

Builders' hoists for goods —

Part 1: Hoists with accessible platforms

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National foreword

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The UK participation in its preparation was entrusted to Technical Committee MHE/6, Hoists for builders types.

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

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This European Standard was approved by CEN on 17 February 2000 and includes Amendment 1 approved by CEN on 12 June 2010.

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Foreword

This document (EN 12158-1:2000+A1:2010) has been prepared by Technical Committee CEN/TC 10 "Lifts, escalators and moving walks", the secretariat of which is held by AFNOR.

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of an identical text or by endorsement, at the latest by January 2011, and conflicting national standards shall be withdrawn at the latest by January 2011.

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 document includes Amendment 1, approved by CEN on 2010-06-12.

This document supersedes EN 12158-1:2000.

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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).

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Introduction

This standard is one of a series of standards produced by CEN/TC 10/SC 1 “Building hoists” as part of the CEN programme of work to produce machinery safety standards.

The standard is a Type C standard relating to safety for builders hoists for goods.

The extent to which hazards are covered is indicated in the scope of this standard. In addition, machinery shall comply as appropriate with  EN ISO 12100:2003  for hazards which are not covered by this standard.

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

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

1 Scope

1.1 This standard deals with power operated temporarily installed builders hoists (referred to as “hoists” in this standard) intended for use by persons who are permitted to enter sites of engineering and construction, serving landing levels, having a load carrying device:

- designed for the transportation of goods only;
- guided;
- travelling vertically or along a path within 15 degrees max. of the vertical;
- supported or sustained by drum driven wire rope, chain, rack and pinion, hydraulic jack (direct or indirect), or an expanding linkage mechanism;
- where masts, when erected, may or may not require support from separate structures;
- which permits the access of instructed persons during loading and unloading;
- which are driven by appointed persons;
- which permits, if necessary, during erection, dismantling, maintenance and inspection, the access and travel by persons who are competent and authorised.

1.2 The standard identifies hazards as listed in clause 4 which arise during the various phases in the life of such equipment and describes methods for the elimination or reduction of these hazards when used as intended by the manufacturer.

1.3 This European standard does not specify the additional requirements for:

- operation in severe conditions (e.g. extreme climates, strong magnetic fields);

- lightning protection;
- operation subject to special rules (e.g. potentially explosive atmospheres);
- electromagnetic compatibility (emission, immunity);
- handling of loads the nature of which could lead to dangerous situations (e.g. molten metal, acids/bases, radiating materials, fragile loads);
- the use of combustion engines;
- the use of remote controls;
- hazards occurring during manufacture;
- hazards occurring as a result of mobility;
- hazards occurring as a result of being erected over a public road;
- earthquakes;
- noise.

1.4 This standard is not applicable to

- builders hoists for persons and materials;
- lifts according to EN 81-1:1998, 81-2:1998 and  EN 81-3:2000 .
- inclined hoists according to  EN 12158-2:2000 .
- work cages suspended from lifting appliances;
- work platforms carried on the forks of fork trucks;
- work platforms;
- funiculars;
- lifts specially designed for military purposes;
- mine lifts;
- theatre elevators;
- special purpose lifts.

1.5 This standard deals with the hoist installation. It includes the base frame and base enclosure but excludes the design of any concrete, hard core, timber or other foundation arrangement. It includes the design of mast ties but excludes the design of anchorage bolts to the supporting structure. It includes the landing gates and their frames but excludes the design of any anchorage fixing bolts to the supporting structure.

2 Normative references

[A1] 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. **[A1]**

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

EN 81-2:1998, *Safety rules for the construction and installation of lifts — Part 2: Hydraulic lifts*

[A1] EN 81-3:2000, *Safety rules for the construction and installation of lifts — Part 3: Electric and hydraulic service lifts* **[A1]**

[A1] *deleted text* **[A1]**

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

[A1] *deleted text* **[A1]**

EN 894-1:1997, *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*

[A1] *deleted text* **[A1]**

EN 982:1996, *Safety of machinery — Safety requirements for fluid power systems and their components — Hydraulics*

EN 1037:1995, *Safety of machinery — Prevention of unexpected start-up*

EN 1088:1995, *Safety of machinery — Interlocking devices associated with guards — Principles for design and selection*

[A1] EN 12158-2:2000, *Builders hoists for goods — Part 2: Inclined hoists with non-accessible load carrying devices* **[A1]**

[A1] EN 12159:2000, *Builders hoists for persons and materials with vertically guided cages* **[A1]**

[A1] EN 60204-1:2006, *Safety of machinery — Electrical equipment of machines — Part 1: General requirements (IEC 60204-1:2005, modified)* **[A1]**

[A1] EN 60204-32:2008, *Safety of machinery — Electrical equipment of machines — Part 32: Requirements for hoisting machines (IEC 60204-32:2008)* **[A1]**

[A1] EN 60529:1991, *Degrees of protection provided by enclosures (IP-Code) (IEC 60529:1989)* **[A1]**

[A1] EN 60947-4-1:2001, *Low-voltage switchgear and controlgear — Part 4-1: Contactors and motor-starters; Electromechanical contactors and motor-starters (IEC 60947-4-1:2000)* **[A1]**

[A1] 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)* **[A1]**

■^{A1} EN ISO 4871:1996, *Acoustics — Declaration and verification of noise emission values of machinery and equipment (ISO 4871:1996)* ■^{A1}

■^{A1} EN ISO 12100-1:2003, *Safety of machinery — Basic concepts, general principles for design — Part 1: Basic terminology, methodology (ISO 12100-1:2003)* ■^{A1}

■^{A1} EN ISO 12100-2:2003, *Safety of machinery — Basic concepts, general principles for design — Part 2: Technical principles (ISO 12100-2:2003)* ■^{A1}

■^{A1} EN ISO 13850:2008, *Safety of machinery — Emergency stop — Principles for design (ISO 13850:2006)* ■^{A1}

■^{A1} EN ISO 13857:2008, *Safety of machinery — Safety distances to prevent hazard zones being reached by upper and lower limbs (ISO 13857:2008)* ■^{A1}

■^{A1} ISO 2408:2004, *Steel wire ropes for general purposes — Minimum requirements* ■^{A1}

ISO 4302:1981, *Cranes — Wind load assessment*

■^{A1} ISO 4309:2004, *Cranes — Wire ropes — Care, maintenance, installation, examination and discard* ■^{A1}

■^{A1} ISO 6336-1:2006, *Calculation of load capacity of spur and helical gears — Part 1: Basic principles, introduction and general influence factors* ■^{A1}

■^{A1} ISO 6336-2:2006, *Calculation of load capacity of spur and helical gears — Part 2: Calculation of surface durability (pitting)* ■^{A1}

■^{A1} ISO 6336-3:2006, *Calculation of load capacity of spur and helical gears — Part 3: Calculation of tooth bending strength* ■^{A1}

■^{A1} ISO 6336-5:2003, *Calculation of load capacity of spur and helical gears — Part 5: Strength and quality of materials* ■^{A1}

3 Terms and definitions

■^{A1} For the purposes of this document, the terms and definitions given in EN ISO 12100-1:2003 and the following apply. ■^{A1}

3.1

builder's hoist

a temporary lifting machine serving landing levels on sites of engineering and construction with a platform, cage or other load carrying device, which is guided

■^{A1} 3.2

working load/rated load ■^{A1}

the maximum load which the hoist has been designed to carry in service

3.3

rated speed

the speed of the platform for which the equipment has been designed

3.4

wire rope hoist

a hoist which uses wire rope as the load suspension system

3.5

positive drive

a drive using means other than friction

3.6

hydraulic hoist

a hoist which uses a hydraulic cylinder to directly or indirectly carry the load

3.7

rack and pinion hoist

a hoist which uses a toothed rack and pinion as the load suspension system

3.8

expanding linkage mechanism

a mechanical linkage system (e.g. scissors) which supports and guides the platform by means of expansion or contraction under the control of an actuator

3.9

base frame

the lowest framework of the hoist, upon which all other components are mounted

3.10

guides

rigid elements which determine the travel way of the platform

3.11

mast

structure that supports and guides the platform

3.12

mast section

indivisible piece of mast, between two adjacent mast joints

3.13

mast tie

a connection system between the mast and any building structure, providing lateral support for the mast

3.14

hoistway

the total space which is travelled by the platform and its load

3.15

platform

the load carrying device including the floor, walls and entrances

3.16

stopping distance

the distance the platform moves from the moment, when the control or safety circuit is broken until the platform has come to a full stop

3.17

overspeed safety device

a mechanical device for stopping and maintaining stationary the platform in the event of overspeed in down direction

3.18

slack rope

a rope, normally under tension, from which all external loads have been removed

3.19

wire rope termination

the adaptation at the end of a wire rope permitting attachment

3.20

landing

a level in a building or construction intended for loading and unloading the platform

3.21

safety distance

a minimum acceptable distance between any moving part of a hoist and any point of access

3.22

guard rail

fixed equipment, other than gates, which is used to prevent people from falling or from reaching hazardous areas

3.23

normal operation

the usual operating conditions for the equipment when in use for carrying loads but excluding routine maintenance, erection, dismantling etc

3.24

in service

a condition during use of the hoist when the platform is in any position, laden or unladen, moving or stationary

3.25

out of service

an installed condition when the platform is positioned such that it is provided with the most shelter from the wind. This is normally, but not necessarily, ground level. The platform is unladen

3.26

competent person

a designated person, suitably trained, qualified by knowledge and practical experience, and provided with the necessary instructions to enable the required procedures to be carried out

4 List of hazards

The list of hazards according to the following tables are based on  EN ISO 12100-1:2003 and EN ISO 12100-2:2003 .

Tables 1.1 and 1.2 show the hazards which have been identified and where the corresponding requirements have been formulated in this standard, in order to limit the risk or reduce these hazards in each situation.

A hazard which is not applicable or is not significant and for which, therefore, no requirements are formulated, is shown in the relevant clauses column as n.a. (not applicable).

Table 1 — Hazards relating to the general design and construction of hoists

	Hazards	Relevant clauses in this standard
1	Mechanical hazards	
1.1	Crushing	5.5.2, 5.5.3, 5.5.6, 5.7.2, 7.1.2.7, 7.1.2.8
1.2	Shearing	5.5, 5.6.1.2, 5.7.2, 7.1.2.7, 7.1.2.8

	Hazards	Relevant clauses in this standard
1.3	Cutting or severing	5.5, 5.6.1.2, 5.7.2, 7.1.2.7, 7.1.2.8
1.4	Entanglement	5.7.2
1.5	Drawing-in or trapping	5.5.2, 5.5.3, 5.6.1.2, 5.7.2, 7.1.2.7
1.6	Impact	5.4.3, 5.6.2, 7.1.2.7, 7.1.2.8
1.7	Stabbing or puncture	n.a.
1.8	Friction or abrasion	5.5.2, 5.5.3, 7.1.2
1.9	High pressure fluid ejection	5.7.3.3, 5.8
1.10	Ejection of parts	5.6.1.2
1.11	Loss of stability	5.2, 5.3, 5.4.1, 5.4.2, 5.6.3, 7.1.2.7.3
1.12	Slip, trip and fall	5.5, 5.6.1, 5.6.2, 5.7.3.3.8, 7.1.2.7.3
2	Electrical hazards	
2.1	Electrical contact	5.9, 7.1.2.7.3
2.2	Electrostatic phenomena	n.a.
2.3	Thermal radiation	n.a.
2.4	External influences	5.7.4.11, 5.9.3
3	Thermal hazards	
3.1	Burns and scalds	n.a.
3.2	Health-damaging effects	n.a.
4	Hazards generated by noise	
4.1	Hearing losses	not dealt with, see 1.3
4.2	Interference with speech	not dealt with, see 1.3
5	Hazards generated by vibration	n.a.
6	Hazards generated by radiation	
6.1	Electrical arcs	n.a.
6.2	Lasers	n.a.
6.3	Ionising radiation sources	n.a.
6.4	Use of H F electromagnetic fields	not dealt with
7	Hazards generated by materials and substances processed, used or exhausted by machinery	
7.1	Contact with or inhalation of harmful fluids, gases, mists, fumes and dusts	n.a.
7.2	Fire or explosion	n.a.
7.3	Biological and microbiological	n.a.
8	Hazards generated by neglecting ergonomic principles in machine design	
8.1	Unhealthy postures or excessive effort	5.1, 5.5.3.1.6, 7.1.2.7.3
8.2	Inadequate consideration of human hand/arm or foot/leg anatomy	5.5, 5.7.2, 7.1.2.7
8.3	Neglected use of personal protection equipment	n.a.
8.4	Inadequate area lighting	7.1.2.7.3
8.5	Mental overload or underload, stress	5.10
8.6	Human error	5.6.3, 5.10, 7.1.2.7, 7.1.2.8, 7.2, 7.3
9	Hazard combinations	not dealt with
10	Hazards caused by failure of energy supply, breaking down of machinery parts and other functional disorders	
10.1	Failure of energy supply	5.7.4.1, 5.9.2, 5.11, 7.1.2.4.1, 7.1.2.5
10.2	Unexpected ejection of machine parts or fluids	5.7.2.3, 5.7.3.3, 5.8

	Hazards	Relevant clauses in this standard
10.3	Failure or malfunction of control system	5.10.2.2, 5.10.3, 5.10.6
10.4	Errors of fitting	5.4.1, 7.1.2.7
10.5	Overturn, unexpected loss of machine stability	5.2, 5.3, 5.4, 7.1.2.7
11	Hazards caused by missing and / or incorrectly positioned safety related measures / means	
11.1	Guards	5.5, 5.6.1.2, 7.1.2.7
11.2	Safety related (protection) devices	5.5.1, 7.1.2.7, 7.1.2.10
11.3	Starting and stopping devices	5.10.5, 5.10.7, 7.1.2.7, 7.1.2.8
11.4	Safety signs and signals	7.2
11.5	Information or warning devices	5.6.3, 7.2
11.6	Energy supply disconnecting devices	5.10.6
11.7	Emergency devices	5.6.2, 5.11, 7.1.2.5, 7.1.2.7, 7.1.2.10
11.8	Feeding/removal means of work pieces	n.a.
11.9	Essential equipment and accessories for safe adjusting and/or maintaining	7.1.2.5, 7.1.2.7, 7.1.2.10
11.10	Equipment evacuating gases	n.a. see 1.3

Table 1.2 — Particular hazards involving the mobility and/or load lifting ability of hoists

	Hazards	Relevant clauses in this standard
	Hazards due to mobility	
12	Inadequate lighting of moving / working area	Not dealt with, see 1.3
13	Hazards due to sudden movement instability etc. during handling	Not dealt with, see 1.3
14	Inadequate/non-ergonomic design of operating position	Not dealt with, see 1.3
15	Mechanical hazards	Not dealt with, see 1.3
16	Hazards due to lifting operations	
16.1	Lack of stability	5.2.5, 5.3, 5.4.1, 5.4.2, 7.1.2.7
16.2	Derailment of the platform	5.4.1, 5.6.1, 5.10.7.2.2
16.3	Loss of mechanical strength of machinery and lifting accessories	5.2, 5.3, 5.5.4, 5.6, 5.7, 7.1.2.10
16.4	Hazards caused by uncontrolled movement	5.5.3, 5.6.2, 7.1.2.8
17	Inadequate view of trajectories of the moving parts	5.5.2.2, 7.1.2.8
18	Hazards caused by lightning	not dealt with, see 1.3
19	Hazards due to loading / overloading	5.2, 5.6, 7.1.2.8

5 Safety requirements and/or measures

5.1 General

The design of the hoist shall consider safe use, erection, dismantling and maintenance. It shall be possible to erect the hoist using safe access methods such as those offered by the platform or equivalent facilities.

The design of all components that have to be handled during erection e.g. mast sections, shall have their weight assessed against manual handling. Where the permissible weight for manual handling is exceeded, the manufacturer shall make available suitable lifting equipment.  All removable and detachable covers shall be retained by captive fastenings. 

5.2 Load combinations and calculations

5.2.1 The structure of the hoist shall be designed and constructed in such a way that its strength is satisfactory under all intended operating conditions, including erection and dismantling and e.g. low temperature environments.

The design of the structure as a whole and each part of it shall be based on the effects of any possible combination of loads as specified in this subclause 5.2. The load combinations shall consider the least favourable locations of the platform and load relative to the mast and its ties, both during the vertical passage of the platform and any horizontal movement, e.g. swivelling of the platform. Ties between the mast and the supporting structure are considered to be part of the hoist structure.

5.2.2 When calculating the hoist structure and every related component, the following forces and loads shall be taken into account:

5.2.2.1 All dead weights with the exception of the platform and equipment which moves together with the platform.

5.2.2.2 Dead weights of the unladen platform and all equipment which moves together with the platform.

5.2.2.3 Dead weight of landing platforms and gates if supported by the hoist.

5.2.2.4 Rated load on the platform

The effect of the forces on the platform and mast resulting from the application of the rated load shall be allowed for in one of the two following ways, which reflect the chosen density of loading on the platform:

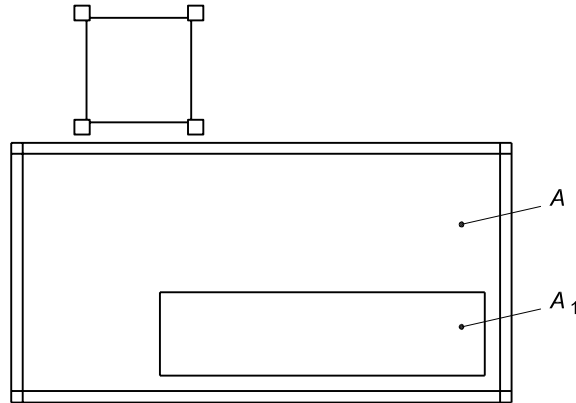
a) If $\frac{F}{A \times 0,75} < 3,0 \text{ kN} / \text{m}^2$

where

F = rated load [kN] and

A = total floor area [m²]

then the rated load shall be assumed to be distributed over a reduced area (A₁) which results in a distribution of 3,0 kN/m². The format and the location of this area shall be taken as that which gives the least favourable stress for the mast and also for the platform. One example is shown in figure 1.



Key

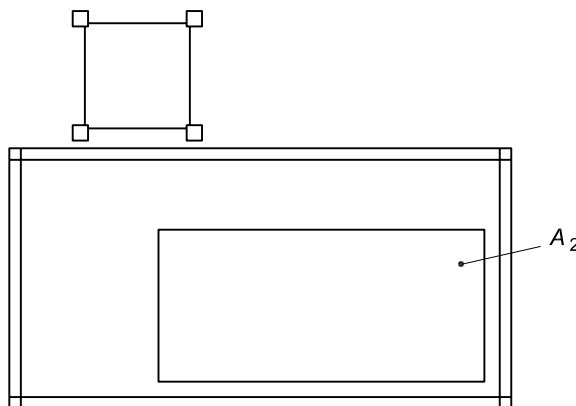
A total floor area[m²]

$A_1 = F[\text{kN}]/3[\text{kN/m}^2]$

Figure 1 — One example of loading according to 5.2.2.4 a

b) if $\frac{F}{A \times 0,75} \geq 3,0 \text{ kN/m}^2$

then the rated load shall be assumed to be distributed over an area (A_2) equivalent to 75 % of the total floor area of the platform. The format and the location of this area shall be taken as that which gives the least favourable stress for the mast and also for the platform. One example is shown in figure 2.



Key

$A_2 = 0,75 A$

Figure 2 — One example of loading according to 5.2.2.4 b

5.2.2.5 Where the uniform distribution of the rated load over the full area of the platform is less than 2,5 kN/m² then, for calculation purposes a minimum of 2,5 kN/m² shall be placed over the whole area (A_3) of the platform. See figure 3.

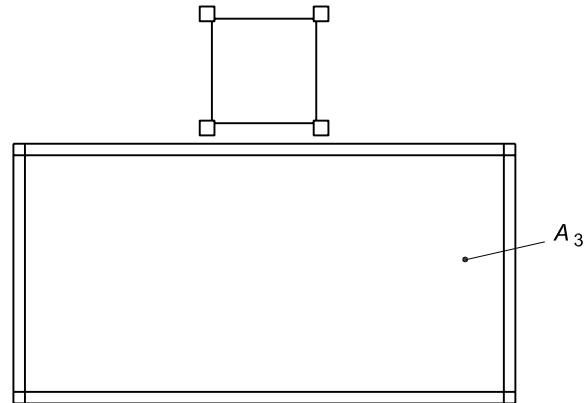


Figure 3 — Evenly distributed load case

5.2.2.6 Forces during loading and unloading shall be considered as the concurrent effect of a vertical force and a horizontal force, each calculated as follows:

- a vertical force F_V of 50 % of the rated load but not less than 2,0 kN, or, for rated loads greater than 20 kN, calculated from the equation

$$F_V = 4 + 0,3 F$$

where F_V = vertical force [kN]

F = rated load [kN]

- a horizontal force F_H of 15 % of the rated load, but not less than 0,3 kN and not more than 2,5 kN,

both forces acting at 1/3 of the width of the platform entrance, at floor level, in the least favourable direction and location. The stresses in the mast and also in the platform shall be calculated for at least the following application points of the loading and unloading forces:

- the platform threshold,
- the leading edge of any ramp or other extension, which is not supported by the landing.

At the same time any remaining part of the rated load shall be applied in the centre of the platform (F_{V1}).

Equivalent forces shall be used to design the landing threshold and all relevant supporting structures. Information shall be given in the instruction handbook with regard to these forces.

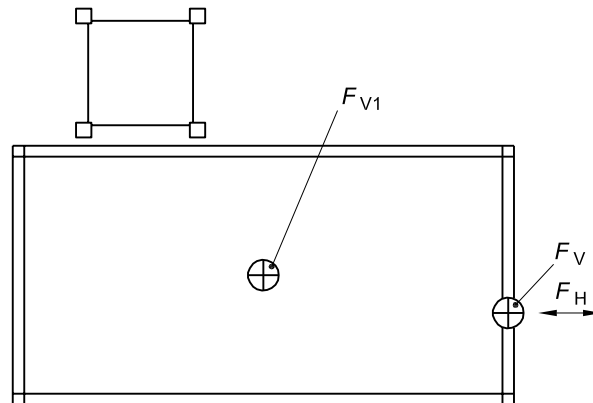


Figure 4 — One example of forces during loading and unloading

5.2.2.7 For hoists according to 5.10.2.2.5, the design of the hoist shall consider failure of the upper terminal stopping switch in combination with impact with the upper buffers both with and without load. The stalling torque and inertia of the drive system shall be taken into account.

5.2.2.8 The effect of moving loads shall be determined by taking the weight of all actual loads (platform, rated load, wire ropes etc.) and multiplying them by an impact factor $\mu = (1,1 + 0,264v)$ where v is the rated speed in m/s. Alternative factors may be used if they can be proved to be more accurate.

5.2.2.9 To determine the forces produced by an operation of the overspeed safety device, the sum total of the travelling load shall be multiplied by the factor 2,5.

A lower factor, but not less than 1,2 can be used if it can be verified by test under all conditions of loading up to 1,3 times rated load including any inertia effects of the drive system.

5.2.2.10 The platform floor surface shall be designed to withstand without permanent deformation a static force of 1,5 kN or 25 % of the rated load, whichever is the greater, but in no case more than 3 kN, the force applied on the least favourable square area of 0,1 m x 0,1 m.

5.2.2.11 Design wind conditions

The aerodynamic pressure q is given by the general equation:

$$q = \frac{v_w^2}{1,6} \quad \text{where}$$

q is the pressure in N/m² and v_w the wind velocity in m/s.

In all cases it shall be assumed that the wind can blow horizontally in any direction and the least favourable direction shall be taken into account.

The calculation shall be done according to **EN** ISO 4302:1981 **EN** with the exception of the following:

5.2.2.11.1 Action of the wind on the platform

When calculating wind pressure on the platform it shall be assumed that the platform walls and any guards are solid and an aerodynamic coefficient of $c = 1,2$ shall be applied. The factor 1,2 covers both the shape factor and the shielding factor.

5.2.2.11.2 Wind pressure

Three design wind conditions shall be taken into account when calculating wind pressure on hoists:

5.2.2.11.2.1 In service wind

Irrespective of height, the minimum value for wind pressure shall be $q = 250 \text{ N/m}^2$ which corresponds to a wind velocity of $v_w = 20 \text{ m/s}$.

5.2.2.11.2.2 Out of service wind

Out of service wind pressure depends on the height above ground and the area where the hoist is installed.

The values of out of service wind pressure are given in table 2. The minimum design wind pressures shall be taken into account

Table 2 — Minimum design wind pressure

Height H of parts of hoist above ground level [m]	Wind pressure q for geographical Region A to E [N/m ²]			
	A/B	C	D	E
0<H≤10	544	741	968	1225
10<H≤20	627	853	1114	1410
20<H≤50	757	1031	1347	1704
50<H≤100	879	1196	1562	1977
100<H≤150	960	1306	1706	2159

The regions A – E are taken from the European Stormwind Map (see Annex A).

5.2.2.11.2.3 Erection and dismantling wind

Irrespective of height, the minimum value for wind pressure shall be $q = 100 \text{ N/m}^2$, which corresponds to a wind velocity of $v_w = 12,5 \text{ m/s}$.

5.2.2.12 The calculation shall take into account errors of erection of at least 0,5 degrees.

5.2.2.13 Forces created by the lower buffers shall correspond to a retardation of 2 g unless a lower value of retardation can be verified.

Forces created by the upper buffers shall correspond to a retardation of 1 g unless a lower value of retardation can be verified.

5.2.3 Safety factors

5.2.3.1 Steel structures

a) Permissible stresses

$$\sigma_0 = \frac{f_y}{S_y}$$

where

— f_y = yield strength [N/mm²]

— S_y = safety factor on yield strength

b) Calculations according to the theory of the second order

The deflection of a structure shall be taken into account when calculating stresses. This is very important when calculating a slender design or using materials with a low modulus of elasticity. This can be done by using the theory of the 2nd order.

$$\sigma_0 = \frac{f_y}{S_y} \text{ or } \frac{f_y'}{S_y} \text{ whichever is the least favourable}$$

where

— f_y' = apparent yield strength [N/mm²]

The safety factors against f_y and f_y' shall be at least equal to those given in the following table 3 - Safety factors for steel structures, which is related to table 5 - load cases.

Table 3 — Safety factors for steel structures

Load Case	Safety Factor (S_y)
A	1,5
B	1,33
C	1,25

5.2.3.2 Aluminium structures

a) Permissible stresses

$$\sigma_0 = \frac{f_y}{S_y} \text{ or } \frac{f_u}{S_u} \text{ whichever gives the lowest value}$$

where

— f_u = tensile strength [N/mm²]

— S_u = safety factor on tensile strength

b) Calculations according to the theory of the second order

The deflection of a structure shall be taken into account when calculating stresses. This is very important when calculating a slender design or using materials with a low modulus of elasticity. This can be done by using the theory of the 2nd order.

$$\sigma_0 = \frac{f_y}{S_y} \text{ or } \frac{f_u}{S_u} \text{ whichever gives the lowest value}$$

The safety factors against f_y and f_u shall be at least equal to those given in the following table 4 - safety factors for aluminium structures, which is related to table 5 - load cases.

Table 4 — Safety factors for aluminium structures

Load case	Safety factor S_y on yield strength	Safety factor S_u on tensile strength
A	1,70	2,50
B	1,55	2,25
C	1,41	2,05

5.2.4 Load cases, the different combinations of loads and forces which are to be calculated

Table 5 — Load cases

Load case number	Load case for:	Forces and effects according to clause 5.2.2.(X) ¹⁾	Load case ²⁾
Ia	Normal use: (structural parts, incl. mast, mast ties, base frame and all other static parts of the structure)	(1) ³⁾ , (3), (11.2.1), (12) (2) multiplied by (8) (4) multiplied by (8)	A
Ib	Normal use: platform	(11.2.1) (2) multiplied by (8) (4) multiplied by (8)	A
IIa	Normal platform loading: masts	(1), (2), (3) (6), (11.2.1)	A
IIb	Normal platform loading: platform	(2), (6) (11.2.1)	A
IIIa	Exceptional forces: mast	(1) ³⁾ , (3), (7), (11.2.1), (12) (2) multiplied by (8) (5) multiplied by (8)	C
IIIb	Exceptional forces: platform	(7), (11.2.1) (2) multiplied by (8) (5) multiplied by (8)	C
IVa	Exceptional safety device effects: mast	(1) ³⁾ , (3), (11.2.1), (12) (2) multiplied by (9) (4) multiplied by (9)	C
IVb	Exceptional safety device effects: platform	(11.2.1) (2) multiplied by (9) (4) multiplied by (9)	C
IVc	Exceptional safety device effects: safety device	(2) multiplied by (9) (4) multiplied by (9)	C
V	Occasional out of service: mast	(1), (3), (11.2.2), (12)	B
VI	Exceptional buffer forces: Effects of the upper buffers on the mast and the platform Effects of the lower buffers on the platform	(1), (2), (7), (13) (1), (2), (4), (13)	C
VII	Separate supporting structure for the landings normal occasional	(3), (6), (11.2.1) (3), (11.2.2)	A B
VIII	Erection (structural parts, including mast, mast ties, base frame and all other static parts of the structure)	(1) ³⁾ , (3), (11.2.3), (12) (2) multiplied by (8) (4) multiplied by (8)	B

1) X refers to the relevant subsection of subclause 5.2.2. For example, for load case II b (normal platform loading, platform) the following forces and loads shall be taken into account: 5.2.2.2, 5.2.2.6 and 5.2.2.11.2.1. These are thus referred to in the table in the abbreviated form (2), (6), (11.2.1)

2) see table 3 and table 4

3) if the platform is guided by an expanding linkage mechanism, the dead load of the linkage mechanism has to be multiplied by the impact factor according to 5.2.2.8.