

FACTORS INFLUENCING WAREHOUSE CONSTRUCTION IN RELATION TO SAFE OPERATION

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Abstract

The article deals with safety in warehouses. The article focuses on work safety for drivers of handling equipment and compliance to technological procedures for loading goods onto shelves. Failure to comply with safety rules causing damage to goods and reduces the efficiency of logistics companies. Currently, safety conditions are being violated because of the employment of unskilled workers - logistics operators. In the Czech Republic a dual system of education does not prepare the appropriate personnel. Main aim of this article is to analyze safety in logistic and focus to safety in warehouses and give possible suggestion how to improve current situation in safety in Czech Republic.

Keywords: Warehouse, logistics, forklift

1. INTRODUCTION

Optimum, safe and economically effective operation of rack warehouses is conditioned by warehouse system project coordination, which is based on the design of:

- suitable racks,
- suitable type of forklift trucks,
- suitable pallets.

These basic elements must comply with requirements for stored goods, which are defined by weight and dimensional parameters. During manipulation with a pallet into a rack compartment, there is a physical interaction of a forklift truck between truck forks and rack construction. Due to this interaction, forces are formed that affect the rack construction. Frictional forces are formed when shifting pallets on rack beams, also vertical stress occurs, in some cases torsional stress as well.

Racks are designed for low random values of transverse loads. Inconsiderate and aggressive manipulation by drivers with insufficient qualifications can cause formation of relatively high forces affecting rack constructions and subsequently their damage. The margin in load capacity of racks, given by the standard safety coefficient during their design, is not a reason for violating technological processes defining operational safety of these racks. [1, 2]

The determination of safety philosophy for statistical analysis and design load, which are influenced by the way of pallet manipulation, is based on the following requirements:

- responsible way of pallet manipulation by an experienced driver,
- space situation enabling sufficient truck manoeuvrability,
- suitable forklift truck appropriate for the intended use.

On the basis of a marketing study, we determine for what type of goods, with what annual volume and average stock turnover the warehouse will be built. It is important to know precise dimensions and weight of unit items

of the given goods, the container type and load units into which the goods will be assembled (most often pallets). On the basis of these parameters, we choose the rack type and its location in the roofed warehouse. Then, according to the arrangement of racks and the design of manipulation areas, a building design company works out designs for warehouse construction. This procedure eliminates cases when supporting columns extend into racks or passages and limit work and movement of handling equipment.

2. MAIN PRINCIPLES OF SAFE OPERATION OF FORKLIFT TRUCKS IN RACK WAREHOUSES

The recommendations are valid for forklift trucks used in rack warehouses with racks with adjustable compartment size, with compartments for one pallet and with racks allowing trucks to drive in. After depositing the pallet on the rack beam or after its lifting from the beam, a dynamic reaction between the rack construction and forklift truck forks occurs, which must be small enough. The size of this dynamic reaction is given by pallet lift height, its weight, distance of load centre of gravity from forks guide, and depends on the correct choice of type and size of truck tires.

The width of warehouse passage and rack arrangement must provide for sufficient forklift truck maneuverability with respect to truck type, overall pallet dimensions including possible goods overhang, bend and inclination, character of loaded goods and number of pallets handled per time unit.

It is forbidden to load the rack above values stated on its type plate, attached to the rack construction. Rack constructions in areas of possible truck collision (warehouse passage corners, rack undercrossings, heels along rack passage posts) must be protected by installing safety guards at least to the height of 0.5 m above floor level (against accidental overload 2.5 kN and 1.25 kN respectively). When handling pallets inside the rack itself, it is forbidden to do both horizontal and vertical movements at the same time. If horizontal movement is in progress, the pallet must be lifted high enough from the supports. The pallet is placed on supports using slow and steady movement, forks must release the pallet so that they do not touch the rack. The pallet must be lifted using slow and steady movement without impacts to any constructional parts of the rack above the pallet (sufficient space must be kept above the upper edge of the load). The pallet must be placed on rack supports so that a sufficiently large support area is ensured. If the rack gets still damaged by the forklift truck, all stored goods must be immediately loaded out of the damaged part of the rack. After a proper repair or possibly replacement of the damaged part of the rack, the rack can be loaded again.

The width S_{mu} of the handling passage for rectangular storing can be determined [5]:

- a) according to technical documentation, e.g. for material transport vehicles,
- b) by calculation, e.g. for transfer trucks:

$$S_{mu} = R + x + 2B \quad (1)$$

where:

R ... truck outer turning radius (mm)

x ... pallet length (mm) exceeding forks length,

B ... safety play ($B = \text{ca. } 200 \text{ mm}$).

The width S_{du} of the handling passage during one-way drive can be determined:

$$S_{du} = S_b + 2B \quad (2)$$

where:

S_b ... width of the transfer truck or the moved load (mm), (depending which dimension is higher),

B ... safety play ($B = \text{ca. } 200 \text{ mm}$).

A two-way passage is double the width of a one-way passage. The rule for passage width says that for one-way transport passages, the width is not set below 2,400 mm, and for two-way passages below 4,000 mm. The lowest width and height of doors, crossings, underpasses, etc. must correspond to the passing clearance of the used handling equipment in an operating position.

During travel, forklift trucks must have their forks and pallet lowered to the height of ca. 100 mm above floor level and with the mast slightly tilted backwards. When transporting less stable loads on pallets, a sufficient mast tilt is the elementary condition for truck drive. When using additional attachments, the mast must be in the position stated in its operating conditions. Trucks cannot travel with lifted loads, because there is a risk of their rollover. The only exception is truck travel at micro-travel speed during stock placement or retrieval operations. Truck travel with a restricted forward view is prohibited. In inevitable situations, when bulky goods restricting driver's forward view must be transported, the truck must travel backwards. For forklift trucks with a pusher, the pusher sliding mechanism must be fully retracted. Due to a transversely positioned seat and a substantially better view of the driver, these trucks are driven backwards. [3]

During stock placement, the driver drives with the forklift truck symmetrically in front of the rack compartment, into which the load will be placed. He visually checks that nothing obstructs the intended manipulation, while the distance from the rack construction is 40 mm. Subsequently, he inserts the pallet into the rack compartment and lowers it on supports so that the pallet protrudes max. 50 mm into the passage and if there is a pallet stored in the compartment, it must be offset at least 40 mm from it. When the pallet is stored safely, the driver lowers the forks so that they release the pallet. They must not touch neither the bottom part of the pallet nor rack supports. [11]

The process is reversed for stock removal, while observing safety precautions so that goods, the rack construction or the truck does not suffer damage and that operating staff including the driver does not suffer any physical harm. During stock removal from higher rack compartments, the driver must visually check and evaluate pallet weight, determine its centre of gravity and decide on the operating procedure. He assesses whether load capacity of the truck is not exceeded and checks if forks length corresponds to pallet depth. If this is not the case, the forks must have a mark, showing how far they can be slid into the pallet so that another pallet is not picked up. The driver carefully lifts the pallet by 40 to 50 mm and slowly slides it out of the rack compartment. [4, 6]

When attending drive-in racks, it is necessary to observe sufficient distances between a pallet base and a lateral guide (if installed) and between two side walls of an entrance channel. Other procedures are the same as in previous paragraphs.

3. PALLET AND ITS LOAD

Used pallets must always be in perfect condition. They must not have any part broken or damaged, nails must not protrude from them and they must not show any other similar faults. The pallet type and its dimensions must ensure its stable position after stacking (must have a supportive area large enough and must be correctly oriented in the compartment). The goods must be loaded on the pallet in a stable position (must form a compact whole with it) and must not exceed its plan to ensure both safe travel and warehouse operations. Overall dimensions must not exceed inner dimensions of rack compartments. Weight of a pallet with load and its centre of gravity position must always be assessed, as well as the distance between pallet and front edge of vertical fork arms in relation to the interpretation of forks centre of gravity. It is prohibited to handle loads that clearly are not suitable for transportation or for warehouse operations. [7, 10, 12].

4. MOST FREQUENT FAILURES IN FORKLIFT TRUCK OPERATION

These are often caused by insufficient maintenance of forklift trucks. Frequent truck overload (insufficient load capacity) causes faster tyre wear and excessive deformation of their sidewalls. This also influences the dynamic reaction of the lift mast during lifting and warehouse operations. An empty truck has roughly the same load on both axles. For a loaded truck, 90 % of the load goes to the front axle (truck kerb weight and load weight).

New trends in truck construction enable reducing their dimensions and weight, while maintaining the same load capacities. This requirement takes into account decreasing dimensions of warehouse passages. The approach to racks and warehouse operations are performed without a sufficient forward view. Insufficient dimensions of the rack compartment require lateral shift of forks to increase truck's manoeuvrability. It is important to note that in practice load side shift is used to a limited extent, because this manipulation requires some time and also some handling capabilities of the truck.

The weight of stored pallets exceeds maximum value stated on the type plate of the rack. Uneven load of rack compartments is also frequent.

Overall dimensions of a pallet with a load (goods) exceed values stated on the type plate of the rack. Goods placed on a pallet have higher overhang, inclination, are unevenly spread, etc. Pallet bend can be caused by the period for which the goods are stored on the pallet. Pallets of incorrect type (dimensions, loading area span, supporting area span, etc.) are inserted into racks. With insufficient lift of the pallet from supports of the rack compartment, the pallet is dragged or pulled across supports. If the pallet is raised too high, it causes impacts to the level of the upper rack compartment. When placing a pallet with insufficient horizontal position, most of its weight is transferred to the first support/beam or the back supporting arm of the pallet compartment receives an impact. [9]

Pallets with different depth (1000 mm and 1200 mm) are stored in a pallet rack. Pallets with higher depth overhang on both sides of the rack beam, which is then not loaded over pallet blocks, but by the bend of the bottom wooden part. It must be assessed whether the supporting arms do not get overloaded. It is strongly recommended not to use this storing method, maybe only in cases when pallets are of a very high quality, guiding lines for placing pallets in the centre of rack compartments are marked in the warehouse and a strict labor discipline is observed. In case of double racks, when a pallet is placed too deeply in a rack compartment, a neighboring pallet will be damaged or even pushed out of its rack compartment, which can endanger the operation and safety in the neighboring passage.

In an adjustable pallet rack compartment, which is equipped by a transverse beam or a bottom plate, it is possible to store two pallets in a row. They must be removed separately. There is a high risk that during removal they can be pulled together, because they are very tightly next to each other, or that after forks are inserted into the front pallet, the back pallet will be lifted as well, without the driver noticing it.

Pallets with higher depths cannot be stored in racks without bottom plates or transverse beams, because the back runner can easily get outside the support, because the truck driver has a restricted view. The same case happens with racks with transverse beams or bottom plates when storing pallets with higher depths.

When approaching a drive-in rack, a pallet is not fully released from the supporting arm and is pushed back by the friction force, which can cause a serious damage of the rack construction.

When building new warehouses, floor levelling also plays an important part, only standard variations are permissible. In case of higher tolerances, rack operation by forklift trucks is more difficult, because a horizontal plane of a loaded pallet cannot be ensured, which represents a risk to operational safety and can lead to damage of goods. Load capacity of the floor or its surface finish must not be underestimated, because it again considerably slows down truck movement and prolongs times of technological operations. Load capacity of

the floor must be set according to an average weight of a loaded pallet and a total load of rack construction by loaded pallets.

An appropriate attention must be paid to handling areas at warehouse entry and exit. These must correspond to the required volumes of inward and outward cargo. On the basis of a marketing study, also means of transport used for goods transportation must be known. In case of lorries, the handling contact takes place via gates with sealing collars, which creates a joint workspace protected against weather influences. Ramps to these gates are equipped with guiding guardrails, because lorries must back up, and the stop is protected by rubber bumpers so that the back wheel arch protection of vehicles is not damaged. If these are railway wagons, they are shunt to the warehouse handling area so that loading and unloading again takes place in a weatherproof environment.

In the Figure 1 you can see typical defects due to improper storage. Defect A represents curved beams and columns. They may cause danger. Defect B represents the slope of the shelf. The maximum slope of the shelf shall not exceed the applicable standard deviation given by standard. Defect C represents weight and positioning of loads. The weight of load must not exceed the mentioned maximum load. The load must be positioned correctly. [8]

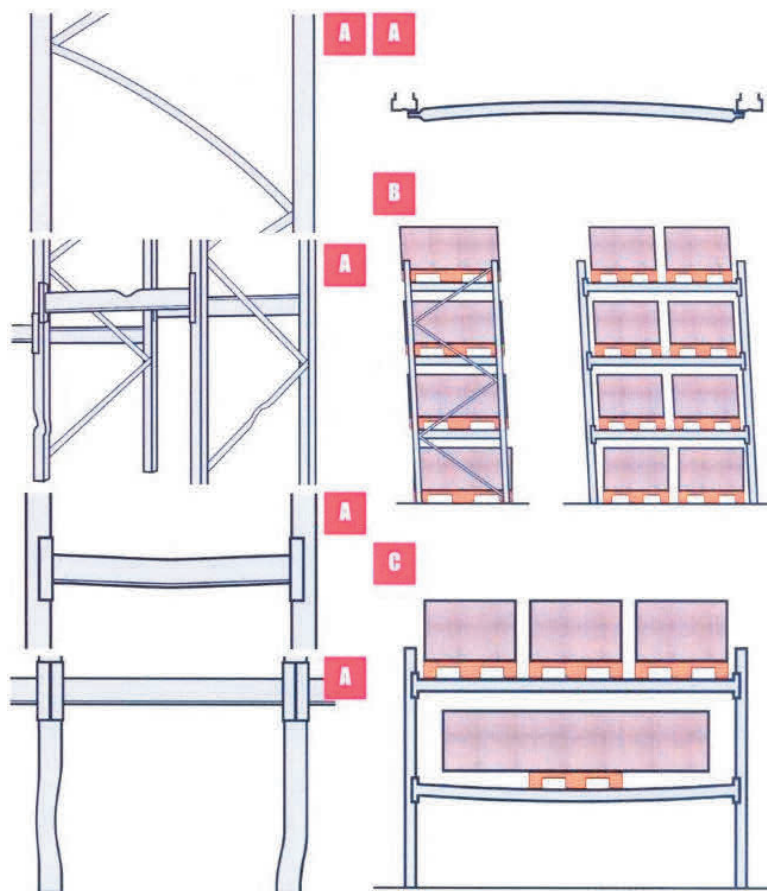


Fig. 1 Typical defects due to improper storage

Warehouse safety is very important part of the warehousing process. Accidents happen in any warehouse, but regular inspections could minimize the number and effect of them. Small changes throughout the year - caused by moving of goods, fitting and refitting of the racks and general knocks through the daily use - can in the end seriously change the capacity of the racks. This can lead to incidents in a warehouse, potentially causing damage to both man and material.

The challenge is to spot the changes early enough to avoid additional future costs, which requires the experience of a trained expert who knows what to look for. Fully certified and highly experienced rack inspectors must be employed to conduct yearly inspections to ensure your facilities are kept safe. Following every inspection a detailed report is provided, offering advice and indicating areas that require immediate action or future attention by using a simple traffic light indicator. Each visit is certified and documentation provided that can be clearly displayed on the racks to confirm our inspection. Inspections must strictly comply with all government guidelines and legislation and any rectification work is fully guaranteed.

There are three main types of risk level. They are explained in the following part. The **EN 15635** defines a standard logical method of recording and reporting damage and problems. A classification system of Green, Amber and Red is used.

- Green level - requiring surveillance only.
- Amber - hazardous damage requiring action as soon as possible.
- Red - very serious damage requiring immediate action.

Green level

- Observed damage but within that level that does not require repair and the damage does not affect the racking capacity.
- Damaged area is recorded/marked.
- The damage is observed continuously and will be evaluated at the next periodic inspection.

Amber level - it is not allowed to insert new pallets in this area before repair is made

- Registered damage that exceeds the maximum dimensions as shown in the standard.
- This applies when damage has caused a deviation of the damaged area which is bigger than the one indicated on the sketch, but less than 2 times the approved deviation.
- Amber mark means that the damage does not require immediate emptying of the racks, but the parts will be replaced within 4 weeks from the date of inspection.
- The damage will be monitored continuously and if the situation worsens, the damage will be changed to red level.

Red level - damage must be repaired urgently

- Registered damage with deviations greater than the dimensions shown in the standard.
- The damage differs more than the specified tolerances times 2.
- This type of damage requires immediate action.
- The rack should be unloaded, isolated and not used until repairs are completed.

5. CONCLUSION

In conclusion, it should be mentioned that ever more frequent transports and higher volumes of transported and stored goods with high value require its protection against damage and partial or complete loss. Therefore it is necessary to secure access to such goods using chip cards. By using these access codes, employees have a limited movement in warehouses and cannot enter areas for which they do not have access. Similarly at admission gates of warehouse areas, lorry drivers receive a chip that guides them to the handling area and limits their free movement. The driver must return this chip upon exit. .Main aim of this article was analyzing

safety in warehouses and give possible suggestion with respect of norm EN 15635 and TAPA (Transported Asset Protection Association) to increase safety in warehouses and logistic center itself.

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