BRITISH STANDARD

BS EN 528:2008

Rail dependent storage and retrieval equipment — Safety requirements

ICS 53.080

BSI
British Standards

National foreword

This British Standard is the UK implementation of EN 528:2008. It supersedes BS EN 528:1997 which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee MHE/14, Rail dependent storage and retrieval equipment - Safety.

A list of organizations represented on this committee can be obtained on request to its secretary.

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Foreword

This document (EN 528:2008) 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of an identical text or by endorsement, at the latest by April 2009, and conflicting national standards shall be withdrawn at the latest by December 2009.

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This European Standard supersedes EN 528:1996.

EN 528:1996 can be further applied until 12/2009.

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) 98/37/EC and 2006/42/EC.

For relationship with EU Directive(s), see informative Annexes ZA and ZB, which are integral parts of this document.

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.

When provisions of this type C standard are different from those that are stated in type A or type 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.

While producing this standard it was assumed that:

a) only competent persons operate the machine;

b) components without specific requirements are:

   1) designed in accordance with the usual engineering practice and calculation codes, including all failure modes;

   2) of suitable mechanical and electrical construction;

   3) made of materials with adequate strength and of suitable quality.

c) harmful materials, such as asbestos are not used as part of the machine;

d) components are kept in good repair and working order, so that the required characteristics remain despite wear;

e) by design of the load bearing elements, safe operation of the machine is assured for loading ranging from zero to 100 % of the rated possibilities;

f) discussions have taken place between the user and the supplier concerning particular conditions for the use and places of use of the machinery;

g) working area is adequately lit;

h) places of installation allow a safe use of the machine.

1 Scope

This standard applies to all types of S/R machines, restricted to the rails on which they travel within and outside the aisles, which embody lifting means and may embody lateral handling facilities, for the storage and retrieval of unit loads and/or long goods such as bar materials and/or for order picking or similar duties. Also included is the transfer equipment used to change between aisles. Control of machines may range from manual to fully automatic.

This standard does not apply to free ranging industrial trucks or robots.

References in this standard to racking, buildings and systems only apply where it is necessary to assess the hazards and risks at their interfaces with S/R machines.

This standard deals with all significant hazards relevant to rail dependent storage and retrieval equipment, when they are used as intended under the conditions foreseen by the manufacturer (see Clause 4).

This standard applies to machines and equipment that are manufactured after the date of issue of this standard.

Illustrations of examples of machines and transfer equipment to which this standard applies are shown in Annex A.

Safety requirements and/or measures in this standard apply to equipment used under indoor conditions. However, additional risk assessments and safety measures need to be considered for uses in severe conditions, e.g. freezer applications, high temperatures, loads, the nature of which could lead to a dangerous situation (e.g. especially brittle loads, explosives), earthquake effects and also contact with foodstuff. Hazards during decommissioning are not covered.

This European Standard also deals with the technical requirements for electromagnetic compatibility (EMC).

Noise emitted by these machines is not considered as significant but as a relevant hazard. This means that the manufacturer of the machine is obliged to carry out noise reduction and indicate the noise level.

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 81-1:1998, *Safety rules for the construction and installation of lifts — Part 1: Electric lifts*

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

EN 363, *Personal fall protection equipment — Personal fall protection systems*

EN 574, *Safety of machinery — Two-hand control devices — Functional aspects — Principles for design*

EN 614-1, *Safety of machinery — Ergonomic design principles — Part 1: Terminology and general principles*

EN 795, *Protection against falls from a height — Anchor devices — Requirements and testing*

EN 894-1, *Safety of machinery — Ergonomic requirements for the design of displays and control actuators — Part 1: General principles for human interactions with displays and control actuators*

EN 894-2, *Safety of machinery — Ergonomic requirements for the design of displays and control actuators — Part 2: Displays*

EN 982, *Safety of machinery — Safety requirements for fluid power systems and their components — Hydraulics*

EN 999, *Safety of machinery — The positioning of protective equipment in respect of approach speeds of parts of the human body*

EN 1037, *Safety of machinery — Prevention of unexpected start-up*

EN 1263-1, *Safety nets — Part 1: Safety requirements, test methods*

EN 1263-2, *Safety nets — Part 2: Safety requirements for the positioning limits*

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 1760-3, *Safety of machinery — Pressure sensitive protective devices — Part 3: General principles for the design and testing of pressure sensitive bumpers, plates, wires and similar devices*

EN 12385-4, *Steel wire ropes — Safety — Part 4: Stranded ropes for general lifting applications*

EN 13411-3, *Terminations for steel wire ropes — Safety — Part 3: Ferrules and ferrule-securing*

EN 13411-6, *Terminations for steel wire ropes — Safety — Part 6: Asymmetric wedge socket*

EN 60204-32:1998, *Safety of machinery — Electrical equipment of machines — Part 32: Requirements for hoisting machines (IEC 60204-32:1998)*

EN 60947-5-1:2004, *Low voltage switchgear and controlgear — Part 5-1: Control circuit devices and switching elements — Electromechanical control circuit devices (IEC 60947-5-1:2003)*

EN 61000-6-2, *Electromagnetic compatibility (EMC) — Part 6-2: Generic standards — Immunity for industrial environments (IEC 61000-6-2:2005)*

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

EN ISO 4871:1996, *Acoustics — Declaration and verification of noise emission values of machinery and equipment (ISO 4871:1996)*

EN ISO 11202, *Acoustics — Noise emitted by machinery and equipment — Measurement of emission sound pressure levels at a work station and at other specified positions — Survey method in situ (ISO 11202:1995)*

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 13849-1:2008, *Safety of machinery — Safety-related parts of control systems — Part 1: General principles for design (ISO 13849-1:2006)*

EN ISO 13850:2008, *Safety of machinery — Emergency stop — Principles for design (ISO 13850:2006)*

EN ISO 13857:2008, *Safety of machinery — Safety distances to prevent hazard zones being reached by upper and lower limbs (ISO 13857:2008)*

EN ISO 14122-3:2001, *Safety of machinery — Permanent means of access to machinery — Part 3: Stairs, stepladders and guard-rails (ISO 14122-3:2001)*

EN ISO 14122-4, *Safety of machinery — Permanent means of access to machinery — Part 4: Fixed ladders (ISO 14122-4:2004)*

ISO 4308-1, *Cranes and lifting appliances — Selection of wire ropes — Part 1: General*

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
control position
every place, from where the machine can be controlled, including external control position (3.2.), emergency control position (3.3) and onboard control position (3.4)

3.2
external control position
control position placed in a safe area, out of the working area of the S/R machine, from where the movements of the machine can be controlled

3.3
emergency control position
position on the machine or inside the danger area of the machine, from where the machine can be controlled in case of fault clearing (emergency) or maintenance works

3.4
onboard control position
protected position on the machine, from where the movements of the machine can be controlled (includes S/R machines according to Clause 6 (with on-board operators))

3.5
operators work area
area on or off the machine where order picking, stocktaking or similar work is carried out

3.6
load handling device
part of the machine for carrying the specified loads

3.7
deterring/impeding device
any physical obstacle which, without totally preventing access to a danger zone, reduces the probability of access to this zone by offering an obstruction to free access

3.8
rated load
maximum load which the machine has been designed to carry, excluding the mass of operator(s) and any part of the machine

3.9
test load
rated load plus additional load for test purposes

3.10
rated speed
maximum speed of the machine for which it has been designed and for which normal operation is guaranteed by the vendor

3.11
safety gear
mechanical device for stopping and maintaining stationary the lifting carriage in case of overspeed in the downward direction

3.12
specified load
load with specified characteristics (mass, dimensions, pallet or container, packaging, etc.) which the machine has been designed to carry

3.13
transfer device
device which is used for transferring a S/R machine from one aisle to another and which is not integral with the S/R machine

3.14
maintenance position
position on or off the machine for safe maintenance and repair

3.15
key
device that can be mechanical, electrical, magnetic or similar with unique characteristics

3.16
maximum working pressure
maximum pressure corresponding to the setting of the pressure relief valve

3.17
operating pressure
pressure under which the system is designed to work

3.18
satellite vehicle
individual vehicle connected to the lifting carriage of the machine and used for transferring loads into or out of the rack structure

3.19
load transfer area
area where loads are transferred into or out of the machine operating area

3.20
work station
place where persons carry out their duties

3.21
traffic area
area that personnel use for travel from one place to another

3.22
system axes
directions, in which the sr-machine can move

NOTE x = aisle length direction; y = aisle vertical direction; z = aisle lateral direction

4 List of significant and relevant hazards

This clause contains all the significant and relevant hazards as far as they are dealt with in this standard, identified by risk assessment significant for this type of machinery and that require action to eliminate or reduce risk.

Table 1 — List of significant and relevant hazards

Hazards		**Corresponding requirements**	
4.1	**Mechanical hazards**		
4.1.1	Crushing from collapse of racking due to contact with the machine	5.4.6.6	Unintentional lowering
		5.6.2	End stops
		5.6.3	Limitation of forces
		5.6.5	Load handling interlocks
		5.10.2	Safety clearances
4.1.2	Shearing of a person on board between moving machine and racking	5.9.2	Maintenance position
		6.3.2/7.2	Safeguard of the operator
4.1.3	Cutting due to broken glass	6.2.2.3 6.2.2.10	Safety glass
		6.2.4.2	Protected lighting
4.1.4	Drawing-in or trapping of a person in a maintenance position when machine operated by a driver	5.9.5	Communication
4.1.5	Impact from: a) Fall of objects from operator's position b) Collision between machine and persons	6.2.2.3	Floor of the onboard control position
		5.9.6	Protection from operating machines
		5.10.3	Limiting access
		5.10.4	Load entry/exit
		5.10.6	Escape
		6.6	Protection of operators in an aisle containing two or more manually operated machines
		10.4.6	Operator check of aisle
		10.4.7	No unauthorised access to the aisles
		10.4.8	Permit to work system
		10.5.2.9	No danger from second machine
4.1.6	Loss of stability	5.5.5 5.8.5	Stability
		5.6.1	Load stability
4.1.7	Slip, trip or fall on operator's platform	5.10.3.2. c)	Access door interlock
		6.2.2.3	Horizontal slip-resistant floor

Table 1 *(continued)*

Hazards		**Corresponding requirements**	
4.1.8	Handling of machine	5.1	Lifting points
		8.1	Erection and dismantling
4.1.9	Falling objects	5.4.7.2	No separation of lifting carriage
		5.4.8.2	No rack and pinion disengagement
		6.2.2.8	Overhead protection
4.1.10	Fall of person from elevated operator position	6.2.1.4	Prevention of falls from access means
		6.2.2.3	Floor design
		6.2.2.4	Safe guard
		6.2.2.5	Guards
		6.2.2.6	Permanent fixed guards
		6.2.2.7	Operator's position door opening
		10.4.15	Operator entering or leaving the machine in position
		10.4.20	Person on load handling device
4.1.11	Defective stopping	5.5.1.1.c)	Emergency braking system
4.1.12	Uncontrolled movements (including unintended movements)	5.3.5	Control devices for powered movements
		5.3.9	Safety requirements related to EMC
		5.4.6.5	Prevention of lowering of the onboard control position
4.1.13	Load falls	5.4.2	Limitation of lifting and lowering movement
		5.4.6.7	Auxiliary hoist valve
		5.6.1	Load stability
		5.6.6	Auxiliary handling equipment
		5.6.7	Load position monitoring
		5.10.5	Load movement over persons
		5.10.7	No unintentional load movement
		5.10.8	Protection from falling loads
		7.4.3	Lead-screw drives (safety nut)
		10.4.10	No overloading
		10.4.11	Load remains on load handling device
		10.4.12	No projection of goods into aisle
		10.4.18	No handling of faulty loads
4.1.14	Collisions	5.5.2.c)	Speed reducing system
		5.5.3.d)	Limitation of travel
4.1.15	Tipping of machine	5.4.3.1	Overload protection

Table 1 *(continued)*

Hazards		**Corresponding requirements**	
		5.5.2	Speed reducing system
		5.5.4	Anti-derailment device
		5.5.5	Stability
		5.6.5	Load handling interlocks
		5.8.1	Machine position on transfer device
		5.8.3	Transfer device movement
		5.8.4	Machine interlocking before transfer
		5.8.5	Stability of transfer device
		6.4.1	Overload protection
4.1.16	Lifting of persons resulting in: a) plummeting of onboard control position b) falling from onboard control position	5.4.4	Safety gear
		5.4.6	Hydraulic lowering control valve
		5.4.7	Lead-screw drives (safety nut)
		5.4.8	Rack and pinion drives
		5.9.2	Protection of maintenance position
		6.2.2	Onboard control position design
		10.4.4	Correct numbers of persons on machine
4.1.17	Derailment of machine	5.5.4	Anti-derailment device
4.1.18	Insufficient strength of parts	5	Compliance with EN standards
4.1.19	Inadequate design of pulleys and drums	5.4.5.1.4 5.4.5.1.5 5.4.5.1.9 5.4.5.1.10	Pulley and drum design requirements
4.1.20	Inadequate selection of suspension elements	5.4.5.1 5.4.5.2 5.4.5.3	Rope, belt and chain selection criteria
4.1.21	Lowering by friction brake	5.4.1	Hoist unit brake
4.2	**Electrical hazards**		
4.2.1	Electrical contact with live conductors	5.1	Compliance with EN standards
		5.7.1	Electrical supply conditions
		5.7.3	Environment
		5.7.4	Supply disconnecting device
4.2.2	Electrostatic phenomena	Not applicable	
4.2.3	Thermal radiation	Not applicable	
4.2.4	External influences	Not applicable	
4.2.5	Lightning	Not applicable	

Table 1 *(continued)*

Hazards		**Corresponding requirements**	
4.3	**Thermal hazards**		
4.3.1	Burns and scalds	Not applicable	
4.3.2	Hot or cold working environment		Extreme thermal conditions: Additional risk assessment needed
4.3.3	Inadequate cab heating/ventilation	Not applicable	
4.3.4	Fire at the operator control position	6.2.2.9	Furnishings difficult to ignite
4.4	**Noise**		
4.4.1	Hearing loss	5	Protection from hearing loss
4.4.2	Interference with communication	5.9.5	Means of communication
4.5	**Vibration**	5.10.7	Protection against unintended load movement
4.6	**Radiation**	Not applicable	
4.7	**Materials and substances**	5	Specified working environment
4.8	**Neglecting ergonomic principles**		
4.8.1	Unhealthy postures or efforts	6.2.2.1	Ergonomic principles
4.8.2	Inadequate consideration of anatomy	6.2.2.1	Ergonomic principles
4.8.3	No personal protection equipment	8.1.3	Provision of personal protection equipment
4.8.4	Inadequate lighting	6.2.2.2	Operator view of his area
		6.2.4.3	Emergency lighting for evacuation
4.8.5	Mental overload or underload	Not applicable	
4.8.6	Human error resulting in: a) unauthorised persons on machines; b) dangerous change to automatic control.	5.3.2	Equipment switch
		10.2.4	Warning signs
		5.3.3	Mode switch
		5.3.4	Key dependence
		5.7.2	Electrical supply conditions
		10.5.2.5	Switch off and lock main isolator
		10.5.2.6	Avoid hazards when switching on power
4.8.7	Lack of visibility	6.2.2.2	Operator view of his area
4.8.8	Inadequate signs/signals/warnings	6.2.3	Operator's warning device
4.8.9	Control devices	5.3.5	Control device for powered movements
		5.3.6	Control device
		5.9.3	Emergency controls
4.8.10	Means of access	5.9.2	Maintenance position
		5.9.7	Access along the mast
		6.2.1.2	Access to onboard control position

Table 1 *(continued)*

Hazards		**Corresponding requirements**	
4.8.11	Use in dark places	6.2.4.1	Adequate lighting for work area
4.9	**Hazard combinations**		
4.9.1	Insufficient evacuation means	6.2.1.3	Safe emergency egress
		10.4.16	Immediate evacuation in emergency
4.9.2	Insufficient instructions	8.1.1	Correct assembly information
		8.2.1	Correct commissioning information
		8.2.2	Instruction manual for commissioning
		10.4	Conditions for the safe operation of equipment
4.9.3	Unauthorised use	5.3.1	Prevention of unauthorised operation
		10.5.2.10	Machine recovery procedure
		8.1.2	Trained personnel for erection etc.
		8.2.3	Trained personnel for commissioning
		10.4.3	Suitable and reliable operators only
		10.4.13	Removal of key for manually controlled machines
		10.4.14	Only one key for automatic machines
4.10	**Functional disorders**		
4.10.1	Failure of energy supply	5.5.1.1.b)	Automatic braking with power failure
4.10.2	Unexpected ejection of fluids	5.4.6.1 5.4.6.2	Pipe and hose pressures
		5.4.6.4	Pressure relief valve
4.10.3	Malfunction of control system	5	Compliance with EN standards
4.10.4	Unexpected loss of machine stability	5.5.4.4	10 mm drop if wheel fails
4.11	**Missing or incorrectly positioned safety related means**		
4.11.1	Safety related devices	5.10.3.3	Sensing devices
		5.10.4	Load entry and exit
		8.2.4	Check safety devices before commissioning
		10.4.5	Behaviour in case of failures
		10.4.9	Safety devices to remain operational
		10.5.3.5	Examination of safety components
4.11.2	Starting and stopping devices	5.5.1	Braking system
		5.5.2	Speed reducing system
		5.5.3	Limitation of travel
		5.8.4	Stop machine from leaving aisle
4.11.3	Safety signs and signals	10.3.1	Identification plate

Table 1 *(continued)*

Hazards		**Corresponding requirements**	
		10.3.2	Carrying capacity
		10.3.4	Warning signs
4.11.4	Information and warning devices	10.3.3	Operating instructions
4.11.5	Energy supply disconnection devices	5.7.4.	Supply disconnecting (isolating) device
4.11.6	Emergency devices	5.3.7	Stop function
		7.3.2	Emergency stop equipment
		5.5.1	Travel unit braking system
		10.5.2.10	Machine recovery procedure
4.11.7	Equipment for safe adjustment and maintenance	5.7.4	Supply disconnecting (isolating) device
		5.9.2	Maintenance position
		5.9.3	Emergency control position
		5.9.5	Communication means
		8.1.3	Correct tools etc. for assembly
4.11.8	Equipment for evacuating gases	Not applicable	

5 Safety requirements and/or protective measures for all types of S/R machines

5.1 Introduction

Machinery shall comply with the safety requirements and/or protective measures of this clause, Clause 6, Clause 7 and Clause 8. In addition, the machine shall be designed according to the principles of EN ISO 12100 (all parts) for relevant but not significant hazards, which are not dealt with by this standard.

Controls and other electrical components shall be in accordance with EN ISO 13849-1, EN ISO 13850 and EN 60204-32 apart from the deviations stated in the following clauses.

Machines and sub-assemblies shall be provided with lifting points unless these are not required by design.

5.2 Control position

S/R machines with one or more on-board operators shall have an onboard control position. This may be mounted on the lifting carriage, move independently of the lifting carriage, or may be mounted in a fixed position on the machine.

In the case of fully automatically controlled machines an onboard control position may be dispensed with, but an emergency control position shall be provided for each machine.

5.3 Control equipment

5.3.1 General

The text of 5.3 and its sub-clauses fully replaces and deviates from the text of 9.4 in EN 60204-32:1998 and its subclauses.

Safety related parts and safety related functions are listed in Table C.1 and Table C.2 respective of Annex C. Performance levels shall be in accordance with the performance levels required in these tables.

Adjustable safety related parts (e. g. electronic control circuitry, software, safety devices) shall be protected against access by unauthorised persons (e. g. by the use of access codes, seals, enclosures, tools).

Safety related parts shall be designed, located or protected to withstand foreseeable strain or damage.

The switching contacts of mechanically actuated electrical safety devices shall be the positive opening type as defined in Clause 3 of EN 60947-5-1:2004. (i.e. “safety switches”).

5.3.2 Prevention of unauthorised operation (equipment switch)

A key operated switch shall be fitted to the control panel of each machine to prevent unauthorised operation. With the key switch in the "off" position, all movements of the machine shall be prevented (see 5.3.3). It shall only be possible to remove the key from this switch in the "off" position.

For manual machines this key allows the operator to take control of the machine. In the case of automatic machines this key, in conjunction with the key in 5.3.3, allow operation of the machine for commissioning, fault finding or any other work where the machine needs to be operated by manual control.

5.3.3 Changing mode of operation (mode switch)

To prevent danger due to a change from manual to automatic control, or vice versa, one or more key operated mode switches, or alternative means providing the same level of safety, shall be provided for each automated machine (see 6.3.1 and 7.3.1). The mode switches are associated with the safety concept of limited access described in 5.10.3.1 (see also Figure A.3 in Annex A). When a mode switch is actuated, powered motion shall cease. The machinery shall then remain in a stationary condition. Separate start devices at the external control position, located if possible in the direct sight of the machine and on the machine (emergency control position or onboard control position), shall be provided to be actuated and thus restart the machine.

It shall only be possible to remove the key from the mode switch on the machine in the "automatic" position and from the mode switch at a control position outside the machine operating area in the "manual" or "off" position.

5.3.4 Key dependence

For manual machines the door key (see 5.10.3.2.b)) shall be the same key as specified in 5.3.2, or permanently attached to it. For automatic machines the door key shall be the same key as specified in 5.3.3, or permanently attached to it. Equivalent key dependent systems, e. g. key transfer systems as described in Annex E of EN 1088:1995, may be used.

Where one machine is dedicated to one enclosed aisle, then each key shall be unique to a machine and the access door associated with the machine operating area.

Where machines are not dedicated to one aisle (e. g. machines with transfer devices, curve going machines) the key shall be unique for each dedicated aisle entrance door. The key for the machines may all be the same but permanently attached to the entrance door key.

5.3.5 Control devices for powered movements

Control devices for all movements shall be designed and arranged so that they may be actuated easily and safely and so that the possibility of unintended actuation is avoided.

For machines with fully enclosed on-board control position (see 6.3.2) the stop category may be 2 (see 5.3.7.1). If a stop command is given, powered motion shall cease and the equipment shall then remain in a stationary condition until the start control device has subsequently been actuated.

5.3.6 Control device identification

Each control device shall be identifiable and clearly marked with the resultant direction of movement in the language of the country of use or by pictograms where appropriate. The way in which the control devices are actuated shall, as far as possible, correspond to the particular movement.

NOTE The application of EN 61310-3 is recommended.

5.3.7 Stop function

5.3.7.1 Stop categories

The stop function shall comply with 9.2.5.3 of EN 60204-32:1998 and 5.2 of EN ISO 13849-1:2008 and shall be:

— category "0" or "1" stop, or

— category "2" stop,

as required by the design (see 9.2.2 of EN 60204-32:1998).

5.3.7.2 Initiation of the stop-function

After a stop function has been initiated powered motion shall cease. If a stop control does not cut off the energy supply (category "2" stop) the stop condition shall be monitored and maintained. The equipment shall then remain in a stationary condition until a start device has subsequently been actuated.

5.3.8 Emergency stop function

5.3.8.1 General

The emergency stop function shall comply with EN ISO 13850:2008, 5.3 of EN ISO 13849-1:2008 and shall be provided to stop the machine without creating additional risks. The stop category 0 or 1 shall be chosen according to the design of the drives.

NOTE Stop category 1 may be used for machines with electronically controlled drives (this deviates from 9.2.5.4.2 of EN 60204-32:1998).

5.3.8.2 Location of actuators

In addition to the requirements of 10.7.1.1 of EN 60204-32:1998 the actuators for the emergency stop function shall be located in all control positions as a minimum.

NOTE The provision of actuators for emergency stop function should be considered for other working positions, e. g. hoist platforms, maintenance platforms, etc.

If an emergency stop device is actuated, the emergency stop function shall be initiated automatically and powered motion shall cease. The equipment shall then remain in a stationary condition until the emergency stop device has been reset and the start device has subsequently been actuated.

5.3.8.3 Electronic devices

Programmable electronic equipment or electronic devices (including electronic sub-assemblies) may be used for emergency stop functions if the devices and equipment are at least in accordance with the requirements of Annex C.

NOTE This is not in accordance with 11.3.4 of EN 60204-32:1998.

5.3.9 Safety requirements related to EMC

NOTE This clause is related to the Machinery Directive.

The machine shall have sufficient immunity to electromagnetic disturbances enabling it to operate as safely as intended and shall not fail to danger, when exposed to the levels and types of disturbance as specified in EN 61000-6-2. The manufacturer of the machine shall design, install and wire the equipment and sub-assemblies, taking into account the recommendations of the supplier(s) of the sub-assemblies, to ensure that the effects of electromagnetic disturbances generated shall not lead to unsafe operation and/or failure to danger.

There shall be no loss of performance or degradation of performance that could lead to danger. In particular, the following losses of performance or degradations of performance shall not occur:

— unexpected start-up (see EN 1037);

— blocking of an emergency stop command, or resetting of the emergency stop function (see EN ISO 13850 and EN 60204-32);

— inhibition of the operation of any safety related circuit including safety related fault detection capabilities.

Information on measures to reduce the effects of electromagnetic disturbances on the machine is given in 4.4.2 of EN 60204-32:1998.

5.4 Hoist unit

5.4.1 Hoist unit brake

5.4.1.1 General

All hoist units shall be equipped with brakes capable of stopping the movements of the hoist unit with its test load safely at its rated speed and maintaining it in its stopped position.

If a holding brake is used together with other equivalent devices, the holding brake must be able to stop any movements in an emergency case with the same conditions as above. In this case limited lifetime of the holding break is accepted.

Brakes shall be applied automatically when the power supply is interrupted.

5.4.1.2 Arrangement

The hoist unit shall be arranged so that the connection between the brake and the drum or sprocket cannot be disengaged.

5.4.1.3 Manual brake release lever

When a manual brake release lever is provided, the brake shall be operational when the lever is released.

5.4.2 Limitation of the lifting and lowering movement

In order that lifting and lowering movements are stopped without undue shock, upper and lower limit stops shall be used to define the extent of the vertical travel. The following shall be provided:

a) preliminary devices for initiating a controlled stop towards the upper and lower hoist limits when variable or multi-step drives are used;

b) control devices (e. g. limit switch or proximity device) which prohibit incorrect hoist direction at the hoist travel limits;

c) ultimate limit switches, which shall be of the positive operating type with direct mechanical actuation in accordance with EN 60947-5-1. If an ultimate limit switch is activated, an emergency stop function in accordance with 5.3.6 shall be initiated automatically. The actuators of theses switches shall be independent of other switches.

   1) Machines with slack rope, chain or belt protection do not require ultimate limit switches for the bottom limit except for continuous rope and chain drives;

   2) time delay within the control function for controlled electrical drives (e. g. DC motors or frequency controlled motors) is permitted; this time delay should not exceed the time required for the stop function of the control system.

d) S/R machines with liftable onboard control position according to 3.3 or 3.4 shall be equipped with buffers or other devices with equivalent function. The maximum deceleration of the vertical movement shall not exceed 3 g for the person(s) on the liftable onboard control position. Calculation of the maximum deceleration (3 g) has to be based on the tripping speed of the overspeed governor.

   NOTE Regarding the equivalent function see 5.5.2 together with an additional (redundant) braking system.

5.4.3 Overload and slack condition protection

5.4.3.1 Overload protection

a) Rated load equal or greater than 1 000 kg:

   Machines shall be equipped with an overload protection system when the rated load is greater than or equal to 1 000 kg.

b) Rated load less than 1 000 kg:

   Where the rated load is less than 1 000 kg, an overload protection system shall be provided:

   1) machines that are practicable to lift person(s);

   2) where there is a risk to persons e.g. due to rack collapse by the machine or breakage of suspension elements (see also 6.4.1).

If an overload condition is detected, a stop function in accordance with 5.3.7.1 shall be automatically initiated.

NOTE The manufacturer should define the setting and the testing method for the overload protection device.

5.4.3.2 Slack condition protection

Hoist units using suspension elements shall be equipped with a device to identify a slack condition that, when actuated, stops all operational movements except lifting at the slowest hoisting speed of the machine. If endless chains or belts are used, this protection is not necessary.

Provisions shall be made to prevent the restarting of the machine until the fault has been cleared by an authorised person.

5.4.4 Safety gear and overspeed governor

5.4.4.1 General

Machines with a lifting carriage, that are practicable to carry person(s) and that can be raised more than 1,5 m, other than those using self-sustaining lead-screw drives or direct acting hydraulic drives, shall be equipped with an independent working safety gear and overspeed governor.

The characteristics of the safety gear and overspeed governor shall be compatible with the relevant characteristics of the machine.

5.4.4.2 Exceptions

Safety gear is not required for machines other than those in 5.4.4.1 unless there is danger to persons.

If a person is on the lifting carriage, e. g. for fault clearing only (without any vertical movements), other means e.g. mechanical devices preventing the lifting carriage fall are allowed only if the use is safe and the lifting carriage can be secured at any height.

5.4.4.3 Operation of the safety gear

The safety gear shall operate by means of an overspeed governor at a speed not higher than 0,7 m/s or 1,4 times the rated speed, whichever is the greater.

Operation of the safety gear at a tripping speed of more than 1 m/s shall not result in an average design retardation of more than 3 g taking into account the mass of the relevant machine parts, the rated load and the operator(s).

The tensile force in the overspeed governor rope produced by the governor, when tripped, shall be at least the greater of the following two values:

a) either 300 N; or

b) twice that necessary to engage the safety gear.

The breaking load of the rope shall be at least 8 times the tensile force produced in the rope of the overspeed governor when tripped.

5.4.4.4 Function of several safety gears

When there is more than one safety gear, their actuators shall be connected (e. g. by mechanical means) to ensure they operate simultaneously.

5.4.4.5 Operation of the safety gear

Operation of the safety gear shall automatically initiate an emergency stop function in accordance with 5.3.7.

5.4.4.6 Breakage of or slackness in the overspeed governor rope or chain

Breakage of or slackness in the overspeed governor rope or chain shall be detected by a safety device. If the device is actuated, it shall automatically initiate an emergency stop function in accordance with 5.3.7.

5.4.4.7 Lead-screw drives or direct acting hydraulic drives

Safety gear is not required for hoist units using self-sustaining lead-screw drives or direct acting hydraulic drives, but equivalent safety means shall be provided. For examples, see 5.4.6.5 and 5.4.7.3.

5.4.5 Suspension elements

5.4.5.1 Wire rope

5.4.5.1.1 General

Wire rope, drum and pulley diameters shall be calculated according to ISO 4308-1. The ratio between the minimum breaking load and the maximum static force for all types of ropes shall be at least 10 for hoist units intended to carry person(s) and at least 5 for other hoist units. It is permitted to use a single rope.

5.4.5.1.2 Size, strength and construction of wire ropes

All wire ropes of one lifting unit shall be of the same size, strength and construction. If they are intended to carry persons, ropes shall be in accordance with EN 12385-4. Other ropes, not complying with the mentioned standard may be used giving the same level of safety providing that ageing, fatigue and wear can be checked on a regular basis.

5.4.5.1.3 Steel wire ropes

Steel wire ropes shall be made of at least 114 wires. The tensile strength of the wires in the rope shall not be less than 1 570 N/mm² but shall not exceed 1 960 N/mm².

5.4.5.1.4 Rope drums

Rope drums shall be provided with a single continuous spiral groove for each rope. The rope shall only be wound on in one layer, unless a special guidance system is used that prevents damage to the rope.

In lowest position of the load handling device there must remain a minimum of 2 turns of rope before the end-fixings on the drum (load handling device in the position of fully compressed buffers).

The rope has to be fixed on the drum in a way, that the connection withstands to a force 2,5 times higher than the force acting when carrying the nominal static load, calculated according to the numbers of turns remaining on the drum. The coefficient of friction has to be calculated with $\mu = 0,1$.

5.4.5.1.5 Ratio of the diameter of pulleys and drums

The ratio of the diameter, of pulleys and drums measured at the centreline of the rope, to the nominal diameter of the rope shall be at least 22 to 1.

5.4.5.1.6 Equalisation of the tension

Means shall be provided to equalise the tension of the wire rope, where more than one element is fixed to one point and its position shall be monitored. If a hazardous condition is detected, an emergency stop function (see 5.3.8) shall be initiated automatically.

5.4.5.1.7 Visual examination

Visual examination of wire ropes and wire rope terminations shall be possible without having to remove the wire ropes or having to disassemble the structural components of the machine.

5.4.5.1.8 Rope terminations

Rope terminations shall have a minimum breaking load of at least 80 % of the minimum breaking load of the rope. Wire rope grips shall not be used for rope terminations for load carrying ropes.

Only the following means shall be used for the terminations of wire ropes:

— aluminium pressed ferrules (see EN 13411-3);

— Flemish eyes (see EN 13411-3); or

— asymmetric wedge socket clevises (see EN 13411-6).

5.4.5.1.9 Prevention of unintentional displacement

Means shall be provided to prevent unintentional displacement of the rope from the rope pulleys, even under slack rope conditions.

5.4.5.1.10 Protection against falling objects

Where there is a risk of a foreign object falling between a rope and a pulley, a protection shall be installed to prevent this.

5.4.5.2 Chain

5.4.5.2.1 General

Chains shall be leaf or roller type only. Round link chains shall not be used. The ratio between the minimum breaking force and the maximum static force for all types of chains at maximum payload and additional loads for all kinds of chains shall be at least 10 for hoist units intended to carry person(s) and at least 5 for other hoist units. It is not mandatory to use more than one chain.

5.4.5.2.2 Size, strength and construction

All lifting chains of one lifting unit shall be of the same size, strength and construction.

5.4.5.2.3 Equalisation of the tension of several chains

Means shall be provided to equalise the tension of the chain, where more than one element is fixed to one point and its position shall be monitored. If a hazardous condition is detected, an emergency stop function (see 5.3.8) shall be initiated automatically.

5.4.5.2.4 Connection between the chain and chain fixing

The connection between the chain and chain fixing shall have a minimum breaking of at least 80 % of the minimum breaking load of the chain.

5.4.5.2.5 Visual examination

Visual examination of the chain and the termination shall be possible without removing the chain or having to disassemble the structural components of the machine.

5.4.5.2.6 Prevention of unintentional displacement

Means shall be provided to prevent unintentional displacement of the chain from the chain wheels or pulleys, even under slack chain conditions.

5.4.5.2.7 Protection against falling objects

Where there is a risk of a foreign object falling between a chain and sprocket or pulley, a form of protection shall be installed to prevent this.

5.4.5.3 Belt

5.4.5.3.1 General

Belts shall be suitable for the environment in which they are intended to operate and shall have steel wire reinforcement. In particular the effects of temperature, humidity and contaminants should be considered. It is permitted to use a single belt.

5.4.5.3.2 Safety factor

The minimum breaking load for a belt at maximum payload and additional loads for all kinds of belts shall be at least 5 times the maximum static load which could occur in each belt. If they are intended to carry persons, the factor of safety shall be 10.

5.4.5.3.3 Size, strength and construction

All belts of one lifting unit shall be of the same size, strength and construction.

5.4.5.3.4 Equalisation of the tension of several belts

Means shall be provided to equalise the tension of the belts, where more than one element is fixed to one point and its position shall be monitored. If a hazardous condition is detected, an emergency stop function (see 5.3.8) shall be initiated automatically.

5.4.5.3.5 End fixings

Open-ended belts shall be secured to the structure or equipment, using clamping devices. This device shall have a breaking load of 100 % of the minimum braking load of the belt.

5.4.5.3.6 Pre-tensioning, axial alignment, pulleys and end fixings

The pre-tensioning and axial alignment of each belt, the design (e. g. diameters, width, shape and material) of the drive and idler pulleys (see e. g. ISO 13050) and the design of the end fixings shall be in accordance with belt supplier's recommendations.

5.4.5.3.7 Visual examination

Visual examination of the belt and the termination shall be possible without removing the belt or having to disassemble the structural components of the machine.

5.4.5.3.8 Prevention of unintentional displacement

Means shall be provided to prevent unintentional displacement of the belt from the pulleys, even under slack belt conditions.

5.4.5.3.9 Protection against falling objects

Where there is a risk of a foreign object falling between a belt and a pulley, a protection shall be installed to prevent this.

5.4.6 Hydraulic drives

5.4.6.1 Cylinders, pipes, valves and fittings

Cylinders, pipes, valves and fittings shall withstand twice the maximum working pressure without permanent distortion or failure in accordance with EN 982.

5.4.6.2 Hoses

Hoses shall be able to withstand 4 times the maximum working pressure.

5.4.6.3 Venting

Means shall be provided for venting entrapped air from hydraulic circuits.

5.4.6.4 Pressure relief valve

A pressure relief valve shall be installed between the pump and the non-return valve and shall operate at no more than 20 % above the operating pressure.

5.4.6.5 Prevention of lowering of the onboard control position

A valve shall be connected directly to the lifting cylinder to prevent lowering of the lifting carriage in case of pipe or hose failure if they are intended to carry people.

5.4.6.6 Parts of the lifting units which enter racks

Where a part of the lifting unit enters a rack, the system shall be so designed that unintentional lowering of the lift unit shall not occur even in the event of a failure of the hydraulic system. This does not apply for leakage at the cylinder (see EN 982).

5.4.6.7 Auxiliary hoist units

For auxiliary hoist units operated by cylinders directly connected to the lifting carriage or forks, valves shall be fitted to prevent uncontrolled lowering in case of pipe or hose failure.

5.4.6.8 Cushion cylinder

The switches in 5.4.2 are not necessary if a cushion cylinder is used to prevent excessive stress.

5.4.7 Lead-screw drive

5.4.7.1 General

The ratio of the ultimate tensile stress of the material used to the design stress of the threads for lead-screws and nuts at maximum payload and additional loads for all kinds of lead-screws shall not be less than 6. A lower safety factor, but not less than 3, may be used on a machine without an elevating control position unless there is a danger to persons.

5.4.7.2 Lead-screw mechanism

The lead-screw mechanism shall be designed to prevent its separation from the lifting carriage during normal use.

5.4.7.3 Load bearing nut

Each lead-screw shall have a load bearing nut and an unloaded safety nut of the same material and size. The safety nut shall only be loaded if the load bearing nut fails. It shall not be possible to raise the lifting carriage when the safety nut is under load. The lead-screw shall have higher wear resistance than the nuts. The safety nut is not necessary if there is no danger for persons.

5.4.7.4 Inspection of the load bearing nut

It shall be possible to inspect the condition of the load bearing nut without major disassembly, for instance by measuring the clearance between the load bearing nut and the safety nut.

5.4.7.5 Lead-screw devices

Lead-screws shall be fitted with devices at both ends to prevent the load bearing and safety nuts from leaving the lead-screw.

5.4.8 Rack and pinion drives

5.4.8.1 General

The ratio of the ultimate tensile stress of the material used to the design stress of racks and pinions at maximum payload and additional loads for all kinds of rack and pinions shall not be less than 6. A lower safety factor may be used on a machine without an elevating control position unless there is a danger to persons.

5.4.8.2 Driving pinion

In addition to the normal mechanisms of the machines, positively acting devices shall also be provided that prevent the driving pinion and the pinion that operates the safety gear from becoming disengaged from the rack. These devices shall ensure that the axial movement of the pinion is limited so that at least $^2/_3$ of the tooth width remains engaged. They shall also restrict the radial movement of the pinion out of its normal combing position to a maximum of $^1/_3$ of the tooth height.

5.4.8.3 Visual examination of the pinions

Visual examination of the pinions shall be possible without the removal of the pinions or major disassembly of structural components.

5.5 Travel unit

5.5.1 Travel unit braking system

5.5.1.1 General

The machine shall be capable of being decelerated and stopped safely from the rated speed with the rated load plus operator(s) without undue shock during normal operation and in the case of an emergency (e. g. overspeed; see 5.5.5) by the following means:

a) electrical or mechanical braking system for normal operation;

b) mechanical braking system to operate automatically in the event of the power supply being interrupted in any way;

c) where machines have an onboard control position or emergency control position and an indirect rope, belt or chain drive travel unit, the braking system shall be effective also in the event of failure of the rope, belt or chain; this brake can be combined with the brake described in 5.5.1.1 b).

5.5.1.2 Additional braking system

An additional braking system is required to operate automatically in the event of failure of the normal operational braking system in the following cases when:

a) curves have to be negotiated at limited speed;

b) end stops (e. g. buffers) are designed for a speed less than 70 % of the rated speed (in this case 5.5.2 b) also applies);

c) there is a danger of collision with other machines (e.g. more than one machine is operating on the same rail) and no other means (e. g. onboard bumpers) are fitted.

The additional braking system shall be able to operate even in the event of gear failure in the travel unit.

5.5.1.3 Machines with front and rear drive units

Where on certain machines there are front and rear drive units each with a separate electrical and mechanical braking system, the addition braking system in 5.5.1.2 may be dispensed with if each braking system is capable of meeting the requirements in 5.5.1.1. It shall be possible to test each braking system individually.

5.5.1.4 Self-acting parking brake

All machines shall be equipped with a self-acting parking brake to prevent unintentional movement of the machine (e. g. during maintenance work). This brake can be combined with the brake described in 5.5.1.1 b) and 5.5.1.1 c).

5.5.2 Speed reducing system

Automatic speed reduction shall be provided in addition to that in 5.5.1.1 when a lower speed is required for safety reasons, for example in the following cases when:

a) curves have to be negotiated at limited speed;

b) end stops are not capable of stopping the machine travelling at rated speed;

c) there is a danger of collision with other machines (e. g. more than one machine is operating on the same rail) and no other means (e. g. onboard buffers) are fitted.

The function of this system shall be automatically monitored. In case of failure, the machine shall be stopped automatically.

5.5.3 Limitation of travel

The following means shall be provided to stop the machine safely at the limit of travel:

a) Buffers or other equivalent devices to absorb the energy of the travel movement. Maximum deceleration shall not exceed 10 m/s^2;

b) Operational device/function in the control circuit to stop the machine before the machine contacts the buffers. This device/function is not required if the buffer is designed for continual use and automatically monitored ensuring it returns to its initial position; travel in the direction of this buffer shall only be possible when the buffer is in its initial position;

c) In addition, an ultimate limit switch of the safety type with direct mechanical actuation. If an ultimate limit switch is actuated, an emergency stop function in accordance with 5.3.8 shall be initiated automatically. The actuator of this switch shall be independent of other switches.

   A time delay within the control function for controlled electrical drives (e. g. DC motors or frequency controlled motors) is permitted. This time delay should not exceed the time required for the stop function of the control system;

d) Means to prevent collisions which may result in injury to personnel or damage to machines when there is a danger of collision with other machines (e. g. more than one machine is operating on the same rail).

5.5.4 Anti-derailment devices

5.5.4.1 General

A device to prevent derailment, e. g. profile plate around the head of the rail, shall be fitted on the machine. This shall be effective even in the case of failure of travel wheels or guide rollers.

5.5.4.2 Rail junctions

Rail junctions shall include interlocking devices to prevent derailment.

5.5.4.3 Rail sweeps

Rail sweeps shall be provided in front of travel wheels.

5.5.4.4 Prevention from dropping

Means shall be provided to prevent the machine from dropping more than 10 mm if a travel wheel or axle fails.

5.5.5 Stability

The machine and the rails shall be designed and built in such a way that the machine will not overturn even during operation of the safety devices.

The stability factor (υ_s) is calculated as follows:

$$\upsilon_s = \frac{\sum \text{stabilising moments}}{\sum overturning\ moments} \quad (1)$$

Stabilising effects resulting from the rated load plus persons and horizontal forces due to the masses associated with the machine may only be taken into account when these actually exist under the defined load combinations. If the stability is assured by additional equipment, this equipment shall be designed for the task. In the case of anti-tipping devices (see 5.5.4.1 and 5.5.4.4) which engage rail heads; the rails, their fixings, the guides and associated parts shall be able to withstand the forces developed.

Horizontal forces due to the mass of the rated load plus persons on the machine and all parts of the machine above the lower carriage shall be multiplied by a factor to take into account the effect of oscillation. This factor shall not be used in the case of buffer impact.

Under normal working conditions, the machine shall be considered safe against overturning when the stability is $\upsilon_S \geq 1{,}5$. This shall take into account the least favourable tipping axis, the moments due to the machine itself and the rated load plus persons, the horizontal forces due to the mass, and where applicable wind loading, for each load condition under the least favourable loading combinations.

In the event of mechanical braking resulting from emergency situations arising from the operation of an emergency stop or the loss of power, v_s may be lower but shall be $\geq 1{,}1$, assuming that no effect from any anti-tipping devices is taken into account.

The factor of oscillation has to be chosen and applied according to the electrical and mechanical drive system (acceleration and deceleration). This factor is to be calculated from the greatest dynamic stress which results from the sudden change of acceleration to deceleration and vice versa and additionally the worst amplitude of the mast.

If machines without anti-tipping devices, with or without load, hit the buffers, the wheel loading shall remain positive.

5.6 Load handling devices

5.6.1 Load stability

The load handling device (e. g. forks or platforms) shall be constructed in such a way that every part of the specified load will remain in a stable position during normal operation (see also 10.4.11).

5.6.2 End stops

All movements shall be limited by mechanical means. If striking the end stops can create undue stresses in the drive system, limiting devices shall be provided in the control circuit.

5.6.3 Limitation of forces

The drive unit for extending the load handling devices shall be fitted with a friction clutch or other device to limit the drive force, and so minimise the risk of injury to persons and damage to the machine and associated storage equipment.

The racking supplier shall be advised of the kinetic energy and additional forces to be able to calculate the resulting forces.

5.6.4 Rotating devices

To restrain the load handling device when stationary, the drive unit for a rotating load handling device shall be fitted with a braking system or a gear that is self sustaining in all modes of operation (e. g. an appropriate worm gear).

5.6.5 Interlocks

Interlocks shall be provided that only allow lateral movement of the load handling device when the machine has stopped. With the load handling device extended, lifting and travelling movements shall only be possible at the slow speed intended for that purpose.

For automatic machines, interlocks (e. g. positional sensors for forks or load) shall be provided to prevent accidental contact of the load or load handling device with racks or other objects, in particular:

a) machine out of position horizontally and/or vertically;

b) load not central;

c) forks not central;

d) aperture occupied.

5.6.6 Auxiliary handling equipment

Auxiliary lifting and pulling devices shall be built in such a way that the load cannot be moved into or over the onboard control position, and in such a way that the operator is protected against falling parts of the load.

5.6.7 Load position monitoring

For automatic machines the load shall be checked for correct positioning on the load handling device before lift or travel movements take place.

5.6.8 Satellite/channel vehicles

5.6.8.1 General

Satellite/channel vehicles shall comply with the requirements of 5.5.1.1, 5.5.4.1, 5.5.4.3, 5.5.4.4, 5.6.1 to 5.6.3.

5.6.8.2 Position of the satellite vehicle

The correct position on the lifting carriage shall be monitored.

5.7 Electrical equipment

5.7.1 General

The electrical equipment for the machines shall be provided in accordance with the applicable clauses of EN 60204-32 together with the particular requirements below. Deviations are stated in the respective clauses.

NOTE Electrical equipment includes materials, fittings, devices, appliances, fixtures, apparatus and the like, used as part of, or in connection with, the electrical installation of the machine. This includes electronic equipment, the means of disconnection from the supply and all wiring on and from the machinery to the means of disconnection from the supply.

5.7.2 Electrical supply conditions

If the equipment is intended for use in electrical supply conditions outside the range of 4.3 of EN 60204-32:1998 (e. g. supply voltage outside the tolerances), then the manufacturer shall make any necessary design modifications, take any necessary safety precautions and/or state any operational restrictions in the "information for use".

5.7.3 Environment

The electrical equipment shall be selected and installed to suit the intended working environment. If the equipment is intended for use in conditions outside the range in 4.4 of EN 60204-32:1998 (e. g. ambient temperature, humidity, altitude, corrosive atmosphere) the environmental design parameters shall be stated in the information for use.

5.7.4 Supply disconnecting (isolating) device

5.7.4.1 General

In deviation from 5.3.1 of EN 60204-32:1998 the functions of disconnection and/or switching the energy supply will be made by:

a) main switch: a supply disconnecting device for each S/R machine, which also switches the fixed supply (e. g. bus-bars, festoon cables);

b) on-board switch: an additional disconnecting device on each machine having onboard control (e. g. motor starters, inverters).

5.7.4.2 Type

Main switch: The main switch shall be either type a), type c) or type d) according to 5.3.2 of EN 60204-32:1998.

On-board switch: the on-board switch shall be either type a), type b) or type c) according to 5.3.2 of EN 60204-32:1998.

5.7.4.3 Means of disconnection for maintenance areas

Where a separate maintenance or repair area is provided, it shall be possible to interrupt the power supply in the same way as in 5.7.4.1 and 5.7.4.2.

5.7.4.4 Unintended connection

An unintended connection between a live and disconnected supply line (e. g. by double current collectors across two bus-bar-sections) caused by the S/R machine or transfer device shall be prevented.

5.7.4.5 Unexpected start up, disconnection and unauthorised, inadvertent and/or mistaken connection

The requirements of 5.4, 5.5 and 5.6 of EN 60204-32:1998 apply to all devices listed in 5.7.4.1.

Devices which are not in accordance with 5.3.2 of EN 60204-32:1998 (e. g. contactors), may be used for entering an aisle, access to the machine or for undertaking minor work in accordance with 5.4 of EN 60204-32:1998.

5.7.5 Protection against electric shock

The specifications of Clause 6 of EN 60204-32:1998 shall apply.

5.7.6 Suspension of safeguarding

The requirements of 9.2.4 of EN 60204-32:1998 will be applied for maintenance, fault clearance, inspection and setting:

a) control devices for dangerous movements shall be hold-to-run devices;

b) relevant movements shall be with reduced speed;

c) emergency stop device shall be provided at the control station;

d) if the nature of the work to be done does not give space enough to escape, the travel distance of the powered movement has to be limited or the enabling devices shall be a three-position type (see 9.2.5.8 of EN 60204-32:1998).

This applies also to portable control stations (see also 5.3.5 and 5.9.3).

5.7.7 Overriding of safety functions

In deviation from 9.3.2 of EN 60204-32:1998 restart after actuation of a safety device shall only be possible in the safe (opposite) direction by using a combination of a key-operated switch and a hold-to-run control device. This applies to the following safety functions:

— ultimate travel;

— slack rope;

— overload;

— safety gear and overspeed governor.

5.8 Transfer device

5.8.1 General

The safety of the transfer device shall be ensured under all operating conditions using the applicable requirements from 5.2 through 5.7. For the environment see 5.10.

5.8.2 Retention of position

It shall only be possible to drive the machine onto or off the transfer device if the transfer device is restrained in its correct position, (e. g. by mechanical interlocking or by brakes) and monitored.

5.8.3 Movement

Movement of the transfer device shall only be possible if the machine is either fully on or fully off the transfer device.

5.8.4 Interlocking

Means shall be provided to prevent the machine from leaving the aisle in the direction of the transfer device when this is not in the correct position for transfer. In accordance with a risk assessment, devices described in 5.5.3 or the equivalent shall be provided.

The machine shall be interlocked to prevent travel in the direction of transfer unless the means of travel limitation are in a position to act as a positive stop.

5.8.5 Stability

Stability during transfer shall be ensured under all operating situations in accordance with 5.5.5.

5.9 Maintenance repair and fault clearance

5.9.1 General

The following minimum requirements shall be provided to ensure safe maintenance, repair and fault clearance.

5.9.2 Maintenance position

For this purpose, temporary or permanent means shall be available either on or off the machine.

For major maintenance work (e. g. work on brakes, gearboxes and control panels), maintenance platforms are necessary. If the floor of the platform is more than 1 m above ground level, protection against falling in the form of a guard rail in accordance with 6.2.2.4 shall be provided.

For minor maintenance work (e. g. clearance of faults in the area of the load handling devices) standing positions are sufficient. If the floor of this standing position is more than 1 m above ground level, protection against falling in the form of a safety harness with restraint lanyard is sufficient.

In all cases a safe means of access shall be provided.

Where a person may be in an on-board maintenance position while the machine is moving, additional protection in accordance with 6.3.2 shall be provided if there is a danger of crushing, shearing or trapping.

5.9.3 Emergency control position

Where other provisions are not made to facilitate the finding and clearing of faults (see 5.2), emergency control positions shall be provided from which the movements of the machine can be observed directly and controlled safely. These positions may be fixed or mobile, permanent or temporary, and situated inside or outside of the machine operating area. The positions shall include:

— means to prevent persons falling from positions raised above 1 m (e. g. handrails in accordance with Clause 7 of EN ISO 14122-3:2001), safety harness with restraint points; emergency control positions on the lifting carriage shall have a platform with minimum dimensions of 0,35 m × 0,35 m;

— means to protect persons at the emergency control position if they are at risk from falling objects from the lifting carriage (see 6.2.2.8);

— safe means of access (e. g. ladder with climb protection according to EN 363 and fixing means Class A1 of EN 795 at the transition points);

— portable or fixed control devices complying with 5.3.5, 5.3.6 and 5.3.7.

If load cannot be handled manually (e. g. loads over 50 kg), an emergency control position or at least an approval button to release the pre-selected movements shall be provided close to or at the load handling devices.

In case of machines where it is not practical to enter the load handling device (e. g. light good S/R machines/miniload machines) the machine can be controlled from the ladder; possibilities to secure the person in a manner that both hands are free for controls (e. g. via short safety belts fixed crossways around the hips and to the vertical stringers) shall be provided.

Where the emergency control position is inside the machine operating area the requirements of the key dependence system (see 5.3.4) shall apply.

5.9.4 Speed limitation

If the emergency control position has no protection, a maximum speed of 0,05 m/s in the x and y direction is permitted.

If the emergency position is equipped with guards against crushing and shearing (e. g. protection at the rack side, or an enclosure of minimum height of 1,1 m), a maximum speed of 0,5 m/s in the x and y direction is permitted.

If the emergency position is designed according to Clause 6, no speed reduction is necessary.

5.9.5 Communication

It shall be ensured that communication is possible (e. g. direct voice, telephone, two-way radio) if maintenance and repair personnel can be at a maintenance position when the machine is under control from the on-board operator's position or emergency control position.

5.9.6 Protection from operating machines (S/R machines and transfer equipment)

When repair or maintenance takes place in an area where a machine or transfer device continues to operate, means shall be provided to protect personnel from the moving machine by measures that comply with the requirements of 5.5.3 (e. g. by temporary buffers) and prevent hazards arising from the electrical supply.

Maintenance and repair personnel shall also be safeguarded against injury from a moving machine by limiting access to the danger zone by means which comply with the requirements of 5.10 (e. g. by barriers, fencing or any other suitable measures) (see 10.5.2.9).

If maintenance is performed in an area in which a machine or transfer equipment shall operate further on, measures following the requirements of 5.5.3 are necessary (e. g. with temporary buffers), to protect personnel against moving machines and prevent danger from the electrical power supply. As an alternative safe shut down devices (e. g. limit switches, light barriers, laser scanners) with an additional brake system according to 5.5.1.2 can be used.

5.9.7 Access along the mast

A ladder for access along the complete height of the mast shall be provided for all S/R machines with a height over 5 m.

Over the height of 5 m a ladder has to be fitted with a safety cage or a fall arrest system in accordance with EN 363 and Class A1 anchor points at transfer positions in accordance with EN 795.

5.10 Machine environment

5.10.1 General

The following covers specific requirements for interfaces with buildings and racks in the context of S/R machines in as much as they are relevant for machine safety.

The forces generated by the machine which are transmitted to the travel and guide rails, racking and buffers, shall be taken into account for all normal and emergency operating conditions. Taking an effective dynamic factor into account, this information shall be determined by the manufacturer of the machine and communicated to the supplier of the racking and/or building.

5.10.2 Safety clearances

Machines and transfer devices shall be manufactured and erected in such a manner that collisions of a machine, transfer device or load with fixed objects (e. g. racks or parts of the building), taking into account tolerances, deflections, vibrations, wear, etc. are prevented.

5.10.3 Safeguarding of persons (Limiting access)

5.10.3.1 General

Persons shall be safeguarded against injury from moving machines at any level by limiting access to the machine operating areas or by the provision of sensors. For a typical installation of an aisle with an access door and a rail dependent S/R machine see Figure A.3. Protection may be achieved for example by one or a combination of the following means stated in 5.10.3.2 to 5.10.3.4. The requirements of 5.10.3.5 also apply.

5.10.3.2 Enclosure, doors and/or removable panels

A perimeter enclosure in accordance with EN ISO 13857:2008, Table 1 and Table 4, but at least 2 m high.

Doors and/or removable panels in the perimeter enclosure:

a) Doors and/or removable panels shall be provided in the perimeter enclosure for access, operation, repair or maintenance.

b) Doors in the enclosure for the entrance and exit of people shall only open outwards and shall be constructed so that they can only be opened from the outside with a key, but can be opened from the inside without a key. The key for the doors shall be the same key or permanently connected to the key for the switches in 5.3.2 or 5.3.3.

c) With a door in the perimeter enclosure open, movement of the machine in the corresponding machine operating area shall be prevented. Restarting can only take place on board the machine or from the control station outside the enclosure with the door closed (see 5.3.2 and 5.3.4). Unexpected start-up shall be prevented in accordance with EN 1037.

d) Access doors to the machine more than 1 m above ground level shall be locked so as to open only when the machine is in the correct position for access.

e) Removable panels that are frequently opened or can be opened without using tools shall be built and protected the same way as doors.

5.10.3.3 Means of separation within racking

A means of separation is required to deter access from one machine operating area into an adjacent machine operating area through the racking.

No additional means of separation is required where the physical gaps through the racking are less than 0,3 m wide.

Where the physical gaps are wider than 0,3 m an additional means of separation is required. This means should take the form of a barrier at least 1,0 m above floor level and an intermediate barrier limiting the clear space to less than 0,5 m. The barrier may consist of e. g. racking members, chain, wire mesh, wire cable. It should be installed between the respective aisles (see Annex B).

5.10.3.4 Sensing devices to protect S/R machines working area

a) Off-board sensors:

These may be light barriers, motion detectors or equivalent means on the perimeter of the enclosure which when activated stop all movements of the machines in time to prevent collision between man and machine taking into consideration the stopping distance (see EN 999). Deviations from the general standard EN 999 should be justified in the risk analyses. These devices shall be automatically monitored (see Annex C). Electro-sensitive protective equipment shall comply with type 2 of EN 61496-1. To prevent access to people, at least two beams at a height of 0,4 m and 0,9 m shall be provided. To prevent danger zones being reached from outside, the arrangement of the beam(s) shall consider the type of hazard. Pressure sensitive protective devices shall comply with EN 1760 (part 1 through part 3).

b) Onboard sensors

These may be (e. g. pressure sensitive safety devices or safety devices with proximity reaction) mounted on the machine to detect persons.

1) Choice, installation and testing of bumpers shall be in accordance with EN 1760-3.

2) People detecting sensors shall fulfil the requirements of EN 61496-1.

Restarting shall only be possible by means which can be activated intentionally by an authorised person in a position from which he can observe the protected area.

Machines with on board sensors according to 5.10.3.4 b) shall be equipped with a ready warning device (e. g. a flashing light) being activated, when machines start moving.

5.10.3.5 Separation of operational areas

a) Automatic machines:

Safety devices as described in 5.10.3.4.b) shall be provided where a machine can change aisles and/or a person could move from an aisle that has been rendered safe into an unsafe area such as a transfer aisle.

b) Manual machines

See 6.2.5.

5.10.3.6 Correct entry/exit procedure

An electrical monitoring system or equivalent shall prevent operation of the machine if the correct entry/exit procedure (mode selection outside – access – mode selection inside – restart or vice versa) has not been followed (see also 5.3.2 and no. 1 of Table C.2 and Figure A.3).

5.10.4 Load entry and exit

5.10.4.1 Load transfer areas

These shall be arranged such that injury to persons due to the movement of the machine is prevented. This requirement for load transfer areas is fulfilled, if access at load entry/exit points is prevented, deterred, or the dangerous movements of the machines are stopped; examples, see Annex D.

The risk of crushing and shearing shall be taken into account in accordance with EN 349 between the pallet and the sides of the opening. If the requirements of EN 349 cannot be fulfilled due to the arrangement of rack and load transfer areas then other means should be taken into account.

If the opening is for the inward movement of pallets, the risk of crushing of the body between the pallet and the sides of the opening shall be taken into account, for example by:

— limiting the force between load unit and obstacle to less than 150 N;

— distance in accordance with EN ISO 13857;

— space of 0,5 m in accordance with EN 349;

— using lateral wings or flaps, which are flexible or which activate sensors.

Access beneath conveyors shall be prevented by limiting the height of the opening to 0,5 m. A test ball of 0,5 m diameter might not pass through.

Authorised access via an interlocked door (see 5.10.3.1) shall be made as convenient as possible to deter personnel seeking access by any other route.

5.10.4.2 Gravity systems in pallet-racking

Where loads are transferred between a machine operating area and order picking positions or input positions in an adjacent area using a gravity system, access to the machine operating area in the area of the gravity system can be prevented by fulfilling all of the following requirements:

— Length of the gravity systems shall be at least 1,2 m up to the machine operating area to separate personnel from the machine operating area (load handling device in the outer position). Falling and walking between the tracks of the gravity system shall be prevented e. g. by flexible netting in accordance with EN 1263-1 and EN 1263-2;

— Measures to deter access on top of gravity lanes shall be taken [e. g. by the arrangement of the gravity system and the shape of the side members (see Annex D, Figure D.4, "Design of Frame Surface")].

Where the above requirements are not fulfilled, access to the machine operating area shall be prevented by one of the means identified in Annex D or similar means giving equivalent safety.

5.10.5 Interaction with other equipment

Special care shall be taken for the safe transfer of the load between the machine and other equipment (e. g. conveyor, automated guided vehicle, transfer car, work station, etc.).

Where a crane with magnetic or vacuum load carrying device is used in conjunction with an S/R machine occupied by an operator, the movement of loads over the machine or control positions separate from the machine shall be prevented.

5.10.6 Escape from dangerous areas

5.10.6.1 Leaving of the aisle

It shall be possible to leave an aisle at both ends.

5.10.6.2 Leaving for emergency purposes

For emergency purposes and with the machine in its normal end position, a 0,5 m long and 2 m high clearance shall be provided at the ends of the aisles for access to the emergency exits (see Annex B, Figure B.2).

5.10.6.3 Clearances at additional equipment

Where additional equipment (e. g. conveyors) is installed at one end of an aisle, it may be acceptable to have reduced clearance where access between the equipment and the machine is normally required for maintenance only.

5.10.6.4 Escape routes which cross aisles

Escape routes which cross aisles have to be avoided, unless demanded by local authorities (e. g. fire authority). In this case such accesses shall be protected against misuse (e. g. by interlocks).

NOTE Cross aisle escape routes are very dangerous because they are difficult to protect in a proper way.

5.10.7 Protection against unintentional load movement

5.10.7.1 Automatic machines

For automatic machines, means shall be provided to prevent loads from being moved within the racking so that they protrude or fall within an aisle or an area accessible to people. Where:

a) exposure to the hazard is infrequent (e. g. for fault rectification or machine recovery not more than once per 8 hour shift per machine) appropriate means may take the form of sensing only (physical safety backstops or electromechanical devices are not mandatory).

b) exposure to the hazard is more frequent (e. g. regular stock checking, regular cleaning during operation of adjacent aisles), a higher level of protection shall be provided. This protection shall include the use of physical safety backstops or solutions with electronic sensing or electromechanical devices meeting the appropriate safety level (see Annex C).

c) unintentional load movement may cause a load to fall into a traffic area (e. g. a walkway beside an external rack face), a greater level of protections is required. Physical means (e.g. screens, nettings, physical safety backstops) or electromechanical devices shall be provided to prevent the load or parts of the load from falling into these areas.

   Either:

   1) this physical means shall have sufficient strength to retain the falling objects and may take the form of a screen. Any perforations in the screen shall be of an appropriate size to prevent the smallest objects from falling through;

   2) where all parts of the specified load form a discrete unit (e. g. storage boxes, box-pallets or containers with objects inside) a physical safety backstop may be sufficient to prevent any parts of the load from falling.

The physical means should be positioned outside the operating clearances of the machine so that it will only be contacted in the event of an error situation.

Where physical safety backstops are required, the resistance of these shall be sufficient to withstand a horizontally applied force of at least 25 % of the weight of the rated load, under the worst conditions, without permanent deformation. The above minimum indication of 25 % is just regarding the mechanical back stop.

The rack shall be designed to withstand the forces caused by the physical means (e. g. backstops) without permanent deformation.

Where physical means are to be used this shall be agreed with the racking supplier in addition with the information in 5.6.3.

5.10.7.2 Machines with on-board control position

For machines with on-board control position see 6.2.2.8.

5.10.7.3 Vibration of the rack

Unintended load movement caused by vibration of the rack shall be taken into account by the system designer.

5.10.8 Protection of work stations and traffic areas

Work stations and traffic areas (even those below floor level) endangered by lifted loads shall be safeguarded against falling loads or lifting carriages.

5.10.9 Protection against falling

Where there is a danger of falling 1 m or more from areas used for adjustment and maintenance operations (e. g. at high-level pick and deposit stations), persons shall be adequately safeguarded.

6 Additional requirements for manual operated machines

6.1 General

This clause deals with machines that are intended to be used by an onboard operator in the normal mode, e. g. for onboard picking.

6.2 Onboard control position

6.2.1 Access to and egress from the onboard control position

6.2.1.1 General

It shall be possible to enter and leave the onboard control position safely, wherever it is, in accordance with the following sub-clauses.

6.2.1.2 Fixed means

Fixed means for access and egress shall be provided in accordance with EN ISO 14122-4 (e. g. by a fixed ladder in combination with a safety cage or a fall arrest system in accordance with EN 363 and Class A1 anchor points at transfer positions in accordance with EN 795).

6.2.1.3 Means for ladder to prevent fall

In deviation with EN ISO 14122-4 means for preventing a fall shall be fitted for ladder flights of more than 5 m starting at a height no greater than 3 m.

Ladders shall be equipped with appropriate means to rest at intervals of not more than 6 m (e. g. resting places or devices to support persons securely).

6.2.1.4 Fixed access

Where a ladder is not possible and only up to a height of 5 m, it may be possible in deviation to 6.2.1.2 to provide a fixed access/egress at a defined position of the machine and/or onboard control position; so that leaving in an emergency shall be possible from all positions by using another suitable system (e. g. inertia reel).

6.2.2 Design and dimensioning of onboard control position

6.2.2.1 Ergonomic principles

Ergonomic principles shall be taken into consideration, in accordance with EN 614-1, EN 894-1 and EN 894-2.

6.2.2.2 Onboard control position

The onboard control position shall be arranged and designed so that the operator has a clear view of his/her immediate working area.

6.2.2.3 Floor of the onboard control position

The floor of the onboard control position shall be within 5° of the horizontal and slip resistant (e. g. chequer plate).

For normal operation, the floor shall be capable of withstanding at least a pressure of 1 800 N/m² and a mass of 100 kg distributed over an area of 0,16 m² at any part of the surface.

If glazing is provided for the floor, it shall be a laminated safety glass type and either of equivalent strength to the floor or be protected to a standard at least equivalent to the floor.

Where grated flooring is used, the holes or openings shall not allow a 30 mm diameter sphere to pass through. The area of each opening shall in no case exceed 900 mm².

6.2.2.4 Safeguard operator against fall

The operator shall be safeguarded against falling from the onboard control position. For this purpose, the position shall be surrounded by guards consisting at least of a guard rail, according to Clause 7 of EN ISO 14122-3:2001 or equivalent protection.

Where picking tables are used as guards, a height of 0,9 m is sufficient.

To facilitate picking the height of the guard may be reduced to 0,9 m.

6.2.2.5 Guards in protected areas

Guards at the sides of the onboard control position are not necessary if the sides of the aisles in which the machine is working will prevent the fall of persons and the machine can only leave the protected area when the floor of the onboard control position is less than 1 m above ground level.

6.2.2.6 Permanent fixed guards

Guards for preventing falls shall be permanently fixed to the onboard control position. Hinged or sliding guard rails shall be interlocked to prevent any movement of the machine when the guard rails are not fully closed, if the floor of the onboard control position can be raised to more than 1,5 m above ground level.

6.2.2.7 Doors

Doors or gates leading into the onboard control position shall not open outwards or downwards. The doors or gates shall be interlocked to prevent any movement of the machine when any door or gate is open.

6.2.2.8 Overhead protection

Overhead protection shall be provided for the operator in the onboard control position. It shall protect the operator at all times during the travelling and hoisting movements of the machine.

This protection shall depend on the mass of the objects likely to fall and the practicality of providing protection against such masses without causing shocks or undue deformation. However, it shall be capable of withstanding a mass of 100 kg distributed over an area of 0,16 m² at any part of its surface without causing any permanent deformation, and be able to prevent small objects from passing though (e.g. nuts and bolts etc.).

6.2.2.9 Structure

Structural parts of the onboard control position shall be non-combustible, and any furnishings shall be difficult to ignite.

6.2.2.10 Safety glass

If glass is used for the onboard control position it shall be of the laminated safety glass type.

6.2.3 Warning and communication equipment

The onboard control position shall be fitted with a distinctive warning device to attract attention (e. g. a horn).

NOTE The onboard control position may be fitted with a system for external communication where direct communication is impossible.

6.2.4 Lighting

6.2.4.1 Onboard control position

The onboard control position and adjacent areas shall have sufficient lighting for the operator to do his work safely.

6.2.4.2 Protection

The lighting system shall be protected from shocks and risk of falling; particular care shall be taken to prevent any fragments from shattered lamps from falling on persons.

6.2.4.3 Emergency lighting

Emergency lighting (e. g., emergency aisle lighting, a torch) shall be provided to enable the operator to leave the onboard control position safely.

6.2.5 Separation of operational areas

Where a machine can change aisles and a person can move from an aisle that has been rendered safe into an unsafe area such as a transfer aisle, an automatic audible and/or visible warning signal shall be provided.

6.3 Control equipment

6.3.1 Mode switch on machine

One of the mode switches in 5.3.3 shall be positioned on the machine.

6.3.2 Safeguard of the operator

Means shall be provided to safeguard the operator(s) against injuries due to contact with objects outside of the onboard control position during movement of the machine.

NOTE Especially it should not be attractive to reach dangerous places until the S/R machine comes to a complete stop (e. g. to pick during positioning).

For this purpose, the onboard control position may be fully enclosed.

Alternatively, two-hand-control of type IIIA according to EN 574 and/or means giving equivalent safety may be used, provided that no part of the body is endangered when the operator is in the correct posture within his range of movement in his driving position. Any additional person on board the machine shall be similarly protected.

6.4 Hoist unit

6.4.1 Overload protection

When an elevating onboard control position is used in conjunction with a lateral handling device, the machine shall be equipped with an appropriate overload protection system which recognises an overload condition in relation to the forces resulting from the working load in the suspension elements, even when the mass of the load is controlled. If actuated all lifting movements shall stop (see 5.4.3.1).

6.4.2 Suspension protection

See 5.4.3.2.

6.5 Acceleration and deceleration

Under normal operating conditions (including emergency stop to category 1 according to 9.2.2 of EN 60204-32:1998) maximum permitted acceleration and deceleration shall be less than 1,5 m/s^2 in the horizontal direction and less than 2,5 m/s^2 in the vertical direction.

Means shall be provided to prevent the operator from losing his balance due to acceleration or deceleration (e.g. handholds or seats).

6.6 Protection of operators in an aisle containing two or more manually operated machines

Means shall be provided to stop any machine in an aisle that can contact an operator when he is going to or leaving his machine via a danger area (space between two machines).

7 Particular requirements for machines without an on-board operator

7.1 General

This clause deals with automatic machines without any onboard control position, e. g. light goods S/R machines (miniload machines).

7.2 External control position (control desk)

Means shall be provided to safeguard the operators against injuries due to contact with objects close to the external control position which can be moving in relation to the operator (see also 5.10.8).

7.3 Control equipment

7.3.1 Mode switch

The mode switch in 5.3.3 and the switch to start operation of the machine at the main control station shall be positioned outside the machine operating area.

7.3.2 Emergency stop equipment

For fully automatic machines, one or more emergency stop devices shall be provided (see 5.3.8.2). Starting of the machine shall only be possible from the main control station after the emergency stopping device has been reset at the location where it was actuated (see 4.1.6 of EN ISO 13850:2008).

7.4 Hoist unit

7.4.1 Limitation of the lifting and lowering movement

System which prevents overloading of the hoist unit may be used in place of the switches in 5.4.2 a) to c).

7.4.2 Slack condition protection

See 5.4.3.2

7.4.3 Lead-screw drives

The safety nut, on hoist units with lead-screw drive, is not required unless there is a danger to persons (see 5.4.7.3).

7.5 Load handling devices

See 5.10.7.1

7.6 Escape

When it is not possible that people go to the other side of the S/R machine inside the rack (gap smaller than 0,3 m), it is allowed to have only one exit on the access side.

8 Installation

8.1 Erection and dismantling on site

8.1.1 Necessary information

The necessary information on the correct assembly sequence, the mass of sub-assemblies and other relevant information in the form of a method statement for a safe system of work shall be provided.

8.1.2 Personnel

Erection, dismantling and disposal work shall be performed by personnel who have been specially trained for that purpose and made aware of the hazards involved. The work shall be supervised by a responsible person.

8.1.3 Tools and protection

Personnel shall be provided with the necessary tools, personal protection equipment and ancillary equipment, e.g. access and lifting.

8.1.4 Deviations

Due to site conditions, it may be necessary to deviate from the method statement. Such deviations shall be established by the responsible person and communicated in writing to the personnel involved as a modified revised statement prior to carrying out the work.

8.2 Commissioning

8.2.1 Method statement

A method statement including information necessary for the commissioning sequence shall be provided.

8.2.2 Instructions

An instruction manual including any necessary technical (e. g. mechanical and electrical) information shall be provided.

8.2.3 Training

Commissioning shall be performed by personnel who have been specially trained for that purpose and made aware of the hazards involved. The work shall be supervised by a responsible person.

8.2.4 Safety devices

The responsible person shall ascertain that the relevant safety devices and systems are fitted and operational before commissioning proceeds.

8.2.5 Individual elements of the machine

Commissioning of individual elements of the machine shall be undertaken in accordance with the technical information supplied by the manufacturer.

8.2.6 Integrated commissioning

Integrated commissioning shall proceed in accordance with the method statement for a safe system of work.

9 Verification of safety requirements and/or measures

NOTE Verification list, see Annex E.

9.1 Examination

9.1.1 General

The machine shall be examined before being used for the first time.

Examination shall ensure that specifications for the construction and equipment as well as general rules on the state of the art have been followed. It consists of design verification, verification of conformity and acceptance testing.

a) Design verification covers the verification of design and manufacturing documentation.

b) Verification of conformity assures that the equipment has been manufactured in conformity with design specifications and proper workmanship.

c) Acceptance testing covers testing under load, a test of the efficacy of safety devices, a check on proper assembly and installation as well as a verification of completeness and correctness of entries in the manufacturer's documentation. The test shall be carried out in such a way as not to endanger persons.

9.1.2 Movements to be done

All movements, for which the installation has been designed, shall be carried out with appropriate care with the test load in those positions which are most unfavourable in terms of stress on the equipment. In this test any next movement shall be started only after all vibrations and oscillations from prior movements have ceased.

9.1.3 Test of the safety gear

If the safety gear (including overspeed governor) is tested in accordance with EN 81-1, the test shall be carried out by intentionally triggering the overspeed governor with the rated load plus the mass of the operator(s) (75 kg each) plus the mass of the relevant parts of the machine at not less than the rated speed of operation.

Otherwise it shall be subject to a free fall test carried out by the manufacturer with the above stated load.

The only deviation from Annex F of EN 81-1:1998 is that the average deceleration γ shall be maximum 3 g.

9.1.4 Verification of the mechanical limits of travel

Evidence (e. g. calculation or simulation) shall be provided that the mechanical limits of travel (buffer or equivalent means including fixings) satisfy the safety requirements in 5.5. The machine shall be run against the buffers only in exceptional circumstances if no other evidence is provided.

9.2 Written record

Written records shall be kept of the results of the examination, including:

— positive means for identification of the machine;

— extent of examination with an indication of further examinations required;

— result of examination indicating the defects found;

— assessment of the effect of the examination on commissioning or continued operation of the equipment;

— name, date and signature of the examining person.

9.3 EMC

Compliance with the EMC requirements of 5.3.9 above shall be checked by carrying out preliminary testing and function testing. If testing of the completed machine is not reasonably practicable due to the size of the machine, the manufacturer shall verify that all appropriate equipment sub-assemblies comply with requirements of 5.3.9. The manufacturer shall also verify that these sub-assemblies are suitably installed and wired to minimise the effects of disturbances on the equipment and in accordance with any recommendations of the supplier(s) of the sub-assemblies.

9.4 Noise

9.4.1 General

The efficiency of technical measures taken at the design stage to reduce noise shall be verified by measuring the A-weighted emission sound pressure level as described below.

9.4.2 Noise measurement

9.4.2.1 General

After the warehouse is in full operation (rails are smooth and the rack is at least 25 % loaded) the A-weighted emission sound pressure level shall be measured in accordance with EN ISO 11202 under the following conditions:

9.4.2.2 Fully automatic machines without work stations

— Measuring place: At a distance of 1 m form the surface of the machine (or the nearest practicable place where people can be exposed) and a height of 1,60 m from the floor or access platform;

— Measurement shall last for a complete travelling and lifting cycle, incorporating the maximum travelling and lifting speeds simultaneously.

9.4.2.3 All types of machines with off-board operator and work stations

— Measuring place: At the work stations with the highest noise levels and at the least favourable conditions;

— Measurement shall last for three continuous complete cycles with full speed and nominal load.

9.4.2.4 Machines with on-board operator

— Measuring place: On-board at the operator's position;

— Measurement shall last for three continuous complete cycles with full speed and nominal load.

9.4.3 Declaration

The noise declaration shall be made in accordance with Annex A of EN ISO 4871:1996. It shall be a dual-number (dual value) declaration: Measured value of the A-weighted emission sound pressure level determined according to the method specified in 9.5 and value of the associated uncertainty K_A. K_A shall be taken equal to 4 dB.

The noise declaration shall refer to this standard and shall stipulate the maximum travelling and lifting speeds.

NOTE Information on noise emission should also be provided in the sales literature.

9.5 Load tests

9.5.1 Test load

The test load shall be suitable for the load handling device, and the weight verifiable to +/- 2 % (e. g. by provision of test weights or by use of a calibrated scale). Test load is the rated load plus additional load (e.g. a person) multiplied by 1,25 for the static test and 1,1 for the dynamic test.

9.5.2 Static load test

With the load carriage at its lowest position but still suspended by the suspension elements, the test load shall be placed on it for a period of 5 min.

After the test period, suspension elements, fixings and pulleys or chain wheels shall be checked for damage or permanent deformation.

In general two tests are required to check for unacceptable permanent deformation. Only the results of the second test are valid.

If no problems are found, the test will be deemed acceptable.

9.5.3 Dynamic load test

After successfully completing the static load test, the test load shall be reduced as required.

The machine shall be exercised in all directions separately, and in the X and Y direction simultaneously up to maximum speed (i. e. under the least favourable conditions).

The machine and safety features shall be observed for correct operation and function. Any unexpected behaviour, noise or vibration shall be investigated.

If no problems are found, the test will be deemed acceptable.

9.5.4 Load test record

The results of the test shall be documented.

10 Information for use

10.1 General

Information for use of the machine shall be provided in accordance with 6.5 of EN ISO 12100-2:2003 and include the following specific information.

10.2 Instruction handbook

10.2.1 General

An instruction handbook shall be provided including at least the following information.

10.2.2 Operation and use

All necessary information for the safe operation and use of the machine and its associated equipment, including requirements and limitations of the specified load, in accordance with 10.4.

10.2.3 Maintenance, repair and fault-clearing

Information for safe maintenance, repair and fault-clearing of the machine and its associated equipment, in accordance with 10.5.

EXAMPLES for safe fault-clearing: Actuated freefall brake, broken pallet in the rack, blocked load handling device on a certain height.

10.2.4 Spare parts

A list of spare parts including their specification, especially if affecting the health and safety of operators.

For wearing parts the approximate frequency and/or conditions for the replacement.

10.2.5 Certification of suspension elements

A certificate of the supplier of the suspension elements shall define the minimum breaking load.

10.2.6 Noise declaration

The noise level and conditions of measurement in accordance with 9.4 shall be stated.

10.2.7 Test report

A test report detailing the static and dynamic tests carried out by the manufacturer or his authorised representative shall be provided.

10.3 Minimum markings

10.3.1 Identification plate

Each machine shall be provided with a durable and legible identification plate including at least the following information:

— business name and full address of the manufacturer and, where applicable, his authorised representative;

— designation of the machinery;

— designation of series or type;

— serial number, if any;

— the year of construction, that is the year in which the manufacturing process is completed;

— rated load (excluding persons);

— number of persons and maximum load permitted to travel on the machine.

10.3.2 Carrying capacity

The rated load and the number of persons permitted to travel on the machine shall be marked so as to be clearly visible on the machine and to the operator.

10.3.3 Operating instructions

Instructions relevant to the operation in accordance with 10.4 shall be displayed at the control position.

10.3.4 Warning signs

To draw attention to particular risks, warning signs in the form of texts and/or pictograms shall be provided, e. g.:

— "Only authorised persons may operate or ride on this machine"; or

— "Access for authorised persons only".

10.4 Conditions for the safe operation of equipment

10.4.1 General

To ensure the proper and safe operation of the machine and if necessary of special devices, the manufacturer shall state in the instruction handbook that the operating requirements stated therein shall be complied with by the user. At least the following operating requirements shall be included:

10.4.2 Intended use

An S/R machine shall be used only for the purpose for which it was originally intended.

10.4.3 Operator

An S/R machine shall only be driven by competent persons, of at least 18 years of age, who have been trained and expressly charged in writing with driving the machine by the user or his authorised representative. This minimum age requirement does not apply when the person is supervised during training.

10.4.4 Number of persons onboard

The number of persons permitted to travel on the machine shall not exceed the maximum number specified by the manufacturer on the identification plate. It is not permitted for unauthorised persons to travel on the machine.

10.4.5 Behaviour in case of failures

In case of recognition of a malfunction or indication of a failure the machine shall not be used until the defect is rectified. All faults shall be notified immediately and the nature of the fault recorded in a fault book or similar record log.

10.4.6 Checking the aisle

Before travelling down a racking aisle, the operator shall make certain that nobody is in the aisle and the aisle is free from obstacles.

10.4.7 Access to the aisles

It is not permitted for unauthorised persons to enter the racking aisle and its approach areas, nor for persons to use it for access to other areas.

Entry to these zones shall be restricted to specially authorised persons who have been properly informed of and use measures provided for their safety.

Each person entering a machine operating area through an open door shall ensure that the main isolator remains disconnected by means of a personal locking device such as a padlock or an equivalent device.

If a person is in a machine operating area he should retain control of the operating key at all times (see 5.3.4).

10.4.8 Permit to work system

Where work can take place in an area adjacent to a machine operating area (e. g. order picking lanes, conveyor load entry/exit points), in addition to technical safety measures a permit to work system shall be used. The permit to work system shall ensure the following:

a) only persons authorised by name in writing to perform specific tasks are permitted to work in the area;

b) authorisation shall only be given to such persons after they have been given the appropriate and relevant training;

c) such training shall ensure that persons understand the following:

   1) nature of the hazards that can arise if the machine operating area beyond the picking face is entered;

   2) precautions to be taken to avoid such hazards;

   3) separate and additional procedures to be followed if it is necessary to enter the machine operating area.

10.4.9 Proper working safety devices

Safety devices for the machine and the machine operating area shall not be rendered inoperable or misused.

10.4.10 Maximum permissible load

The maximum permissible loading of the machine shall not be exceeded.

10.4.11 Load

The load shall be arranged on the load handling device so that it is not possible for it to move about or to drop off during normal operation. Arrangement of the load shall ensure that no part of it extends beyond the extremities of the load profile.

10.4.12 Free travel area

Goods shall be stored in the racking so that they do not project into the machine travel area.

10.4.13 Safe key procedure

On manually controlled machines the operator, when leaving/joining the machine, shall prevent it being used without authorisation by removing the key from the key-operated switch and keeping it.

10.4.14 Only one key

In the case of fully automatic installations, only one key (or set of keys, see 5.3.4) shall be available for use. If it is necessary that more than one person has to go inside the dangerous zone and on the lifting carriage, the person with the key is responsible for all persons.

10.4.15 Entering the onboard control position

In normal operation, the operator shall only enter or leave the onboard control position when the machine is in the position provided for this purpose.

10.4.16 Emergency

In case of emergency, all personnel shall leave the machine immediately using the escape facilities provided.

10.4.17 Emergency procedures

Persons authorised to use the machine shall practice during initial training and periodically, at least once a year, emergency procedures including using the escape routes.

10.4.18 Defective load

If loads are faulty or badly packed or if the load make up accessory (e. g. pallet) is faulty, the load units shall not be stored.

10.4.19 Safe leaving of the machine

Personnel shall leave the machine only where and when it is safe to do so.

10.4.20 Person on the load handling device

No person is permitted on the load handling device unless it is specially designed and intended for that purpose.

10.4.21 Regular testing

The user shall ensure that all tests required are carried out at the specified intervals.

Significant faults and defects discovered shall be corrected immediately.

10.5 Maintenance, inspection and testing

10.5.1 General

In order to ensure proper and safe maintenance and to ensure inspection and testing of the machine and if necessary special devices, the manufacturer shall state in the instruction handbook that the information on maintenance, inspection and testing contained therein shall be complied with by the user. Where applicable, the information shall include, but not be limited to, the following.

10.5.2 Maintenance

10.5.2.1 Regular intervals

Maintenance work shall be carried out at regular intervals in accordance with the manufacturer's documentation. Existing regulations and safety requirements shall be observed.

10.5.2.2 Safe maintenance

Maintenance shall be carried out safely and so as to ensure safe functioning of the machine between maintenance intervals.

10.5.2.3 Maintenance staff

Maintenance shall be carried out by a staff that is fully acquainted with the machine and the warehouse equipment. This standard, the instructions and valid general safety requirements shall be observed.

10.5.2.4 Records

Maintenance records shall be kept.

10.5.2.5 Main isolator

Before maintenance work commences, the main isolator shall be switched off and locked (see 5.7.4). The key shall be kept in a safe place.

10.5.2.6 Avoid electric hazards

If for such work it is necessary to switch on the electric power to move the machine, appropriate measures shall be taken to avoid hazards to persons (see 5.9.6).

10.5.2.7 Safe working

Work shall be carried out from safe positions. If it is not possible to perform work from such positions, staff shall be protected by other temporary measures (e. g. by the use of the safety harness, blocking the movement of the hoist unit).

10.5.2.8 Damage found during maintenance work

Defects or damage found during maintenance work shall be corrected immediately or reported for repair. In the event of an obvious hazard for the operator or the machine, the equipment shall be stopped immediately; the machine shall not be started again before the defect has been repaired.

10.5.2.9 Two or more machines on one rail

In the case of two or more machines running on one rail, it shall be ensured that the personnel performing the work is not exposed to any danger from the other machine(s) still in operation. Where possible the machine to be serviced shall be moved to a separate secure area. If the machine cannot be moved, procedures shall be implemented to protect the personnel working on this machine from the operating machines (see 5.9.6).

10.5.2.10 Machine recovery

When any of the safety devices in 5.3.7, 5.4.3, 5.4.4, 5.5.1.2 and 5.5.3.c) have been activated, provisions shall be made to ensure that the cause of activation has been rectified and the safety device has been correctly reinstated before normal operation is resumed. The correct machine recovery procedure shall be described in the instruction handbook (see 10.2.2).

10.5.3 Periodic maintenance and testing

10.5.3.1 Minimum maintenance

Machines shall be maintained as to their operational safety in accordance with the instruction handbook but at least once a year. This periodic maintenance shall be carried out by persons authorised and trained for this duty.

The periodic maintenance shall include a visual inspection, a functional test at rated load and additional load (e. g. operator) of the condition of structural components and the machine, a verification of completeness and the correct functioning of all safety devices. The functioning of the overspeed governor shall be tested by manual triggering. This may be done with the safety gear uncoupled.

10.5.3.2 Test after works

Machines shall also be tested after major repairs (e. g. repairs on structural components by welding) and conversion work. The extent of testing required is determined by the extent of repair or conversion work to be done.

10.5.3.3 Written records

Written records shall be kept of the results of all inspections and maintenance. These records shall contain the findings of the first and of the subsequent periodic inspections together with those of tests after major repair and conversion work and, if applicable, certificates of type approval and of testing done during manufacturing.

The records shall include the information in 9.3 except that the name and signature shall be of both the authorised person and the responsible user of the equipment.

10.5.3.4 Date of next inspection

The date of the next inspection shall be displayed in a clearly visible manner in the control position. In the case of a machine without an onboard control position the inspection date must be displayed in a clearly visible place near the machine.

10.5.3.5 Limited lifetime components

Safety components that are designed with a limited service life shall be examined by a competent person at the end of the period fixed by the manufacturer to determine the effects of wear and tear on the continued safe use of the machine. Depending on the result of this examination, the components shall be assessed for continued use, repair or replacement.

Annex A
(informative)

Illustration of types of machines and transfer equipment

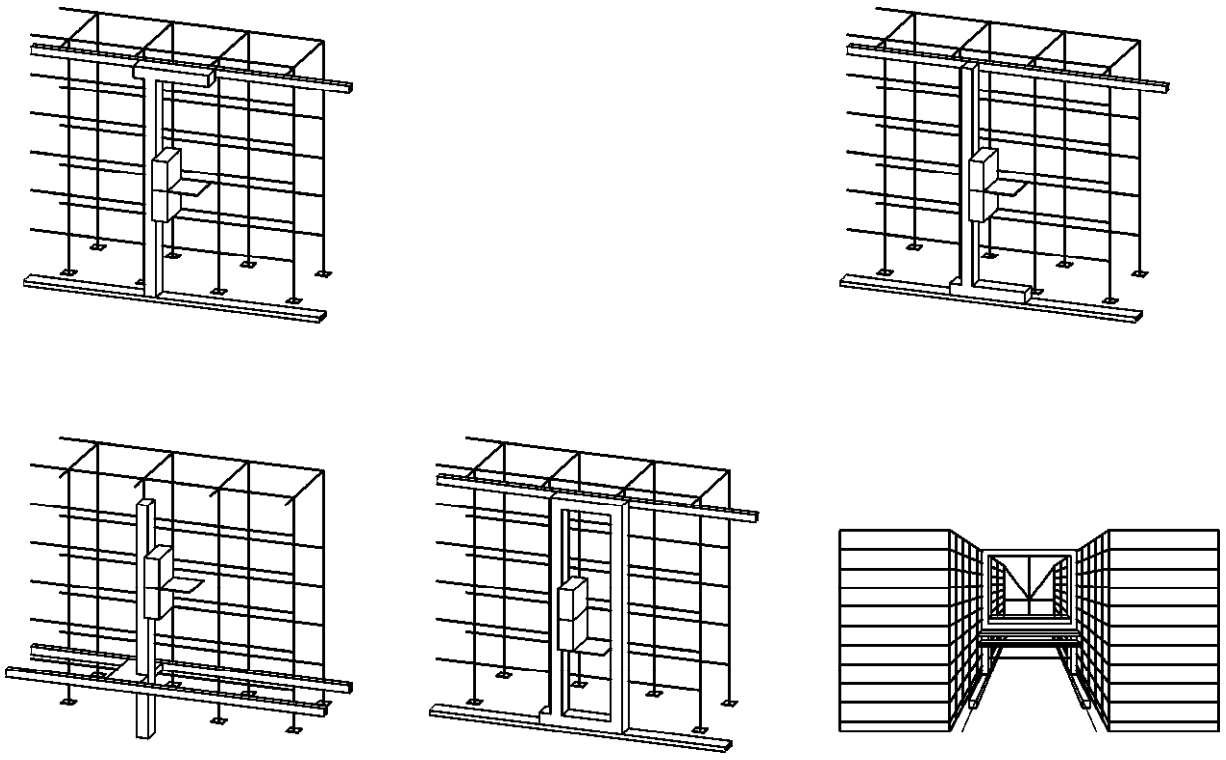


Figure A.1 — Examples of rail dependent storage and retrieval equipment

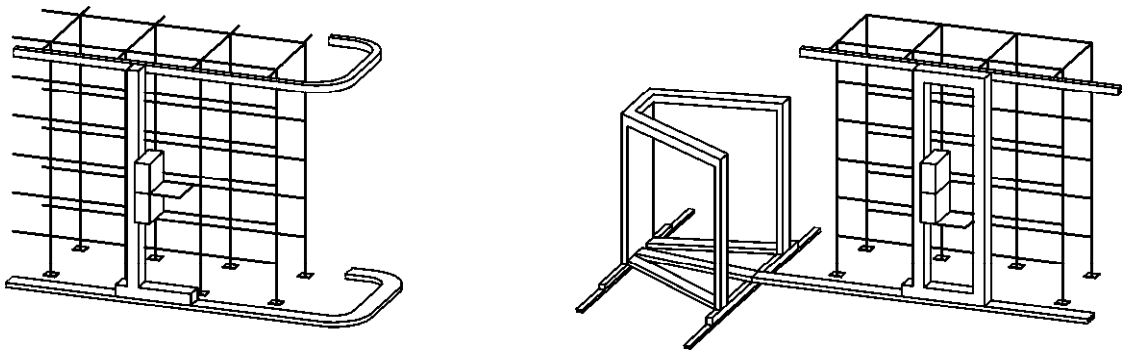
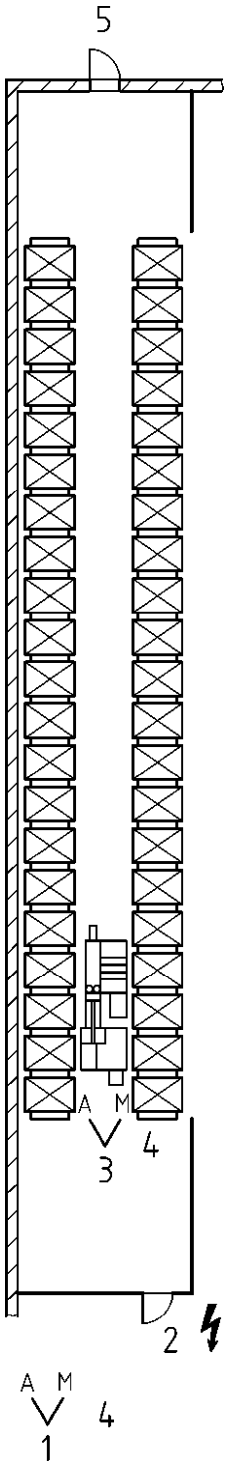


Figure A.2 — Examples of transfer equipment



Key

1 mode switch AUTOMATIC/MANUAL, key possible to remove only in manual mode

2 door that can be opened only with key from the outside and always from the inside; the door is electrically monitored

3 mode switch at S/R machine with the positions AUTOMATIC/MANUAL; key that can be removed only in position AUTOMATIC (preselection of automatic mode)

4 start device (e. g. start push button)

5 escape door, electrical monitored.

A automatic mode

M manual mode

Step control:

A) go in for manual drive – return for automatic

1 / 2 / 3 / 4 – 3 / 2 / 1 / 4

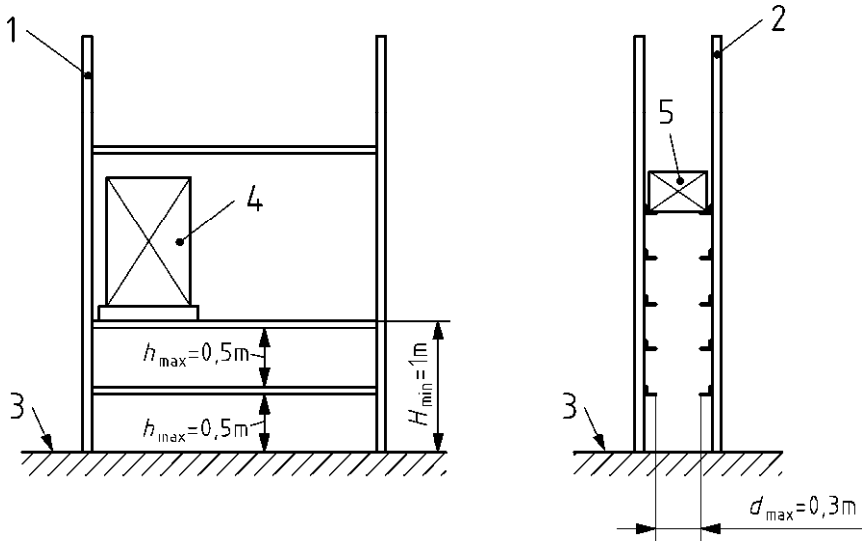
B) go in e.g. for maintenance – return out for automatic

1 / 2 – 2 / 1 / 4

Figure A.3 — Key dependent concept for automatic S/R machines

Annex B
(informative)

Means of separation within racking



Key
1 pallet rack
2 miniload rack
3 floor level
4 pallet in a rack
5 bin in a rack

Figure B.1 — Means of separation with racking (see 5.10.3.3)

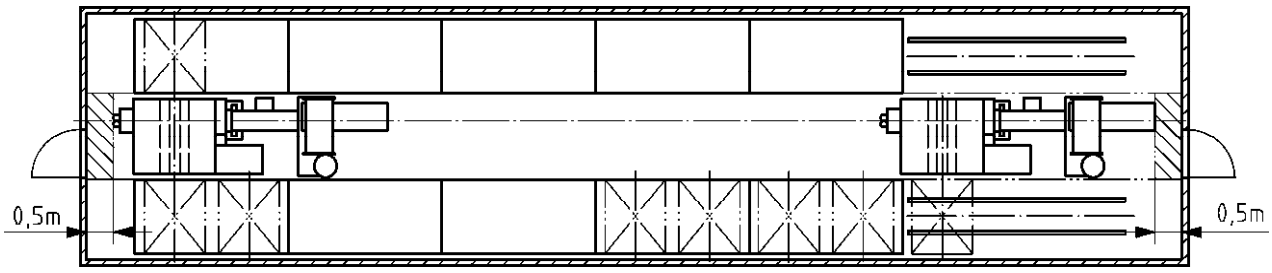


Figure B.2 — Leaving for emergency purposes

Annex C
(normative)

Safety levels according to EN ISO 13849-1

This normative annex has been prepared under the following assumption:

— risk assessment was carried out using the risk graph of Annex A of EN ISO 13849-1:2008;

— performance levels for motors, brakes and structural elements (e. g. limit stops) are not considered;

— performance levels reflect the state of the art.

Table C.1 — Performance levels at the level of safety related parts

The performance levels apply to safety related parts not to safety related functions as given in the relevant clauses of this standard unless otherwise stated; performance level in case of exception: see remarks.

Safety related parts	**Clause EN 528**	**Performance level**	**Remarks**
Prevention of unauthorised operation (equipment switch)	5.3.2	c	
Changing mode of operation (mode switch)	5.3.3	c	For safe access to the machine operating area, 5.3.4 also applies (see also Table C.2).
Start device	5.3.3	c	
Control devices for powered movements	5.3.5	b/c	Performance level shall be reached according to 5.3.7.
Hoist unit brake	5.4.1.1	c	Performance level c relates to the brake contactor.
Limitation of the lifting and lowering movement – Preliminary devices	5.4.2 a)	b	See also Table C.2.
Limitation of the lifting and lowering movement – Control for correct direction	5.4.2 b)	b	See also Table C.2.
Limitation of the lifting and lowering movement – Ultimate limit switches	5.4.2 c)	c	See also Table C.2.
Limitation of the lifting and lowering movement – Buffers or other equivalent devices	5.4.2 d)	-(d)	Performance level d applies, if no suitable buffer to absorb the energy of the lifting movement is used.
Overload protection	5.4.3.1	c	
Slack condition protection	5.4.3.2	c	.
Operation of the safety gear – Monitoring of the safety gear	5.4.4.5	c (b)	Performance level b where additional measures are included (e.g. free wheel device in case of chain drive) on hoist unit which do not effect safety

Table C.1 *(continued)*

Safety related parts	**Clause EN 528**	**Performance level**	**Remarks**
Breakage of or slackness in the overspeed governor rope or chain Monitoring of the drive for the overspeed governor	5.4.4.6	c	
Lead-screw drives or direct acting hydraulic drives Safety gear and overspeed governor	5.4.4.7	c	
Equalisation of the tension – Monitoring the suspension of the elements	5.4.5.1.6 5.4.5.2.3 5.4.5.3.4	b	
Hydraulic drives – Pressure relief valve	5.4.6.4	c	
Hydraulic drives – Unintentional lowering	5.4.6.5 5.4.6.6	c	
Hydraulic drives – Valves of the auxiliary hoist unit	5.4.6.7	c	
Lead-screw drive – Monitoring the safety nut	5.4.7.3	c	
Travel unit braking system – Braking system for normal operation	5.5.1.1 a)	b	
Travel unit braking system – Mechanical braking system	5.5.1.1 b)	c	Performance level c relates to the brake contactor.
Travel unit braking system – Additional braking system	5.5.1.2	c	Performance level c relates to the brake contactor (see also Table C.2).
Speed reducing system	5.5.2	d	
Limitation of travel – Buffers or other equivalent devices	5.5.3 a)	- (d)	Performance level d applies, if no suitable buffer to absorb the energy of the travel movement is used (see also Table C.2)!
Limitation of travel – Operational device to interrupt the power supply	5.5.3 b)	b	
Limitation of travel – Monitoring of the buffer	5.5.3 b)	c	
Limitation of travel – Ultimate limit switch	5.5.3 c)	c	
Limitation of travel – Means to prevent collisions	5.5.3 d)	d	
Anti-derailment devices	5.5.4.1	d	Performance level d applies only when the derailing is not prevented by purely mechanical devices.

Table C.1 *(continued)*

Safety related parts	**Clause EN 528**	**Performance level**	**Remarks**
Anti-derailment devices – Interlocking devices	5.5.4.2	d	Performance level d applies only when the derailing is not prevented by purely mechanical devices.
Load handling devices – End stops	5.6.2	b	Performance level b applies only to the additional limiting devices.
Load handling devices – Limitation of forces	5.6.3	b	Performance level b applies only to the other limiting devices.
Load handling devices – Rotating devices – Braking system	5.6.4	c	Performance level c applies to the brake contactor.
Load handling devices – Satellite vehicles – Position monitoring	5.6.8.2	b	Performance level b applies to all the different field devices. However, a higher safety level shall be reached by the interlocks, sequence control and plausibility checks within the control system (e.g. PLC).
Supply disconnecting (isolating) device – a) main switch b) on-board switch	5.7.4.1	c	
Means of disconnection for maintenance areas – Maintenance area isolator	5.7.4.3	c	
Unintended connection	5.7.4.4	c	Performance level c applies to the electrical components.
Unexpected start up, disconnection and unauthorised, inadvertent and/or mistaken connection	5.7.4.5	c	Performance level c applies to the electrical components.
Suspension of safeguarding — Hold to run devices	5.7.6 a)	b	Performance level b applies to all the different field devices. However, a higher safety level shall be reached by the sequence control and plausibility checks within the control system (e.g. PLC).
Suspension of safeguarding — Reduced speed	5.7.6 b)	d (b)	Performance level b applies only to all the different field devices.
Suspension of safeguarding — Emergency stop device	5.7.6 c)	c	
Suspension of safeguarding — Limited space to escape	5.7.6 d)	d (c)	Performance level c applies to the three position enabling device. Performance level d applies to the control system.

Table C.1 *(continued)*

Safety related parts	**Clause EN 528**	**Performance level**	**Remarks**
Overriding of safety functions Key-operated switch Hold-to-run control device	5.7.7	 c b	
Transfer device – Retention of position	5.8.2	d	
Transfer device – Movement	5.8.3	d	
Transfer device – Interlocking	5.8.4	d	Where a mechanical solution is used the requirements given in clauses 5.5.1, 5.5.2 and 5.5.3 shall be taken into account.
Maintenance and repair – Speed limitation	5.9.4	b	Hold-to-run control and emergency stop shall be included at the emergency control position.
Maintenance and repair – Protection from operating machines	5.9.6	 c	.
Machine environment – Safeguarding of persons (limiting access)	5.10.3	b	Performance level b only applies to electrical warning means.
Machine environment – Enclosure, doors and/or removable panels	5.10.3.2 c)	c	
Machine environment – Enclosure, doors and/or removable panels – Interlock of the access door more than 1 m above ground level	5.10.3.2 d)	c	Performance level c applies to the additional locking device.
Machine environment – Enclosure, doors and/or removable panels – Interlock of movable panels	5.10.3.2 e)	c	
Machine environment – Sensing devices to protect S/R machines working area	5.10.3.4	d	Performance level d only applies for the sensing devices.
Machine environment – Separation of operational areas	5.10.3.5	c	
Machine environment – Load entry and exit – Load transfer areas	5.10.4.1	c	
Machine environment – Load entry and exit – Gravity systems	5.10.4.2	c	
Machine environment – Interaction with other equipment	5.10.5	d	Applies to the control of the S/R machine.

Table C.1 *(continued)*

Safety related parts	**Clause EN 528**	**Performance level**	**Remarks**
Machine environment – Escape from dangerous areas Escape routes which cross aisles	5.10.6.4	Not defined	Escape routes which cross aisles are not permitted. If local authorities require escape routes which cross the aisles the safety measures and the appropriate safety performance levels shall be defined together with them. The requirements of 5.10.2 should be considered as minimum requirements.
Machines with onboard operator – Onboard control position – Design and dimensioning of onboard control position – Interlock of guards preventing falls	6.2.2.6	c	
Machines with onboard operator – Onboard control position – Design and dimensioning of onboard control position – Interlock of doors or gates leading into the control position	6.2.2.7	c	
Machines with onboard operator – Separation of operational areas	6.2.5	c	
Machines with onboard operator – Control equipment – Two hand controls	6.3.2	c	
Machines with onboard operator – Hoist unit – Overload protection	6.4.1	c	
Machines with onboard operator – Hoist unit – Slack condition protection	6.4.2	c	
Machines without onboard operator – Control equipment – Emergency stop equipment	7.3.2	c (d/e)	If single electronic devices (e.g. emergency stop relays) are used for the emergency stop system these components shall be performance level d with permanent monitoring. If electronic devices are the only means to transmit emergency stop commands or programmable controllers are integrated in the emergency stop system the system shall be performance level e.

Table C.2 — Performance levels at the level of safety functions

The performance levels apply to safety functions. A safety function is carried out by one or a combination of safety related parts. The requirements of the safety related parts are given in the relevant clauses of this standard.

N°	Safety function	Clause EN 528	Performance Level	Comments
1	Function to monitor access by doors	5.3.3 5.3.4 5.10.3.3 5.10.3.6	b	In addition with the requirements for 5.3.3, 5.3.4, 5.10.3.3 and 5.10.3.6 in Table C.1, the safety function performed by the devices shall be performance level b. This Performance level b applies only for the monitoring of the access.
2	Stop function	5.3.7	d	
3	Emergency stop function	5.3.8 5.3.8.1 5.3.8.3	c/e	If single electronic devices (e.g. emergency stop relays) are used for the emergency stop system these components shall be performance level c with permanent monitoring. If electronic devices are the only means to transmit emergency stop commands or programmable controllers are integrated in the emergency stop system the system shall be performance level e.
4	Function to stop lifting movement at travel limit and in case of power failure	5.4.1.1 5.4.2 a), b), c)	*	
5	Function to stop travelling movement at travel limit (e.g. ends of aisles), in case of power failure, in case of collision if more than one machine is working on the same rail	5.5.1.1 5.5.1.2 5.5.3	*	
6	Function for additional breaking and speed reduction when curves have to be negotiated at limited speed	5.5.1.2 a) 5.5.2	*	The safety level is provided by this clause in addition with the function to stop travelling movement at travel limit (e.g. ends of aisles), in case of power failure, in case of collision if more than one machine is working on the same rail.
7	Function for additional breaking and speed reduction when end stops are not capable of stopping the machine travelling at more than 70 % of the rated speed	5.5.1.2 b) 5.5.2	*	The safety level is provided by this clause in addition with the function to stop travelling movement at travel limit (e.g. ends of aisles), in case of power failure, in case of collision if more than one machine is working on the same rail.

Table C.2 *(continued)*

N°	Safety function	Clause EN 528	Performance Level	Comments
8	Function to prevent collision of the load and load handling devices with the rack	5.4.6.6 5.6.2 5.6.3 5.6.5 5.6.7 5.6.8.2 5.10.7.1	*	
9	Load handling devices – Interlocks	5.6.5 a), b)	b	Performance level b applies to all the different field devices. However, a higher safety level shall be reached by the interlocks, sequence control and plausibility checks within the control system (e.g. PLC).
10	Load handling devices – Interlocks	5.6.5 c)	d	
11	Load handling devices – Rack aperture occupied	5.6.5 d)	b	
12	Load handling devices – Load position monitoring	5.6.7	b	Performance level b applies to all the different field devices. However, a higher safety level shall be reached by the interlocks, sequence control and plausibility checks within the control system (e.g. PLC).
13	Function of control devices for dangerous movements (manual control system)	5.7.6	c	
14	Interlocking function with transfer devices	5.8.2 5.8.3 5.8.4	*	
15	Function to permit only slow speed if operator is at the emergency control position	5.3.7 5.9.4	*	Hold to run control and emergency stop shall be included at the emergency control position.
16	Function to stop the machine when access through emergency escape doors and panels is necessary	5.10.3.2 c) 5.10.3.2 e) 5.10.3.4 5.10.6.4	*	Escape routes which cross aisles are not permitted. If local authorities require escape routes which cross the aisles the safety measures and the appropriate performance level shall be defined together with them. The requirements of 5.10.3 should be considered.
17	Machine environment – Protection against unintentional load movement Rack aperture sensor	5.10.7.1 a)	b	

Table C.2 *(continued)*

N°	Safety function	Clause EN 528	Performance Level	Comments
18	Machine environment – Protection against unintentional load movement Push through protection	5.10.7.1 b)	(-) (c)	(–) No Performance level because of mechanical solution. (c) Performance level c applies for electromechanical protection system or electronic sensing device.
19	Machine environment – Protection against unintentional load movement – Push through protection	5.10.7.1 c)	(-) (c)	(–) No Performance level because of mechanical solution (c) Performance level c applies for electromechanical protection system.
* Safety level is given by the combination of the involved safety related parts (see Table C.1).				

Annex D
(informative)

Examples for the design of load entry/exit points to prevent or deter access to danger areas or protect persons in accordance with 5.10.4

D.1 General

The following subclauses show the most used safety measures to prevent or deter the misuse of load entry/exit points to gain access to danger areas but do not exclude other measures.

D.2 Measures against access between the conveyor and fixed guard

The area between the conveyor and the fixed guard (fencing) should be protected against access by e. g. sloping plates marked in warning colours (black/yellow – see Figure D.1). For distances of more than 0,5 m deterring nets or mats as described in D.4.4 should be provided.

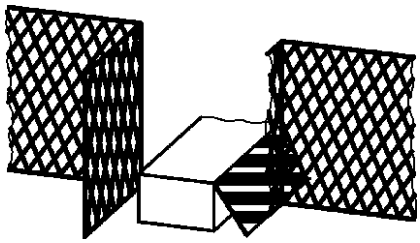


Figure D.1 — Sloping plates

D.3 Load entry/exit opening height

D.3.1 Load entry/exit height less than or equal to 0.5 m

If the load entry/exit height is 0,5 m maximum and complies with EN ISO 13857 for safety distances, no further safeguarding measures against access are required.

NOTE If danger zones can be reached through the load entry/exit the requirements of 5.9 apply.

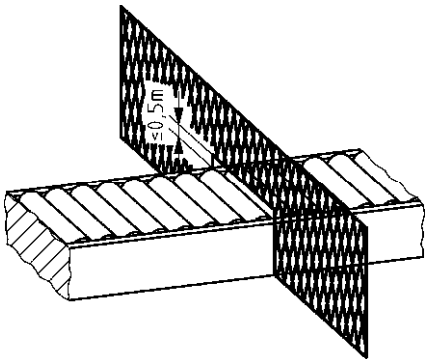


Figure D.2 — Load entry/Exit height up to 0,5 m

D.3.2 Load entry/exit height more than 0,5 m

If the load entry/exit height is greater than 0,5 m access may be prevented by a deterring/impeding device at least 1 m high (see list a)) arranged in accordance with Table 1 of EN ISO 13857:2008, and personnel access in accordance with list b).

a) Deterring/impeding device;

A conveyor height ≥ 1 m may be considered in a certain number of cases sufficiently dissuasive to prevent access to the installation, on condition that (see Figure D.3):

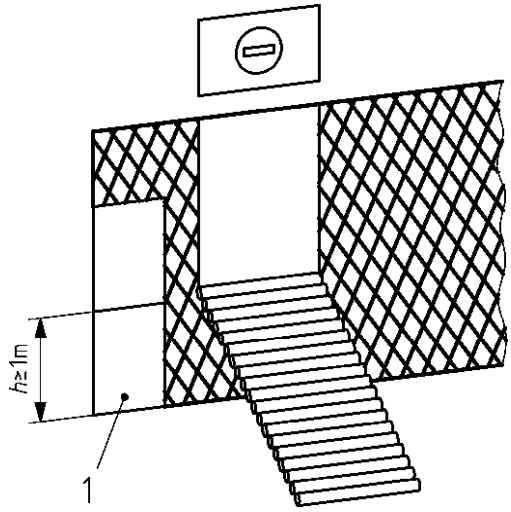
— conveyor is fixed to the floor;

— access to the automated area is not possible beneath the conveyor or at floor level between the conveyor and the edges of the opening;

— movement of persons along the conveyor itself is not facilitated by its structure (steps);

— warning sign indicates that access via the conveyor is forbidden;

— type of the conveyor does not facilitate the movement of persons along it.



Key

1 lockable or interlocking access gate

Figure D.3 — Load entry/Exit height more than 0,5 m

b) Access

Authorised access via an interlocked door should be adjacent to the conveyor to deter personnel seeking access by any other route.

D.3.3 Load entry/exit/other solutions

If the conditions of D.3.1 or D.3.2 are not fulfilled, measures according to D.4 or D.5 should be provided, and the conveyor should have a minimum length of 1,2 m in the conveying direction or a minimum length of 2 m if the conveyor height is less than 0,3 m.

D.4 Measures which deter access

D.4.1 General

If the frame width is 4 cm and more the possibility of walking on the frame of the conveyor should be minimised by the design of its surface (see Figure D.4).

NOTE These solutions do not prevent walking on chains or rollers.

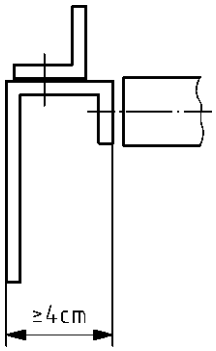


Figure D.4 — Design of frame surface

D.4.2 Roller conveyors

D.4.2.1 Gravity roller conveyors

For a roller length of 0,85 m minimum (i. e. width of the conveyor) and gap between rollers of 0,1 m maximum the possibility of walking on the conveyor is deterred. Where roller tracks are used, entry between the tracks should be deterred, e. g. by the use of a deterring net or mat as described in D.4.4.

D.4.2.2 Powered roller conveyors

The gap between the rollers should be selected to minimise the possibility of standing or walking on the rollers (e. g. 0,12 m minimum gap). People are to be deterred from stepping between the rollers at conveying levels of 0,5 m or less, e. g. by fixing a tightly tensioned net, capable of bearing a person, or a building reinforcing mat of about 0,15 m grating beneath the rollers at about 0,3 m height above the floor.

D.4.3 Twin chain conveyors

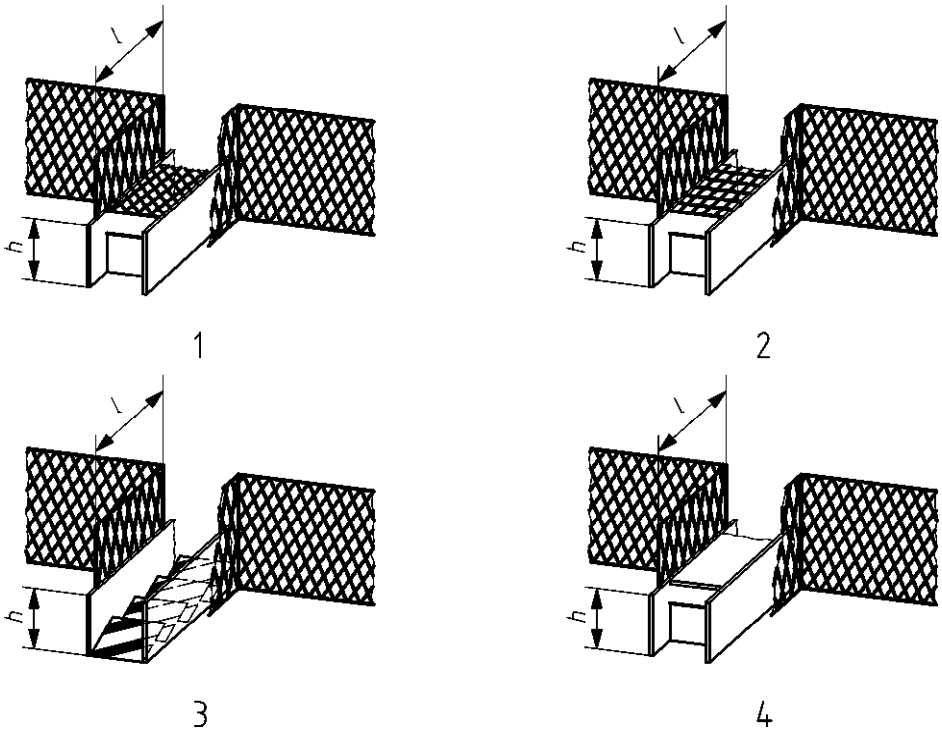
To deter people from walking between the chains in the case of chain distances of more than 0,85 m and a chain width of less than 40 mm, the area between the chains should be equipped, e. g. with one of the following means (see Figure D.5) :

— deterring net or mat as described in D.4.4;

— sloping plates marked in warning colours (black/yellow);

— pressure sensing floor marked in warning colours (black/yellow) – not for use in case of a fall hazard.

For chain distances of less than 0,85 m and/or a chain width of 40 mm or more, other means should be considered (see D.4).



Key

1 steel wire fibre rope net
2 building reinforcing mat
3 sloping plates
4 pressure sensing floor

$l \geq 1{,}2\ m\ if\ \ h \geq 0{,}3\ m$

$l \geq 2\ m\ if\ \ h < 0{,}3\ m$

Figure D.5 — Area between chains of twin chain conveyors

NOTE Figures above just show the possible solutions for the load exit. For load entry additional means to prevent crushing and shearing have to be added according to the general requirements (D.2).

D.4.4 Deterring net

Deterring persons from walking on the floor between parts of the conveyor or between the sides of the conveyor and the surroundings, e. g. fencing can be made by a tensioned steel wire rope net or fibre rope net with a maximum mesh size of 0,15 m × 0,15 m.

This net should be capable of bearing a load of 200 kg applied on an area with a dimension of 0,1 m × 0,25 m at any point of the net without wire or rope breaking. When applying this load the net should not come into contact with the floor or parts of the conveyor below.

D.5 Measures that prevent access

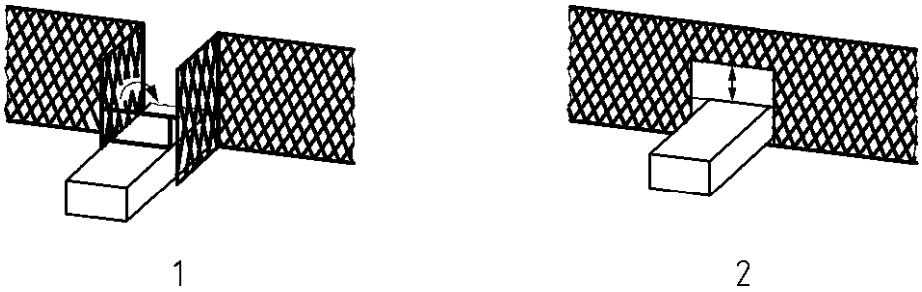
D.5.1 General

If foreseeable misuse is possible, e. g. misbehaviour because of normal carelessness or because the way of the lowest resistance will be taken (e. g. conveyors) to get admittance to an dangerous area, it is not enough to deter the admittance, but it must prevented, as shown in the following example. The measures to be taken are to be fixed in a written risk analysis.

In case of danger areas behind the safeguards in D.4.2 and D.4.3, safety distances in accordance with Table 1 of EN ISO 13857:2008, should be provided.

D.5.2 Mechanical guards

Mechanical guards, e.g. swing gates, powered sliding doors, may be provided. The guard should only be released or opened to allow the passage of conveyed material.



Key

1 gate

2 door

Figure D.6 — Mechanical guards

NOTE Figures above just show the possible solutions for load exit. For load entry additional means to prevent crushing and shearing have to be added according to the general requirements (D.2).

D.6 Protecting devices

Protecting devices, in particular opto-electronic protecting devices (light guards) complying with EN 61496-1, may be provided. The installation has to be in accordance with EN 999, such that hazardous machinery will be stopped before it can be reached.

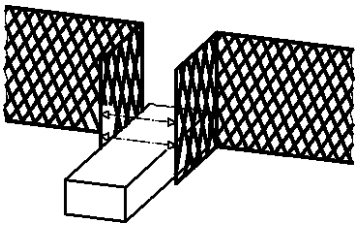


Figure D.7 — Protecting devices

NOTE Figures above just show the possible solutions for load exit. For load entry additional means to prevent crushing and shearing have to be added according to the general requirements (D.2).

Annex E
(normative)

Verification of safety requirements and/or measures

Safety requirements and/or measures given in the Clause 5 to Clause 8 of this standard shall be verified according to the table below. It includes the following types of verification:

1) visual inspection, the result of which only is to establish that something is present (e. g. a guard, marking or a document);

2) measuring, the result of which is that the stated measurable parameters have been met (e. g. geometric dimensions);

3) functional tests, the result of which shows that the adequate signals intended to be forwarded to the main control system of the complete machine are available and comply with the requirements and technical documentation;

4) calculation, the result of which complies with the characteristics of the relevant requirement;

5) special verification, the procedure being given under "remarks" or in the referred clause.

As an S/R machine is generally assembled at its place of use, verification shall preferably be made at the appropriate time:

— at the design (D),

— manufacturing (M),

— assembling (A), and/or

— commissioning stage ©.

All safety measures and dimensions should be verified during design stage.

The mentioned verification procedures are generally necessary for all machines. Certain verification procedures are only made as type-test and those procedures are marked by the addition of “(T)” in the following table.

Table E.1

Sub-clause	Visual inspection	Measu-ring	Functional tests	Calcu-lation	Special verification	Remarks
5.1, Para 3	M					
5.2					D	Design verification
5.3.1, Para 2					D	Meeting of the performance level
5.3.1, Para 3			C			
5.3.1, Para 4	A					
5.3.1, Para 5	C					
5.3.2			C			
5.3.3			C			

Table E.1 *(continued)*

Sub-clause	Visual inspection	Measu-ring	Functional tests	Calcu-lation	Special verification	Remarks
5.3.4			C			
5.3.5, Para 1	A					
5.3.5, Para 2,sentence 1					D	Verification of the control
5.3.5, Para 2, sentence 2			C			
5.3.6	A		C			
5.3.7.1					D	Verification of the control
5.3.7.2			C			
5.3.8.1					D	Verification of the control
5.3.8.2	A		C			
5.3.8.3					D	Verification of the control
5.3.9	M/A				D	
5.4.1.1			C			
5.4.1.2	M				D	
5.4.1.3			C			
5.4.2	A		C			For hydraulic drives see also 5.4.6.8.
5.4.3.1			C			
5.4.3.2			C			
5.4.4.1	M				D	Special verification necessary in case of persons carried on board
5.4.4.2					D	Hazards for persons
5.4.4.3, Para 1			C(T)			
5.4.4.3, Para 2			C(T)	D		
5.4.4.3, Para 3		C(T)			D	
5.4.4.3, Para 4				D		
5.4.4.4	A		C			
5.4.4.5			C			
5.4.4.6	A		C			
5.4.4.7						See 5.4.6.5 or 5.4.7.3.
5.4.5.1.1				D		
5.4.5.1.2				D		
5.4.5.1.3				D		
5.4.5.1.4				D		
5.4.5.1.5				D		
5.4.5.1.6	A		C			
5.4.5.1.7					D	Possibility of examination
5.4.5.1.8	A			D		
5.4.5.1.9	A					

Table E.1 *(continued)*

Sub-clause	Visual inspection	Measu-ring	Functional tests	Calcu-lation	Special verification	Remarks
5.4.5.1.10	A					
5.4.5.2.1				D		
5.4.5.2.2				D		
5.4.5.2.3	A		C			
5.4.5.2.4				D		
5.4.5.2.5					D	Possibility of examination
5.4.5.2.6	A					
5.4.5.2.7	A					
5.4.5.3.1					D	Checking of the environmental conditions
5.4.5.3.2					D	
5.4.5.3.3					D	
5.4.5.3.4	A		C			
5.4.5.3.5				D		
5.4.5.3.6					D	
5.4.5.3.7					D	Possibility of examination
5.4.5.3.8	A					
5.4.5.3.9	A					
5.4.6.1					D	
5.4.6.2					D	
5.4.6.3	A		C			
5.4.6.4	A		C			
5.4.6.5	A		C(T)			
5.4.6.6			C(T)		D	
5.4.6.7			C		D	
5.4.6.8					D	
5.4.7.1				D		
5.4.7.2					D	
5.4.7.3	A*				D	* 3rd sentence
5.4.7.4					D	
5.4.7.5					D	
5.4.8.1				D		
5.4.8.2					D	
5.4.8.3					D	
5.5.1.1			C			
5.5.1.2			C		D	
5.5.1.3			C		D	
5.5.1.4			C		D	
5.5.2			C			

Table E.1 *(continued)*

Sub-clause	Visual inspection	Measu-ring	Functional tests	Calcu-lation	Special verification	Remarks
5.5.3 a)	A		C*	D		* For non-mechanical devices
5.5.3 b)	A		C			
5.5.3 c)	A		C			
5.5.3 d)			C			
5.5.4.1	M					
5.5.4.2	A		C			
5.5.4.3	A					
5.5.4.4					D	Design verification
5.5.5				D		
5.6.1					D	Tests
5.6.2			C*		D**	* Control functions ** Design verification
5.6.3		M(T)	C			
5.6.4		M(T)	C			
5.6.5			C			
5.6.6			C			
5.6.7			C			
5.6.8.1						See sub-clauses referred.
5.6.8.2			C			
5.7.2					D	Checking of the chosen electrical equipment
5.7.3					D	Checking of the chosen electrical equipment
5.7.4.1	M		C			
5.7.4.2				D		
5.7.4.3	A		C			
5.7.4.4			C			
5.7.4.5				D		
5.7.5	A					
5.7.6	A		C			
5.7.7			C			
5.8						See sub-clauses referred.
5.8.2			C			
5.8.3			C			
5.8.4			C			
5.8.5						See 5.5.5.
5.9.2	A					
5.9.3	A					
5.9.4			C			
5.9.5			C			

Table E.1 *(continued)*

Sub-clause	Visual inspection	Measu-ring	Functional tests	Calcu-lation	Special verification	Remarks
5.9.6	A					
5.9.7	A					
5.10					D	
5.10.2		A			D	
5.10.3	A		C			
5.10.3.1	A		C			
5.10.3.2		A				
5.10.3.3	A		C			
5.10.3.4 a)	A		C			
5.10.3.5			C			
5.10.4.1	A		C*			* Control functions
5.10.4.2	A				C*	* Operating instructions
5.10.5	A		C*			* Control functions
5.10.6.1	A				D	Design verification
5.10.6.2		C			D	Design verification
5.10.6.3					D	Design verification
5.10.6.4	A		C*			* Control functions
5.10.7.1 a), b)			C			
5.10.7.1 c)					D	
5.10.7.2						See 6.2.2.8.
5.10.7.3			C	D		
5.10.8				D		
5.10.9	A					
6.2.1.2	A			D		
6.2.1.3	A			D		
6.2.1.4	A			D		
6.2.2.1					D	Design of the onboard control position and arrangement of displays and control actuators
6.2.2.2	A					
6.2.2.3, Para 1	A					
6.2.2.3, Para 2 + 3				D	A	
6.2.2.3, Para 4		M				
6.2.2.4		A				
6.2.2.5	A					
6.2.2.6			C			
6.2.2.7	A		C			
6.2.2.8				D	A	Test
6.2.2.9					D	Choice of materials

Table E.1 *(continued)*

Sub-clause	Visual inspection	Measu-ring	Functional tests	Calcu-lation	Special verification	Remarks
6.2.2.10					D	Choice of materials
6.2.3			C			
6.2.4.1			C			Lighting dependent on the task
6.2.4.2	A*				D**	* Arrangement / ** Choice of the lighting
6.2.4.3			C			
6.2.5			C			
6.3.1	A					
6.3.2	A					
6.4.1			C			
6.4.2						See 5.4.3.2.
6.5, Para 1		C		D		
6.5, Para 2	A					
6.6			C			
7.2						See 5.10.8.
7.3.1						See 5.3.3.
7.3.2						See 5.3.8.2.
7.4.1						See 5.4.2 a) to c).
7.4.2						See 5.4.3.2.
7.4.3						See 5.4.7.3.
7.5						See 5.10.7.1.
7.6					D	
8.1					M	Assembling instructions
8.2					A	Commissioning instructions

Annex ZA
(informative)

Relationship between this European Standard and the Essential Requirements of EU Directive Machinery 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.

Annex ZB
(informative)

Relationship between this European Standard and the Essential Requirements of EU Directive Machinery 2006/42/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 one means of conforming to Essential Requirements of the New Approach Directive 2006/42/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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