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Safety requirements for cableway installations designed to carry persons - Civil engineering works

Sicherheitsanforderungen für Seilbahnen für den Personenverkehr - Bauwerke

Prescriptions de sécurité pour les installations a câbles transportant des personnes - Ouvrages de génie civil

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English version

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This European Standard was approved by CEN on 12 August 2004.

CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration. Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Central Secretariat or to any CEN member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the Central Secretariat has the same status as the official versions.

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EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

Management Centre: rue de Stassart, 36 B-1050 Brussels

Contents

page

1	Scope	4
2	Normative references	4
3	Terms and definitions	6
4	Symbols and abbreviations	6
5	General requirements.....	7
6	Hazard scenarios and safety measures	8
7	Actions and environmental influences.....	8
8	Limit states	24
9	Verifications	25
10	Type of construction	37
11	Type of civil engineering works	39
12	Protection of workers.....	43
Annex A (normative)	Documentation	46
Annex B (informative)	Extracts from ENV 1991-1:1994.....	49
Annex C (informative)	A-deviations	55
Annex ZA (informative)	Relationship between this European Standard and the Essential Requirements of EU Directive 2000/9/EC relative to cableway installations designed to carry persons	56

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Foreword

This document (EN 13107:2004) has been prepared by Technical Committee CEN/TC 242 "Safety requirements for passenger transportation by rope", 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 April 2005, and conflicting national standards shall be withdrawn at the latest by April 2005.

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

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

This European Standard forms part of the standards programme adopted by CEN Technical Board in relation to safety requirements for passenger transportation by rope. This programme comprises the following standards :

- 1) Safety requirements for cableway installations designed to carry persons - Terminology
- 2) Safety requirements for cableway installations designed to carry persons - General requirements
- 3) Safety requirements for cableway installations designed to carry persons - Calculations
- 4) Safety requirements for cableway installations designed to carry persons - Ropes
- 5) Safety requirements for cableway installations designed to carry persons - Tensioning devices
- 6) Safety requirements for cableway installations designed to carry persons - Drive systems and other mechanical equipment
- 7) Safety requirements for cableway installations designed to carry persons - Carriers
- 8) Safety requirements for cableway installations designed to carry persons – Electrical equipment other than for drive systems
- 9) Safety requirements for cableway installations designed to carry persons - Civil engineering works
- 10) Safety requirements for cableway installations designed to carry persons - Pre-commissioning inspection, maintenance and operational inspection and checks
- 11) Safety requirements for cableway installations designed to carry persons - Recovery and evacuation
- 12) Safety requirements for cableway installations designed to carry persons - Operation
- 13) Safety requirements for cableway installations designed to carry persons - Quality assurance

This series of standards form a complete set with regard to the design, manufacture, production, maintenance and operation of all installations for passenger transportation by rope.

In respect to ski-tows the drafting of this European Standard has been guided by the works of the International Organisation for Transportation by Rope (OITAF).

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

1 Scope

This document specifies the safety requirements applicable to civil engineering works for installations for passenger transportation by rope. It is essential that its requirements are met by taking into account the various types of installations and their environment.

It includes requirements relating to the prevention of accidents and the protection of workers.

It does not apply to installations for transportation of goods by rope nor to inclined lifts.

This document is applicable to:

- new cableways ;
- alterations of existing cableways as far as the safety of civil engineering works or part of it is involved.

2 Normative references

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

ENV 1090-1, *Execution of steel structures – Part 1 : General rules and rules for buildings.*

ENV 1090-2, *Execution of steel structures – Part 2: Supplementary rules for cold formed thin gauge components and sheeting.*

EN 1537, *Execution of special geotechnical work – Ground anchors.*

EN 1709, *Safety requirements for cableway installations designed to carry persons - Pre-commissioning inspection, maintenance, operational inspection and checks.*

prEN 1907:2004, *Safety requirements for cableway installations designed to carry persons – Terminology.*

EN 1908, *Safety requirements for cableway installations designed to carry persons - Tensioning devices.*

EN 1909, *Safety requirements for cableway installations designed to carry persons – Recovery and evacuation.*

ENV 1991-1:1994, *Eurocode 1 : Basis of design and actions on structures - Part 1 : Basis of design.*

EN 1991-1-1, *Eurocode 1: Basis of design and actions on structures - Part 1-1: Actions on structures - Densities, self-weight and imposed loads.*

EN 1991-1-2, *Eurocode 1: Actions on structures - Part 1-2: General actions - Actions on structures exposed to fire.*

EN 1991-1-3, *Eurocode 1 - Actions on structures - Part 1-3: General actions - Snow loads.*

EN 1991-1-5, *Eurocode 1 : Basis of design and actions on structures - Part 1-5 : Actions on structures - Thermal actions.*

EN 1991-2, *Eurocode 1: Actions on structures - Part 2: Traffic loads on bridges.*

ENV 1991-2-4, *Eurocode 1 : Basis of design and actions on structures - Part 2-4 : Actions on structures - Wind actions.*

ENV 1991-2-6, *Eurocode 1 : Basis of design and actions on structures - Part 2-6 : Actions on structures - Actions during execution.*

ENV 1991-2-7, *Eurocode 1 : Basis of design and actions on structures - Part 2-7 : Actions on structures - Accidental actions due to impact and explosions.*

ENV 1991-4, *Eurocode 1 : Basis of design and actions on structures - Part 4 : Actions in silos and tanks.*

ENV 1991-5, *Eurocode 1 : Basis of design and actions on structures - Part 5 : Actions induced by cranes and machinery.*

ENV 1992-1-1, *Eurocode 2 : Design of concrete structures - Part 1: General rules and rules for buildings.*

ENV 1992-2, *Eurocode 2 : Design of concrete structures - Part 2 : Concrete bridges.*

ENV 1992-3, *Eurocode 2 : Design of concrete structures - Part 3 : Concrete foundations.*

ENV 1993-1-1, *Eurocode 3 : Design of steel structures - Part 1-1 : General rules and rules for buildings.*

ENV 1993-2, *Eurocode 3: Design of steel structures - Part 2: Steel bridges.*

ENV 1993-3-1, *Eurocode 3 : Design of steel structures - Part 3-1 : Towers, masts and chimneys - Towers and masts.*

ENV 1994-2, *Eurocode 4 : Design of composite steel and concrete structures - Part 2 : Composite bridges.*

ENV 1995, *Eurocode 5 : Design of timber structures.*

ENV 1996, *Eurocode 6 : Design of masonry structures.*

ENV 1997, *Eurocode 7 : Geotechnical design.*

ENV 1997-1, *Eurocode 7 : Geotechnical design - Part 1 : General rules.*

ENV 1998, *Eurocode 8 : Design provisions for earthquake resistance of structures.*

ENV 1998-3, *Eurocode 8 : Design provisions for earthquake resistance of structures - Part 3 : Towers, masts and chimneys.*

ENV 1999, *Eurocode 9 : Design of aluminium structures.*

EN 12223, *Non-destructive testing - Ultrasonic examination - Specification for calibration block No. 1*

EN 12397, *Safety requirements for cableway installations designed to carry persons – Operation.*

EN 12408, *Safety requirements for cableway installations designed to carry persons – Quality assurance.*

EN 12927-1, *Safety requirements for cableway installations designed to carry persons – Ropes - Part 1 : Selection criteria for ropes and their end fixings.*

EN 12927-2, *Safety requirements for cableway installations designed to carry persons – Ropes - Part 2 : Safety factors.*

EN 12927-3, *Safety requirements for cableway installations designed to carry persons – Ropes – Part 3 : Long splicing of 6 strand hauling, carrying hauling and towing ropes.*

EN 12927-4, *Safety requirements for cableway installations designed to carry persons – Ropes - Part 4 : End fixings.*

EN 13107:2004 (E)

EN 12927-5, *Safety requirements for cableway installations designed to carry persons – Ropes – Part 5 : Storage, transportation, installation and tensioning.*

EN 12927-6, *Safety requirements for cableway installations designed to carry persons – Ropes – Part 6 : Discard criteria.*

EN 12927-7, *Safety requirements for cableway installations designed to carry persons – Ropes – Part 7 : Inspection, repair and maintenance.*

EN 12927-8, *Safety requirements for cableway installations designed to carry persons – Ropes – Part 8 : Magnetic rope testing (MRT).*

EN 12929-1, *Safety requirements for cableway installations designed to carry persons - General requirements - Part 1 : Requirements applicable to all installations.*

EN 12929-2, *Safety requirements for cableway installations designed to carry persons – General requirements – Part 2: Additional requirements for reversible bicable aerial ropeways without carrier truck brakes.*

EN 12930, *Safety requirements for cableway installations designed to carry persons – Calculations.*

EN 13223, *Safety requirements for cableway installations designed to carry persons - Drive systems and other mechanical equipment.*

EN 13243, *Safety requirements for cableway installations designed to carry persons – Electrical equipment other than for drive systems.*

ENV 13670-1, *Execution of concrete structures - Part 1: Common.*

prEN 13796-1, *Safety requirements for cableway installations designed to carry persons – Carriers - Part 1 : Grips, carrier trucks, on-board brakes, cabins, chairs, carriages, maintenance carriers, tow-hangers.*

prEN 13796-2, *Safety requirements for cableway installations designed to carry persons – Carriers - Part 2 : Slipping resistance tests for grips.*

prEN 13796-3, *Safety requirements for cableway installations designed to carry persons – Carriers - Part 3 : Fatigue testing.*

ISO 1000, *SI units and recommendations for the use of their multiples and of certain other units.*

ISO 12494, *Atmospheric icing of structures.*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in prEN 1907:2004 and in ENV 1991-1:1994 apply. Some definitions are listed in B.1.

4 Symbols and abbreviations

4.1 SI units

4.1.1 SI units shall be used in accordance with ISO 1000.

4.1.2 For calculations the following units are recommended:

— actions (forces and loads)	kN, kN/m, kN/m ²
— unit mass (density)	kg/m ³
— unit weight(kg/m ³ × g)	kN/m ³
— stresses and strength	N/mm ² , MN/m ² , MPa
— moments (bending ...)	kN.m

4.2 Symbols used in this document

Symbols used in this document conform to the Structural Eurocodes ENV 1991 to ENV 1999 and are defined where they appear for the first time in the text.

5 General requirements

5.1 Application of this standard

The requirements of this document apply to all installations along with EN 1709, EN 1908, EN 1909, EN 12397, EN 12408, EN 12927-1, EN 12927-2, EN 12927-3, EN 12927-4, EN 12927-5, EN 12927-6, EN 12927-7, EN 12927-8, EN 12929-1, EN 12929-2, EN 12930, EN 13223, EN 13243, prEN 13796-1, prEN 13796-2, prEN 13796-3.

5.2 Safety principles

The safety principles set out in EN 12929-1 apply. The design and execution of all civil engineering works for installations for passenger transportation by rope shall meet the requirements of ENV 1991-1.

NOTE More information is given in B.2.

5.3 Safety analysis

5.3.1 Reliability differentiation

The reliability required for the civil engineering works of cableways shall be obtained by design and execution according to ENV 1991 to ENV 1999 and to this document as well as appropriate quality assurance measures.

NOTE More information is given in B.3.

5.3.2 Design situations

Design situations are classified as follows:

- persistent situations which refer of the conditions of normal use ;
- transient situations which refer to temporary conditions applicable to the structure, e.g. during construction or repair ;
- accidental situations which refer to exceptional conditions applicable to the structure or to its environment, e.g. to fire, derailment, impact, avalanches, local failure ;
- seismic situations, which refer to conditions applicable to the structure when subjected to seismic events.

5.3.3 Design working life

5.3.3.1 The design working life is the assumed period for which a structure is to be used for its intended purpose with anticipated maintenance but without major repair being necessary.

5.3.3.2 It is recommended to adopt the following periods:

- 30 years in general ;
- 50 years for bicable aerial ropeways ;
- 100 years for funicular railways.

5.3.4 Durability

5.3.4.1 The durability of civil engineering works shall be assessed according to the requirements of ENV 1991-1.

5.3.4.2 The relevant ENV 1991 to ENV 1999 as well this European Standard specify the appropriate measures.

NOTE More information is given in B.3.

6 Hazard scenarios and safety measures

6.1 Hazard scenarios

For the purpose of this document hazards and hazard scenarios (any event which directly gives rise to a hazardous situation) are specified in clauses 7 and 9.

6.2 Safety measures

The following safety measures shall be taken into account in order to avoid or to limit the consequences of hazards and hazard scenarios. Particular regard shall be paid to maintenance of civil engineering works.

NOTE More information is given in B.4.

7 Actions and environmental influences

7.1 General

7.1.1 Principal classifications

7.1.1.1 An action (F) is :

- a) a direct action, e.g. a force or load applied to the structure ; or
- b) an indirect action, e.g. an imposed or constrained deformation, or an imposed acceleration caused, for example, by temperature changes, moisture variation, uneven settlement or earthquakes.

7.1.1.2 Actions are classified :

- a) by their variation in time :
 - 1) permanent actions (G), e.g. self-weight of the structure, immovable fittings, ancillary and fixed equipment or ground actions ;

- 2) variable actions (Q), e.g. imposed loads, actions induced by the ropes, traffic loads, wind actions or snow loads ;
 - 3) accidental actions (A), e.g. due to onboard brakes and jammed grips, derailment, avalanches, explosions or impact from vehicles.
- b) by their spatial variation :
- 1) fixed actions, e.g. self-weight ;
 - 2) free actions, e.g. moving loads, wind actions, snow loads.
- c) by their nature and/or the structural response :
- 1) static actions, which do not cause significant acceleration of the structure or structural member ;
 - 2) dynamic actions, which cause significant acceleration of the structure or the structural member.

7.1.2 Characteristic and representative values of actions

7.1.2.1 The characteristic value of an action is its main representative value.

7.1.2.2 Characteristic values of actions (F_k) are specified :

- in EN 12930 ;
- in EN 1991-1-1 to ENV 1991-2-7 as well as EN 1991-2, ENV 1991-4 and ENV 1991-5, as a mean value, a higher or a lower value, or a nominal value (which does not refer to a known statistical distribution) ;
- in the design, provided that the provisions specified in ENV 1991 are observed by competent persons.

7.1.2.3 For permanent actions the characteristic value (G_k) shall be determined as follows :

- a) if the variability of G is small one single value G_k may be used ;
- b) if the variability of G is not small, two values shall be used; an upper value $G_{k,sup}$ and a lower value $G_{k,inf}$.

7.1.2.4 For variable actions the characteristic value (Q_k) corresponds to either :

- a) an upper value with an intended probability of not being exceeded or a lower value with an intended probability of not falling below during some reference period ;
- b) a nominal value which may be specified in cases where a probability distribution is not known.

7.1.2.5 For accidental actions the representative value is generally a characteristic value (A_k) corresponding to a specified value.

7.1.2.6 For multi-component actions the characteristic action is represented by a group of values, to be considered alternatively in design calculation.

7.1.2.7 In most common cases the other representative values of a variable actions are :

- combination value generally represented as a product $\psi_0 Q_k$;
- frequent value generally represented as a product $\psi_1 Q_k$;
- quasi-permanent value generally represented as a product $\psi_2 Q_k$.

7.1.3 Environmental influences

The environmental influences which can affect the durability of the structure shall be considered in the choice of structural materials, their specification, the structural concept and detailed design. ENV 1992 to ENV 1999 specify the relevant measures.

NOTE Full information on the subjects mentioned in 7.1 is given in ENV 1991-1 and its annexes.

7.2 Actions for aerial ropeways

7.2.1 General

Actions for aerial ropeways are classified according to 7.1.1.2 a) :

- a) permanent actions ;
- b) variable actions ;
- c) accidental actions.

7.2.2 Permanent actions

7.2.2.1 General

Permanent actions act throughout a given design situation; their variation in magnitude with time is negligible in relation to the mean value, or their variation is always in the same direction (monotonic) until the action attains a certain limit value.

As a general rule the following actions are considered as permanent actions:

7.2.2.2 Self-weight

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The self-weight of a structure includes the loads arising exclusively from the mass of the structural elements and can be represented in most cases by a single characteristic value, calculated on the basis of the nominal dimensions and the densities given in EN 1991-1-1.

The self-weight of non-structural elements as far as their position is fixed shall be considered as characteristic values. This refers for example to partition walls and panelling, railings, safety barriers, lifts and moving staircases, fittings as well as ancillary and fixed equipment. Whenever one of the elements listed above is movable the corresponding actions shall be considered as variable actions (imposed loads).

7.2.2.3 Ground actions

These actions include the pressure on basement walls and foundations induced by earth loads as well as pore water pressure and other ground actions.

As a general rule the characteristic values of ground actions shall be taken in accordance with ENV 1997.

7.2.3 Variable actions

7.2.3.1 General

Variable actions are those actions which are not likely to act throughout a given design situation; their variation in magnitude with time is neither negligible in relation to the mean value nor monotonic.

As a general rule the following actions are considered as variable actions :

7.2.3.2 Actions induced by ropes and carriers

Each rope action shall be considered as an individual case (see also 9.2.5). Dynamic effects as well as friction effects shall be considered where relevant (see 7.2.3.3 and 7.2.3.4). The most unfavourable load arrangement shall be taken into account in the design of structures.

- a) actions induced by the carrying-hauling rope(s) of continuous or pulsed movement aerial ropeways ;
- b) actions induced by the track- and haulage rope(s) of pulsed movement or reversible aerial ropeways ;
- c) actions induced by other ropes such as tension ropes, recovery ropes, evacuation ropes or signalling ropes ;
- d) actions induced by carriers affecting the structure directly.

The characteristic values of the actions specified above shall be taken in accordance with EN 12930.

7.2.3.3 Dynamic effects

Dynamic effects include :

- a) dynamic effects which are induced by the passage of carriers on line support structures. The characteristic value of the global rope action shall thereby be increased or reduced by the characteristic value of the load of an empty or loaded carrier, which shall be multiplied by the dynamic coefficients Φ given below. The combination, which gives the most unfavourable action effect on the structural element considered shall be taken into account ;
 - 1) for monocable and double monocable aerial ropeways :
 - for compression towers, combined support/compression towers, as well as similar structures Φ shall be taken equal to 1,0 ;
 - for support towers, Φ shall be taken equal to 0,5 ;
 - 2) for bicable aerial ropeways :
 - for line support structures Φ shall be taken equal to 0,2 ;
- b) other dynamic effects which are induced by longitudinal forces due to the passage of grips and which act perpendicularly to the corresponding rope support forces on line support structures. The forces act on both sides of a line support structure and in the direction of travel. The characteristic values shall be taken as follows :
 - 50 % of the actual load on one roller for compression or support/compression towers ;
 - 25 % of the actual load on one roller for support towers.

Lower values shall be justified.

7.2.3.4 Friction effects

Friction effects are generally defined as a rope action multiplied by the friction coefficient.

The nominal values of friction coefficients shall be taken in accordance with EN 12930.

7.2.3.5 Imposed loads

The characteristic values of imposed loads shall be taken in accordance with EN 1991-1-1 or shall be specified in the utilisation plan (see A.2.1) when not specified by EN 1991-1-1.

The characteristic values of imposed loads on work platforms shall be taken as follows :

- q_k = 2,0 kN/m² as a distributed load, or, where relevant ;
- Q_k = 2,0 kN as a concentrated load in the most unfavourable position ;
- q_k = 0,5 kN/m as a horizontal line force acting transversally on the railings.

7.2.3.6 Force against guides

They include the forces due to the impact of a carrier against the guides, but only in those cases where the guides do not allow the maximum transversal oscillation as specified in EN 12929-1.

The characteristic values of these forces shall be obtained from dynamic considerations.

7.2.3.7 Wind actions

They include wind actions in and out of operation, which shall be applied to stations, line support structures and their equipment.

According to ENV 1991-2-4, the characteristic value of the global wind force, F_w , shall be obtained from :

$$F_w = q_{ref} c_e(z_e) c_f c_d A_{ref} \tag{1}$$

where

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q_{ref} is the reference mean wind velocity pressure [according to ENV 1991-2-4] ;

$c_e(z_e)$ is the exposure coefficient [according to ENV 1991-2-4] ;

c_f is the force coefficient [according to ENV 1991-2-4] ;

c_d is the dynamic coefficient [according to ENV 1991-2-4] ;

A_{ref} is the reference area for c_f [according to ENV 1991-2-4].

- a) the characteristic value of wind actions on ropes and carriers shall be taken in accordance with ENV 1991-2-4 and EN 12930 ;
- b) aerodynamic coefficients for ropes, stations, line support structures and similar structures shall be taken in accordance with ENV 1991-2-4, whereas aerodynamic coefficients for carriers shall be taken in accordance with prEN 13796-1 ;
- c) the characteristic value of wind actions **out of operation** shall be taken in accordance with ENV 1991-2-4. If necessary and appropriate national or regional wind maps shall be taken into account or the opinion of competent persons obtained. In ENV 1991-2-4 , most wind maps are based on the basic value of the reference wind velocity $v_{ref,0}$;

The reference wind velocity, v_{ref} , is defined as the 10 minute mean wind velocity at 10 m above ground of terrain category II having an annual probability of exceedence of 0,02 (commonly referred to as having a mean return period of 50 years) ;

- d) the characteristic value of the wind action **in operation** shall be taken from expression (1). However, the minimum value of the wind pressure w_{min} shall be taken as:

$$w_{\min} = q_{ref} C_e(Z_e) C_d = 0,25 \text{ kN/m}^2 \quad (2)$$

- e) when combining wind actions and ice loading the local environmental conditions may be considered (see note in Table1).

7.2.3.8 Snow actions

These actions include snow loads to be taken into account for the platforms of line support structures and for stations as well as the actions induced by snow creep and slipping on structures or parts of structures :

- a) the characteristic value of snow loads, based on an annual probability of in excess of 0,02, shall be taken in accordance with EN 1991-1-3. If necessary and appropriate national or regional snow maps shall be taken into account or the opinion of competent persons obtained.
- b) the characteristic values of snow creep and slipping shall be specified by competent persons.

7.2.3.9 Ice loading

Ice loading includes those loads which are to be applied, when relevant, to line support structures or to the external equipment of stations; not only the load but also the shape of ice-loading (e.g. the increase of surface of a steel bar) shall be taken into account.

The characteristic value or design value respectively of ice loading, applied to line support structures and the external equipment of stations, shall be specified by the client and the designer in co-ordination with competent; if possible the characteristic value should be based on an annual probability of in excess of 0,02.

Information on ice loading is given in ISO 12494.

7.2.3.10 Forces induced by the drive and the brakes

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The characteristic values of the forces induced by the drive and the brakes shall be taken in accordance with EN 12930 and EN 13223.

7.2.3.11 Actions induced by tensioning, lifting, pulling-down

The characteristic values of the actions induced by the tensioning as well as the lifting or pulling-down of ropes (during maintenance) shall be taken in accordance with EN 1908 and EN 12930.

7.2.3.12 Actions (normal) against buffers

During normal operation actions against the buffers are induced by :

- the impact of a counterweight or a tensioning carriage ;
- the impact of a carrier against the buffers in a station.

The characteristic values of the forces specified above shall be taken in accordance with EN 1908 and EN 13223.

7.2.4 Accidental actions

7.2.4.1 General

Accidental actions are usually of very short duration and are unlikely to occur with a significant magnitude over the period of time under consideration during the design working life of a structure. An accidental action can be expected in many cases to cause severe consequences unless special measures are taken.