



**BSI Standards Publication**

# **Safety rules for the construction and installation of lifts — Special lifts for the transport of persons and goods**

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Part 44: Lifting appliances in wind turbines

## National foreword

This British Standard is the UK implementation of EN 81-44:2024.

The UK participation in its preparation was entrusted to Technical Committee MHE/4, Lifts, hoists and escalators.

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

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English Version

Safety rules for the construction and installation of lifts -  
Special lifts for the transport of persons and goods -  
Part 44: Lifting appliances in wind turbines

Règles de sécurité pour la construction et l'installation  
des élévateurs - Élévateurs particuliers destinés au  
transport des personnes et des matériaux -  
Partie 44 : Élévateurs pour éolienne

Sicherheitsregeln für die Konstruktion und Installation  
von Aufzügen - Besondere Aufzüge für den Transport  
von Personen und Gütern - Teil 44: Aufzüge in  
Windenergieanlagen

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COMITÉ EUROPÉEN DE NORMALISATION  
EUROPÄISCHES KOMITEE FÜR NORMUNG

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## European foreword

This document (EN 81-44:2024) 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of an identical text or by endorsement, at the latest by January 2025, and conflicting national standards shall be withdrawn at the latest by January 2025.

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

This document is part of the EN 81 series of standards. The structure of the EN 81 series is described in CEN/TR 81-10:2008.

This document has been prepared under a standardization request addressed to CEN by the European Commission. The Standing Committee of the EFTA States subsequently approves these requests for its Member States.

For the relationship with EU Legislation, see informative Annex ZA, which is an integral part of this document.

Any feedback and questions on this document should be directed to the users' national standards body. A complete listing of these bodies can be found on the CEN website.

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

## Introduction

This document is a type-C standard as stated in EN ISO 12100:2010.

This document is of relevance, in particular, for the following stakeholder groups representing the market players with regard to machinery safety:

- machine manufacturers (small, medium and large enterprises);
- health and safety bodies (regulators, accident prevention organizations, market surveillance etc.).

Others can be affected by the level of machinery safety achieved with the means of the document by the above-mentioned stakeholder groups:

- machine users/employers (small, medium and large enterprises);
- machine users/employees (e.g. trade unions, organizations for people with special needs);
- service providers, e.g. for maintenance (small, medium and large enterprises);
- consumers (in case of machinery intended for use by consumers).

The above-mentioned stakeholder groups have been given the possibility to participate at the drafting process of this document.

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

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

## 1 Scope

**1.1** This document specifies the safety requirements for the construction and installation of power operated lifting appliances installed permanently for indoor or outdoor service in wind turbines and intended for access to workplaces on wind turbines, including rescue and evacuation procedures. A lifting appliance serves defined landing levels and can move persons to working positions where they are carrying out work (which could be from the carrier) and has a carrier which is:

- a) designed for the transportation of persons and goods;
- b) guided;
- c) travelling vertically or along a path within 15° maximum from the vertical;
- d) supported or sustained by rack and pinion or rope traction drive;
- e) travelling with a speed not more than 0,7 m/s;
- f) able to operate in a temperature range between -25 °C to + 55 °C.

**1.2** This document does not cover hazards related to:

- a) noise;
- b) the use of the lifting appliance for erection or dismantling of the wind turbine;
- c) lightning protection;
- d) use in potentially explosive atmospheres;
- e) electromagnetic compatibility (emission, immunity);
- f) transporting of goods outside the carrier;
- g) the use of combustion engines;
- h) hydraulic and pneumatic drive units;
- i) the use of lifting appliances in floating wind turbines;
- j) use during earthquakes.

**1.3** This document is not applicable to lifting appliances manufactured before the date of its publication.

## 2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 81-20:2020, *Safety rules for the construction and installation of lifts — Lifts for the transport of persons and goods — Part 20: Passenger and goods passenger lifts*

EN 81-43:2009, *Safety rules for the construction and installation of lifts — Special lifts for the transport of persons and goods — Part 43: Lifts for cranes*

EN 81-50:2020, *Safety rules for the construction and installation of lifts — Examinations and tests — Part 50: Design rules, calculations, examinations and tests of lift components*

EN 795:2012, *Personal fall protection equipment — Anchor devices*

EN 894-1:1997+A1:2008, *Safety of machinery — Ergonomics requirements for the design of displays and control actuators — Part 1: General principles for human interactions with displays and control actuators*

EN 1808:2015, *Safety requirements for suspended access equipment — Design calculations, stability criteria, construction — Examinations and tests*

EN 1991-1-3:2003<sup>1</sup>, *Eurocode 1 — Actions on structures — Part 1-3: General actions — Snow loads*

EN 10264-1:2012, *Steel wire and wire products — Steel wire for ropes — Part 1: General requirements*

EN 10264-2:2021, *Steel wire and wire products — Steel wire for ropes — Part 2: Cold drawn non alloy steel wire for ropes for general applications*

EN 10264-3:2023, *Steel wire and wire products — Steel wire for ropes — Part 3: Round and shaped non alloyed steel wire for high duty applications*

EN 10264-4:2012, *Steel wire and wire products — Steel wire for ropes — Part 4: Stainless steel wire*

EN 12385-1:2002+A1:2008, *Steel wire ropes — Safety — Part 1: General requirements*

EN 12385-2:2002+A1:2008, *Steel wire ropes — Safety — Part 2: Definitions, designation and classification*

EN 12385-3:2020, *Steel wire ropes — Safety — Part 3: Information for use and maintenance*

EN 12385-4:2002+A1:2008, *Steel wire ropes — Safety — Part 4: Stranded ropes for general lifting applications*

EN 13001-2:2021, *Crane safety — General design — Part 2: Load actions*

EN 13411-1:2002+A1:2008, *Terminations for steel wire ropes — Safety — Part 1: Thimbles for steel wire rope slings*

EN 13411-2:2001+A1:2008, *Terminations for steel wire ropes — Safety — Part 2: Splicing of eyes for wire rope slings*

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<sup>1</sup> As impacted by EN 1991-1-3:2003/A1:2015 and EN 1991-1-3:2003/AC:2009.

- EN 13411-3:2022, *Terminations for steel wire ropes — Safety — Part 3: Ferrules and ferrule-securing*
- EN 13411-4:2021, *Terminations for steel wire ropes — Safety — Part 4: Metal and resin socketing*
- EN 13411-5:2003+A1:2008, *Terminations for steel wire ropes — Safety — Part 5: U-bolt wire rope grips*
- EN 13411-6:2004+A1:2008, *Terminations for steel wire ropes — Safety — Part 6: Asymmetric wedge socket*
- EN 13411-7:2021, *Terminations for steel wire ropes — Safety — Part 7: Symmetric wedge socket*
- EN 60204-1:2018, *Safety of machinery — Electrical equipment of machines — Part 1: General requirements (IEC 60204-1:2016)*
- EN 60529:1991<sup>2</sup>, *Degrees of protection provided by enclosures (IP Code) (IEC 60529:1989)*
- EN IEC 60947-4-1:2019<sup>3</sup>, *Low-voltage switchgear and controlgear — Part 4-1: Contactors and motor-starters — Electromechanical contactors and motor-starters (IEC 60947-4-1:2018)*
- EN 60947-5-1:2017<sup>4</sup>, *Low-voltage switchgear and controlgear — Part 5-1: Control circuit devices and switching elements — Electromechanical control circuit devices (IEC 60947-5-1:2016)*
- EN ISO 12100:2010, *Safety of machinery — General principles for design — Risk assessment and risk reduction (ISO 12100:2010)*
- EN ISO 13849-1:2023, *Safety of machinery — Safety-related parts of control systems — Part 1: General principles for design (ISO 13849-1:2023)*
- EN ISO 13850:2015, *Safety of machinery — Emergency stop function — Principles for design (ISO 13850:2015)*
- EN ISO 13851:2019, *Safety of machinery — Two-hand control devices — Principles for design and selection (ISO 13851:2019)*
- EN ISO 13854:2019, *Safety of machinery — Minimum gaps to avoid crushing of parts of the human body (ISO 13854:2017)*
- EN ISO 13857:2019, *Safety of machinery — Safety distances to prevent hazard zones being reached by upper and lower limbs (ISO 13857:2019)*
- EN ISO 14119:2013, *Safety of machinery — Interlocking devices associated with guards — Principles for design and selection (ISO 14119:2013)*
- EN ISO 14122-3:2016, *Safety of machinery — Permanent means of access to machinery — Part 3: Stairs, stepladders and guard-rails (ISO 14122-3:2016)*
- EN ISO 14122-4:2016, *Safety of machinery — Permanent means of access to machinery — Part 4: Fixed ladders (ISO 14122-4:2016)*

<sup>2</sup> As impacted by EN 60529:1991/AC:2016-12, EN 60529:1991/A1:2000, EN 60529:1991/A2:2013 and EN 60529:1991/A2:2013/AC:2019-02.

<sup>3</sup> As impacted by EN IEC 60947-4-1:2019/AC:2021-04 and EN IEC 60947-4-1:2019/AC:2020-05.

<sup>4</sup> As impacted by EN 60947-5-1:2017/AC:2020-05.

ISO 6336-1:2019, *Calculation of load capacity of spur and helical gears — Part 1: Basic principles, introduction and general influence factors*

ISO 6336-2:2019, *Calculation of load capacity of spur and helical gears — Part 2: Calculation of surface durability (pitting)*

ISO 6336-3:2019, *Calculation of load capacity of spur and helical gears — Part 3: Calculation of tooth bending strength*

ISO 6336-5:2016, *Calculation of load capacity of spur and helical gears — Part 5: Strength and quality of materials*

### 3 Terms, definitions, symbols and abbreviated terms

#### 3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in EN ISO 12100:2010, EN 81-43:2009 and the following apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

- IEC Electropedia: available at <https://www.electropedia.org/>
- ISO Online browsing platform: available at <https://www.iso.org/obp>

##### 3.1.1

##### **lifting appliance**

machine with a carrier which is guided and intended for transport between different levels

##### 3.1.2

##### **base frame**

lowest framework of the rack and pinion lifting appliance upon which all other components are mounted

[SOURCE: EN 81-43:2009, definition 3.7, modified – term “rack and pinion” added, term “lift” replaced with “lifting appliance”]

##### 3.1.3

##### **carrier**

load carrying unit including floor, walls, doors and roof

[SOURCE: EN 81-43:2009, 3.13, definition modified]

##### 3.1.4

##### **interlocking device**

##### **interlock**

mechanical, electrical or other type of device, the purpose of which is to prevent the operation of hazardous machine functions under specified conditions (generally as long as a guard is not closed)

[SOURCE: EN ISO 12100:2010, 3.28.1]

**3.1.5****guard locking device**

device intended to lock a guard in the closed position and linked to the control system

Note 1 to entry: Interlocking device [3.1.4] with additional function of keeping the guard locked when the hazardous machine functions are in operation.

[SOURCE: EN ISO 14119:2013, 3.4]

**3.1.6****landing**

level in the wind turbine intended for loading and unloading the carrier (3.1.3)

[SOURCE: EN 81-43:2009, 3.21, modified]

**3.1.7****landing zone**

zone, extending above and below the landing level, in which the carrier floor has to be to enable the corresponding landing door to be unlocked

**3.1.8****overspeed safety device**

mechanical device for stopping and maintaining stationary the carrier in the event of over-speed

**3.1.9****fall arrest device**

mechanical device for stopping and maintaining stationary the carrier in the event of drive wire rope failure

**3.1.10****evacuation**

specific actions required to safely release persons entrapped in the carrier without external help

**3.1.11****rescue**

specific actions required to safely release persons entrapped in the carrier

**3.1.12****rigid guiding**

guiding means where the carrier is guided by rigid rail or profile (e.g. mast guiding or ladder guiding)

**3.1.13****mast guiding**

structure that supports and guides the carrier

**3.1.14****ladder guiding**

ladder that guides the carrier and that can be used for climbing

**3.1.15****obstruction detection device**

protective equipment detecting obstacles during the travel of the carrier (i.e. persons or objects)

**3.1.16**

**working load limit**

**WLL**

maximum load that a drive unit, fall arrest device and/or an overspeed safety device is authorized to sustain as designated by the manufacturer

**3.1.17**

**rated load**

**$m_H$**

load of persons and/or equipment that a lifting appliance has been designated to carry by the manufacturer in normal use

**3.1.18**

**traction hoist drive**

assembly through which a wire rope is conveyed as a result of friction between the wire rope and the traction assembly with no tail load

**3.1.19**

**rope guiding**

guiding by means of tensioned steel wire ropes that prevent the carrier from swinging and rotating while being stationary and during travel

**3.1.20**

**drive wire rope**

active wire rope carrying the suspended load

**3.1.21**

**secondary wire rope**

wire rope not normally carrying the suspended load but rigged to work in conjunction with a fall arrest device

**3.1.22**

**buffer**

resilient stop at the end of travel comprising a means of braking using fluids or springs (or other similar means, e.g. rubber)

**3.1.23**

**vision panel**

transparent or perforated panel intended to provide a line of sight inside or outside the carrier

**3.1.24**

**pit**

recessed area, which is part of the liftway and has closed sides and is only accessible from above through the liftway

### 3.2 Symbols and abbreviations

| Symbols,<br>abbreviations | Description                                                                                |
|---------------------------|--------------------------------------------------------------------------------------------|
| $A_{ref}$                 | Area of the lifting appliance on which the wind acts                                       |
| $C_e$                     | Exposure coefficient related to snow loads                                                 |
| $D$                       | Pulley pitch diameter                                                                      |
| $F_{min}$                 | Minimum breaking load of wire rope                                                         |
| $F_w$                     | Wind load                                                                                  |
| $H$                       | Pitch ratio                                                                                |
| $S$                       | Maximum tensile load in the rope                                                           |
| $S_c$                     | Snow load on the carrier                                                                   |
| $S_k$                     | Characteristic value of snow load on the ground                                            |
| $S_d$                     | Shock load coefficient                                                                     |
| $St$                      | Test load                                                                                  |
| $Tm$                      | Dynamic tensile force                                                                      |
| $WLL$                     | Working load limit                                                                         |
| $Z_p$                     | Drive rope factor                                                                          |
| $c_a$                     | Aerodynamic coefficient                                                                    |
| $d$                       | Rope diameter                                                                              |
| $f_{Rd}$                  | Limit design stress                                                                        |
| $f_{Rd\sigma}$            | Limit design normal stress                                                                 |
| $f_{Rd\tau}$              | Limit design shear stress                                                                  |
| $f_u$                     | Ultimate strength                                                                          |
| $f_y$                     | Yield strength (= $f_o$ in Eurocode 9)                                                     |
| $m_c$                     | Mass of unloaded carrier                                                                   |
| $m_e$                     | Mass of tools and equipment                                                                |
| $m_H$                     | Rated load                                                                                 |
| $m_m$                     | Mass of material in the lifting appliance                                                  |
| $m_p$                     | Assumed mass of a person                                                                   |
| $m_{pc}$                  | Mass of the power and control cables                                                       |
| $m_{pce}$                 | Partial mass of the power cable based on traveling height depending on the overload system |
| $m_R$                     | Mass of the drive ropes (for traction hoist drive)                                         |

| Symbols, abbreviations | Description                                                                                    |
|------------------------|------------------------------------------------------------------------------------------------|
| $m_{Re}$               | Partial mass of the drive wire rope based on traveling height depending on the overload system |
| $m_w$                  | Mass of the tension weights (for traction hoist drive)                                         |
| $n$                    | Number of persons in the lifting appliance                                                     |
| $n_r$                  | Number of load carrying ropes                                                                  |
| $q$                    | Wind pressure                                                                                  |
| $v_{ref}$              | Reference storm wind speed                                                                     |
| $\gamma_f$             | Material safety factor for parts with continuous stress                                        |
| $\gamma_m$             | Resistance coefficient                                                                         |
| $\gamma_p$             | Partial safety factor for load                                                                 |
| $\mu_1$                | Impact factor                                                                                  |
| $\mu_1(0^\circ)$       | Snow load shape coefficient                                                                    |
| $\sigma_a$             | Allowable stress                                                                               |
| $\sigma_c$             | Calculated stress                                                                              |
| $\sigma_{Sd}$          | Design normal stress                                                                           |
| $\varphi_7$            | Dynamic factor due to buffer loads                                                             |
| $\tau_{Sd}$            | Design shear stress                                                                            |

## 4 List of significant hazards

Significant hazards are listed in Annex F, Table F.1.

## 5 Safety requirements

### 5.1 General

Machinery shall comply with the safety requirements and/or protective/risk reduction measures of this clause. In addition, the machine shall be designed according to the principles of EN ISO 12100:2010 for relevant but not significant hazards which are not dealt with by this document.

### 5.2 Loads and calculations

#### 5.2.1 Design loads

##### 5.2.1.1 General

All suspended loads shall be taken into account (i.e. including power cables, cable trolley, ropes and tension weights) which are subject to the component of part reviewed.

### 5.2.1.2 Dead weights

The following masses are part of the total dead weight and shall be taken into account in calculations related to the lifting appliance and the lifting appliance components:

- $m_c$  is mass of the unloaded carrier;
- masses of all additional equipment which moves together with the lifting appliance in the load combination concerned and partial masses based on travelling height depending on the overload system design which moves together with the lifting appliance such as:
  - $m_R$  is total mass of the drive wire ropes (only traction hoist drive);
  - $m_{pc}$  is total mass of the power and control cables;
  - $m_w$  is total mass of the tension weights (only traction hoist drive);
  - $m_{Re}$  is partial mass of drive wire rope (only traction hoist drive) from the carrier to the suspension beam or maximum distance between landings if the lifting appliance control is designed to stop the lifting appliance at landings during movement in case of overload;
  - $m_{pce}$  is partial mass of power cables from the carrier to the top landing (trailing cable configuration) or from the carrier to the cable suspension point (travelling cable configuration). Alternatively, the maximum distance between landings shall be used if the lifting appliance control is designed to stop the lifting appliance at landings during movement in case of overload.

Depending on the overload system design (according to 5.8.4) and the different load combinations (see 5.2.2), the dead weights are calculated from following mass combinations:

- 1) Load combinations: A, B, C1, C3, C4, C5 and C6

The following masses shall be considered for overload system Type 1:  $m_c, m_{pc}, m_{Re}, m_{pce}$

The following masses shall be considered for overload system Type 2 and Type 3:  $m_c, m_{pc}, m_{pce}$

- 2) Load combination: C2

The following masses shall be considered for overload system Type 1:  $m_c, m_{pc}, m_{Re}, m_{pce}, m_R, m_w$

The following masses shall be considered for overload system Type 2 and Type 3:  $m_c, m_{pc}, m_{pce}, m_R, m_w$

### 5.2.1.3 Rated loads in the lifting appliance

The rated load  $m_H$  of the lifting appliance and the maximum number of persons (n) permitted in the lifting appliance are to be stated by the lifting appliance manufacturer.

When calculating the lifting appliance and every related part, the following rated loads shall be taken into account as a minimum:

$$\text{for one person} \quad m_H = m_p + m_e + m_m \quad (\text{Minimum for 1 person: } m_H = 120 \text{ kg}) \quad (1)$$

$$\text{for two persons} \quad m_H = (2 \times m_p) + (2 \times m_e) + m_m \quad (\text{Minimum for 2 persons: } m_H = 240 \text{ kg}) \quad (2)$$

$$\text{for three or more persons} \quad m_H = (n \times m_p) + (1,5 \times m_e) + m_m \quad (3)$$

where

- $m_H$  is rated load;
- $m_p$  is 80 kg (mass of person);
- $m_e$  is 40 kg (mass of tools and equipment);
- $m_m$  is the mass of other possible material in the lifting appliance (can be 0 kg);
- $n$  is number of persons.

The rated load is evenly distributed over the floor area of the carrier. Where the uniform distribution of the rated load over the full area of the carrier floor is less than 4,0 kN/m<sup>2</sup> then, for calculation purposes of the floor, a minimum of 4,0 kN/m<sup>2</sup> shall be placed over the whole area of the carrier floor.

#### 5.2.1.4 Effect of friction forces

The friction forces acting on the carrier generated by guiding means and transmission chain shall be taken into account, see Table 2.

#### 5.2.1.5 Loads exerted by persons

##### 5.2.1.5.1 General

When calculating the lifting appliance and every related part, the following loads, exerted by persons, shall be taken into account.

Walls shall be capable of withstanding a load of 300 N applied normally at the least favourable point without permanent deformation. The load shall be applied by pulling or pushing over a flat area of 100 mm × 100 mm. For elastic deformation, see 5.6.3.

Carrier doors and vision panels and their guides shall be capable of withstanding a load of 300 N applied normally at any position without permanent deformation. The load shall be applied by pulling or pushing over a flat area of 5 cm<sup>2</sup>.

##### 5.2.1.5.2 Individual loads (not to be combined with other loads)

The carrier floor surface shall be designed to withstand without permanent deformation a local static load of 1,5 kN applied on the least favourable square area of 0,2 m × 0,2 m.

If the carrier roof is accessible, it shall be designed to withstand

- an evenly distributed load of at least 3,0 kN placed on the least favourable square area of 1,0 m<sup>2</sup>. If the roof area is smaller than 1,0 m<sup>2</sup>, 3,0 kN shall be applied to the full roof area;
- a local static load of 1,2 kN applied on the least favourable square area of 0,2 m × 0,2 m without permanent deformation.

The full height landing gates shall be designed to withstand, without permanent deformation and without elastic deformation greater than 15 mm, a local static load of 300 N at the least favourable point on either face, using a rigid square or round flat face of 5 cm<sup>2</sup>.

The reduced height landing gates shall be designed to withstand, without permanent deformation, a local static load of 1 kN vertically applied at the least favourable point along the top of the gate.

The same values for the resistance coefficient for materials as in the load combination A from Table 3 shall be used for the above-mentioned load cases in this clause.

The reduced height landing gates shall be designed to withstand horizontal loads according to EN ISO 14122-3:2016, 8.1 and 8.2, with a minimum horizontal load of 300 N.

#### 5.2.1.5.3 Loads caused by falling person

When calculating the structure where the anchor device is attached, a load of a falling person of 6 kN shall be taken into account (for safety factors see Table 2).

When more than 1 anchor device is attached to the carrier, it is assumed that loads can't occur in more than one anchor device at the same time, so the structure shall be calculated for each anchor device separately, not for all the anchor devices at the same time.

#### 5.2.1.6 Wind loads for outside operating lifting appliances

##### 5.2.1.6.1 Formulas for calculation of the wind loads

Wind loads shall be calculated according to EN 13001-2:2021.

$$F_w = q \times c_a \times A_{ref} \quad (4)$$

where

$F_w$  is the wind load acting perpendicularly to the longitudinal axis of the member under consideration;

$q$  is the wind pressure:  $q(3)$  in service,  $q(z)$  out of service;

$c_a$  is the aerodynamic coefficient of the member under consideration.

The coefficient  $c_a$  shall be used in combination with the characteristic area  $A_{ref}$ . Values of  $c_a$  shall be those from EN 13001-2:2021, Annex A. For the carrier, it shall be assumed that the carrier walls are solid and an aerodynamic coefficient  $c_a$  of 1,2 shall be applied. The factor 1,2 covers both the shape factor and the shielding factor.

Wind loads are assumed to act horizontally at the centre of the area of the component parts of the lifting appliance in any direction. The least favourable direction shall be taken into account.

The wind loads acting on a lifting appliance shall be considered to be acting on the suspension points and/or on relevant tower interface components.

##### 5.2.1.6.2 Lifting appliances in service

The wind pressure to consider is  $q(3) = 250 \text{ N/m}^2$  (wind speed  $v_{(3)} = 20 \text{ m/s}$ ).

##### 5.2.1.6.3 Lifting appliances out of service

The wind pressure  $q(z)$  is as defined in EN 13001-2:2021, 4.2.4.2.

When available, detailed (national) wind maps or local meteorological data shall be used as sources for the reference storm wind velocities  $v_{ref}$  e.g. EN 1991-1-4:2005<sup>5</sup>. In the absence of more precise data, a storm wind map of Europe given in Figure 1 can be used. This indicates the regions, where the same reference storm wind velocities are applicable. The reference storm wind velocities for these regions are given in Table 1.

<sup>5</sup> As impacted by EN 1991-1-4:2005/A1:2010 and EN 1991-1-4:2005/AC:2010.

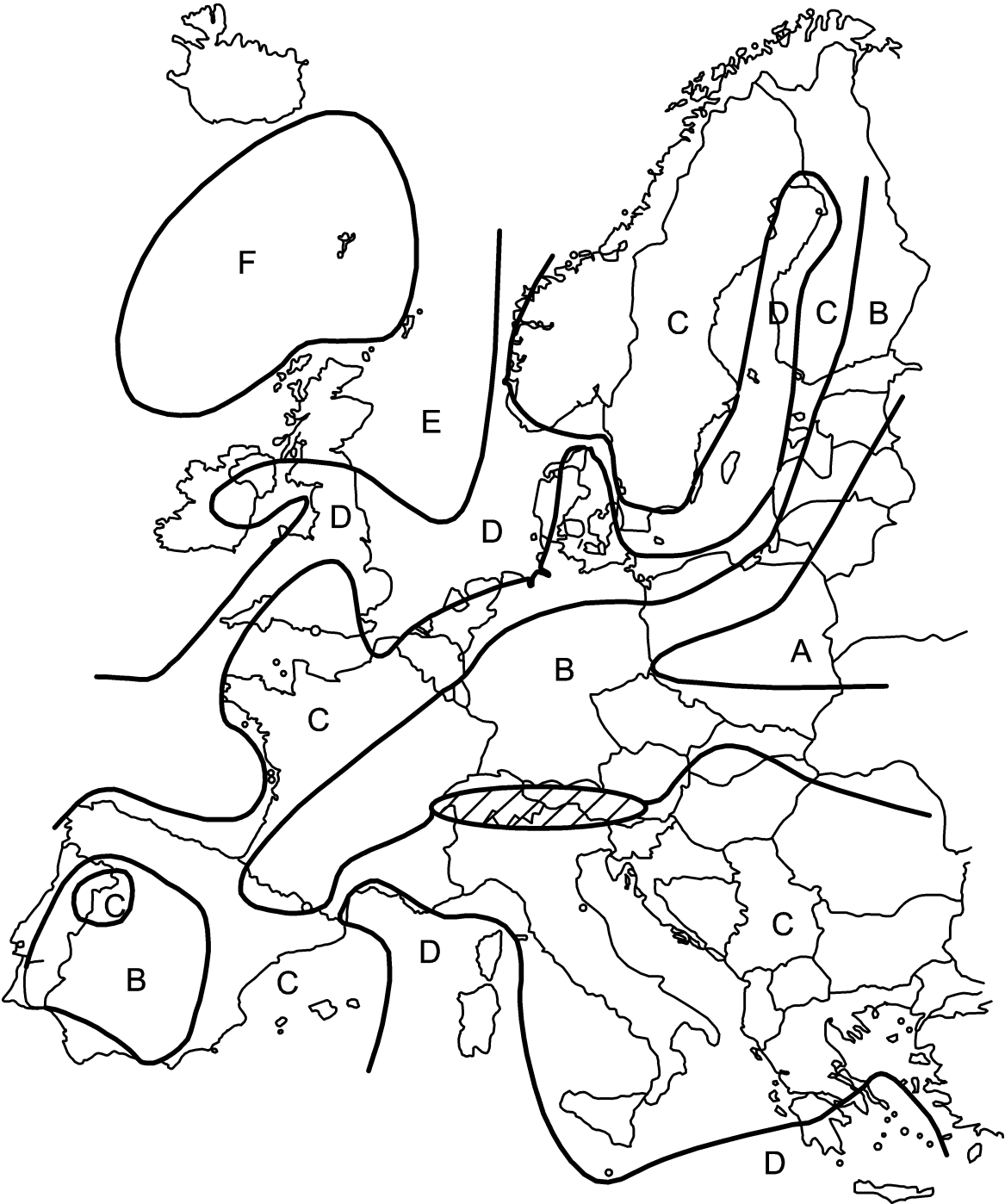


Figure 1 — Map of Europe indicating regions where the same reference storm wind velocities are applicable

Table 1 — Reference storm wind speeds in dependence on regions in Europe as shown in Figure 1

| Region          | A / B | C  | D  | E  |
|-----------------|-------|----|----|----|
| $v_{ref}$ [m/s] | 24    | 28 | 32 | 36 |

NOTE Figure 1 and Table 1 are from EN 13001-2:2021.

Reference storm wind velocity shall be separately specified and applied in the design for lifting appliances used in region F, where  $v_{ref} \geq 36$  m/s.

#### 5.2.1.7 Loads caused by snow or ice

Where relevant, snow and ice loads shall be specified and taken into account. Snow load is considered as a dead load located on the roof of the carrier.

Snow load shall be calculated as follows:

$$S_c = \mu_1(0^\circ) C_e S_k \text{ [kN/m}^2\text{]} \quad (5)$$

where

- $\mu_1(0^\circ)$  is snow load shape coefficient. In general, the snow is prevented from sliding off the roof and  $\mu_1(0^\circ)$  shall be at least 0,8;
- $C_e$  is exposure coefficient.  $C_e$  shall be taken from Table 5.1 of EN 1991-1-3:2003<sup>1</sup>;
- $S_k$  is characteristic value of snow load on the ground.  $S_k$  shall be calculated using areal equations in Table C.1 of EN 1991-1-3:2003<sup>1</sup>.

#### 5.2.1.8 Loads caused by temperature variation

The load bearing structures shall be designed to ensure that thermal movement will not cause overstressing of the structure.

#### 5.2.1.9 Loads caused by buffers

Where applicable, loads created by the buffers shall be calculated allowing for an average deceleration of 1 g or lower if actual value. Effect of the buffer on the carrier and on the pit or base shall be taken into account.

#### 5.2.1.10 Seismic loads

Seismic movements shall be taken into account by choosing the load combination C6, considering the lifting appliance is out of service and no load is carried in the carrier.

The calculation method could be equivalent static analysis or dynamic analysis. The calculation shall be carried out using the local spectrums.

### 5.2.2 Load combinations

The following sets of load combination shall be considered:

- A: Regular loads

Normal use of lifting appliance with regular loads (dead weight, rated loads);

- B: Occasional loads

Normal use combined with occasional loads (in-service wind, snow and ice, temperature);

- C: Exceptional loads

Normal use combined with exceptional loads (personal falling accident, triggering of overspeed safety device, in and out of service wind, collision to buffers, overload).

NOTE In some applications a load from load combinations B occurs frequently enough to require inclusion in the fatigue assessment. The stresses from these exceptional loads are handled in the same way as those from the regular loads.

**Table 2 — Load combinations and safety factors**

| Category of loads      | Clause in this document                                                                                                                                                                                           | Loads                                                 | No. | Load combinations A | Load combinations B | Load combinations C |         |     |                           |     |    |
|------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------|-----|---------------------|---------------------|---------------------|---------|-----|---------------------------|-----|----|
|                        |                                                                                                                                                                                                                   |                                                       |     |                     |                     | C1                  | C2      | C3  | C4                        | C5  | C6 |
| A<br>Regular loads     | 5.2.1.2                                                                                                                                                                                                           | All dead weights with the exception of the carrier    | 1   | 1,7                 | 1,7                 | 1,1                 | $\mu_1$ | 1,1 | 1,1                       | 1,1 |    |
|                        | 5.2.1.2                                                                                                                                                                                                           | Dead weight of the unloaded carrier                   | 2   | 1,7                 | 1,7                 | 1,1                 | $\mu_1$ | 1,1 | 1,1                       | 1,1 |    |
|                        | 5.2.1.3                                                                                                                                                                                                           | Rated load by persons and material evenly distributed | 3   | 1,7                 | 1,7                 | 1,1                 | $\mu_1$ |     | 1,1                       | 1,3 |    |
|                        | 5.2.1.5.1                                                                                                                                                                                                         | Loads exerted by persons                              | 4   | 1,35                | 1,35                |                     |         |     | 1,1                       |     |    |
|                        | 5.2.1.4                                                                                                                                                                                                           | Friction forces                                       |     | 1,1                 | 1,1                 |                     |         |     |                           |     |    |
| B<br>Occasional loads  | 5.2.1.6.2                                                                                                                                                                                                         | In-service wind loads                                 | 5   |                     | 1,16                |                     | 1,1     |     |                           |     |    |
|                        | 5.2.1.7                                                                                                                                                                                                           | Snow and ice                                          | 6   |                     | 1,35                | 1,1                 | $\mu_1$ |     |                           |     |    |
|                        | 5.2.1.8                                                                                                                                                                                                           | Temperature                                           | 7   |                     | 1,16                |                     |         |     |                           |     |    |
| C<br>Exceptional loads | 5.2.1.5.3                                                                                                                                                                                                         | Personal falling accident                             | 8   |                     |                     | 1,5                 |         |     |                           |     |    |
|                        | 5.2.1.6.3                                                                                                                                                                                                         | Out-of-service wind loads                             | 9   |                     |                     |                     |         | 1,1 |                           |     |    |
|                        | 5.2.1.9                                                                                                                                                                                                           | Loads created by the buffers                          | 10  |                     |                     |                     |         |     | 1,1<br>$\times \varphi_7$ |     |    |
|                        | 5.2.1.10                                                                                                                                                                                                          | Seismic loads / accelerations                         | 12  |                     |                     |                     |         |     |                           |     | 1  |
| $\varphi_7$            | Dynamic factor due to buffer loads, see EN 13001-2:2021.                                                                                                                                                          |                                                       |     |                     |                     |                     |         |     |                           |     |    |
| $\mu_1$                | Impact factor caused by triggering of overspeed safety device or fall arrest device:<br>Maximum impact factor from the lifting appliance drop tests ( $S_d$ , see A.2.10) or 3 (maximum allowable impact factor). |                                                       |     |                     |                     |                     |         |     |                           |     |    |
| A                      | Normal use of the lifting appliance with regular loads                                                                                                                                                            |                                                       |     |                     |                     |                     |         |     |                           |     |    |
| B                      | Load combination A combined with wind in service, snow and ice, temperature (only when operating outside)                                                                                                         |                                                       |     |                     |                     |                     |         |     |                           |     |    |
| C1                     | Personal falling accident                                                                                                                                                                                         |                                                       |     |                     |                     |                     |         |     |                           |     |    |
| C2                     | Triggering of fall arrest device or overspeed safety device                                                                                                                                                       |                                                       |     |                     |                     |                     |         |     |                           |     |    |
| C3                     | Wind loads for outside operating lifting appliances – Lifting appliance out of service condition                                                                                                                  |                                                       |     |                     |                     |                     |         |     |                           |     |    |
| C4                     | Carrier contacts the buffer                                                                                                                                                                                       |                                                       |     |                     |                     |                     |         |     |                           |     |    |
| C5                     | Overload condition                                                                                                                                                                                                |                                                       |     |                     |                     |                     |         |     |                           |     |    |
| C6                     | Lifting appliance out of service condition                                                                                                                                                                        |                                                       |     |                     |                     |                     |         |     |                           |     |    |

### 5.2.3 Calculation of static and fatigue strength

#### 5.2.3.1 Load-bearing structures

##### 5.2.3.1.1 General

For the defined load combinations, the calculation of the different members of structures is set out allowing a safety margin for the critical stresses. The following common failure modes shall be taken into account:

- limit of strength exceeded (yield, ultimate);
- elastic instability;
- fatigue limit exceeded;
- deformation limits exceeded.

##### 5.2.3.1.2 Limit design stresses for steel and aluminium structures

The limit design stress  $f_{Rd}$ , used for the design of structural members, shall be calculated as follows:

$$f_{Rd\sigma} = \frac{f_y}{\gamma_m} \quad (6)$$

$$f_{Rd\tau} = \frac{f_y}{\sqrt{3} \gamma_m} \quad (7)$$

where

- $f_{Rd\sigma}$  is limit design normal stress;
- $f_{Rd\tau}$  is limit design shear stress;
- $f_y$  is the nominal value of the yield strength of the material;
- $\gamma_m$  is resistance coefficient.

**Table 3 — Resistance coefficient for materials**

|                                   | Material  | Load combination A | Load combination B | Load combination C |
|-----------------------------------|-----------|--------------------|--------------------|--------------------|
| Resistance coefficient $\gamma_m$ | Steel     | 1,1                | 1,1                | 1,1                |
|                                   | Aluminium | 1,27               | 1,27               | 1,27               |

For the structural member to be designed it shall be proven that:

$$\sigma_{Sd} \leq f_{Rd\sigma} \text{ and } \tau_{Sd} \leq f_{Rd\tau}$$

where

$\sigma_{Sd}$  and  $\tau_{Sd}$  are the design stresses. In case von Mises equivalent stress is used,  $\sigma_{Sd}$  is the limit design stress;

$f_{Rd\sigma}$  and  $f_{Rd\tau}$  are the corresponding limit design stresses. In case von Mises equivalent stress is used,  $f_{Rd}$  is the limit design stress.

#### 5.2.3.1.3 Checks against fatigue of structures

For parts subject to fatigue of the lifting appliance structures the minimum number of load cycles shall be 31 500 using the load spectrum factor 1,0.

The proof of fatigue strength shall be executed by applying the load combination A, setting all partial safety factors  $\gamma_p = 1$ .

#### 5.2.3.1.4 Check of the carrier structure during fall arrest device activation (Load combination C2)

For load combination C2, the following acceptance criteria apply:

$$\sigma_c < f_u$$

where

$\sigma_c$  is calculated stress;

$f_u$  is ultimate strength.

An additional calculation based on load combination C2 shall be performed where variable weights based on travelling height dead weights ( $m_{Re}$  and  $m_{PCe}$ ) shall not be considered. This calculation shall be checked according to 5.2.3.1.2.

#### 5.2.3.2 Mechanisms

##### 5.2.3.2.1 General

Components of mechanisms, such as shafts, gears, bearings, shall be designed taking into account the failures caused by dynamic load, fractures, crippling, fatigue and excessive wear.

##### 5.2.3.2.2 Calculation against breaking

In the calculation of the mechanisms on strength against breaking is checked, whether the calculated stress is not greater than the permissible stress, which is dependent on the breaking strength of the material used.

The calculated stress  $\sigma_c$  shall be smaller or equal than the allowable stress  $\sigma_a$  obtained by dividing  $f_u$  by a material safety factor  $\gamma_f$  depending on the load combinations set out in Table 4.

$$\sigma_a = \frac{f_u}{\gamma_f} \text{ for normal stress} \quad (8)$$

$$\sigma_a = \frac{f_u}{\sqrt{3}\gamma_f} \text{ for shear stress} \quad (9)$$

where

- $\sigma_a$  is allowable stress;  
 $f_u$  is ultimate strength;  
 $\gamma_f$  is material safety factor for parts with continuous stress.

**Table 4 — Value of  $\gamma_f$  for carbon steel and stainless steel**

|                             | <b>Load combination A</b> | <b>Load combination B</b> | <b>Load combination C</b> |
|-----------------------------|---------------------------|---------------------------|---------------------------|
| Value of $v_R$              | 2,2                       | 2,2                       | 1,8                       |
| Allowable stress $\sigma_a$ | $f_u / 2,2$               | $f_u / 2,2$               | $f_u / 1,8$               |

For the ultimate strength  $f_u$  of the material see the specific standards and literature.

### 5.2.3.2.3 Calculation against fatigue and wear

#### 5.2.3.2.3.1 General

A fatigue stress analysis shall be made for all mechanisms, load bearing components and joints which are critical to fatigue (e.g. shafts and gearing). This analysis shall take into account the degree of stress fluctuation and the number of stress cycles, which can be a multiple of the number of load cycles.

The determination of the number of stress cycles and load spectrum, the predictable use of lifting appliance shall be taken into account. As a minimum, the manufacturer shall take the following into account for parts subject to fatigue and wear of the driving mechanism (e.g. hoists, gears), except for surfaces in contact with wire ropes:

- 50 % of the movements with 50 % of the rated load in the carrier;
- 50 % of the movements with rated load in the carrier;
- for the calculation of the drives each movement consists of acceleration from rest to rated speed travel at rated speed for nominal travel distance – deceleration to full stop;
- operating hours 250 h.

NOTE Resistance against wear of sheaves can be determined by tests.

For each component the least favourable combination of upwards and downwards movements shall be taken into account.

Each shaft shall possess a minimum safety factor of 1,5 for rolled and forged steel against the appropriate endurance limit, taking into account all notch effects.

#### 5.2.3.2.3.2 Rack and pinion

Each pinion shall possess a minimum safety factor of 2,0 against the endurance limit for tooth strength, taking into account the maximum wear as stated in the manufacturer's instruction handbook. Each pinion shall possess a minimum safety factor of 1,4 against the endurance limit for pitting.

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

#### 5.2.4 Calculation for the suspension

Suspensions shall be designed and constructed to withstand the loads derived from the static and dynamic tests and any additional dynamic loads caused by a failure of a hoist or drive wire rope.

The loads producing lateral sway can be caused by wind, movement of the platform or surges caused by the starting and stopping of the lifting appliance.

#### 5.2.5 Calculation for drive and secondary wire ropes

##### 5.2.5.1 General

These requirements apply to all drive and secondary wire ropes involved directly or indirectly in supporting a carrier.

Drive and secondary wire rope shall be the same type.

Maximum tensile load in the rope,  $S$ , is equal to the  $WLL$  of the hoist divided by the number ( $n_r$ ) of drive wire ropes used in that hoist carrying the suspended load.

$$S = WLL / n_r \quad (10)$$

where

$WLL$  is working load limit of the drive unit;

$n_r$  is number of load carrying ropes.

The calculated drive wire rope factor  $Z_p$  of the drive wire rope shall be as follows:

$$Z_p = F_{min} / S \quad (11)$$

where

$Z_p$  is equal to or greater than 10;

$F_{min}$  is minimum breaking load of the wire rope.

##### 5.2.5.2 Proof of fatigue strength of drive wire ropes

The design life of the rope in cycles or hours shall be defined by lifting appliance manufacturer. Fatigue strength of rope shall be proven by calculations or by tests according to B.2.6.

#### 5.2.6 Calculation methods

Guidance on suitable standards for calculation methods is given in Annex G.

### 5.3 Liftway protection, base enclosure and landing access

#### 5.3.1 General

A lifting appliance, when installed for use, shall have a dedicated travel path and protected landings.

Depending on the rated speed and the use of obstruction detection devices the liftway shall be protected with suitable solutions, see Table 5.

**Table 5 — Criteria for liftway protection**

| Type of lifting appliance                                                                                                                                      | Base enclosure                           |                                             |                                                  | Liftway protection                       |                                             |                                                  |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------|---------------------------------------------|--------------------------------------------------|------------------------------------------|---------------------------------------------|--------------------------------------------------|
|                                                                                                                                                                | Full height landing protection (5.3.3.3) | Reduced height landing protection (5.3.3.4) | Open reduced height landing protection (5.3.3.4) | Full height landing protection (5.3.3.3) | Reduced height landing protection (5.3.3.4) | Open reduced height landing protection (5.3.3.4) |
| Lifting appliance with speed $\leq 0,4$ m/s no obstruction detection device                                                                                    | x                                        |                                             |                                                  | x                                        |                                             |                                                  |
| Lifting appliance with speed $\leq 0,4$ m/s with obstruction detection device on bottom                                                                        | x                                        | x                                           | x                                                | x                                        | x                                           |                                                  |
| Lifting appliance with speed $\leq 0,4$ m/s with obstruction detection device on top and bottom                                                                | x                                        | x                                           | x                                                | x                                        | x                                           | x                                                |
| Lifting appliance with speed $> 0,4$ m/s                                                                                                                       | x                                        |                                             |                                                  | x                                        |                                             |                                                  |
| Lifting appliance with speed $\leq 0,4$ m/s and no obstruction detection device and distance from inside of the landing protection to the carrier $\geq 0,5$ m | x                                        | x                                           | x                                                | x                                        | x                                           | x                                                |

### 5.3.2 Liftway protection

#### 5.3.2.1 General

The liftway protection shall withstand the same load as landing gates, see 5.2.1.5.2.

All safety distances where not already stated in this standard, shall comply with EN ISO 13857:2019. All gaps to avoid crushing of parts of the human body shall comply with EN ISO 13854:2019.

#### 5.3.2.2 Clearance around the carrier

In the landings and base enclosure, the liftway protection according to Table 5 is required. In other cases, provisions in Table 6 are required (i.e. on partial platforms, ladders).

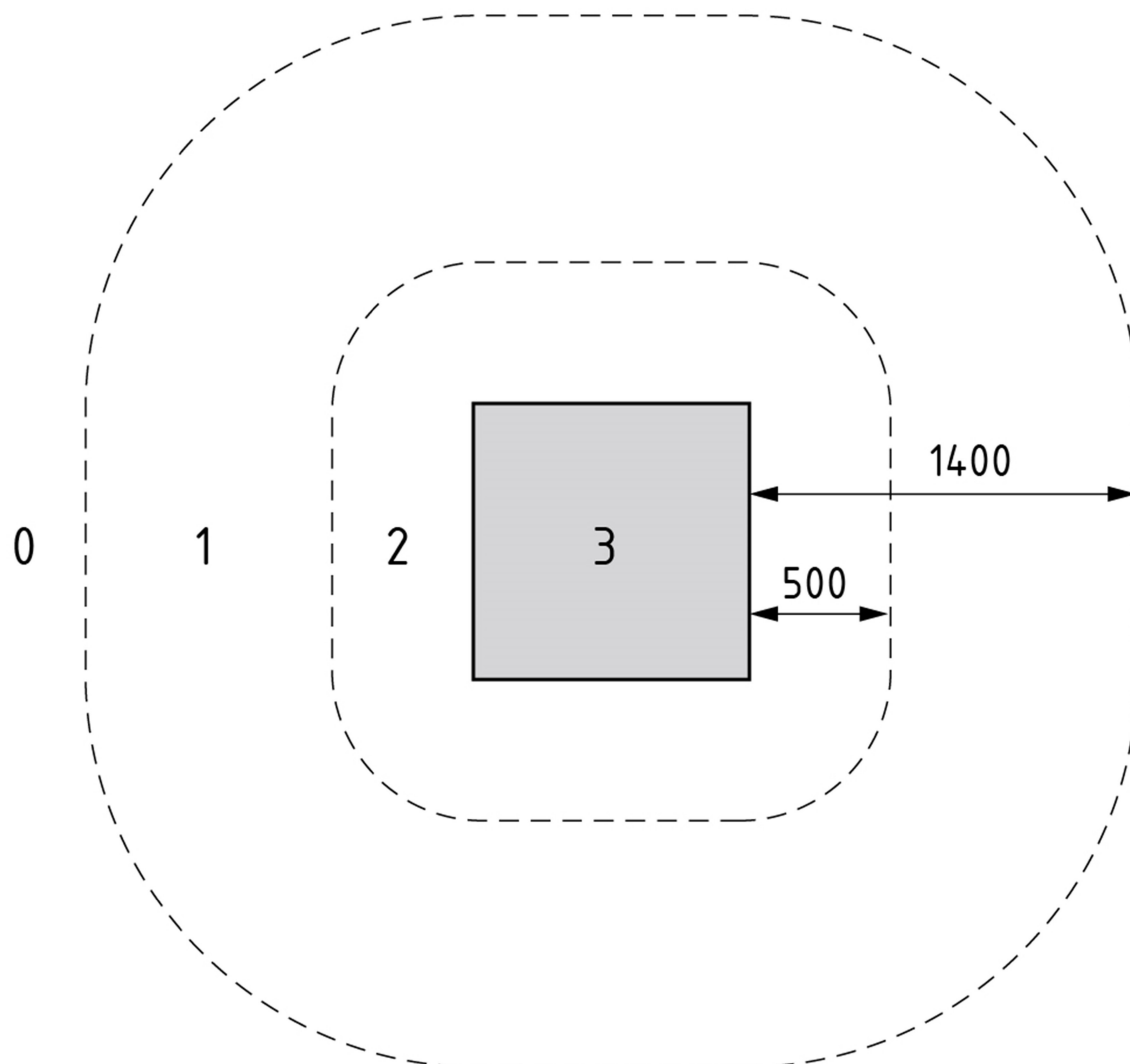
Access to the safety clearance zone 3 according to Table 6 shall only be possible during evacuation, rescue and maintenance procedures.

**Table 6 — Clearance around the carrier and related safety measures**

| Safety clearance zone     | Distance to carrier                                   | Maximum travel speed 0,4 m/s | Top and bottom obstruction detection device |
|---------------------------|-------------------------------------------------------|------------------------------|---------------------------------------------|
| 0                         | ≥ 1 400 mm or according to EN ISO 13857:2019, Table 1 |                              |                                             |
| 1                         | 500 mm to < 1 400 mm                                  | x                            |                                             |
| 2                         | 50 mm to < 500mm                                      | x                            | x                                           |
| 3                         | < 50 mm (in travel path)                              | x                            | x <sup>a</sup>                              |
| <sup>a</sup> See Table 7. |                                                       |                              |                                             |

Safety clearance zones are described in Figure 2.

Dimensions in millimetres

**Figure 2 — Safety clearance zones**

To assess the safety clearance of a climbing ladder, a safe climbing area described in Figure 3 shall be respected.

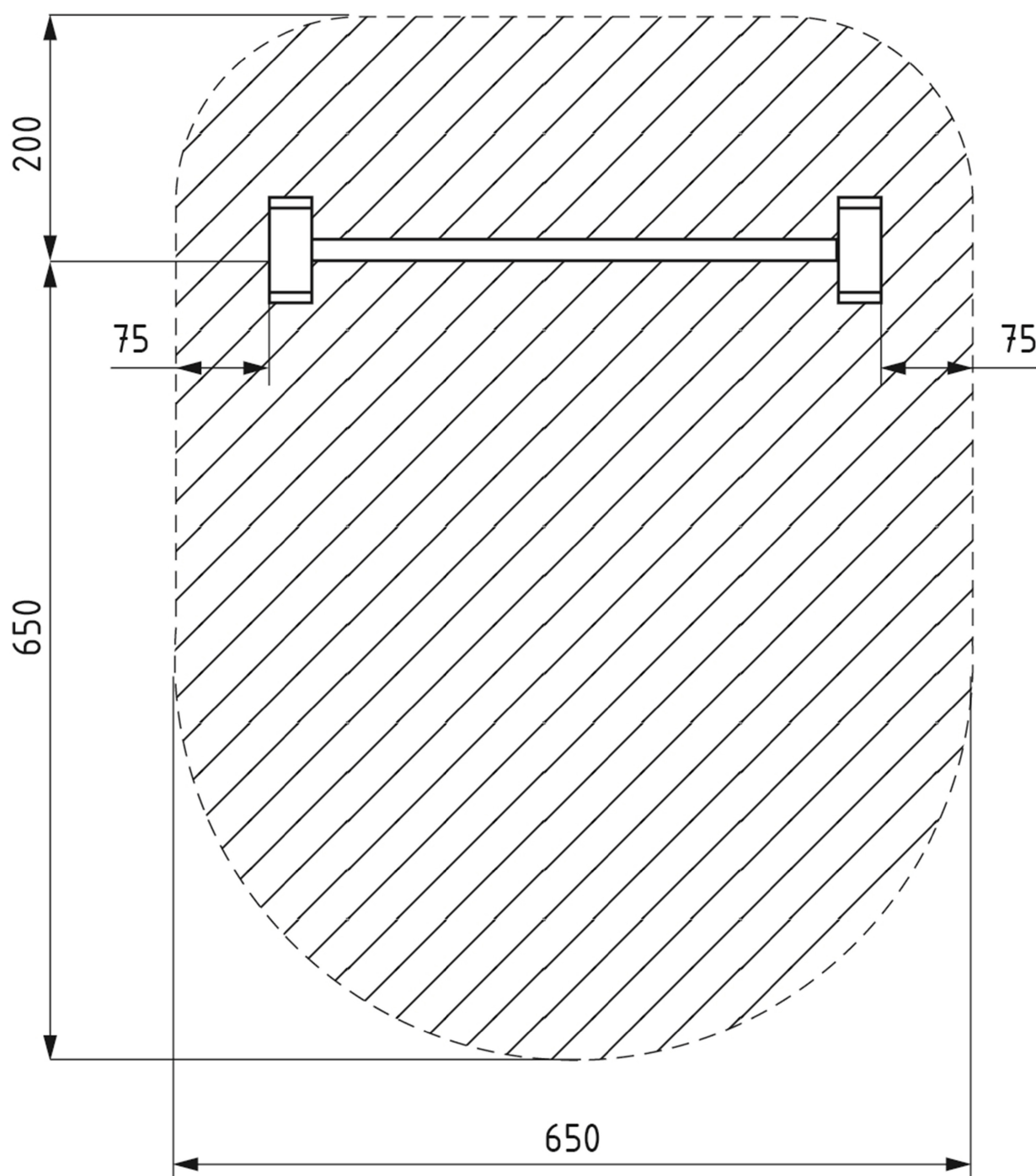


Figure 3 — Safe climbing area

### 5.3.2.3 Clearances beneath the carrier

When a pit is provided it shall give space in accordance with EN 81-20:2020, 5.2.5.8. If a pit is not provided, mechanical means (e.g. a moveable prop, manual locking of an overspeed safety device or equivalent) shall be provided to create a minimum vertical clearance of at least 1,8 m. The clearance shall extend under the entire area of the carrier. It shall be possible to erect and dismantle the means provided without any person having to be beneath the carrier.

A limit switch in accordance with 5.8.7.4 shall monitor the means provided above to ensure the lifting appliance cannot move whilst the prop or equivalent is in place.

### 5.3.2.4 Clearances above the carrier

When the top of the carrier is used as working platform according to 5.6.4.2, the free distance between any part of the carrier and any part of structures above the carrier shall be at least 300 mm and a refuge space to accommodate a rectangular block not less than 0,50 m × 0,70 m × 1,0 m secured by mechanical means shall be provided.

When the top of the carrier is not used as working platform (see 5.6.4.2) and the carrier has reached its highest possible position, the free distance between any part of the carrier and any part of structures above the carrier shall be at least 100 mm.

If the top of the carrier is not allowed to be accessible, additional marking shall be put on the carrier roof to indicate that it is prohibited to stand on the carrier roof.

NOTE Maintenance possibilities to be considered with the design of the carrier.

## 5.3.3 Liftway protection at landings

### 5.3.3.1 General requirements

When the lifting appliance is erected, it shall be provided with landing gates at every point of entry including the base enclosure.

The type of the liftway protection at landings shall be in accordance with Table 5.

Landing gates shall not open towards the liftway. In case the gates are being used to access the ladder (ladder guided lifting appliances), they shall be self-closing.

Landing gates shall have a minimum clear width opening of 0,5 m.

It shall be possible to see that the carrier is at the landing (e.g. by using indicators according to EN 81-20:2020, 5.3.7.2).

Landing gates shall be guided, and their movement shall be limited by mechanical stops.

Power operated landing gates are not permitted.

Landing gates shall not be opened or shut by a device which is mechanically, or by other means, operated by the movement of the carrier.

Means shall be provided to reduce any horizontal distance between the sill of the carrier and the sill of the landing for maximum 100 mm (C), as well as any openings between the carrier and the landing access side protection to not more than 180 mm (A) before access can be achieved between the carrier and the landing (see Figures 4 to 6).

Landing gates shall be fitted with interlocking devices according to 5.8.7.1.

When, e.g. for maintenance purposes, the lifting appliance base enclosure is accessed by the landing gate at base level, the landing gate shall be openable from the inside without a key or any tool, or be fitted with means allowing climbing over the landing protection in case trapped key systems are used.

### 5.3.3.2 Vertical sliding gate

Vertical sliding gate panels shall be supported by at least two independent suspension elements.

Flexible suspension elements shall possess a safety factor of at least 6 against their minimum breaking strength. Means shall be provided for retaining them in their pulleys or sprockets.

Pulleys used in connection with vertical sliding gates shall have a diameter of at least 15 times the rope diameter. Wire rope terminations shall be formed by means of metal filled sockets, self-tightening wedge type sockets, hand spliced eyes, ferrule secured eyes or any other system with equivalent safety. U bolt grips shall not be used.

Any tension weight used in connection with a gate shall be guided and shall be prevented from running off the guides even in the event of failure of its suspension.

The tension weight(s) shall not be heavier than the door leaf and the load for opening and closing the door shall not exceed 50 N.

### 5.3.3.3 Full height landing protection

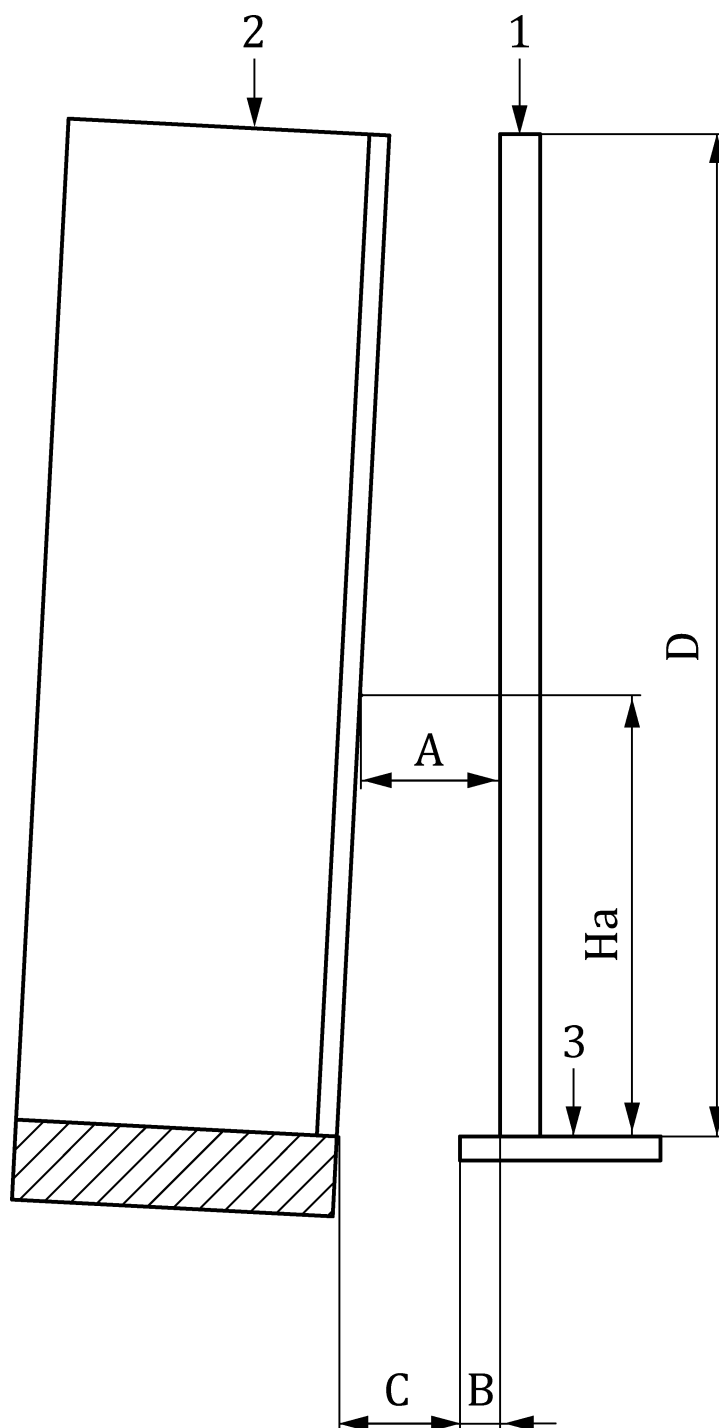
When required by Table 5 full height landing protection shall be provided.

The minimum height of the full height landing protection shall be 2,5 m.

The height of the clear opening in the landing gate frame shall be not less than 2,0 m above the landing threshold.

The dimensions between the closed carrier gate and the closed landing gate shall be according to Figure 4 when the carrier is at the landing zone. Dimension A shall be measured from height 1,1 m ( $H_a$ ) from the landing level (3). Dimensions B and C shall be measured from the landing level.

It shall not be possible to place a ball with a diameter of 180 mm in any gap between the closed carrier door and landing gate door.



### Key

|   |                    |    |                                                            |
|---|--------------------|----|------------------------------------------------------------|
| 1 | landing protection | B  | is max. 80 mm                                              |
| 2 | carrier            | C  | is max. 100 mm                                             |
| 3 | landing level      | D  | is min. height of full height landing protection (= 2,5 m) |
| A | is max. 180 mm     | Ha | is measuring height                                        |

**Figure 4 — Full height landing gate**

The size of any perforation or opening in a closed liftway protection and/or gates related to the clearances from adjacent moving parts shall be in accordance with EN ISO 13857:2019, Table 4.

Any clearances around the edges of each gate or between gate sections shall conform to EN ISO 13857:2019, Table 4 except for under the gate where the clearance shall not exceed 10 mm.

#### **5.3.3.4 Reduced height landing protection**

The criteria for using reduced height landing protection is given in Table 5. See also Figures 5, 6 and 7.

The minimum height of the reduced height landing protection shall be 1,1 m.

The dimensions between the closed carrier gate and the closed landing gate shall be according to Figure 5 when the carrier is at the landing zone. Dimension A shall be measured from the top of the landing gate. Dimensions B and C shall be measured from the landing level.

The reduced height landing gate shall cover the full width of the opening.

Reduced height landing protections in combination with liftway access during evacuation or rescue shall be fitted with means to allow climbing over the landing protection. Means shall be provided to attach personal fall protection equipment during the climb over the reduced height landing protection.

An open reduced height landing protection including the gate shall be in accordance with EN ISO 14122-3:2016, 7.1. A toe board fixed to the gate or fixed to the platform shall be present in the opening of the gate.