

Rail dependent storage and retrieval equipment — Safety requirements

ICS 53.080

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 It supersedes BS EN 528:1997 which is withdrawn.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.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

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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of an identical text or by endorsement, at the latest by April 2009, and conflicting national standards shall be withdrawn at the latest by December 2009.

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

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	Pulley and drum design requirements
		5.4.5.1.5	
		5.4.5.1.9	
		5.4.5.1.10	
4.1.20	Inadequate selection of suspension elements	5.4.5.1	Rope, belt and chain selection criteria
		5.4.5.2	
		5.4.5.3	
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 brake 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 these 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.