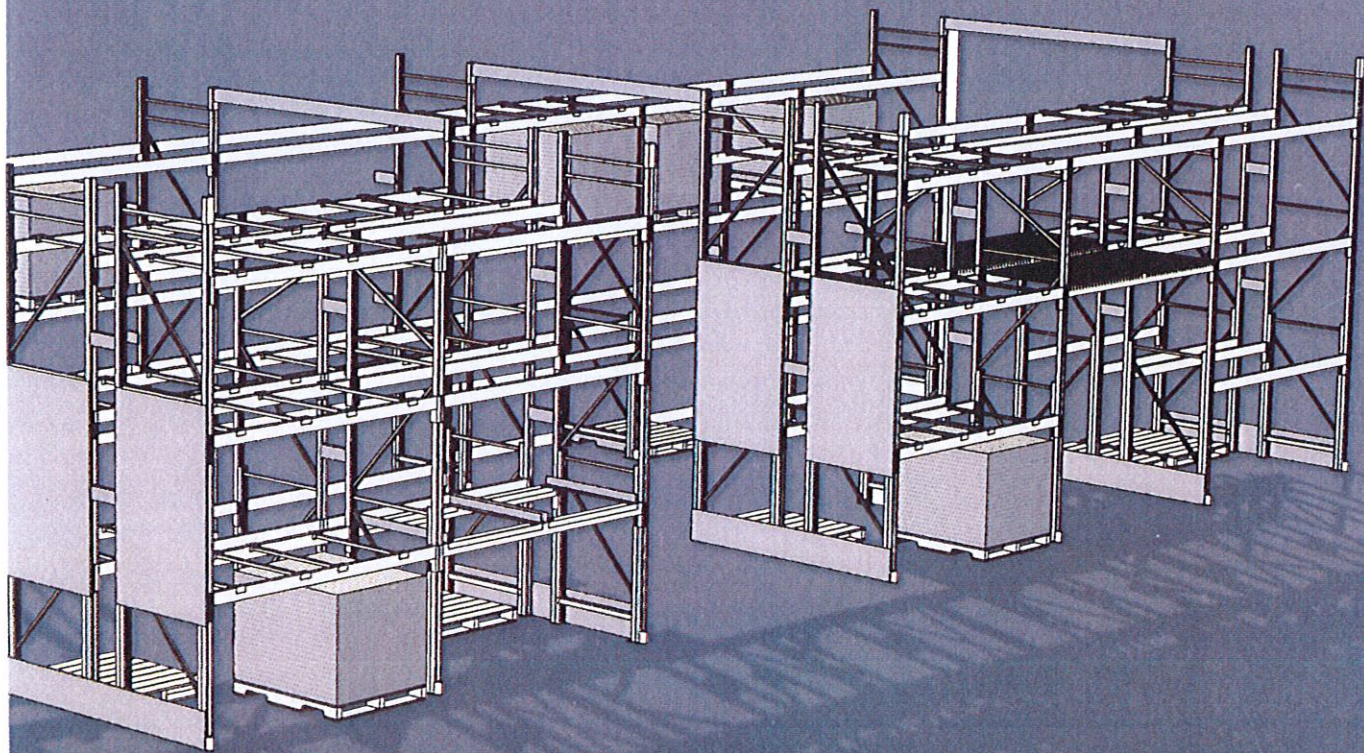


Safety of Pallet Racks

*Construction, purchase,
installation and use*



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***Construction, purchase,
installation and use***

This document was prepared by the CSST, Direction de la prévention-inspection, in collaboration with the Direction des communications.

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Forward

Numerous industrial accidents are caused by the installation and use of pallet racks, or pallet racking. In Québec, the absence of specific regulations or standards has made it necessary to develop this Prevention Guide on the *Safety of Pallet Racks*.

To meet the need for information on preventive measures expressed by the industry, the Commission de la santé et de la sécurité du travail (CSST) has drawn upon the expertise and collaboration of its inspectors and various specialists, such as manufacturers, users and occupational health and safety consultants. While developing this guide, the CSST representatives also took part in CSA's Standardization Committee work on the development of standards for the design, construction, and use of pallet racks. For this reason, its content reflects the direction CSA has taken for the standards on pallet racks that will be adopted.

The CSST wishes to underline the collaboration of the Office québécois de la langue française, and its partnership with members of the École Polytechnique de Montréal and the Université de Montréal for the terminological research and the implementation of the pallet rack terminology in the field.

This Prevention Guide is aimed at inspectors, company managers, occupational health and safety officers, and rack users, including installers, suppliers, distributors and manufacturers. Its goal is to provide companies with information on the preventive measures to be adopted, and to offer them support in the application of these measures.

This Guide is a prevention tool and, as such, has no legal value or regulatory power.

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Part One • General

1 Preamble and Scope

Preamble

For economic and practical reasons, floor storage is obviously limited. This situation has led to the improvement of above-floor storage techniques over the years.

One of the most common practices today is the use of **pallet racks** (*palettiers*) or **racking** to store various types of merchandises, mainly in warehouses and industrial and/or commercial establishments. In some commercial establishments, clients circulate in aisles where racking is set up, since the sales area also serves as a warehouse.

A wide variety of pallet racks for specific types of applications are sold on the market. Since the construction of pallet racks is not regulated, their quality varies greatly. In fact, while some manufacturers, distributors or installers provide excellent quality products and services, others have a tendency to offer their customers cost-effective racks, at times jeopardizing quality and safety.

Pallet racking poses a danger for users, including the workers themselves and anyone else who happens to be nearby. When they collapse, they can cause accidents, serious injuries, or even death.

Pallet racks usually come crashing down due to a weakness in:

- design;
- installation;
- use;
- maintenance; or
- repairs.

Even if manufacturers or suppliers are required to provide racking that is safe, it is up to the employer to ensure the safety of the rack structures that are set up in his facility.

In the current context, users do not always find it easy to figure out which measures should be adopted to make pallet racks secure.

Scope

Even though this document mainly focuses on **single deep and double deep pallet racks**, the preventive measures described herein can also be used as a guide for the purchase and use of other types of racking, such as:

- drive-in and drive-thru pallet racks;
- mobile pallet racks;
- pallet flow, or push-back pallet racks;
- cantilever racks.

Preventive measures specific to each type of racking may also apply.

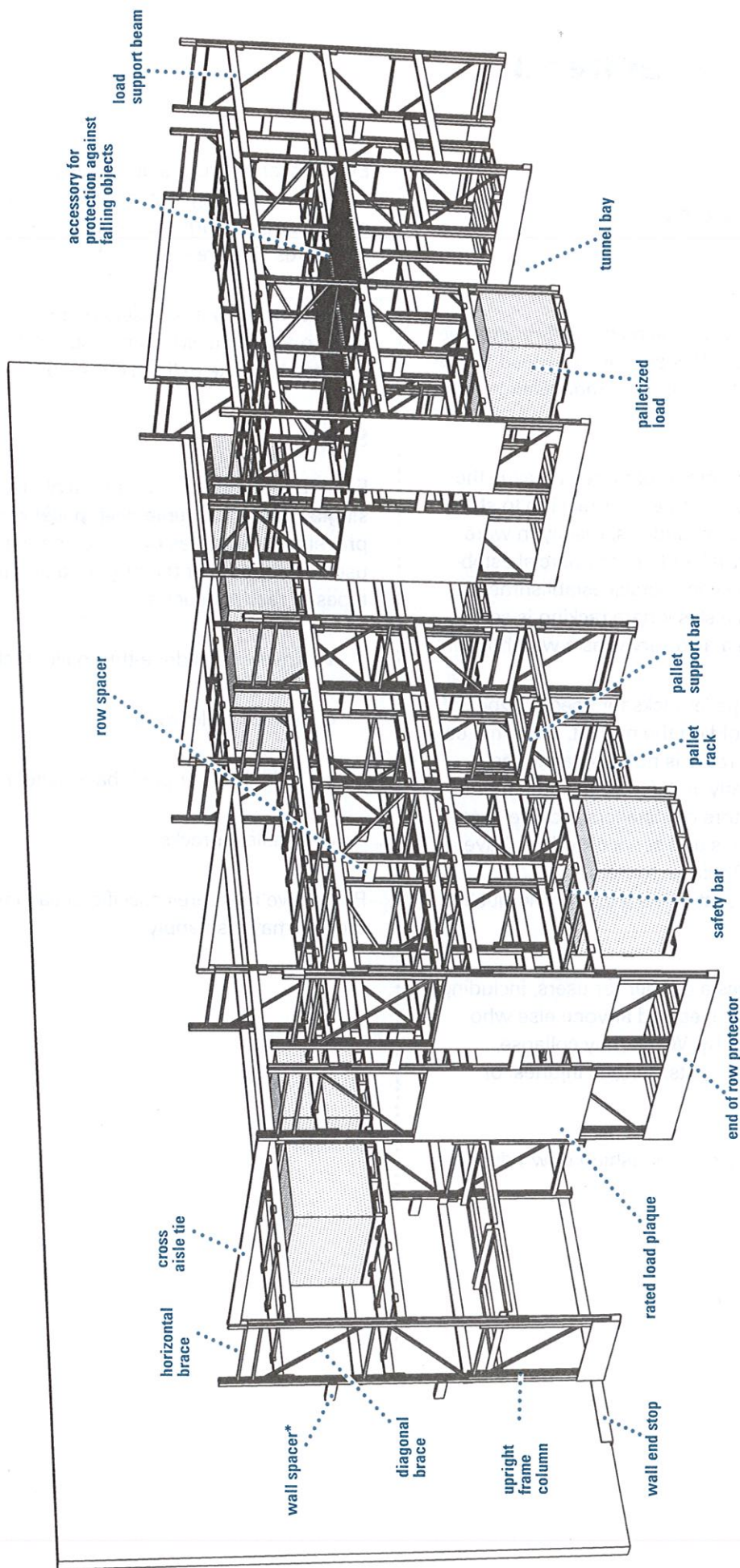


Figure 1. Rack components and accessories
(Illustration: Technirack)

* Not recommended

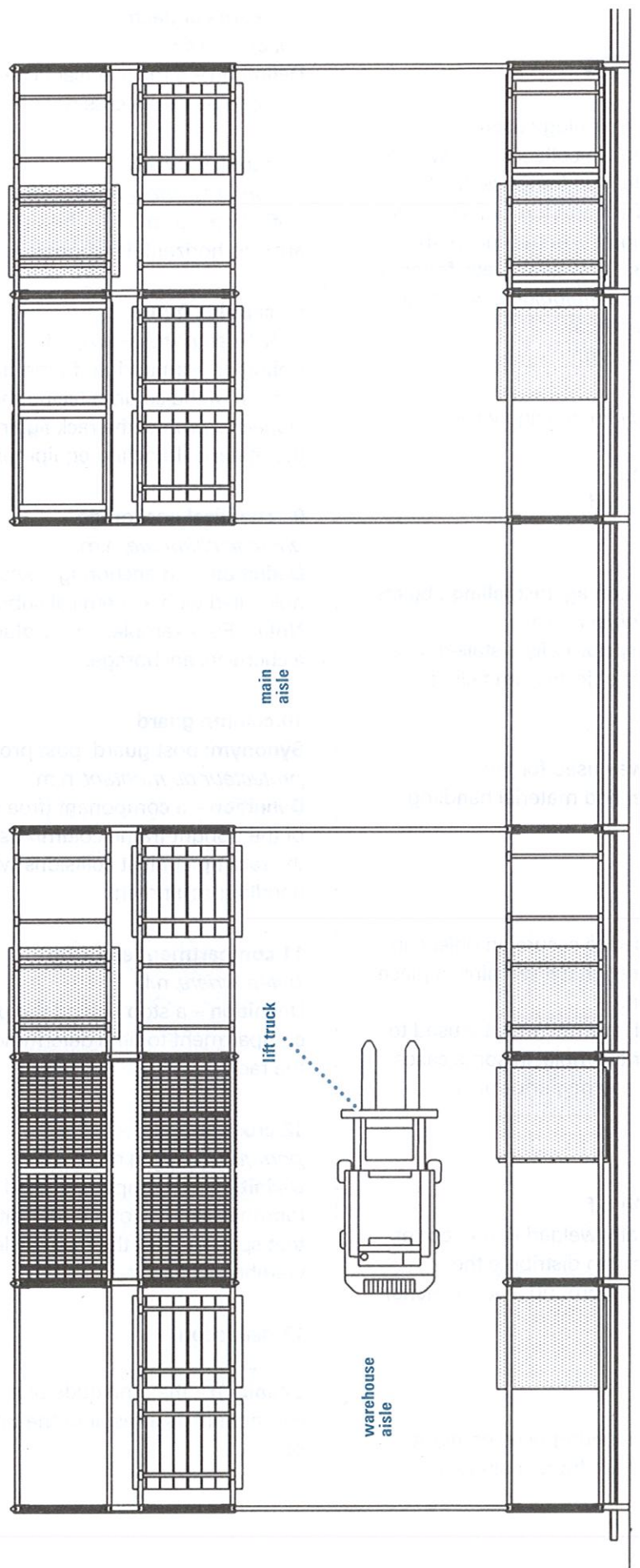


Figure 2. Warehouse aisle and main aisle (Top view)
(Illustration: Technirack)

Note – The pallet rack terminology used in this document was developed in collaboration with the Office québécois de la langue française, the École Polytechnique de Montréal and the Université de Montréal. This terminology is enhanced by the use of notes, synonyms, illustrations, etc. found in *Le grand dictionnaire terminologique*, which can be accessed via the Internet at: www.granddictionnaire.com.

Each term is followed by French equivalent in *italics*, followed by n. f. (feminine noun) and n. m. (masculine noun), and an English definition.

1. accessory for protection against falling objects
accessoire antichute d'objets, n.m.

Definition – an accessory normally installed on a rack structure to prevent objects from falling.

2. aisle *allée, n.f.*

Definition – a passageway used for the movement of personnel and material handling equipment.

3. anchorage

ancrage, n.m.

Definition – a device used to secure an object, in order to provide a base so that it remains in place or maintains its position.

Note – An expansion-sleeve bolt may be used to anchor a pallet rack, for example. In some cases, a chemical anchorage may be performed.

4. base plate

Synonym: footplate

plaque de pied d'échelle, n.f.

Definition – a plate usually welded to the foot of the upright frame column to distribute the weight of the loads on the ground, and to anchor the frame.

5. bay

travée, n.f.

Definition – a series of superimposed compartments between two upright frame columns.

6. beam connector

attache de lisse, n.f.

Definition – a mechanical fastener used to secure the load beam onto its upright frame columns.

7. cantilever rack

râtelier en porte-à-faux, n. m

Definition – a structure furnished with cantilever arms to horizontally support long objects.

8. cant-leg frame

échelle en porte-à-faux, n.f.

Definition – an upright frame having the lower portion of the column facing the warehouse sloped to protect the rack against collisions with the material handling equipment.

9. chemical anchorage

ancrage chimique, n.m.

Definition – an anchoring device secured into a hole filled with a chemical substance.

Note – For example, epoxy glue may be used as a chemical anchorage.

10. column guard

Synonym: post guard, post protector

protecteur de montant, n.m

Definition – a component (free standing or not) of the upright frame column used to protect the racking against collisions with the material handling equipment.

11. compartment end stop

butée arrière, n.f.

Definition – a stop behind the pallet rack compartment to help determine the depth of the rack.

12. cross aisle tie

portique d'allée, n.m.

Definition – a component used to connect the topmost sections of the upright frame columns that spans across the main aisle and the warehouse aisle.

13. deflection

flèche, n.f.

Definition – the amplitude of a curve in a component as a result of the unit loads acting on it.

14. diagonal brace

diagonale d'échelle, n.f.

Definition – a component used to diagonally connect the upright frame columns of a pallet rack for added resistance and rigidity.

15. double deep pallet rack

Synonyms: double deep selective pallet rack;

double depth selective pallet rack

palettier à double profondeur, n.m.

rayonnage à palettes à double profondeur, n.m.

Definition – a fixed storage rack that allows for the storage of two loads, usually palletized, running the depth of the rack system.

16. drive-in pallet rack

palettier ouvert sur une face, n.m.

rayonnage à palettes à accumulation statique

ouvert sur une face, n. m.

Definition – a drive-in/drive-thru system where material handling equipment can enter the racking system to place and retrieve loads, usually palletized, from a single warehouse aisle.

17. drive-in/drive-thru pallet rack

palettier à accumulation statique, n.m.;

rayonnage à palettes à accumulation statique, n.m.

Definition – a static pallet rack allowing material handling equipment to drive deep within the storage system to set down and/or remove the loads, usually palletized, that rest on beams running the depth of the rack system.

18. drive-thru pallet rack

palettier ouvert sur deux faces, n.m.;

rayonnage à palettes à accumulation statique

ouvert sur deux faces, n.m.

Definition – a drive-in/drive-thru system where material handling equipment can enter deep within the rack structure to place and retrieve loads, usually palletized, from two warehouse aisles.

19. dynamic pallet rack

palettier dynamique, n.m.;

rayonnage à palettes dynamique, n.m.

Definition – a class of racking that includes the mobile pallet rack and the gravity pallet rack.

20. fixed storage rack

palettier frontal, n.m.

rayonnage à palettes frontal, n.m.

Definition – a static rack system that allows material handling equipment to deposit or retrieve loads, usually palletized, from the warehouse aisle.

21. gravity pallet rack

Synonym: gravity flow rack

palettier à gravité, n.m.

rayonnage à palettes à gravité, n.m.

Definition – a dynamic rack system where loads, usually palletized, are powered by gravity within the rack structure.

22. horizontal and diagonal braces

contreventement d'échelle, n.m.

Definition – an assembly consisting of bracing members used to connect two upright frame columns to ensure that the structure retains its shape and remains stable.

23. horizontal brace

traverse d'échelle, n.f.

Definition – a component that horizontally connects the upright frame columns.

24. load capacity

capacité nominale, n.f.

Definition – the maximum load that can be lifted and handled with material handling equipment under specific conditions.

Note – The specific location of the unit load's center of gravity, for example, is one of those specific conditions.

25. main aisle

allée de circulation, n.f.

Definition – an aisle that is wide enough to safely accommodate the personnel and the material handling equipment. It usually spans the length of the facility, and provides access to the warehouse aisles and the walkways.

26. mobile pallet rack

Synonym: sliding pallet rack

palettier mobile, n.m.;

rayonnage à palettes mobile, n.m.

Definition – a dynamic rack system with mobile rows that can be moved to create a warehouse aisle required for storage operations.

Note – the depth of the compartment is determined by the depth of the palletized unit load, its width by the two uprights on each bay, and its height by the pairs of superimposed beams, or by the floor and the first pair of beams, or by the available height over the last pair of beams.

27. pallet flow rack

Synonyms: flow-thru rack; live storage rack

palettier à accumulation dynamique, n.m.;

rayonnage à palettes à accumulation dynamique, n.m.

Definition – a gravity pallet rack on which unit loads that are usually palletized are loaded on one side and retrieved from the other.

28. pallet rack beam

lisser de palettier, n.f.

Definition – a horizontal component furnished with beam brackets to connect the frames of a bay to accommodate loads that are usually palletized.

29. pallet rack compartment

alvéole de palettier, n.f.

Definition – a space for a pallet rack to accommodate palletized unit loads.

30. pallet rack upright frame

échelle de palettier, n.f.

Definition – an assembly made up of columns connected together with horizontal and diagonal braces, and fitted with base plates.

31. pallet rack

Synonyms: pallet racking; pallet rack

palettier, n.m.; *rayonnage à palettes*, n.m.

Definition – a structure mainly consisting of upright frames and load support beams to accommodate loads, usually palletized, during storage operations.

32. pallet support bar

barre de support de palette, n.f.

Definition – a component installed perpendicular to the load support beams to support a palletized unit load whose size prevents it from being installed directly onto the beams.

33. pallet

palette, n.f.

Definition – a platform used to support at least one package, both of which make up the palletized unit load.

34. palletized unit load

charge palettisée, n.f.

Definition – an assembly consisting of a pallet, or other similar support, and a supported unit.

35. push-back pallet rack

palettier à gravité inversée, n.m.;

rayonnage à palettes à gravité inversée, n.m.

Definition – a gravity pallet rack where loads, usually palletized, are loaded and unloaded from one side.

36. rated load

charge nominale, n.f.

Definition – the maximum mass of the unit load specified for the use of an equipment, a machine or a structure under normal conditions.

37. row end protector

protecteur de bout de rangée, n. m.

Definition – a component (free standing or not) of the upright frame secured to the floor slab at the end of a row, or along a tunnel bay, to protect the racking against collisions with the material handling equipment.

38. row spacer

entretoise de jumelage, n.f.

Definition – a component used to connect the uprights of a double row of racks for added stability and to maintain even spacing between the racks.

39. row

rangée, n. f.

Definition – a series of bays arranged side by side.

40. safety bar

barre de sécurité, n.f.

Definition – a component installed perpendicular to the load support beam to help support a load that is usually palletized.

41. safety pin

goupille de sécurité, n.f.

Definition – a device installed in the beam connector to resist the accidental dislodgment of the beam connector from the upright frame column.

42. single deep pallet rack

Synonym: selective pallet rack

palettier à simple profondeur, n.m.;

rayonnage à palettes à simple profondeur, n.m.

Definition – a fixed storage rack for the storage of one single load, usually palletized, running the depth of the rack system.

43. stak system

palettier à crémaillères, n.m.;

rayonnage à palettes à crémaillères, n.m.

Definition – a fixed storage rack with upright frame columns equipped with a hanging system for pallets specially designed for this system.

Note – By analogy, the term “stak system” refers to a slotted structure used to raise or lower a moving part.

The English designation Stak System is a trademark commonly used in the technical field.

44. static pallet rack

palettier statique, n. m

rayonnage à palettes statique, n. m.

Definition – a class of racking that includes the fixed storage rack and the drive-in/drive-thru pallet rack.

45. tunnel bay

tunnel de palettier, n. m

Definition – a passageway created in a row of racking to allow an intersecting aisle to be created.

46. upright frame column

montant d'échelle, n.m.

Definition – a vertical component of the upright frame with equidistant anchor points for the installation of load support beams.

47. walkway

allée piétonne, n.f.

Definition – an aisle reserved for pedestrian traffic.

48. wall end stop

butée de protection murale, n.f.

Definition – a stop behind the pallet rack compartment designed to prevent impacts with the wall.

49. wall spacer

barre de raccord au mur, n.f.

Definition – a component used to connect a pallet rack upright frame to an adjacent wall while remaining separated by a specific distance.

Note – The use of a wall spacer is not recommended since the racking is a free-standing structure and, as such, should not be secured to the wall of a building.

50. warehouse aisle

allée de service, n.f.

Definition – an aisle used for manoeuvring during stocking operations.

3 Laws, regulations, standards and reference documents applicable to pallet racks

Currently, there are no rules or standards on pallet racks in Québec or in Canada. There are, however, standards in Europe and the United States, but these documents do not have any regulatory power in Québec.

The CSST is taking part in the Canadian Standards Association (CSA) Standardization Committee

work. In 2004, it finished developing Canadian draft standards on the design, construction and use of pallet racks that were published in 2005 under the following titles: CSA A344.1-05, *User Guide for Steel Storage Racks*, and CSA A344.2-05 *Design and Construction of Steel Storage Racks*.

The Tables below include some of the laws, regulations, standards and other reference documents that were used to produce this Guide.

Table 1: Federal and provincial laws and regulations applicable to pallet racks		
Provinces/ Canada	Title of the law or regulation	Explanation
Québec	<i>Act respecting occupational health and safety</i> (R.S.Q., C.S-2.1)	Section 2: Object, Participation of workers Section 51: Employer's obligations Section 63: The Supplier
Québec	<i>Regulation respecting occupational health and safety</i> D.885-2001	Division III: Establishment Conditions Division X: Storage and Handling of Dangerous Substances Division XXIII: Handling and Transporting Material Division XXIV: Piling of Materials
Ontario	<i>Regulation for Industrial Establishments</i> , R.R.O. 1990, Reg. 851	Section 7: <i>Pre-Start Health and Safety Reviews</i> "Guidelines for Pre-Start Health and Safety Reviews: How to Apply Section 7 of the Regulation for Industrial Establishments" (Publications Section, Ministry of Labour, Ontario, April 2001) A Health and safety review is required before the implementation of a project, in particular upon installation of pallet racks. In the situations provided for by the Regulation, an engineer must write a report to specify the measures to be taken to ensure equipment safety. Section 45: <i>Material, articles or things</i>
British Columbia	<i>Occupational Health and Safety Regulation</i> B.C. Reg. 296/97	Policy Item R4.43-1 RE: General Conditions – Storing and Handling Materials – Stacking Materials (<i>Steel Pallet Racks</i>)
Canada	<i>Canada Occupational Health and Safety Regulations</i>	Part XIV: Materials Handling
Canada	<i>National Building Code</i> (NBC)	Building structure overloads Seismic zones
Canada	<i>National Fire Code of Canada</i> (NFCC)	Safety measures regarding the storage of loads on pallet racks

Table 2: Standards and reference documents on the design, construction and use of pallet racks

Country	Title of the standard or reference document	Explanation
Canada	CSA A344.1-05 <i>User Guide for Steel Storage Racks</i>	Canadian Standards Association (CSA) standard on the use of pallet racks.
Canada	CSA A344.2-05 <i>Standard for the Design and Construction of Steel Storage Racks</i>	Canadian Standards Association (CSA) standard on the design, construction and installation of pallet racks.
USA	ANSI MH 16.2-1984 <i>Manual of Safety Practices – A Code of Safety Practices for the Use of Industrial and Commercial Steel Storage Racks</i>	Standard developed by the <i>Rack Manufacturers Institute</i> (RMI) and adopted as a national standard by the <i>American National Standards Institute</i> (ANSI). It deals with the safety rules and prevention in the use of pallet racks.
USA	<i>Rack Manufacturers Institute</i> (RMI) – <i>Specification for the Design, Testing and Utilization of Industrial Steel Storage Racks</i> – 2002 Edition	This edition replaces the previous 1974 version which was adopted as a national standard in the US (ANSI MH 16.1-1974 <i>Specification for the Design, Testing and Utilization of Industrial Steel Storage Racks</i>).
USA	ANSI MH 28.1-1997 <i>American National Standard for the Design, Testing, Utilization and Application of Industrial Grade Steel Shelving – Specifications</i>	National standard published by the American organization <i>Storage Equipment Manufacturers Association</i> (SMA). This standard applies to systems designed for manual loading and unloading only.
USA	NFPA 231 <i>General Storage</i> , NFPA 231C <i>Rack Storage of Materials</i>	<i>National Fire Code</i> – Canada 1995. (CNPI), First modifications of June 1999, makes references to these two standards <i>National Fire Protection Association</i> in Clauses 3.2.1.1 and 3.2.3.3. These standards have now become part of NFPA 230 <i>Standard for the Fire Protection of Storage</i> , 1999 Edition.
Great Britain	SEMA/FEM 10.2.02 <i>Code of Practice for the Design of Static Racking</i>	Document published by the British organization <i>Storage Equipment Manufacturers Association</i> (SEMA), a member of the European Federation of Material Handling and Storage Equipment-FEM.
Great Britain	<i>Code of Practice for the Use of Static Pallet Racking</i> (1994)	Document published by the British organization <i>Storage Equipment Manufacturers Association</i> (SEMA).
Great Britain	FEM 10.2.04 <i>Guidelines for the Safe Use of Static Steel Racking and Shelving User Code</i> November 2001	Document published by the European Federation of Material Handling and Storage Equipment-FEM as a reference for the inspection of damages to racking components.

Table 2 Standards and reference documents on the design, construction and use of pallet racks (continued)

Country	Title of the standard or reference document	Explanation
France	<i>La sécurité dans l'utilisation des rayonnages</i> (1992)	Document based on the recommendations of builders who are members of the <i>Syndicat des industries de matériels de manutention</i> (SIMMA) in France and published by the latter, for the use of pallet racks.
France	<i>Règles de calcul des rayonnages</i> (1991)	Document published by the <i>Syndicat des industries de matériels de manutention</i> (SIMMA), explaining the different safety factors, the data to consider for the calculation of pallet racks and the calculation and test methods.
France	FEM 10.2.02 Recommandation pour la conception des rayonnages statiques en acier à palettes et à tablettes – First Edition: October 1998	Document published by the <i>Syndicat des industries de matériels de manutention</i> (SIMMA), a member of the Fédération européenne de la manutention. This document is the equivalent of the English version SEMA/FEM 10.2.02 mentioned earlier.
France	<i>Les rayonnages métalliques</i> – 2001 Edition	Brochure published by the Institut national de recherche et de sécurité (INRS).

4 Risks associated with the use of pallet racks

4.1 Accident investigation reports

Although there are no statistics on the number of industrial accidents involving racking in Québec, each year accidents occur when loads stored on pallet racks are handled. The accident investigation reports were analyzed to underline the cause of these accidents. Table 3 summarizes some of the accidents involving racking that have occurred in Québec.

4.2 Main risks associated with the use of pallet racks

As demonstrated by the accident investigation reports and a review of the scientific documents, the main risks workers are exposed to when handling loads stored on racking are caused by:

- the total or partial collapse of a pallet rack;
- falling loads;
- falls from heights;
- other factors.

4.2.1 Total or partial collapse of a pallet rack

The total or partial collapse of a pallet rack may be caused by:

- an unplanned modification of the rack configuration in the drawings and specifications (e.g., a change in the load support beam position, the elimination of beams);
- a load distribution on a rack that differs from the established loading plan;
- a localized or general overload that exceeds the rated loads;
- impacts with a rack structure normally caused by a lift truck;
- damages or inadequate repairs to at least one pallet rack component;
- the deterioration of the rack components due to the environment (corrosion) or stored products (salt, acid, etc.);
- a lack of awareness with respect to the structural capacity of the pallet rack.



Figure 3. Collapsed pallet rack
(Photo: CSST)

4.2.2 Falling loads

Loads may come crashing down due to:

- the use of pallets that are in bad condition, not resistant enough or unsuitable for the racking;
- loads that are improperly packed, resulting in a lack of cohesion between the loading units, or producing packaging that is not strong enough;
- loads that are improperly balanced on the front and rear beams, with no 50 mm to 100 mm (2- 4 in.) overhang to ensure stability;
- missing or defective accessories for protection against falling objects (e.g., solid pallet decks, wire mesh decks, screen panels, nets);
- a lack of visibility by the operator as a result of poor lighting;
- a miscalculation by the lift truck operator of the height required to place and/or retrieve a load;

- the placement of a load in a rack compartment where another load has already been deposited;
- the impact on a load upon depositing another load in an adjacent compartment;
- the unhooking of a beam occurring during the uplifting of a load with the lift truck.

4.2.3 Falls from heights

Falls from heights may be caused by:

- the use of equipment that is unsuitable for lifting a worker (e.g., a lift truck equipped with a platform that does not meet the requirements of the *Regulation respecting occupational health and safety*, Section 261);
- the absence of a means for protection against falls (guardrail, safety harness, etc.), or the use of unsuitable equipment;
- the lack of safe work methods, or the use of bad work practices.

4.2.4 Other factors

Other factors that may contribute to accidents are:

- the lack of operator training;
- environmental conditions (humidity, corrosion);
- ergonomic risks.

Table 3 Summary of accidents associated with racking that have occurred in Québec

Case No.	Summary of accident	Causes of accident
No. 1	<ul style="list-style-type: none">• Location: A food industry company warehouse.• Consequence: A worker was fatally injured.• Summary: A temporary pallet rack collapsed, and loads fell on the worker seated next to the pallet rack.	<ul style="list-style-type: none">• Failure of a pallet rack upright frame following repair work involving the butt welding of two portions of a column.• The supplier did not establish any inspection procedure for the rack components before it was delivered and installed at the customer's premises.• Inadequate repair method that failed to take into account the quality of the steel used and the racking manufacturer's recommendations.• Impacts between the lift truck and the pallet rack.
No. 2	<ul style="list-style-type: none">• Location: A new refrigerated warehouse of a food industry company.• Consequence: No injured worker. Material damages exceeding \$600,000.• Summary: A new, recently loaded, pallet rack collapsed.	<ul style="list-style-type: none">• Badly designed and improperly installed H-beams (poutres d'appui) on which the pallet rack uprights were resting.• Lack of rigidity in the uprights.• Inadequate anchoring to the concrete floor slab.
No. 3	<ul style="list-style-type: none">• Location: The warehouse of a food industry wholesaler.• Consequence: A worker died.• Summary: A pallet rack collapsed following an indirect impact between the lift truck and an upright frame column.	<ul style="list-style-type: none">• An unprotected upright frame column was struck by a hand-operated truck that encroached on the main aisle, this truck having first been struck by the lift truck driven by the worker.
No. 4	<ul style="list-style-type: none">• Location: A snowplow blade warehouse.• Consequence: A worker died.• Summary: A box containing five blades fell from a cantilever-rack, hitting another blade being transported on the fork of a lift truck. This blade also struck a worker.	<ul style="list-style-type: none">• Improper cantilever rack configuration.• The loads on the cantilever racks were unbalanced and unstable.
No. 5	<ul style="list-style-type: none">• Location: A warehouse located next to a plant assembly line that manufactured electrical products.• Consequence: Four workers were seriously injured.• Summary: A cement block wall collapsed behind the pallet rack following the impact with a pallet being handled by a lift truck.	<ul style="list-style-type: none">• Insufficient clearance between the pallet rack and the back wall.• Absence of rear end stops.
No. 6	<ul style="list-style-type: none">• Location: The warehouse of a metal pipe company.• Consequence: An operator died.• Summary: The operator driving a leased narrow aisle lift truck was fatally crushed against the pallet rack when the truck backed up.	<ul style="list-style-type: none">• The characteristics of the leased truck were different from those of the truck normally used by the worker.• Absence of protective bars behind the operator of the narrow aisle lift truck.

5.1 Classification of the pallet racks

There are different types of racks, several of which are configured using the same basic components: upright frames and load support beams. The diagram in Figure 4 divides the racking into two broad categories: the static rack system and the dynamic rack system.

The **static rack system** includes two types of racking: the **fixed storage pallet rack**, (*palettier frontal*) and the **drive-in/drive-through pallet rack** (*palettier à accumulation statique*). The fixed storage rack has a front loading/unloading point; it includes the **single deep pallet rack** (*palettier à simple profondeur*), the **double deep pallet rack** (*palettier à double profondeur*), and the **stak system** (*palettier à crémaillères*). In the **drive-in/drive-thru system**, loads can either be placed and retrieved from **one side** (*drive-in*), or **deposited from one side and retrieved from the other** (*drive-thru*).

The **dynamic rack system** also includes two types of racking: the **mobile pallet rack** (*palettier mobile*), and the **gravity pallet rack** (*palettier à gravité*). The latter can either be a **pallet flow** (*à accumulation dynamique*), or a **push-back** (*à gravité inversée*) system.

Other storage systems that are not necessarily intended for palletized unit loads are available, such as the **cantilever rack** (*râtelier en porte-à-faux*).

5.2 Description of the pallet racks

5.2.1 Single deep pallet rack

The single deep pallet rack allows for easy access to all the stored pallets, since each one immediately faces an aisle. However, the depth of storage in a warehouse with this type of system is reduced, since several aisles are required. Their use is generally more labor-intensive because of the increased material-handling operations.

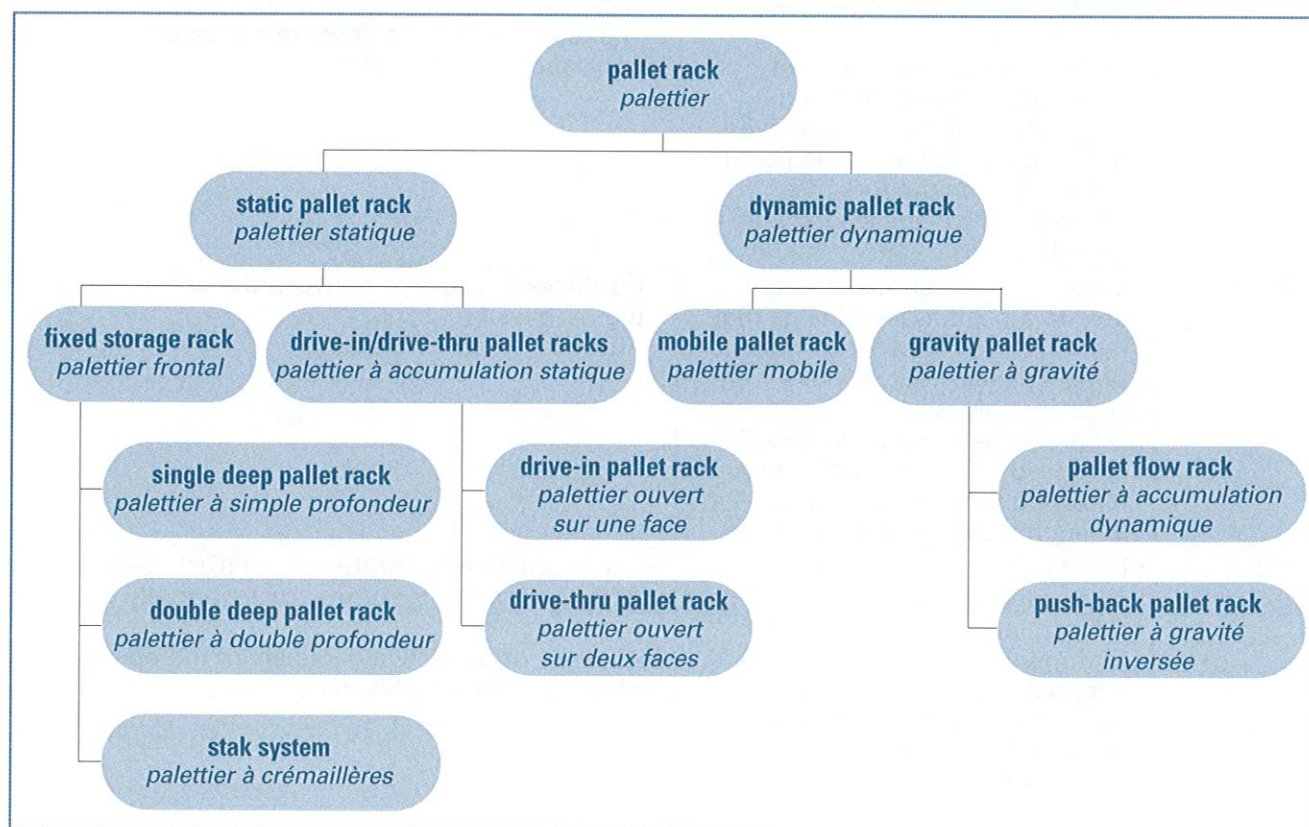
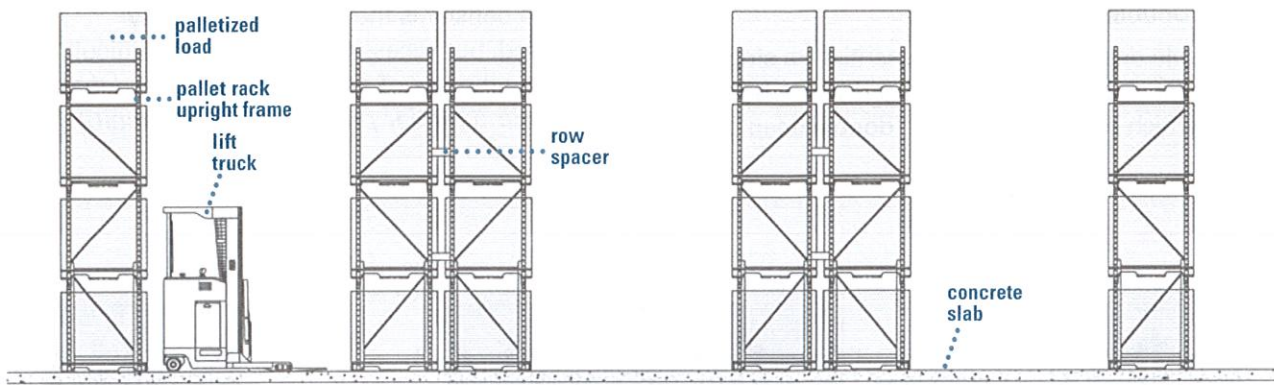


Figure 4. Classification of the pallet racks
(Source: Diane Riopel, École Polytechnique de Montréal, June 2004)



Figures 5a. Single deep pallet racks
(Illustration: Technirack)

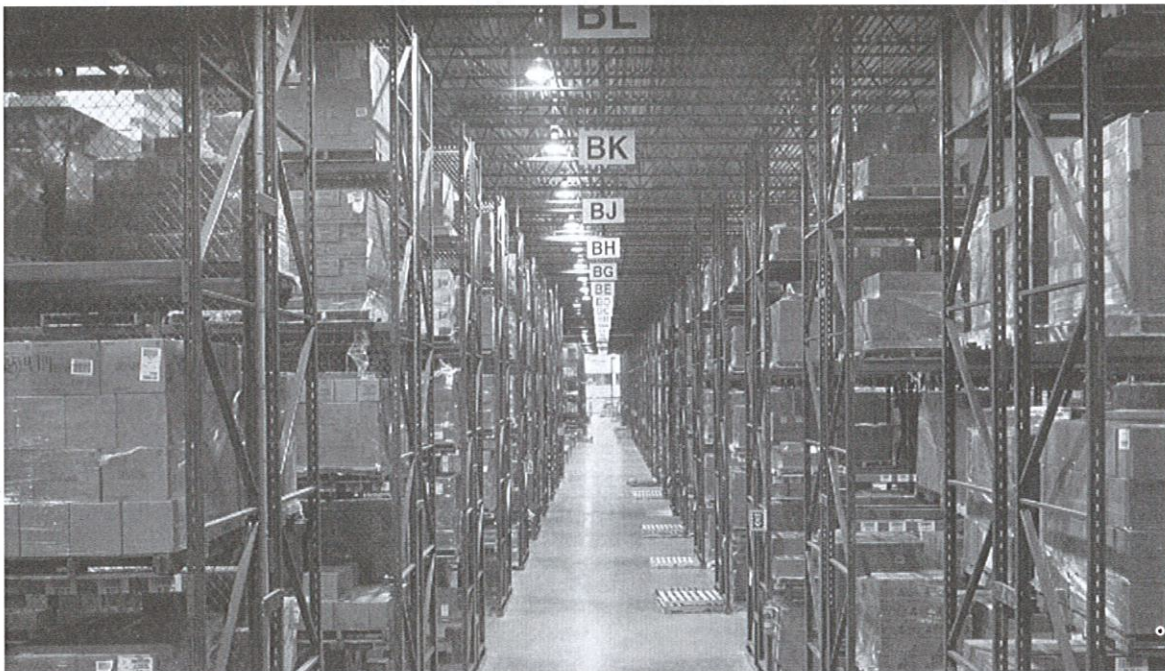


Figure 5b. Single deep pallet racks
(Photo: Technirack)

5.2.2 Double deep pallet rack

The double deep pallet rack is essentially a single deep pallet rack to which a second row has been added, which explains the term "double deep".

Storage density is therefore substantially increased, but access to loads is more difficult, requiring the use of a reach fork lift truck (*chariot élévateur à tablier porte-fourche rétractable*).

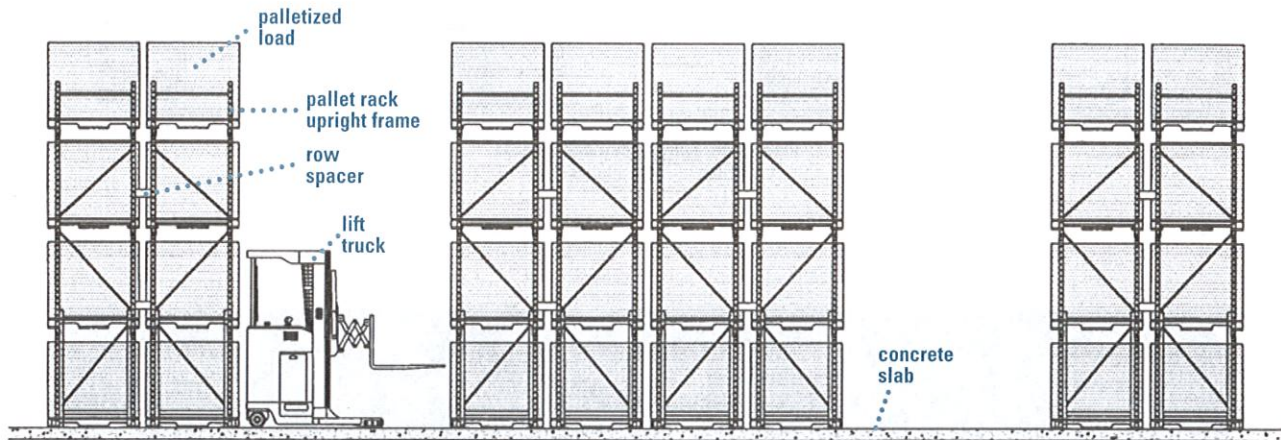


Figure 6a. Double deep pallet racks
(Illustration: Technirack)



Figure 6b. Double deep pallet racks
(Photo: Technirack)

5.2.3 Drive-in/drive-thru pallet rack

In the drive-in/drive-thru rack system, the lift truck can travel deep within the rack structure for load placement or retrieval. The racking rests on load support beams that run the depth of the rack structure.

The drive-in/drive-thru system offers one of the highest density storage capabilities by using the minimum amount of floor space. However, since the lift truck is driven directly into the system, the risk of collisions with the structure is high. This type of rack implies the use of pallets that are in good condition, since defective pallets can cause serious accidents (e.g., loads falling on the operator).

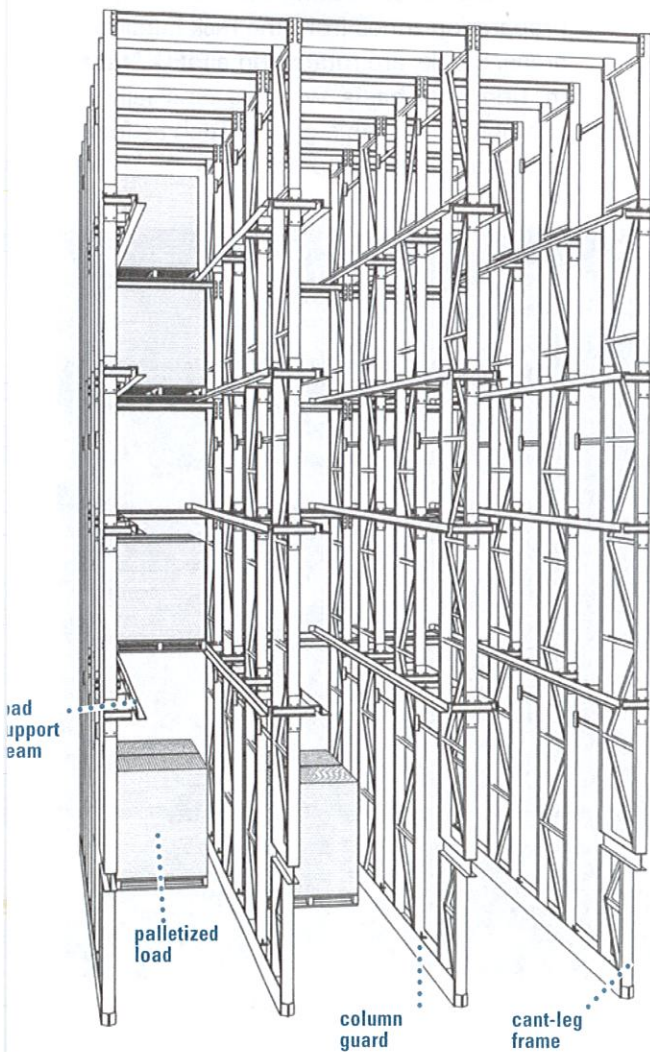


Figure 7a. Drive-in pallet rack open on one side (Illustration: Technirack)

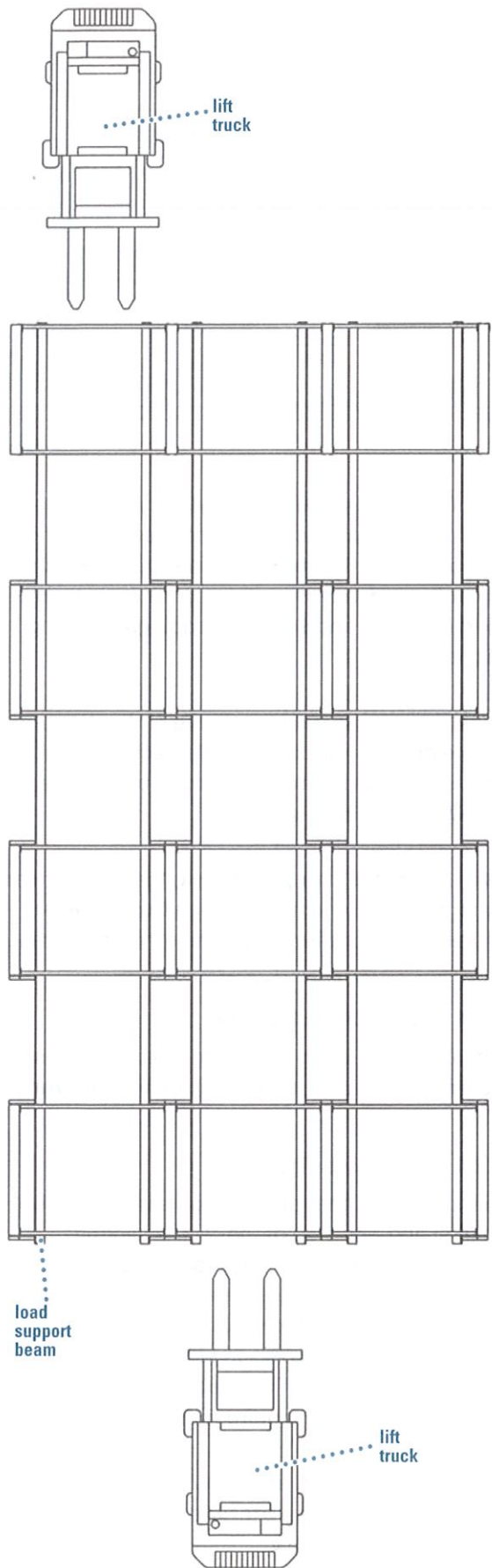


Figure 7b. Drive-through pallet rack open on two sides (Top view) (Photo: Technirack)

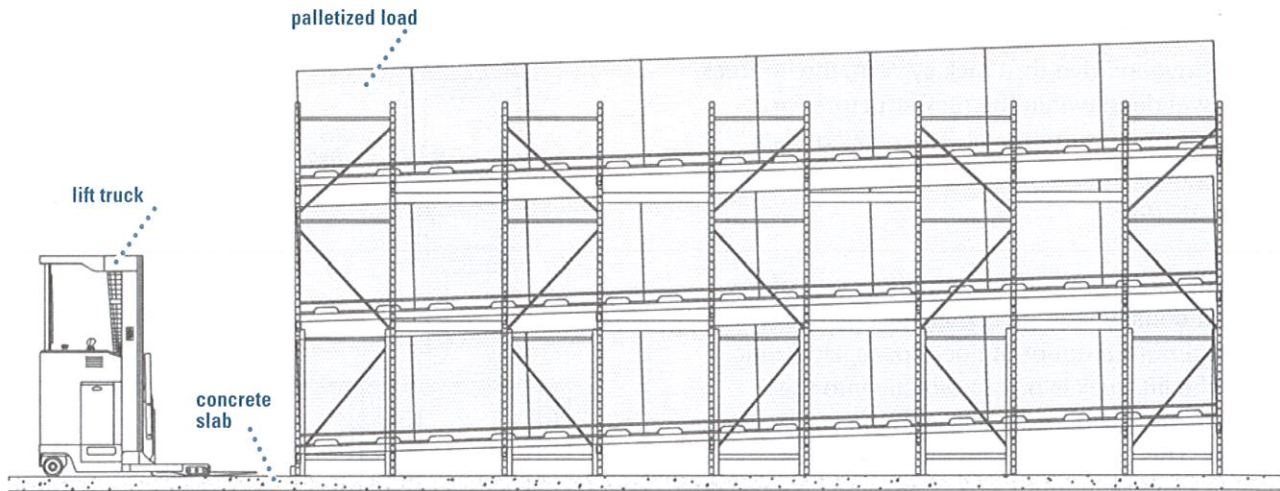


Figure 8a. Pallet flow rack
(Illustration: Technirack)

Column guards shall be installed on the floor slab to guide the operator while manoeuvring the vehicle inside the structure. This type of racking is configured in two ways: a common entry/exit loading point, and separate loading/unloading aisles.

With the **drive in pallet rack**, the lift truck enters a single aisle in front of the pallet rack. The last load to be deposited is the first load to be retrieved (**LIFO: last-in; first-out**).

With the **drive-thru pallet rack**, the lift truck can enter the rack structure through two separate aisles, one in the front, and the other in the rear.

5.2.4 Dynamic pallet rack

There are two types of dynamic rack systems: the **gravity pallet rack** and the **mobile pallet rack**.

5.2.4.1 Gravity pallet rack

In this system, the racks rest on sliding rails or rollers, and one side of the rack is slightly lower than the other. These racks are powered by gravity, and require less aisles than the fixed storage racks. Although storage density is a very interesting factor, access to stored loads is nonetheless limited. The mobile components of this type of system require more maintenance.

There are two types of gravity pallet rack systems: the **flow-thru, or live storage rack**, and the **push-back pallet rack**.

- **Flow-thru pallet rack**

In this type of system, pallet loads are deposited from one aisle and removed from the other. This system offers the advantage of separating the order preparation zones from the rack loading areas. Stocks are rotated on a **FIFO "first in, first out" basis**, which is especially useful for perishable goods, such as food and pharmaceutical products.



Figure 8b. Pallet flow rack
(Photo: Technirack)

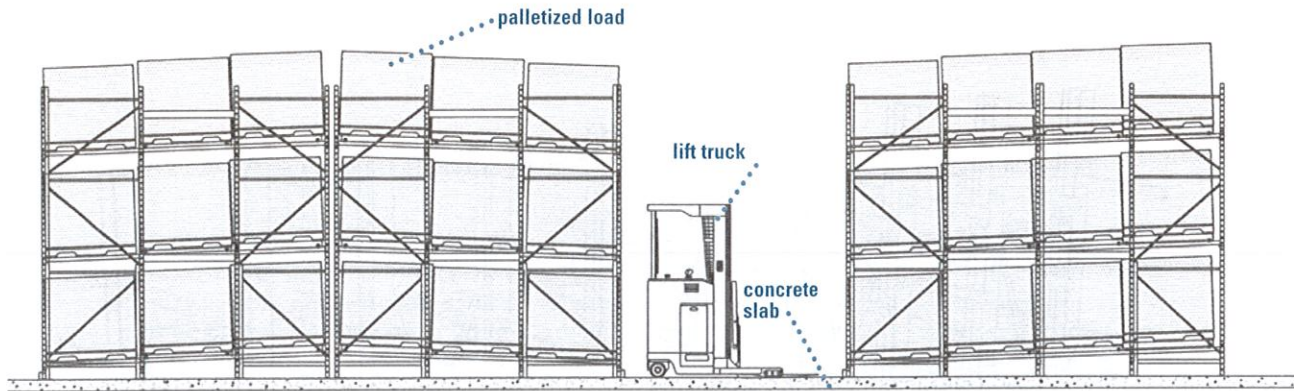


Figure 9a. Push-back pallet racks
(Illustration: Technirack)

- **Push-back pallet rack**

In the push back system, pallet loads are set down and retrieved from the same aisle. As a new pallet is loaded, it pushes back the other pallets on the same row. These racks are often placed against the wall of a building, and are rotated on a **LIFO: last in; first out** basis.

5.2.4.2 Mobile pallet rack

These are basically fixed storage racks set up on a rail system attached to the floor. This allows the rows to move by creating an aisle at a desired location to access a specific load. Rows containing heavy loads are moved by a motorized unit. Various safety devices, such as audible or visual alarms, may be incorporated into the system to control the risk of collapse when rows are moved.



Figure 9b. Push-back pallet racks
(Photo: Technirack)

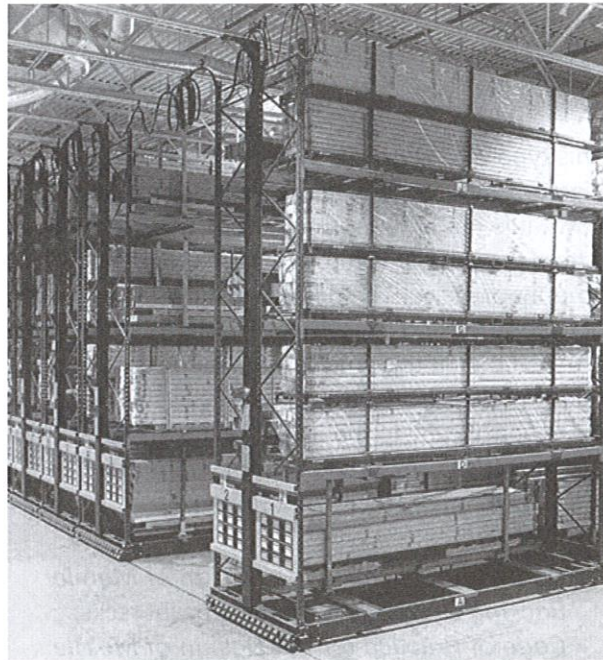


Figure 10. Mobile or sliding pallet racks
(Photo: Technirack)

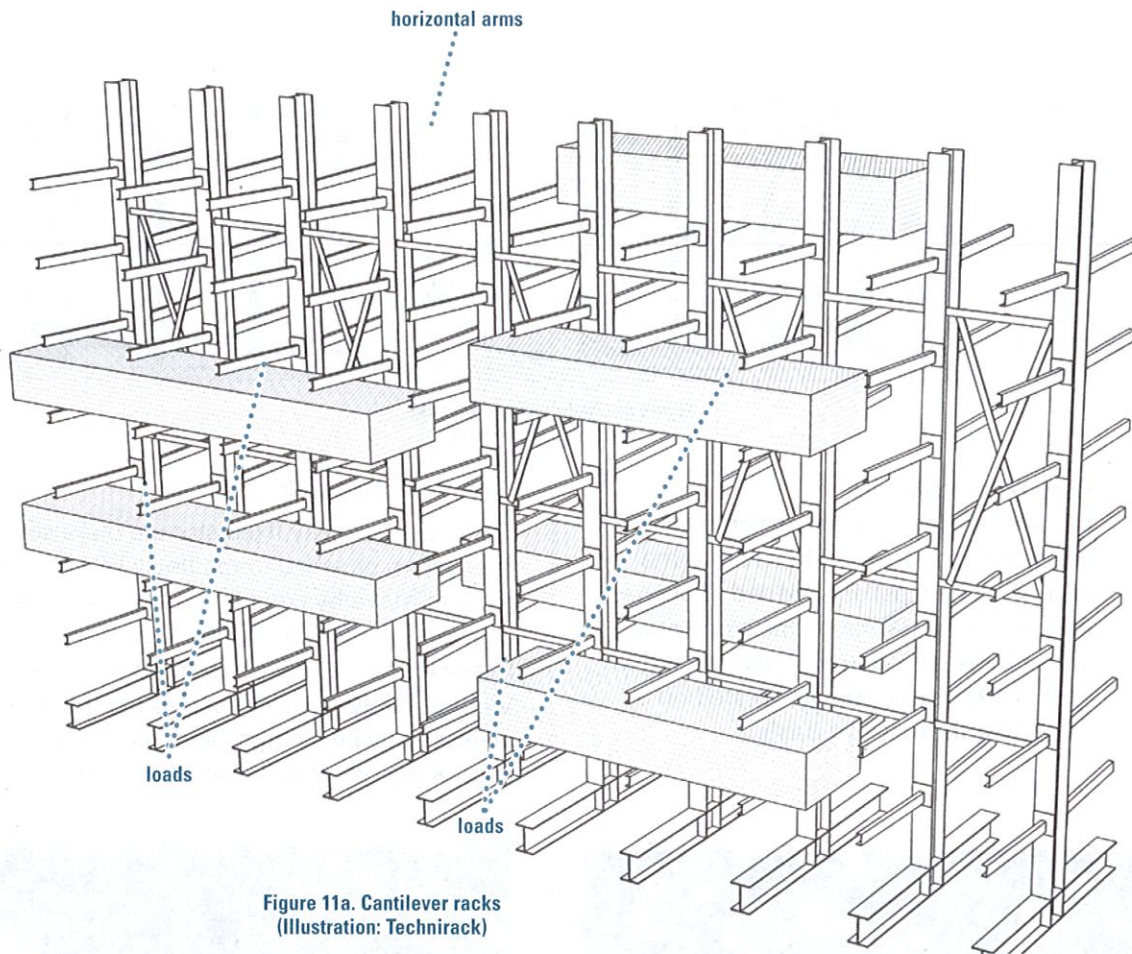


Figure 11a. Cantilever racks
(Illustration: Technirack)

This type of system allows for high-density storage, with reduced handling times (pallet load flow). It is therefore normally used in warehouses where the priority is to use up the maximum amount of space. The design, installation and use of mobile racking must meet specific rules that are not included in this Guide. Interested readers can refer to documents on this specific system, and more specifically to the following codes published by the British organization Storage Equipment Manufacturers Association (SEMA):

- *Code of Practice for the Design of Mobile Racking Systems*, for mobile pallet racks;
- *Code of Practice for the Design of Mobile Shelving Systems*, for shelves usually reserved for archival storage.

5.2.5 Cantilever rack

Cantilever racks are not part of the large family of racking. They are not designed for the storage of palletized unit loads, but rather for the storage of long and cumbersome objects, such as pipes, metal extrusions, carpet rolls, etc. In this system, horizontal arms are secured to vertical columns with welds, bolts or brackets. They are installed

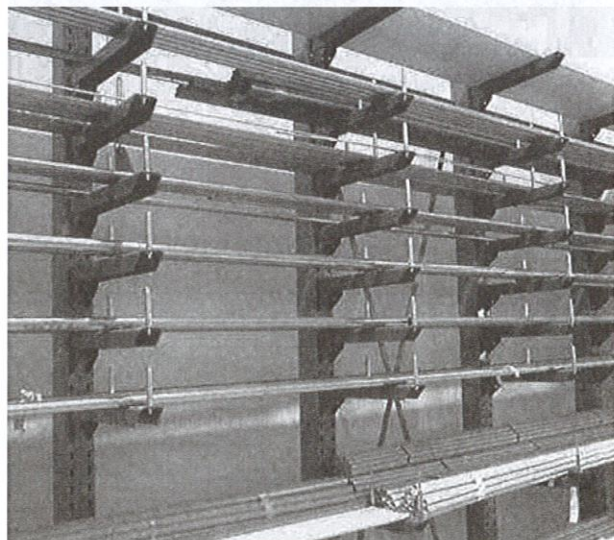


Figure 11b. Cantilever racks for light loads with arms furnished with end stops
(Photo: Technirack)

from one side or both sides of the columns, and should have end stops to prevent objects from falling.

Cantilever racks provide relatively low-density storage. Their design, installation and use are governed by specific rules that are not included in this Guide.

The characteristics of the different types of racking are summarized in the following table.

Table 4 Table comparing the characteristics of the different types of racking								
	Single-deep (à simple profondeur)	Double-deep (à double profondeur)	Drive-in (ouvert sur une face)	Drive-thru (ouvert sur deux faces)	Pallet flow (à accumulation dynamique)	Push-back (à gravité inversée)	Mobile	Cantilever (râtelier en porte-à-faux)
Installation cost/ Unit load	\$\$	\$\$	\$\$\$	\$\$\$\$	\$\$\$\$	\$\$\$\$	\$\$\$\$\$	\$\$\$
Storage density	Low	Average	High	High	High	Average	High	Low
Load flow	High	Average	Average	Average	High	Average	Low	Variable
Load access	Excellent	Excellent	Average	Low	Low	Average	Average	Good
Load rotation	Variable	LIFO	LIFO	Variable	FIFO	LIFO	FIFO	Variable
Aisles	Several	Some	Few	Few	Few	Few	Few	Several

FIFO (first-in, first-out; *premier entré, premier sorti*)

LIFO (last-in, first-out; *dernier entré, premier sorti*)

6.1 Type of pallets

A pallet is a platform onto which goods are deposited for handling, storage, and transportation purposes. It can also be considered as a product packaging unit to protect the merchandise and facilitate its handling, storage, distribution and transport. Even though pallets sold on the market are predominantly made with wood, they can also be built using different materials, such as plastic, carton or metal, and are sold in a variety of shapes. Pallets are handled with fork lift trucks, stackers, pallet jacks, or other suitable equipment.

The documentation includes several definitions of the different types of pallets, some of which are defined according to the type of entry or deck, or their future use. There are general use pallets (*palettes d'usage général*), and special-use pallets (*palettes d'usage spécialisé*).

6.1.1 General use pallets

The general use pallets that are normally used by companies are, for example, the standard 1,220 mm x 1,016 mm (48 in. x 40 in.) CPC pallet, the orange CPC pallet, and the blue CHEP-style pallet. CPC stands for Canadian Pallet Council (*Conseil canadien des palettes*), while CHEP refers to the *Commonwealth Handling Equipment Pool*.

These pallets are used to handle, store and transport merchandise, and are divided into two categories: the expendable pallet, and the reusable pallet.

- **Expendable pallets (or disposable or non-reuseable pallets)** are used only once, and therefore form part of the packaging. These pallets are not only less costly, but they are often made with substandard wood, chipboard, carton or expanded polystyrene. Concerned about environmental protection, Canadian companies are becoming less inclined to use expendable pallets as general use pallets, and even aim to reduce or eliminate their use altogether over the next few years.
- **Reusable pallets**, as opposed to expendable pallets, can be recycled several times, with an average lifespan of 5 to 6 years. There are three types of reusable pallets:
 - the **captive pallet**, for internal use only;
 - the **returnable pallet**, which belongs to a company to which it is returned after each use;
 - the **exchange pallet**, which can also be pooled.

Even though reusable pallets are more ruggedly built than expendable pallets, and have a better finish, the management and control of their recovery and exchange represent significant drawbacks.

6.1.2 Special-use pallets

Special-use pallets are designed for the handling, storage and transport of specific types of packages, either because of their shape, or because of the damage the packages are likely to sustain. These types of pallets are custom-made for handling specific products, such as **drum pallets, roller pallets, container pallets**, etc.

6.2 Design principles of general use pallets

Pallets can be built in two ways: with **blocks** and **stringerboards**, or with **stringers** (*longerons or longrines*) also called chevrons in Europe. These elements are used as spacers between two deckboards, or as anchor points secured to the floor, and are arranged so as to make room for the forks of the lift truck, the stacker, or the pallet jack. The stringer is a rectangular cross-sectional bar, while the block is a short component in the shape of a cube or cylinder. When pallets are built with blocks, they shall be assembled with stringerboards (*boards having the same width as the blocks*) to support the deck. In North America, 90% to 95% of pallets are assembled with stringers, while in Europe, only expendable pallets are built this way.

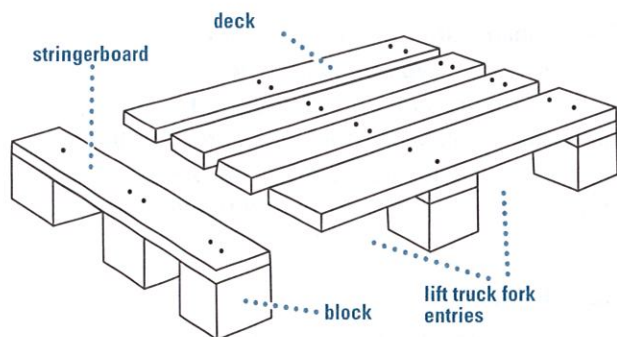


Figure 12. Pallet made with blocks and stringerboards (Illustration: OQLF)

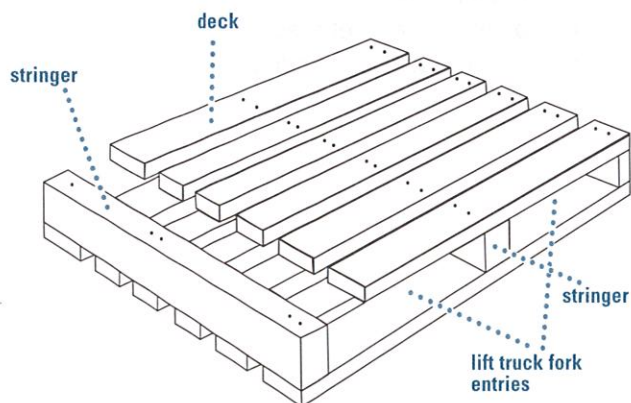


Figure 13. Pallet made with stringers (Illustration: OQLF)

6.2.1 Entry point

This is an opening on the side of a pallet that allows the fork of the material handling equipment to pass through. The pallet may have two-way, four-way (or partially), or multiple entries.

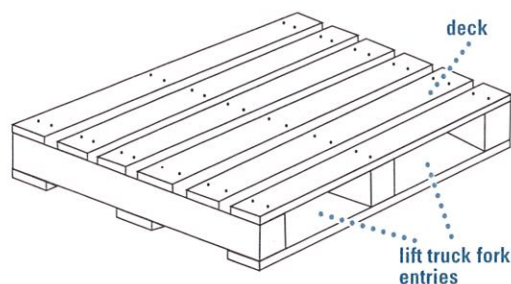
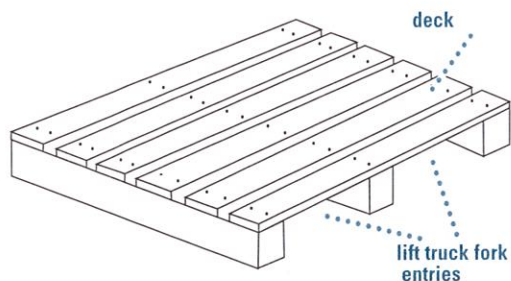


Figure 14. Pallets with two-way entries (Illustration: OQLF)

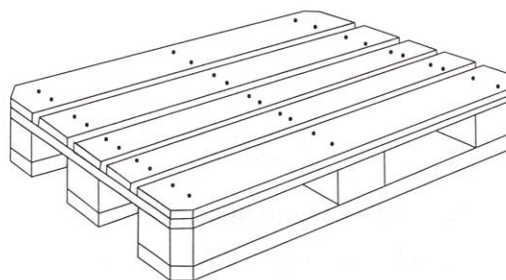


Figure 15. Pallet with four-way entries (Illustration: OQLF)

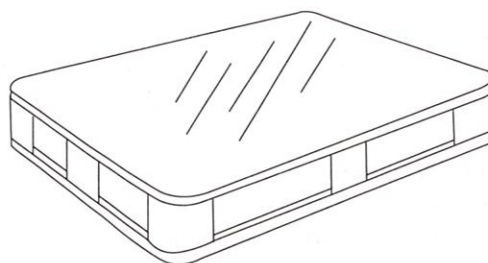


Figure 16. Pallet with multiple entries (Illustration: OQLF)

6.2.2 Deck

The deck is the section of a pallet that accommodates the load (**top deck**) or is used as the stand point (**bottom deck**). A deck is called **closed deck** when it has no spacings between the components (all board are in contact with each other), while the opposite, called **open deck**, does have spacing. The pallet may be **single** or **double deck**.

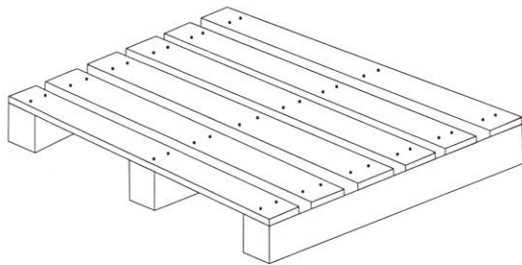


Figure 17. Single-decked pallet
(Illustration: OQLF)

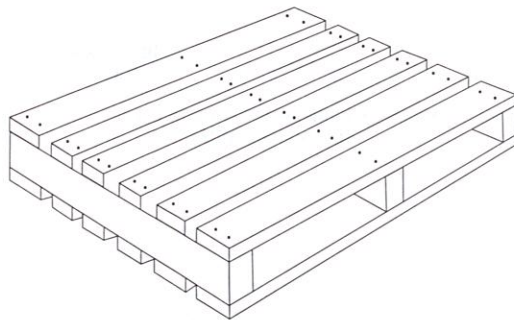


Figure 18. Double-decked pallet
(Illustration: OQLF)

6.2.3 Materials used to build pallets

Currently, pallets are made with four types of material: wood, plastic, metal and carton. About 90% of pallets are made with wood.

6.2.3.1 Wood

Wooden pallets can either be made of solid wood or pressed wood. In North America, three categories of wood are used in solid wood pallets: high-density hardwood (the hardest of woods), low-density hardwood (the softest of woods), and softwood (or resinous wood). The latter is becoming increasingly popular with pallet and box pallet manufacturers.

Pressed wood pallets consist of fine wood particles, or fibers, produced by shredding by-products from sawmills or packaging waste, and bonded together with a synthetic resin that is incorporated when the wood is compressed. The markup price of this type of pallet is low, and they can fit together. However, they are neither rigid nor very resistant, and cannot be repaired.

6.2.3.2 Plastic

Plastic pallets are generally reserved for the storage and handling of food and pharmaceutical products, and are not only more expensive, but are also more resistant and durable than wooden pallets. They can be reused, since they do not absorb humidity, cannot be altered by acids or solvents, are chemically inert, and do not retain any contaminants likely to produce bacteria. On the other hand, their low resistance to high or low temperatures, and their high cost, are some of the disadvantages of this system.

6.2.3.3 Metal

Metal pallets are more resistant and more rigid than any other type of pallet. They come in various shapes and different types. For example, aluminum pallets are now widespread in the food and pharmaceutical industries, because they are durable, sturdy, lightweight and unalterable.

6.2.3.4 Carton

Carton pallets, albeit less expensive, are too fragile according to some experts. Thanks to new materials and more effective glues, it could become an alternative to single-use wood pallets. They can be almost entirely recycled, and are even made from recycled products.

6.3 Standardization of pallets

The increasing popularity of pallets, and the rising need in terms of storage, handling, transport and marketing, has made it necessary to standardize the design and construction of pallets. Up until now, established standards have governed pallets and wood containers, which represent 90% of the pallets sold on the market. These standards specify their dimensional, qualitative and mechanical characteristics, as well as their construction materials, in order to guide the user who develops the specifications.

There exists national standards, such as the NF standards in France, the ASTM and NWPCA (*National Wood Pallet and Container Association*) standards in the United States, and the CSA standards in Canada, as well as international standards, such as the ISO series of standards, that specify recommendations intended for users, as well as strength test procedures. Following are some examples of ASTM (*American Society for Testing and Materials*) standards:

- ASTM D1185, *Standard Test Methods for Pallets and Related Structures Employed in Materials Handling and Shipping*;
- ASTM D6253, *Standard Practice for Marking of Pallets*;
- ASTM D6199, *Standard Practice for Quality of Wood Components of Containers and Pallets*;
- ASTM F680, *Standard Test Methods for Nails*.

6.4 Standardized pallet sizes

In North America, the standard general use pallet measures 1,220 mm x 1,016 mm (48 in. x 40 in.), and is slightly bigger than the standard 1,200 mm x 1,000 mm (47.24 in. x 39.37 in.) European pallet.

However, special-use pallets can vary in size, such as the square pallet measuring 1,220 mm x 1,220 mm (48 in. x 48 in.).

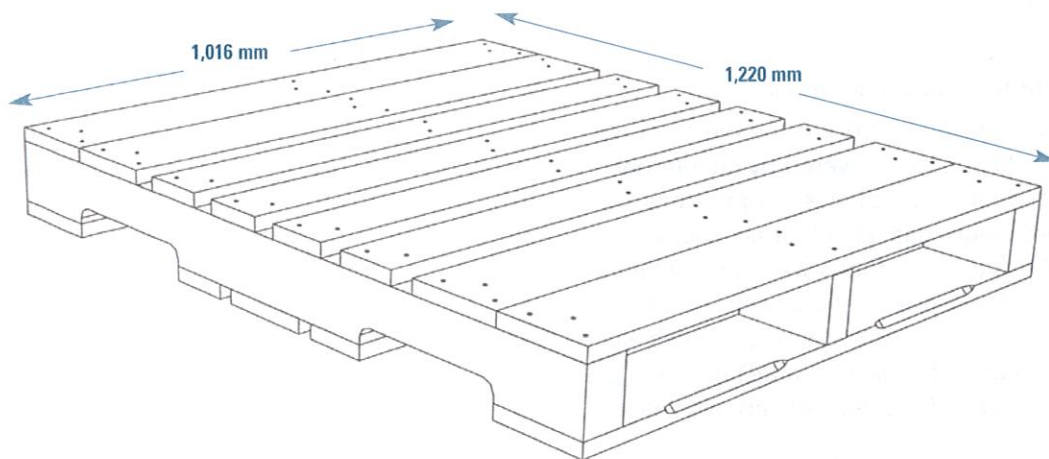


Figure 19. Standard North American 1,220 mm x 1,016 mm pallet
(Illustration: Technitrack)

Note– This section was adapted from the IND6209 Lecture Notes, *Implantation et manutention, Section 8 – Palette*, written by Marcel Brunet, P. Eng. and Diane Riopel, P. Eng., Ph.D., École polytechnique de Montréal. The pallet illustrations were taken from the *Lexique de la palettisation*, Clément Croteau, Office québécois de la langue française, Les Publications du Québec, 1998.

Lift trucks are used to move, set down or retrieve loads stored on racking. Since they operate around the aisles and inside the rack structure, they are often in direct contact with pallet components. They must therefore be suitable for the type of loads that are handled and the type of racking that is set up.

Under the *Regulation respecting occupational health and safety* (Section 256), lift trucks shall be in conformance with one of the following standards:

- ASME B56.1-1993, *Safety Standard for Low Lift and High Lift Trucks*;
- CSA B335.1-1977, *Low Lift and High Lift Trucks*;
- ANSI B56.1-1975, *Low Lift and High Lift Trucks*.

7.1 Main types of lift trucks

There are a wide variety of lift trucks, some very versatile, and others designed for specific applications.

7.1.1 Counterbalanced lift truck

The counterbalanced lift truck is the most popular within the industry. It is powered by an internal combustion engine (diesel, gas, propane gas, or liquefied petroleum gas (LPG)), or an electric motor, and has three or four solid rubber wheels (or hard wheels) or pneumatic wheels. Some have special attachments and/or accessories, such as clamps, rotating heads, ram attachments, etc. Load capacity and lift height can vary with each lift truck.

Because it is so versatile, this lift truck is used to load and unload trucks and/or trailers, to move loads inside or outside buildings, or to pick up and retrieve loads.

This type of truck is generally used for lifting loads at heights under 6 m (20 ft.). It can navigate aisles as narrow as 3.3 m (11 ft.), and can be used in all types of rack structures, except the double deep system.

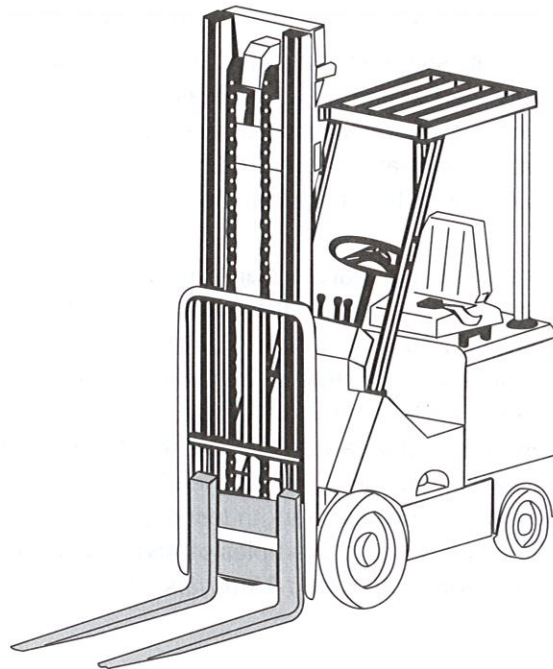


Figure 20. Counterbalanced lift truck
(Illustration: OQLF)

7.1.2 Narrow aisle straddle truck

Narrow aisle straddle truck (*chariot élévateur à fourche entre longerons pour les allées étroites*) can navigate aisles as narrow as 2.4 m (8 ft.). It is furnished with an electric motor and solid rubber wheels, and has a maximum stack height of 12 m (40 ft.). It can be used in all types of racking, except the double deep system, and the operator can either sit or stand.

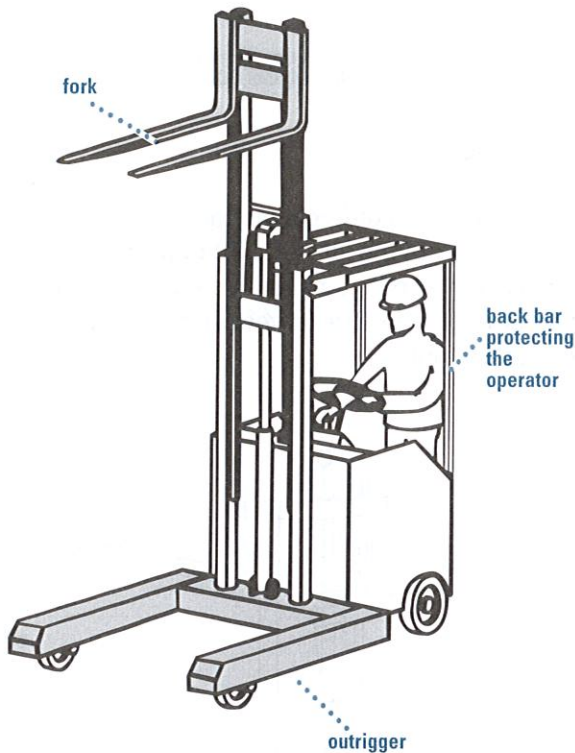


Figure 21. Narrow aisle straddle truck (Illustration: OQLF)

7.1.3 Reach fork lift truck

The main feature of the reach fork lift truck (*chariot élévateur à tablier porte-fourche rétractable*) is the fork installed on an extending scissor mechanism to reach the farthest loads stored in double deep racking.

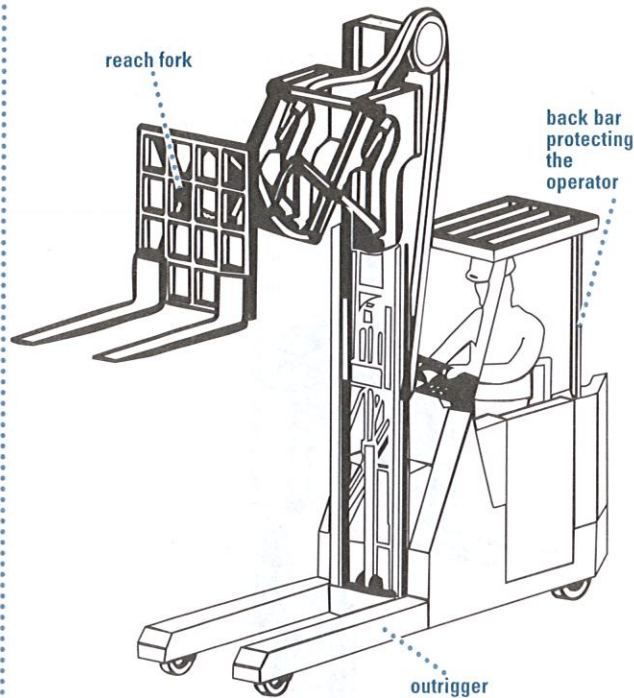


Figure 22. Reach fork lift truck (Illustration: OQLF)

7.1.4 Order picking truck

Order pickers (*chariots élévateurs à poste de conduite éleuable*) are used to manually prepare customer orders for quantities that are usually smaller than those of single pallets. The operator can rise several meters with the load to manually prepare orders from a customer list and replenish the stocks.

This type of lift truck can circulate in very narrow aisles up to 1.8 m (6 ft.) wide, and reach heights of up to 12 m (40 ft.). However, lift trucks capable of reaching heights of 6 to 9 m (20 to 30 ft.) are the most common.

The platform shall be protected with a guardrail, and all workers shall wear a safety harness, in conformance with the requirements of the *Regulation respecting occupational health and safety*, Section 346.

If the pallet is replaced with a work platform to accommodate the operator, then this change to the lift truck shall be approved by the manufacturer, or an engineer, in accordance with the *Regulation respecting occupational health and safety*, Section 245,7°.

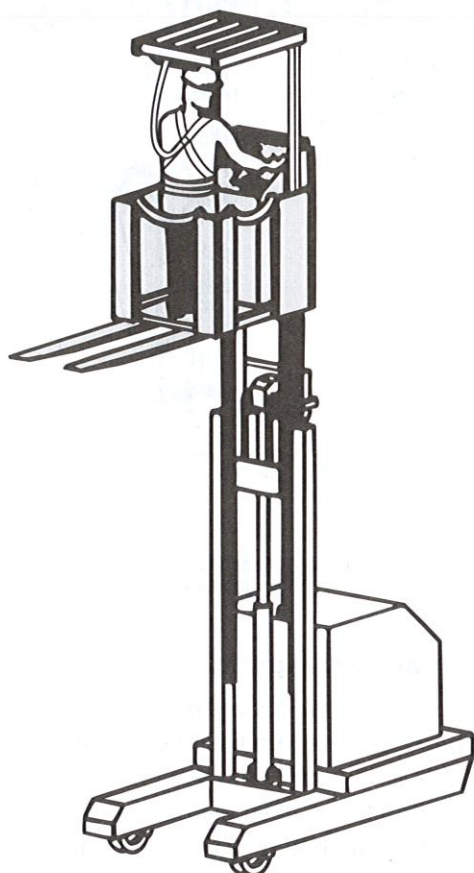


Figure 23. Order picking truck
(Illustration: OQLF)

7.2 Pallet jack

The pallet jack (*transpalette*) is a material handling equipment with two horizontal forks or stringers to support loads, equipped with rollers or small retractable wheels. It is used to move palletized unit loads over a short distance, and is not designed for stacking. It may or may not be motorized, and the operator can either walk or stand on the machine.

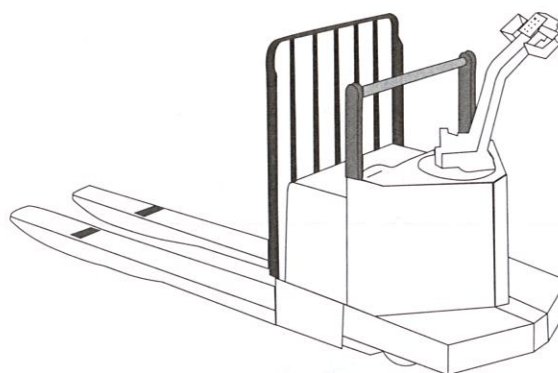


Figure 24. Power-operated pallet jack
(Illustration: OQLF)

7.3 Stacker

It is important to differentiate the stacker (*gerbeur*) from the lift truck. The primary function of a stacker is to be able to lift a unit load which may or may not be palletized. The operator is always on foot.

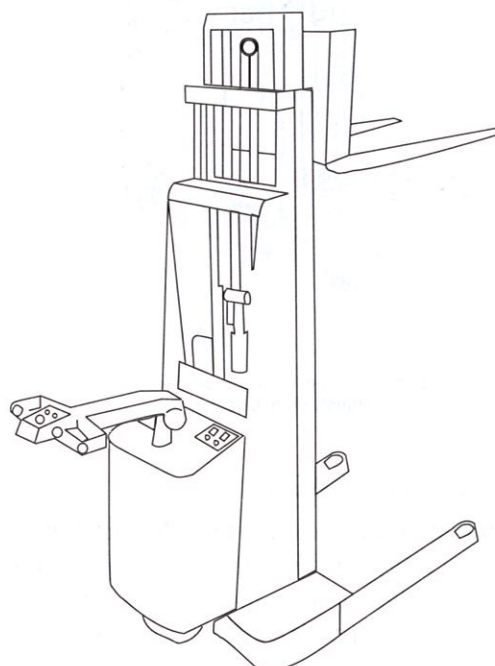


Figure 25. Stacker
(Illustration: OQLF)

Note – The lift truck illustrations were taken from the *Lexique des chariots élévateurs*, Clément Croteau, Office québécois de la langue française, Les Publications du Québec, 1989

Part Two • Preventive Measures

8 Design & construction of pallet racks

8.1 Safety standards to follow when designing pallet racks

Several standards on the design, construction and use of pallet racks are recognized within the industry, such as the RMI standards in the US, *Specification for the Design, Testing and Utilization of Industrial Steel Storage Racks – 2002 Edition*, or ANSI MH 16.2-1984 *Manual of Safety Practices – A Code of Safety Practices for the Use of Industrial and Commercial Steel Storage Racks*, as well as those of SEMA in Great Britain, or the Fédération européenne de la manutention (FEM).

In Canada, the two standards below were published in 2005 by the Canadian Standards Association (CSA), and can be used as a reference by racking manufacturers and users:

- CSA A344.1-05 *User Guide for Steel Storage Racks*;
- CSA A344.2-05 *Standard for the Design and Construction of Steel Storage Racks*.

For steel quality, CSA draft standard A344.2 specifies the requirements to follow in the following publications:

- CSA S16-01 *Limit States Design of Steel Structures / Règles de calcul aux états limites des charpentes en acier*;
- CSA S136-01 (ANSI: AISI/COS/NASPEC: 2001) *North American Specification for the Design of Cold-Formed Steel Structural Members / Spécification nord-américaine pour le calcul des éléments de charpente en acier formés à froid*.

As for welding, CSA standard A344.2-05 refers to the requirements of the following publications:

- CSA S136-01 Annex B, and CSA S16-01;
- CSA W59-03 *Welded Steel Construction (Metal Arc Welding) / Construction soudée en acier (Soudage à l'arc)*.

8.2 Pallet rack upright frame

8.2.1 Description

Pallet rack upright frames (*échelles de palettiers*) consist of two **columns** that redirect the vertical forces towards the ground. The columns generally consist of various types of thin-walled, open steel sections that are constructed from cold-formed elements or structural shapes. They differ from one another, in part because of their shape, width or gauge, as well as the characteristics of the steel used, the forming process, and the position and quantity of the anchors securing the beam brackets.

Horizontal (*traverses*) and **diagonal braces** (*diagonales d'échelle*) connect the two columns of an upright frame. These components, including their quantity and location, determine in part the load capacity of the frame, and its ability to resist impacts.

Base plates (see Figure 27) secured at the base of the columns distribute the load to the floor to prevent localized deformations, and to anchor the pallet rack to the floor slab. They are generally rectangular in shape, and measure about 8 to 10 cm x 12 cm (3 to 4 in. x 5 in.). Two holes behind the column accommodate the anchor bolts. Since these holes are very close to one another, there is a risk of chipping the concrete floor when screwing in the bolts. On some base plate models, the holes are at the front and rear of the column, so that the bolts can be anchored without damaging the concrete.

Some manufacturers offer other models of varying shapes that can generally accommodate different column protection or reinforcing systems.

Steel leveling pads (or shims) equal in size to the base plate can be installed underneath it to correct an uneven floor, and maintain the plumb tolerance of the columns.

The frames generally vary in length between 1 to 10 m (3 to 35 ft.), with a depth of between 0.6 to 1.6 m (24 to 64 in.).

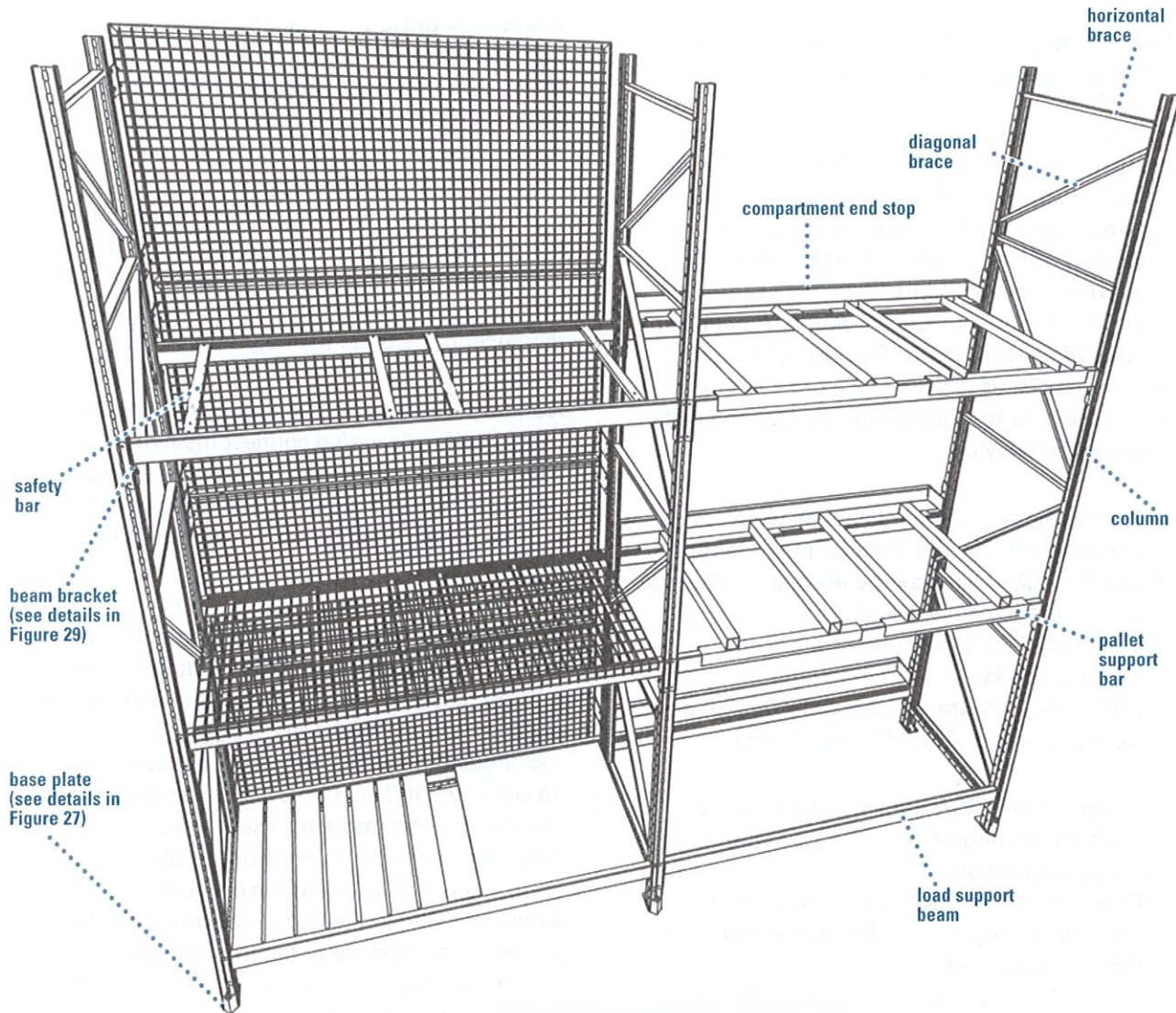


Figure 26. Rack components and accessories
(Illustration: Technirack)

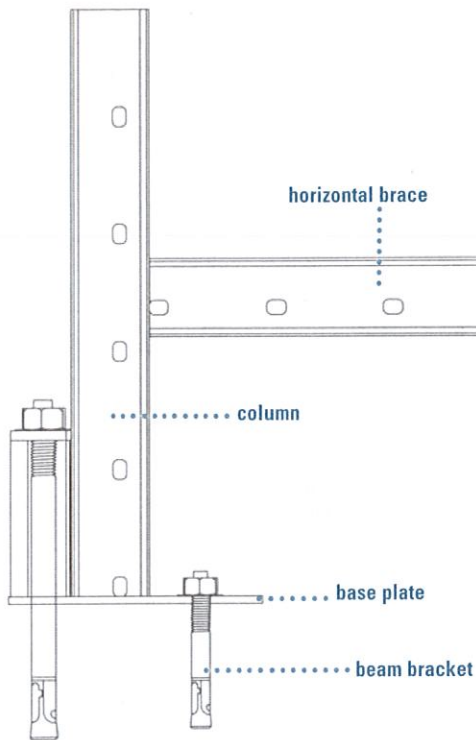


Figure 27. Base plate and anchor bolts
(Illustration: Technirack)

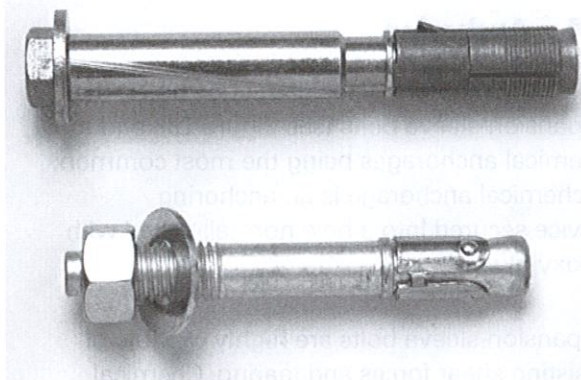


Figure 28. Expansion sleeve anchor bolts
(Photo: Maurice Vézinet)

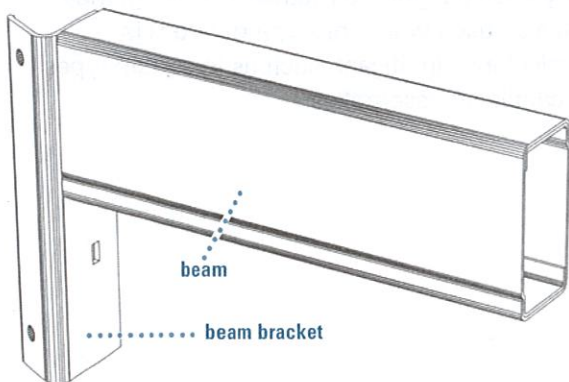


Figure 29. Beam bracket
(Illustration: Technirack)

8.2.2 Design of pallet rack upright frames

Some of the factors that determine if a frame will remain rigid are:

- the height of the first horizontal brace (or the distance between the ground and the first horizontal brace);
- the spacing between the horizontal braces;
- the physical characteristics of the bracing (angle iron, C-shaped section, tubular section, etc.);
- the type of fastener between the column and the bracing members (tack welding, complete joint penetration weld, bolts, etc.).

It is important to extend the diagonal braces deep into the column to improve the stability of the frame.

Several types of frames are available, the most common being the type Z configuration where bracing members are installed to form the letter "Z". Even though type X configurations are less common, they are preferable especially due to their stability and impact resistance.

The use of *cant-leg* frames (*échelles en porte-à-faux*; see Figure 30) is also widespread. The bottom of the frame facing the aisle is truncated and replaced with structural steel, thus leaving more space at ground level in front of the aisle to help the operator manoeuvre the lift truck.

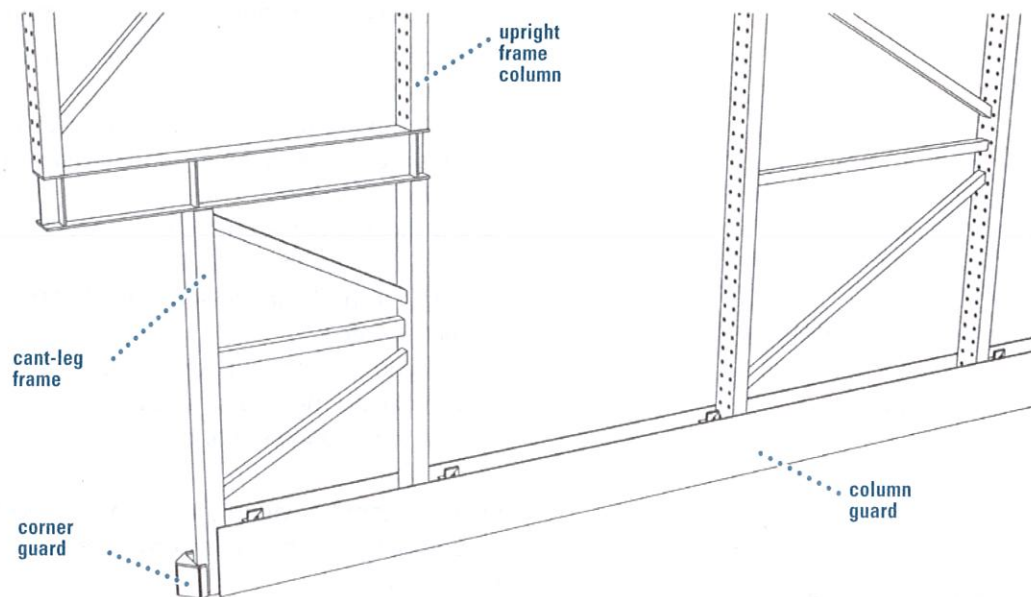


Figure 30. Cant-leg frame
(Illustration: Technirack)

8.3 Beams

8.3.1 Description

The **beam** (*lisse*) is a horizontal beam with **beam connectors** (*attaches de lisse*; see Figure 29) at each end to secure the different frame columns; the stored loads rest on the beams. Since the connectors secure the beams to the columns, they play a major role in ensuring racking stability.

As with the columns, the shape, width, length and gauge, as well as the characteristics of the steel used and the forming process, are all factors that determine the load-carrying capacity of the beams, whose length generally varies between 1.2 m and 4.2 m (4 ft. and 14 ft.).

Various types of beams are sold on the market, the most common being the box beam (*lisse à caisson*), and the built-in step beam (*lisse à épaulement*).

The box beam consists of two C-shaped sections that fit into each other, and are generally welded to form a unit resembling a closed box.

The built-in step beam is a box beam where one section is perpendicular on one side to form an edge on which an accessory for protection against falling objects can rest (steel or wood panel).

8.4 Anchoring

There are different types of **anchor bolts**, the expansion-sleeve bolts (see Figure 28), and the chemical anchorages being the most common. A chemical anchorage is an anchoring device secured into a hole normally filled with epoxy glue.

Expansion-sleeve bolts are highly capable of resisting shear forces and tearing. Chemical anchors are used in specific situations, such as when the concrete is not strong enough to hold a standard anchoring device. As well, since they have a higher resistance to tearing, they are also used when this type of stress is particularly significant, such as in certain types of cantilever assemblies.

8.5 Accessories

There is a wide range of accessories, each having a definite function, to help improve the rack structure's stability, impact resistance and safety.

8.5.1 Row spacers

The row spacer (*entretoise de jumelage*) allows the connection of uprights placed back-to-back on two different rows. This vastly improves the stability of the entire unit by maintaining an even spacing between the frames.

8.5.2 Safety bars

Safety bars (*barres de sécurité*) shall be installed on the load support beams to prevent loads from falling, and secured to the beams. They are usually

installed in pairs, perpendicular to the beams, into which they can be fitted, depending on the system. They are not designed to support the entire weight of the load.

8.5.3 Pallet support bars

Contrary to safety bars, pallet support bars (*barres de support de palettes*) are designed to support the entire load in cases where the size, resistance, or type of pallet being used prevents it from being deposited directly onto the beams. The support bars leave enough space to allow the fork of the lift truck to pass under a load that is not resting on a pallet (e.g., planks); they also must be secured to the beams.

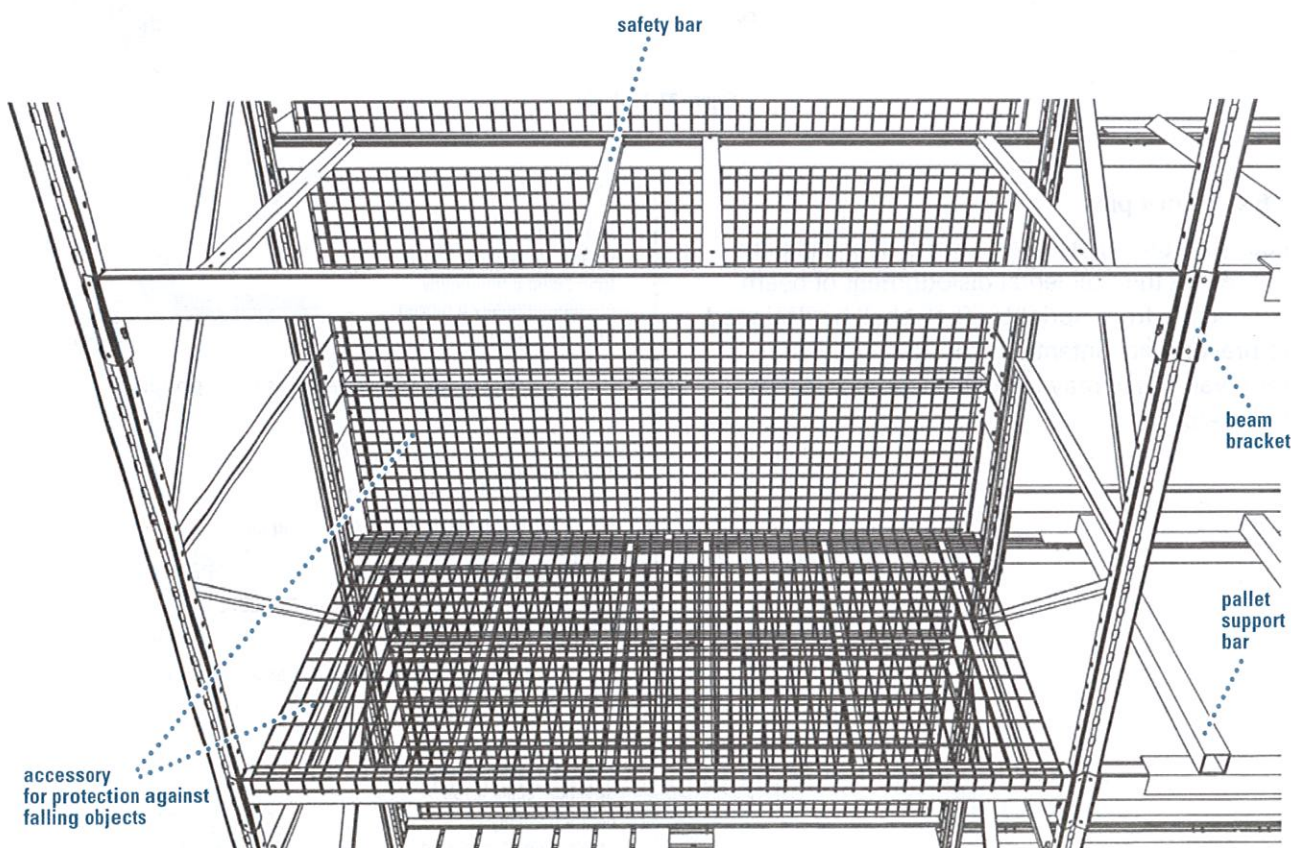


Figure 31. Rack accessories: safety bars, pallet support bars and accessories for protection against falling objects (Illustration: Technirack)

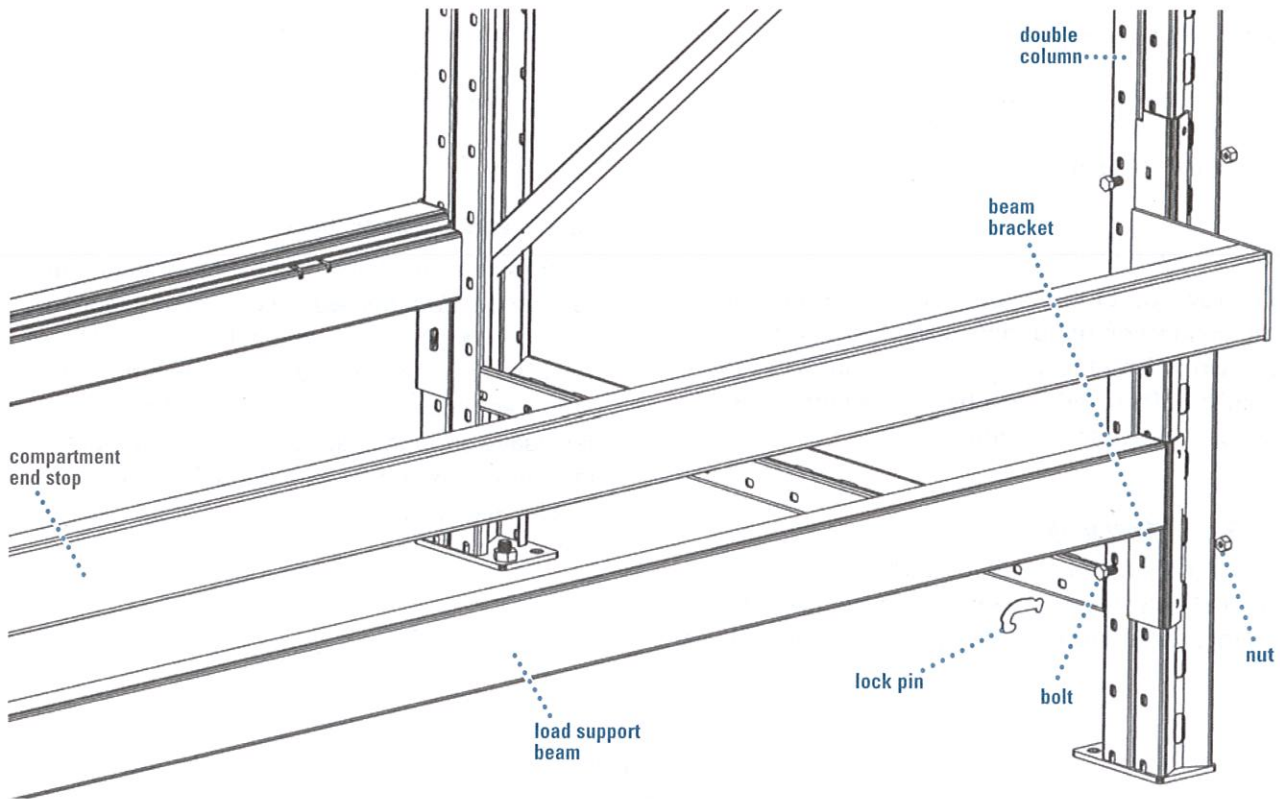


Figure 32. Lock pin

8.5.4 Lock pins

Lock pins are installed at the end of each beam to prevent the accidental dislodgment of beam connectors from uprights. They shall be designed to prevent their intentional or unintentional removal. These may include shear pins, screw bolts, etc.

At the top of the pin, a small end stop prevents it from being intentionally or unintentionally removed from the column.



Figure 32a. Recommended as a lock pin design

The pin is inserted in the column with a hammer, and thus cannot be intentionally or unintentionally removed from it. However, particular attention should be given to the wear and tear on each side of the stem.



Figure 32b. Recommended as a lock pin design

The pin is not securely attached, since it can be intentionally or unintentionally removed.



Figure 32c. Not recommended as a lock pin design

8.6 Component identification

According to Section 6, Product Identification, in CSA Standard A344.2, *Standard for the Design and Construction of Steel Storage Racks*, “beams and frames shall bear a permanent identification mark that is traceable to their manufacturer”. They shall also bear an identification code, and specify the properties of the components.

These properties shall be determined by the manufacturer, or an engineer, before the component is installed.

The manufacturers shall maintain records to ensure that they can determine the component properties from a permanent identification mark or code. The tests performed to establish the component’s capabilities shall also be included in the record.

8.7 Pallet rack rated load plaque

It is recommended to install plaques to specify the rated load of a pallet rack. The plaques shall be corrosion resistant, placed in such a manner as to be easily read by the operator, and contain

the following information, at the very least:

- manufacturer’s name;
- maximum beam capacity;
- maximum bay capacity.

The maximum beam capacity (*charge maximale admissible par alvéole*) is the load that can be placed on two beams.

The maximum bay capacity (*charge totale admissible d’une travée*) is the load that can be placed in each bay, excluding the loads that are deposited on the ground.

If the rated load is the same for all the beams in one bay, one plaque placed on the first beam of that bay is sufficient.

If the rated load is the same for all the beams in one row, one plaque installed at the end of that row is sufficient.

It is also recommended to add the following marking on the plaque: **“The rated load or the configuration of the pallet rack, shall not be modified in any way without prior approval from the manufacturer or the engineer”**.

ABC Racking Inc.

Rated Load of the Racking

- Maximum beam capacity: _____ Kg
- Maximum bay capacity: _____ Kg

Attention: The rated load or the configuration of the pallet rack shall not be modified in any way without prior approval from the manufacturer, or an engineer.

Figure 33. Example of a pallet rack rated load plaque

9

Used pallet racks

Purchasing a used rack from a supplier, or at an auction, is a very common practice, since purchasers often consider this to be an economical solution. However, this type of racking may be a source of danger. In fact, the person who purchases racking that has already been used rarely knows its manufacturer, characteristics, and previous operating conditions. This information is critical, since it helps determine if the rack is suitable for its intended use. Certain precautions must therefore be taken when purchasing and installing reused pallet racks.

9.1 Component condition

All the components of a reused pallet rack should be closely examined. A good visual inspection is critical, but it is only the first step of the component evaluation process. The inspection should focus mainly on freshly repainted areas, any damages sustained by the components (dents, cracks, bulges), the integrity of the components (e.g., repairs through welding), and any sign of corrosion.

The disassembly, transportation and reassembly of reused pallet racks may damage the components. Particular attention should be given to the beam brackets, since they play a major role in ensuring the stability of the structure.

Damaged components and fasteners must be rejected.

9.2 Rated load of used racks

Before purchasing a reused pallet rack, the purchaser shall ensure that its rated load is suitable for its intended use which, in this case, is not always known.

The rated load may be obtained from the original drawings or specifications for an unmodified rack, or otherwise, from the manufacturer or an engineer.

When different components of a reused rack are purchased separately, the rated load of the resulting unit shall be determined by the manufacturer (if all components are from the same manufacturer), or an engineer.

The supplier shall give the purchaser all the information relating to the rated load, based on the configuration shown in an assembly drawing.

The plaque shall contain the information specified under Section 8.7, Pallet rack rated load plaque in this Guide.

9.3 Installation of used racks

Reused pallet racks shall be designed and installed according to the same recommendations as new pallet racks, with special attention to missing components (e.g., missing bracing members in an upright), and the compatibility between each component (e.g., misaligned safety pin holes). Consequently, the use of new components with reused components, or of components from different manufacturers, is to be avoided.

10.1 Planning the pallet rack purchasing and installation details

When planning to purchase racking, it is important to take into account the characteristics of the building, including the characteristics of the soil it will be built on, and the column locations. The type of merchandise that will be stored, the workers who will be handling it, and the inventory management methods that will be used, are also factors to be taken into consideration. Finally, the lift trucks that will be traveling inside the warehouse will be chosen according to the height of the rack structure, and their characteristics will determine the width of the aisles.

Whether the warehouse is to be newly designed or simply modified, the collaboration between the pallet rack and the lift truck suppliers, and the user, is essential. Advice from a logistics planner can also be useful.

10.2 Preparing the specification

In order to be able to provide the user the racking that is suited to his needs, the supplier shall obtain from the user information pertaining to: the loads to be stored, the characteristics of the storage area, and the material handling equipment. This information is included in the record form. Some suppliers use a standard form to collect data from the customer. An example of a **record form** is provided in Appendix 1.

The development of a detailed record form is essential to ensure that the user acquires racks that meet his needs in terms of use, safety and costs. Several problems may be avoided if this step is taken seriously.

Based on the complexity of the project and the production targets, the record form may be developed in collaboration with a storage specialist or a logistics planner, who shall take into account inventory management, order preparation, product distribution, shipping and receiving, as well as the flow of goods, and their location inside the warehouse.

Data to be included in the record form

The specifications shall include the following information, at the very least:

- Nature of the loads
- Load characteristics
- Load support means
- Load layout and rotation
- Type of lift trucks used
- Characteristics of the storage area
- Environmental conditions
- Seismic hazards
- Clearances
- Accessories and protective devices
- Lighting

10.2.1 Nature of the loads

The nature of the loads to be stored may influence the rack design, and that of the warehouse in which they will be installed, and more specifically dangerous substances that are likely to damage the rack components (e.g., a corrosive substance). The regulatory requirements on the storage and handling of dangerous substances shall therefore be observed, specifically those in Section X, *Storage and handling of dangerous substances*, in the *Regulation respecting occupational health and safety*, and in the relevant clauses in NFPA 30 *Flammable and Combustible Liquids Code*. These requirements specify, among other things, the limits to follow with respect to the amount of some substances that can be stored, as well as the rules governing the segregation of certain products.

The National Fire Code (NFC) and the *National Building Code (NBC)* have provisions on the preventive measures to adopt, such as the maximum distances to cover to reach the exits and the automatic sprinkler system.

10.2.2 Load characteristics

In addition to taking into account the nature of the loads to be stored, the pallet rack supplier shall also consider:

- the load weight;
- the specific location of the load's center of gravity;
- the load size (width, depth, height).

The supplier can then provide the proper rated load, and the clearance around the stored loads. The supplier shall immediately be informed of any change to the characteristics of the loads to be stored.

When calculating the maximum beam capacity, the racking manufacturer normally considers the load that spans the length of the beam to be uniformly distributed, and to be evenly balanced between the back and the front beams.

10.2.3 Load support means

The loads may or may not be palletized.

Palletized unit loads

The information to be provided shall include the following information:

- types of pallets;
- weight and size of the pallets;
- specific location of the palletized loads' center of gravity;
- pallet load capacity;
- pallet entry (the side of the pallet facing the aisle).

The rack supplier shall be informed if more than one type of pallet is used.

Non-palletized loads

If the user intends to store non-palletized loads (e.g., containers, barrels, planks), the supplier shall be informed, since the rack design may eventually be modified by adding special accessories.

10.2.4 Load layout and rotation

The supplier shall be informed of the layout of the various loads on the racking, and the inventory management methods (FIFO, LIFO) that are applied.

10.2.5 Types of lift trucks used

The types of lift trucks that are used shall determine, among other things:

- the width of the aisles;
- the maximum loading height;
- the need for a guidance system.

If the user already owns lift trucks, he shall provide the supplier with all the necessary information, such as:

- the type of lift truck;
- the maximum lift height;
- the load-carrying capacity
- the width, including the pallet and the load;
- the swing radius;
- the height of the lowered mast (especially if tunnel bays are to be installed).

On the other hand, if the user still has not purchased any lift trucks, the type of racking that is chosen could determine the type of lift trucks that are used.

10.2.6 Characteristics of the storage area

The building and its foundation are important factors to consider when designing the racking.

Building characteristics

The building in which the pallet racks will be installed has special characteristics that must be taken into account, specifically:

- the dimensions;
- the location and size of the columns;
- the heating, ventilation and refrigeration units;
- the piping and water mains (gas, water);
- the electrical equipment and light fixtures;
- the location of sprinklers and fire-fighting equipment;
- the location of exits.

This information may be obtained from the building plans. The installation of racking in an existing building often obliges the supplier to adapt them to the equipment that is already in place.

Soil characteristics

The soil and the foundations shall be capable of resisting the loads that are applied to them. The following data shall be provided:

- the thickness of the concrete slab;
- the evenness of the concrete;
- the characteristics of the reinforcing bars and their location;
- the location of the ducts and conduits (electricity, plumbing, etc.).

In addition, certain characteristics of the soil and the building shall also be provided:

- the engineering properties of the soil (for the slabs);
- the building's structural characteristics, including the design criteria and the relevant data for seismic analysis (for raised floor slabs).

10.2.7 Environmental conditions

The supplier shall also be informed of the environmental conditions under which the rack system will be installed. If it is installed in a cold environment (outside or in a cold-storage warehouse), the supplier shall ensure that the selected materials and the manufacturing methods to be used are suitable for these operating conditions. Also, any relevant data on the harsh environment (e.g., humidity, pollution, corrosive agents) shall be provided to the supplier.

10.2.8 Seismic hazards

If the user wishes to have seismic hazards taken into account in the design of the structure, he shall inform the supplier, who will take into account the seismic data stipulated in the *National Building Code* (NBC), specifically in Appendix C, Table C-2, *Design Data for Selected Locations in Canada*, when designing the rack system.

It must be noted that racking designed to resist overloads due to seismic hazards are more secure, since they have more bracing members, and the anchorages are more resistant. This type of rack structure is less likely to come cascading down when a row of racks collapses after being struck by a lift truck. This type of system is also recommended in superstores that are open to the public, and for the storage of dangerous substances.

10.2.9 Clearances

It is important to determine the clearances right from the start, at the design phase.

If the clearances are insufficient, the risk of damage to the loads and racks increases. The lift truck supplier should be consulted to ensure that the clearances are sufficient to allow the operator to handle the loads in a safe manner.

The clearances to consider are:

- the space around the loads;
- the space around the pallet rack;
- the width of the warehouse aisles;
- the width of the main aisles;
- the boundaries of the walkways.

Aisle width

When designing racks, the tendency is to minimize aisle width to maximize storage space. The aisle width is determined by the size of the lift trucks, and of the loads that they carry. Aisles shall be kept well lit and unobstructed.

Pedestrian walkways

Walkways reserved for pedestrians shall be specifically planned to isolate them from the aisles reserved for lift trucks. Unless they are physically contained with equipment, walls or merchandise, they shall be clearly marked, normally with 10 cm (4 in.) wide yellow lines traced on the floor.

Tables 5 and 6 on the following pages indicate the recommended clearances for single deep and double deep pallet racks, and for drive-in and drive-thru pallet racks.

Except for the requirements in the different regulations, such as the *Regulation respecting occupational health and safety*, (Sections 15 and 288), or the *Canada Occupational Health and Safety Regulations* (Section 14.45), that are designated as such in Tables 5 and 6, the other safe widths are specified in the reference document, *Les rayonnages métalliques*, published by the Institut national de recherche et de sécurité (INRS) in France, 2001 Edition. They are included in these tables as references.

Table 5 Recommended clearances for single deep/double deep pallet racks

Number	Clearance	Recommended space
1	Clearance between two loads and between one load and the upright frame	At least 75 mm (3 in.) (Source: <i>Les rayonnages métalliques</i> , INRS)
2	Clearance between one load and the overhead beam	At least 75 mm (3 in.) This clearance will be increased for the top beams to allow the safe handling of the loads. (Source: <i>Les rayonnages métalliques</i> , INRS)
3	Pallet overhanging	Between 50 mm and 100 mm (2 in. and 4 in.) over the front and back beams.
4	Clearance between two loads - placed in two back-to-back compartments	At least 100 mm (4 in.) (Source: <i>Les rayonnages métalliques</i> , INRS)
5	Clearance for a service aisle	<ul style="list-style-type: none">• One-way traffic: At least the length of the truck, including its load, plus 150 mm (6 in.) on each side, or according to the lift truck manufacturer's recommendation (<i>Canada Occupational Health and Safety Regulations</i>, Section 14.45).• Two-way traffic: Consult the lift truck manufacturer.
6	Clearance for a main aisle	<ul style="list-style-type: none">• One-way and two-way traffic: According to the lift truck manufacturer's recommendation.
7	Clearance between one load and an automatic sprinkler system (<i>Regulation respecting occupational health and safety</i> , Section 288)	At least 450 mm (18 in.)
8	Walkways or gangways (<i>Regulation respecting occupational health and safety</i> , Section 15)	<ul style="list-style-type: none">• At least 600 mm (24 in.) wide, or more to allow the safe handling of materials.• At least 1,100 mm (43 in.) wide, if the walkway serves as direct access to an exit.• Have a free space of at least 2,000 mm (80 in.) above the floor, unless a danger sign is posted.

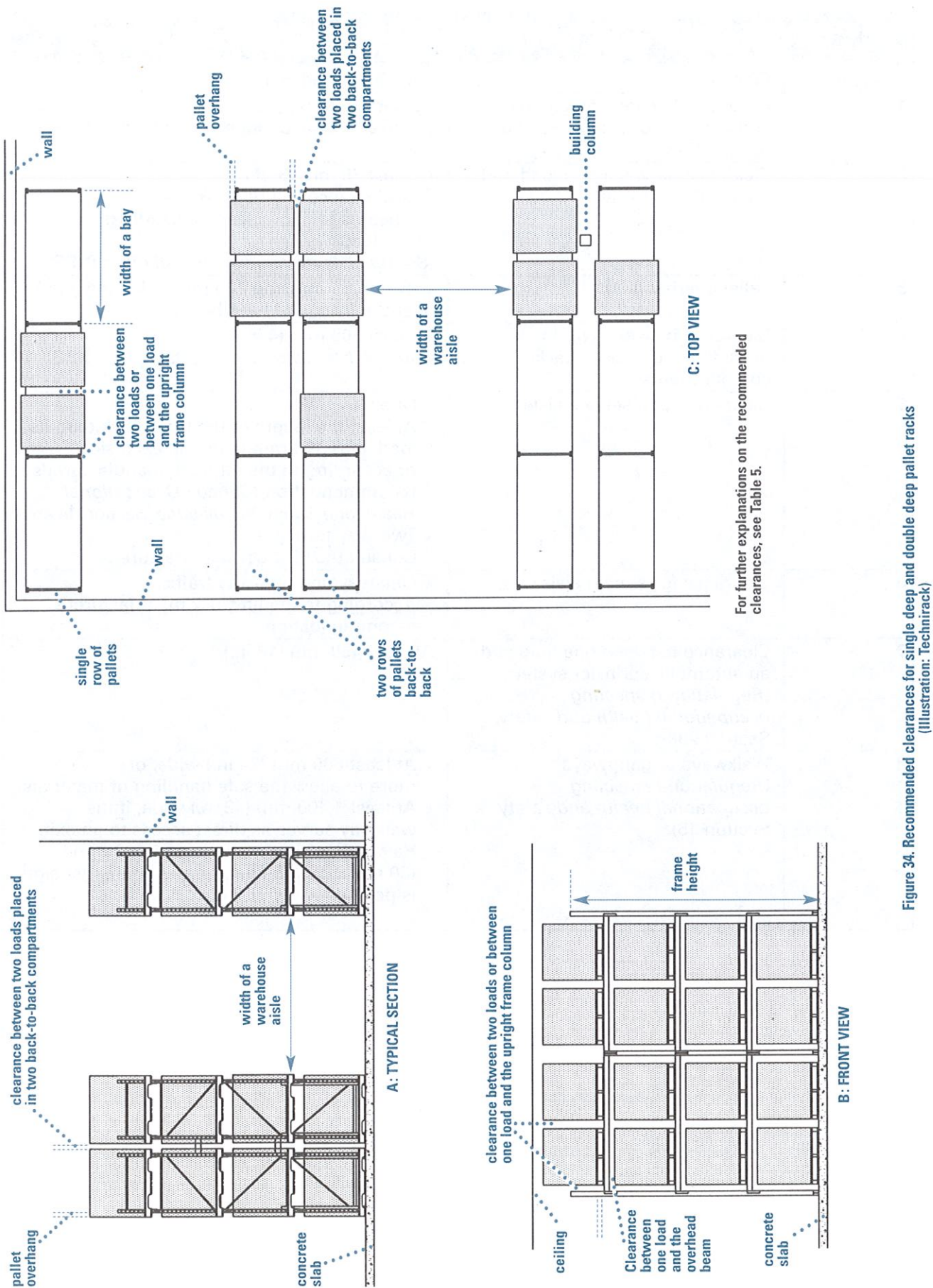
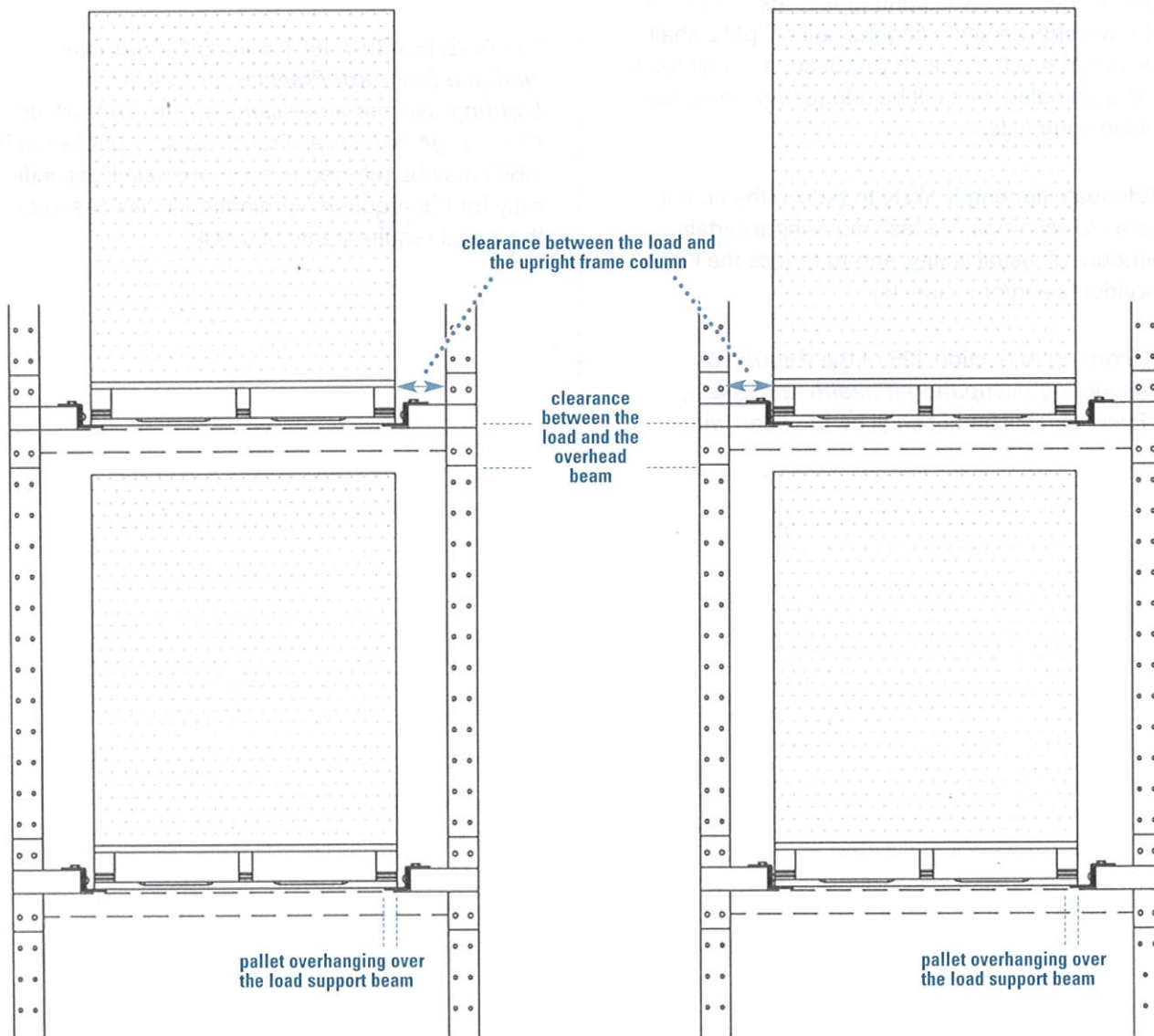


Figure 34. Recommended clearances for single deep and double deep pallet racks
(Illustration: Technirack)

Table 6 Recommended clearances for drive-in/drive-thru pallet racks

Number	Clearance	Recommended space
1	Clearance between the load and the upright frame column	At least 75 mm to 100 mm (3-4 in.). (Source: <i>Les rayonnages métalliques</i> , INRS)
2	Pallet overhanging the beam	At least 20 mm (3/4 in.). (Source: <i>Les rayonnages métalliques</i> , INRS)
3	Clearance between the load and the overhead beam	At least 100 mm (4 in.). (Source: <i>Les rayonnages métalliques</i> , INRS)
4	Depth clearance between two loads	At least 25 mm (1 in.). (Source : <i>Les rayonnages métalliques</i> , INRS)



For further explanations on the recommended clearances, see Table 6.

Figure 35. Recommended clearances for drive-in and drive-thru pallet racks
(Illustration: Technirack)

10.2.10 Accessories and protective devices

The following accessories and protective devices shall be specified in the record form, and shall be taken into account when determining aisle space:

- column guards;
- guard rails;
- safety pins;
- safety bars;
- pallet support bars;
- accessories for protection against falling objects;
- compartment end stops.

10.2.11 Lighting

Light fixtures shall be installed over the aisles so that the work areas are properly lit, without producing glare. The lighting fixtures installed in the warehouse, including the safety lights, shall be out of reach of the lift trucks and the unit loads being handled, or shall be adequately protected against impacts.

Adequate lighting is likely to reduce the time it takes to accomplish a task requiring a certain amount of visual acuity, and to reduce the risk of accidents and/or incidents.

According to Section 125 of the *Regulation respecting occupational health and safety*, "Every establishment shall be provided with

natural or artificial lighting the intensity of which depends on the nature of the work performed at any work station or the nature of the places, where workers circulate in order to provide the illumination levels stipulated in Schedule VI." of the Regulation. The illumination levels shall therefore be determined by evaluating the visual requirements of the task.

Some tasks may require lower levels, such as a periodic security check, where a minimum of 50 lux is acceptable.

On the other hand, tasks such as driving a lift truck, reading a purchase order, or evaluating the height required to place and/or retrieve a load, require a significantly higher illumination level.

The ANSI/IES-RP-7-1991 standard, *American National Standard Practice for Industrial Lighting* (*Norme américaine sur les méthodes d'éclairage industriel*, French version published in 1997) may be referred to for more details, specifically for the required illumination levels based on the visual requirements of a task.

11.1 Responsibilities

As with the design, the installation of racking shall be carried out according to specific rules to ensure the stability of the unit and, consequently, the safety of the workers and the protection of the merchandise.

It is the responsibility of the supplier to provide the user and the installer with the installation drawings and specifications. Racking shall be installed by the manufacturer himself, one of his representatives, or experts in the field. The user shall retain all the documentation.

The pallet racks shall be self supporting, since any attachment to the building structure is generally prohibited unless the building was specifically designed for this purpose. When it is absolutely necessary to secure racking to a building structure, the forces transmitted to the building as a result shall not exceed its capabilities, and the requirements of the *National Building Code* (NBC) shall be adhered to.

Any modification to the rack system that is not specified in the original specifications, namely to their configuration or location, shall be submitted to the pallet rack supplier, or to an engineer, before being performed, and the new rated load, the specifications and the installation tolerances shall be determined by the supplier, or an engineer.

During the installation work, certain preventive measures shall be implemented to ensure the safety of the installers, specifically by:

- securing the area by creating a safety perimeter;
- limiting the pedestrian and vehicular traffic;
- taking preventive measures against falls from heights, as well as any measures relating to the use of the handling and hoisting equipment.

11.2 Upright frame configurations

Figure 36, on the following page, illustrates the types Z and X configurations. Apart from the type X configurations represented in g) and h), the type Z frames with alternate diagonal braces, such as those shown in a), b) and c), are preferable to those illustrated in d), e) and f). In fact, the configurations in a), b) and c) allow the movement of the loaded topmost section of the upright frames to be reduced to a minimum.

Configurations that have a tendency to create a movement towards the rear of the top section of a frame being loaded, such as the ones shown in d) and e), are to be avoided.

Frame configurations such as those illustrated in f), are acceptable. However, loads deposited in an asymmetrical fashion on racks built with this type of frame could produce a situation similar to the one illustrated in d).

On the other hand, a type d) configuration in a cant-leg frame allows movement towards the rear, which offsets the alternate pattern that tends to create a movement towards the front.

11.3 Beam locations

The proper location of the beams is critical to ensure the rack's load-carrying capacity and stability. The frame-beam configuration shall be specified by the manufacturers in the installation instructions and drawings.

The installer shall ensure that the lock pins are properly secured at the end of each beam.

Since any modification to the height of a beam, or the removal of a beam, will affect the rack structure's load-carrying capacity and stability, no modification shall be carried out without first consulting the manufacturer.

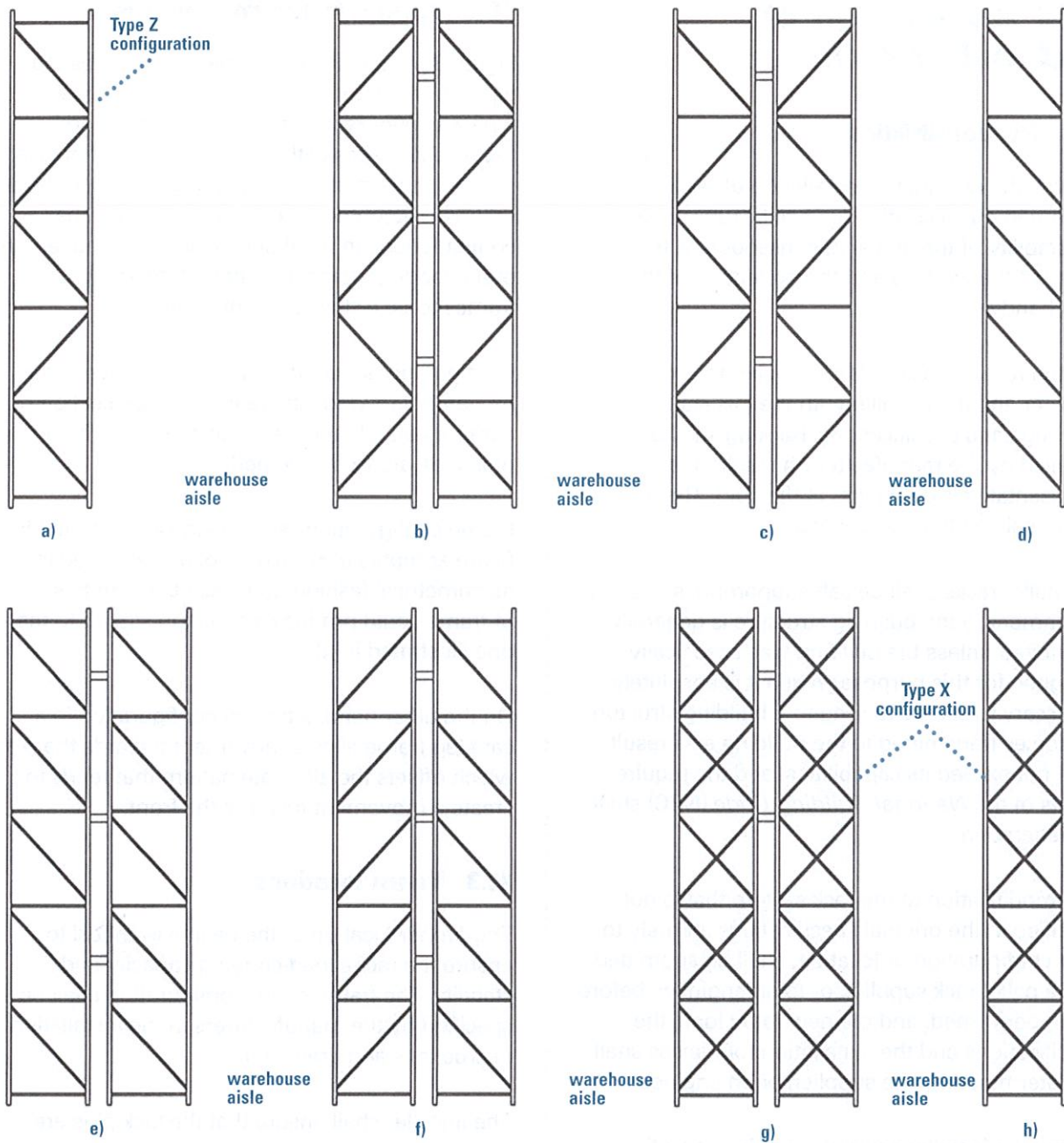


Figure 36. Types Z and X upright frame configurations
(Illustration: Technirack)

11.4 Height-to-width ratio

The height (H)-to-width (W) ratio is the factor that has the most influence on the rack's stability and, as such, serves to determine the needs in terms of anchorages, row spacers and cross aisle ties.

The height-to-width ratio is calculated using the following data:

- H is the height of the last level of the pallet rack beam;
- W is the width of the upright (for back-to-back racking, W = the width of the two frames, plus the width of the row spacer).

11.5 Anchoring

When using lift trucks, it is recommended to properly anchor the upright frames to the floor slab, without exception, to increase the rack's stability.

Lift trucks circulating in very narrow aisles, or in drive/drive-thru systems, and the use of order pickers, increase the risk of collisions with racking. Particular attention should therefore be given to the proper anchoring of the frames to the floor.

Installing two anchors instead of only one will also help prevent the column from pivoting upon impact.

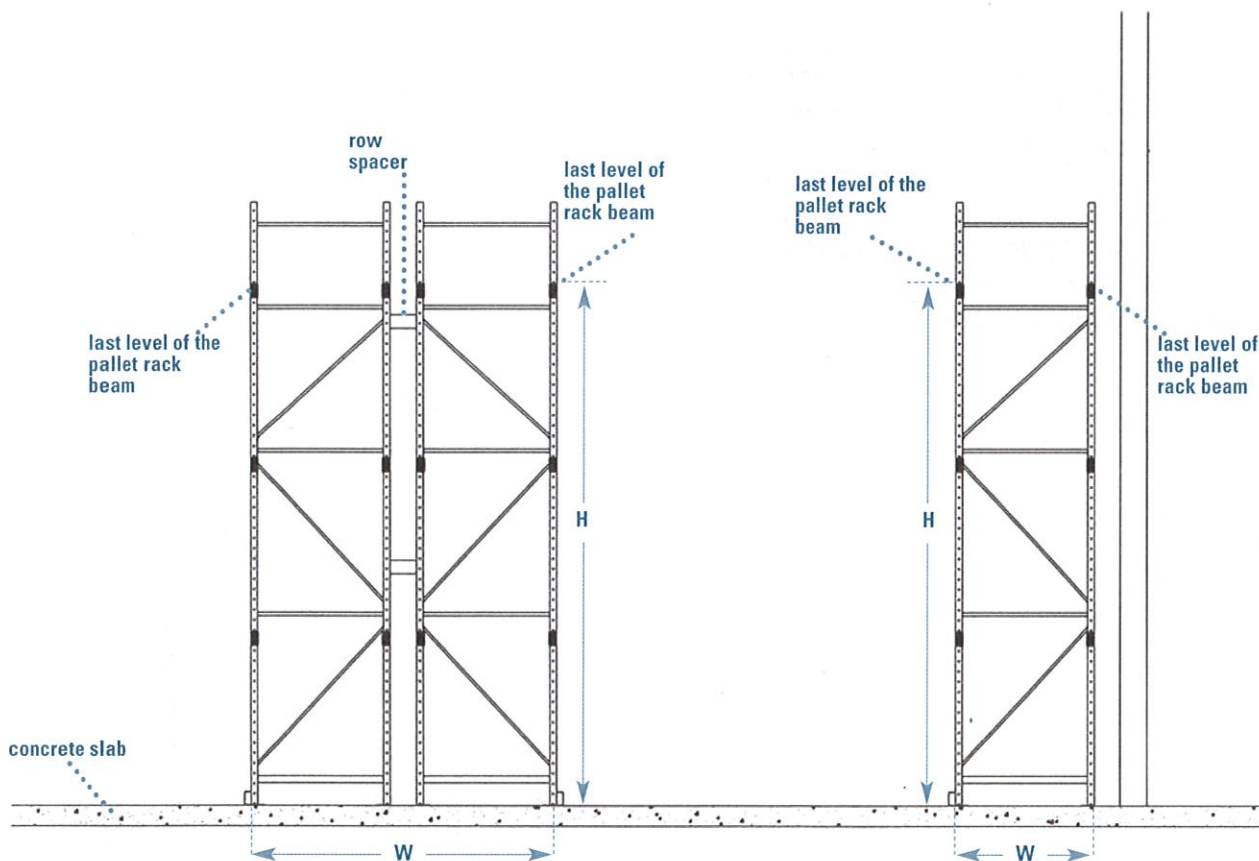


Figure 37. Width-to-height ratio
(Illustration: Technirack)

The bolt holes shall be far enough apart to avoid the risk of chipping or cracking the concrete, and the anchor bolts shall be installed and tightened in accordance with the bolt manufacturer's recommendations.

11.6 Plumb condition of the columns

The maximum permissible deviation from plumb (out-of-plumb) of each column shall be 1/240 of column height in an unloaded rack, or ½ in. for each 10 ft. of frame height.

For example, in a 6,000 mm (20 ft.) column, the maximum permissible deviation from plumb shall be 25 mm (1 in.), or $6,000 \text{ mm} / 240 = 25 \text{ mm}$, based on a 1/240 ratio.

The 1/240 ratio used for an unloaded rack is equivalent to the one required by American standardization organizations, such as RMI, and Canadian Standards Association (draft standard A344.1 *User Guide for Steel Storage Racks*). The requirements of the European organizations, however, are much more stringent. For example, the *User Code* (FEM 10.2.04) published by the Fédération européenne de la manutention recommends a ratio of 1/350.

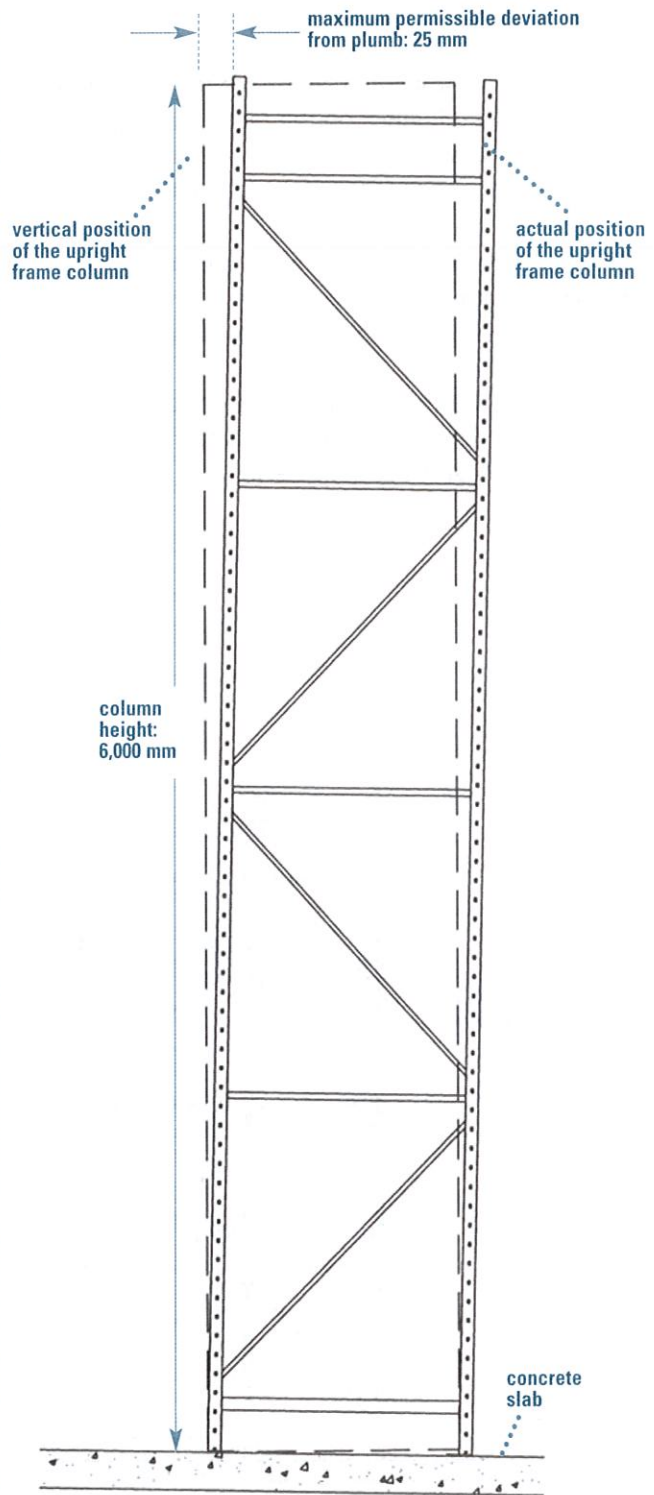


Figure 38. Out-of-plumb columns in an unloaded pallet rack (Illustration: Technirack)

11.7 Leveling adjustment

When shims are required to maintain the permissible tolerance from plumb, steel leveling pads equal in size to the base plate may be placed under the plates. A sufficient number of wedges 1 mm to 6 mm thick with holes drilled to match those of the base plates shall be provided.

The adjustment shall not be excessive, since it may interfere with the proper anchoring of the upright frame columns. The steel wedges shall also be tightly fastened to each other and to the base plates to prevent movement (e.g., by securing two anchor bolts into each base plate, or by welding them together).

Height difference following the leveling adjustment of two successive frame columns

The FEM 10.2.04 *User Code* recommends that this height difference not exceed 1/500 of the bay width.

For example, if two frames are separated from one another by 2,500 mm (about 8 ft.), the height difference following a level adjustment should not exceed 5 mm (about ¼ in.), or $2500/500 = 5$ mm, based on FEM's recommendations.

However, this 1/500 ratio is not mentioned in CSA draft standard A344.1 User Guide for Steel Storage Racks, and is therefore not a mandatory requirement, especially since it does not seem to affect the rack's structural behavior.

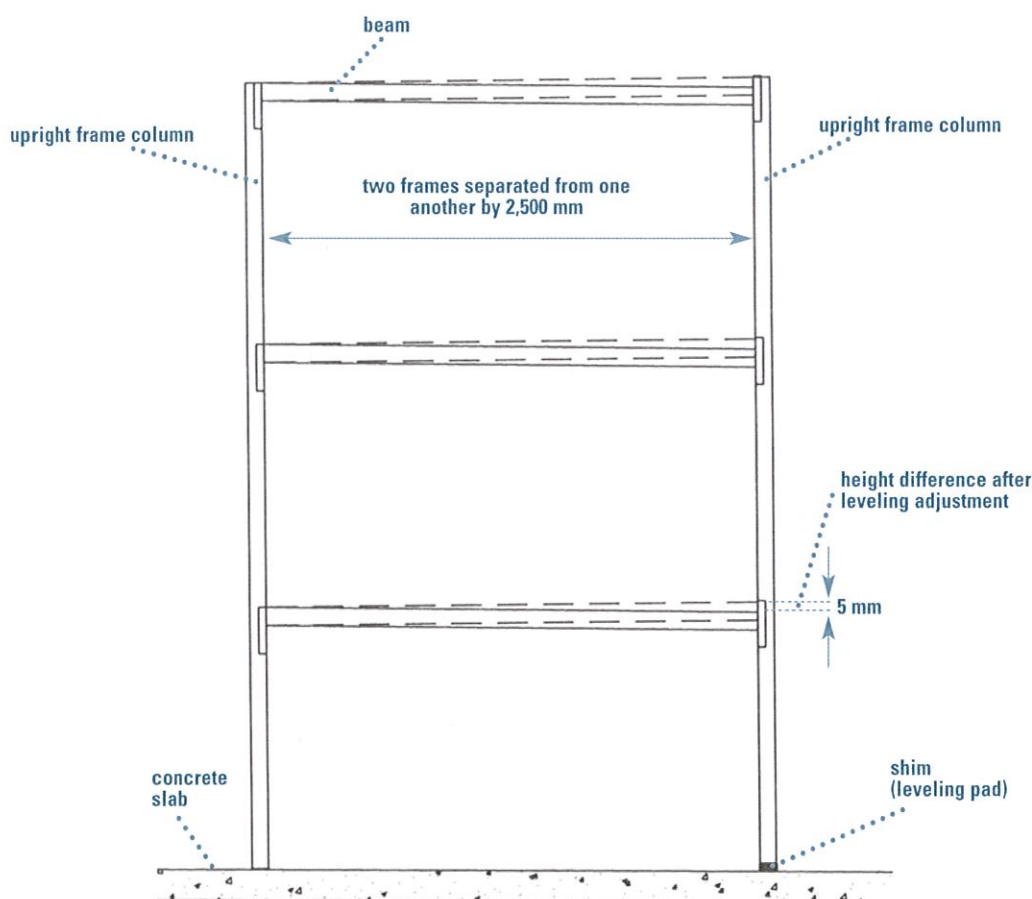


Figure 39. Height difference after the leveling adjustment of two successive frame columns (Illustration: Technirack)

11.8 Row spacers and cross aisle ties

To increase the stability of the rack structure, row spacers and cross aisle ties shall be installed and placed in accordance with the drawings and specifications established by the manufacturer, or an engineer. The closer a row spacer is to a horizontal brace, the more the impact from a lift truck against the first frame will be transmitted to the frame behind it.

11.9 Verifying the post-installation conformance of pallet racks

After the installation, and before loading begins, the racking shall be inspected by the manufacturer, or his representatives. To that end, a **checklist for single deep and double deep pallet racks**, to be used as a work tool or a quick reference guide, is included in Appendix 2 of this Guide.

12 Using pallet racks

Loading and unloading operations imply the use of lift trucks. Driving lift trucks, and storing or handling loads on pallet racks, create safety hazards that should not be neglected. The manner in which the lift trucks are driven affects the safety of the pedestrians and the protection of rack components. Lack of training, excessive speed, congestion in the main aisles, the use of pallets and lift trucks that are unsuitable for the loads being transported, are all factors that contribute to accidents.

12.1 Personnel training

All personnel required to work around a rack system shall be knowledgeable with respect to the rated load of the racking, the characteristics of the stored loads, the operating conditions of the lift trucks, and the vehicles operating around the racks.

More specifically, all the operators shall be required to receive training on safe driving practices. In addition to the usual topics on lift trucks and safe driving practices, the training programs shall cover the effects of impacts on the racking, with a focus on the importance of avoiding collisions, especially by reducing speed.

The operators and the workers shall also be made aware of the importance of reporting any damages sustained by the components.

12.2 Load layout in the rack structure

- The rated load shall be adhered to, since a localized overload may cause a permanent deformation of the load beams or beam brackets, among other things.
- The pallet loads stored on the racking shall be arranged in such a manner as to provide the clearances recommended in Tables 5 and 6, of Section 10, for example:
 - the pallets on the beams bordering the aisle shall have an overhang of between 50 mm and 100 mm (2 in. and 4 in.);

- The clearance between two loads shall be at least 75 mm (3 in.).
- Storage operations shall not interfere with the lighting.
- Dangerous substances shall be safely stored in sealed containers, and spills shall be cleaned up as soon as possible.
- Any load that is likely to break up shall be properly secured on the pallet by strong packaging.
- The loads shall be evenly distributed and securely fastened on the pallets.
- The loads shall not overhang over the pallet by more than 50 mm (2 in.).

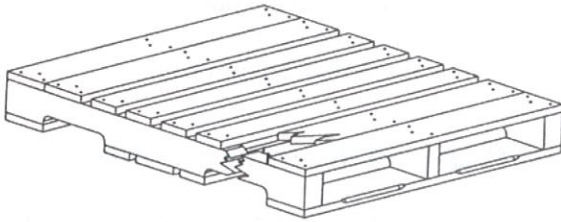
12.3 Preparing the customer orders

- All customer orders shall be prepared in the designated areas.
- If the work requires an elevating station, a suitable lift truck, such as an order picker, shall be used.
- The warehouse aisles and the main aisles shall be kept free of obstructions to provide enough space for the operators to manoeuvre the lift trucks.
- Goods in transit shall be deposited in the designated areas.

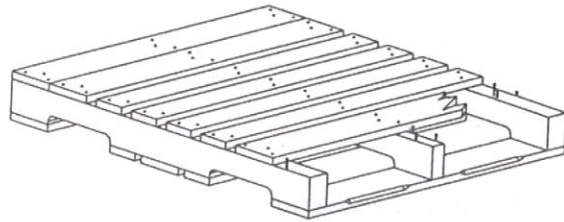
12.4 Precautions to take when using pallets

- Only the type of pallet that is compatible with the pallet rack (size, weight, resistance, etc.) shall be used.
- Expendable pallets (disposable or non-reusable pallets) shall not be deposited on a rack, unless a reusable pallet is placed underneath.
- Particular attention should be given to pallets of European origin that may be found in drive-in/drive-thru structures (*palettier statique ouvert sur une face ou ouvert sur deux faces*), since their size is slightly different from that of North American pallets. For example, the standard 1,200 mm x 1,000 mm (47,24 in. x 39,37 in.) European pallet is smaller than its standard 1,220 mm x 1,016 mm (48 in x 40 in.) North American counterpart.

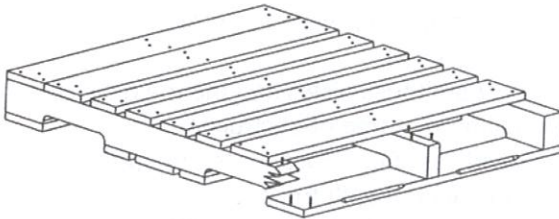
- Pallets shall be regularly inspected, and damaged pallets shall be rejected.
- It is recommended to reject pallets with one or several of the following defects:
 - missing, deficient, split, or broken stringers;
 - missing, deficient, split, or broken boards;
 - protruding nails.



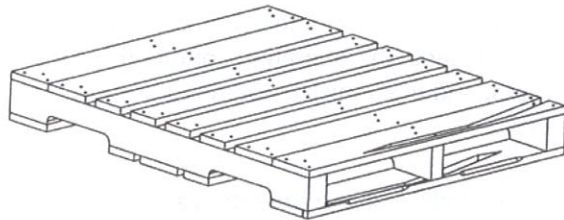
Broken stringer



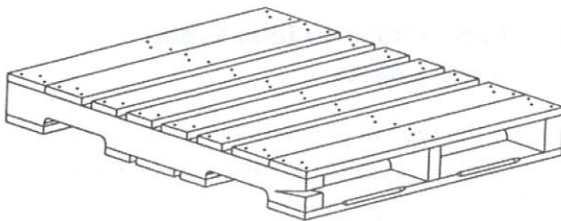
Missing and broken boards



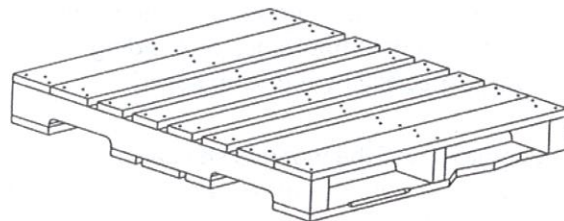
Deficient stringer



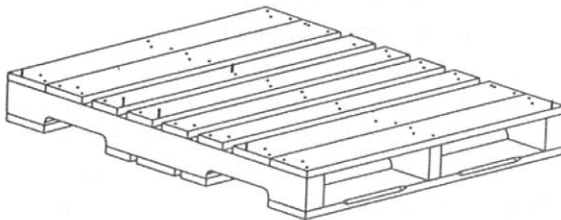
Split boards



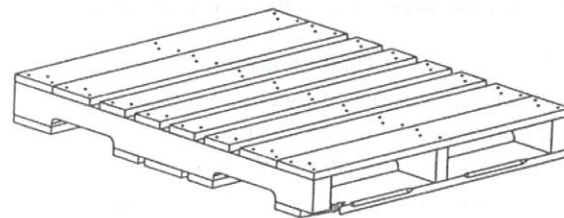
Split stringer



Broken board



Protruding nails



Broken board

Figure 40. Damaged pallets to be rejected
(Illustration: Technirack)

12.5 Protection against falls from heights

- Workers are permitted to rise with the lift truck if the requirements in Section 3.10.7 of the *Safety Code for the construction industry* are adhered to.
- Any modification to a lift truck, such as adding or extending a work platform on an order picker, shall be pre-approved by the lift truck manufacturer, or an engineer.
- The protection against falls shall, at all times, be adapted to the work, and be consistent with the Regulation.
- Unless the racking has been designed for this purpose, pedestrians are prohibited from circulating on it.

12.6 Protection against falling objects

Accessories for protection against falling objects are installed on the pallet rack beams and behind a compartment to prevent objects from falling off the racking, specifically when the compartment is over a walkway or a main aisle. Protective devices include the following items.

12.6.1 Net

An accessory installed under, or behind, the load support beams to prevent objects from falling off the racks, specifically when a compartment is placed over a walkway, or is adjacent to a main aisle.

12.6.2 Screen panels or grid decks

When the backs of some compartments are bordering walkways, warehouse aisles, transit zones, workstations or any other area where pedestrians may circulate, accessories for protection against falling objects that are suitable for the stored pallet unit loads, shall be installed, such as grid decks, screen panels, solid panels, or any other accessory capable of preventing the merchandise from falling.

These accessories for protection against falling objects shall be installed at a height of approximately 1 m (40 in.) between the ground and the top of the stored loads. The loads shall not rest against any of these accessories.

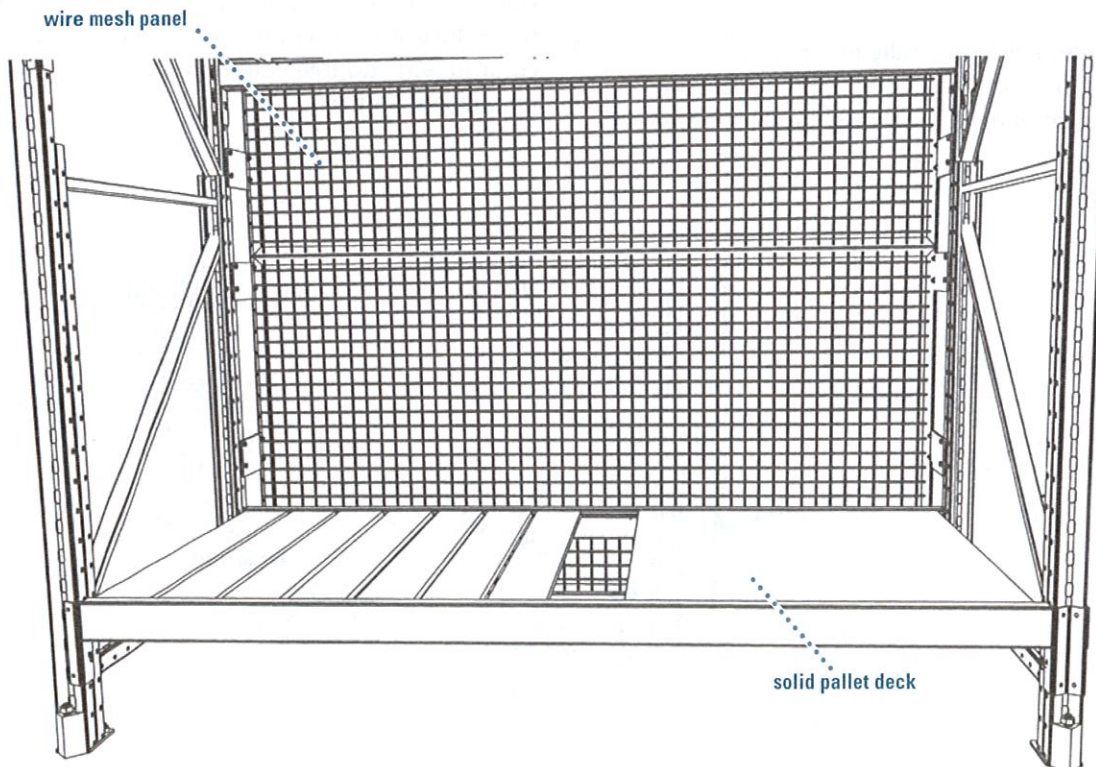


Figure 41. Accessories for protection against falling objects
(Illustration: Technirack)

When non-palletized loads, or loads having a base with a particular configuration (e.g., a round shape), are stored in racking, accessories that allow to adequately retain and support these loads shall be provided for. These accessories shall be designed so as to prevent any movement that may cause them, or the loads, to fall accidentally.

When smaller pallets, or pallets that are less resistant than those for which the racking has been designed, are stored on a rack, accessories that allow to adequately retain and support these pallets, shall be provided for (e.g., pallet support bars or a solid pallet deck).

12.7 Protection against impacts

Protective devices are used to increase the rack's resistance to impacts. They can be divided into two broad categories: column guards and row end protectors.

12.7.1 Column guards

These devices are installed in front of, or around, a column that is at risk of sustaining an impact, as a means of protection.

Column guards are generally in the form of a casing anchored to the ground, rectangular or V-shaped, that partially or totally covers the base

of the column. They consist of an end stop or a corner guard to further protect the column.

To be effective, column guards must be installed at the right height. For example, if most of the damage sustained by the columns is at a height of 500 mm (20 in.), a protective device at a height of 300 mm (12 in.) will be useless.

The protectors may be self-contained, or either bolted or welded to the column at the manufacturer's.

Upon impact, the self-contained protector, slightly recessed from the column, may be subjected to some deformation which is not transmitted to the column. However, this type of protector is an added obstacle in an aisle, since it is recessed, and its height is also more limited since it tends to bend.

Protectors incorporated into the columns are less cumbersome. Since they are secured to the column, they are more likely to transfer the stress caused by an impact.

Some manufacturers also suggest incorporating protectors into the columns, to produce oversized column (e.g., double columns) that are more impact-resistant.

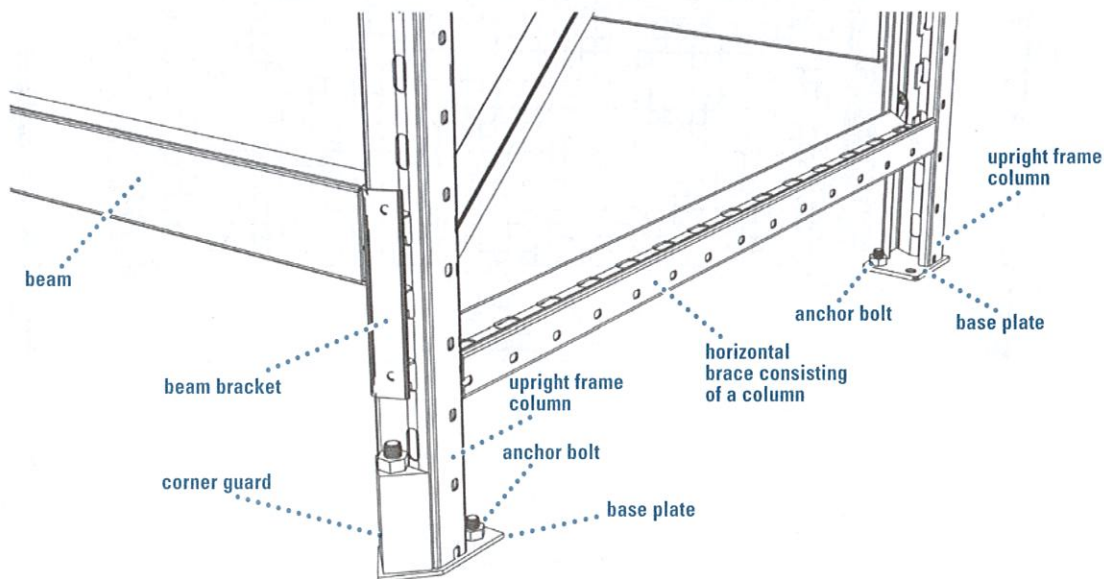


Figure 42. Built-in column protection
(Illustration: Technirack)

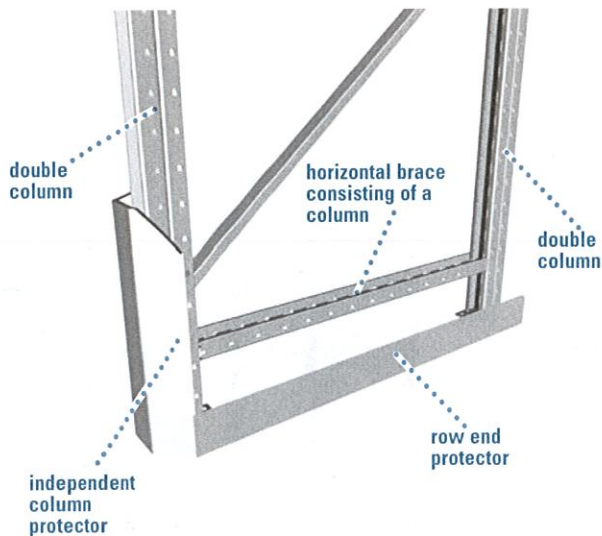


Figure 43. Independent column protection
(Illustration: Technirack)



Figure 44. Row end protector
(Illustration: Technirack)



Figure 45. Protective barrier separating the pedestrian walkway and the main aisle
(Illustration: Technirack)

12.7.2 Row end protectors

Row end protectors are most often guard rails used to ensure the protection of the racking at the end of each row, or along tunnel bays. Since they are generally independent of the racking, they must be anchored to the ground. It is recommended to paint them in bright colors, such as yellow or orange.

Just like column guards, row end protectors shall be installed at the right height.

Their height and resistance shall be determined by the type of lift truck that is being used, and the area where impacts are most likely to occur.

12.8 Precautions to take when using lift trucks

In recent years, storage heights have increased considerably, while the width of the warehouses and main aisles has been reduced. As a result, certain layouts, and certain devices and/or accessories, may become necessary to avoid collisions with the components.

12.8.1 Width of the warehouse aisles

The width of a warehouse aisle where counterbalanced lift trucks travel usually varies between 3.3 m and 3.6 m (11-12 ft.). In recent years, aisles have been known to be as narrow as 2.4 m to 3 m (8-10 ft.), or even narrower (1.8 m or 6 ft. maximum). In order to adapt to these new requirements, lift truck manufacturers now offer equipment that is increasingly efficient and specialized.

Reducing the width of the aisles and, as a result, the manoeuvring space on each side of the lift truck, increases the risk of accidental impacts with the rack structure. In order to minimize those risks, guidance systems are available to assist the operator when he enters an aisle, or travels in an aisle and/or inside a racking, such as the drive-in/drive-thru system.

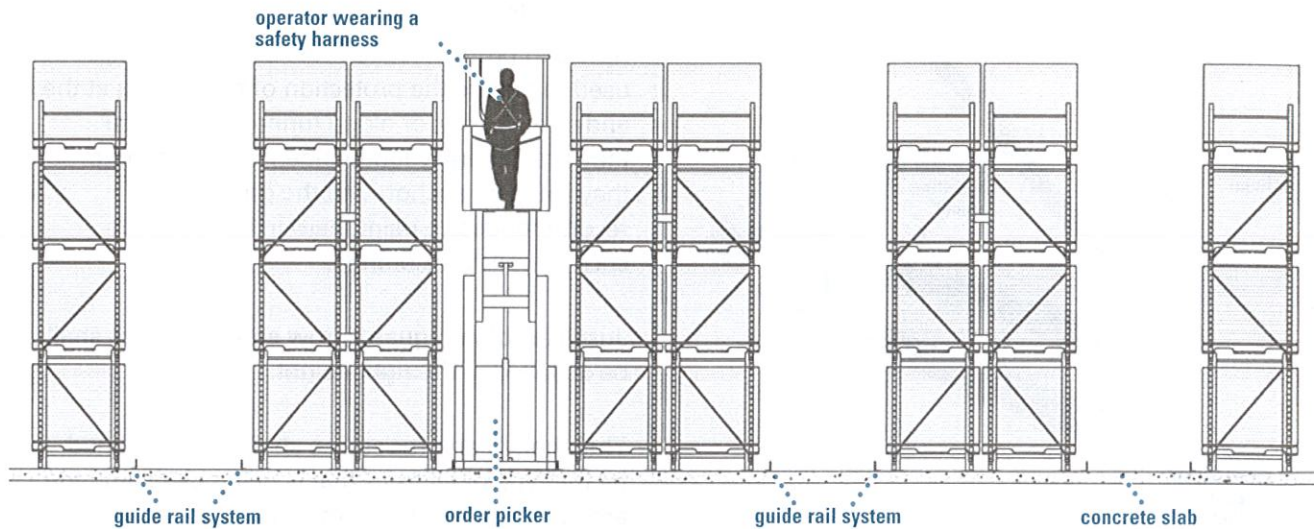


Figure 46. Very narrow warehouse aisle and order picker
(Illustration: Technirack)

12.8.2 Stack height

Starting at a certain height, the placement and retrieval of loads are hard to judge. It is therefore recommended to use load positioning equipment. The hoisting mechanism may be furnished with a camera, a stack height selector, or an automatic tracking system. The operator may also rely upon special markings on the lift truck's mast.

Even with this type of equipment, placing and retrieving loads over a certain height will surely require the operator to stretch his neck and strain his eyes, thus increasing the risk of injuring himself and of damaging the material.

Also, when pallet loads are stored very high, the lift truck becomes very unstable during handling. To prevent the lift truck from overturning, it is imperative for the operator to follow the manufacturer's recommendations. Systems controlling the lift truck's speed and movements based on the height of the load being handled may be useful in situations like these.

12.8.3 Safety devices

Some safety devices may be used to improve the lift truck's performance and operational safety.

- **Back bar (operator)**

This system consists of one or two bars installed behind an operator who is standing on a narrow aisle straddle truck, or on a reach fork lift truck (see Figures 21 and 22) to prevent objects placed sideways on a lift truck (e.g., beams) from penetrating inside the cab. Guardrails and protective devices installed on the ground may be used in the same manner.

• Guidance systems

Guidance systems help the operator manoeuvre the lift truck when entering a very narrow aisle. Some systems completely control the lift truck, while others assist the operator. In particularly narrow aisles, where manoeuvrability is rather limited, the risk of impacts with the rack components is higher. By steering the vehicle and controlling the speed, the guidance system enhances the operator's safety, and prevents the material from being damaged while improving productivity.

Various guidance systems are currently available on the market, such as the:

- guide rail system;
- inductive system (wire guidance)
- optical guidance system;
- laser guidance system.

One of the most common is the guide rail system. Steel rails designed to resist impacts with lift trucks are secured on each side of the aisle to guide the lift truck as it travels up and down the warehouse aisle, thus eliminating impacts with the rack structure. Small rollers are sometimes mounted to each side of the lift truck, at the base, to facilitate guidance.

Regardless of the type of guidance system that is chosen, its design and installation shall be made in close collaboration with the lift truck and racking manufacturers, to ensure that the guidance system, the lift truck and the rack structure are safe and compatible.

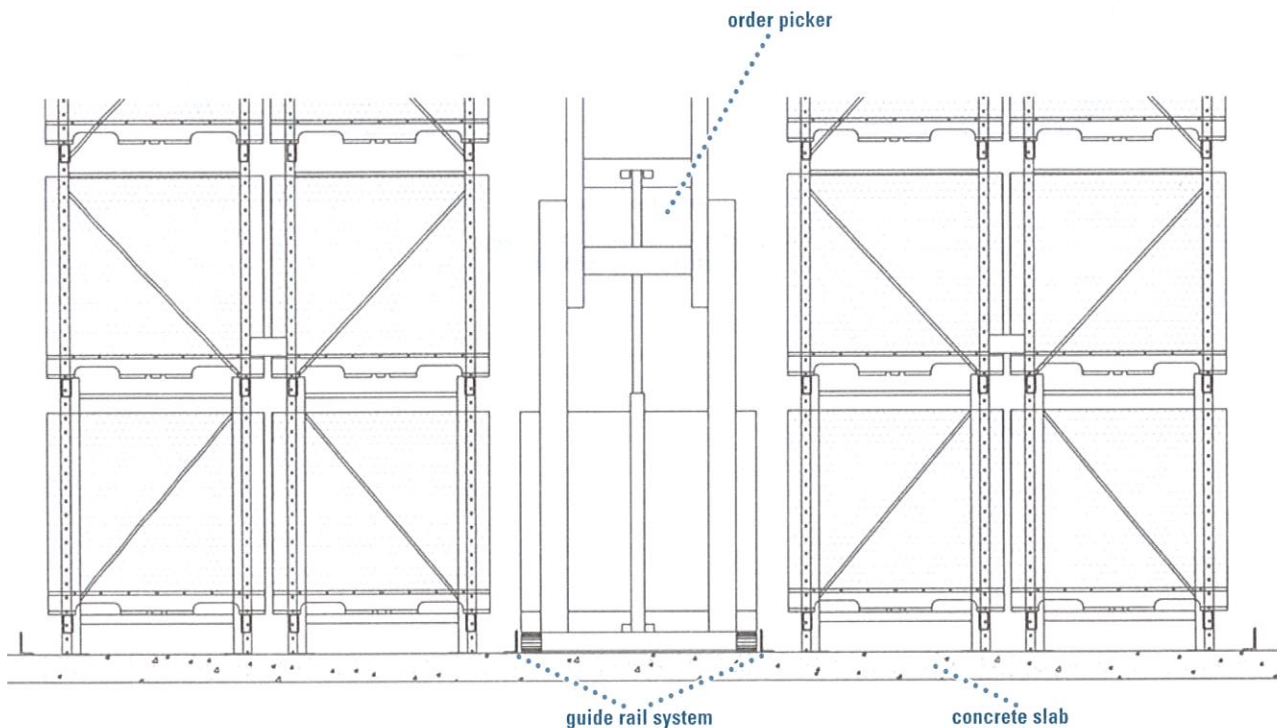


Figure 47. Guide rail system
(Illustration: Technirack)

- **Entrance guide**

The entrance guide is a device that allows the proper steering of the lift truck as it enters an aisle. It is particularly useful in the drive-in/drive-thru system, and in narrow aisles where order pickers travel. The guide, which is shaped like a funnel with the narrower end at the aisle entrance, shall be designed to resist impacts.

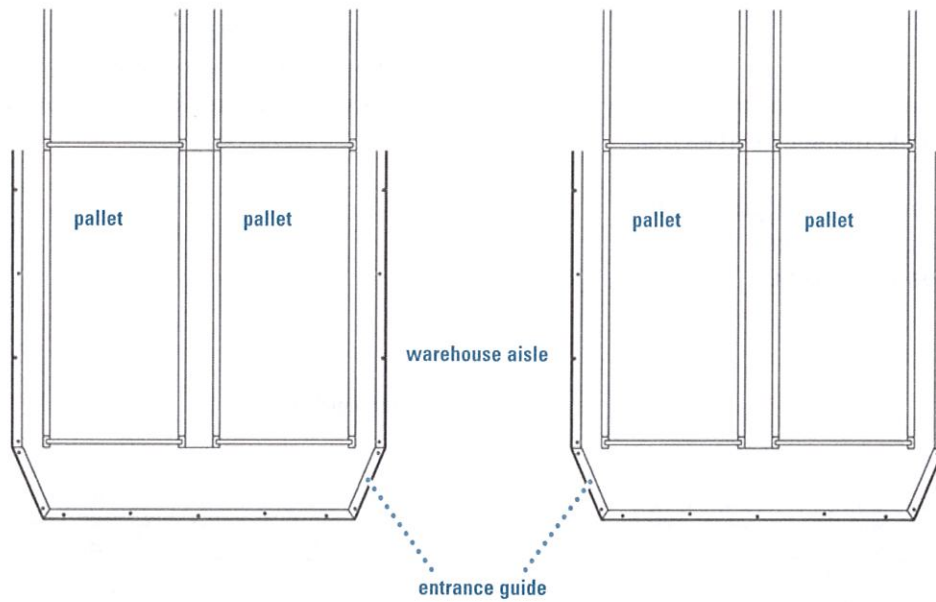


Figure 48. Entrance guide (Top view)
(Illustration: Technirack)

13 Inspection, maintenance and repair of pallet racks

Pallet racks, or racking, are structures that often give the impression of being durable, even though they are subjected to dynamic and static forces, impacts and environmental conditions that affect their integrity and capabilities. For this reason, they need to be periodically inspected and maintained to ensure that they remain in good condition, and that both the personnel and the material are well protected.

The inspection and maintenance of the racking is the responsibility of the user, who may turn to specialists in the field for assistance when some operations require a certain expertise.

This section gives recommendations and suggestions on the:

- type and frequency of the inspections;
- components to be examined and inspected;
- parameters and tolerances to be monitored;
- assessment of damages;
- corrective measures to be taken.

13.1 Types of inspections

The user shall implement an inspection and maintenance program that includes:

- daily inspections;
- scheduled inspections (visual and detailed).

13.1.1 Daily inspections

The objective of daily inspections is to report visible anomalies, such as:

- deformed components;
- misplaced loads;
- missing lock pins;
- missing anchor bolts;
- obstructed warehouse aisles and main aisles.

13.1.2 Scheduled inspections

Scheduled inspections are performed visually and with measuring instruments.

- The objective of the **visual inspection** is to systematically report the condition of the racking and its surroundings.
- **Detailed inspections** are used to assess the plumb condition of the columns, and the deformation of the beams and frames. Measurements must be taken with simple instruments, such as a level and a metallic straight edge. It may be necessary to unload certain sections of the pallet rack to measure the permanent deformation of some components.

A **periodic inspection checklist for single deep and double deep pallet racks** is included in Appendix 3 of this Guide.

13.2 Frequency of scheduled inspections

The frequency of the scheduled inspections shall be determined by consulting the racking manufacturer, and by taking into account the following factors:

- the degree of difficulty of the task performed by the operator;
- the variety of pallets or unit loads being handled;
- the number of vehicles operating around the racking;
- the handling of corrosive products that could affect the integrity of the structure;
- the environmental conditions that could affect the integrity of the racking (e.g., temperature, humidity, corrosive atmosphere).

The frequency of the scheduled inspections shall be reviewed periodically, particularly following:

- a change in the work organization;
- a change in the work environment;
- a modification of the handled pallet unit loads;
- a change in the handling equipment;
- an increased rate of the incidence of damages.

13.3 Pallet rack inspection procedure

13.3.1 Accessibility of the components

Upon inspection of the rack system, the accessibility to its different components is a determining factor. In any racking, damages are more likely to occur in the periphery. Since damages may also affect sections that are difficult to see, it may become necessary to unload some pallets to closely examine each component.

13.3.2 Assessment of the general configuration of the pallet racks

- Inspect the racking configuration, including any modifications that have been made, to ensure that it conforms to the original drawings and specifications provided by the manufacturer. Any modification shall be approved by the manufacturer, or an engineer. The user shall retain all the documentation.
- Inspect the loads stored on the racks to ensure that they are consistent with the rated load established by the manufacturer, or an engineer.
- Check if the components are compatible. Look for signs of incompatibility between the components (e.g., components of different colors, and lock pins holes on load support beams and upright frame columns that are misaligned, are signs of incompatibility).

13.3.3 Assessment of damages to the uprights (columns, bracing)

Damages to the frame components reduce their rated load. The heavier the damage, the lower the rated load.

Damage assessment is a very difficult and complex task. CSA standard A344.1-05, *User Guide for Steel Storage Racks*, refers pallet rack users to the *User Code* published by the Fédération européenne de la manutention (FEM 10.2.04), more specifically to its section titled "Safety of Equipment in Use and Evaluation of Damaged Components" for more details.

A **damage assessment procedure for upright frame components** that has been adapted from the document mentioned above (FEM 10.2.04) is included in Appendix 4 of this Guide.

When a frame component is determined to be unsafe, it shall be clearly indicated as such. The section where the damaged components are located shall be immediately cleared, and precautionary measures shall be taken to prevent the section from being reloaded before all the necessary repairs have been carried out.

13.3.4 Inspection of the upright frame columns

In pallet racks where loads are equal to the rated load, the maximum permissible deviation from plumb (out-of-plumb) of the columns should not exceed 1/200 of column height.

This 1/200 ratio is recommended in the FEM 10.2.04 User Code, but is not mentioned in the CSA standard A344.1-05, *User Guide for Steel Storage Racks*. However, if racking is installed according to the 1/240 ratio (unloaded), as recommended in the CSA standard A344.1-05, it becomes very difficult to obtain a maximum permissible deviation from plumb of 1/200 once the rack has been loaded. To be able to follow the recommendation in the FEM User Code, a 1/350 ratio shall be provided for as soon as the rack structure is installed. However, it is important to note that neither a 1/350 ratio (unloaded), nor a 1/200 ratio (loaded), is required in either the RMI or the CSA standard. Consequently, conformance to the 1/200 ratio is not mandatory.

In the example below, for a 6,000 mm (20 ft.) column, the maximum permissible deviation from plumb in a loaded pallet rack should not exceed $6,000 \text{ mm} / 200 = 30 \text{ mm}$ (about 1 ¼ in.), as per the FEM User Code.

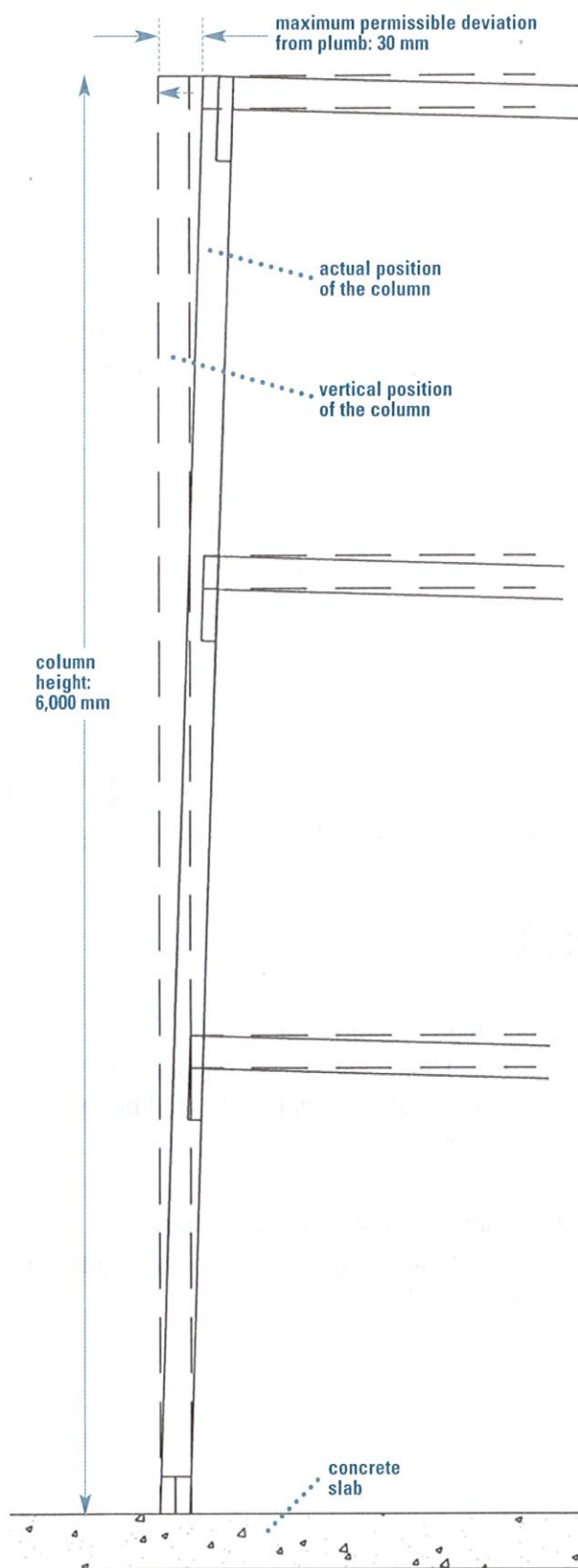


Figure 49. Out-of-plumb columns in a loaded pallet rack
(Illustration: Technirack)

13.3.5 Inspection of the base plate leveling pads and anchors

Verify that:

- the base plates are in contact with the ground;
- the leveling pads are well seated;
- the anchors are in good condition, and in sufficient quantities, in accordance with the manufacturer's recommendations.

13.3.6 Inspection of the beam deflection

When pallet support beams are loaded in accordance with the rated load, the beam deflection does not normally exceed 1/180 of the span.

This ratio is mentioned in CSA standard A344.1-05, *User Guide for Steel Storage Racks*, and in the RMI *Standard in the US, Specification for the Design, Testing and Utilization of Industrial Steel Storage Racks*, 2002 Edition. European organizations, such as FEM, recommend a more stringent ratio of 1/200.

The deflection shall disappear when the beams are unloaded, and should not be confused with the permanent deformation caused by an overload, or by damages resulting from an impact. Several deformed beams in a rack indicates that the rated load has been exceeded.

In the example shown in Figure 50, the maximum distortion (deflection) of a 3,600 mm (12 ft.) beam shall be $3,600 \text{ mm} / 180 = 20 \text{ mm}$ (about $\frac{3}{4}$ in.).

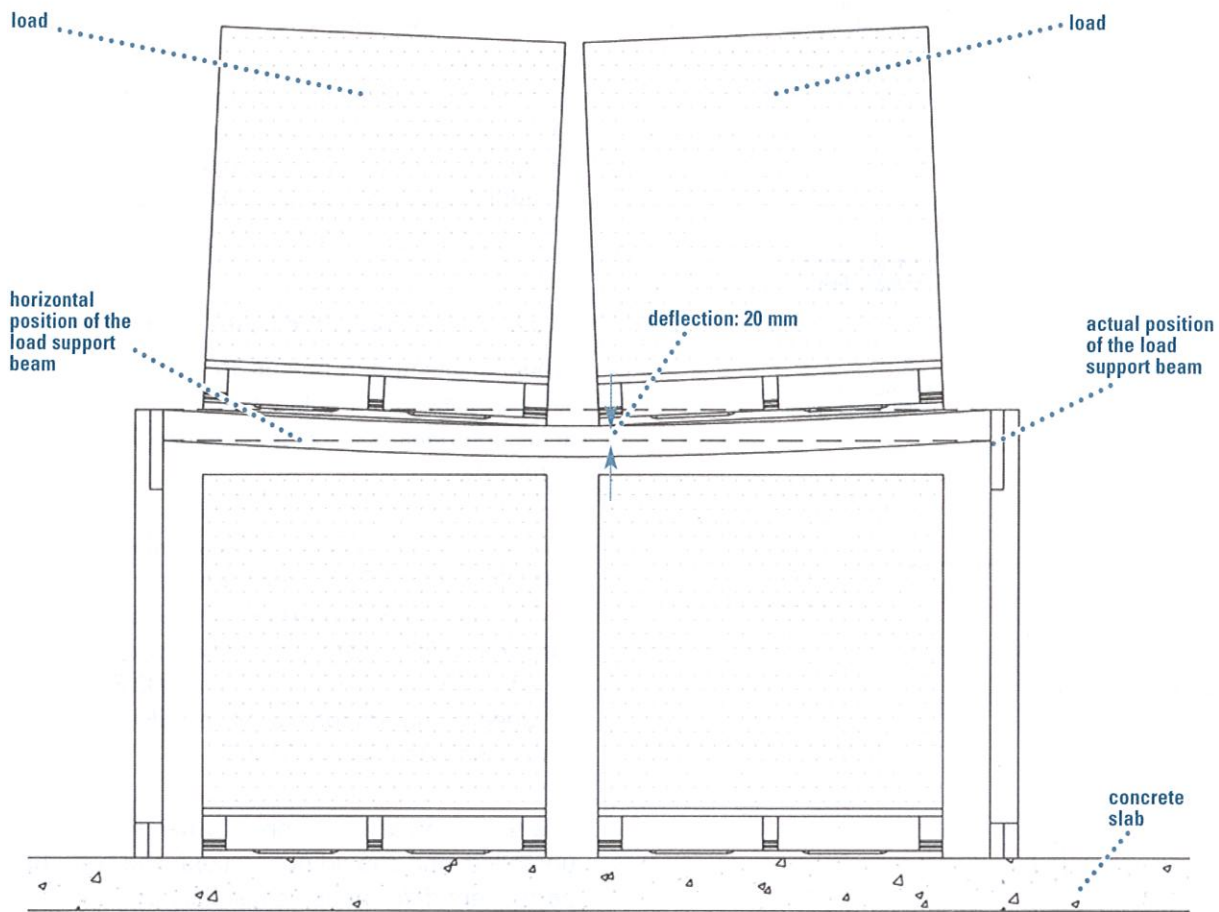


Figure 50. Loaded beam deflection
(Illustration: Technirack)

13.3.7 Inspection of the beams and the beam connectors

Check for:

- any sign of visible deformation;
- the presence of cracks or defects in the welds.

If this is the case, the beam shall be unloaded, and the manufacturer shall be consulted.

13.3.8 Inspection of the safety pins

- All **pins** should be secured at each end of the beams, in good condition, and impossible to remove, either intentionally or unintentionally.
- All **bolt nuts** should be securely tightened.

13.3.9 Signs of corrosion

Inspect the beams and frames for signs of corrosion; damaged components shall be sanded and repainted, if need be.

13.3.10 Inspection of rated load plaque

Inspect each racking to ensure that the rated load plaque is installed.

13.3.11 Inspection of rack accessories

Inspect the following accessories to ensure that they are installed and in good condition:

- row spacers;
- column guards;
- accessories for protection against falling objects.

13.3.12 Inspection of the site conditions

Check if:

- the floor is free of cracks, does not sag, and is level;
- the lighting is adequate;
- the lighting fixtures are within reach of the lift trucks and the loads during handling operations;
- the minimum clearance (450 mm) between the tops of the loads and the sprinklers is in compliance;
- the main aisles are wide enough, unobstructed, and in good condition;
- the walkways are wide enough;
- the work stations are outside the warehouse aisles and the main aisles.

13.3.13 Inspection of personnel training

Check if:

- the lift-truck operators have received the required training on safe driving practices;
- the operators are aware of the effects of the impacts on the racking;
- the workers have received the training necessary to report visible anomalies;
- the workers have received the required training on the work hazards (e.g., falling from heights, foot injuries caused by heavy objects);
- the workers have received the required training on preventive measures (e.g., the use of a safety harness);
- the workers are trained on the safe work methods for preparing the customer orders from the ground, and/or from heights.

13.4 Repair or replacement of damaged components

All damaged components shall be replaced with new components that are identical or equivalent to the original components, in compliance with the manufacturer's instructions. Cracked or split components shall be replaced. Components damaged by corrosion shall be replaced or repaired. Changing the direction of the diagonal braces upon repair is prohibited.

Repairs shall be carried out according to the manufacturer's recommendations, unless the repair method has been approved by an engineer, to guarantee a resistance at least equal to that of the original component.

Repairs such as adjusting the components, welding component sections, and capping and/or splicing damaged sections without first consulting the manufacturer or his designated representative, or an engineer, are prohibited.

13.5 Pallet rack inspection record

It is recommended that the rack user keep a record that would include the following information:

- the dates and the details observed during the daily inspections;
- the dates and the observations made during the scheduled inspections;
- the repair or replacement dates of the damaged components.

13.6 Damaged upright frame columns

The following photos illustrate damaged frame columns.

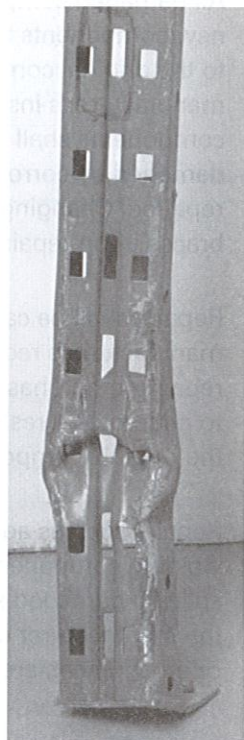


Figure 51a. Column damaged by repetitive impacts from the front and the side (Front view)
(Photo: Maurice Vézinnet)

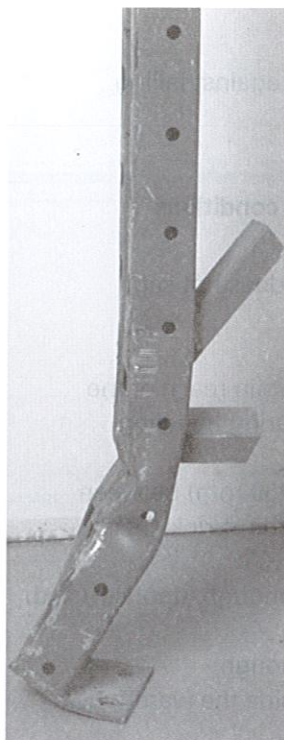


Figure 51b. Same damaged column (Side view)
(Photo: Maurice Vézinnet)

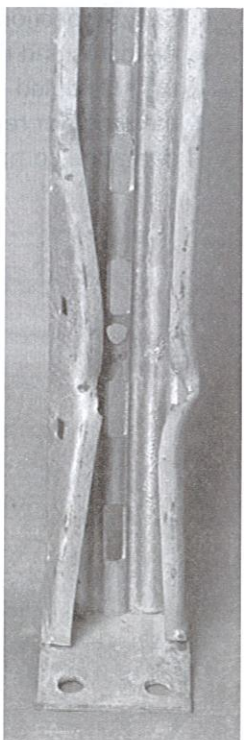


Figure 52a. Galvanized steel column damaged by impacts from the rear (Rear view)
(Photo: Maurice Vézinnet)

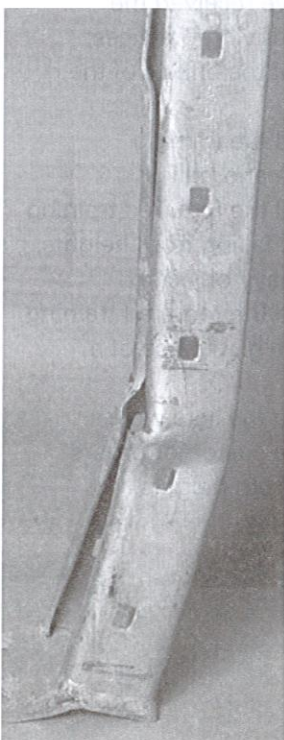


Figure 52b. Same damaged column (Side view)
(Photo: Maurice Vézinnet)

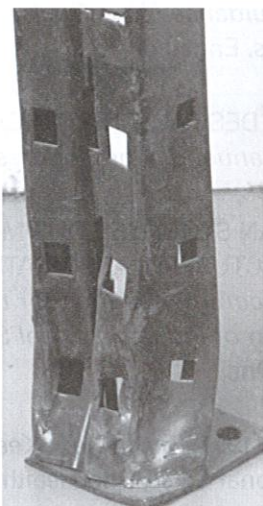


Figure 53. Damaged column:
The weld near the base plate
gave way
(Photo: Maurice Vézinnet)

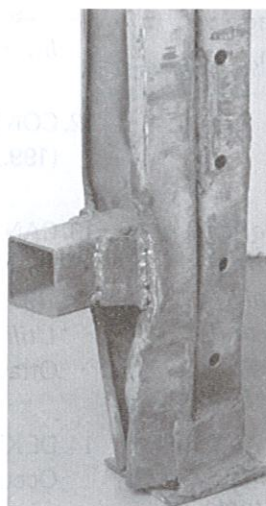


Figure 54. Damaged double column:
Substandard weld, worn and deformed
column due to friction with the lift truck
outriggers
(Photo: Maurice Vézinnet)

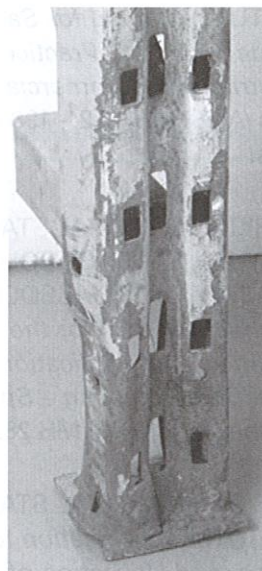


Figure 55. Corroded steel
column worn by friction and
rewelded
(Photo: Maurice Vézinnet)

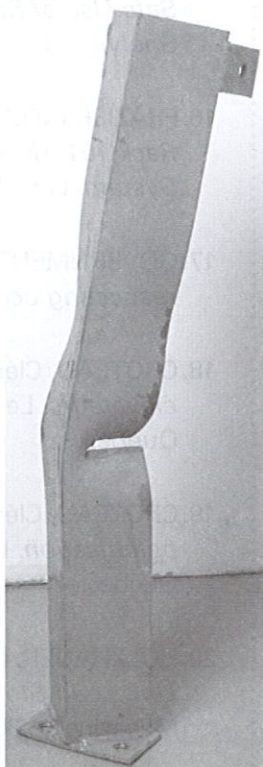


Figure 56. Damaged column guard
(Photo: Maurice Vézinnet)



Figure 57. Damaged column
repaired by electrode
welding
(Photo: Maurice Vézinnet)

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Appendix 1

Record Form

Record Form

1. Rack User Identification

1.1 Company Name and Address

Company:

Address:

Activity:

☐ Warehouse

☐ Retail Sale

Purchasing Manager:

Date of Order:

1.2 Warehouse Operations

☐ Manual pick-up (ground)

☐ Mechanized pick-up (stacking)

☐ Manual pick-up from heights (order picker)

☐ Other activities (if so, specify):

2. Description of pallet unit loads to be stored

2.1 Nature of loads

Briefly describe the nature of the loads to be stored (e.g., mechanical parts, automobile parts, cosmetics, food products, etc.)

2.2 Special characteristics of the loads to be stored

Flammable or combustible substances

☐ YES

☐ NO

(If so, specify the name of the substances):

Automatic sprinklers required?

☐ YES

☐ NO

Toxic substances

☐ YES

☐ NO

(If so, specify the name of the substances):

Corrosive substances

☐ YES

☐ NO

(If so, specify the name of the substances):

Perishable goods

☐ YES

☐ NO

(If so, specify the name of the products):

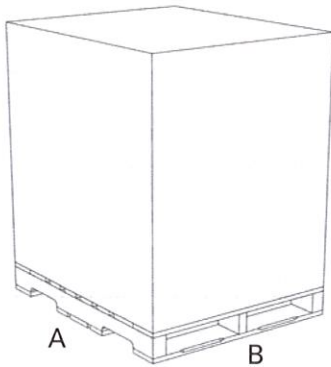
Is product rotation required?

☐ YES

☐ NO

Others substances (specify):

Load sizes



(Illustration: Technirack)

Load width (A): _____

Load depth (B): _____

C Load height + the pallet (C): _____

Load weight + the pallet: _____

Load overhang over the pallet: _____

Pallet overhang over the front and back beams: _____

Layout of the pallet facing the aisle: ☐ Side A ☐ Side B

2.4 Load configuration

Particular configuration ☐ YES ☐ NO

If so, specify the shape (e.g., cylindrical, asymmetric, etc.): _____

2.5 Load support means

Are the loads laid out on the pallets ☐ YES ☐ NO

If not, describe the loads: _____

If so, check the type of pallets used:

- ☐ Reusable pallets
- ☐ Expendable pallets
- ☐ Special use pallets
- ☐ Others (specify): _____

Material used to construction the pallet:

☐ Wood

☐ Plastic

☐ Carton

☐ Other (specify): _____

Pallet sizes:

☐ Standard, 1,220 mm x 1,016 mm (48 in. x 40 in.), North American pallet

☐ Standard, 1,200 mm x 1,000 mm (47,24 in. x 39,37 in.), European pallet

☐ Other (specify): _____

3. Handling procedures

3.1 Lift trucks

Counterbalanced lift truck

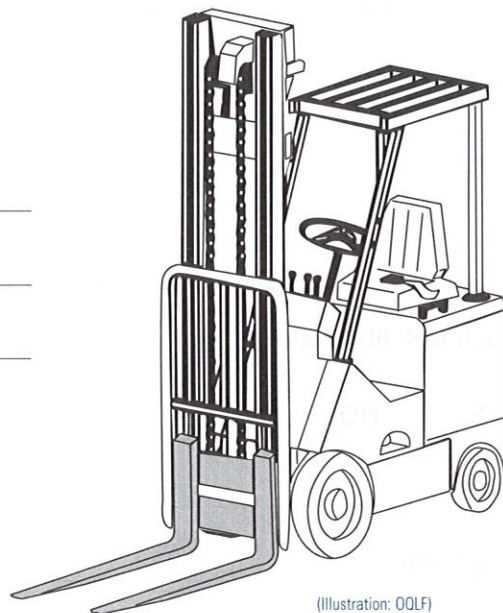
☐ YES ☐ NO

☐ YES ☐ NO

Quantity: _____

Manufacturer: _____

Dimensions: _____



(Illustration: OQLF)

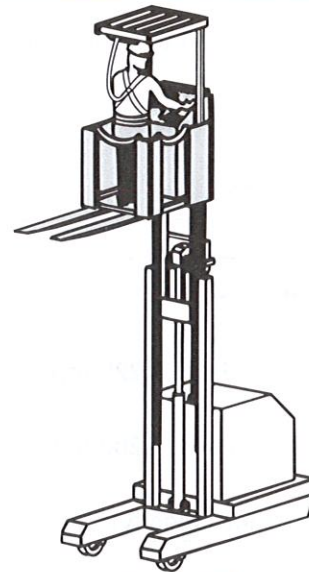
Order picker:

☐ YES ☐ NO

Quantity: _____

Manufacturer: _____

Dimensions: _____



(Illustration: OQLF)

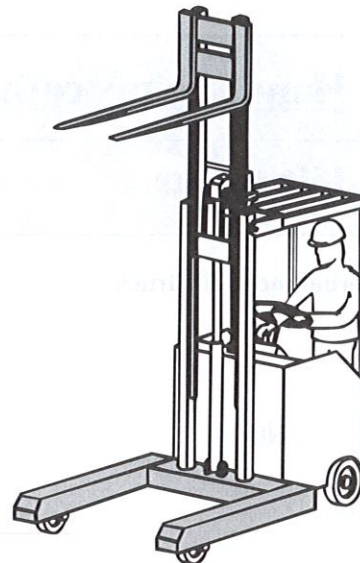
Narrow aisle straddle truck:

☐ YES ☐ NO

Quantity: _____

Manufacturer: _____

Dimensions: _____



(Illustration: OQLF)

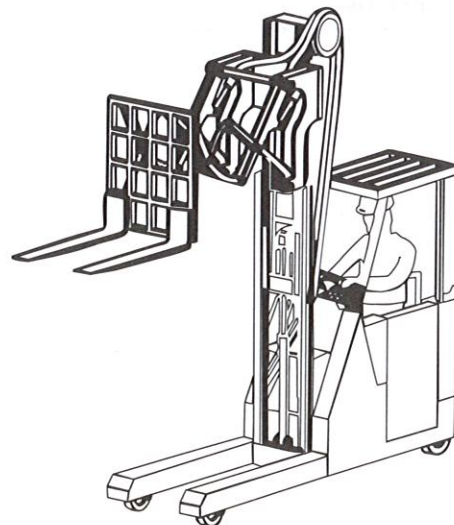
Reach fork lift truck:

☐ YES ☐ NO

Quantity: _____

Manufacturer: _____

Dimensions: _____



(Illustration: OQLF)

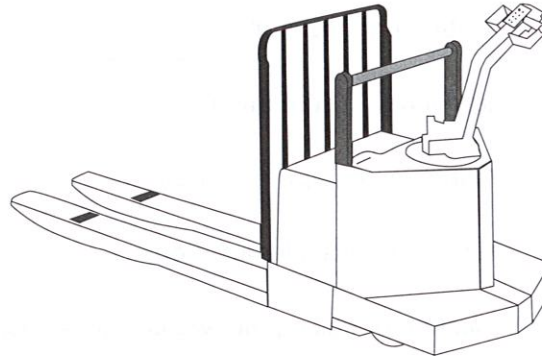
3.2 Other types of material handling equipment (e.g., pallet jacks)

Specify the type: _____

Quantity: _____

Manufacturer: _____

Dimensions: _____



(Illustration: OQLF)

4. Storage site characteristics

4.1 Rack location

Will the racking be installed outside? ☐ YES ☐ NO

If so, specify the soil characteristics: _____

4.2 Building characteristics

Surface of the storage area: _____

Height: _____

Width: _____

Length: _____

Type of heating unit: _____

Temperature: _____

Type of refrigerating equipment: _____

Minimum temperature upon pallet installation: _____

Minimum temperature upon pallet use: _____

Type of ventilation equipment: _____

Check the data provided:

- ☐ Column location and sizes
- ☐ Heating unit location
- ☐ Refrigerating equipment location
- ☐ Ventilation equipment location
- ☐ Automatic sprinkler locations
- ☐ Location of gas piping, water mains, etc.
- ☐ Light fixture locations
- ☐ Emergency door/exit locations
- ☐ Electrical panel locations

4.3 Soil characteristics

Soil characteristics

- ☐ Slab on grade
- ☐ Raised floor slab
- ☐ Other (specify):

Concrete slab thickness: _____

Uneven ground? ☐ YES ☐ NO

Difference in ground level observed: _____ /1000 mm

Number of differences:

- ☐ Very few
- ☐ Average
- ☐ Several

- ☐ Check if the drawings and specifications indicate the location of the steel reinforcements and ducts/conduits are provided.

Comments:

4.4 Description of the physical environment

Does the surrounding environment have specific characteristics (is it humid, corrosive, etc.)?

- ☐ YES ☐ NO

If so, specify:

Are walkways required? ☐ YES ☐ NO

If so, specify the location:

Are the work stations adjoining the racking, or close by?

- ☐ YES ☐ NO

Does the racking have to be designed to resist overloads caused by seismic hazards?

- ☐ YES ☐ NO

If so, indicate the name of the city/municipality where the seismic data is to be considered:

5. Work organization

Shifts:

- ☐ Day
☐ Evening
☐ Night

6. Type of racking to be set up (after consulting with the supplier)

- ☐ Single deep
- ☐ Double deep
- ☐ Drive-in
- ☐ Drive-thru
- ☐ Mobile
- ☐ Pallet flow
- ☐ Push-back
- ☐ Cantilever

Component identification:

- ☐ Manufacturer's ID
- ☐ Permanent identification code traceable to the component properties

7. Pallet rack protective devices (after consulting with the supplier)

Column guards: ☐ YES ☐ NO

Row end protectors: ☐ YES ☐ NO

Compartment end stops: ☐ YES ☐ NO

Wall end stop: ☐ YES ☐ NO

Accessories for protection against falling objects: ☐ YES ☐ NO

If so, check one of the following:

☐ Net

☐ Wire mesh screens

☐ Screen panels

☐ Solid panels

☐ Wire mesh shelving

☐ Others (specify):

Other devices (specify):

Signature of Purchasing Manager:

Date:

Appendix 2

*Single deep/double
deep pallet
rack installation checklist*

Single deep/double deep pallet rack installation checklist

Name of the establishment (user): _____

Name of the pallet rack manufacturer: _____

Catalogue No.: _____

Name of the installer: _____

Inspected by: _____

Inspection date: _____

ITEMS TO BE INSPECTED	YES	NO	N/A	OBSERVATIONS – CORRECTIONS If required, indicate the item to be corrected (e.g., upright frame no., load beam no., etc.)
1. Drawings and specifications				
1.1 The drawings and specifications are available.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
1.2 The drawings and specifications are approved by the manufacturer, or an engineer, including the modifications that were made upon installation.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
2. Aisle width				
2.1 The walkways are wide enough to allow the safe handling of the material, and are at least 600 mm (24 in.).	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
2.2 The width of the warehouse aisles is at least equal to the width of the loaded lift truck, plus 150 mm (6 in.) on each side, or to the width recommended by the lift truck manufacturer.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	

ITEMS TO BE INSPECTED	YES	NO	N/A	OBSERVATIONS – CORRECTIONS If required, indicate the item to be corrected (e.g., upright frame no., load beam no., etc.)
2.3 The width of the main aisles (for two-way traffic) is at least equal to the width of the loaded lift truck, plus 1,000 mm (40 in.).	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
2.3 The width of the main aisles (for one-way traffic) is at least equal to the width of the loaded lift truck, plus 1,400 mm (55 in.).	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
3. Rack stability				
Plumb-of-column				
3.1 The maximum permissible deviation from plumb of each column in an unloaded pallet rack shall be 1/240 of column height, or equal to the limit specified by the manufacturer, or an engineer.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Row Spacer				
3.2 The row spacers are installed and placed in accordance with the drawings and specifications established by the manufacturer, or an engineer.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Cross aisle ties				
3.3 The cross aisle ties are installed and placed in accordance with the drawings and specifications established by the manufacturer, or an engineer.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Base plate anchoring				
3.4 All base plates are secured with at least one anchor bolt.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	

ITEMS TO BE INSPECTED	YES	NO	N/A	OBSERVATIONS – CORRECTIONS If required, indicate the item to be corrected (e.g., upright frame no., load beam no., etc.)
3.5 The anchor bolts are tightened according to the bolt manufacturer's recommendations.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
3.6 The concrete floor slab is free of cracks near the base plates.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Shims				
3.7 The leveling pads are well seated.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
3.8 The leveling pads are equal in size to the base plates.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
3.9 The leveling pads are well secured to the base plates (e.g., with two anchor bolts, or by welding).	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
4. Rack components				
Upright frames				
4.1 The frames are positioned and installed in accordance with the drawings and specifications established by the manufacturer, or an engineer.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
4.2 The frames are in good condition.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Beams				
4.3 The beams are in good condition.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	

ITEMS TO BE INSPECTED	YES	NO	N/A	OBSERVATIONS – CORRECTIONS If required, indicate the item to be corrected (e.g., upright frame no., load beam no., etc.)
4.4 The beam positions are in conformance with the drawings and specifications established by the manufacturer, or an engineer.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
4.5 The safety pins are secured at each end of the beams.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
4.6 The safety pins are designed so as to prevent their intentional or unintentional removal.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Component identification				
4.7 The frames and beams bear a permanent identification mark that is traceable to their manufacturer, or another means of identification.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
4.8 The frames and beams are from the same manufacturer.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
4.9 The frames and beams are compatible with one another.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
5. Protective devices				
Protection against impacts				
5.1 Column guards are installed.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
5.2 Row end protectors are installed.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	

ITEMS TO BE INSPECTED	YES	NO	N/A	OBSERVATIONS – CORRECTIONS If required, indicate the item to be corrected (e.g., upright frame no., load beam no., etc.)
Protection against falling objects				
5.3 Accessories for protection against falling objects are installed over the walkways, and behind the compartments where pedestrians may circulate.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
5.4 At least two safety bars are installed for each pallet position.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
5.5 The safety bars are secured to the beams.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
5.6 The pallet support bars are secured to the beams.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
6. Plaques				
Pallet rack rated load plaque				
6.1 The rated load plaques are visible, and are easily read by the operator.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
6.2 The rated load plaques contain the following information, at the very least:				
• manufacturer's name;	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
• maximum beam capacity	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
• maximum bay capacity	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	

ITEMS TO BE INSPECTED	YES	NO	N/A	OBSERVATIONS – CORRECTIONS If required, indicate the item to be corrected (e.g., upright frame no., load beam no., etc.)
Sign panels 6.3 Indicator panels are installed to indicate: <ul style="list-style-type: none">● direction of traffic;● stops;● traffic information;● walkways.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Inspection performed by: _____				
Signature: _____				
Date: _____				

Appendix 3

*Periodic inspection checklist
for single/deep pallets*

Periodic inspection checklist for single/double deep pallets

Name of the establishment (user):

Name of the pallet rack manufacturer:

Catalogue No.:

Name of the installer:

Inspected by:

Inspection date:

Frequency of inspections:

- ☐ Once every six months
- ☐ Once a year
- ☐ Once every two years
- ☐ Other (specify):

ITEMS TO BE INSPECTED	YES	NO	N/A	OBSERVATIONS – CORRECTIONS If required, indicate the item to be corrected (e.g., upright frame no., load beam no., etc.)
1. Drawings and specifications				
1.1 The drawings and specifications are available.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
1.2 The drawings and specifications are current.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
1.3 The drawings and specifications are approved by the manufacturer, or an engineer, including the modifications.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	

ITEMS TO BE INSPECTED	YES	NO	N/A	OBSERVATIONS – CORRECTIONS If required, indicate the item to be corrected (e.g., upright frame no., load beam no., etc.)
2. Preventive maintenance and inspection program				
2.1 A maintenance and inspection program is implemented.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
2.2 The workers carry out the daily inspections of the racking to report any visible anomalies.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
3. Aisle width				
3.1 The walkways are wide enough to allow the safe handling of the material, and are at least 600 mm (24 in.).	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
3.2 The width of the warehouse aisles is at least equal to the width of the loaded lift truck, plus 150 mm (6 in.) on each side, or to the width recommended by the lift truck manufacturer.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
3.3 The width of the main aisles (for one-way traffic) is at least equal to the width of the loaded lift truck, plus 1,000 mm (40 in.).	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
3.4 The width of the main aisles (for two-way traffic) is at least equal to the width of the loaded lift truck, plus 1,400 mm (55 in.).	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	

ITEMS TO BE INSPECTED	YES	NO	N/A	OBSERVATIONS – CORRECTIONS If required, indicate the item to be corrected (e.g., upright frame no., load beam no., etc.)
4. Rack stability				
4.1 The deflection of the beams loaded in accordance with the rated load does not exceed 1/180 of the span.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Row Spacers				
4.2 The row spacers are installed and placed in accordance with the drawings and specifications established by the manufacturer, or an engineer.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Cross aisle ties				
4.3 The cross aisle ties are installed and placed in accordance with the drawings and specifications established by the manufacturer, or an engineer.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Base plate anchoring				
4.4 All base plates are secured with at least one anchor bolt.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
4.5 The anchor bolts are tightened in accordance with the bolt manufacturer's recommendation.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
4.6 The concrete floor slab is free of cracks near the base plates.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Shims				
4.7 The leveling pads are well seated.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	

ITEMS TO BE INSPECTED	YES	NO	N/A	OBSERVATIONS – CORRECTIONS If required, indicate the item to be corrected (e.g., upright frame no., load beam no., etc.)
4.8 The leveling pads are equal in size to the base plates.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
4.9 The leveling pads are well secured to the base plates (e.g., with two anchor bolts, or by welding).	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
5. Component condition				
Columns, frames				
5.1 The upright frames have no damage due to impact (e.g., dents, cracks, bulges, etc.).	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
5.2 The frames show no signs of corrosion damage.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
5.3 The horizontal and diagonal braces have no damaged due to impact (e.g., dents, cracks, bulges, etc.)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
5.4 The horizontal and diagonal braces show no signs of corrosion damage.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Beams				
5.5 The beams show no signs of permanent deflection when unloaded.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	

ITEMS TO BE INSPECTED	YES	NO	N/A	OBSERVATIONS – CORRECTIONS If required, indicate the item to be corrected (e.g., upright frame no., load beam no., etc.)
5.6 The beams and the beam connectors have no damaged due to impact (e.g., deformations, cracks in the welds, etc.).	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
5.7 The beams and the beam brackets show no signs of corrosion damage.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
5.8 The beam positions are in conformance with the drawings and specifications established by the manufacturer, or an engineer.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
5.9 The safety pins are secured at each end of the beams.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
5.10 The safety pins are designed so as to prevent their intentional or unintentional removal.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Component identification				
5.11 The frames and beams bear a permanent identification mark that is traceable to their manufacturer, or another means of identification.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
5.12 The frames and beams are from the same manufacturer.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
5.13 The frames and beams are compatible with one another.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	

ITEMS TO BE INSPECTED	YES	NO	N/A	OBSERVATIONS – CORRECTIONS If required, indicate the item to be corrected (e.g., upright frame no., load beam no., etc.)
6. Repairs performed on the components				
6.1 The frames and beams are repaired according to the manufacturer's recommendations, or an engineer's.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
7. Protective devices				
Protection against impacts				
7.1 The column guards and the row end protectors are in good condition.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Protection against falling objects				
7.2 Accessories for the protection against falling objects are installed over the walkways and behind the compartments where pedestrians may circulate.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
7.3 At least two safety bars are installed for each pallet position.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
7.4 The safety bars are secured to the beams.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
7.5 The pallet support bars are secured to the beams.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	

ITEMS TO BE INSPECTED	YES	NO	N/A	OBSERVATIONS – CORRECTIONS If required, indicate the item to be corrected (e.g., upright frame no., load beam no., etc.)
8. Clearances and load layout				
8.1 The clearance between the top of the loads and the automatic sprinkler system is at least 450 mm (18 in.), in conformance with the <i>Regulation respecting occupational health and safety</i> , Section 288.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
8.2 The clearance between two loads, or between one load and an upright frame, is at least 75 mm (3 in.). Note – This clearance is recommended in <i>Les rayonnages métalliques</i> , published by INRS (France).	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
8.3 The clearance between one load and the overhead beam is at least 75 mm (3 in.). Note – This clearance is recommended in <i>Les rayonnages métalliques</i> , published by INRS (France).	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
8.4 The clearance between two palletized unit loads placed in two back-to-back compartments is at least 100 mm (4 in.). Note – This clearance is recommended in <i>Les rayonnages métalliques</i> , published by INRS (France).	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	

ITEMS TO BE INSPECTED	YES	NO	N/A	OBSERVATIONS – CORRECTIONS If required, indicate the item to be corrected (e.g., upright frame no., load beam no., etc.)
8.5 The palletized unit loads are placed so that the pallet overhang over the front and back beams is between 50 mm and 100 mm (2 and 4 in.).	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
9. Pallet condition				
9.1 The pallets have no defects and are undamaged (e.g., missing, deficient, split, or broken stringer or floorboard; protruding nails).	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
9.2 The pallets have the proper load capacity to prevent their deformation when loaded.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
9.3 The pallets used on the racking are all reusable.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
9.4 The expendable pallets used on the racking are placed on reusable pallets.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
10. Plaques				
Pallet rack rated load plaques				
10.1 The rated load plaques are visible, and are easily read by the operator.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	

ITEMS TO BE INSPECTED	YES	NO	N/A	OBSERVATIONS – CORRECTIONS If required, indicate the item to be corrected (e.g., upright frame no., load beam no., etc.)
11.4 The warehouse aisles and the main aisles are cleared and free of obstacles.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
11.5 The work stations are outside the warehouse aisles and the main aisles.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
12. Personnel training				
12.1 The lift truck operators have received the required training on safe driving practices.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
12.2 The operators are aware of the effects of impacts on racking.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
12.3 The workers have received the training necessary to report visible anomalies.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
12.4 The workers have received the required training on the work hazards (e.g., falling from heights, foot injuries caused by heavy objects).	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
12.5 The workers have received the required training on the use of personal protection equipment (e.g., a safety harness).	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
12.6 The workers are trained on the safe work methods for preparing the customer orders from the ground, and from heights.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	

Inspected by:

Signature :

Date:

Appendix 4

*Damage assessment procedure
for pallet rack upright
frame components*

Damage assessment procedure for pallet rack upright frame components

1. Measurement method of damages to the upright frame components

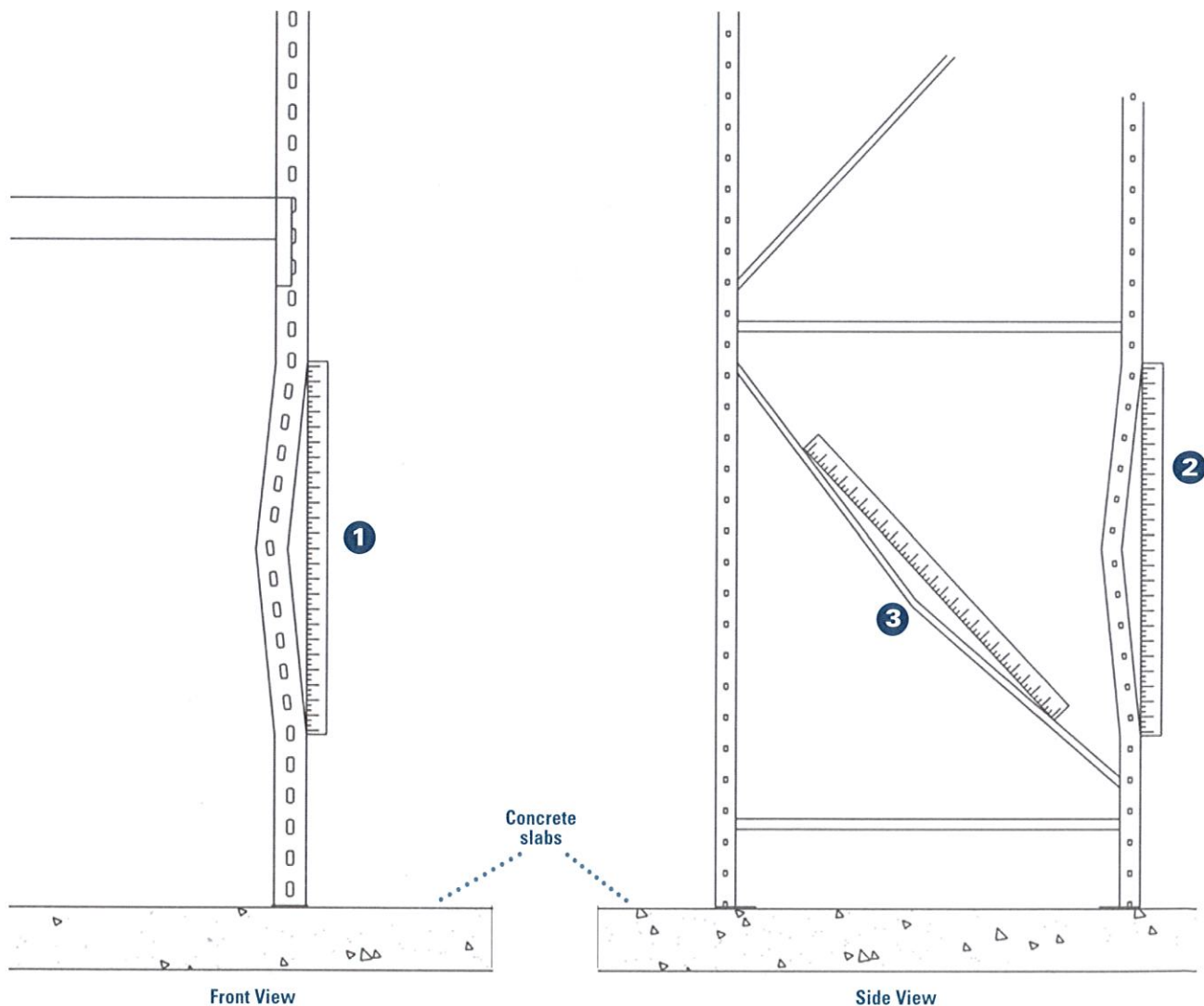
Place a 1 m long metal ruler against a damaged component, with the damaged section aligned with the middle section of the ruler, as illustrated in the Figure below.

- 1 Check the gap between the upright frame column and the ruler to make sure it does not exceed **5 mm** on the side of the damaged section.

- 2 Check the gap between the upright frame column and the ruler to make sure it does not exceed **3 mm** at the front of the damaged section.

- 3 Check the gap between the horizontal (or diagonal) brace and the ruler to make sure it does not exceed **10 mm**.

Measurements are only carried out with a ruler if the damages create a bulge. This method is not recommended for localized damages, such as dents, tears and splits.



Measurement method of damages to the frame components
(Illustration: Technirack)

2. Classification of damages

Damages sustained by upright frame components are divided into three categories:

2.1 GREEN RISK Damage requiring surveillance.

This category involves any damage that does not exceed the limits specified in the Figure on the preceding page.

This damage category is not considered severe. Upright frame components with such damages can still be used until the next scheduled inspection. However, the damages should be noted in the inspection record, and the components should be reevaluated in future inspections.

2.2 YELLOW RISK Damage requiring action as soon as possible.

This category involves any damage that is up to twice the limits specified in the Figure on the preceding page.

This damage category is severe enough to require repairs, but not severe enough to require the immediate unloading of the damaged section of the pallet rack. However, when a rack section is unloaded, it should not be reloaded before all the necessary repairs have been carried out.

If the damaged section remains loaded for several days after the damages have been assessed, it should be unloaded to allow the repairs to be carried out as soon as possible.

The user shall isolate the damaged section to ensure that it will not be used before all the

necessary repairs have been carried out, and the repaired racking has been approved by the manufacturer, or an engineer. For example, self-adhesive labels may be affixed on the racking to prevent the damaged section from being reloaded before all the necessary repairs have been carried out.

For all practical purposes, any racking that has sustained damages in the **YELLOW RISK** category should be reclassified in the **RED RISK** category if all the necessary repairs have not been carried out within four weeks.

2.3 RED RISK Very severe damages requiring an immediate response

This category involves very severe damages that are more than over twice the limits specified in the Figure on the preceding page.

This category involves very severe damages requiring the immediate unloading of the damaged rack section. It is strictly forbidden to use the damaged section until all the necessary repairs have been carried out. This type of repair normally involves the replacement of the damaged components. All the repair work shall be approved by the manufacturer, or an engineer.

The user shall put into place a procedure to isolate the damaged section to prevent its use before repairs are carried out. For example, a damaged bay should be unloaded in the presence of a representative designated by the employer, and the zone should be cordoned off with a colored tape to prevent its use.

* The English version of this Appendix is a translation of the French version, which was adapted from Section 10.7, Rules for the Measurement and Classification of Damage to Uprights and Bracing Members, published by the Fédération européenne de la manutention, Section X, FEM 10.2.04, Guidelines for the Safe Use of Static Steel Racking and Shelving, User Code, November 2001.

Appendix 5

*English-French lexicon
on racking*

English-French lexicon on racking

accessory for protection against falling objects	accessoire antichute d'objets
aisle	allée
alveole	alvéole
anchor	ancrage
anchorage	ancrage
base plate	plaque de pied d'échelle
bay	travée
beam bracket	attache de lisse
beam connector	attache de lisse
cantilever rack	râtelier en porte-à-faux
cant-leg frame	échelle en porte-à-faux
chemical anchorage	ancrage chimique
clearance	espace libre
column guard	protecteur de montant
column protector	protecteur de montant
compartment end stop	butée arrière
component	composant
constituent	composant
cross aisle tie	portique d'allée
deflection	flèche
deflexion	flèche
diagonal brace	diagonale d'échelle
double deep pallet rack	palettier à double profondeur
double deep selective pallet rack	palettier à double profondeur
double depth selective pallet rack	palettier à double profondeur
double-deep rack	palettier à double profondeur
drive-in pallet rack	palettier ouvert sur une face
drive-in/drive-through pallet racks	palettier à accumulation statique
drive-in/drive-thru pallet racks	palettier à accumulation statique
drive-through pallet rack	palettier ouvert sur deux faces
drive-thru pallet rack	palettier ouvert sur deux faces
dynamic pallet rack	palettier à accumulation dynamique
fix storage rack	palettier frontal
fixed storage rack	palettier frontal
flow-through rack	palettier à accumulation dynamique
flue space	espace libre
footplate	plaque de pied d'échelle
footway	allée piétonne
gravity pallet rack	palettier à gravité
gravity-flow rack	palettier à gravité
guard rail	protecteur de bout de rangée
header aisle	allée de circulation

horizontal and diagonal braces
horizontal brace
intersecting aisle
leveling pad
leveling strip
leveling wedge
live storage rack
load beam
load capacity
load support beam
loading pallet
loading platform
lock pin
main aisle
mobile pallet rack
operating aisle
operating alley
pallet
pallet flow rack
pallet rack
pallet rack beam
pallet rack compartment
pallet rack upright frame
pallet racking
pallet storage rack
pallet support bar
palletized load
palletized unit load
pedestrian lane
pedestrian walkway
pedestrian way
post guard
post protector
protective barrier
push-back pallet rack
rated load
restraint bar
right angle stacking aisle
row
row connector
row end protector
row spacer
safety bar
safety pin

contreventement d'échelle
traverse d'échelle
allée de circulation
cale
cale
cale
palettier à accumulation dynamique
lisse de palettier
capacité nominale
lisse de palettier
palette
palette
goupille de sécurité
allée de circulation
palettier mobile
allée de service
allée de service
palette
palettier à accumulation dynamique
palettier
lisse de palettier
alvéole de palettier
échelle de palettier
palettier
palettier
barre de support de palette
charge palettisée
charge unitaire palettisée
allée piétonne
allée piétonne
allée piétonne
protecteur de montant
protecteur de montant
garde-corps
palettier à gravité inversée
charge nominale
garde-corps
allée de service
rangée
entretoise de jumelage
protecteur de bout de rangée
entretoise de jumelage
barre de sécurité
goupille de sécurité

selective pallet rack
service aisle
service alley
shim
single deep pallet rack
single deep selective pallet rack
single depth pallet rack
single depth selective pallet rack
single-deep rack
single-depth rack
sliding pallet rack
stak system
static pallet rack
storage aisle
storage alley
stringer
transverse aisle
tunnel bay
upright frame column
walk
walkway
wall connector
wall end stop
wall spacer
warehouse aisle

palettier à simple profondeur
allée de service
allée de service
cale
palettier à simple profondeur
palettier à simple profondeur
palettier à simple profondeur
palettier à simple profondeur
palettier à simple profondeur
palettier à simple profondeur
palettier mobile
palettier à crémaillères
palettier statique
allée de service
allée de service
lisse de palettier
allée de circulation
tunnel de palettier
montant d'échelle
allée piétonne
allée piétonne
barre de raccord au mur
butée de protection murale
barre de raccord au mur
allée de service