

English Version

## Power-operated mobile racking and shelving, carousels and storage lifts - Safety requirements

Elévateurs de stockage, carrousels et rayonnage mobile à commande mécanique - Prescriptions de sécurité

Kraftbetriebene verschiebbare Paletten- und Fachbodenregale, Umlaufregale und Lagerlifte - Sicherheitsanforderungen

This European Standard was approved by CEN on 23 September 2007.

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## Foreword

This document (EN 15095:2007) has been prepared by Technical Committee CEN/TC 149 "Power-operated warehouse equipment", the secretariat of which is held by DIN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by May 2008, and conflicting national standards shall be withdrawn at the latest by May 2008.

This document has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association, and supports essential requirements of EU Directive(s).

For relationship with EU Directive(s), see informative Annex ZA, which is an integral part of this document.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN [and/or CENELEC] shall not be held responsible for identifying any or all such patent rights.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland and the United Kingdom.

## Introduction

This standard is a type C standard as stated in EN ISO 12100.

The machinery concerned and the extent to which hazards, hazardous situations and hazardous events are covered are indicated in the scope of this standard.

For machines designed and built according to the specifications of this Type C Standard the following applies:

"When provisions of this type C standard are different from those which are stated in type A or B standards, the provisions of this type C standard take precedence over the provisions of the other standards for machines that have been designed and built according to the provisions of this type C standard."

When this standard was prepared it was assumed that:

- only trained staff would operate, repair or maintain the machine;
- components without special requirements are
  - 1) sized in accordance with good engineering practice and methods of calculation including all types of failure;
  - 2) correctly constructed mechanically and electrically;
  - 3) made of materials of adequate loading capacity and of suitable quality;
  - 4) made of materials that are fit for that purpose.
- components are kept in a good repair and operating condition so that the required characteristics can be maintained in spite of wear and tear;
- sizing of load bearing parts ensures safe operation of the machine in a loading range from 0 % to 100 % of the nominal capacity and during testing conditions if applicable;
- details of particular conditions of use and the installation site are agreed between user and manufacturer;
- working area is adequately illuminated;
- installation site permits safe operation of the machine.

## 1 Scope

1.1 This European Standard deals with the safety requirements for the following types of power-operated storage equipment:

- storage carousels;
- storage lifts;
- mobile shelving, pallet racking and cantilever racking

with the objective of eliminating or minimising the hazards described in Clause 4. These hazards can arise during installation, starting up, operation, maintenance, testing and dismantling of the equipment.

1.2 It is essential that the safety requirements and/or measures taken in this standard be applied to storage equipment which operates indoors. Under difficult conditions, it is essential that additional hazard analysis and safety measures be taken into account, e. g. outdoor conditions, freezer applications, high temperatures, corrosive environment, strong magnetic fields, risk of explosive atmosphere, radioactive conditions, storage goods which due to their nature could generate hazardous situations (e. g. molten metal, acids/alkalis, fragile goods or explosives), effects of earthquakes and also contact with food.

1.3 Examples of power-operated storage equipment to which this standard applies are shown in Annex A.

1.4 With regard to buildings and parts of buildings, this standard applies only insofar that an assessment regarding hazards and risks in connection with interfaces to the storage equipment is carried out.

1.5 Storage equipment whose only power source is directly used human labour or gravity are excluded from the scope of application of this standard.

1.6 Power-operated storage equipment or parts of them do not fall under the regulations for passenger lifts. They are intended to handle and store goods. They are not intended to transport passengers under normal use (except for maintenance) and therefore not considered to be lifts (elevators).

1.7 This standard does not take hazards into account, which arise from noisy environments or environments subject to electromagnetic interference outside the range quoted in EN 61000-6-2.

## 2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 294:1992, *Safety of machinery — Safety distance to prevent danger zones being reached by the upper limbs*

EN 349:1993, *Safety of machinery — Minimum gaps to avoid crushing of parts of the human body*

EN 811, *Safety of machinery — Safety distances to prevent danger zones being reached by the lower limbs*

EN 1760-1, *Safety of machinery — Pressure sensitive protective devices — Part 1: General principles for the design and testing of pressure sensitive mats and pressure sensitive floors*

EN 1760-2, *Safety of machinery — Pressure sensitive protective devices — Part 2: General principles for the design and testing of pressure sensitive edges and pressure sensitive bars*

EN 12369-1, *Wood-based panels — Characteristic values for structural design — Part 1: OSB, particleboards and fibreboards*

EN 60204-1:2006, *Safety of machinery — Electrical equipment of machines — Part 1: General requirements (IEC 60204-1:2005, modified)*

EN 60335-1, *Household and similar electrical appliances — Safety — Part 1: General requirements (IEC 60335-1:2001, modified)*

EN 60950-1:2006, *Information technology equipment — Safety — Part 1: General requirements (IEC 60950-1:2005, modified)*

EN 61496-1, *Safety of machinery — Electro-sensitive protective equipment — Part 1: General requirements and tests (IEC 61496-1:2004, modified)*

EN ISO 12100-1:2003, *Safety of machinery — Basic concepts, general principles for design — Part 1: Basic terminology, methodology (ISO 12100-1:2003)*

EN ISO 12100-2:2003, *Safety of machinery — Basic concepts, general principles for design — Part 2: Technical principles (ISO 12100-2:2003)*

EN ISO 13849-1, *Safety of machinery — Safety-related parts of control systems — Part 1: General principles for design (ISO 13849-1:2006)*

EN ISO 13850, *Safety of machinery — Emergency stop - Principles for design (ISO 13850:2006)*

ISO 6336-1, *Calculation of load capacity of spur and helical gears — Part 1: Basic principles, introduction and general influence factors*

ISO 6336-2, *Calculation of load capacity of spur and helical gears — Part 2: Calculation of surface durability (pitting)*

ISO 6336-3, *Calculation of load capacity of spur and helical gears — Part 3: Calculation of tooth bending strength*

ISO 6336-5, *Calculation of load capacity of spur and helical gears — Part 5: Strength and quality of materials*

ISO 6336-6, *Calculation of load capacity of spur and helical gears — Part 6: Calculation of service life under variable load*

ISO 10823, *Guidelines for the selection of roller chain drives*

### 3 Terms and definitions

For the purposes of this document, the terms and definitions given in EN ISO 12100-1:2003 and the following apply.

#### 3.1

##### **carousels**

horizontal and/or vertical circulating storage equipment with load carriers (freely suspended carriers, suspended rods or others)

NOTE They can be provided with one or more access openings (see Figure A.1 and Figure A.2)

## 3.2

### **storage lifts**

designed to take goods placed on load carriers (e. g. storage containers). The in-built lift unit carries the load carriers (e.g. storage containers) from an access opening to storage locations in a racking tower, or from a storage location to an access opening. Storage lifts can have one or more access openings on one or more levels (see Figure A.3)

## 3.3

### **mobile shelving**

mobile shelving comprises a series of hand loaded adjustable load carrying surfaces (shelves) supported by upright frames all of which is in turn fixed to a movable base unit. This base unit is supported on wheels mounted in the base unit which run on rails mounted in or on the floor. The system is designed to be loaded by hand with multiple loads all of which are substantially less than the total carrying capacity of the shelf. The system is not designed to be loaded or unloaded by mechanical equipment (see Figure A.4)

## 3.4

### **mobile racking**

mobile racking comprises a skeleton framework of fixed or adjustable design supporting unit loads generally without the use of shelves. This skeleton framework is in turn fixed to movable base units supported on wheels mounted in the base unit, which run on rails mounted in the floor. The system is designed for the storage of unit loads where loading or unloading is generally by mechanical means (see Figure A.5)

## 3.5

### **cable barriers**

current carrying access barrier

## 3.6

### **access opening**

opening in cladding or covers for the purposes of loading and unloading

## 3.7

### **compartment load**

intended permissible uniformly distributed load of a horizontal load carrying surface between two upright frames

## 3.8

### **bay load**

sum of compartment loads between two upright frames (including base supported compartment load)

## 3.9

### **accidental stop**

stopping of racking equipment running against an obstacle

## 3.10

### **normal stop**

stopping of a mobile rack under controlled manner

## 3.11

### **emergency stop**

stopping of the machine as a result of the operation of an emergency device

## 3.12

### **authorised person**

person instructed to operate the machine and/or to carry out specified maintenance or other work which may have safety implications

## 3.13

### **operator**

person authorised to operate machines

**3.14****global aisle-free**

system to stop and inhibit the movement of racks unless the aisle has been observed and confirmed to be clear of obstructions and all personnel

**4 Significant hazards**

NOTE Under this section the significant hazards are listed:

**4.1 Mechanical hazards****4.1.1 Crushing and shearing hazards**

These hazards can occur, when parts move towards, relative to, or past one another, or towards, relative to or past fixed parts whereby people or parts of their body can be crushed or severed.

**4.1.2 Entanglement hazards**

These hazards can occur, when projecting sharp edges, teeth, wedges, screws, lubricating nipples, shafts, ends of shafts or similar items move in such way that people, parts of their body or their clothing can be caught and carried along.

**4.1.3 Drawing-in hazards**

These hazards can occur, when parts move in such way that a narrow throat is formed in which people or parts of their body or their clothing can be pulled in.

**4.1.4 Hazards from impact/collision**

These hazards can occur, when parts move relative to people in such way that they themselves or parts of their body can be injured through being impacted or run into.

**4.1.5 Hazards arising from objects falling out and/or dropping**

These hazards can occur through objects falling out of and/or dropping from the storage equipment, parts of the storage equipment or the stored goods.

**4.1.6 Hazards arising from potential failure of structure**

These hazards might be caused, for example, by failure of supporting parts or fastenings.

**4.1.7 Hazards arising from slipping, stumbling or falling**

These hazards can occur, for example, due to the construction of flooring in the area of mobile storage equipment.

**4.1.8 Hazards arising from potential lack of tipping stability**

These hazards can occur for example due to incorrect motor power/braking, inappropriate wheel carriage design.

**4.2 Electrical power hazards**

Electrical hazards can occur for example through:

- direct or indirect contact with live parts as a consequence of damage to the insulation or ingress of dirt, water etc.;
- incorrect isolation of power supply to the system or parts of the system due to inappropriate circuit design.

#### **4.3 Hazards through ignoring ergonomic principles in machine design**

These hazards can arise for example, as a result of:

- badly arranged operating equipment and working places;
- excessive strain on operating staff in regard to speed and energy requirements.

#### **4.4 Hazards caused through failure of power supply, failure of machine parts or other functional faults**

Hazards caused by failure of the power supply can occur when storage equipment or storage goods run backwards or fall unintentionally.

Hazards caused by failure of machine parts, such as the failure of suspension chains.

#### **4.5 Hazards arising from inappropriate design or failure of safety systems**

These hazards can, for example, occur through:

- unfavourable positioning of emergency shutdown devices;
- inappropriate positioning of safety related devices;
- inappropriate choice of safety devices;
- missing or faulty interlocking of maintenance access covers with the drive.

#### **4.6 Hazards caused through electromagnetic influences**

These hazards can, for example, occur through:

- inappropriate design of electrical control system;
- inappropriate selection of electrical subassemblies.

#### **4.7 List of significant hazards**

Table 1 shows a list of significant hazardous situations and hazardous events that could result in risks to persons during normal use and foreseeable misuse. It also contains the relevant clauses in this standard that are necessary to reduce or eliminate the risks associated with those hazards.

Table 1 — List of significant hazards

	Hazard	Danger point	Requirements section
<b>1</b>	<b>Mechanical hazards</b>		
1.1	Crushing hazards	General Dangerous movements Contactless protective devices Operating opening Access openings Remedying malfunctions Edges Operating aisles Safety devices	5.1 5.2.1.2, 5.2.3.5 5.2.1.9 5.2.2.1 5.2.2.1 5.2.3.1, 5.2.3.2 5.2.4.3 5.2.4.6 5.2.4.7
1.2	Shearing hazards	General Dangerous movements Openings Operating opening Access openings Remedying faults Building clearances	5.1 5.2.1.5 5.2.2.1, 5.2.3.1 5.2.2.1 5.2.3.1.1 5.2.3.4, 7.1.4 5.2.4.2, Annex B
1.5	Hazards arising through drawing-in or entanglement	General Dangerous movements Uneven loading Remedying faults Floor clearances Building clearances	5.1 5.2.1.9, 5.2.3.1 5.2.2.2.3 5.2.3.4 5.4.2 5.2.4.2, Annex B
1.6	Hazards arising from impact	Hand drive Dangerous movements Uneven loading Remedying faults Drawers Operating aisles	5.2.1.10 5.2.1.9 5.2.2.2.3 5.2.3.5 5.2.4.5 5.2.4.6, 5.2.4.7
1.10	Hazards arising through parts of machinery of storage goods falling out or dropping down	Installation Transporting persons Components, drawers Carousels	5.2.1.2 5.2.3.5 5.2.4.5 5.2.2.2.3

Table 1 (continued)

	Hazard	Danger point	Requirements section
1.11	Loss of stability (of machinery or machine parts)	General Installation Stability Breakage	5.2.1 5.2.1.2 5.2.1.3 5.2.1.4
1.12	Hazards arising from slipping, stumbling and falling over in connection with machinery (because of mechanical construction)	Transporting persons Floor Chassis covering	5.2.3.5 5.4.2 5.2.4.4
<b>2</b>	<b>Electrical hazards</b>		
2.1	Electrical contact (direct or indirect)	Isolating devices Environment Wiring method	5.3.1.2 5.3.1.3 5.3.1.4
2.3	Thermal radiation or occurrences such as splashing of melted parts, chemical reactions with short circuits, overloading etc.	Isolating devices Environment Wiring method	5.3.1.2 5.3.1.3 5.3.1.4
<b>8</b>	<b>Hazards arising through neglect of ergonomic principles in machine design (incompatibility with human characteristics and ability) e. g. through</b>		
8.1	Unhealthy postures or excessive physical strain	Pick-up and deposit areas Control elements Control stations	5.4.1 5.4.3 5.4.4
8.2	Insufficient consideration of human anatomy with respect to hands/arms and feet/legs	Design of floor Operating elements	5.4.2 5.4.3
8.4	Failure to provide suitable local lighting	Transporting persons Design of floor	5.2.3.5 5.4.2
8.6	Incorrect human behaviour	In-aisle protection, Information for the user	5.2.4.7.2), 7.1.5, 7.1.1
<b>10</b>	<b>Hazards arising through faults in the power supply, breaking off of machine parts and other malfunction such as</b>		
10.1	Faults in the power supply (to the drive and/or the control system)	General	5.5.1
10.2	Accidental ejection of machine parts	Suspension chains	5.2.1.5
10.3	Malfunction, fault in the control system (unexpected start, unexpected rotation)	Suspension chains Control systems	5.2.1.5 5.5.2
10.5	Rotation, unexpected loss of stability of machine	Suspension chain	5.2.1.5
<b>11</b>	<b>Hazards arising through (intermittent) failure and/or incorrect location of protection measures/protection devices, e. g.</b>		
11.1	All types of isolating protective devices	Transporting persons Emergency and stop devices Emergency shutdown devices	5.2.3.5 5.5.2.1 5.5.2.3

Table 1 (continued)

	Hazard	Danger point	Requirements section
11.2	All types of safety (protective) equipment	Emergency and stop devices Emergency shutdown devices	5.5.2.1 5.5.2.3
11.3	Starting and braking equipment	Uneven loading	5.2.2.2.3
11.5	All types of information and warning systems	Operating instructions Minimum marking	7.1 7.2
11.6	Isolating the power supply	General	5.5.1
11.9	Equipment and accessories required for setting and/or repairs	Remedying faults	5.2.3.4

## 5 Safety requirements and protective measures

### 5.1 General requirements

Storage equipment shall conform to the safety requirements and/or protective measures of this section and also to the requirements of EN ISO 12100-1 and EN ISO 12100-2 concerning relevant but not significant hazards, which are not dealt with in this standard.

Storage equipment and their accessories shall be suitable for operation in the intended condition of use in the working environment for which they have been designed.

Care shall be taken to review the safety aspects of the interfaces with other storage products such as mobile and static racking or pedestrian access areas.

### 5.2 Mechanical hazards

#### 5.2.1 Design and Installation

##### 5.2.1.1 General

Storage equipment shall be designed and installed in such a way that it is able to support the load of the storage goods safely when used in a correct manner.

The stability and load carrying capacity shall be sufficient for the operating loads and be established through calculations of the carrying capacity of the load bearing elements or via static load tests.

The intersection between single components shall be co-ordinated (e. g.: connecting forces, -moments and -stiffness's, as well as electrical, pneumatic and hydraulic connections).

##### 5.2.1.2 Installation

Storage equipment and their accessories shall be constructed so that they can be safely installed. If necessary anchorage points for safety harnesses shall be provided.

Storage equipment shall be aligned vertically to the tolerances specified by the designer and as laid down in the installation instructions.

The maximum deviation from the vertical shall not exceed 1/350 of the height.

### 5.2.1.3 Stability

The stability factor in the serviceability state (normal operation) with regard to tipping due to inertia forces or due to horizontal placement loads considered separately shall be at least 2.0:

$$\text{Stability factor} = \frac{\text{Static moment}}{\text{Tipping moment}} \geq 2,0$$

To cater for an accidental stop in mobile storage equipment the designer shall base his calculation on an assumed stopping distance of 15 mm. For this situation the stability factor is allowed to be  $\geq 1,1$ .

Established proof of stability shall also be provided for the partially loaded condition.

Pattern loading to check the tipping stability in case of mobile storage equipment:

- only top most storage level is loaded, single sided;
- all storage levels are loaded, single sided, with the exception of the level directly supported by the base of the mobile equipment.

Pattern loading to check the tipping stability in case of vertical carousels:

- only top most storage level is loaded.

For other products stability shall be checked in the worst possible loading condition.

### 5.2.1.4 Safeguarding against failure of racking

The basis of design for steel bases and rack structures will be in accordance with EN 1993-1-1 and EN 1993-1-3 as far as it applies to these structures.

Inertia forces due to accidental stop (stopping distance max. 15 mm) have to be considered with a load factor: 1,1.

### 5.2.1.5 Safeguarding against failure of suspension and drive elements of carousels and storage lifts

The storage equipment manufacturer shall have a certificate on chains/ropes/belts (or other) showing the minimum design breaking load of chains/ropes/belts (or other) and refer to that certificate for each purchase.

To minimise calculation and validation effort (e. g. wear, and tear, contamination, shock loading during the lifetime of the equipment) it is permitted to use the following simplified methods:

#### a) Vertical carousels

The suspension chains shall be designed in accordance with ISO 10823 to withstand, without breaking, 7 times the maximum static force or 5 times the maximum dynamic force occurring during fully loaded operation. For the calculation of the maximum break load is the sum of the load fixed on maximum length of vertical chain segments located over each other mandatory (see Annex E).

#### b) Horizontal carousels

No specific condition is required if failure of the drive elements results in a fail-safe condition, otherwise a) applies.

#### c) Storage lifts

The suspension chains, ropes, belts and other suspension elements shall be designed to withstand, without breaking, 7 times the maximum static force or 5 times the maximum dynamic load force occurring during fully

loaded operation. The requirements for rack and pinion systems are given in Annex D. If personnel are being transported see also 5.2.3.5.

Storage lifts with a working load limit of 1 000 kg or more shall be provided with an overload protection.

#### 5.2.1.6 Actions (Loads and forces)

When verifying the level of safety with regard to stability and failure, the following possible combination of actions shall be considered:

- sum of self-weights;
- sum of specified imposed loads (e. g. design values for shelf loads and weight of load units);
- placement loads, as a consequence of the method of manual or mechanical operating the storage equipment;
- inertia forces due to normal stop and emergency stop.

The initial non-verticality imperfection may not be regarded as a loading, but shall be treated as an initial property of the structure. Nevertheless it is allowed to take the non-verticality into account as an equivalent horizontal load at each storage level.

This imperfection shall be taken into account in the longitudinal as well as in the transversal direction, but not simultaneously.

#### 5.2.1.7 Locks against falling out and/or down

Components of storage equipment shall be designed or secured in such a way that they cannot fall out or down (e. g. clipped or hooked-in components, drawers).

#### 5.2.1.8 Deflection

The following deflection limits shall be considered for the maximum permissible imposed load, if no specific requirements have to be fulfilled:

- steel: span/200;
- timber or wood-based: span/150.

but taking into account the influence of the load duration according to EN 12369-1.

$$\text{Final deflection} = (\text{short term deflection}) \times (1 + k_{def})$$

where

$$k_{def} = \text{load duration factor depending on material type and load duration classification}$$

#### 5.2.1.9 Safeguarding hazardous locations

Dangerous locations (e. g. crushing, drawing-in, shearing locations) on storage equipment shall be guarded, where safety distances according to EN 294 and EN 811 respectively the minimum distances to avoid crushing according to EN 349 are not maintained.

If guards are used, they shall be fixed in a reliable manner and of adequate mechanical strength. It shall only be possible to remove them with a tool or they shall be interlocked with the drive.

## EN 15095:2007 (E)

As far as contactless safety equipment is used, it shall conform to safety category 2 (testing) in accordance with EN ISO 13849-1 respectively Type 2 according to EN 61496-1.

In order to prevent unintended dangerous movements during maintenance there shall be available fixing devices designed to suit the machine which can be securely attached. The required parts shall be delivered with the machinery.

### 5.2.1.10 Manually operated drive

Storage equipment which is designed for optional hand operation shall be so designed that the power operated drive is not able to activate the manually operated drive. This applies also to emergency operation.

### 5.2.1.11 Main switch

Storage equipment shall be equipped with a main switch.

It shall be possible to secure main switches in the "Off" position against unintentional and unauthorised operation.

Instead of a main switch, a plug-in connection is permissible up to a nominal current of 16 A and total motor output up to 3 kW.

### 5.2.1.12 Tripbars

Tripbars shall work over the full length. Limit switches which are operated by the tripbars shall be of a positive operated type and interlocked with the drive so that when they are operated the dangerous movement is safely stopped. Automatic re-starting shall be prevented.

NOTE See EN 1760-2 and EN 50047 for design shapes of position switches.

## 5.2.2 Carousels

### 5.2.2.1 Openings

#### 5.2.2.1.1 General

To safeguard the operating personnel against dangerous movement of load bearing devices of carousels the following protective measures are necessary.

#### 5.2.2.1.2 Opening for picking

Dangerous areas and shearing points shall be protected e. g. by trip bars, contactless safety devices.

#### 5.2.2.1.3 Carousels with more than one access opening

Carousels with more than one access opening shall be fitted with electrically interlocked doors or monitoring elements so that only one access opening can be used at a time. Monitoring elements can be motion sensors, switching mats, light barriers or similar devices.

The monitoring and interlocking elements shall be in compliance with EN ISO 13849-1 as defined after the risk analysis for the whole machine.

#### 5.2.2.1.4 Cladding

Covers on Carousels which have to be opened by the operator when dealing with operating faults shall be electrically interlocked with the drive.

## 5.2.2.2 Protection

### 5.2.2.2.1 Safe vertical and horizontal movements

If storage accessories (e. g. drawers, bins, trays) are not in driving position, the movement shall be impossible.

### 5.2.2.2.2 Protection against uncontrolled forward and backward motion through uneven loading

Generally vertical carousels shall be designed so that unintentional forward and backward movement is prevented effectively, when the highest degree of uneven loading distribution occurs (load difference between front and rear loading planes). For storage units of more than 3 tonnes load capacity devices are permitted which indicate optically or acoustically when the uneven loading distribution has reached the permissible limit and which prevent starting up or interrupt the moving operation in the critical direction when the limit has been exceeded. The correct sequence of loading and unloading shall be described in the operating manual.

For carousels with storage goods of almost the same shape and a complete view into the unit (e. g. carpet display units), it is sufficient to design the drive for the highest permitted degree of uneven loading distribution and to provide definite instructions in the operating manual.

### 5.2.2.2.3 Protection against items falling off

Carousels shall be provided with safety measures against items falling off. Panelling, covering and protection devices shall be adequately dimensioned and secured. Protective measures shall not generate new dangerous locations.

## 5.2.3 Storage lifts

### 5.2.3.1 Openings

#### 5.2.3.1.1 Openings for picking

Areas where there is a possibility of entanglement or shearing shall be protected either by interlocked doors or light curtains at the outer rim of the picking opening or by means of light curtains at another position together with mechanical design which prevents the occurrence.

**EXAMPLE** The danger of entanglement between a load bearing device and picking opening is avoided, if the picking opening is designed smooth and when the distance between load bearing equipment and picking opening is either less than 5 mm or more than 50 mm.

A warning label has to be mounted durable and easy visible at the opening with clear declarations of the risks.

It shall be ensured that a load carrier e. g. storage container which is being dealt with at an access opening cannot be called up from a different access opening.

#### 5.2.3.1.2 Opening for maintenance

Access openings for maintenance if provided shall be guarded in accordance with EN 953. They shall only be opened with a special tool or shall be interlocked with the electrical drive.

### 5.2.3.2 Protection against items falling off

Storage lifts shall be provided with safety measures against falling items. Panelling, covering and protection devices shall be adequately secured. Protective measures shall not generate new dangerous locations.

### **5.2.3.3 Cladding**

Covers on storage lifts which have to be opened by the operator when dealing with operating faults shall be interlocked with the drive.

### **5.2.3.4 Anti-drop system**

An anti-drop device for the use of a fall arrester shall be fitted in the storage equipment and extending to the full height of the equipment.

### **5.2.3.5 Transporting people during installation, maintenance and fault repair of storage lifts**

If the machine is designed for service personnel to ride or stand on the lifting platform for installations, maintenance and repair, the following design requirements shall be met:

- static load factor of 10 shall be applied for personnel, tools and self weight of platform;
- active overload protection system while transporting people shall be provided;
- independent working safety gear and overspeed governor in accordance with EN 81-1;
- "travelling-with" hold-to-run two hand controller is required which shall:
  - 1) comply with category 2 of EN ISO 13849-1;
  - 2) also be capable of providing an acoustic signal;
  - 3) inactivate the main control function except the emergency stop;
  - 4) prevent horizontal movements of load carriers towards the storage place.
- travel speed under maintenance conditions shall not exceed 0,05 m/s; if the platform is equipped with guards (minimum height: 900 mm, minimum distance of the handrail to fixed points of the lift: 100 mm) a maximum speed of 0,15 m/s is allowed;
- platform for transporting the person shall be of a non-slip design and be fitted with raised sides at least 50 mm high on all sides;
- survival space of 1,5 m height shall be provided;
- means shall be provided to anchor the person being transported against a fall. This shall be ensured by anchoring points on the platform;
- control equipment on the platform shall have priority over all other control equipment.

## **5.2.4 Mobile shelving, pallet racking and cantilever racking**

### **5.2.4.1 Floor clearances**

In order to avoid injury to feet, the distance between the bottom edges of mobile storage equipment (also of safety devices) and the floor shall not exceed 15 mm for:

- handloaded mobile shelving equipment;
- those used in office and filing areas.

For mechanically loaded mobile storage equipment a distance of 30 mm shall not be exceeded at any point. Uneven floors shall be levelled. For higher floor clearances, injuries to feet shall be prevented through installing additional safety measures.

#### 5.2.4.2 Clearance to building parts

For mobile storage equipment, the distance to the walls parallel to the driving direction shall either be between 0,05 m and 0,18 m or at least 0,5 m. The clearance of 0,5 m shall be measured from the most protruding part of the wall. The wall shall be even and not flexible and at least 2,0 m high relative to the standing area in the case where the clearance lies between 0,05 m and 0,18 m. The distance to adjacent storage equipment and similar units shall be at least 0,5 m unless special safety devices are installed. If crushing and shear locations with the ceiling can occur, the distance from the upper edges of the mobile parts to the ceiling shall be at least in accordance with Table 1 in EN 349:1993 for hands.

See Annex B and Table 1 of EN 294:1992; EN 349 and EN 811.

#### 5.2.4.3 Clearance between edges (mobile shelving and racking)

Crushing of fingers shall be prevented. A possibility is to ensure that the minimum distance (d) between firm edges of mobile storage equipment will be at least 25 mm up to a height of 2,50 m.

Distance pieces shall be fastened permanently. Their shape, method of fixing and material shall be selected so that they do not present a hazard. They shall be dimensioned such that the clearance of at least 25 mm is ensured for jutting out parts. Edge strips – if provided – shall be flexible and shall not produce crushing or shearing locations (see Annex B).

#### 5.2.4.4 Carriage decking

To safeguard dangerous locations, coverings in accessible areas of the storage equipment shall be secured for walking on.

#### 5.2.4.5 Drawers

Drawers shall not open unintentionally.

#### 5.2.4.6 Safety devices for mobile shelving

Mobile shelving shall be provided with safety equipment and defined methods of use to prevent hazards arising from moving shelving with personnel present in the aisles.

Mobile shelving that can be stopped with a force of 500 N or less is excluded from the requirements of this clause.

Examples of safety equipment that can be incorporated into such systems may include:

- cable barriers across the ends of the aisles preventing access while movement is possible;
- switch bars or contactless safety devices in the foot area shall be fitted to both longitudinal sides of the chassis of the moveable units. Both sides shall function within an open aisle.

Switch bars shall have red and white markings.

Activation of switch bars shall stop the base safely in a controlled manner within the travelling distance of the switch bar. The max. travelling distance shall be 100 mm

- permission switch, permitting the closure of an aisle after visual inspection
- detection devices preventing movement of the system while personnel are at risk.

#### **5.2.4.7 Safety devices for mobile racking**

Mobile racking shall be fitted with protective devices to prevent hazards arising from moving racking conforming to EN 61496-1, EN 1760-1 and EN 1760-2, etc. where appropriate.

Activation of safety devices shall stop the base safely in a controlled manner within the travel distance of the device.

They shall be at two levels:

- 1) at a global level detecting entry into an aisle in a block of mobile rack e. g. light barriers. After actuating the safety device, movement of the mobile racks shall only be possible after resetting of the system adjacent to the open aisle (except in the case of maintenance-mode). Reset devices shall be positioned so that the operator has a clear view into the aisle to be closed;
- 2) at a local level on the face of each mobile base in this case. Switch bars or contactless safety devices in the foot area shall be fitted to both longitudinal sides of the chassis of the movable units. Both sides shall function within an open aisle. Switch bars shall have red and white marking.

Automatic restart of the mobile rack after the release of the safety device shall be prevented.

Switch bars or contactless safety devices shall extend to the end area of the chassis. Where this is not practical for construction reasons, they shall end not more than 100 mm from the end face of the unit. This exposed area shall be indirectly protected by separate means e. g. the global level detecting entry (see Figure B.4).

#### **5.2.4.8 Maintenance operation for mobile pallet racking**

Mobile pallet racks may be fitted with a maintenance override key switch to operate the racks without activating the safety elements. Normal operation shall be prevented in this situation.

### **5.3 Electrical hazards**

#### **5.3.1 Electrical equipment**

##### **5.3.1.1 General**

The electrical part of storage equipment shall be in accordance with generally accepted electrical standards, particularly

- EN 60204-1;
- EN 60950-1;
- EN 60335-1.

**NOTE** The electrical equipment includes material, connections, appliances, devices, fastenings, units and similar items used as part of or in connection with the electrical installation of the storage equipment including devices for isolating the power supply. It also includes the electronic equipment, disconnection devices for the power supply and all the wiring on and of the storage equipment to the disconnection device for the power supply.

##### **5.3.1.2 Isolating equipment**

An isolating device shall be provided which fulfils the requirements of EN 60204-1.

When the storage equipment is part of a system which is subdivided into several sections, each with its own power supply, it shall be possible to isolate each section from the power supply in order to carry out maintenance.

If parts of the electrical equipment are still alive after the isolating device has been switched off, (e.g. due to connections between sections of a system of storage equipment), such parts shall be marked and or safeguarded against direct contact (see EN 60204-1).

### **5.3.1.3 Environment**

Coverings (housings, cabinets, sockets) for the electrical equipment shall provide suitable protection. For example coverings for electrical equipment in rooms shall at least provide protection class IP 22, for motors IP 23. If they are located outside and liquid can penetrate through they shall provide protection class of IP 55 or better according to EN 60529.

The equipment shall withstand the normal vibration and shaking which occur with storage equipment without dangerous breakdown.

### **5.3.1.4 Wiring method**

The wiring method used for storage equipment shall fulfil the requirements of Clause 3 of EN 60950-1:2006 or Clauses 12 and 13 of EN 60204-1:2006.

## **5.4 Ergonomics**

### **5.4.1 Pick-up and deposit areas at carousels and storage lifts**

For work to be carried out in the sitting position, the pick-up and deposit areas in front of access openings shall be arranged between 680 mm and 750 mm and for standing work between 750 mm and 1 150 mm above floor level.

### **5.4.2 Floor surfaces for mobile storage equipment**

In order to avoid stumbling points in the area for mobile storage equipment, the rails shall be fitted flush with the floor (see Annex D). Alternatively the floors shall be levelled using panels of appropriate height over the total racking area. The steps resulting from fitting the panels shall be chamfered or marked with a yellow and black danger mark, unless they are clearly visible through general lighting.

Remaining steps shall not exceed 4 mm.

End stops shall be flush with the floor or shall be made clearly visible through danger marking.

### **5.4.3 Controls**

Controls shall be marked distinctively and permanently. They shall be easy to reach and ergonomically designed. Except for automatic operation, the moving direction shall be clearly marked.

### **5.4.4 Location of control stations**

Control stations shall be located and designed so that the operator is able to operate the control elements without hindrance and observe all movements of the storage equipment which could lead to a hazard.

## 5.5 Power supply faults, machine parts failing or other malfunctions

### 5.5.1 General

It shall be ensured that all movements are automatically stopped on power failure, unless a power backup system is present to take over all functions including safety devices. The stopping distance shall be as short as possible and yet be compatible with the safety of the system. Unintentional Movements shall be prevented.

### 5.5.2 Controls and control systems

#### 5.5.2.1 Safety elements and safety circuits

Safety elements and safety circuits shall conform to EN ISO 13849-1 and fulfil at least the requirements of category 1 (see also 5.2.1.9).

#### 5.5.2.2 Control systems

Control systems and control equipment shall be designed in accordance with the applicable European Standards (e. g. EN 60204-1:2006, 9.4).

For carousels and storage lifts switching over from automatic operation to manual operation or special modes of operation and vice-versa is only permissible using special key operated hold-to-run control units which are placed outside dangerous areas (e. g. spring loaded key switches), see 5.4.4.

The selector may be replaced by another selection method which restricts the use of certain functions of the machinery to certain categories of operator (e. g. access codes for certain numerically controlled functions, etc.).

#### 5.5.2.3 Emergency shutdown

The emergency shutdown function shall be in accordance with EN ISO 13850 and EN 60204-1.

The category shall be selected so that the storage equipment is stopped within the shortest possible distance.

Emergency STOP buttons shall be placed at all control stations where automatic movement can be initiated with the exception of additional cableless control stations, providing that a global Aisle-free system is incorporated. For mobile racking and shelving systems with a stop button on each mobile and an aisle length of less than 20 m one emergency stop button placed at a location where an overview of the block is possible, is sufficient. When the block width exceeds 25 m additional emergency stop buttons are necessary.

Emergency STOP buttons shall be of a latching type, manually reset.

Emergency STOP buttons shall be physically wired into the contactor circuit or have an equivalent level of safety as defined in EN ISO 13850.

The minimum height of an emergency shutdown unit from the floor shall be 0,6 m and the maximum height 1,9 m.

Mobile shelving that can be stopped with a force of 500 N or less is excluded from the requirements of this clause.

## 6 Verification of the safety requirements and/or protective measures

### 6.1 Conformity of safety measures to safety requirements

The safety requirements and/or safety measures of Clause 5 and 7 of this standard shall be checked in conjunction with the following table. It includes the following checking methods:

#### a) Visual inspection

The result of which simply confirms the presence of an item (e. g. protective device, marking, European Standards,...);

#### b) Measurements

The result of which shall confirm that the specified, measurable parameter has been complied with (e.g. geometrical dimensions);

#### c) Functional test

The result of which shall verify that the signals which are to be transmitted to the main control system of the total installation are available and that these comply with the requirements of the technical documentation;

#### d) Special tests

The procedure is described in the column "Remarks" or in the individual clauses.

The time of the check is depicted as follows:

- design stage (D);
- manufacturing stage (M);
- assembly stage (A) and/or;
- putting into operation stage (C).

Table 2

Clause	Visual inspection	Measurement	Functional test	Special test	Remarks
5.2.1				D	horizontal forces
5.2.1.2		A			verticality
5.2.1.3				D	stability
5.2.1.4			C	D	safeguarding against falling out and dropping
5.2.1.5			D		breakage
5.2.1.6	C			D	stiffness
5.2.1.8		A		D	deflection
5.2.1.9			A	D	dangerous spot
5.2.1.9			C	D	contactless safety devices
5.2.1.10			C	D	hand drive
5.2.1.11				D	main switch
5.2.1.12			C	D	switch bar
5.2.1.12				D	movements
5.2.2.1			C	D	more than one opening
5.2.2.2		C		D	unbalanced loading
5.2.2.2.3	C			D	falling objects
5.2.2.1.4			C	D	cladding
5.2.3.1			C	D	more than one opening
5.2.3.5				D	remedying faults
5.2.4.1		C		D	floor clearances
5.2.4.2		A		D	building clearances
5.2.4.3		C		D	edge clearances
5.2.4.4	A			D	carriage decking
5.2.4.5			C	D	drawers
5.2.4.6	C			D	safety devices
5.2.4.7					
5.3.1		C	C	D	electrical equipment
5.3.1.2	A	C		D	isolating equipment
5.3.1.3				D	environment
5.3.1.4	A			D	wiring
5.4.1		A		D	pick-up + deposit area
5.4.2	A			D	Floor
5.4.3	A			D	Controls

Table 2 (continued)

Clause	Visual inspection	Measurement	Functional test	Special test	Remarks
5.4.4	A			D	Location of control stations
5.5.1			A	D	general
5.5.2.1				D	Safety elements and circuits
5.5.2.2			A	D	control system
5.5.2.3			C	D	stopping devices
5.5.2.3		A		D	emergency shutdown circuit
5.5.2.3	C				emergency shutdown
7.1				D	operating instructions
7.2	C			D	minimum marking

## 6.2 Design/Manufacturing phase

The verification shall ensure that:

- design calculations are comprehensive and conform to the technical specifications of this standard in respect of the performance capacity and safety of the storage equipment;
- manufacturing drawings of all safety equipment for operating, checking and maintaining the machinery are included;
- operating instructions include information on installation and putting into operation;
- information concerning transport of the storage equipment is complete and available.

## 6.3 At the installation site, before power is switched on

The verification shall ensure that:

- reference documents such as operating or commissioning instructions, circuit diagrams, technical drawings, test equipment etc. are present;
- all equipment necessary to comply with the installation or commissioning instructions have been correctly installed;
- accessibility is available to reach operating, setting and maintenance locations safely, furthermore that the clearances for personnel to comply with the relevant sections of this standard;
- all emergency exit routes from the working area have been clearly marked and ancillary equipment e. g. emergency lighting is operational.

## 6.4 Commissioning

### 6.4.1 Tests

The following shall be verified to confirm that they are functioning in accordance with this standard:

- safety aspects;
  - 1) isolation and connection of the power supply;
  - 2) starting and stopping movements;
  - 3) emergency shutdown devices;
  - 4) limit switches;
  - 5) acoustic and optical warning devices;
  - 6) interlocks;
  - 7) other safety devices.
- speed and movement areas of all moving parts comply with the prescription of this standard;
- specified safety clearances preventing access to hazardous locations are adhered to;
- minimum distances for preventing crushing of parts of the body between parts of machinery or between machinery parts and stationary/moving obstructions external to the machinery are adhered to.

## 7 Information for the user

### 7.1 Instruction handbook

#### 7.1.1 General

The instruction handbook shall be in accordance with Clause 6 of EN ISO 12100-2:2003. The information shall include the conditions under which the equipment is intended to be used, in particular with regard to:

- materials to be handled and stored: indication of the maximum permissible characteristics, e.g. dimensions and weight;
- operating conditions: indication of the operating mode(s), e.g. automatic or manual operation;
- range of intended environmental conditions, e.g. temperature, relative humidity.

Details of safety functions and list and location of safety devices shall also be provided.

The instruction handbook shall also contain information on prohibited applications such as:

- storage of unit loads different from those specified;
- man-riding and climbing on the storage equipment.

Measures for rescuing persons shall be specified to cover the case of failure of the drive, controls, power supply and to cover human emergencies such as fainting, injury etc.

### 7.1.2 Instructions for the installation of the equipment

When the equipment is handed over unassembled, the manufacturer shall provide with the equipment the necessary assembly specifications preferably with drawings showing at least:

- maximum weights, dimensions and lifting points of the separate components supplied;
- assembly phases and technical requirements;
- handling method required;
- floor loadings for individual pieces of equipment;
- requirements for anchoring and fixing points.

### 7.1.3 Instructions for the use of the equipment

The instruction handbook shall include, in addition to Clause 6 of EN ISO 12100-2:2003 the following information:

- instructions, that only authorised personnel shall start and operate the system;
- emergency stopping devices shall be made known to all appropriate personnel;
- all restarting operations on equipment which has been inoperative because of an emergency or accidental stop shall be preceded by an inspection aimed at:
  - 1) determining the cause of the emergency or accidental stop;
  - 2) repairing the fault;
  - information that stopped equipment is not a safe equipment where stored energy may be released unintentionally or by incorrect maintenance procedures. Information about correct maintenance procedures, e. g. freeing a blockage.

The instruction handbook shall draw the attention of the user to:

- ensure that the storage system is not overloaded;
- not modify the equipment nor dismantle it without respecting assembly instructions or consulting the manufacturer or his authorised representative;
- all loading and working stations shall be kept clear.

### 7.1.4 Instructions for maintenance (see EN ISO 12100-2:2003, 6.5.1 e))

The equipment shall be maintained according to the guideline of the supplier (at least once per year).

For determining the sequence of maintenance work the operation environment has to be considered.

The checking and the maintenance work shall be documented.

The instruction handbook shall specify in particular:

- technical knowledge and skills of the maintenance staff specially for particular operations which need specific competence, and that all adjustments, whether mechanical or electrical, shall be carried out by persons authorised to do so in accordance with a safe system of work;

- conditions under which maintenance works and rectification of faults on storage equipment or systems can be performed, e. g. by requiring that the equipment is isolated, protected against unexpected start-up and measures are taken against unexpected movements;
- condition under which a person being transported or working at height shall be permanently secured or protected against a fall;
- in addition at least one other person shall be "on watch" from a safe position outside the storage equipment and adjacent to an emergency power off switch. A reliable means of communication shall be in place between this person and the person on the equipment;
- list of wearing parts as well as the approximate frequency and conditions for their replacement;
- a list of parts to be checked periodically;
- conditions for examination and discard of wire ropes, chains, belts and rack pinions;
- that access to maintenance and inspection points shall be kept clear of obstacles;
- inspection and adjustment of storage equipment, in normal use, shall only be carried out with safety devices in position;
- repairs and removal of protective enclosures or panels shall only be carried out after stopping the equipment and starting devices have been rendered inoperative by persons authorised to do so in accordance with a safe system of work. If any fixing devices are necessary to prevent unintended movement then all maintenance staff shall be fully trained in their use. Information about their use shall be given;
- only trained staff is permitted to work on parts of drives and load bearing and load handling devices within the storage lift and vertical carousel.

### **7.1.5 Training**

The manufacturer shall indicate operator training requirements and give details of this training.

## **7.2 Marking**

### **7.2.1 Rating plate**

The equipment shall be marked at least with the following:

- name and address of the manufacturer;
- year of manufacture;
- designation of series or type;
- serial number;
- rated power supply.

### 7.2.2 Load bearing capacity

The load bearing capacity shall be indicated legibly and indelibly at loading points, in so far as the loading of the equipment is not automatically limited by the type of load suspension device or loading method. Where applicable, the following loads shall be indicated:

- permissible compartment load/carrier load;
- permissible bay load/total load;
- permissible non-uniform/uneven distributed load.

### 7.2.3 Abbreviated operating information

The most important items of the operating instructions concerning safe operation shall be given as pictograms or in abbreviated text. For example:

- clear open aisle before selecting new aisle;
- no climbing on racks;
- do not overload the storage system;
- words "for more information on the safe use of the machine see the instruction handbook".

### 7.2.4 Warnings and recommendations

Important warnings and recommendations if required shall be in accordance with ISO 3864-2.

Clear visible warnings shall direct to the possible risks and the resulting safe procedure.

A warning label has to be mounted durable and easy visible at the opening for maintenance with clear declarations of the risks and also the correct procedure in case of maintenance.

## Annex A (informative)

### Types of power-operated storage equipment

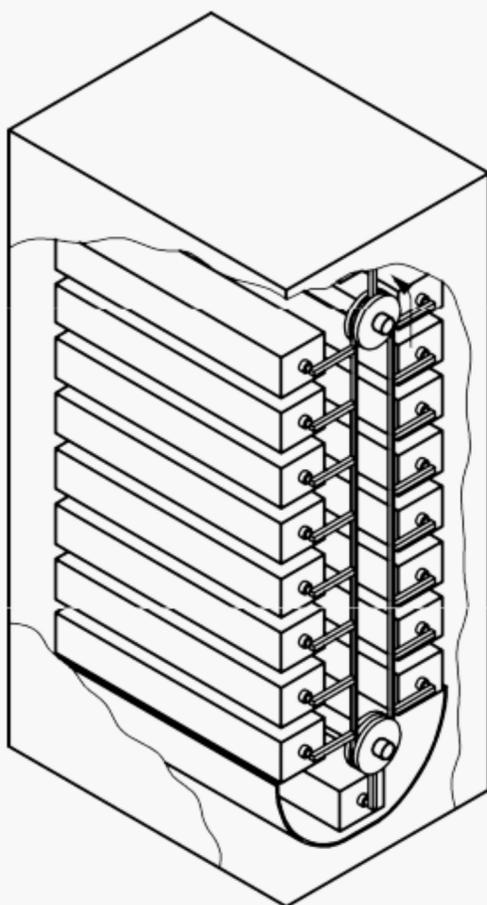


Figure A.1 — Storage equipment with vertically circulating carriers (vertical carousels)

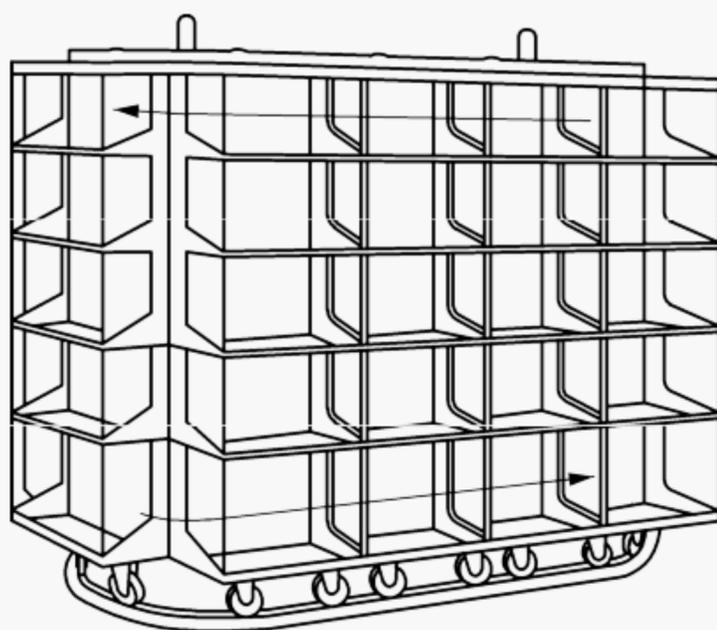


Figure A.2 — Storage equipment with horizontally circulating carriers (horizontal carousels)

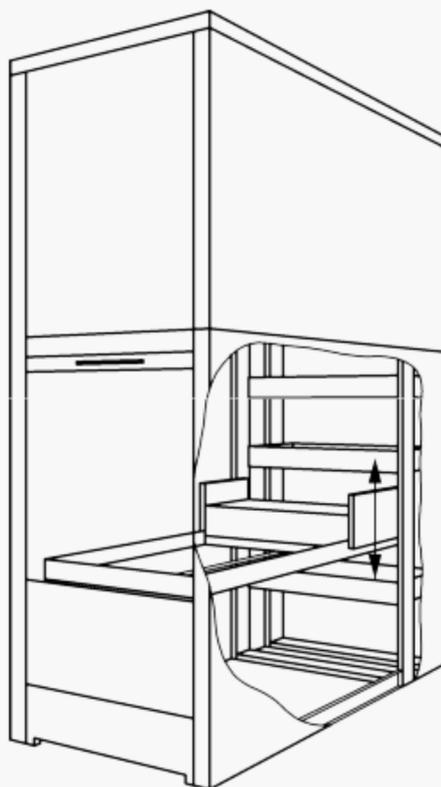
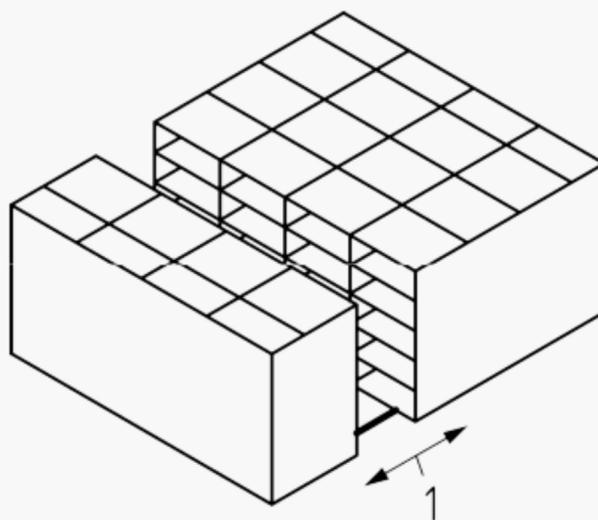


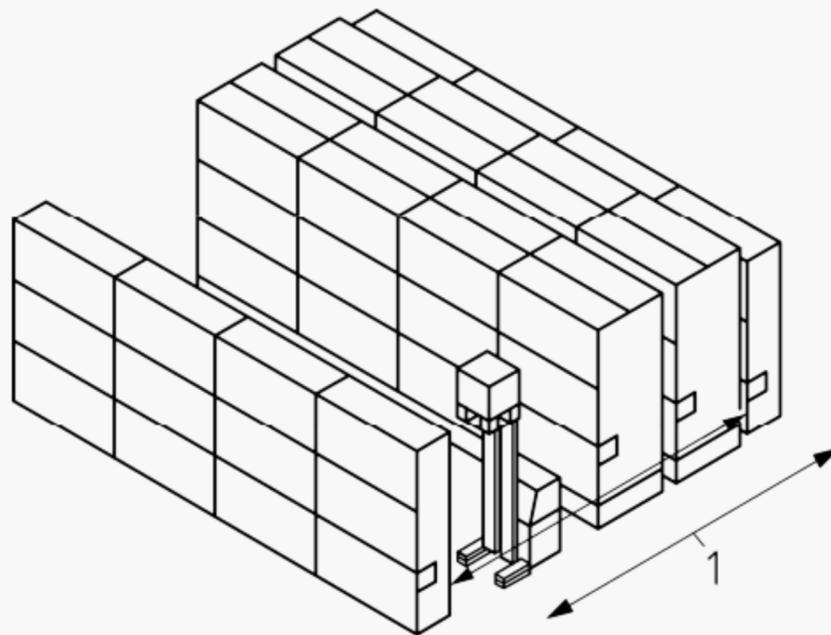
Figure A.3 — Storage lift



**Key**

1 driving direction

Figure A.4 — Mobile shelving



**Key**

1 driving direction

**Figure A.5 — Mobile racking**



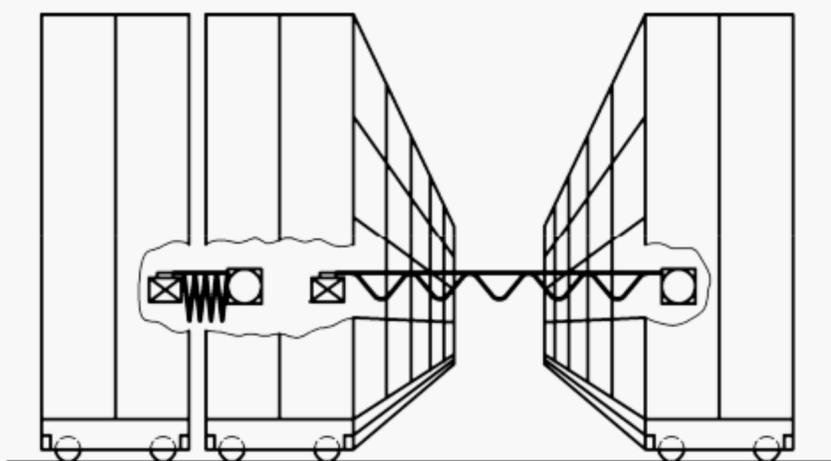
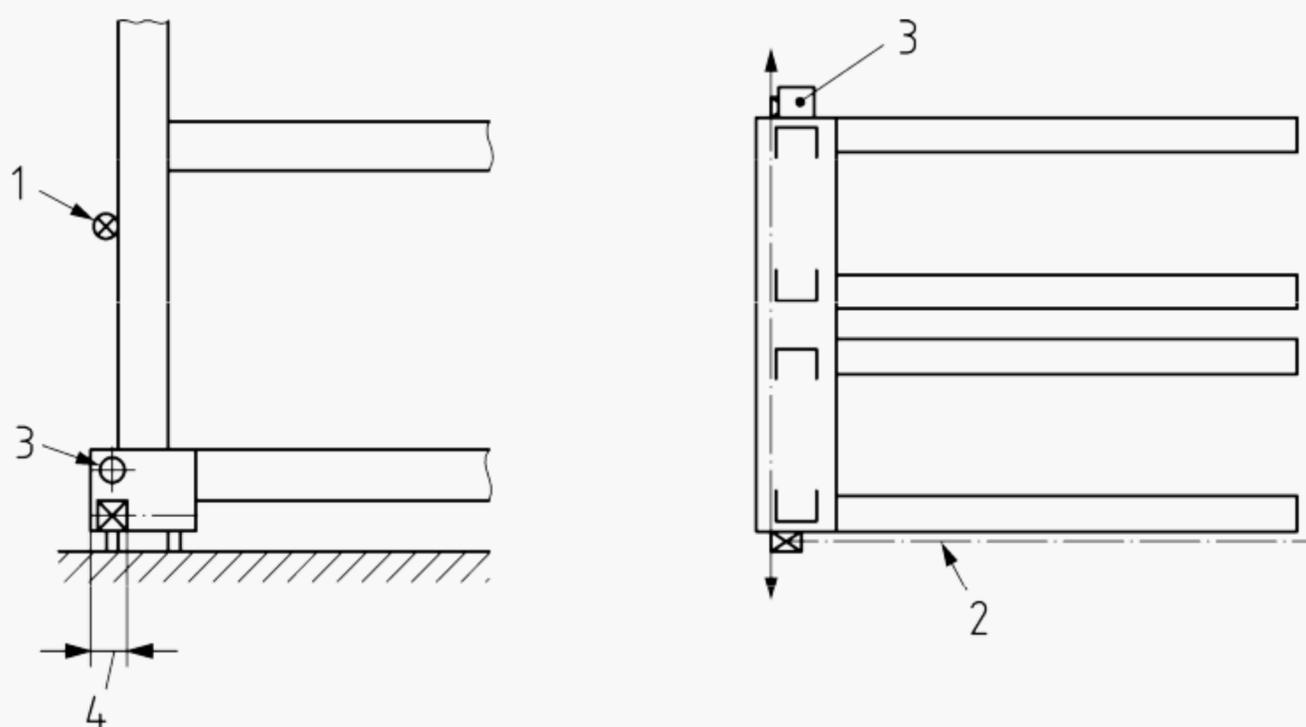


Figure B.3 — Example of a cable barrier



**Key**

- 1 safety device at global level
- 2 safety device at local level
- 3 buffer
- 4 exposed area max. 100 mm

Figure B.4 — Example of local protection on mobile racking according to 5.2.4.7

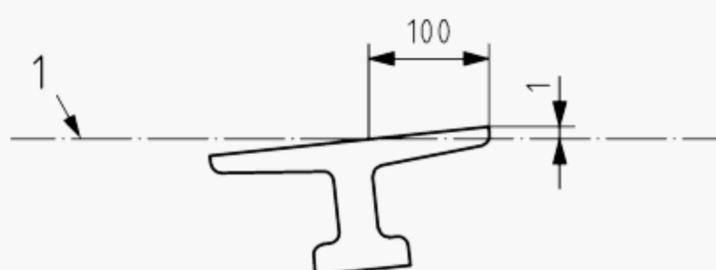
## Annex C (informative)

### Rail tolerances for mobile racking

#### C.1 General

Tolerances given below are indicative only however they are the tolerances that have been considered in specifying the inertia forces in this annex. Tolerances are those expected at the time of installation. Lesser tolerances are possible however require special design consideration.

**C.2** The slope across the width of a rail such as may be caused by twist in the rail section shall not exceed 1 mm in 100 mm.

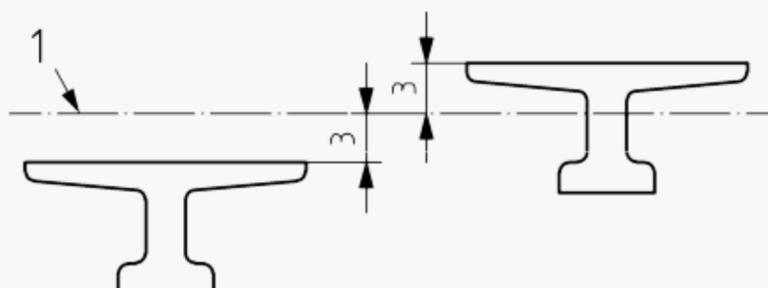


#### Key

1 true level

Figure C.1 — Twist of the rail

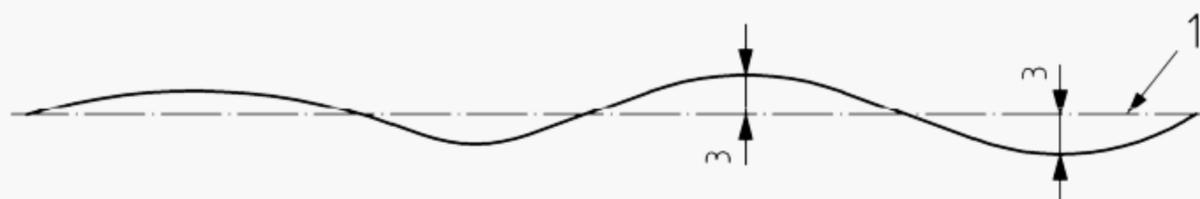
**C.3** Rails shall be installed to  $\pm 3$  mm of a common datum level within a common operating system. This will be both along and across the direction of the tracks.



#### Key

1 datum

a) Maximum absolute vertical tolerance 1



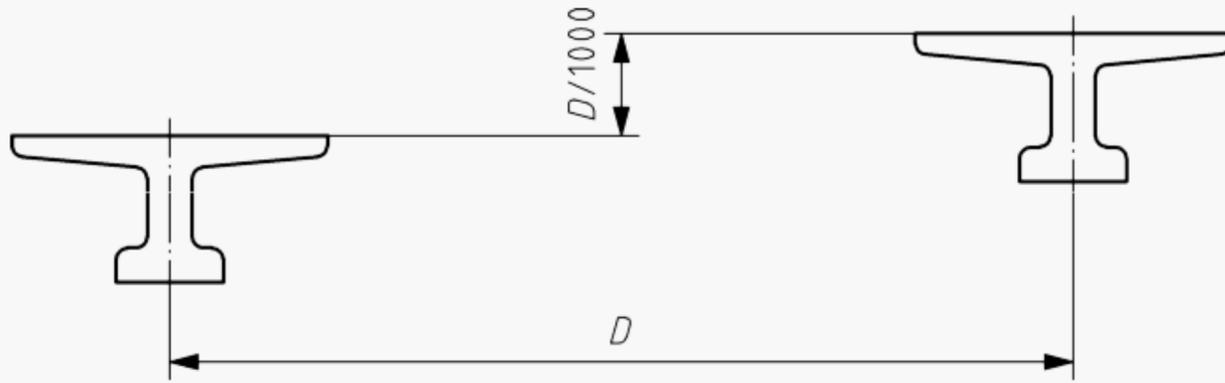
#### Key

1 true level

b) Maximum absolute vertical tolerance 2

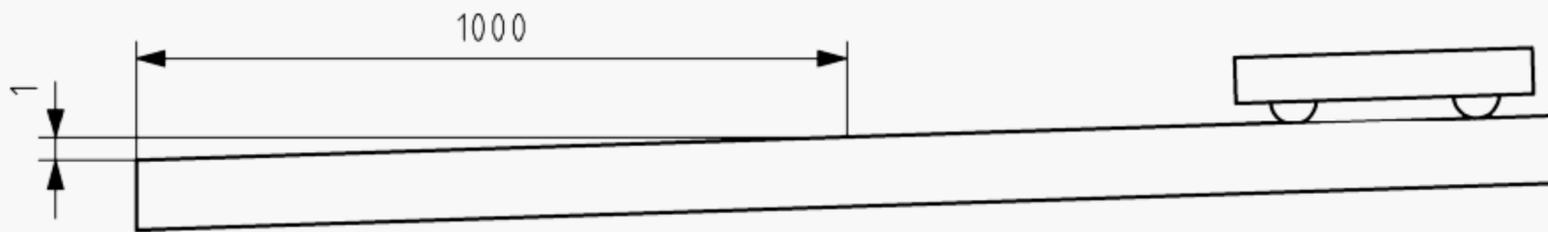
Figure C.2 — Maximum absolute vertical tolerances

**C.4** The differences in level between adjacent rails at any position shall be limited to 1:1 000 of the distance between them measured at 90° to the rails.



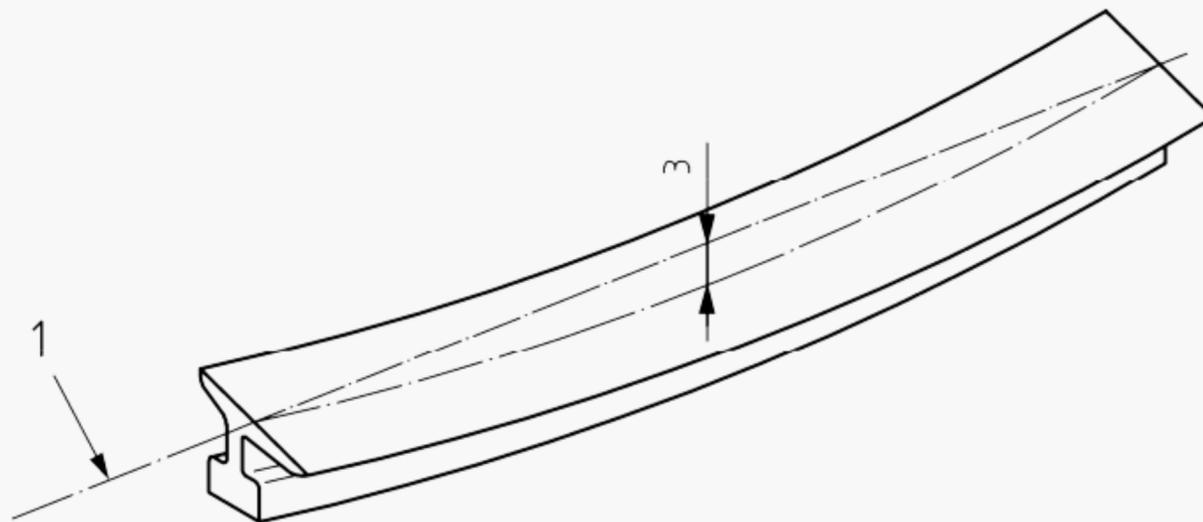
**Figure C.3 — Maximum relative vertical tolerance**

**C.5** At any point on the rail the slope along the rails shall not exceed 1 mm over a 1 000 mm gauge length measured along the centre line of each rail or wheel track.



**Figure C.4 — Maximum inclination of the rails**

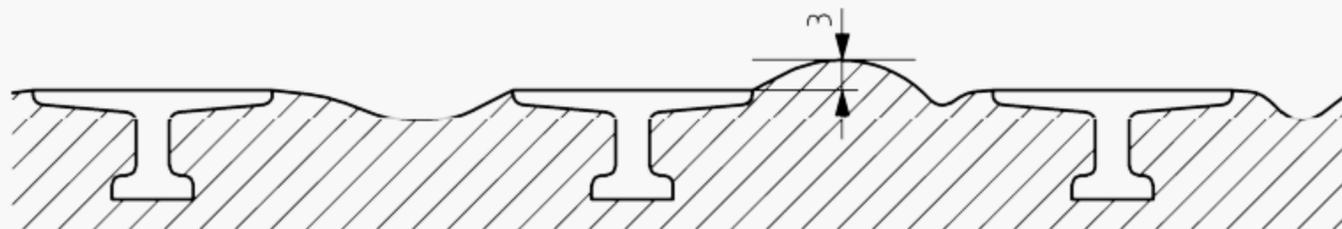
**C.6** The plan straightness of the rails shall be within 3 mm of the defined centre line of the rails.



**Key**  
 1 straight line, Datum

**Figure C.5 — Straightness of the rails**

**C.7** The finished floor level including any floor coverings between the rails shall not be more than 3 mm higher than the adjacent rail surface and be flush with the surface of the rails at the rail edges.



**Figure C.6 — Uneven floor**

**C.8** The flatness of the floor within a common operation system shall meet the truck manufacturer's requirements where appropriate.

Rails to be embedded into a concrete floor shall be fixed to the sub base to hold them firmly in position for line and level before and during the pouring of the concrete. All necessary precautions shall be taken to ensure that no positional or rotational changes can occur to the rail.

## Annex D (normative)

### Rack and pinion

#### D.1 Pinion

Each pinion shall be designed according to ISO 6336 with regard to tooth strength and pitting and shall take into account the following requirements:

- each pinion shall possess a minimum safety factor of 2,0 against the endurance limit for tooth strength, taking into account the maximum wear as stated in the manufacturer's instruction handbook;
- each pinion shall possess a minimum safety factor of 1,4 against the endurance limit for pitting;
- analysis shall be made with a minimum load-spectrum factor of 0,5 on rated load;
- minimum number of load cycles for a rack and pinion lift shall be based on  $1,5 \times 10^6$  – intermittent duty (e. g. 10 years, 52 weeks per year, 100 h per week, and 30 cycles per hour).

#### D.2 Rack(s)

**D.2.1** The rack shall be securely attached. Joints in the rack shall be accurately aligned to avoid faulty meshing or damage to teeth.

**D.2.2** The rack shall be made of material having properties matching those of the pinion in terms of wear and shall be designed according to ISO 6336, with regard to tooth strength and pitting.

The rack shall possess a minimum safety factor of 2,0 against the static limit for tooth strength, taking into account the maximum wear as stated in the manufacturer's instruction handbook.

#### D.3 Rack/pinion(s) engagement

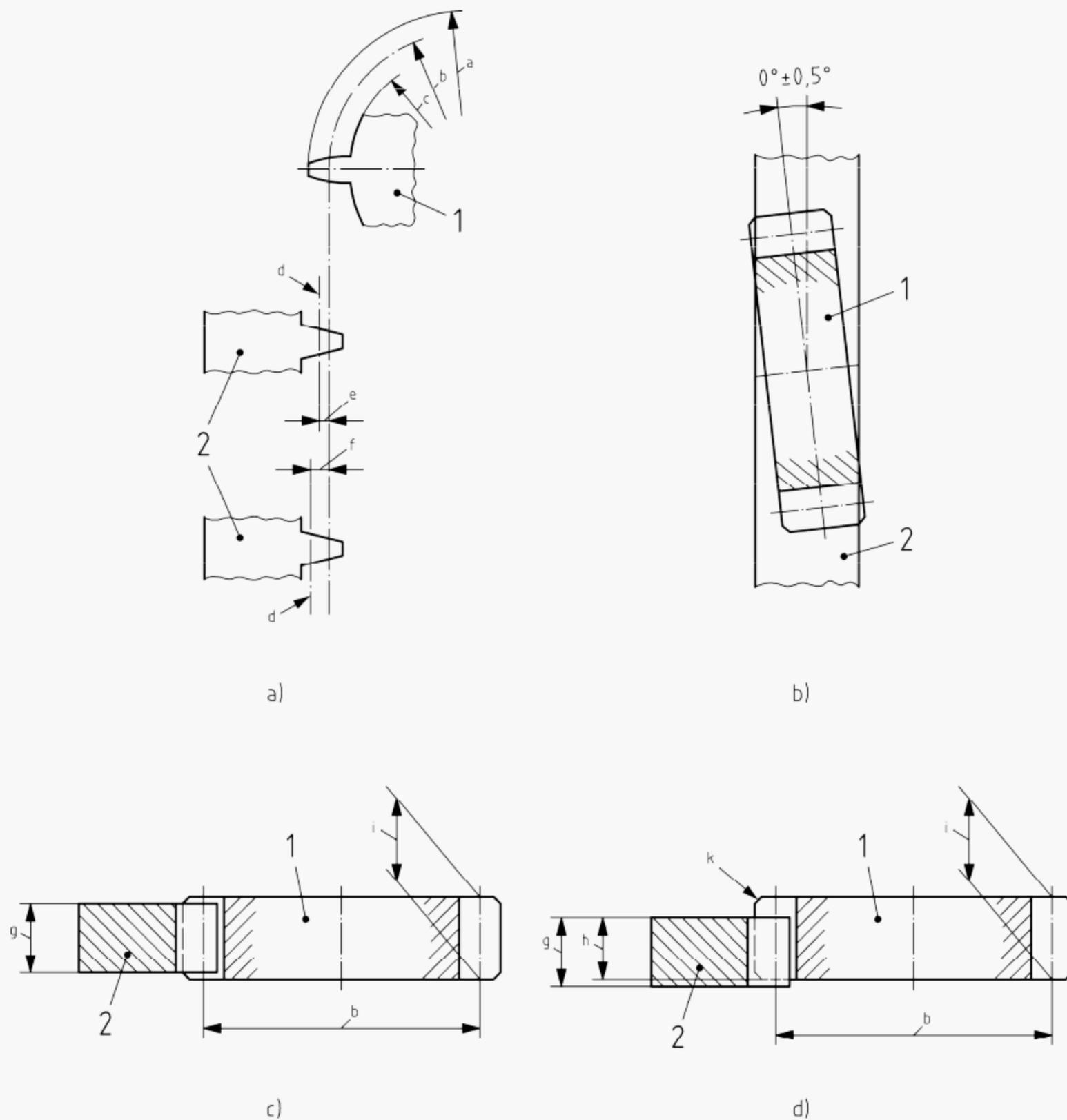
**D.3.1** Means shall be provided to maintain the rack and all the driving and safety device pinions in correct mesh under every load condition. Such means shall not rely solely upon the car guide rollers or shoes.

The correct mesh shall be when the pitch circle diameter of the pinion is coincident with, or not more than 1/3 of the module out beyond the pitch line of the rack (see Figure D.1 a)).

**D.3.2** Further means shall be provided to ensure that in the event of failure of the means provided in D.3.1, the pitch circle diameter of the pinion shall never be more than 2/3 of the module out beyond the pitch line of the rack (see Figure D.1 b)).

**D.3.3** Means shall be provided to ensure that the width of the rack is always in full lateral engagement with pinion teeth of full form (see Figure D.1 c)).

**D.3.4** Further means shall be provided to ensure that in the event of failure of the means, not less than 90 % of the width of the rack shall be in lateral engagement with pinion teeth of full form (see Figure D.1 d)).



**Key**

- 1 pinion
- 2 rack

- a outside diameter of pinion
- b pitch diameter of pinion
- c base diameter of pinion
- d pitch line of rack
- e 1/3 module
- f 2/3 module
- g rack width
- h 90 % of rack width
- i pinion teeth of full form at b
- k chamfer

**Figure D.1 — Rack / pinion(s) engagement**

## Annex E (informative)

### Chains in vertical carousels

Calculation of the design load for chains in vertical carousels (see 5.2.1.5).

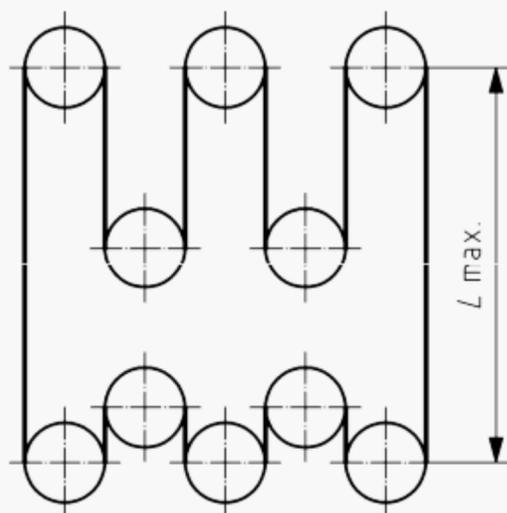


Figure E.1 — Third deep system

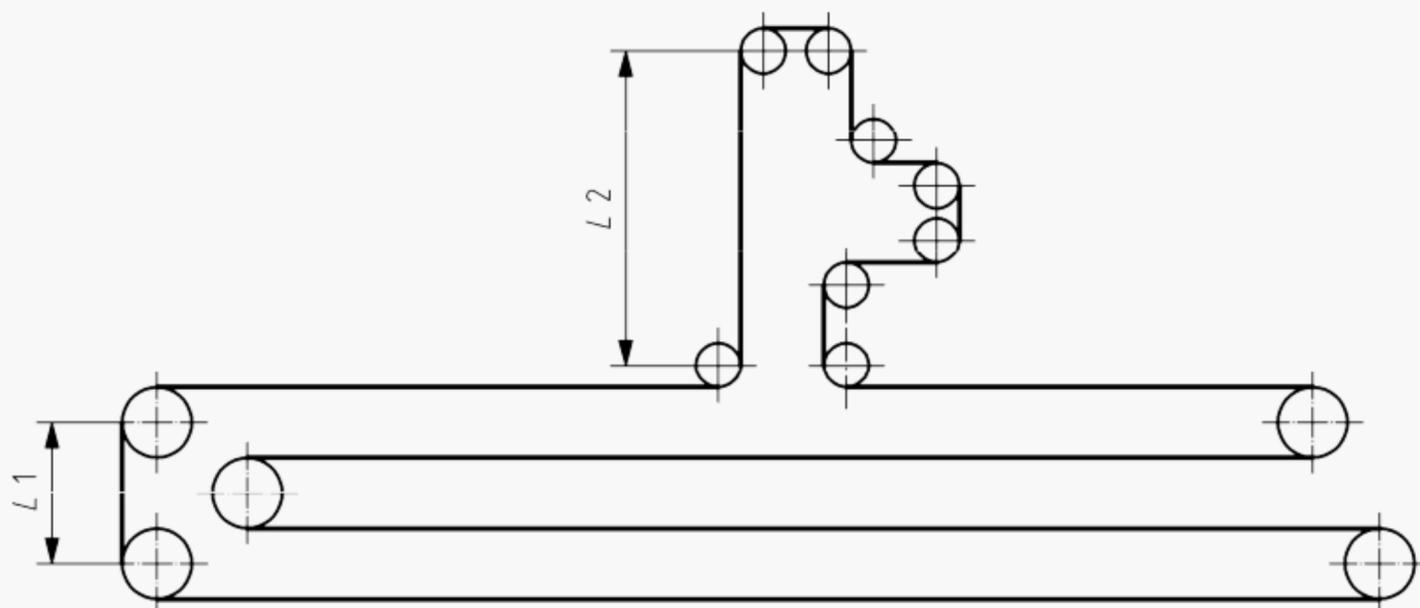


Figure E.2 — Horizontal system

## Annex ZA (informative)

### Relationship between this European Standard and the Essential Requirements of EU Directive 98/37/EC

This European Standard has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association to provide a means of conforming to Essential Requirements of the New Approach Directive Machinery 98/37/EC, amended by 98/79/EC.

Once this standard is cited in the Official Journal of the European Communities under that Directive and has been implemented as a national standard in at least one Member State, compliance with the normative clauses of this standard confers, within the limits of the scope of this standard, a presumption of conformity with the relevant Essential Requirements of that Directive and associated EFTA regulations.

**WARNING** — Other requirements and other EU Directives may be applicable to the product(s) falling within the scope of this standard.

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