areas or areas where aboveground electrical and telephone utility lines would provide a hindrance to the safe storage or movement of goods, all electrical and telephone lines will also be buried.

APPENDIX A

REFERENCES

Government Publications.

Occupational Safety and Health Act, Part 1910.96.

Department of Defense.

4270.1-M Construction Criteria Manual.

Department of the Army.

EM 1110-3-130 Geometrics for Roads, Streets, Walks,
and Open Storage Areas.

EM 1110-3-131 Flexible Pavements for Roads, Streets,
Walks, and Open Storage Areas.

EM 1110-3-132 Rigid Pavements for Roads, Streets,
Walks, and Open Storage Areas.

EM 1110-3-152 Railroads.

EM 1110-3-164 Water Supply, Water Distribution.

EM 1110-3-190 Electrical-Power Supply and Distribution.

Nongovernment Publications.

National Fire Protection Association (NFPA), Batterymarch Park,
Quincy, MA 02269.

Fire Protection Handbook.

No. 10-1981 Portable Fire Extinguishers.

No. 13-1980 Installation of Sprinkler Systems.

No. 30-1981 Flammable and Combustible Liquids Code.

No. 46-1978 Storage of Forest Products.

No. 231A-1975 Outdoor General Storage.

EM 1110-3-150

9 Apr 84

Ramsey, C.G., and Sleeper, H.R., "Architectural Graphic Standards,"
American Institute of Architects, John Wiley and Sons, New York,
NY.