College of Engineering
Industrial Engineering Department

King Saud University

IE 450
Industrial Facility Design

Unit (7a): Shipping & Receiving Area design

1) Definition
2) Components of receiving and shipping area
3) Equipment used in receiving and shipping area
4) Area Design

1- Definition

Receiving Area: is the area in which items and material are received. A number of tasks are performed such as:

- preparing for the arrival of trailers,
- selecting the appropriate handling equipment and unloading,
- examining and organizing the shipment, and
- preparation of receiving reports.

Shipping Area: is the area in goods are shipped. A number of tasks are performed such as:

- preparing trailers for shipping,
- examining and organizing the shipment
- selecting the appropriate handling equipment and loading, and
- preparation of shipping reports.

2- Components of receiving and shipping area

A. Docking Area (Unloading or shipping area) : It consists of:

- Number of platforms,
- Area of loading and unloading and handling equipment move and Maneuvering.
- Trailers waiting area.

B. Supporting Area support area: It consists of:

- Personnel Area (offices, bathrooms and drivers lounge).
- Handling equipment storage and maintenance areas.
- Buffer area for pallets & packaging.
- Waste disposal area.

3a- Equipment of receiving and shipping

A. Doors Equipment (platform exits), they include:

- Air Curtains: airflow through the exit to prevent insects, wind and weather factors.
- Strip plastic curtains doors: separate areas without traffic crashes.
- Hinged doors: doors close for safe and permanent separation.
- Swinging doors: self-closing and secured.
- Impact Doors: swing doors with collision support by pillars and electronic accessibility when the collision.
- Sliders: rollers doors open to different slots, either manually or automatically.
- Overhead doors: doors open up manually or automatically.

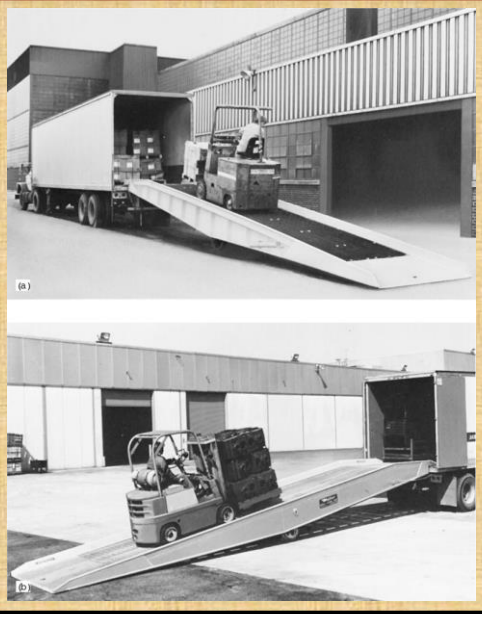
B. Levels settlement Equipment: Equipment to settle the level between the trailer and the platform dock or ground, they include:

A. Dock Levelers: settle the difference between the dock height and the trailer berth.
B. Bumper Pads: settle overlap between the dock fixed height and mobile trailer.
C. Dock Shelters: cover the settlement and overlapping points for the prevention of environmental factors.

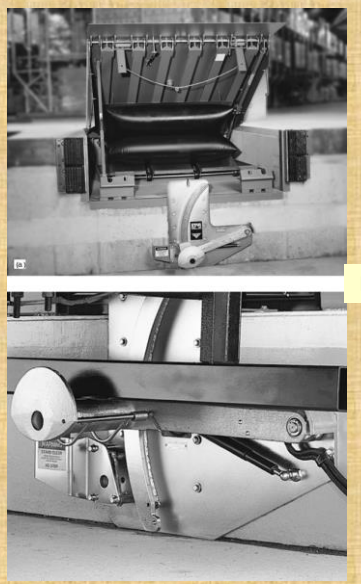
C. Examples:

3b- Equipment of receiving and shipping

Yard ramps



3b- Equipment of receiving and shipping



Permanent adjustable dock board

3b- Equipment of receiving and shipping

Truck Leveler

3b- Equipment of receiving and shipping

Lifting Device

Protection Device

4- Receiving and Shipping Area Design

Steps for calculating receiving and shipping area:

- Define the desired receiving and/or shipping items.
- Determine the number of loading docks and unloading.
- Design Trailer docking area and its shape.
- Determine space allowed for material handling equipment maneuvering on docking.
- Calculate the total area including comprehensive support area.

4a- Finding items required for receiving and shipping

Collect the required data in the table which include:

- Data for the following items varieties:
  - ✓ From repots find Existing items data.
  - ✓ Form Market analysis and a list of materials find new items data.
- Data on the types of trailers (shape and size)
- Data on the types of materials and handling equipment

Company:----------					Prepared by:----------		Date:-------		Page: to	
Receiving material (Items): ----------					Shipping material (Items):----------					
Items data							Trailer type		MH Equip.	
Description	Unit load				Quantities	Frequency	Mode	Specification	Method	Time
	Type	Size	Weight	Capacity						

4b- Finding Number of docks

A. Type of Data Collected:

- Frequency Rates of receipt or shipped items and their distributions.
- Standard Times of unloading and loading (service rates) and distributions.
- Trailers arrival times and distributions.

TIME STANDARD WORK SHEET

Company BCD Prepared by JA
Process Unload cartons, palletize, and store
Starting Point Spot carrier
Ending point Close truck door dispatch truck
Date_____ Sheet 1 of 1

Step	Description	Crew Size	USDA Reference Table Number	Productive Labor (Hours)
1	Spot carrier.	1	XII	.1666
2	Open truck door.	1	XII	.0163
3	Remove bracing.	1	XII	.1101
4	Get bridge plate.	1	XII	.0310
5	Position bridge plate.	1	XII	.0168
6	Place empty pallet at truck tailgate. Repeat 40 times.	1	XX	.2333
7	Unload cartons onto pallet. Repeat 640 times.	1	XIV A	1.5360
8	Pick up loaded pallet and move out of truck. Repeat 40 times.	1	VI	.3800
9	Transport pallet to storage area (100 ft) and return to truck. Repeat 40 times.	1	XI	.6040
10	Store pallet. Repeat 40 times.	1	VI	.1760
11	Remove bridge plate.	1	XII	.0048
12	Close truck door and dispatch truck.	1	XII	.0068
		Total		3.2817 hr

B. Methods for docks

- Simple calculation from data collected.
- Queue Lines theory by finding the rates and distributions.
- Simulation in the case of random data.

4b- Finding Number of Docks

Example:

At a site, materials quantity of 7500 lb./hr. can be handled for loading or unloading from three trailers of capacity of 4290 lb. each. Calculate the number of docks assuming the time trailer leaving the site is 10 min.

Solution:

- The time required for loading or unloading: 4290/7500 = 0.572 hr. = 34.3 min
- Total time for trailer service = 34.3 + 10 = 44.3 min.
- The number of trailer can be served on the dock = 60 / 44.3 = 1.34 truck / hr.
- Number of docks = [number of trailers / number of trailer can be served] +1= [3 / 1.35] + 1 = 3 docks

4b- Finding Number of Docks

Solution using queue conceps; Assume

1. Arrival rate is Poisson with $\lambda = 3$ (truck/hr.)
2. Service rate is Exponential with $\mu = 1.34$ (truck/hr.)
3. Ratio = $\lambda/\mu = 2.22$; then you need 3 docks

Solution using queue equations

1- equations for one server M/M/1/∞/

$$\rho = \frac{\lambda}{\mu}$$
$$P_o = 1-\rho$$
$$P_n = (\rho)^n P_o, \ldots\ldots\ldots n = 1,2,\ldots\ldots$$
$$L_q = \frac{\rho^2}{1-\rho}$$
$$L = \frac{\rho}{1-\rho}$$
$$W = \frac{L}{\lambda}$$
$$W_q = \frac{L_q}{\lambda}$$

2- multi server Equations M/M/S/∞ /

$$\rho = \frac{\lambda}{S\mu}$$
$$P_o = \frac{1}{\left[\left(\sum_{n=0}^{S-1}\frac{1}{n!}\left(\frac{\lambda}{\mu}\right)^n\right)+\frac{1}{S!}\left(\frac{\lambda}{\mu}\right)^S\left(\frac{1}{1-\rho}\right)\right]}$$
$$P_n = \begin{cases}\frac{1}{n!}\left(\frac{\lambda}{\mu}\right)^n P_o, \ldots\ldots\ldots\ldots 0 \le n \ge S \\ \frac{1}{S!S^{n-S}}\left(\frac{\lambda}{\mu}\right)^n P_o, \ldots\ldots\ldots\ldots n \ge S\end{cases}$$
$$L_q = \frac{P_o}{S!}\left(\frac{\lambda}{\mu}\right)^S \frac{\rho}{(1-\rho)^2}$$
$$L = L_q + \frac{\lambda}{\mu}$$
$$W_q = \frac{L_q}{\lambda}$$
$$W = W_q + \frac{1}{\mu}$$

4b- Finding Number of Docks

Assume the number of docks = 3

1. Calculate the probability of a trailer existence (representing (P0, P1, P2) (the possible existence of (0, 1, and 2))
2. Calculate the average number of trailers waiting Lq queue L system
3. Calculate the average of the existence of the trailers waiting Wq in queue system W time

$$\lambda = 3, \quad \mu = 1.354, \quad ratio = \frac{\lambda}{\mu} = \frac{3}{1.354} = 2.215, \quad \rho = \frac{3}{1.354\times 3} = 0.73855$$

$$P_o = 1\Big/\left[\left(\sum_{n=0}^{2}\frac{1}{(n)!}(2.215)^n\right)+\frac{1}{3!}(2.215)^3\frac{1}{(1-0.73855)}\right] =$$

$$= \frac{1}{1+2.215+\frac{1}{(2)!}(2.215)^2+\frac{1}{(3)!}(2.215)^3\frac{1}{0.26144}} = 0.079392$$

$$P_1 = \frac{1}{(1)!}(2.215)\times P_o = 2.215\times 0.079392 = 0.17586$$

$$P_2 = \frac{1}{(2)!}(2.215)^2 \times P_o = 2.45311\times 0.079392 = 0.19476$$

$$P_3 = \frac{1}{(3)!}(2.215)^3 \times P_o = 1.8112\times 0.079392 = 0.1438$$

$$L_q = \frac{0.079392}{3!}\times(2.215)^3 \times \frac{0.73855}{(1-0.74855)^2} = 1.5538 \quad Trucks$$

$$L = 1.5538 + 2.215 = 3.7688 \quad Tucks$$

$$W_q = \frac{1.5538}{3} = 0.51792 \quad hours$$

$$W = 0.51792 + \frac{1}{1.354} = 1.2565 \quad hours$$

4b- Finding Number of Docks

4. Calculate the cost using economic analysis assuming; the dock operating cost = 48 SR/hr., the trailer operation cost = 64 SR/hr.

in the case of the number of docks = 3 then the cost is:

Loading and unloading cost per hour = dock operating cost + trailer operation cost = 3×48 +1.257×64×3 = 385.36 SR/hr.

5. Repeat steps (3 and 4) assuming a number of docks to find the optimal number of docks and the result is shown in the table.

No. of Docks	3	4	5
Cost, SR/hr.	385.36	352.76	386.64

4c- Design of trailer area

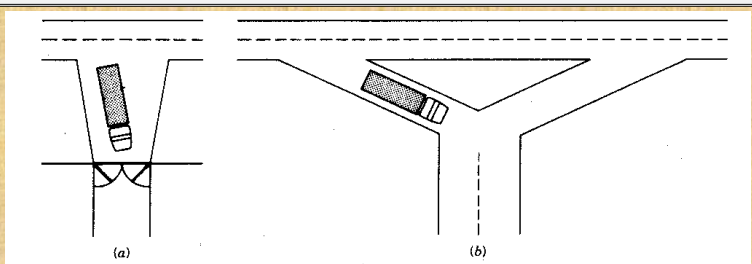
Area of trailers and trucks contains:

1) Entry and waiting area
2) Loading and unloading area

4c- Design of trailer area

1) *Entry and awaiting area*

- the movement flow forms of trailer traffic are analyzed taking into account the following:
- Width of two-way roads > (24 ft. / 7 m), and the gate width > (28 ft. / 8.5 m).
- Width of one-way roads > (12 ft. / 3.5 m), and the gate width > (16 ft. / 5.5 m).
- In the case of a pedestrian; add (4ft. / 1.5 m) to road width, and add (6ft. / 2 m) to gate width.
- Intersections is to be at least of radius (50ft. / 15 m) for ease of movement.
- Traffic will be counter-clockwise for ease of movement left steering wheel (steering wheel left).
- Trailers waiting area is adjacent to the area of loading and unloading to allow sufficient awaiting trailers.



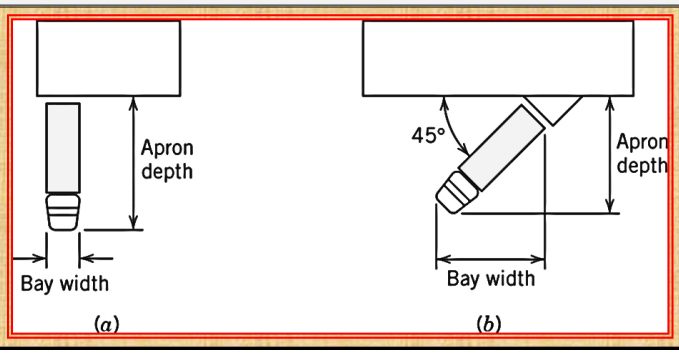
Recessed and "Y" approaches to facilitate truck access to property. (*a*) Recessed truck entrance. (*b*) "Y" truck entrance.

4c- Design of trailer area

2) *Loading and unloading area; it contains:*

a) Dock area: area for handling the material (maneuvering and buffers and flow area)
b) Trailer waiting yard at dock area: it is the adjacent area to dock and determined considering the trailer dimensions, its standing position and the method of maneuvers to stop and the inclination angle of the trailers with respect to dock.

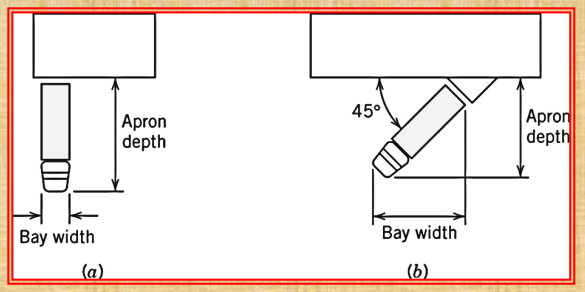
The figure below shows basic positioning of trailer in front of dock.



4c- Design of trailer area

Space fo 90^0 dock

Truck Length (feet)	Dock Width (feet)	Apron Depth (feet)
40	10	46
	12	43
	14	39
45	10	52
	12	49
	14	46
50	10	60
	12	57
	14	54
55	10	65
	12	63
	14	58
60	10	72
	12	63
	14	60

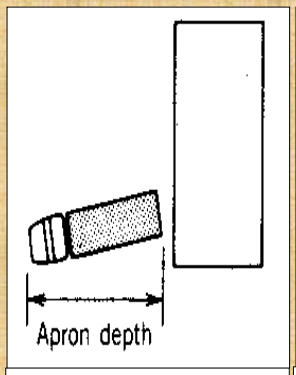


Dock space for 65 foot trailer

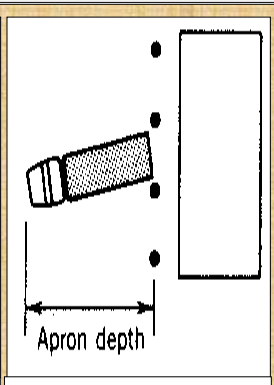
Dock Width (feet)	Finger Angle (degrees)	Apron Depth (feet)	Bay Width (feet)
10	10	50	65
12	10	49	66
14	10	47	67
10	30	76	61
12	30	74	62
14	30	70	64
10	45	95	53
12	45	92	54
14	45	87	56

4c- Design of trailer area

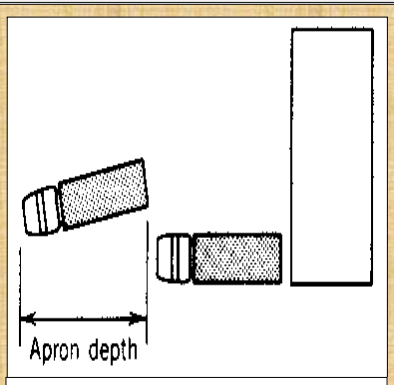
The figure below shows basic move and maneuver of trailer in front of dock at 90^0 angle.



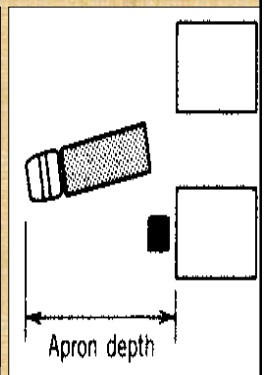
Dock for number of trailers without separate support



Dock for number of trailers with separate support



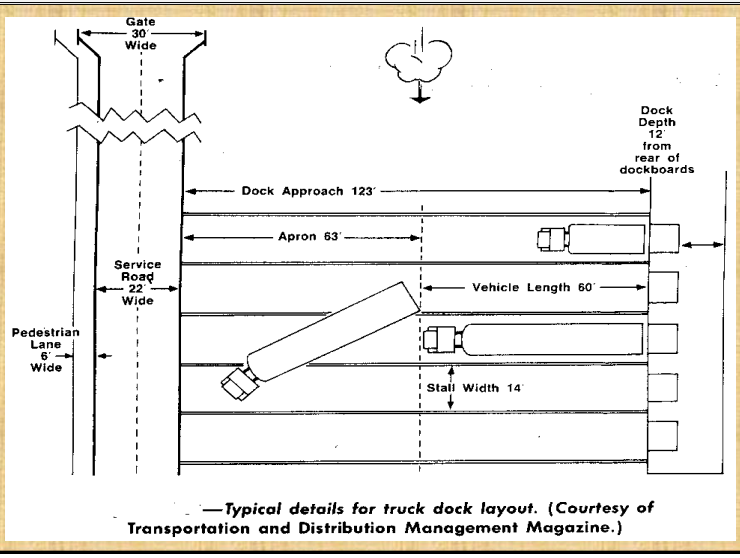
Dock for number of trailers with extra depth for maneuvering



Docks for number of trailers with separate space for maneuvering

4d- Design of receiving/shipping area

The figure below shows detailed layout for receiving/shipping Area.



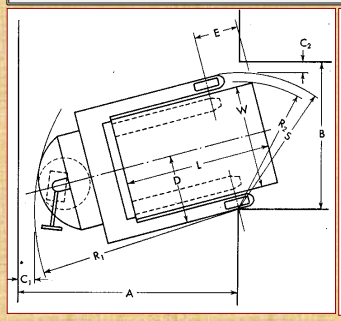
—*Typical details for truck dock layout.* (Courtesy of Transportation and Distribution Management Magazine.)

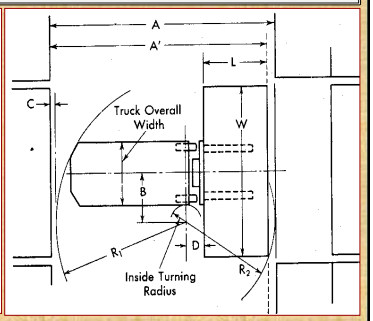
4e- Material handling Maneuvering Area

This depends on the type of material Handling Equipment as shown in table.

Maneuvering Area	
Material Handling equipment utilized	**Minimum maneuvering allowance, (ft.), m**
Tractor	**(14), 4.27**
Platform Truck	**(12), 3.66**
Forklift Truck	**(12), 3.66**
Narrow aisle Truck	**(10), 3.05**
Hand lift (jack)	**(8), 2.44**
Four-wheel hand Truck	**(8), 2.44**
Two-wheel hand Truck	**(6), 1.83**
Manual	**(5), 1.52**

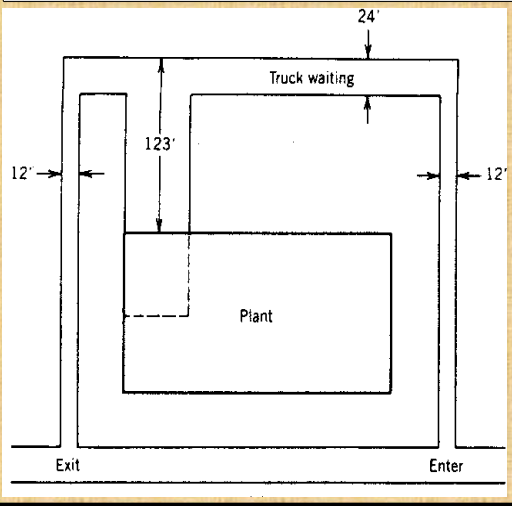
Example How forklift truck maneuvering area can be calculated





4f- Example for Area Calculation

Example 1: Factory is located north highway as shown in Figure. A receiving and shipping area is required, and it includes two docks for receiving and two shipping docks. the largest trailer to be served is of 60 ft. length that enter from the East of the plant and exit from the West. It was decided on the following:-



- The area is located at North west of the factory.
- Entry road at East and exit road at West (width of 12ft.)
- Waiting area at North (width of 24ft.)
- Trailer dock at an angle of 90^0 (width of 12ft.)
- Forklift is used for loading and unloading
- Buffers are required for 52 pallets (48 x 40 x 42 in)

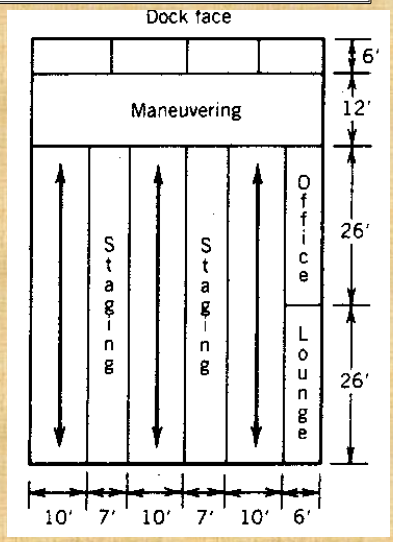
- ***Find the required receiving/shipping area; assuming any missing data***

4f- Example for Area Calculation

Solution: figure below show the design and dimensions. This is obtained based on the following:

- Width of dock = trailer width x number of docks =12 x 4 =48 ft.
- Apron (depth) = trailer depth +Depth of maneuver = 60+63 = 123 ft. It is the distance from north to dock face)
- Since left truck is used, the maneuvering distance =12+6 = 18 ft.; and maneuvering area = 18 x 48 =864 ft^2
- Two buffer with three aisles (assuming width of buffer=10ft.) are designed as follow:
  - Two pallets are stacked in a row. Since there are 52 pallets, hence, 26 rows art to be sacked.
  - Since two buffers are required, 13 row are stacked. hence, buffer Length (48/12 x 13) = 52 ; and buffer width (42/12x2) =7
  - Thus, the area of buffers = 52 x {7x2 + 10x3} = 2239 ft^2
- Estimate data for trucker's lounge, offices ,
- The total area is:

Maneuvering area	864 ft^2
Staging area	2288 ft^2
Truckers' lounge	150 ft^2
Office	150 ft^2
	3452 ft^2
or more realistically,	3500 ft^2



4f- Example for Area Calculation

Example 2: A company receives trucks that hold 4500 kg each. 2000 kg can be unloaded from the truck every hour and 15 minutes is allowed for the truck to leave and anther truck to pull in. If seven trucks are to be serviced at the busiest time of the day, Determine: -

i- The number of docks.

ii- The required space of the dock area for size 16m x 3m truck. Assume any missing data.

i- Number of docks

Truck Unload time, Tu = [4500/2000]	=	2.25	Hr.
Truck Time at dock (service time) , Ts =Tu+(15/60)	=	2.5	Hr./truck
Service rate = 1/service time = 1/Ts	=	0.4000	Truck/hr.
Arrival time per truck, Ta = 8 hr./Number of truck =8/7	=	1.1429	Hr./truck
Arrival rate =1/arrival time = 1/Ta	=	0.875	Truck/hr.
Number of docks = Arrival rate /service	=	2.1875 ≈ 3	Docks

ii- Area determination

Assume 90^0 docks

Assume clearance between docks =0.5 m

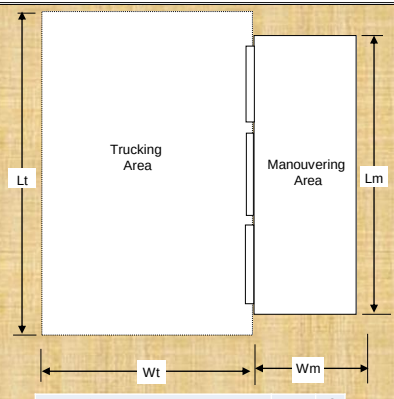
Assume clearance for platform depth =1 m

Assume platform depth = 3m

Assume clearances for truck area for length =1 m and width =3 m

Dimension determination

Lm, maneuvering length = 3-docks truck width + clearances= 3*3 +4*0.5	=	11	m
Wm, maneuvering width =platform depth + clearances = 3 +1	=	4	m
Lt, Trucking length =3-docks truck width + clearances = 3*3+4*0.5+2*1	=	13	m
Wt, Truck width = 2*Truck length + clearances = 2*16 +3	=	35	m



Area of trucks = 13*35 = 455 m^2

Area of maneuvering = 11*4 = 44 m^2

4g- Example for data

Example for data required for receiving and shipping area

Data		
Weekly estimated data	Receiving	Shipping
No. of units	81	4
No. of shipments	60	5
Total weights	500 kg	4500 kg
Volume	30 m^3	50 m^3
Working hrs.	20	0.5

4g- Example for Area table

Estimated areas for Receiving and shipping			
Receiving area		Shipping Area	
Area components	Area, m^2	Area components	Area, m^2
Dock Platform to maneuver for maximum unit load	36	Package accumulation units area	54
Unpack and sorting	18	Packaging and labeling	9
Temporary store	36	Temporary store	18
Inspection of received items	9	Wait for loading shipment	27
Wait for move to store/production	9	Loading pallet dock	18
Trailers area (4.2m x 12m)	51	Trailers area (4.2m x 12m)	51
Barriers and dampers	-	Barriers and dampers	-
Aisles (50% of temporary store)	18	Aisles (50% of temporary store)	9
MH equip. Store	8	MH equip. Store	8
Office	10	Office	10
Total	195	Total	194