BS EN 13223:2015

BSI Standards Publication

Safety requirements for cableway installations designed to carry persons — Drive systems and other mechanical equipment

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National foreword

This British Standard is the UK implementation of EN 13223:2015. It supersedes BS EN 13223:2004 which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee MCE/20, Aerial ropeways.

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

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

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Safety requirements for cableway installations designed to carry persons - Drive systems and other mechanical equipment

Prescriptions de sécurité pour les installations à câbles transportant des personnes - Entraînements et autres dispositifs mécaniques

Sicherheitsanforderungen an Seilbahnen für den Personenverkehr - Antriebe und weitere mechanische Einrichtungen

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COMITÉ EUROPÉEN DE NORMALISATION
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Foreword

This document (EN 13223:2015) 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of an identical text or by endorsement, at the latest by January 2016, and any conflicting national standards shall be withdrawn at the latest by January 2016.

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

This document supersedes EN 13223:2004.

This document has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association, and supports the essential requirements of EU Directive 2000/9/EG.

For the relationship with EU Directive 2000/9/EG, see informative Annex ZA, which is an integral part of this document.

With respect to EN 13223:2004, the following significant amendments have been made:

— In Clause 1, an addition about employee protection has been added.

— In Clause 3, terms and conditions have been removed.

— In 4.2.2, clauses l) and p) have been defined more precisely.

— In 6.2.6, the requirement for the interruption of the power flow to the main drive motor has been amended.

— In 6.3.1, the requirement for the speed of the auxiliary drive has been removed.

— In 6.8.4, it has been defined more precisely that only the safety components must be calculated with the mentioned safety factors.

— 6.9.2.3 has been expanded.

— In 7.3.1, the requirement has been narrowed in terms of the need for monitoring the types of control systems.

— In 8.2.2, the allowable difference in the speed value has been defined with 10 % of the nominal speed.

— In 8.3.2, the response effect of the 10 % overspeed trigger has been defined more precisely.

— In 8.3.3, the response effect of the 20 % overspeed trigger has been defined more precisely.

— In 8.4.2, the reference to Appendix A has been removed.

— 8.4.3 has been rewritten to uniformly define the safety requirement for braking systems.

— In 8.6.7, the requirement for sufficient static friction has been added.

— In 8.6.9, the monitoring requirement has been extended to all DC motors.

— 9.1.1 has been expanded.

— In 9.1.2, the requirement for the minimum delay has been redefined.

— 9.1.3 has been clarified.

— 9.3.1 has been clarified.

— In 9.3.6, the requirement of 20 % overspeed trigger has been removed.

— In 9.4, the reference standards for pneumatic systems have been added.

— 10.3.4 has been defined more precisely.

— 11.7.2 has been defined more precisely.

— 11.8.7 has been defined more precisely.

— In 11.9.1, the reference to the appendices has been removed.

— In 12.1.3, content has been revised. The safety factor for calculating fatigue has been defined.

— In 12.2.6, the requirement has been extended to all sheaves.

— In 12.2.8, the response effect of the monitoring has been defined more precisely. The requirement for evacuation ropes has been defined.

— 13.1.2 has been redrafted. The slip resistance has been defined.

— In 14.2 the requirement for evacuation ropes has been defined.

— 14.3 has been redrafted.

— 15.1.2 has been defined more precisely.

— In 17.1.1.4, the requirement was removed that the devices must be located in the stations.

— 17.8.3 has been defined more precisely.

— 17.9 has been clarified.

— In 18.1.1.2, the exceptions have been expanded to the station area of all types of systems.

— In 18.1.1.3, the exceptions have been expanded to the station area of aerial ropeways.

— In 18.1.1.4, the requirement for new and unformed linings has been applied.

— In 18.1.3.5, the option of using an appropriate safety device has been introduced.

— In 18.2.3, the requirement has been expanded to the entire track rope shoe.

— In 18.2.8, the option has been introduced to not require rope catching devices on the track rope shoes.

— 18.2.10 has been clarified.

— In 18.3.2 the requirement has been removed, because the reference to EN 12929-1 is sufficient.

— 20.3.2 has been redrafted.

— Annex A has been changed to “Informative”. The content of Table A. 1 has been revised.

— Annex B has been changed to “Informative”. The content of Table B. 1 has been revised.

— Annex ZA has been revised.

This European Standard is part of a series of standards on safety requirements for cableway installations designed for passenger transport. This series consists of the following standards:

— EN 1907, relating to *Terminology*

— EN 12929 (all parts), relating to *General requirements*

— EN 12930, relating to *Calculations*

— EN 12927 (all parts), relating to *Cables*

— EN 1908, relating to *Tensioning devices*

— EN 13223, relating to *Drive systems and other mechanical equipment*

— EN 13796 (all parts), relating to *Carriers*

— EN 13243, relating to *Electrical equipment other than for drive systems*

— EN 13107, relating to *Civil engineering works*

— EN 1709, relating to *Pre-commissioning inspection, maintenance, operational inspections and checks*

— EN 1909, relating to *Recovery and evacuation*

— EN 12397, relating to *Operation*

— EN 12408, relating to *Quality control*

Together these form a series of standards applicable to the design, manufacture, installation, maintenance and operation of all cableway installations designed for passenger transport.

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

In accordance with CEN-CENELEC Internal Regulations, the national standards institutes of the countries listed below are required to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, FYR Macedonia, Malta, the Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey, and the United Kingdom.

1 Scope

This European Standard specifies safety requirements for the mechanical and electrical devices of the drive system and other mechanical devices for cableway installations designed to carry persons. This standard is applicable to the various types of installations and takes into account their environment.

This European Standard applies to the design, manufacture, installation, maintenance and operation of the mechanical and electrical devices of the drive system and other mechanical devices for cableway installations designed to carry persons.

It includes requirements concerning the prevention of accidents and the protection of workers without prejudice to the application of national regulations.

National regulations regarding building or construction or that are designed to protect particular groups of people, remain unaffected.

It does not apply to installations for the transportation of goods, or to lifts.

Clauses 6 to 11 apply to the mechanical and electrical devices of the drive system.

Clauses 12 to 20 apply to other mechanical devices.

2 Normative references

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

EN 1709, *Safety requirements for cableway installations designed to carry persons – Precommissioning inspection, maintenance and operational inspections and checks*

EN 1907, *Safety requirements for cableway installations designed to carry persons – Terminology*

EN 1908:2015, *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*

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

EN 10204, *Metallic products – Types of inspection documents*

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

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

EN 12927 (all parts), *Safety requirements for cableway installations designed to carry persons – Ropes*

EN 12929-1:2015, *Safety requirements for cableway installations designed to carry persons – General requirements – Part 1: Requirements for all installations*

EN 12929-2:2015, *Safety requirements for cableway installations designed to carry persons – General requirements – Part 2: Additional requirements for reversible bi-cable aerial ropeways without carrier truck brakes*

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

EN 13107, *Safety requirements for cableway installations designed to carry persons – Civil engineering works*

EN 13243:2015, *Safety requirements for cableway installations designed to carry persons – Electrical equipment other than for drive systems*

prEN 13796-1:2012, *Safety requirements for cableway installations designed to carry persons – Carriers – Part 1: Grips, carrier trucks, on-board brakes, cabins, chairs, carriages, maintenance carriers, towhangers*

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

EN 13796-3, *Safety requirements for cableway installations designed to carry persons – Carriers – Part 3: Fatigue tests*

EN ISO 898 (all parts), *Mechanical properties of fasteners made of carbon steel and alloy steel (ISO 898, all parts)*

EN ISO 4414, *Pneumatic fluid power — General rules and safety requirements for systems and their components* (ISO 4414)

EN ISO 5817, *Welding — Fusion-welded joints in steel, nickel, titanium and their alloys (beam welding excluded) – Quality levels for imperfections (ISO 5817)*

EN ISO 9606-1, *Qualification testing of welders — Fusion welding — Part 1: Steels* (ISO 9606-1)

ISO 281, *Rolling bearings — Dynamic load ratings and rating life*

ISO 6336 (all parts), *Calculation of load capacity of spur and helical gears*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in EN 1907 and the following apply.

3.1
automatic operation
whole route, which is controlled automatically from the control console and which in special circumstances can be partly influenced from the control points

3.2
manual control
whole route, which is controlled solely by the operator at the control console

3.3
electrical stop
emergency main drive motor
emergency auxiliary drive motor
bringing the cableway to a standstill by interrupting the respective safety circuit by means of an emergency stop with the aid of the main drive motor or the auxiliary drive motor

3.4
emergency stop using service brake
process in which, after the appropriate safety circuits have been broken, the service brake is applied and the energy flow to the main or auxiliary motor is interrupted

3.5
emergency stop using safety brake
process in which, after one of the appropriate safety circuits has been broken or by mechanical tripping, the safety brake is applied and the energy flow to the main motor interrupted

3.6
braking force closed-loop control
process during the braking procedure in which the braking force is controlled by a closed loop in accordance with a preset deceleration value so that the cableway is brought to a stop under as constant a deceleration as possible

3.7
braking force setting
setting the braking force by the control system, based on the torque generated by the main drive motor immediately before the stop is initiated, where the braking force remains constant until the installation has come to rest

3.8
deceleration monitoring
monitoring the deceleration caused by stopping the cableway by means of the main motor or a mechanical brake

3.9
normal stopping point
normal stopping position of the carrier in the stations in cableways with reversible or pulsed movement operation

3.10
retraction distance
distance of the carriage from the stopping point in the station when the other carriage at the opposite station has contacted the buffer

3.11
entry monitoring
monitoring of the speed in the station entry area

3.12
position monitor checking
various checks of the position monitor, which are distinguished as follows:

3.12.1
fixed point checking
checking the information provided by the position monitor on the position of the carrier in relation to a fixed point on the line

3.12.2
synchronicity monitoring
monitoring the information provided by one position monitor on the position of the carrier compared with a second position monitor

3.12.3
zero position check
check made to confirm that the position monitors are in the starting positions when the carriers are in the station

3.13
minimum speed
minimum speed

3.14
main carrier rail
structure on which carriers are moved in normal operation from the entrance to the exit of a station

3.15
continuous operation
operating state where the installation is operated continuously with either a full or partial load

4 General requirements

4.1 Application of the standard

The requirements of this document, together with those of EN 1709, EN 1908, EN 1909, EN 12397, EN 12408, EN 12927 (all parts), EN 12929 (all parts), EN 12930, EN 13243, EN 13107, and EN 13796 (all parts) apply to all cableway installations.

4.2 Safety principles

4.2.1 General

The safety principles set out in EN 12929-1 apply.

For the electrical equipment of the drive system, the safety principles of EN 13243 are applicable.

4.2.2 Hazard scenarios

The following events may lead to hazardous situations which may be avoided or limited by the safety requirements of this document:

a) derailment of ropes;

b) obstruction of the operating movement of ropes due to obstruction by mechanical devices or hooking over parts of the installation;

c) damage to or failure of drive and braking devices and support and guiding elements of ropes due to wear, heat, corrosion or fatigue;

d) failure of drive and braking devices and support and guiding elements of ropes and other mechanical devices in stations and on the line due to inadequate dimensioning;

e) reduction of the force transmission from the drive sheave to the haulage rope or carrying hauling rope;

f) reduction of the frictional force of the braking device;

g) hooking or falling of carriers at line support structures and in stations;

h) collision of carriers or between a carrier and an obstacle when entering into, exiting from and passing through stations;

i) faulty attachment or detachment of carriers with detachable grips;

j) excessive deceleration or acceleration of the haulage ropes and carrying hauling ropes and of the carriers;

k) exceeding the maximum permissible speed;

l) unintentional starting of the ropeway;

m) hazards to persons in passageways and working areas, due to mechanical devices;

n) inadmissible pitch between carriers;

o) operation in unfavourable weather conditions (e.g. wind, frost, icing, rain);

p) foreseeable misconduct of personnel (passengers, operating personnel, third parties).

4.2.3 Safety measures

Safety measures shall be taken to avoid the hazard scenarios listed in 4.2.2.

The measures specified in this document are essentially construction-related and should achieve the following aims:

a) prevention of rope derailment;

b) in the event of rope derailment: catching the rope, prevention of hooking or jamming the rope, and bringing the installation to a standstill;

c) prevention of derailment, falling, hooking and dangerous collision of carriers;

d) prevention of failure of mechanical and hydraulic safety devices;

e) detection of hazardous malfunctioning of detachable grips and bringing the carriers safely to a standstill;

f) detection of inadmissible pitch between carriers and taking the required measures;

g) prevention of insufficient or excessive deceleration and excessive acceleration of haulage and carrying hauling ropes and carriers;

h) detection of exceeding of maximum permissible speed and bringing the ropeway to a standstill;

i) detection of unintentional starting of the ropeway and taking the required measures;

j) protection of persons against falling and against contact with moving parts;

k) prevention of hazards to persons due to collision with carriers.

5 General requirements for hydraulic devices

The requirements of EN 1908 apply for hydraulic devices.

6 General requirements for drive systems

6.1 General principles

6.1.1 The general requirements of EN 12929-1 shall be observed in the design of devices in drive systems.

6.1.2 The drive system shall permit start-up and stopping several times consecutively.

6.1.3 The requirements for other electrical devices are contained in EN 13243.

6.2 Main drive system

6.2.1 The main drive system shall permit as smooth a start as possible and travel in either direction, regardless of load. It shall be designed for continuous operation with the most unfavourable loading condition and at the maximum permissible speed.

6.2.2 It shall be possible to start the installation with the main drive at an average acceleration of not less than 0,15 m/s^2 with the most unfavourable load. For aerial ropeways, an average acceleration of 0,5 m/s^2 and an instantaneous acceleration (average acceleration over 0,5 s) of 1,5 m/s^2 shall not be exceeded.

6.2.3 The speed shall be continuously adjustable over the whole range between the minimum speed and the maximum permissible speed. For test runs with no significant load, it shall be possible to maintain a speed of approximately 0,3 m/s during the period required to travel the whole length of the line.

6.2.4 It shall be possible to maintain the predetermined speed accurately enough and keep it stable for all load conditions occurring during normal operation.

6.2.5 Deviations from the speed setpoint shall not exceed $\pm$ 5 %.

6.2.6 If the cableway has to be brought to a stop, the power supply to the main motor shall be shut off automatically by two circuits (redundancy) of which at least one shall be galvanic or of an equivalent system. In the case of an emergency stop using service brake or an emergency stop using safety brake, the power supply shall be shut off immediately, otherwise it shall be shut off no later than the time when the installation comes to rest.

6.2.7 In the case of a multiple-motor drive, the motors shall be loaded in accordance with their power in every operating condition.

6.3 Auxiliary drive

6.3.1 The auxiliary drive shall be capable of maintaining operation at a speed corresponding to the requirements.

6.3.2 In addition, the other requirements of 6.2.1 shall be met.

6.4 Recovery drive and evacuation drive

6.4.1 The recovery drive is used only to recover the carriers (in accordance with EN 1909).

6.4.2 The recovery drive shall be designed to operate for three times the duration of the maximum required recovery time and at a travelling speed of not less than 0,5 m/s.

6.4.3 The recovery drive shall be provided with the safety devices which are required for safe recovery at the requisite speed.

6.4.4 For the recovery drive to remain capable of operation even in the case of failure of all safety devices, it shall be possible to bypass these in accordance with EN 13243.

6.4.5 The electrical devices of the emergency and evacuation drive shall be as simple as possible in construction. It shall be possible to ensure their operability in a simple manner.

6.4.6 The electrical equipment of these drives shall be separate from each other and from that of the main drive so that any interactions between the various drives are kept to a minimum.

6.4.7 In addition, the following apply for recovery drives:

a) it shall be possible to put the recovery drive into operation within 15 min;

b) it shall not be possible for serious faults to occur during changeover;

c) errors on the part of the controller of the recovery drive, e.g. wrong direction of travel, shall not result in any overloading of mechanical parts or grips;

d) emergency drives with remote control shall also be operable in case of failure of this device.

6.5 Types of control systems

6.5.1 The installation may be started and its operation partly controlled:

a) by the engineer from the control console (control console control system);

b) by personnel from the control points in the carriers (carrier control system);

c) by personnel from the control points on the station platforms (platform control system);

d) by means of special devices (for example, timers, passenger counters) or by passengers (automatic control system);

e) on service runs, by personnel from a control point at the counter station or return station (service run control system).

6.5.2 Regardless of the other types of control system available, each cableway shall be provided with a control console control system.

6.5.3 Only one type of control system shall be operational at any time. In particular, the travel command shall only be capable of being given from the control points belonging to the corresponding control system.

6.5.4 Switching from one type of control system to another shall only be possible with the cableway at a standstill and it shall be possible to make such a change rapidly.

6.6 Safety functions and control devices

6.6.1 If a safety function is initiated or an emergency stop device is operated, the cableway shall automatically be brought safely to a stop (electric stop, emergency stop using service brake or emergency stop using safety brake) and/or start-up shall be automatically blocked by breaking the relevant safety circuit.

NOTE Bringing safely to a stop also means that, after a safety function has been initiated, if no more torque shall be applied by the main or auxiliary drive, an emergency stop using service brake or, if appropriate, an emergency stop using safety brake is initiated.

6.6.2 Failure of the main power supply shall not impair the action of the safety functions or shall result in the cableway being put into a safe state. This shall not prevent the recovery drive from being used.

6.6.3 After the initiation of a safety function or if an emergency stop device has been operated, start-up shall only be possible after manual resetting in the control room or at other points with equivalent operating and indicating devices and resetting:

a) shall only be effective when the cableway is at a standstill;

b) shall not adversely affect the operability of the safety function or of the emergency stop device itself.

6.6.4 Operation of a maintenance switch (safety switch) shall:

a) initiate stopping of the cableway by means of a brake acting on the drive sheave or on a sheave with sufficient static friction, i.e. the corresponding safety circuit shall be interrupted; and

b) prevent restart by means of a brake acting on the drive sheave.

6.6.5 For the suspension of safety functions, EN 13243 shall be observed.

6.7 Motors

6.7.1 General requirements

The operating conditions, climatic conditions and height above sea level shall be taken into account in the dimensioning and design of motors.

6.7.2 Internal combustion engines

6.7.2.1 Internal combustion engines shall be stationary installations and shall be provided with a battery-powered starter.

6.7.2.2 Exhaust gases from internal combustion engines shall be led to the open air. The supply of air to and from the motor shall be ensured.

6.7.2.3 At least the oil pressure and the motor temperature shall be monitored.

6.8 Gearboxes

6.8.1 Gearboxes shall be designed for all intended operational loading conditions.

6.8.2 Gearbox casings and their fixings, insofar as they transmit rope loads, shall be designed with a safety factor of 3,5 with respect to the elastic limit.

6.8.3 The lubrication of gearboxes shall be ensured over the whole range of operating speeds and ambient temperature which may occur in operation. This applies also for the auxiliary drive and the recovery drive, as well as when operating in reverse.

6.8.4 Gear teeth shall be designed in accordance with recognised standards (especially ISO 6336 (all parts)), taking operating conditions into account; for gearboxes which are classified as safety components, the fatigue failure safety factor at the base of the gear tooth shall be not less than 1,7. The safety factor for the tooth flank shall be not less than 1,0.

6.9 Power transmission devices

6.9.1 Mechanical power transmission

6.9.1.1 Flat belts may not be used for power transmission. Chain drives may be used for the main and auxiliary drive only in closed housings with continuous lubrication.

6.9.1.2 Devices for power transmission such as couplings, transmission shafts, etc., shall be designed for all intended operating load conditions.

6.9.1.3 The end positions of clutches shall be able to be mechanically locked and shall be electrically monitored.

6.9.2 Hydraulic power transmission

6.9.2.1 The general requirements of EN 1908 shall be observed.

6.9.2.2 It shall be possible, in all operating conditions, to start the installation smoothly and to bring it to a stop in either direction.

6.9.2.3 On application of the brakes, the oil pump shall automatically be placed in the neutral position (interruption of the oil supply) or brought to idle; for recovery drives, this may be done manually.

6.9.2.4 At least the oil pressure and the oil temperature shall be monitored.

7 Open-loop and closed-loop control systems

7.1 General

7.1.1 The progress of a run shall be controlled either automatically (automatic operation) or manually (manual operation).

7.1.2 A travel command shall only be effective if all the required conditions for start-up are met, including in particular:

a) the cableway shall be at a standstill;

b) the electrical equipment for setting the travel speed shall be in the zero position;

c) the service brake shall not be released;

d) the installation shall be ready for operation;

e) the required ready commands shall be given.

NOTE The ready commands given depend on the type of cableway, type of control system etc.

7.1.3 Control commands both for reversing the direction of travel as well as for returning shall only become effective after the cableway has been brought to a stop.

7.1.4 When returning, the transmission of a start command shall not result in an automatic acceleration.

7.1.5 The control system shall ensure that the maximum permissible travel speed for the particular type of operation is not exceeded. (e.g. during normal operation, when returning).

7.1.6 If the setpoint value for the travel speed can be preset by different devices, the control system shall ensure that the setpoint value which results in the lowest travel speed is effective.

7.1.7 The travel speed shall be capable of being both limited prior to the run and also limited and reduced at any time during the run from the control console. It shall also be capable of being reduced at any time from other control points (according to the type of cableway, position etc.).

7.1.8 For chairlifts, it shall be possible during operation to reduce the speed from the loading and unloading points to a previously adjusted value.

7.1.9 After a reduction in the travel speed, it shall only be possible to initiate an acceleration from the control point from which the reduction was initiated.

7.1.10 Control commands to reduce the travel speed shall have priority over other control commands with the exception of stop commands.

7.1.11 The ready command:

a) shall only be effective in the control system if the installation is ready for operation;

b) shall be cancelled if a stop command is given;

c) shall be automatically cancelled after a maximum of 30 sec if the travel command is not given.

7.2 Speed control on the line and at the entrance to stations for reversible cableways and pulsed movement aerial ropeways

7.2.1 If the maximum travel speed is greater than the permissible travel speed over the line support structures or the passing loop in the case of a funicular, the control system, depending on its type, shall ensure that the speed is reduced accordingly in good time.

7.2.2 Depending on its type, the control system shall ensure that the speed is reduced in good time before the stations.

7.2.3 The creep speed shall be chosen so that the cabins come to rest at the intended stopping point and/or can safely contact the end buffers.

7.3 Control console and other control points

7.3.1 Each installation shall have at least one control console. From this, it shall be possible to control and stop the cableway and to monitor the different types of control system for the main and auxiliary drive systems.

7.3.2 From other control points, it shall be possible to stop and, if necessary, control the cableway.

7.3.3 In the case of reversible aerial ropeways and funicular railways, the current position of the carriers on the line shall be indicated at the control console by a position indicator. In addition:

a) the position indicator shall recognize the direction of travel, even if there is a change of direction of travel on the line;

b) when a normal stopping point is reached in at least one station, the position indicator shall be automatically corrected so that it is in the correct initial position before the start of the next run;

c) there shall be a scale with a suitable graduation unless the distance of a carrier to the driving station is given in metres;

d) the position of the line support structures, the beginning of the entry deceleration area, fixed check points, certain important points for the entry monitoring system and other important points on the line shall be indicated;

e) the position indicator shall operate independently of the drive in use, with the exception of the emergency drive;

f) the position indicator shall remain functional even if the position monitor fails.

7.4 Position monitor

7.4.1 The position monitor is used to supply signals for the travel-dependent control system and to monitor the travel program between the two stations.

7.4.2 Representation of the line by the position monitor shall be based, except in justified cases, on the number of revolutions of a return or deflection sheave or on an absolute travel detector. The drive for the detector shall only be provided via gears or by electrical or electronic devices of at least equivalent reliability. Deviations from the actual carrier position shall be corrected automatically at the end positions.

NOTE A justified case is, for example, a cableway in which there is only one sheave, the drive sheave, in the drive station.

7.4.3 Except in justified cases, the travel detectors for position monitors shall take their information from two independent sheaves.

NOTE A justified case is, for example, a cableway in which there is only one sheave, the drive sheave, in the drive station, or if there is only a single winch drum.

7.4.4 The direction of travel shall be recognized by the position monitor itself.

7.4.5 In the event of a mains failure, the position monitor shall maintain operability.

7.4.6 If required, corrections to the length of the position monitor representation shall be capable of being carried out by suitably trained personnel.

7.4.7 For electronic position monitors, the following are also applicable:

a) the position monitor shall permit adjustment with adequate accuracy for the installation;

b) the various signals and parameters relevant for safety shall be easy to check by the operating personnel;

c) each position monitor shall display in metres the distance of a carrier from one of the two stations;

d) after any fault, normal operation shall only be possible again once the position monitor has been synchronized with the line representation.

7.4.8 For mechanical position monitors, the following are also applicable:

a) the position monitor shall permit adjustment with adequate accuracy for the installation;

b) at least the scale, the two end positions and the position of the fixed point checks shall be indicated on the position monitor itself.

8 Safety functions and devices for drive systems

8.1 General

8.1.1 For safety functions and devices, the safety principles of EN 12929-1 and EN 13243 shall apply.

NOTE A possible way of complying with these safety principles could be to duplicate a device with corresponding function checks, as for example entry monitoring, haul rope monitoring.

8.1.2 The response values of safety functions for monitoring variable quantities shall be adjustable within suitable limits for the installation.

8.2 Monitoring actual speed, direction of travel and standstill

8.2.1 All actual speed values used for safety functions shall be monitored by means of at least one reciprocal permanent comparison; for example the setpoint speed value shall be compared with a monitored actual speed value.

8.2.2 The monitoring devices for actual speed values shall respond when there is a difference of more than 20 % of the nominal speed, but with a maximum of 0,8 m/s, between the values, and those for the setpoint speed values when there is a difference of 10 % of the nominal speed, but with a maximum of 0,6 m/s.

8.2.3 Monitoring shall verify whether the minimum speed (0,1 m/s – 0,5 m/s according to the type of installation) is attained within a set time (approx. 5 s) after the travel command has been given and whether during travel it falls below this value for more than this period, except in test runs (see 6.2.3).

8.2.4 The conformity of the actual direction of travel to the direction of travel command given shall be monitored (travel direction monitoring).

8.2.5 The travel direction monitoring system may be based on speed or distance. It shall respond at a travel speed of more than 0,3 m/s or a maximum distance travelled of 1 m.

8.2.6 If the cableway begins to move from standstill without a travel command, with the control system active and only one brake applied, the other brake shall - except in justified cases - also be actuated with the maximum specified braking force (standstill monitoring).

8.2.7 The standstill monitoring system may be based on speed or distance. It shall respond at a travel speed of more than 0,3 m/s or a maximum distance travelled of 1 m.

8.3 Speed monitoring on the line

8.3.1 The permissible speed shall be monitored independent of the direction of travel. Two independent speed monitoring devices shall be provided, one of which is to respond at a first threshold value of 10 % overspeed and the other at a second threshold value of 20 % overspeed. The following apply:

8.3.2 The 10 % overspeed trigger shall operate if the maximum permissible speed for the type of operation is exceeded and an emergency stop with service brake is activated.

8.3.3 The 20 % overspeed trigger shall respond if the maximum permissible speed of the installation is exceeded. It shall be actuated, and an emergency stop with safety brake shall be activated, by means of a mechanical or electrical device which is connected as directly as possible to the movement of the rope.

The following conditions shall be observed:

a) the overspeed trigger shall be fastened to a sheave in accordance with 9.10.1 and either influenced by this sheave or driven by gears from it. Chain or toothed belt drives are permissible but shall be monitored;

b) the trigger shall operate in both directions of travel;

c) the trigger shall operate and be adjustable with a tolerance of 5 % of the maximum permissible speed;

d) automatic resetting after operation is not permissible.

8.3.4 With the recovery drive, the overspeed trigger shall respond at an overspeed of 20 % of the maximum permissible speed with this drive system.

8.3.5 If reduction of speed on the track (e.g. at line support structures, passing loops) has to be monitored, the requirements for entry monitoring shall be observed by analogy.

8.4 Speed monitoring at the entrance to stations in reversible or pulsed movement cableways

8.4.1 Speed in the station entry area shall be monitored (entry monitoring).

8.4.2 The entry monitoring system shall interrupt the relevant safety circuits if the travel speed has not been reduced enough before the stations.

8.4.3 After any response of the entry monitoring system, the carriers shall be brought to rest so that a sufficient safety distance remains to the end of the cableway line. Swinging of carriers shall be taken into account. The increased travel distance which results if deceleration monitoring of the service brakes is triggered shall be taken into account.

8.4.4 If the normal entry monitoring system is suspended, the speed at one point at the entrance is nevertheless to be monitored. This monitoring shall ensure that the maximum permissible speed for arriving at the buffers is not exceeded.

8.4.5 At least one speed measuring element for the entry monitoring system shall, except where justified, be driven directly or influenced by a return or deflection sheave. The drive shall be provided only via gears or equivalently reliable electrical or electronic devices.

NOTE A justified case is, for example, where the drive system in the drive station has only one sheave, the drive sheave.

8.4.6 For position monitors, the following position monitor checks shall be available and functioning to ensure the safety function:

a) fixed point checks;

b) synchronization monitoring;

c) zero position checks.

8.5 Deceleration monitoring

8.5.1 Deceleration monitoring shall be functional in all selected and actual directions of travel, and also in case of electrical power supply failure or electrical supply asymmetry.

8.5.2 The deceleration monitoring shall monitor the progress of the stopping process and prevent the maximum permissible stopping distance from being exceeded.

8.6 Other safety functions and devices

8.6.1 The various drive systems shall be interlocked so that at any one time only one drive can be put into operation.

8.6.2 Switching from one drive system to another shall trigger an emergency stop with safety brake.

8.6.3 In the case of a multi-motor drive, if the cableway can also be driven by a single motor, the relevant interlocks shall be provided.

8.6.4 The opening of the service brake at the beginning of the run, the opening of the safety brake at the beginning of the run at the latest and both remaining open during the run shall be monitored.

8.6.5 Sudden changes in torque - caused by faults in the electrical drive system – which exceed the characteristic values, shall be avoided as far as possible.

NOTE Such changes cannot be completely excluded, for example, sudden shut-off of a regulator output.

8.6.6 The torque monitoring system shall respond when the torque required for operation with the most unfavourable load is exceeded by more than 20 %; this applies during start-up as well as during steady operation.

8.6.7 The power transmission between the drive motor and drive sheave shall be monitored. The braking triggered by this monitoring shall affect the drive sheave or another sheave which has sufficient static friction.

8.6.8 Hazards as a result of electrical supply failure or electrical supply asymmetry shall be prevented.

8.6.9 The required field current for DC motors shall be monitored if this is necessary for the safety of the installation.

8.6.10 In a reversible cableway, if the normal stopping point in the end stations is passed, an emergency safety brake shall be applied by an additional independent device.

8.6.11 In single-track reversible cableways and funiculars, a further additional device shall stop the installation in good time if the transmission of signals between the stations fails and the normal stopping point in the counter station is passed.

NOTE In cableways with adhesion drive, the torque monitoring system according to 8.6.5 may be sufficient if it responds before the installation is overloaded (rope slip, buffer force).

9 Brakes for drive systems

9.1 General

9.1.1 All drives (main drive, auxiliary drive, recovery drive and evacuation drive) shall be fitted with two brakes which are independent of each other. If the cableway or the evacuation cableway can be decelerated to a standstill with the recovery drive or the evacuation drive respectively, one brake acting on the drive sheave or on a sheave with sufficient static friction. The brakes shall be designed to operate by friction. Different drives may be served by the same brakes.

9.1.2 Each of the two brakes shall bring the ropeway to a standstill even under the most unfavourable foreseeable load conditions.

Each brake shall be designed so that a calculated mean deceleration can be achieved in relation to a total stopping distance of:

— at least 0,3 m/s^2 is observed for chairlifts with carriers with fixed grips;

— at least 0,5 m/s^2 for all other ropeway systems. Delays of at least 0,3 m/s^2 are permitted if the permissible stopping distances for the protection functions can be maintained.

In the event of a decrease of 15 % in the friction value of a brake, the installation shall still be able to be brought to rest with this brake.

9.1.3 The braking system shall enable the braking force to be modified to suit the current load conditions, if braking may be hazardous to persons or could cause material damage.

Under normal braking conditions, the calculated deceleration over the stopping distance shall not exceed 1,25 m/s^2 for uni-directional aerial ropeways and 2 m/s^2 for reversible aerial ropeways, pulsed movement aerial ropeways and funicular railways.

In the following cases, decelerations of up to 2,5 m/s^2, or higher values in the case of bi-cable aerial ropeways, is permitted if tests show that the ropes will not be lifted off the line support structures and the carriers will not strike the line support structures:

— in the event of defective brake adjustment or control in the most unfavourable load case;

— in the case of a safety brake out of adjustment in the most unfavourable load case;

— in the event of the simultaneous operation of both brakes, if this is not reliably prevented.

9.1.4 For service and safety brakes, each brake shall have its own braking surface. Exceptions are permissible in justified cases where equivalent safety is demonstrated.

Design measures shall be taken to protect the braking surfaces from being contaminated, especially by oil and grease.

The braking effect shall be ensured under all operating and ambient conditions.

9.1.5 If a brake can be triggered both automatically and manually, the triggering mechanisms for manual operation shall not hinder the automatic triggering of these brakes and vice versa.

9.2 General requirements for service brakes and safety brakes

9.2.1 The braking force shall be produced by weights or by releasing pre-loaded compression springs and shall be applied mechanically.

9.2.2 The braking force shall be adjustable and shall be capable of being reduced completely to zero.

9.2.3 Service brakes and safety brakes shall be kept open by means of a hydraulic, electrical or pneumatic passive circuit.

9.2.4 If a brake comes into operation while the installation is running, even if only partially, or if the pressure in a brake which is kept open hydraulically or pneumatically falls below the prescribed value, the brake affected shall be fully activated by interruption of the corresponding safety circuit.

9.2.5 The surface pressure exerted by the braking force shall be distributed as evenly as possible over the brake lining and shall be equal over all the linings of a brake.

9.2.6 It shall be possible to compensate for any wear on the brake linings by adjustment; in the case of the service brake, the wear shall be monitored.

9.2.7 It shall be possible to check the reserve distance remaining when the brakes are closed.

9.2.8 It shall be possible to distribute the brake shoe clearance evenly.

9.2.9 The braking surfaces of sheaves, discs and drums shall be machined and fitted to an accuracy appropriate to the tolerances for clearances in the brakes.

9.2.10 The braking effect shall be the same in both directions of travel.

9.3 Hydraulic devices for brakes

9.3.1 For brakes which are kept open hydraulically, the requirements of EN 1908 shall be observed on the hydraulic systems.

9.3.2 The hydraulic circuits of the different brakes shall be separate, at least from the pressure generator to the oil reservoir. There shall be a second independent pressure generator to cover the event of failure of the main pressure generator.

9.3.3 Any reduction of pressure in the hydraulic circuit of one brake shall not cause a reduction in pressure in the hydraulic circuits of other brakes that might impair their functioning.

9.3.4 The braking effect shall be caused by pressure reduction in the corresponding hydraulic circuit; at the same time, except in the case of brakes with feedback control, the pressure line shall be shut off or adequately throttled.

9.3.5 The opening of the hydraulic circuit of the safety brake by means of electrically operated valves shall be designed to be redundant. The functioning of these valves shall be monitored and controlled.

9.3.6 Independent backflow lines for the safety brake shall be provided for the device which triggers the brake when the maximum speed is exceeded by 20 % and the device for triggering the brake mechanically by hand.

9.3.7 The pressure in the hydraulic system of each brake shall be clearly and visibly indicated.

9.3.8 It shall be possible to open and close the brakes for the recovery drive even in the event of failure of the hydraulic circuits necessary for the main and auxiliary drive systems.

9.4 Pneumatic devices for brakes

For pneumatic devices, analogous requirements as for hydraulic devices apply. EN 1908 and EN ISO 4414 shall be observed.

9.5 Electrical devices for brakes

9.5.1 The power supply for the electrical equipment acting on the service brake and the safety brake shall be such that in the event of an electrical power failure - except in justified cases - unintentional simultaneous application of both service brake and safety brake is avoided.

9.5.2 In the event of an electrical supply failure or electrical supply asymmetry, the safety brake shall not automatically be applied before the cableway has stopped, except where the application of the safety brake is triggered by other safety devices.

9.5.3 The braking force control or setting system shall remain capable of functioning even in the event of electrical supply failure or asymmetry in the power supply.

9.6 Design of brakes

9.6.1 Braking forces shall be calculated in accordance with EN 12930.

9.6.2 Brake components (except for springs) shall have a safety factor with respect to the elastic limit of not less than 3,5 times for static loads. Higher dynamic closing forces (e.g. caused by falling weights) shall be taken into account.

9.6.3 The mechanical parts of brakes shall be dimensioned for all operating conditions which may occur.

9.6.4 In the dimensioning of brakes, the permissible level of heating shall not be exceeded, even after three successive brakings under the most unfavourable load and speed conditions.

9.6.5 In brakes without automatic adjustment, brake springs shall be chosen so that 1 mm wear for each brake lining does not cause a reduction in braking force of more than 10 %.

9.6.6 Springs used for brake force storage shall be guided and may be used up to a maximum of 80 % of the spring travel. If safety against buckling can be proved, guides are not required. In the event of rupture of one spring element, the braking force shall not be reduced by more than 15 %.

9.7 Braking force control system

The braking force control system shall enable the ropeway to be brought to a standstill with as constant a rate of deceleration as possible.

9.8 Braking force setting system

With a braking force setting system, torque of the main drive motor shall be applied immediately before stopping for controlling the braking force; temporary torque values may be disregarded. Changes in the torque after the power supply to the drive motor has been interrupted shall not have any effect on the braking force.

9.9 Service brake

9.9.1 The braking force of the service brake shall be controlled by the deceleration it produces. This may be omitted if it has been demonstrated during test runs that, when both service and safety brakes operate together under the most unfavourable load conditions, the deceleration does not exceed 2,5 m/s^2 (this value may be exceeded in bi-cable aerial ropeways), the ropes are not lifted off the line support structures and the carriers do not strike the line support structures.

9.9.2 If conditions in the installation permit, or if the requirements in 9.9.1 are observed, the braking force of the service brake may take full and immediate effect, either by means of a load-dependent braking force setting system or independently of the load.

9.9.3 The maximum operationally specified braking force of the service brake shall – independent of the closed-loop braking force control system or braking force setting system – be effective at the latest at the time the drive sheave stops or after the end of the maximum permissible braking time.

9.10 Safety brake

9.10.1 The safety brake shall act on the drive sheave or another sheave with sufficient static friction around its circumference or on the drum or on a braking rim fixed directly to the sheave or drum.

9.10.2 Either a closed-loop braking force control system or a braking force setting system may be fitted.

9.10.3 If the safety brake has been brought into action by safety devices, it shall only be possible to release it or trigger its release from the machine room or the control console.

9.10.4 When the safety brake operates, the maximum operationally specified braking force of the safety brake shall – independent of the closed-loop braking force control system or braking force setting system – be effective at the latest at the time the drive sheave stops or after the end of the maximum permissible braking time.

10 Types of stop

10.1 General

10.1.1 For all cableways, at least one stopping system with closed-loop control shall be provided giving as far as possible a constant monitored deceleration.

10.1.2 Emergency stopping with service brake may be replaced by an electrical stop, if equivalent safety is demonstrated.

10.1.3 An electrical stop shall be capable of being interrupted at all times by an emergency stop using service brake and an emergency stop using safety brake and, similarly, an emergency stop using service brake by an emergency stop using safety brake.

10.2 Normal stopping

10.2.1 Normal stopping may be achieved by the drive motor or other systems. The cableway shall be brought to rest without excessive dynamic effects on the ropes and carriers.

10.2.2 In reversible aerial ropeways, pulsed movement aerial ropeways and funiculars, the service brake and if necessary the safety brake shall operate automatically with full braking force and the power to the main drive motor shall be interrupted at the normal stopping places in the stations at the latest (see 6.2.6).

10.3 Emergency stop with drive motor

10.3.1 In the case of an electrical stop, the cableway shall be brought to a standstill by the main motor with an adequate and as constant as possible monitored deceleration.

10.3.2 An electrical stop shall be initiated automatically if the relevant safety circuit is broken.

10.3.3 It shall be possible to initiate an electrical stop manually from the control console and from other positions (see Annex A and the requirements for maintenance switches (safety switches) and emergency stop buttons in EN 13243).

10.3.4 The maximum deceleration shall not exceed 1,25 m/s^2.

10.3.5 Just before the proper completion of the electrical stop, i.e. on reaching minimum speed, the full braking force of the service brake shall be applied and the power to the main motor shall be interrupted (see 6.2.6).

10.3.6 The deceleration during an electrical stop shall be monitored by a monitoring system.

10.3.7 For any auxiliary drive system which may exist, these requirements apply as appropriate.

10.4 Emergency stop with service brake

10.4.1 The service brake shall operate automatically and simultaneously or immediately thereafter the power to the main motor shall be cut off (see 6.2.6), whenever:

a) the relevant safety circuit is interrupted;

b) an electrical stop is initiated but is not operational because of the type of control selected (manual control);

c) the electrical stop is almost completed, i.e. minimum speed is reached;

d) the service stop is almost completed, i.e. minimum speed is reached;

e) the normal stopping point has been reached.

10.4.2 It shall be possible to initiate an emergency stop with service brake manually from the control console and from other positions (see the requirements for maintenance switches (safety switches) and emergency stop buttons in EN 13243).

10.4.3 The deceleration during an emergency stop with service brake shall be monitored by a monitoring system.

10.5 Emergency stop with safety brake

10.5.1 In addition to the methods of actuation in 10.5.2, the safety brake shall operate automatically and at the same time or immediately thereafter the power to the main drive motor shall be interrupted (see 6.2.6) if the corresponding safety circuit is interrupted.

10.5.2 It shall be possible to operate the safety brake manually from the control console, from the control point for the recovery drive and from other positions (see the requirements for maintenance switches (safety switches) and emergency stop buttons in EN 13243). At least one of these operating devices shall be mechanical.

10.5.3 The deceleration produced by a safety brake with a closed-loop braking force control system or braking force setting system shall be monitored by a deceleration monitoring system.

11 Requirements for drive systems for ski-tows

11.1 General

For the drives of ski-tows, only the following parts of Clauses 6 to 9 apply, together with the additional requirements listed below.

Deviations may be permitted in justified cases (e.g. low-level ski-tows).

11.2 Basis

See 6.1.1 to 6.1.3.

11.3 Drive system

11.3.1 The drive system shall permit as smooth a start as possible, independent of loading. It shall be dimensioned for continuous operation under the most unfavourable loading condition and at the highest permissible speed.

11.3.2 Starting up with an average acceleration of at least 0,15 m/s^2 shall be possible in the most unfavourable loading condition.

11.3.3 If the ski-tow has to be stopped, the power to the main drive motor in an emergency stop shall immediately be interrupted galvanically.

11.4 Drive motors

11.4.1 General requirements

See 6.7.1.

11.4.2 Internal combustion motors

See 6.7.2.1 and 6.7.2.2.

11.5 Gearboxes

11.5.1 See 6.8.1 and 6.8.2.

11.5.2 Lubrication of gearboxes shall be ensured over the whole range of operating speeds and the ambient temperature occurring during operations.

11.5.3 Gear tooth calculations shall be carried out in accordance with recognized standards (ISO 6336 (all parts)) and taking into account the operating conditions.

11.6 Power transmission devices

11.6.1 Mechanical power transmission

11.6.1.1 See 6.9.1.2 and 6.9.1.3.

11.6.1.2 Flat belts and open chains may not be used for power transmission.

11.6.1.3 If there is an additional drive system for maintenance and inspection, a chain drive may be used for this, provided:

— it can be connected simply and quickly;

— no lubricant can be thrown onto the braking surfaces.

11.6.2 Hydraulic power transmission

See 6.9.2.1 and 6.9.2.3.

11.7 Control systems

11.7.1 A start-up command shall only be effective if all required conditions for start-up are fulfilled. These include in particular:

a) the ski-tow shall be stationary;

b) if applicable:

1) the electrical operating means for setting the speed shall be in the zero position;

2) the service brake shall not be open;

3) the ready for start-up conditions shall prevail;

4) the required ready signals shall exist.

11.7.2 If the drive devices enable operation in reverse for maintenance, giving a start command for this mode of operation by means of a technical device shall be made difficult.

11.7.3 If safety functions are suspended, automatic acceleration shall not take place after the start-up command has been given for any type of drive.

11.7.4 See 7.1.11.

11.7.5 Each installation shall have at least one control console. From this, it shall be possible to control, stop and monitor the ski-tow.

11.8 Safety functions and devices

11.8.1 See 8.1.1.

11.8.2 See 8.1.2.

11.8.3 If a safety function responds or an emergency stop device is actuated so that the corresponding safety circuit in accordance with Annex B is broken, the ski-tow shall automatically come safely to rest and/or start- up shall be automatically blocked.

11.8.4 Loss of the main power supply shall not impair the operation of the safety functions or shall result in putting the ski-tow into a safe state.

11.8.5 See 6.6.3.

11.8.6 Maintenance switches (safety switches) shall stop the ski-tow and prevent it starting up again by the operation of a brake, if there is one, operating on the drive sheave, by breaking the safety circuit.

11.8.7 For electric variable speed drive systems, the following applies:

11.8.7.1 The actual speed shall be monitored by comparing it with the setpoint speed. For drive system powers less than 20 kW, monitoring the speed in accordance with 11.8.7.4 is sufficient.

11.8.7.2 The monitoring system in accordance with 11.8.7.1 shall respond if the difference between the two values exceeds 10 %.

11.8.7.3 It shall be monitored whether the minimum speed is reached within a set time (approximately 5 s) from the start-up command and whether the speed drops below the minimum speed during operation, except during test runs.

11.8.7.4 The permissible speed shall be monitored. A monitoring system shall be provided which shall respond at an overspeed of more than 10 %.

11.8.8 If there is an additional drive system, the different drive systems shall be interlocked so that only one drive system can operate at any one time.

11.8.9 For other drive systems (e.g. hydraulic), 11.8.7 and 11.8.8 shall be observed by analogy.

11.8.10 See 8.6.8.

11.8.11 See 8.6.9.

11.9 Brakes

11.9.1 See 9.2.1 – 9.2.9.

11.9.2 See 9.3.1.

11.9.3 See 9.6.1.

11.10 Stopping the ski-tow

Any brakes which may exist shall operate automatically, and at the same time or immediately afterwards the power supply to the main motor shall be interrupted (11.3.3), if the corresponding safety circuit is broken.

12 Sheaves

12.1 Dimensioning

12.1.1 The least favourable combinations of simultaneously occurring loads shall be taken into account in the dimensioning of sheaves.

12.1.2 In sheaves with more than one groove, the increased rope tensions between drive and counter sheaves due to the lacing tensions produced by different groove base diameters shall be taken into account. Dimensioning shall take into account the least favourable combination of rope tensions with the maximum permissible coefficient of friction increased by 30 %.

12.1.3 Sheaves shall be dimensioned to withstand fatigue in accordance with recognized standards (e.g. EN 1993 (all parts)). The safety factor, referring to the fatigue strength of the Wöhler curve, which is based on a survival property of 95 %, shall be at least 1,15. When establishing the working life of evacuation rope sheaves as well as tension sheaves, the minimum number of 500 000 stress range cycles shall not be undercut.

In addition, sheaves shall have a safety factor with respect to the elastic limit of at least 3,5. When considering lacing tensions at sheaves, a safety factor of at least 2,0 times with respect to the elastic limit shall also be demonstrated.

12.1.4 A permissible friction coefficient according to EN 12930 shall be taken into account for the transmission of tangential forces on the drive sheave.

12.2 Construction

12.2.1 Welded sheaves shall be constructed so that the influence of residual stresses is kept to a minimum or taken into account.

12.2.2 Sheaves shall be lined with rubber or a suitable plastic material. Grooves shall be provided in the lining for guiding the rope.

12.2.3 Sheave flanges shall be shaped so as to hinder deropement. Flanges shall project above the top edge of the lining by at least the diameter of the rope.

12.2.4 In installations where the carrier grips do not travel round the sheaves, deropement of carrying-hauling and haulage ropes from the sheaves shall be prevented by design measures. These design measures shall be effective even for slack ropes.

12.2.5 In installations where the grips travel round the sheaves, the sheaves shall be fitted on both sides with correspondingly dimensioned anti-deropement devices or rope-catchers.

12.2.6 Sheaves shall be fitted with adjustable groove scrapers; these shall be insulated if the corresponding rope is insulated.

12.2.7 Groove scrapers and their fixings shall be designed to withstand a force of 5 kN acting on the front edge.

12.2.8 If sheaves are mounted on shafts or rotating axles, devices for catching the sheaves are to be provided, these being designed to prevent deropement in the event of failure of the shafts or axles; if brakes act on the sheave, these brakes shall remain capable of functioning. In continuous movement aerial ropeways, the correct position of the drive, return and deflection sheaves shall be monitored electrically. The triggering and monitoring of the drive sheave shall trigger the emergency stop safety brake.

Rope catchers are not required for evacuation ropes, provided the sheave, axes and shafts are dimensioned to withstand fatigue.

12.2.9 For the diameter of drive sheaves, deflection sheaves and sheaves for evacuation drives, the requirements of EN 12927 (all parts) apply.

12.2.10 Drive sheaves and their counter-sheaves with more than one groove shall be supported by bearings on both sides or supported on fixed axles. Devices shall be provided to enable the groove depths to be precisely monitored and corrected if necessary.

13 Winch drives

13.1 General

13.1.1 Winch drums shall be dimensioned in accordance with recognized good practice.

13.1.2 For winch drives, the end fixing of the haulage rope shall be dimensioned including its support with a 3-time safety factor against rope slippage. When doing so, the maximum operational rope control as well as a maximum of three turns remaining on the drum shall be taken into account. In this case, a maximum friction coefficient between the rope and drum of μ = 0,08 shall be assumed.

13.2 Design

13.2.1 For the diameter of winch drums, EN 12927-2 applies.

13.2.2 Under all operating conditions, at least five turns of the haulage rope shall remain on the drum; the rope end shall be firmly anchored and secured in position (see EN 1908).

13.2.3 For rope drums for winch drives, unimpeded winding on and off of the rope without any overriding or jamming shall be ensured.

14 Shafts and axles for sheaves and winch drums

14.1 The most unfavourable combinations of simultaneously occurring loads shall be taken into account in the dimensioning of shafts and axles.

14.2 Shafts and axles which are subject to dynamic stresses shall be dimensioned to withstand fatigue in accordance with recognized standards. The safety factor, relative to the fatigue limit of the Wöhler curve, based on a 95 % survival probability shall be at least 1,5. When establishing the working life of shafts and axes for evacuation ropes, the minimum number of 500 000 stress range cycles shall not be undercut.

14.3 In addition, shafts and axles shall have a safety factor of at least 3,5. When lacing tensions are taken into account, sheaves with more than one groove shall also have a safety factor of at least 2 times with respect to the elastic limit.

15 Bearings

15.1 Dimensioning

15.1.1 Bearings shall be used in accordance with the manufacturer's instructions and specifications.

15.1.2 Taking the most unfavourable operating loads into account, the rated life of roller bearings for drive sheaves and deflection sheaves of carrying hauling ropes and haul ropes, winch drums and for gear shafts (with the exception of input shafts) shall be at least:

— 25 000 operating hours for main drive systems;

— 15 000 operating hours for auxiliary drive systems;

— 2 500 operating hours for recovery and evacuation drive systems.

The lifetime of roller bearings shall be calculated in accordance with ISO 281.

In the case of drive sheaves with more than one groove and their counter-sheaves, half of the increase in the rope tensions due to lacing tensions shall be included as an additional load, in accordance with 12.1.2.

15.2 Design

15.2.1 Drive and deflection sheaves for carrying hauling and haul ropes and winch drums shall be secured against bearing failures.

15.2.2 In the event of failure, including seizure, of the bearing on sheaves having a bearing on one side, design measures shall ensure that a dangerous axial displacement or falling of the sheaves are prevented. Tension rope sheaves may be excluded from this.

16 Rope guides in stations

16.1 General

The devices for supporting and guiding the ropes shall be designed so that the ropes can be guided safely and without damage.

The feasibility of carrying out operating checks and maintenance work shall be taken into account at the design stage.

16.2 Guides for track ropes

16.2.1 Track ropes shall be guided by shoes, sheaves or roller chains. Track rope shoes, sheaves and roller chains shall be designed respectively in accordance with 18.2.1, Clause 12 and EN 1908.

16.2.2 Devices for connecting track ropes to the main carrier rail shall be designed so that the transition of the carriers can be made smoothly and without risk of derailment.

16.3 Guides for moving ropes

16.3.1 Sheaves, rollers and roller batteries shall be aligned in the plane formed by the moving incoming and outgoing rope; exceptions may be permissible for drive sheaves and deflection sheaves having more than one groove, as well as at points where the gauge of the ropeway changes. Reference is made to EN 12929-1.

16.3.2 Design measures shall be taken to ensure the correct movement of the rope onto and off sheaves, rollers and roller batteries.

16.3.3 For the design of sheaves, see Clauses 12, 14 and 15.

16.3.4 18.1 shall be observed for the design of rollers.

16.4 Safety devices

For installations with detachable grips, stopping the installation in the event of deropement of moving ropes at stations and their entries and exits shall be ensured by automatic devices.

17 Station equipment

17.1 Carrier rails

17.1.1 Main carrier rails

17.1.1.1 Derailment and falling of carriers shall be prevented by design measures. Forces due to boarding and alighting shall be taken into account here.

17.1.1.2 The main carrier rail shall be designed and fixed so that fully loaded carriers may travel along it without interruption.

17.1.1.3 The ends of the main carrier rail shall be designed so that carriers can enter and leave it smoothly and without risk of derailment. The entry of the carrier shall be ensured even from a derailed rope, and for rope which lies on the rope-catcher on the line support immediately preceding the station.

17.1.1.4 In the case of detachable cableways, a device which enables a damaged carrier to be taken out of operation shall be provided.

17.1.2 Sidings

17.1.2.1 Sidings shall be designed so that carriers can be transferred without risk of derailment

17.1.2.2 The connection of sidings to the main carrier rail shall be protected so that if the point is incorrectly positioned, the entry of a carrier into the siding area is prevented: incorrect positioning shall be indicated.

17.1.3 Track end buffers

17.1.3.1 Buffers shall be applied at the ends of the tracks of funicular railways and bi-cable reversible aerial ropeways.

17.1.3.2 For bi-cable reversible aerial ropeways, buffers shall be dimensioned to withstand the force of the maximum permissible retraction distance and withstand the impact of the carrier at the lowest monitored speed of travel and shall be designed so that the carrier truck cannot climb up.

17.1.3.3 In funicular railways, the distance between the buffers and the carriage when it passes the emergency end switch (monitoring the stopping position) at the lowest monitored speed of travel shall be not less than the braking distance when the safety brake is operated.

17.1.3.4 The buffers of funicular railways shall be designed for the incident impact energy of the carrier corresponding to 1/3 of the lowest monitored speed of travel. In valley stations, the static slopewise component of the weight of a fully loaded carrier shall be taken into account, if the latter is greater than the load resulting from the above impact energy.

17.1.3.5 For the calculation and design of supporting structures, the forces determined in accordance with 17.1.3.2 and 17.1.3.4 shall be considered as variable influences.

17.2 Attachment and detachment areas

17.2.1 Attachment and detachment areas shall be designed so that carriers can ensure correct attachment and detachment, regardless of the speed of travel, and also with 50 % carrier overload. Travel in the reverse direction at reduced speed shall be possible.

17.2.2 Attachment and detachment areas shall be protected from any effects of the weather which may hinder the attachment or detachment process. Accessibility for operating checks and maintenance shall be taken into account.

17.2.3 Guide and control rails along the attachment and detachment areas shall be designed, dimensioned and fixed to avoid faulty attachment and detachment and derailments.

The relative positions of the grip device and the rope shall be adjustable.

17.2.4 The rope and grip guides necessary for correct attachment and detachment shall be fitted in the attachment and detachment area.

17.2.5 Mechanical devices shall prevent the occurrence of hazardous operating conditions due to faulty detachment.

17.2.6 Falling and slipping along the rope of an incorrectly attached carrier after the attachment point shall be prevented; for carriers which are attached to two separate carrying hauling ropes with at least two clamps per rope, the requirements for preventing slipping may be considered as fulfilled, refer to EN 12929-1.

17.3 Acceleration and deceleration devices

17.3.1 The requirements of EN 12929-1 apply.

17.3.2 Acceleration and deceleration devices shall be designed so that average acceleration and deceleration do not exceed 1,5 m/s^2.

17.3.3 During attachment of the grip to the rope, the difference in speed between the grip and the moving rope shall not exceed 0,3 m/s.

17.3.4 The speed and direction of travel of acceleration and deceleration devices shall automatically adapt to the movement of the rope.

17.3.5 If acceleration or deceleration of the carriers is achieved by friction, tests shall be carried out on the power transmission under dry conditions, relative to the average acceleration or deceleration, to demonstrate a safety factor against slipping of at least 2 times. In the case of inclined main carrier rails, this proof refers to the additional acceleration or deceleration forces to be produced by friction

17.3.6 In addition, when the ropeway is stationary, the acceleration and deceleration devices shall prevent unintentional movement of the carriers on the main carrier rails.

17.3.7 Acceleration and deceleration devices shall also be capable of functioning when the recovery drive is in use.

17.3.8 In the event of failure of acceleration and deceleration devices, recovery shall be possible.

17.3.9 Acceleration and deceleration devices shall be protected from effects of the weather which could hinder their functioning. Accessibility for operating checks and maintenance shall be taken into account.

17.4 Devices for maintaining pitch between carriers on the line

17.4.1 The requirements of EN 12929-1 shall be applied.

17.4.2 Devices shall be provided in each station to ensure that the pitch between carriers on the line does not fall below the minimum permissible value.

17.4.3 It shall be possible to maintain the scheduled pitch between carriers irrespective of the speed of the cableway and of the loading of the carriers.

17.4.4 A device for setting the pitch between carriers shall be provided in at least one station. If the device for setting the pitch is only available in one station, the movement of the carriers through the other stations shall be arranged so that the pitch between carriers remains within permissible limits.

17.5 Devices for moving carriers and passenger loading bands

17.5.1 Devices for moving carriers

17.5.1.1 Devices for moving carriers along the main carrier rail shall be designed to ensure that carriers can be transferred from one device to the next.

17.5.1.2 The values for stations given in EN 12929-1 shall be applied to the speed of devices for moving carriers in loading and unloading areas.

17.5.1.3 Devices for moving carriers shall permit the ropeway and its carriers to travel in reverse.

17.5.2 Passenger loading bands

17.5.2.1 The requirements of EN 12929-1 shall be applied to passenger loading bands. In addition, the following points shall also be observed.

17.5.2.2 The passenger loading band shall also be accessible to pedestrians.

17.5.2.3 The width of the passenger loading band shall exceed the width of the row of seats on the carrier on both sides by 0,10 m to 0,15 m and the loading band shall be marked corresponding to the number of seats.

17.5.2.4 The passenger loading band shall only be brought to rest with a deceleration which is acceptable to the passengers (maximum 0,5 m/s^2).

17.5.2.5 The passenger loading band shall be stationary when the ropeway travels in reverse.

17.5.2.6 Design measures shall be taken to avoid passengers being caught between the loading band and components and coverings, even after a fall.

17.5.2.7 If the access barrier is not controlled by the chair which shall be loaded next, the distance between chairs shall be monitored; in the event of deviations which may prejudice a regular loading of the chairs, the cableway shall be brought to rest.

17.5.2.8 If the actual speed of the passenger loading band differs by more than 0,1 m/s from the set speed, the passenger loading band shall be automatically brought to rest.

17.5.2.9 Bringing the passenger loading band to rest shall also cause the ropeway to come to rest and vice versa.

17.5.2.10 It shall be possible to maintain operation even when the passenger loading band is stationary. For this operational case, no speed higher than that provided for in EN 12929-1 for ropeways without passenger loading band shall be possible.

17.6 Closing and opening devices for carriers

17.6.1 In detachable grip cableways with closed carriers, the door closing device shall be located at the end of the boarding area and before reaching the acceleration device.

It shall be possible to open the doors fully only after the carrier has cleared the deceleration device and reached the unloading area and the predetermined speed for that area.

17.6.2 If open carriers are equipped with protection against the weather (hoods), automatic opening and closing devices shall be provided. The closing process shall be automatic for unoccupied carriers and the hoods shall be secured against opening on the line. If hoods on occupied chairs are closed automatically, this shall not endanger the passengers in any way. The weather protection shall be fully opened when the passengers reach the unloading area. If the opening and closing devices do not permit travelling in reverse, it shall be possible to take them out of operation.

17.7 Carrier guides

17.7.1 Carrier guides shall be provided where this is required for safe operation; they shall be arranged out of the reach of the passengers.

17.7.2 Carrier guides shall be designed so that carriers with the maximum permissible transverse and longitudinal oscillation are guided safely, taking into account possible changes in height during operation. In addition, the requirements of EN 12929-1 shall be observed.

17.7.3 Carrier guides shall operate smoothly and shall not suffer any permanent deformation due to guiding loads.

17.8 Safety devices for cableways with detachable grips

17.8.1 The following shall be monitored during attachment and detachment processes:

— the open position of the jaws of the grip before the attachment point, even when travelling in reverse;

— the correct position of the ropes at the point of attachment and detachment;

— the correct position of the jaws of the grip around the rope after the attachment process, even when travelling in reverse;

— a sufficient gripping force; this monitoring may take place before, during or after the actual process of attachment, see the requirements for attaching to the rope in prEN 13796-1:2012;

— the correct separation of the rope and the grip after the detachment zone, even when travelling in reverse.

17.8.2 For the pitch between carriers, the following shall be monitored:

— the smallest permissible distance between carriers on the line;

— a sufficient safety distance between carriers in stations (in accordance with EN 12929-1).

17.8.3 The end positions of the points on the main carrier rail shall be monitored.

17.9 Other monitoring devices

As a minimum, the following functions and processes shall be monitored by technical means:

— closing and locking the carrier doors for unidirectional aerial ropeways;

— closing and locking the automatically-activated carrier doors for reversible aerial ropeways and funicular railways;

— closing the manually-activated carrier doors for reversible aerial ropeways and funicular railways;

— locking the carrier doors for funicular railways on the line;

— the position of folding, moveable or similar mechanical devices (work platforms, moveable loading and unloading platforms etc.) which could protrude into the limit profile of the carriers;

— the position of mechanically operated platform doors;

17.10 Anchoring devices for detensioning the ropes

The necessary anchoring devices for detensioning ropes shall be provided in the stations. These shall be designed to withstand the loads occurring during maintenance. Their load capacity shall be permanently marked on them as a maximum permissible load.

17.11 Support structures

Support structures to which loads are applied by mechanical devices shall be designed and dimensioned in accordance with the requirements of EN 13107.

18 Mechanical devices on the line

18.1 Guides for moving ropes

18.1.1 Rollers

18.1.1.1 A soft lining which protects the rope (modulus of elasticity not greater than 5 000 N/mm^2) shall be used as the running surface for the rope. A groove shall be provided in this lining to guide the rope in accordance with 18.1.1.2 or 18.1.1.3.

18.1.1.2 The total groove depth (D_1 - D_2)/2 of rollers for carrying-hauling ropes shall be at least equal to one third of the rope diameter, and at least 10 mm.

The flange of the roller shall extend beyond the roller lining by at least 1/6 of the rope diameter, and at least 5 mm.

The depth of the groove in the roller lining shall be at least 1/10 of the rope diameter.

— D_1 = diameter of the outer roller flange, in mm.

— D_2 = diameter at the base of the groove in a new lining ring, in mm.

Exceptions are permissible in the station area.

18.1.1.3 The total depth of the groove (D_1 - D_2)/2 for rollers for haulage ropes shall be at least 1,5 times the rope diameter, and at least 50 mm. Exceptions are permissible in station areas of aerial ropeways as well as funicular railways.

18.1.1.4 The flanges of rollers for haulage ropes for mono-cable continuous movement aerial ropeways shall permit a transverse swaying of the carrier grips of at least 0,20 rad, with new, unformed linings.

18.1.1.5 When dimensioning rollers, external loads due to deflection of the rope, impact of grips and transverse winds in accordance with EN 12930, as well as the internal forces due to the pre-stressing of the lining, shall be taken into account. In addition, the minimum safety factors with respect to the elastic limit set out in 18.1.3.7 shall be maintained.

18.1.1.6 Roller bearings shall be designed and calculated in accordance with 15.1. The calculated life of roller bearings shall be at least 25 000 hours; wind loads may be disregarded for this purpose.

18.1.2 Sheaves

For sheaves on the line, the requirements in accordance with Clauses 12, 14 and 15 shall be applied.

18.1.3 Roller batteries for haulage and carrying-hauling ropes

18.1.3.1 The rope load shall be distributed as far as possible evenly on the rollers.

18.1.3.2 The smallest load on roller batteries, with the rope moving at a uniform speed, shall correspond to the minimum load specified in EN 12930.

18.1.3.3 Roller batteries that do not distribute loads evenly between the different rollers are permissible if it can be shown that operational safety is ensured under all load conditions, especially taking into account the danger of deropement due to wind, maintenance of clearances and the mechanical conditions.

18.1.3.4 It is permissible for the minimum rope load on individual rollers in the battery to be smaller than the load specified in EN 12930, even so far as to result in lift-off.

18.1.3.5 The freedom of movement of the battery rockers shall be limited to ensure passage of the grips:

— if a roller becomes seized, provided it is not monitored by a safety function;

— if a roller is missing;

— if the rope is wholly or partly derailed from the rollers onto the rope-catchers.

18.1.3.6 In the event of a deropement where the rope misses the first or last rope-catcher, the rotation of the rockers shall be limited. The roller batteries and the devices limiting rotation shall be capable of withstanding the resulting loads.

18.1.3.7 Rockers and axles of roller batteries and their fixings shall have the following minimum safety factors with respect to the elastic limit under the load conditions described below:

— maximum rope load with uniform movement: …… 3,5;

— maximum rope load in operation with uniform movement and wind load at a dynamic pressure of 0,25 kN/m² on the rope and the carriers in the adjacent semi-spans; the wind load shall be uniformly distributed over the first two rollers next to the span: …… 1,5;

— maximum rope load when the cableway is not operating and with wind load differing from the requirements of EN 12930, at a dynamic pressure of 1 kN/m^2 on the rope or, in systems without garaging facilities, on the rope with empty carriers in the adjacent semi-spans; the wind load shall be distributed as above: …….. 1,1;

— maximum rope load and friction load with uniform movement of the rope in the rope-catchers with a coefficient of friction of 0,2: …… 1,5;

— maximum rope load and friction load with uniform movement of the rope in the rope-catchers with a coefficient of friction of 0,2 for the case as specified in 18.1.3.6: …… 1,1.

18.1.3.8 Plain bearings shall be made of materials which are known not to cause any unacceptable wear of the axles. The superficial pressure shall be verified.

18.1.4 Suspended supports for haul ropes

18.1.4.1 Suspended supports may only be permissible when two or more track ropes are used for each side of the ropeway.

18.1.4.2 The suspended supports shall not prevent the onboard brakes from functioning.

18.1.5 Deropement protection for carrying-hauling ropes

18.1.5.1 In order to prevent inwards deropement, roller batteries shall each be fitted with deropement protection devices, at least at the height of the first and last rollers. An additional deropement protection device shall be provided near the middle of roller batteries with more than 8 rollers.

18.1.5.2 The deropement protection device shall be designed so as to prevent the grips from hooking or the rope from jamming.

The distance of the deropement protection device from the roller flange shall not exceed 1/4 of the rope diameter or more than 8 mm.

18.1.5.3 The deropement protection device shall be capable of withstanding a load of 5 kN parallel to the roller axle.

18.1.6 Re-engagement devices for haul ropes

18.1.6.1 Roller batteries for haul ropes in aerial ropeways shall be fitted with external and internal rope re-engagement devices.

18.1.6.2 External rope re-engagement devices in bi-cable unidirectional aerial ropeways having a low haul rope position are to lead towards the shaft of the line support structure and shall be designed so that they offer little resistance to the derailed haul rope as it slides upwards.

18.1.6.3 The derailed haul rope shall be prevented from hooking up on the line support structure or the rope re-engagement devices.

18.1.7 Rope-catchers for carrying-hauling ropes

18.1.7.1 Roller batteries shall be equipped with rope-catchers for catching outwardly derailed ropes.

18.1.7.2 Each rope-catcher shall be arranged so that the plane passing through its outer edge and the axis of the rope positioned in the groove in the roller is inclined at least 0,785 rad to the vertical and so that the plane passing through its outer edge and the axis of the rope lying on rim of the outer flange of the roller is inclined at least 0,524 rad to the vertical.

18.1.7.3 Rope-catchers shall be designed so that:

— it is possible for grips to pass them by ensuring that the rope enters the rope-catcher correctly and has a favourable position within it; this shall not be adversely affected by the movement of the roller batteries;

— the depth of the groove is not less than half the diameter of the rope;

— under the most unfavourable load condition, a minimum safety factor of 1,5 times with respect to the elastic limit is maintained. For actions resulting from deropement, in accordance with EN 12930.

18.1.7.4 Line support structures with a compression function shall additionally be fitted with rope-catching arms which are independent of the roller batteries and their main axles. Reference is made to EN 12929-1 and EN 12930. For dimensioning the catcher arms, a minimum safety factor of 1,5 times with respect to the elastic limit shall be maintained under the most unfavourable load condition.

18.1.8 Devices for detection of a deropement

18.1.8.1 Roller batteries for carrying-hauling ropes shall be fitted with switches on the line support structures which will initiate a stopping of the cableway in the event of a deropement.

18.1.8.2 The switches on the line support structures shall correspond to the requirements of EN 13243 and shall not automatically reset after a deropement.

18.1.8.3 The switches on the line support structures shall be located on the lead-on side of the roller batteries when the ropeway is travelling in the normal direction and, in the case of more than four rollers, also on the lead-off side. They shall be triggered immediately by a deropement from both rollers of the first rocker and, in the case of roller batteries with more than four rollers, also by a deropement from both rollers of the last rocker.

18.1.8.4 The operation of the switches on the line support structures shall be independent of the position and movement of the derailed rope.

18.1.8.5 The switches on the line support structures shall be tested for safe functioning at the effective carrying-hauling rope gradients of an installation.

18.2 Guiding of track ropes

18.2.1 It shall be possible to adjust track rope supports.

18.2.2 Track rope supports shall not limit the longitudinal and transverse freedom of oscillation of the carriers in accordance with EN 12929-1. The underside of the supports shall be designed so that carriers swinging longitudinally do not become caught by the supports.

18.2.3 Track rope shoes shall be lined with a suitable material and provided with the necessary lubricating devices to protect the track ropes and reduce friction. Grooves of track rope shoes shall be suitable for the diameter of the track rope.

18.2.4 The length of the track rope shoes shall be such that, with the least favourable rope tensions and with a working load increased by 10 %, the track ropes are supported on radii in accordance with EN 12927 (all parts). In addition, the ends of track rope shoes shall be rounded off with a radius of at least 5 times the diameter of the track rope; the length of the rounding off shall be at least 3 times the diameter of the track rope.

18.2.5 The rope shoes of aerial ropeways without carrier-truck brakes shall wrap at least 180° around the track ropes.

18.2.6 The following shall be observed for ropeways with carrier-truck brakes:

— beyond the area where the track rope always lies on the rope shoe, the rope shoes shall not wrap around the haul rope by more than 120°;

— the rope shoes shall be shaped such that they can be passed over even when the carrier-truck brake is closed and so that the jaws of the brakes are prevented from climbing up on the shoes.

18.2.7 When track rope clamps are installed, they shall be positioned far enough within the area of permanent track rope support that they cannot be damaged by oscillations of the rope. They shall not hinder either the operation of the carrier-truck brake or the longitudinal movement of the ropes.

18.2.8 When a track rope deropement cannot be excluded, at the track rope shoes, at least two rope-catching devices shall be provided on both the inside and the outside of the track. Each deropement into a rope-catching device shall be able to be detected and shall bring the cableway to rest.

18.2.9 The dimensioning of track rope shoes shall take place in accordance with EN 12930 and EN 13107.

18.2.10 Where a heavy build-up of ice on track ropes and track rope shoes is considered a factor to be taken into consideration in the safety analysis, design measures shall be taken against the danger of deropement.

18.3 Guides for carriers of aerial ropeways

18.3.1 EN 12929-1 shall be taken into account for the design of the guides.

18.3.2 Carrier guides shall reduce transverse oscillation of carriers to the permissible level in accordance with EN 12929-1.

18.3.3 For dimensioning, impact loads shall be considered as exceptional actions. Calculations shall be carried out in accordance with EN 13107. If necessary, the guides shall be capable of absorbing energy. In addition, fatigue of material due to vibrations of the guides shall be taken into account.

18.4 Other line support structure fittings

18.4.1 Rope lifting devices

18.4.1.1 Line support structures shall be fitted with fixed devices from which the rope lifting equipment can be suspended.

18.4.1.2 For compression line support structures and support structures with support compression sheave batteries, anchorages shall be provided for the lifting equipment on the ground or on the foundations in the vertical plane containing the rope.

18.4.1.3 The following shall be taken into account in dimensioning the rope lifting devices:

— the maximum rope load according to EN 12930 and EN 13107;

— the layout of the lifting equipment;

— the directions of the loads occurring during lifting.

The loads which are applied shall be considered as variable actions. Calculations shall be carried out in accordance with EN 13107.

18.4.1.4 Compression line support structures shall be provided with devices on which the lifting equipment for lowering the roller batteries can be fixed.

18.4.2 Working platforms and ladders

18.4.2.1 The requirements of EN 12929-1 shall be taken into account.

18.4.2.2 Working platforms shall be provided on the line support structures for evacuation along the rope and for maintenance work on roller batteries. These shall be independent of the roller batteries.

The following shall be taken into account for the design and dimensioning of working platforms:

— they shall support a concentrated load of 2 kN at the most unfavourable position;

— they shall be suitable for the average rope gradient;

— they shall not limit the longitudinal and transverse freedom of the carriers to sway;

— the stresses due to their own vibration;

— accident prevention and protection of workers in accordance with EN 13107.

The loads which are applied shall be considered as variable actions. Calculations shall be carried out in accordance with EN 13107.

18.4.3 Notices

The following notices shall be placed on the line support structures:

— the consecutive numbering of the line support structures;

— no access by unauthorized persons;

— maximum permissible loads for rope lifting jibs.

19 Materials

19.1 Choice of materials

19.1.1 General requirements

19.1.1.1 The materials to be used shall be selected according to construction conditions and conditions of use and shall comply with the relevant European Standards; reference is made to EN 12929-1.

19.1.1.2 Flammable materials may not be used for components which are subject to rope loads, except for linings of sheaves, rollers, roller chains and winches, as well as insulating material.

19.1.2 Steels

19.1.2.1 Steels shall be selected in accordance with European Standards.

19.1.2.2 To avoid brittle fracture, the lowest operating temperatures, the thickness of components and the rate of stress application shall be taken into account in selecting steels. Reference is made to EN 1993-1-1.

19.1.2.3 For steels not covered in EN 1993-1-1, the notched bar impact toughness shall be verified under the appropriate conditions.

19.1.2.4 When selecting the steel, attention shall also be paid to:

— any change in mechanical characteristics due to heat treatment;

— the welding processes, taking the relevant ISO standards into account;

— the manufacturing processes, in order to avoid stress concentrations or surface defects which might lead to failure.

19.1.3 Cast materials

Cast materials shall be selected in accordance with the relevant European Standards.

19.1.4 Light metal alloys

Light metal alloys shall be selected in accordance with the relevant European Standards.

In particular, their structural characteristics and strength shall be taken into account.

19.1.5 Screw fasteners

Screw fasteners for safety components shall be selected in accordance with EN ISO 898 (all parts).

19.2 Verifications and tests

19.2.1 For safety components, the following verifications and tests are required:

— specific test reports in accordance with EN 10204 or equivalent certificates relating to the characteristics of the materials used;

— non-destructive tests; the type and extent of testing as well as the permissible defects shall be determined in accordance with the relevant standards; in the absence of standards, the determination shall be made by the manufacturer.

19.2.2 At least the following components shall be tested for unacceptable external and internal defects:

— shafts and axles of sheaves;

— main axles of roller batteries;

— axles of roller batteries with bearings only on one side;

— sockets of socket end fixings;

— axles of end fixings of ropes and tensioning devices;

— flanges and bodies of the lead-on rollers of roller batteries, if these consist of light metal castings.

19.2.3 Load-bearing welded joints of safety components shall be tested in accordance with EN ISO 5817.

19.2.4 Load-bearing welded joints in safety components shall be made by experienced and appropriately trained personnel. Such personnel shall be certified in accordance with EN ISO 9606-1 or an equivalent standard to prove their capability.

20 Requirements for other mechanical devices for ski tows

20.1 General

For other mechanical devices for ski-tows, only Clauses 12 to 19 apply, together with the additional requirements listed below.

For low level ski-tows, exceptions are permissible in accordance with EN 12929-1.

20.2 Sheaves in stations

20.2.1 Dimensioning

20.2.1.1 See 12.1.1.

20.2.1.2 The drive, deflection and return sheaves shall be dimensioned adequately for fatigue in accordance with recognized standards (e.g. EN 1993 (all parts)). The safety factor, referring to the fatigue strength of the Wöhler curve, which is based on a survival probability of 95 %, shall be at least 1,15. In addition, all sheaves shall have a factor of safety of at least 2,5 times with respect to the elastic limit.

20.2.1.3 Transmission of circumferential force in accordance with EN 12930.

20.2.2 Design

20.2.2.1 Sheaves shall be lined with rubber or suitable plastic material; for return and deflection sheaves, exceptions are permissible.

20.2.2.2 For sheaves for towing ropes in stations, devices to keep the rope groove free of ice and snow shall be provided if the rim does not extend at least as high as the nominal diameter of the towing rope.

20.2.2.3 For the diameters of drive, deflection, and return sheaves, the requirements of EN 12927-2 shall be observed.

20.3 Shafts and axles

20.3.1 For dimensioning, see also 14.1 and 14.2.

20.3.2 In addition, shafts and axles shall have a factor of safety of at least 3,5 times with respect to the elastic limit.

20.4 Bearings

20.4.1 Dimensioning

20.4.1.1 See 15.1.1.

20.4.1.2 The calculated life of roller bearings for drive, deflection, and return sheaves shall be at least 15 000 operating hours.

20.4.2 Design

The bearing support for sheaves for towing ropes in stations shall be designed such that unacceptable tilting or dropping of the sheave is prevented in the event of failure of a bearing.

20.5 Rope guides in stations

20.5.1 General

See 16.1.

20.5.2 Guides for moving ropes

20.5.2.1 Sheaves, rollers and roller batteries shall lie in the plane formed by the incoming and outgoing rope.

20.5.2.2 Sheaves shall be equipped with rope-catchers. The return path of the towing rope in the upper station shall be arranged so that a towing rope which deropes from one of the roller batteries leading onto the sheave and misses the rope-catcher remains on the sheave.

This may be dispensed with if deropement of the towing rope is prevented by other measures.

20.5.2.3 To guide the rope on sheaves, rollers, roller batteries or sheaves whose height can be adjusted shall be provided.

These are not required for low-level ropes or for moveable sheaves.

20.5.3 Safety devices

Line support structure switches on the incoming and outgoing roller batteries at the stations shall cause the installation to stop in the event of deropement.

20.6 Devices in stations

20.6.1 Guidance of towhangers

Guides for towhangers shall be provided where these are required for safe operation.

20.6.2 Other safety devices

20.6.2.1 The position of folding, moveable or similar mechanical devices (for example, work platforms) which could protrude into the limit profile of the carriers, shall be monitored.

20.6.2.2 The requirements of EN 12929-1 for unloading areas shall also be applied.

20.6.3 Anchor points for detensioning ropes

See 17.10.

20.7 Mechanical devices on the line

20.7.1 Guides for moving ropes

20.7.1.1 General requirements for rollers and sheaves on the line

20.7.1.1.1 See 18.1.1.1 and 18.1.1.6.

20.7.1.1.2 The total groove depth $(D_1 – D_2)/2$ of rollers and sheaves shall be at least 1/5 the diameter of the rope and at least 5 mm. The projection of the roller flange above the roller lining and the depth of the groove in the roller lining shall each be at least 1/10 the diameter of the rope:

— D_1 = diameter of the outer roller flange, in millimetres;

— D_2 = diameter of a new lining insert at the bottom of the groove, in millimetres.

20.7.1.2 Sheaves on the line

20.7.1.2.1 The requirements of the following clauses shall be observed for sheaves on the line of ski tows: 20.3, 20.4, 20.5.2.2, 20.5.3.

20.7.1.2.2 If a sheave is used for guiding the sheaves on a line support structure, the diameter of the sheave shall be at least 40 times the nominal diameter of the rope for a deflection of up to 0,30 rad, and at least 60 times the nominal diameter of the rope for deflections greater than 0,30 rad.

20.7.1.3 Roller batteries

20.7.1.3.1 See 18.1.3.8.

20.7.1.3.2 For towing ropes up to 16 mm in diameter, the diameter of the rollers shall be at least 200 mm and the deflection of the towing rope shall not exceed 0,15 rad. For towing ropes over 16 mm in diameter, these limits are 250 mm and 0,10 rad respectively.

20.7.1.3.3 The rope load shall be distributed as far as possible evenly on the rollers.

20.7.1.3.4 Support-compression roller batteries and support-compression sheaves shall be designed to give secure guidance to the towing rope and a smooth passage for grips.

20.7.1.3.5 The rollers shall be arranged in batteries so that the load is automatically distributed evenly among them. Single rollers shall only be used as guide rollers.

20.7.1.3.6 Roller batteries shall be supported in bearings so that they can only rotate about axes parallel to and at right-angles to the lift track. For ski-tows on glaciers, suspensions which move freely in all directions are permissible.

For roller batteries which can rotate about an axis parallel to the lift track and for roller batteries which can move freely in all directions, lead-on and lead-off rollers with deeper grooves shall be used.

20.7.1.3.7 Roller batteries and sheaves shall be adjustable for proper running of the rope on them.

20.7.1.3.8 The rockers and axles of roller batteries and their fastenings shall have at least the following safety factors with respect to the elastic limit:

— the greatest support load with uniform motion:…….. 2,5;

— the greatest support load in operation, with uniform motion and a wind load corresponding to a dynamic pressure of 250 N/mm^2 on the rope or tow hangers in the adjacent half-spans, evenly distributed over all the rollers:…… 1,5;

— the greatest support load out of operation and a wind load deviating from the requirements of EN 12930 corresponding to a dynamic pressure of 1 kN/m^2 on the rope and the tow hangers, with the wind load distributed as above:……. 1,1.

20.7.1.4 Protection against deropement for towing ropes

20.7.1.4.1 Roller batteries and rope sheaves on line support structures shall be equipped with guards against inward deropement of the towing rope, at least at the first and last roller in the case of roller batteries.

The guards may be dispensed with if the inside flange of the roller projects above the bottom of the groove by at least twice the nominal diameter of the towing rope.

20.7.1.4.2 See 18.1.5.2.

20.7.1.5 Rope-catching devices for towing ropes

20.7.1.5.1 Roller batteries and sheaves on the line shall be provided with rope-catchers to catch a rope which has deroped to the outside.

20.7.1.5.2 Rope-catchers shall be arranged so that their outer edges reach a plane which contains the axis of a rope which has climbed up onto the rim of the roller flange and is inclined at least 0,50 rad.

20.7.1.5.3 Rope-catchers shall be designed so that good leading in and a favourable position of the rope in the catcher enable the passage of fixed grips through the catcher; this shall not be affected by movement of the roller battery.

20.7.4.5.4 In the horizontal curves of the track, the provisions of EN 12929-1 shall be applied.

20.7.1.6 Devices for detecting deropement

Roller batteries and sheaves for towing ropes shall be provided with switches on the line support structures in accordance with 18.1.8.

20.7.2 Guidance of tow hangers

The requirements of EN 12929-1 in respect of longitudinal and transverse swaying shall be applied.

20.7.3 Other equipment for line support structures

20.7.3.1 Rope-lifting devices

20.7.3.1.1 Line support structures shall be designed or equipped so that the towing rope can be lifted completely off.

20.7.3.1.2 Detachable lifting devices may be used in place of permanently fixed devices. These shall be secured against capsizing by their construction.

20.7.3.1.3 For dimensioning, the following shall be taken into account:

— the greatest rope support load out of operation;

— the arrangement of the lifting equipment;

— the direction of the loads occurring during lifting.

20.7.3.2 Work platforms and ladders

20.7.3.2.1 Line support structures shall be provided with access ladders and easily accessible work platforms. The platforms shall be independent of the roller batteries. The requirements of EN 12929-1 shall be observed.

20.7.3.2.2 For line support structures where the height of the towing rope is less than 4 m, portable ladders are permissible.

20.7.3.2.3 In addition, the following shall be observed:

— stresses due to resonant vibration;

— accident prevention and occupational health and safety in accordance with EN 13107.

20.7.3.3 Notices

See 18.4.3.

20.8 Materials

See Clause 19.

Annex A
(informative)

Effects of safety devices and functions for all cableway installations, excluding ski-tows

This Annex summarizes the safety devices and functions established in the Standards and lists their required or customary effects.

Meaning of abbreviations:

AZ = Indication, Signal
AG = Start-up blocked
EH = Electrical stop
NH-BB = Emergency stop with service brake
NH-SB = Emergency stop with safety brake
x = Effect required according to the technical design

Table A.1

No.	Text	Standard	Clause	Effect				
				AZ	AG	EH	NH-BB	NH-SB
1	**Drive system**							
1.1	Monitoring two actual values	EN 13223: 2015	8.2.1			x	x	x
1.2	Monitoring actual value against setpoint value	EN 13223: 2015	8.2.1				x	x
1.3	Minimum speed monitoring	EN 13223: 2015	8.2.3				x	x
1.4	Travel direction monitoring	EN 13223: 2015	8.2.4				x	x
1.5	Standstill monitoring	EN 13223: 2015	8.2.6				x	x
1.6	Overspeed trigger 10 %	EN 13223: 2015	8.3.2				x	
1.7	Overspeed trigger 20 %	EN 13223: 2015	8.3.3					x
1.8	Chain or toothed belt monitoring	EN 13223: 2015	8.3.3 a)				x	
1.9	Entry monitoring	EN 13223: 2015	8.4.1				x	x
1.10	Entry monitoring at one point of entry if the normal entry monitoring is cancelled	EN 13223: 2015	8.4.4				x	x
1.11	Fixed point check	EN 13223: 2015	8.4.6 a)			x	x	
1.12	Synchronicity check	EN 13223: 2015	8.4.6 b)			x	x	

No.	Text	Standard	Clause	Effect				
				AZ	AG	EH	NH-BB	NH-SB
1.13	Zero position check	EN 13223: 2015	8.4.6 c)		x		x	
1.14	Speed monitoring passing line support structures and passing loops	EN 13223: 2015	7.2, 8.3.2				x	
1.15	Deceleration monitoring EH	EN 13223: 2015	10.3.6				x	x
1.16	Deceleration monitoring NH-BB	EN 13223: 2015	10.4.3					x
1.17	Deceleration monitoring NH-SB	EN 13223: 2015	10.5.3				x	x
1.18	Monitoring the end positions of switch couplings (effect dependent on the position of the switch coupling)	EN 13223: 2015	6.9.1.3				x	x
1.19	Monitoring of the changing between different drive systems	EN 13223: 2015	8.6.2					x
1.20	Multi-motor drive: changeover monitoring	EN 13223: 2015	8.6.3				x	
1.21	Monitoring the open position of the service brake	EN 13223: 2015	9.2.4				x	
1.22	Monitoring the open position of the safety brake	EN 13223: 2015	9.2.4					x
1.23	Monitoring the closed position of the service brake	EN 13223: 2015	7.1.2 c)		x		x	
1.24	Effect of the service brake during travel	EN 13223: 2015	9.2.4				x	
1.25	Effect of the safety brake during travel	EN 13223: 2015	9.2.4					x
1.26	Monitoring the wear of brake linings of the service brake	EN 13223: 2015	9.2.6	x	x	x	x	
1.27	Monitoring the position of the drive sheave on uni-directional aerial ropeways	EN 13223: 2015	12.2.8					x
1.28	Torque monitoring	EN 13223: 2015	8.6.6				x	x
1.29	Power transmission monitoring (main drive motor – drive sheave)	EN 13223: 2015	8.6.7				x	x
1.30	Loss of electrical power supply or asymmetry in network	EN 13223: 2015	8.6.8				x	
1.31	Field current monitoring	EN 13223: 2015	8.6.9				x	
1.32	Acceleration monitoring	EN 13223: 2015	6.2.2				x	
1.33	Overrunning the normal stopping point	EN 13223: 2015	8.6.10					x
1.34	Overrunning the normal stopping point in the return station of reversible aerial ropeways	EN 13223: 2015	8.6.11				x	x

No.	Text	Standard	Clause	Effect				
				AZ	AG	EH	NH-BB	NH-SB
1.35	Internal combustion motor: monitoring the oil pressure	EN 13223: 2015	6.7.2.3	x				
1.36	Internal combustion motor: monitoring the temperature	EN 13223: 2015	6.7.2.3	x				
1.37	Hydraulic power transmission: monitoring the oil pressure	EN 13223: 2015	6.9.2.4					x
1.38	Hydraulic power transmission: monitoring the temperature	EN 13223: 2015	6.9.2.4	x				
1.39	Monitoring the redundant valves in the safety brake	EN 13223: 2015	9.3.5		x	x		x
1.40	Monitoring the position of the return and deflection sheaves on drive sheaves on uni-directional aerial ropeways	EN 13223: 2015	12.2.8			x	x	x
1.41	Monitoring the position of the drive sheaves on bi-cable reversible aerial ropeways without carrier truck brakes	EN 12929-2:2015	6.2.1					x
1.42	Monitoring the position of return and deflection sheaves on bi-cable reversible aerial ropeways without carrier truck brakes	EN 12929-2:2015	6.18			x	x	x
2	**Other mechanical devices**							
2.1	Monitoring the rope guidance in station areas	EN 13223: 2015	16.4			x	x	
2.2	Monitoring the attachment process	EN 13223: 2015	17.8.1			x	x	
2.3	Monitoring the pitch between carriers	EN 13223: 2015	17.8.2			x	x	
2.4	Monitoring switches in the main carrier rail	EN 13223: 2015	17.8.3			x	x	
2.5	Monitoring closing and locking of carrier doors for uni-directional aerial ropeways	EN 13223: 2015	17.9			x	x	
2.6	Monitoring the carrier doors for reversible aerial ropeways and funicular railways	EN 13223: 2015	17.9		x	x	x	
2.7	Monitoring locking of carrier doors for funicular railways on the line	EN 13223: 2015	17.9			x	x	x
2.8	Monitoring folding or moveable devices	EN 13223: 2015	17.9 20.6.2.1			x	x	
2.9	Monitoring mechanically operated platform doors	EN 13223: 2015	17.9			x	x	
2.10	Monitoring timely dismounting of passengers in chairlifts	EN 12929-1:2015	11.3.6			x	x	
2.11	Monitoring hydraulic switch valves	EN 1908: 2015	7.4			x	x	x
2.12	Monitoring tension travel	EN 1908: 2015	5.2.3.3			x	x	
2.13	Monitoring the hydraulic pressure of the	EN 1908:	8.2.2			x	x	

No.	Text	Standard	Clause	Effect				
				AZ	AG	EH	NH-BB	NH-SB
	tensioning device	2015						
2.14	Fault with the loading band	EN 13223: 2015	17.5.2.8 17.5.2.9			x	x	
2.15	Load measurement for reversible aerial ropeways and funicular ropeways	prEN 1379 6-1:2012	12.1.12		x			
2.16	Monitoring the transverse sway	EN 12929-2:2015	6.13	x		x	x	
3	**Other electrical devices**							
3.1	Maintenance switch (safety switch)	EN 13223: 2015	6.6.4				x	x
3.2	Emergency stop button	EN 13243: 2015	6.4.8			x	x	x
3.3	Interruption, short circuit, earthing of monitored ropes	EN 13243: 2015	7.1.2, 7.1.3, 7.1.4			x	x	x
3.4	Monitoring the on-board brakes in reversible aerial ropeways	EN 13243: 2015	7.2				x	x
3.5	Monitoring the on-board brakes in funicular railways	EN 13243: 2015	7.2					x
3.6	Rope position monitoring	EN 13243: 2015	7.3			x	x	
3.7	Monitoring the earthing potential of the haul rope or the towing rope	EN 13243: 2015	5.2.9		x	x	x	
3.8	Monitoring of other ropes (e.g. auxiliary ropes) with respect to incorrect positioning against the haul rope	EN 12929-2:2015	6.16			x	x	

Annex B
(informative)

Effects of safety devices and functions for ski tows

This Annex summarizes the safety devices and functions established in the Standards and lists their required or customary effects.

Meaning of abbreviations:

AZ = Indication, Signal
AG = Start-up blocked
NH = Stop in accordance with 11.10
x = Effect required according to the technical design

Table B.1

No.	Text	Standard	Clause	Effect		
				AZ	AG	NH
1	**Drive system**					
1.1	Monitoring actual value against setpoint value	EN 13223:2015	11.8.7.1			x
1.2	Minimum speed monitoring	EN 13223:2015	11.8.7.3			x
1.3	Overspeed trigger 10%	EN 13223:2015	11.8.7.4			x
1.4	Monitoring the end position of switch couplings	EN 13223:2015	11.6.1			x
1.5	Changing between different drive systems	EN 13223:2015	11.8.8			x
1.6	Loss of electrical power supply or asymmetry in network	EN 13223:2015	11.8.10			x
1.7	Field current monitoring	EN 13223:2015	11.8.11			x
1.8	Internal combustion motor: monitoring the oil pressure	EN 13223:2015	11.4.2	x		
1.9	Internal combustion motor: monitoring the temperature	EN 13223:2015	11.4.2	x		
1.10	Hydraulic power transmission: monitoring the oil pressure	EN 13223:2015	11.6.2			x
1.11	Hydraulic power transmission: monitoring the temperature	EN 13223:2015	11.6.2	x		
2	**Other mechanical devices**					
2.1	Monitoring loading	EN 12929-1:2015	11.7.6			x
2.2	Monitoring the rope guidance in station areas and station approach batteries	EN 13223:2015	20.5			x
2.3	Monitoring hydraulic switch valves	EN 1908:2015	7.4			x
2.4	Monitoring tension travel	EN 1908:2015	5.2.3.3			x
2.5	Monitoring drop in hydraulic pressure of the tensioning device	EN 1908:2015	8.2.2			x
2.6	Monitoring the erection platform	EN 13223:2015	17.9 20.6.2.1			x
3	**Other electrical devices**					
3.1	Maintenance switch (safety switch)	EN 13243:2015	12.8.7			x
3.2	Emergency stop button	EN 13243:2015	12.8.8			x
3.3	Interruption, short circuit, earthing of monitored ropes	EN 13243:2015	12.10.2, 12.10.3, 12.10.4			x
3.4	Rope position monitoring	EN 13243:2015	12.11			x
3.5	Monitoring service brake	EN 13223:2015	11.7.1 b)		x	x
3.6	Monitoring the open position of the service brake	EN 13223:2015	11.9.1			x
3.7	Monitoring wear of the brake pads	EN 13223:2015	11.9.1	x		
3.8	Monitoring the earthing potential of the towing rope	EN 13243:2015	12.4.6		x	x

Annex C
(informative)

Technical documentation

Sufficient technical documentation should be drawn up for the components which fall within the scope of this standard to enable conformity with the provisions of the standard to be checked. It shall be possible to check the documentation.

The documentation shall include, in particular:

a) documentation for the devices in the stations:

   1) general arrangement drawings of the stations; in particular they shall include the arrangement of all parts critical for operation; in cableways with detachable grips, the length of the braking distance in the event of disturbances to the attachment process; devices for detensioning the rope;

   2) drawings of the sheave bearing arrangement, anchorages, tension devices;

   3) calculations for the sheave bearing arrangement, anchorages, tension devices;

   4) drawings of the support structures for sheave bearings, anchorages, tensioning devices and for the entry and exit rails in cableways with detachable grips;

   5) static calculations for the support structures for drive systems, sheave bearings, anchorages and tensioning devices;

   6) drawings and strength calculations for the tensioning devices;

b) documentation for drive systems and brakes:

   1) general arrangement drawings for the drive systems, on which the technical data for the individual components are shown;

   2) description of the functions in which the essential interrelations are set out;

   3) calculations for the drive systems and the brakes: confirmation of power, the adequacy of the drive system, the effectiveness of the service brake and the safety brake and the mechanical stresses in the brakes;

   4) drawings of the service brake and the safety brake;

   5) general circuit diagrams and cabling diagrams for the electrical parts of the drive systems;

   6) drawings of the position monitor, including its drive system;

c) documentation for sheaves, rollers and track rope shoes:

   1) drawings of the sheaves, including their axles and shafts and the bearing arrangements: for fixed grip mono-cable ropeways, diagrams showing the passage of grips at rope deviations, clearances and guidance of chairs;

   2) drawings of the track rope shoes with diagrams showing the clearances in relation to the carrier truck and the suspension;

3) drawings of the sheaves and roller batteries and their arrangement; diagrams showing the relative clearances of grips and suspensions; diagrams of the devices for protecting the rope guides;

4) calculations for the sheaves and roller batteries including their axles and shafts and bearing arrangements, for the track rope shoes and their fixing;

d) documentation for control and safety devices:

1) general circuit diagrams and cabling diagrams for the control devices and electrical safety circuits;

2) description of the circuit diagrams in which the essential interrelations of the control and safety devices are set out.

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

This European Standard has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association to provide a means of conforming to Essential Requirements of the New Approach Directive 2000/9/EC relative to cableway installations designed to carry persons.

Once this standard is cited in the Official Journal of the European Union under that Directive and has been implemented as a national standard in at least one Member State, compliance with the Clauses of this standard given in Table ZA.1 confers, within the limits of the scope of this standard, a presumption of conformity with the corresponding Essential Requirements of that Directive and associated EFTA regulations.

Table ZA.1 — Correspondence between this European Standard and Directive 2000/9/EC relative to cableway installations designed to carry persons

Clause(s)/Subclause(s) of this EN	Essential Requirements (ERs) of Directive 2000/9/EC	Qualifying remarks/Notes
All Clauses of this standard	4.2	
4.2	2.2, 2.7	
Clause 6	4	
6.2	2.4	
6.3	2.4	
6.4	2.4, 4.2.2, 7.2	
6.5	7.1	
6.6	2.7	
6.7.1	2.3, 2.4	
6.7.2	2.9, 7.1.1	
6.8	4.2	
6.9	4.2	
Clause 7	4.3, 7.1	
7.2	3.1.4	
Clause 8	2.7, 3.1.4, 4	
8.5	4.2.3.2	
Clause 9	4.2.3	
Clause 10	2.4, 2.7.2, 2.7.3	
Clause 11	4.2	
11.2	4.2	
11.3	4.2	
11.4	2.4, 2.9, 7.1.1	
11.5	4.2	

Clause(s)/Subclause(s) of this EN	Essential Requirements (ERs) of Directive 2000/9/EC	Qualifying remarks/Notes
11.6	4.2	
11.7	7.1	
11.8	2.7	
11.9	4.2.3	
11.10	2.7	
Clause 12	2.4, 2.6.1, 2.6.2, 4.1	
12.2.8	2.7	
Clause 13	2.4, 2.6.1, 2.6.2, 4.1	
Clause 14	2.4, 2.6.1, 2.6.2	
Clause 15	2.4, 2.6.1, 2.6.2	
Clause 16	3.2.1, 4.1	
17.1	3.2.1	
17.2	5.6	
17.3	2.3, 3.1.4, 3.2	
17.4	3.1.4	
17.5	3.1.4, 3.2	
17.6	5.1, 5.3	
17.7	3.2.1,	
17.8	2.7.1	
17.9	2.7.1	
17.10	2.5.1, 2.8, 7.1.1	
17.11	2.4	
18.1	4.1	
18.2	4.1	
18.3	3.2.1	
18.4	2.4, 2.5.1, 2.8, 3.2.1, 7.3.2,	
18.4.3	7.1	
Clause 19	2.4, 2.6.1, 2.6.2	
20.2	2.4, 2.6.1, 2.6.2, 4.1	
20.3	2.4, 2.6.1, 2.6.2	
20.4	2.4, 2.6.1, 2.6.2	
20.5	3.2.1, 4.1	
20.6	3.2.1	
20.7	3.2.1, 4.1	
20.7.3	2.4, 2.5.1, 2.8, 3.2.1, 7.1, 7.3.2	
20.8	2.4, 2.6.1, 2.6.2	
Annex A	2.7, 4.1.2, 4.2	
Annex B	2.7, 4.1.2, 4.2	

WARNING — Other requirements and other EU Directives may be applicable to the product(s) falling within the scope of this standard.

Bibliography

[1] EN 287 (all parts), *Qualification test of welders - Fusion welding*

[2] EN 1993 (all parts), *Eurocode 3 - Design of steel structures*

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