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INDUSTRIAL PLANTS

Chapter sixteen:

Industrial trucks

**DOUBLE DEGREE MASTER IN
“PRODUCTION ENGINEERING AND MANAGEMENT”**

**SEAT OF PORDENONE
UNIVERSITY OF TRIESTE**

Generality

The **industrial trucks** are the means of handling (transport and often lifting) discontinuous and more used in factories and warehouses.

The different types can vary in:

- maximum height of lifting;
- gripping devices;
- how to load;
- depth of storage;
- capacity (load useful that can be transported on the vehicle);
- position of the load;
- position of the driver;
- type of engine;
- type of wheels;
- travel speeds.



Generality

The possible uses of trucks are:

- loading and unloading of vehicles;
- movements in yards of the plants;
- movement in the production departments;
- picking operations (fractionated sampling of load units of the lower level by loading unit of higher level);
- storage of units loads (UdC).

It is evident that in relation to the specific application will be chosen different technical solutions.



Generality

The decision to use a type of truck in particular depends on:

- lifting height from the ground;
- amplitude of the corridors (mutual influence);
- characteristics of routes (distances, frequency of travel, slopes of the traits etc.);
- characteristics of the UdC, such as length, width, height, shape, weight etc.;
- degree of automation required (by manual trucks at AGV - Automated Guided Vehicle - systems);
- regularity of the surfaces (types of wheels).



Generality



Truck AGV



Manual truck

Generality

The main types of industrial trucks include:

- the **transporter trucks**: hand pallet trucks, electric pallet trucks and tractors;



Hand and electric pallet truck



Electric tractor for towing

Generality

The main types of industrial trucks include:

- the **stacker trucks**: trucks with operator on the ground, with operator on board, with front-loading and side loading;



Stacker trucks with operator on the ground, with operator on board and lateral with operator on board

Generality

The main types of industrial trucks include:

- the **picking trucks** (for picking).

There are trucks with lifting guide, designed for picking operations (manual removal and storage of goods from shelves) inside industrial buildings



Generality

In motorized trucks can have:

- electric motors (current continues - DC - or current alternate - AC);
- combustion engines (fueled by diesel, petrol or liquid gas).

The choice must take account of:

- purchase costs;
- operating costs;
- maintenance costs.

The electric trucks have start-up times shorter and more rapidly reach the operating speed.

The diesel trucks are more robust and therefore more suitable for heavy work and on uneven ground (to example outdoor operations).

The carriages with internal combustion engines can only be used outdoors due to emissions from the exhaust gas.

In the presence of several electric trucks must involve an area of recharge of batteries, which must be confined in a separate ventilated room (aspiration) to the containment of vapors of sulfuric acid.

Forklifts trucks

The **forklifts trucks** are the most common type of truck in the industry.

Allow to perform the operations of loading and unloading of unit loads on pallets or in containers.

They may have the shunter on board or to the ground.

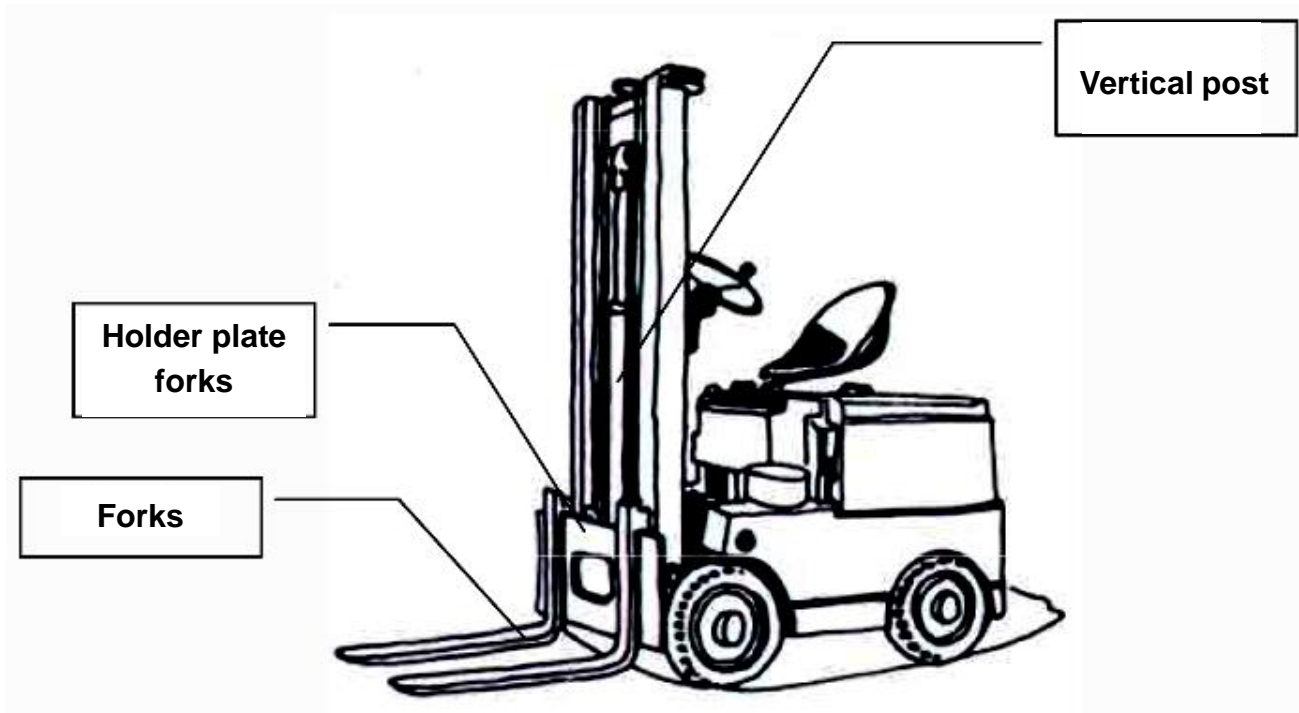
The **forks** are mounted on a sliding plate on a vertical upright.

The upright can then be fixed to the structure of the truck or partly fixed and partly movable (telescopic strut).

The lifting of the forks is controlled by the motor or a pneumatic system, while the descent is usually by gravity (the motion, however, is withheld).

Forklifts trucks

Forklift trucks

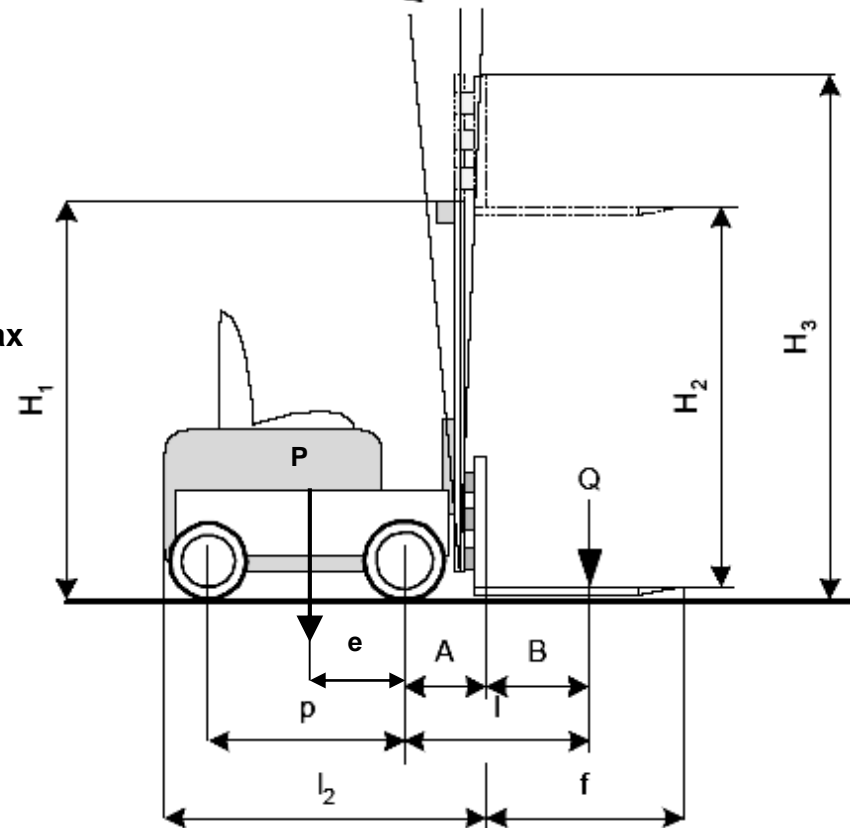


Forklifts trucks

The size characteristics of a forklift truck are the following:

Training: is the possibility of the upright to tilt forward and backward (to the maximum of 2-3° forward and 8-10° backward)

- H₁:** height of the truck to uprights lowered
- H₂:** maximum height of lifting of the forks
- H₃:** maximum encumbrance in height with forks raised to the max
- A:** distance (surface front of forks - front wheel axle)
- B:** distance (center of gravity of load - front wheel axle)
- p:** step of the wheels
- l:** distance (center of gravity of load - front wheel axle)
- l₂:** length of the truck without forks
- f:** length useful of the forks
- Q:** gross weight of cargo carried



Forklifts trucks

The capacity is constant for each truck is:

$$C = l \cdot Q$$

with: l = distance, Q = gross weight.

It can therefore determine:

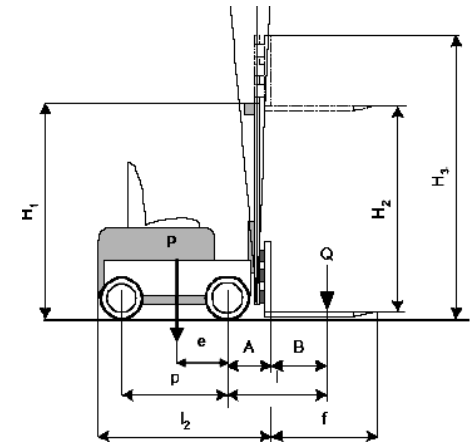
- the maximum encumbrance of the UdC:

$$l = \frac{C}{Q}$$

- the maximum capacity of the truck for a given length of the UdC:

$$Q = \frac{C}{l}$$

Usually the manufacturer provides the maximum range of the truck, the position of center of gravity (B) and the distance between the front surface of the forks and the axis of the front wheels, one can get the capacity of the truck C .



Forklifts trucks

In the event that the nominal flow rate of the lift truck is of 20 kN, that the center of gravity is to the distance B of 700 mm from the front surface of the forks and that the distance between the front surface of the forks and the axis of the front wheels A is 450 mm, is:

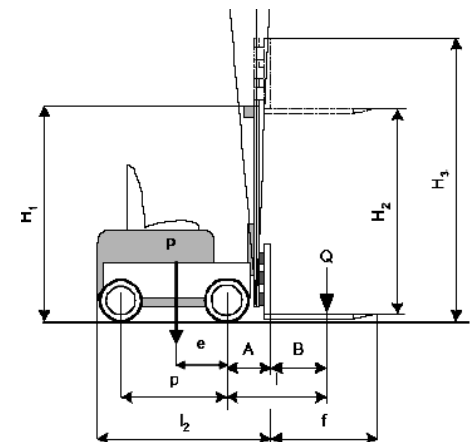
$$l = A + B = 450 + 700 = 1150 \text{ mm}$$

$$C = \frac{1150 \cdot 20}{1000} = 23 \text{ kN m}$$

The nominal flow indicated by the manufacturer for a particular position of the center of gravity is obtained from the equilibrium condition of the overturning moment ($M_R = Q \cdot l$) and that stabilizing ($M_S = P \cdot e$).

The coefficient of static security to the longitudinal overturning is given by the relation:

$$K = \frac{M_S}{M_R} = \frac{P \cdot e}{Q \cdot l}$$

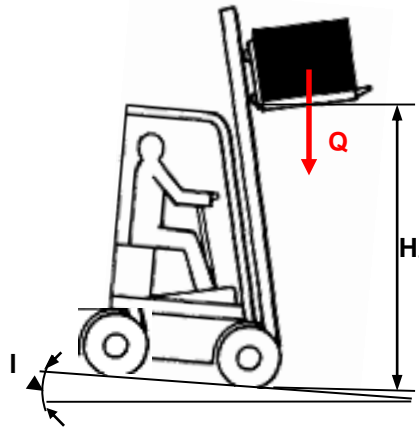


Forklifts trucks

The UNI ISO 22915 requires the forklift to 3 or 4 wheels, to uprights tilted or not, with load willing to overhang and operator on foot or aboard, to satisfy the specific stability tests.

a) **stability test longitudinal in the stacking**

The forklift truck must be placed on a horizontal platform with the axis of the front wheels parallel to the axis of rotation of the platform



having denoted by:

Q = test load (rated capacity or maximum load of the truck)

H_1 = maximum height of lifting of the forks

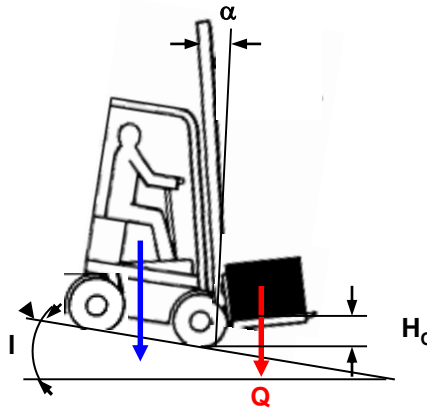
I = inclination of the test platform (4% for $Q < 50$ kN)

Forklifts trucks

The UNI ISO 22915 requires the forklift to 3 or 4 wheels, to uprights tilted or not, with load willing to overhang and operator on foot or aboard, to satisfy the specific stability tests.

b) **stability test longitudinal in the movement**

The forklift truck must be placed on a horizontal platform with the axis of the front wheels parallel to the axis of rotation of the platform



having denoted by:

Q = rated capacity of the truck

H_o = height of the forks from the inclinable platform (300 mm)

α = maximum inclination backward of the uprights

l = inclination of the test platform (18%)

Forklifts trucks

The UNI ISO 22915 requires the forklift to 3 or 4 wheels, to uprights tilted or not, with load willing to overhang and operator on foot or aboard, to satisfy the specific stability tests.

c) lateral stability test of the stacking

The forklift truck has to be disposed on the platform so that the straight line joining the center of a front wheel with the projection perpendicular to the platform of the point of intersection between the longitudinal centerline of the carriage and the axis of the rear wheels is parallel to the axis of rotation of platform

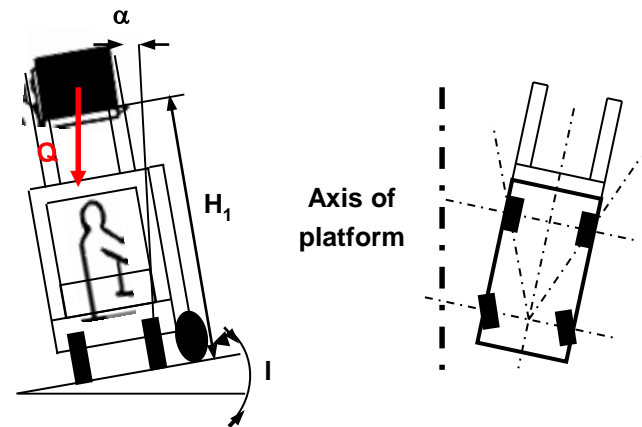
with:

Q = rated capacity of the truck

H_1 = maximum height of lifting of the forks

α = maximum inclination backward of the uprights

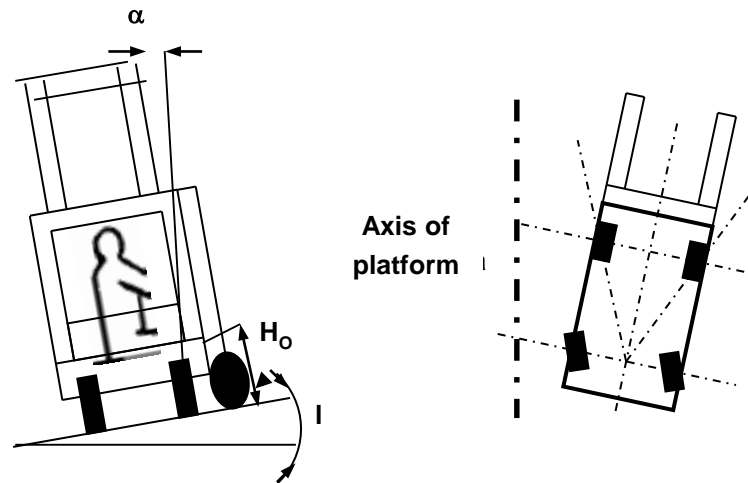
l = inclination of the test platform (6%)



Forklifts trucks

The UNI ISO 22915 requires the forklift to 3 or 4 wheels, to uprights tilted or not, with load willing to overhang and operator on foot or aboard, to satisfy the specific stability tests.

d) lateral stability test on the move with truck unloading



indicating with:

H_o = height of the forks from the inclinable platform (300 mm)

α = maximum inclination backward of the uprights

l = inclination of the test platform (50% for $Q < 50$ kN and 40% for $Q > 50$ kN)

Forklifts trucks

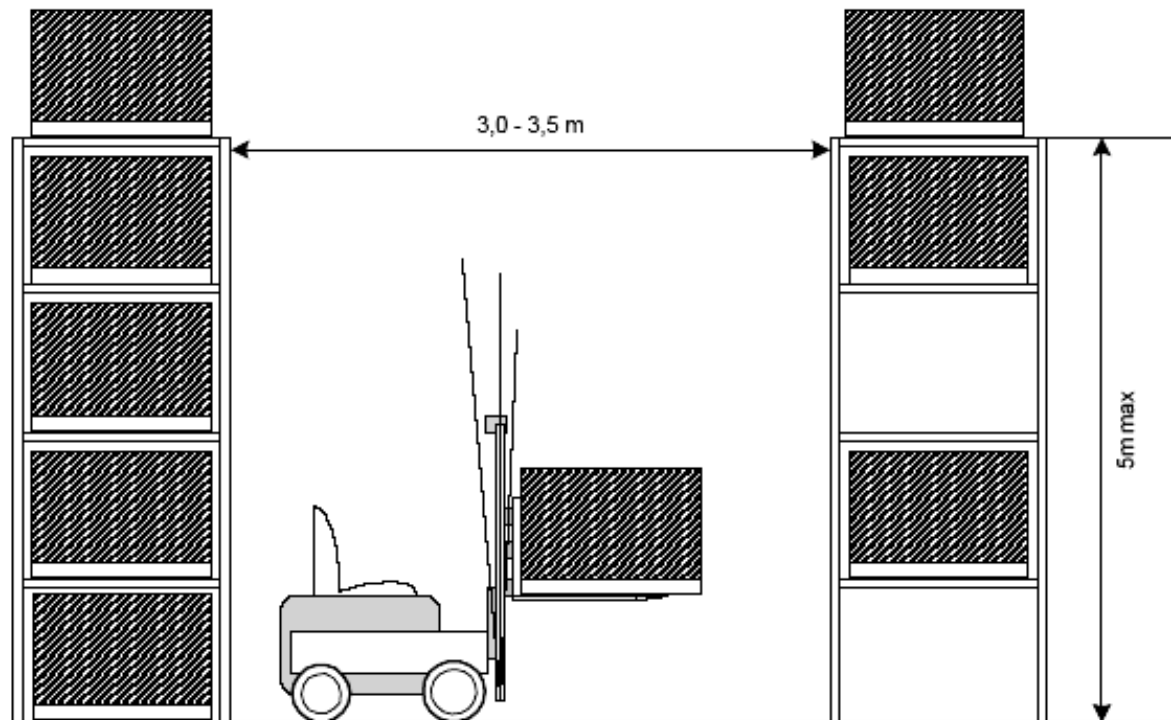
The **lifting height of the forks** is an important parameter of the forklift trucks from which depends on the maximum height of storage of the materials

The capacity of a forklift truck decreases with the height of the lifting forks. If the truck has the uprights tilt able its scope is affected with the load lifted with inclination forward of the uprights, compromising its stability. If the slope of the posts is backwards, lifting heights of the forks above 5 m influence the capacity of the truck.

Forklifts trucks

You may have **forklift trucks to counterbalanced with front loading:**

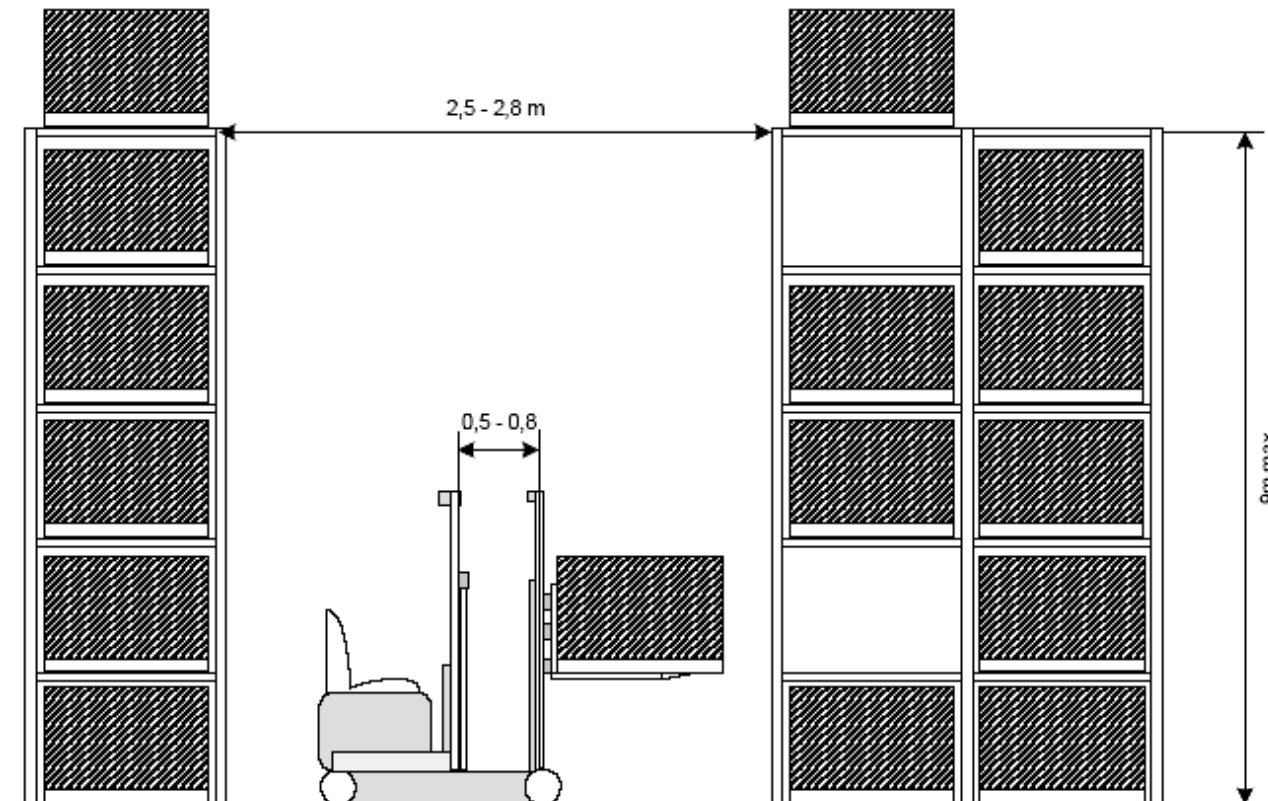
- with electric motor with a maximum capacity of the truck Q of 40 kN up to 6 m in height;
- with diesel engine with maximum capacity of the truck Q of 60 kN up to 6 m in height.



Forklifts trucks

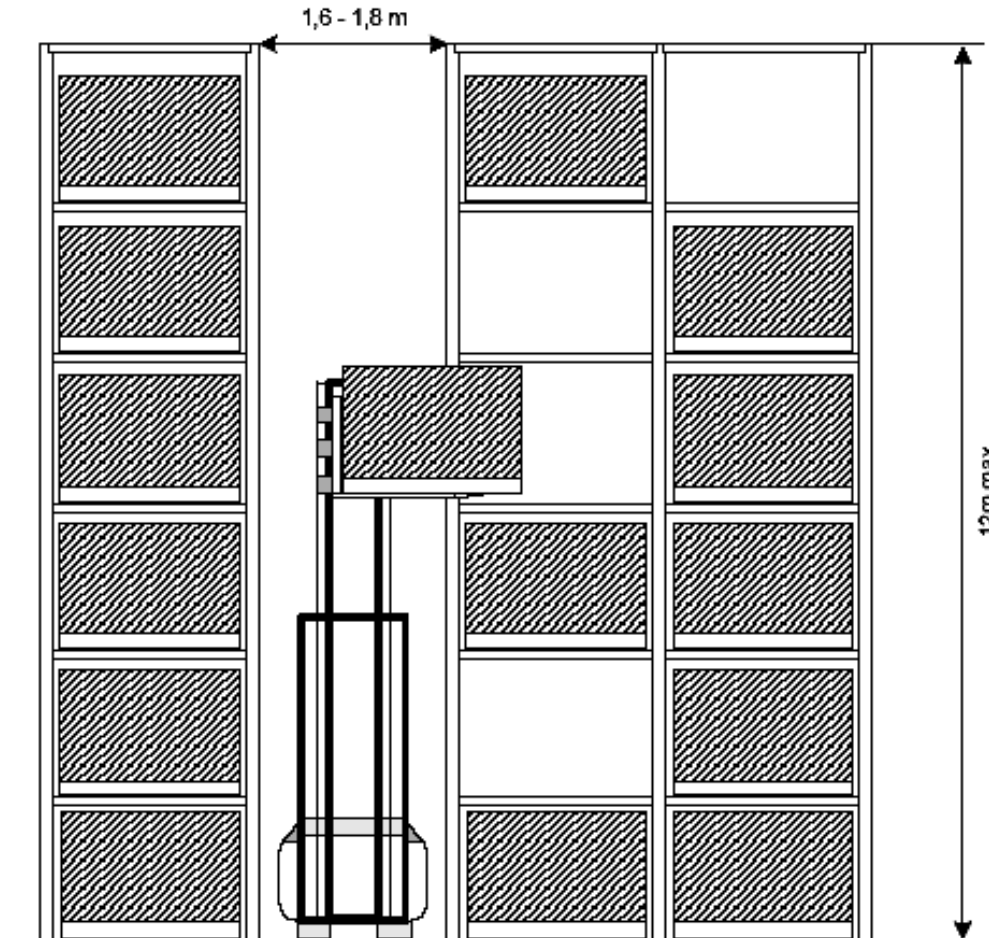
The **forklift trucks with retractable mast** can be both at counterweight both provided with breeds of support.

The center of gravity is always within the polygon circumscribed by the wheels of the truck: this allows for greater stability.



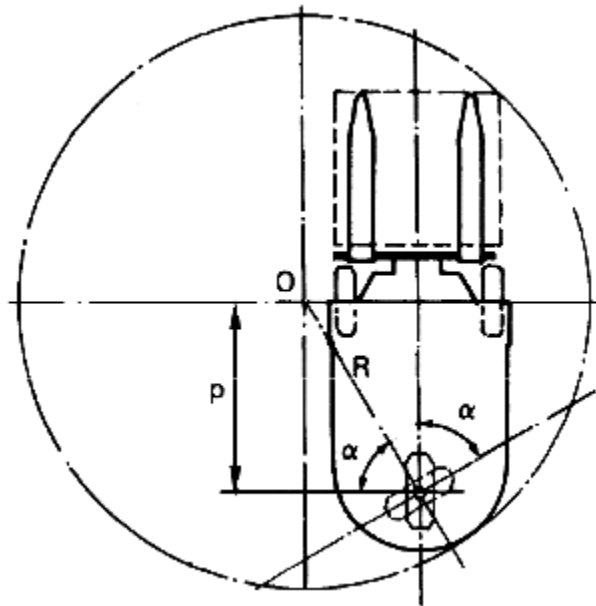
Forklifts trucks

The **forklift trucks with side loading or trilateral must** not be positioned perpendicularly to the shelving for picking and unloading.



Forklifts trucks

The **minimum radius of steering** in the event of a truck with a single steerable wheel (rear), we have for the maximum steering angle α :



$$p = R \cdot \sin \alpha \qquad R = \frac{p}{\sin \alpha}$$

Forklifts trucks

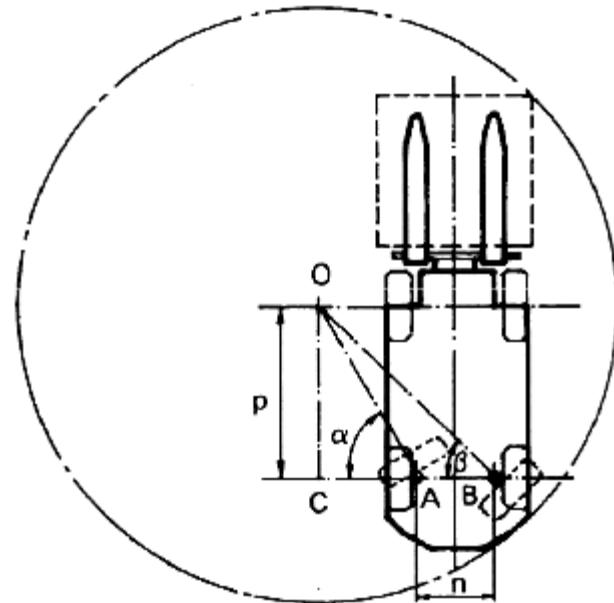
In the case of a truck with two rear steerable wheels is noted that even if the steered wheels assume different angles, their axes of rotation, however, meet a single point which lies on the axis of the front wheels.

It has for the maximum angles of steering α and β :

$$p = \overline{AC} \cdot \operatorname{tg} \alpha = \overline{BC} \cdot \operatorname{tg} \beta$$

$$n = \overline{BC} - \overline{AC} = p \cdot \left(\frac{1}{\operatorname{tg} \beta} - \frac{1}{\operatorname{tg} \alpha} \right)$$

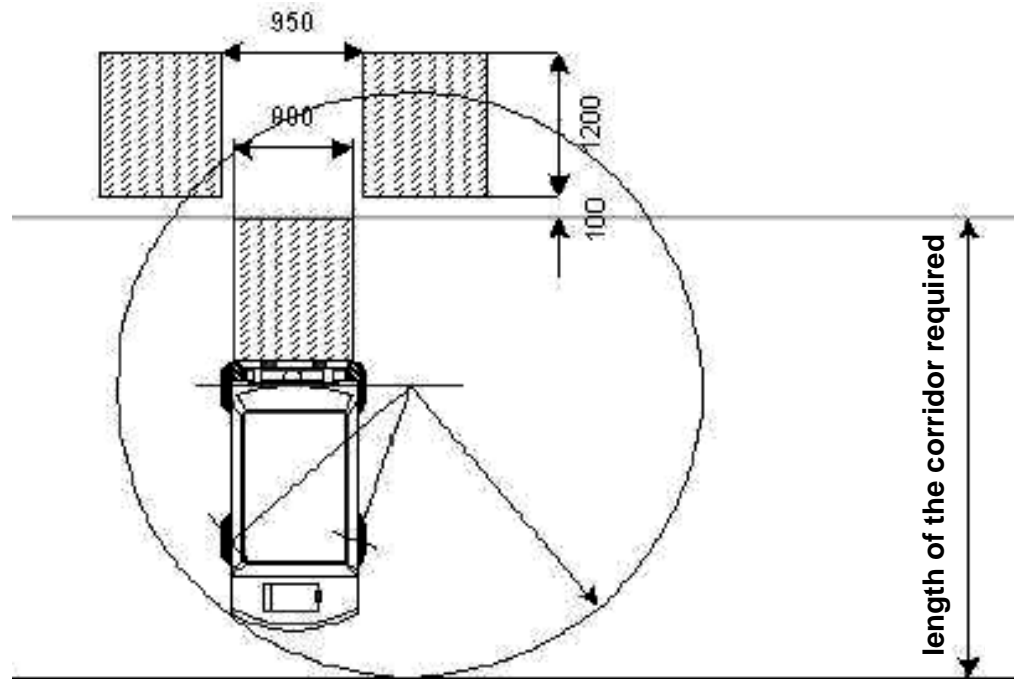
$$p = \frac{n}{(\operatorname{ctg} \beta - \operatorname{ctg} \alpha)}$$



Forklifts trucks

It can therefore determine the minimum radius of rotation in the middle point of the rear axle of the truck.

Know R and the dimensions of the truck, you can determine the minimum radius of encumbrance in phase of steering of the truck. It will add to this minimum the safety clearances.



Forklifts trucks

Other data concerning the **performance** of trucks:

- travel speed with and without load (typical values: 10-20 km/h);
- lifting speed of the forks with and without load (0,2-0,5 m/s);
- rate of descent of the forks with and without load (0,4-0,6 m/s);
- slope surmountable with and without load (6-9%);
- towing capacity on the hook with and no load own.

Piker trucks

Are of trucks used only for the actual operation of picking on shelves that grow in height.

I can lift loads up to medium to large heights of 9 m.

The travel speeds can reach values of 10 km/h.

The lifting speeds can reach up to 20 m/minute.

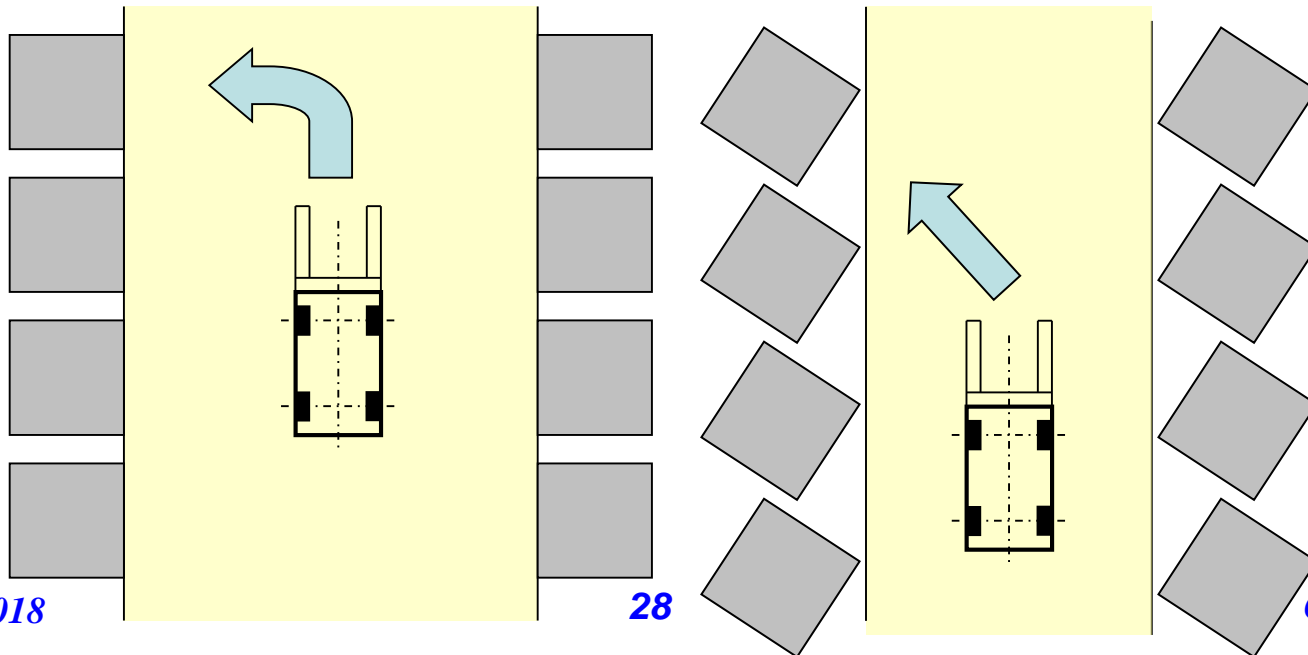


Type of forklift trucks and special tools for trucks

The fundamental point to realize the movement within a plant is to reduce to a minimum width of the passages, which can be obtained:

- a) adopting of the particular mode of arrangement of the material along the corridors

Is possible to arrange the UdC not normally to the axis of the corridor, but obliquely from the same axis (reducing the width of the corridors, but increases the length).



Type of forklift trucks and special tools for trucks

The fundamental point to realize the movement within a plant is to reduce to a minimum width of the passages, which can be obtained:

b) using of the special trucks

- **truck straddle**, which has a footprint smaller radii while steering has a smaller footprint in length, creating greater stability of the truck. They are equipped with front wheels of small diameter and must be accompanied by the two front arms to load itself and withdraw or deposit it. In this way, the UdC should be arranged at a greater distance or in a shelf raised above the floor of ground



Type of forklift trucks and special tools for trucks

The fundamental point to realize the movement within a plant is to reduce to a minimum width of the passages, which can be obtained:

b) using of the special trucks

- **truck equipped with articulated device for the advancement of the forks**



Type of forklift trucks and special tools for trucks

The fundamental point to realize the movement within a plant is to reduce to a minimum width of the passages, which can be obtained:

b) using of the special trucks

- **truck at fork sliding on the plate support and demountable**



Type of forklift trucks and special tools for trucks

The fundamental point to realize the movement within a plant is to reduce to a minimum width of the passages, which can be obtained:

b) using of the special trucks

- **truck at fork at action trilateral (batching of the load trilateral)**, which allows handling of the loads from the front and on the two sides of the corridor without the trolley carries the maneuvers of steering



Type of forklift trucks and special tools for trucks

The fundamental point to realize the movement within a plant is to reduce to a minimum width of the passages, which can be obtained:

b) using of the special trucks

- **truck at action trilateral with great lifting height of the forks of the height and preset automatic of the height**



Type of forklift trucks and special tools for trucks

The fundamental point to realize the movement within a plant is to reduce to a minimum width of the passages, which can be obtained:

b) using of the special trucks

- **truck at lifting platform for the handling of containers by means of elements at rollers**



Type of forklift trucks and special tools for trucks

In the case of handling of packages does not constituting the UdC, are installed on lift trucks of the Implement.

You can have:

- **implement to jaws for the handling of packages cylindrical**



Paper roll clamps

Type of forklift trucks and special tools for trucks

In the case of handling of packages does not constituting the UdC, are installed on lift trucks of the Implement.

You can have:

- **implement to jaws for the handling of cardboard boxes without pallet**



Pull and push the load borne



Gripper for cardboard

Type of forklift trucks and special tools for trucks

In the case of handling of packages does not constituting the UdC, are installed on lift trucks of the Implement.

You can have:

- **special equipment for forklift trucks for handling of drums, bags, bales, bulk materials etc.**



Plates rotating



Pliers for stems

Type of forklift trucks and special tools for trucks

In the case of handling of packages does not constituting the UdC, are installed on lift trucks of the Implement.

You can have:

- **arms of forks to variable center distance for the handling of UdC of different sizes**



Extension of the load