



ORGANIZZAZIONE INTERNAZIONALE TRASPORTI A FUNE  
INTERNATIONALE ORGANISATION FÜR DAS SEILBAHNWESEN  
ORGANISATION INTERNATIONALE DES TRANSPORTS A CABLES  
INTERNATIONAL ORGANIZATION FOR TRANSPORTATION BY ROPE  
ORGANISACION INTERNACIONAL DES TRANSPORTES POR CABLE

Technical recommendations in effect

**BOOK 11-1**  
**replaces book n. 11**  
**(Edition 2012)**

# **RECOMMENDATIONS FOR THE CONSTRUCTION AND OPERATION OF NON-PUBLIC ROPEWAYS FOR TRANSPORTATION OF PEOPLE AND GOODS**

This Recommendation is not mandatory but provides guidance to the profession. Its application would be desirable in all countries, however, without prejudice to national standards as well as requirements specified by public authorities.



ROMA 1957  
PARIS 1963  
LUZERN 1969  
WIEN 1975  
MÜNCHEN 1981  
GRENOBLE 1987  
BARCELONA 1993  
SAN FRANCISCO 1999  
INNSBRUCK 2005  
RIO DE JANEIRO 2011

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Sede: I-00188 ROMA | Via Suzzara, 19

**O . I . T . A . F .**

**International Organization for Transportation by Rope  
O.I.T.A.F.**

**RECOMMENDATIONS FOR THE CONSTRUCTION AND  
OPERATION OF NON-PUBLIC ROPEWAYS  
FOR TRANSPORTATION OF  
PEOPLE AND GOODS**

**REVERSIBLE AERIAL ROPEWAYS**

— 2012 —

**BOOK N. 11-1**

**replaces book n. 11**

## Foreword

O.I.T.A.F. decided to revise Book 11 "Recommendations for the Construction and Operation of Non-public Ropeways for Transportation of People and Goods—Reversible Aerial Ropeways" published in 1993.

The objective of this revision was to update the Recommendations to take account of current developments in the ropeway industry.

The outcome entails a high level of safety.

In preparing these Recommendations, the Working Group paid special attention to ensuring safe design as well as easy operation and maintenance.

These Recommendations complement but do not replace national standards.

They have been guided by the "essential requirements" of the European Cableway Directive 2000/9/EC.

In those countries in which the European Directive 2000/9/EC ("Cableway Directive") forms the legal basis for passenger ropeways, these Recommendations can only be applied to ropeways that are not included in the scope of the above Directive, i.e.

- a) installations used for agricultural purposes,
- b) mining installations,
- c) on-site installations used for industrial purposes (note for Austria: industry is subject to the *Gewerbeordnung* — Trade, Commerce and Industry Regulation Act).

In any event, the installations mentioned above are subject to Directive 2006/42/EC ("Machinery Directive") in Europe. Other European directives, such as the Low Voltage Directive 2006/95/EC and the EMC Directive 2004/108/EC may also apply. These OITAF Recommendations are not a harmonized standard under Directive 2006/42/EC. As a result, when these OITAF Recommendations are applied in an EU member state, compliance with the essential requirements of Directive 2006/42/EC has to be demonstrated separately within the framework of the mandatory conformity assessment procedure according to Directive 2006/42/EC. This also applies to any other relevant conformity assessment procedure.

The Recommendations were prepared in co-operation between the following representatives of manufacturers and public authorities from Germany, France, Italy, Switzerland and Austria:

Michel Daniel	Poma, Voreppe, F
Reisch Walter	Reisch Maschinenbau, Frastanz, A
WILLI Robert	Reisch Maschinenbau, Frastanz, A
Schmelzenbach Josef	Steurer Seilbahnen, Doren, A
Seyfried Frank	TÜV-Süd, Munich, D
Imgrüth Hans-Ruedi	Histec Engineering, Buochs CH
Andersag Roman	Gantner, Sulz, A
Wagner Frank	Fachausschuss Bahnen, VBG, Erfurt, D
Kolbitsch Robert	DAV, Munich, D
Oberdorfer Klaus	Office of the Tyrolean Government (A)
Grubinger Georg	Office of the Salzburg Government (A)
Mader Oskar	SEIK GmbH, I
Barbolini Nicola	Ropeway Office, Bozen, I
Metzler Walter	Office of the Vorarlberg Government (A)
Läßer Markus	Office of the Vorarlberg Government (A)
Kaizler Christian	Office of the Vorarlberg Government (A), chairman of the Working Group

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## Article 1 GENERAL

- 1.1 These Recommendations lay down the essential requirements for the design, construction and commissioning of non-public ropeways (reversible aerial ropeways), including operational and maintenance requirements. They complement but do not replace national standards. Their application as effective national technical rules would be desirable in all countries.

These Recommendations do not impose strict limits but are intended to make a contribution to promoting progress and define principles. They do not rule out new materials, new theories, innovative systems and construction types and new design methods just because they did not exist or were not known at the time when these Recommendations were drawn up.

For those reasons, the individual points of these Recommendations have to be seen and interpreted in light of local conditions if they are not sufficiently elastic or comprehensive. If adequately justified, any deviation from this text may be submitted to the competent supervisory authorities for examination and approval. If appropriate, explanatory technical documentation or the results of tests performed or accepted by recognized and approved bodies may be supplied in order to facilitate decision-making by the authorities.

- 1.2 These Recommendations do not apply to public reversible ropeways built as bicable or monocable ropeways or funiculars.
- 1.3 To the extent that these Recommendations do not contain any provisions, construction and operations have to be in line with the recognized state of the art. Deviations from these Recommendations are possible if at least an equivalent level of safety is demonstrated.
- 1.4 Safety of persons:  
The safety of users, workers and third parties is a fundamental requirement for the design, construction and operation of installations.
- 1.5 Safety principles:  
All installations must be designed, built, operated and serviced in accordance with the following principles, which are to be applied in the order given:
- eliminate or, if that is not possible, reduce risks by means of design and construction features
  - define and implement all necessary measures to protect against risks which cannot be eliminated by the design and construction features,
  - define and state the precautions which should be taken to avoid the risks which it has not been possible to eliminate completely by means of the provisions and measures referred to in the first and second indents.

- 1.6 Consideration of external factors:  
Ropeways must be designed and constructed so as to make it possible to operate them safely, taking into account the type of ropeway, the nature and physical features of the terrain on which it is installed, its surroundings and atmospheric and meteorological factors, as well as possible structures and obstacles located in the vicinity either on the ground or in the air.
- 1.7 Dimensions:  
The installation must be dimensioned, designed and constructed to withstand, with a sufficient degree of safety, all stresses encountered under all foreseeable conditions, including those which occur when not in operation, and taking account in particular of outside influences, dynamic effects and fatigue phenomena, while complying with the acknowledged rules of the art, in particular with regard to the choice of materials.
- 1.8 Assembly:  
The installation must be designed and constructed in such a way as to ensure that it can be safely assembled and put into place. Assembly mistakes must be made impossible, either as a result of construction or by means of appropriate markings.
- 1.9 The design, construction work and construction management may only be carried out by companies or persons having the required technical expertise.
- 1.10 For each installation, the terms of use defining the material ropeway's scope of application have to be agreed between the operator and the manufacturer.  
Building thereon, the designer and the manufacturer have to prepare a complete analysis of all foreseeable hazards in consultation with the operator that results into a risk assessment identifying the measures which are taken to reduce the risks to an acceptable level.

## **Article 2 DEFINITIONS**

### **Operations log book:**

Documentation recording all the checks and maintenance work performed.

### **Durability:**

Compliance with the requirements of structural safety and fitness for use within the framework of intended utilization and foreseeable influencing factors without unforeseen maintenance and repair work.

### **Monocable ropeway:**

Ropeway in which one or more carrying-hauling ropes carry and, at the same time, move the carriers.

### **Influencing factors:**

have an effect on the ropeway as a result of its construction and utilization as a consequence of:

- mechanical stress (loads, forces),
- chemical action (salts, hazardous substances, organic compounds),
- biological factors (bacteria, insects, fungi, algae),
- environmental factors (wind, hail, snow, ice, sunlight, temperature, humidity, lightning, fire),
- combinations of influencing factors (ice/wind, avalanches, mudslides, flooding, rockfalls, landslides).

### **Electrical equipment:**

Electrical equipment comprises control, monitoring and safety devices, communications and information devices, lightning protection devices, lighting installations as well as electric motors.

### **Carrier:**

Consists of:

- carrier truck and/or grip
- cabin or transport bucket
- suspension gear connecting the cabin or transport buckets with the carrier truck or grip

**Note:** If passengers are to be transported in buckets, the buckets need to have a roof and circumferential walls with a height adjusted to the way passengers are transported (standing, seated).

### **Danger:**

Critical situation characterized by a leading hazard and accompanying circumstances.

### **Hazard scenario:**

Any event that directly results in dangers.

### **Planned service life:**

The period envisaged for utilization.

### **Space envelope:**

The space envelope describes the possible positions of the carrier and other moving parts of the ropeway.



**Maintenance:**

Simple and regular measures taken to ensure fitness for use.

**Non-public ropeway:**

Non-public ropeways are operated exclusively for the internal transportation of freight and a group of authorized persons. There is no obligation to operate the ropeway. The group of authorized persons is restricted to the employees and members of the operator as well as persons connected with the operation or whose transportation appears to be necessary in the public interest. The guests of hotels, restaurants and similar establishments are not eligible for internal transport. The group of authorized persons is familiar with the special characteristics of the relevant ropeway operations.

**Recovery drive:**

Drive that permits operations at reduced speeds but at the same level of safety in case of a failure of the main drive system.

**Utilization:**

The use of the ropeway described in the terms of use.

**Use-related requirements:**

Requirements for characteristics of the ropeway resulting from its intended use.

**Terms of use:**

The terms of use have to be drawn up in a dialog between all parties involved in the ropeway's construction and operation and serve as a project basis for the construction of the ropeway.

The terms of use define the "non-public ropeway" in a comprehensive way. They have to specify at least one operating mode according to Article 17 and submit it to a risk assessment.

See: *Checklist for terms of use, Annex I*

**Roller assembly:**

Group of rollers arranged one behind the other, including their support structure, for deflecting a moving rope.

**Dismantling:**

Orderly demolition or disassembly of a structure with components and construction materials being sorted with a view to proper disposal.

**Safety objective:**

Qualitative and quantitative definition of the requirements to be met by the ropeway in case of extraordinary events and conditions.

**Gravity operation:**

The ropeway can move down to the lower station based on the excess of downhill forces alone. This may depend on the load level and the line section.

**Roller:**

Rotating rope support whose radius is smaller than the rope's bending radius at the point of contact.

**Note:** As a rule, the rope is deflected by less than 5°.

**Sheave:**

Rotating rope support that imparts its radius of curvature to the rope.

**Funicular:**

Installation on which one or more carriers are moved by one or more ropes on a dedicated ground-based track.

**Environmental factors:**

Physical, chemical or biological environmental influences that may negatively affect the structural safety, fitness for use and durability of an installation.

**Vibrations:**

Specification of inadmissible vibrations. The vibration limit is exceeded if experts assess that the vibration is expected to result in damage to the installation or its components or early replacement or if the vibrations/oscillations give rise to unacceptable noise.

**Economic efficiency:**

Efficient use of financial and natural resources in relation to the total period of design, construction and utilization

**Reliability:**

A measure of the likelihood that the requirements of safe operations and availability are met.

**Bicable ropeway:**

Ropeway on which carriers are borne and moved by two separate ropes or groups of ropes called track ropes and haul ropes.

**ROPES:** are classified as follows:

**Moving rope:**

Rope designed for large longitudinal movement.

**Note:** In general, one or more carriers are or can be attached to moving ropes.

**Aviation marker rope:**

Static rope designed for carrying balls in contrasting colors making it easier for pilots to recognize parts of ropeway installations.

**Carrying-hauling rope:**

Moving rope designed for hauling and, at the same time, carrying the carriers.

**Counter rope:**

Moving rope that does not link the carriers via the drive sheave on a bicable ropeway or funicular and that has an end connection on the carriers.

**Note:** The term "câble-lest" may be used instead of "contre-câble" in French; in English, the term "ballast rope" may be used instead of "counter rope" if the drive station is located on the mountain.

**Fixed rope, static rope:**

Rope that is fixed at least on one end and, if appropriate, is borne by one or more rope supports.

**Rope loop (closed), endless loop:**

Rope loop closed by splicing.

**Note:** In an open loop, the ends of the rope are fixed to the carrier or carrier truck.

**Signal cable, control cable, control line:**

Static rope exclusively used for transmitting electric control signals and telephone calls.

**Tensioning rope:**

Rope that connects the non-fixed end of a static rope or the sheave of a rope loop with the tensioning device.

**Track rope:**

Static rope carrying the carriers that move on it by means of a carrier truck.

**Anchoring rope:**

Rope that transmits forces from the track ropes and/or towers or other parts of the installation to the anchorages.

**Haul rope:**

Moving rope that moves the carriers attached to it, but does not carry them.

### **Article 3 RISK ASSESSMENT**

For all installations, a risk assessment has to be prepared for each mode of operation (see Article 17) and each phase of its life cycle.

On the basis of the terms of use, the risks to be assumed for the ropeway's operation are analyzed. The analysis is to ensure that the framework conditions jointly defined by the owner and builder in the terms of use are taken into account in the design and construction of the installation so that a satisfactory level of safety is achieved. This analysis has to be performed using an accepted or well-established method with account being taken of the state of the art and the complexity of the installation.

In particular, the analysis covers the safety devices and their effect on the installation.

The risk assessment considers all the risks and hazardous situations analyzed. The protective measures required derive from this assessment.

### **Article 4 DOCUMENTATION AND EVIDENCE TO BE PROVIDED**

4.1 The following documentation is required for presenting the project for the construction or significant modification of a ropeway:

- a) Technical report with a description of the project
- b) Terms of use
- c) Overview map on a scale of 1:25,000 or 1:50,000 showing the ropeway line
- d) Longitudinal section and site map on a maximum scale of 1:2,000 showing terrain and rope lines, stations and line structures, intersections with power lines, railroads, roads and paths as well as structures located close to the ropeway
- e) Rope and longitudinal section calculations, evidence of the drive power required and the guaranteed transmission of the circumferential force
- f) Station plans on a maximum scale of 1:100 with layout plans, sections and views, including technical facilities
- g) Risk assessment
- h) Fire safety concept

4.2 By the time of commissioning at the latest, documents have to be submitted on the following items:

- a) Buildings
- b) Mechanical equipment of the stations
- c) Line structures
- d) Carriers together with grips and proof of free movement
- e) Electrotechnical equipment
- f) Operating manual
- g) Maintenance manual
- h) Test certificates
- i) Evacuation devices and evacuation plan
- j) Commissioning report
- k) Review of interfaces
- l) Fire prevention measures
- m) Implementation of the measures defined in the safety report

## Article 5 SPACE ENVELOPE AND TRACK GAUGE

The space envelope of aerial ropeways has to be examined for the cases "in service" and "not in service". Consideration has to be given to:

- Lateral deviation of the ropes;
- Vertical deviation of the ropes;
- Transverse sway of carriers;
- Longitudinal sway of carriers;
- Hand area.

The superposition of transverse and longitudinal sway may be neglected.

In the "not in service" case, carriers have to be taken into account if they remain on the line and are to be assumed to be empty.

- 5.1 The space envelope has to be dimensioned appropriately for the operating conditions defined in the terms of use. If the carrier's transverse sway is less than 0.20 rad and its longitudinal sway is less than 0.30 rad, evidence for the adequacy of the space envelope has to be provided. The space envelope also has to take account of lateral deflection caused by wind in line with the terms of use.
- 5.2 A minimum safety distance of 0.50 m laterally and 0.12 m below should be maintained between the space envelope of the carrier body and components of the ropeway. In hazardous areas for persons, the above safety distances have to be maintained at any rate.
- 5.3 If this space envelope is not achieved in stations, measures have to be taken to safely prevent collisions.
- 5.4 At two-track ropeways, the distance between the ropes has to be so wide at the point where track ropes or carrying-hauling ropes cross that collisions and rope entanglements are impossible under the operating conditions defined in the terms of use. If a minimum distance of 0.5 m is not reached between carriers swaying inward by 0.20 rad, evidence of safe operation has to be provided.
- 5.5 At one-track ropeways with a haul or carrying-hauling rope loop, the horizontal distance between a carrier swaying by 0.20 rad and the opposite haul or carrying-hauling rope has to be at least 1.00 m on spans with chord lengths of up to 300 m under the wind conditions defined in the terms of use.  
In the case of spans with chord lengths of more than 300 m, this distance has to be increased by at least 0.20 m per 100 m of additional length.

The distances may be smaller than indicated above if contacts between the carrier and the opposite haul or carrying-hauling rope are impossible.

- 5.6 At funiculars, a lateral safety distance of at least 0.50 m from the car has to be maintained in areas hazardous for persons when the funicular is in service.

## Article 6 SAFETY ZONES

6.1 The vertical clearance between the deepest position of the moving parts of the ropeway and the ground and any obstacles must not fall below the following values with account being taken of snow heights to be expected and dynamic influences:

in inaccessible terrain	2.50 m
in accessible terrain	3.50 m
across roads	4.50 m
across buildings	2.50 m

The distances to the terrain may be reduced to 0.50 m if these areas are fenced off.

Distances to roads may be reduced with the consent of the road operator. In that case, additional safeguarding measures are required.

The distance to buildings has to be so large that burning objects do not endanger the ropeway.

Dynamic influences have to be taken into account by increasing the vertical sag:

- of track ropes by 5%,
- of moving ropes by 15%.

6.2 The clearance between ropeway components and fixed objects not belonging to the ropeway has to ensure safe operation under the operating conditions defined in the terms of use. The minimum distance of swinging ropes and/or carriers swinging laterally by 0.2 rad to fixed objects not belonging to the ropeway has to be 1.50 m. Evidence for safe operation has to be provided. The lateral deflection of the ropes by wind is to be taken into account by assuming a dynamic pressure of at least 150 N/m<sup>2</sup>. For spans with a length of more than 400 m, the reduced lengths indicated in Article 7.6 may be used.

6.3 In areas where the ropeway crosses or comes close to power lines, the relevant national safety regulations have to be complied with. If necessary, protections have to be provided.

6.4 In areas where the ropeway crosses or comes close to other ropeways, safe operation has to be ensured for both ropeways.

6.5 Relevant national regulations on aeronautical obstructions have to be complied with.

## Article 7 LOAD ASSUMPTIONS, CONSTRUCTION WORK AND SAFETY MARGINS

- 7.1 Rope calculations and the calculation of the bearing loads of stations and towers have to be performed for stationary loads and uniformly moving loads. The masses to be accelerated also have to be taken into account in the calculation of the drive power. The following assumptions have to be used for the design of the overall installation:
- |  |  |
|--|--|
| — Mass of one person   | 80 kg  |
| — Coefficient of friction between ropes and rollers            | 0.03   |
| — Coefficient of friction between track ropes and rope saddles | 0.10   |
| — Acceleration max.  | 0.4 m/s <sup>2</sup>                             |
| — Deceleration until stop max.                                 | 0.6 m/s <sup>2</sup>                             |
| — Intrinsic deceleration max.                                  | 1.2 m/s <sup>2</sup>                             |
| — Service brake: Braking deceleration min.                     | 0.5 m/s <sup>2</sup> , max. 1.5 m/s <sup>2</sup> |
| — Safety brake: Braking deceleration min.                      | 0.5 m/s <sup>2</sup> , max. 1.5 m/s <sup>2</sup> |
| — Service and safety brake max.                                | 2.5 m/s <sup>2</sup> (applies to all load cases) |
- 7.2 The calculation of slip resistance on the drive sheave has to be based on 1.5 times the maximum circumferential force for uniform motion. For rubber-lined drive sheaves, the coefficient of friction used must not be higher than 0.25. Other lining materials may be used, if evidence of the coefficient of friction is provided. If necessary, the environmental influences specified in the terms of use have to be taken into account as well.
- 7.3 The wind forces specified in the terms of use are used as a basis for dimensioning the components and safe operation. However, the values used must be at least as follows:
- |                  |                       |
|------------------|-----------------------|
| — in service     | 250 N/m <sup>2</sup>  |
| — not in service | 1200 N/m <sup>2</sup> |
- Local characteristics and/or deviations from the values can be taken into account on the basis of related expert opinions.
- 7.4 For the calculation of wind forces acting on the different reference surfaces, the following coefficients have to be used:
- |                                    |     |
|------------------------------------|-----|
| Ropes                              | 1.2 |
| Tubular towers with ladders        | 1.2 |
| Rectangular towers                 | 1.3 |
| Lattice towers                     | 2.8 |
| Roller assemblies and rope saddles | 1.6 |
| Carriers                           | 1.4 |
- 7.5 For spans that are longer than 400 m, a reduced length  $l_{red} = 240 + 0.4 l$  may be used for calculating wind forces, with  $l$  being the effective chord length.
- 7.6 Rope anchorages and parts of the load-bearing structure, with the exception of foundations, have to be dimensioned for a static rope load augmented by 20%.
- 7.7 For the dimensioning of towers and saddles, the friction forces of the track ropes acting in the most unfavorable direction as calculated in accordance with 6.1 have to be multiplied by a factor of 2.0.

- 7.8 In areas that are particularly exposed to the risk of ice buildup, ice loads have to be taken into account.  
The extent of additional loads, such as ice and snow, has to be defined in the terms of use and taken into account in the calculations of all the components affected.
- 7.9 The foundations of stations and line structures have to be built in line with the terms of use and ensure safe operation in all operating cases. They have to be built in line with the recognized state of the art.
- 7.10 It has to be demonstrated that the towers and station components subject to static loading reach at least 1.7-fold resistance to yield stress. Otherwise, it has to be demonstrated that dimensioning complies with the applicable standards.
- 7.11 Components subject to dynamic loading and the carrier's load-bearing components have to reach at least 2.5-fold resistance to yield stress.
- 7.12 All components made of steel have to be protected against corrosion in accordance with the terms of use.

**Article 8 ROPES**

- 8.1 Only locked coil ropes or galvanized stranded ropes may be used as track ropes. They must be made in one piece. Excess lengths must be provided for moving the rope three times by the longest supporting length.
- 8.2 Only galvanized stranded lang-lay ropes may be used as haul ropes and carrying-hauling ropes.
- 8.3 Haul ropes for operating winches may also be regular lay ropes.
- 8.4 The minimum diameter of haul ropes has to be 8 mm.
- 8.5 Tensioning ropes must be fine-wire regular lay ropes with one strand layer. The strands have to be arranged in the parallel lay.
- 8.6 The required properties of the wire ropes have to be evidenced by test certificates.
- 8.7 Special-purpose rope wire has to be used for the ropes.
- 8.8 The tensile safety factor must not fall below the following values in relation to the calculated breaking load:
 

Track rope	3.2
Haul rope	4.5
Haul rope for winch operation	7.0
Carrying-hauling rope	4.5
Tensioning rope	4.5
Signal cable	2.5 (1)
Aviation marker rope	2.5 (1)

In winch operation, the safety factor for haul ropes with diameters exceeding 15 mm may be reduced by 0.1 per millimeter of additional rope diameter down to a minimum value of 5.0.



- (1) 1.2 in the case of signal cables or aviation marker ropes firmly anchored on both ends with account being taken of the most unfavorable climatic conditions.
- 8.9 The minimum rope tension of the track rope has to correspond at least to the 40-fold roller load (roller load factor).  
The minimum rope tension of the track rope has to correspond at least to the 8-fold maximum transverse force (transverse force factor).
- 8.10 The relation between the highest grip load to the lowest haul rope tension must be at least 20.
- 8.11 Rope terminations and connections must be implemented in such a way that they are protected against corrosion and can be easily checked.  
Wedge-type sockets have to be positioned so that the rope is not bent as far as possible in the socket area.
- 8.12 In winch operation, the following applies to rope terminations:  
At the carrier, only terminations shall be permitted whose clamping force does not depend on the tensile force and which cannot rotate.  
At least three residual turns have to remain on the winch drum. The free end of the rope has to be secured adequately in a way reducing rope wear.
- 8.13 Carrying-hauling rope connections have to be made by long splicing. The minimum splice length has to be 1,200 times the nominal rope diameter. There may be a maximum of three splices in a carrying-hauling rope loop. The minimum distance between the ends of two splices has to be 3,000 times the nominal rope diameter. Spliced connections are not permitted in case of winch operation.
- 8.14 Work on ropes may only be performed by persons familiar with such work.

## **Article 9 ROPE ANCHORING AND TENSIONING**

- 9.1 Track ropes may be either firmly anchored or tensioned by means of an automatic tensioning device. In the case of firmly anchored track ropes, all possible load cases according to the terms of use have to be taken into account in the rope calculations.
- 9.2 If track ropes are anchored on drums, a minimum of three turns have to remain on the drum. The free end of the rope has to be secured by means of a profiled rope clamp. Attention has to be paid to protecting the drum and the rope layers against the entry of water from haul ropes running in close proximity.
- 9.3 Clamps used at rope ends have to be dimensioned to reach at least triple slip resistance.
- 9.4 When track ropes are anchored using profiled rope clamps, a control clamp has to be mounted a short distance after them.
- 9.5 Haul ropes and carrying-hauling ropes have to be kept at the tension required for transmitting the circumferential force. If required by the rope's catenary or external factors, a suitable re-tensioning device or an automatic tensioning device has to be installed. If required by operating conditions or icing, the tensioning motion has to be dampened.

## **Article 10 STATION BUILDINGS**

- 10.1 The mechanical and electrotechnical equipment of the stations either has to be weatherproofed or installed in such a way that it is not exposed to the weather. This equipment has to be accessible for maintenance purposes and secured against unauthorized use.
- 10.2 Lighting has to be installed in the stations for the ropeway's operation during darkness.
- 10.3 Objects that may put the ropeway's operation at risk must not be kept in the stations.
- 10.4 A sign has to specify the maximum number of persons and the maximum permissible load to be transported per carrier. Information has to be given on special aspects of carrier loading. A sign has to prohibit access to the stations by unauthorized persons.
- 10.5 Rules of conduct have to be affixed in the stations (in particular, no smoking and no open flame).
- 10.6 The counterweight pits have to be drained and accessible down to the bottom of the pits. They have to be secured to prevent persons from falling.
- 10.7 Internal combustion engines have to be installed in a room separated from the ropeway equipment.
- 10.8 Persons must not be endangered by the carriers entering or leaving the stations. Carrier locations have to be marked.
- 10.9 Facilities for carrier maintenance have to be available in one of the stations.
- 10.10 Fall protection devices have to be provided at dangerous places in the stations.

## **Article 11 TOWERS**

- 11.1 Towers have to be anchored in concrete foundations; anchorage in rock is permitted.
- 11.2 Towers may only be guyed with ropes in justified cases.
- 11.3 The bearing load of the track rope on tower saddles has to be determined in line with the conditions specified in the terms of use; however, it has to be at least equal to the wind force resulting from a side wind acting with a dynamic pressure of at least 500 N/m<sup>2</sup> on half the length of the two adjacent spans. The reduced rope lengths according to 6.6 may be used in calculations. The track rope must not leave the tower saddles even if the greatest rope force occurring is increased by 30%. If hold-down devices are installed, they must not hinder the movement of the rope in the saddle's groove. Evidence has to be provided demonstrating that the track rope lies securely on the track rope saddle. To reduce lateral loads acting on the track rope saddle as a result of lateral wind forces, the use of pivoting track rope saddles is preferable.

- 11.4 The horizontal deflecting force of the track rope resulting from a widening or deviation of the track must not exceed 5% of the smallest bearing load. In case of bigger changes in the track, suitable curve saddles have to be installed with appropriate haul rope guides. Evidence has to be provided for safe rope support and operation-induced transverse sway.
- 11.5 The radius of the track rope saddles has to be at least equal to:
- 250 times the rope diameter for saddles over which a rope moves.
  - The radial acceleration must not exceed  $2.5 \text{ m/s}^2$ .
  - In the case of static and non-traveled ropes, the values applying to anchoring drums have to be used.
- 11.6 Tangential contact with the rope saddle radius according to 11.5 also has to be ensured even at 120% of the effective mass.
- 11.7 The rope groove for the track rope has to be wider than the rope's nominal diameter by at least 5% and has to be such that it encompasses the track rope by at least 2.60 rad. The grooves of the track rope saddle must be smoothed and, if necessary, have to be provided with lubricators.
- 11.8 Rope grooves in which the track rope moves have to be made of sliding materials. The ends of the track rope saddles have to be rounded.
- 11.9 Rollers have to be provided to guide the haul rope or carrying-hauling rope on the saddles. The number of the rollers has to be determined as a function of the magnitude of the bearing load and the roller lining used. The deflection angle per roller has to be in line with the permissible load on the roller or roller lining and must not exceed 0.08 rad for carrying-hauling rope rollers and 0.12 rad for haul rope rollers.
- 11.10 Roller assemblies for carrying-hauling ropes have to be arranged in such a way that all rollers are loaded uniformly.
- 11.11 In the case of carrying-hauling ropes, the roller load must not be less than 500 N at a nominal running speed of up to 2.5 m/s. At running speeds of more than 2.5 m/s, the roller load has to be increased by 20 N per 0.1 m/s of increase in the running speed.
- 11.12 On each side, the support load of carrying-hauling ropes indicated in [N] has to equal at least ten times the sum of the adjacent chord lengths in [m].
- 11.13 In the case of carrying-hauling ropes, the minimum support load has to be maintained on hold-down roller assemblies when the vehicle loaded with the maximum permissible effective mass is present on these roller assemblies.
- 11.14 In the case of carrying-hauling ropes, the minimum roller load in support roller assemblies has to be guaranteed even when the rope tension force is increased by 30%.
- 11.15 If the minimum loads according to 11.13 or 11.14 are not complied with, counter-rollers have to be installed to ensure safe rope guidance.

- 11.16 On the first and last roller of roller assemblies for carrying-hauling ropes, rope deflectors have to be installed on the inside. Catching devices that permit the passage of the grips have to be mounted on the outside.
- 11.17 The catching devices have to be designed in such a way that a carrying-hauling rope slipping off the roller rim at an inclination of 0.54 rad in relation to the roller's plane is still caught.
- 11.18 The roller assemblies have to be equipped with switches that shut down the drive in the event of rope derailment. These switches must not be dependent on the position of the carrying-hauling rope and must not automatically return to the standby state.
- 11.19 Inner and outer rope re-engagement devices have to be mounted in order to safely return the haul rope back to the rollers.  
In the case of electrically insulated haul ropes, at least the outer rope re-engagement device has to be grounded.
- 11.20 Intermediate stations may be provided with fixed or mobile boarding ramps. When fixed ramps are used, measures have to be taken to protect persons from being trapped or falling when the carrier passes through the station. Areas in which there is a risk of falls have to be secured. Dangerous points of mobile ramps have to be monitored in the safety circuit.  
The standard stopping point of the carrier has to be indicated at the operator's stand.
- 11.21 Towers have to be provided with ladders and service platforms. Signs have to indicate that unauthorized persons must not ascend the towers. Towers have to be numbered sequentially. It has to be ensured that the service platforms can be safely accessed from the ladder.
- 11.22 Towers have to be equipped in such a way that the ropes can be completely lifted from their supports.

## **Article 12 STATION EQUIPMENT**

- 12.1 Ropeways have to be equipped with a motor drive.
- 12.2 Motorized emergency drives are required if evacuation is impossible in gravity operation. In the case of gravity operation, the brakes have to be suitable for it.
- 12.3 Test runs must be performed at a speed adjusted to the test method. The drive has to be suitable for the speed of the test run.
- 12.4 It must be possible to see the entry and exit, the display and measuring devices and as large a part of the line as possible from the control room.
- 12.5 Moving parts of the ropeway located in the operation and passageway areas have to be guarded against accidental contact.
- 12.6 The drive has to be equipped with a service brake and a safety brake. The braking force has to be generated by weights or pressure springs. The force must be transmitted mechanically. The braking force has to be adjustable.

12.7 The following monitoring devices have to trigger the appropriate safety functions.  
Abbreviations and symbols used:

Must	The function must be monitored at any rate
RA	On the basis of a risk assessment, the function may not be monitored.
Sig	Signaling, display
DB	Departure blocked
El.stop	Electric stop
ES SvB	Emergency stop with service brake
ES SfB	Emergency stop with safety brake
X	Response required
O	Response required depending on the situation

Safety function	Relevance	Sig	DB	El.st op	ES SvB	ES SfB	Comment
Actual-actual speed monitoring	RA				O	O	Monitoring of actual speed(s) at least by continuous mutual comparisons
Monitoring of target vs. actual speed	RA				X		Monitoring of target speed comparing it with actual speed
Monitoring of minimum speed	Must				X		
Monitoring of direction of travel	Must				X		
Monitoring of standstill	Must				O	O	
10% overspeed	Must				X		
20% overspeed	Must					X	Any chains or belts have to be monitored
Entry monitoring	Must				X		
Selective entry monitoring	Must				X		If regular entry monitoring is suspended
Fixed-point monitoring	RA				X		
Synchronism control	RA				X		
Zero position check	RA		X				
Monitoring of speed at towers	RA				X		
Deceleration monitoring— el.stop	RA				X		
Deceleration monitoring—ES SvB	RA				X		
Monitoring of switching between different drives	Must					X	
Monitoring of the service brake's open position	RA				X		
Monitoring of the safety brake's open position	Must					X	
Monitoring of the service brake's closed position	RA		X				
Monitoring of power transmission (main drive—drive sheave)	RA					X	
Monitoring of power consumption by the main drive motor: Peak current	Must				X		
Overrunning of the end point	Must				O	O	
Overrunning of the end point in the opposite station of reversible ropeways	Must				O	O	
Monitoring of cooling system	RA		O	O	O		
Monitoring of gearbox oil pressure	RA		O	O	O		
Internal combustion engine: Monitoring of oil pressure	Must	X					
Internal combustion engine: Temperature monitoring	Must	X					
Hydraulic transmission: Monitoring of oil pressure	Must					X	
Hydraulic transmission: Temperature monitoring	Must	X					

Safety function	Relevance	Sig	DB	El.st op	ES SvB	ES SfB	Comment
Monitoring of the safety brake's redundant valves	Must		X				
Monitoring of carrier doors (closing and locking) in stations	RA		X				
Monitoring of carrier doors (closing and locking) on the line	RA				X		
Monitoring of folding or sliding devices	RA				X		
Monitoring of hydraulic changeover valves	RA				O	O	
Monitoring of the tensioning path	RA				O	O	
Monitoring of the hydraulic pressure of the tensioning device	RA				O	O	
Motor circuit breaker	RA				O	O	
Fuses and automatic circuit breakers of important circuits	RA				O	O	
Maintenance switch (safety switch)	Must					X	
Emergency stop button	Must			O	O	O	
Interruption, short circuit, fault to ground of monitored ropes	RA			O	O		
Monitoring of on-board brake of funiculars	RA					X	
Rope position monitoring	RA			O	O		
Sheave position monitoring	RA					X	?

The above specifications are based on EN 13223.

- 12.8 The sections have to be limited by means of limit switches. They have to be actuated directly by the carrier. In the case of one-track ropeways, the limit switch may be actuated differently in justified cases.
- 12.9 Emergency limit switches have to be mounted immediately after the limit switches.
- 12.10 In line with the mode of operation and the risk assessment, shut-off devices have to be mounted and designated at clearly visible and easily accessible points of the stations.
- 12.11 Measures have to be taken to safely prevent that the installation is inadvertently set in motion during servicing and maintenance work.
- 12.12 Brake tests have to be performed using suitable load masses.
- 12.13 A self-adjusting carrier position indicator has to be installed in the control room. This indicator has to show the locations of the stations and towers.
- 12.14 Vehicle position indicators, position monitors and devices for monitoring the running speed are to get data from non-driving sheaves as far as possible.
- 12.15 Buffers must be mounted to stop the carrier if it travels beyond the end positions. The buffer has to be designed so that neither the carrier is damaged nor the passengers are injured when the carrier hits the buffer at the maximum entry speed.
- 12.16 The need for installing a winch drive has to be justified for areal ropeways.
- 12.17 In the case of winch operation, the distance between the axle of the winch drum and the first deflection roller must not be less than 25 times the effective drum width if there is no rope winding device.

- 12.18 Not more than five rope layers may be wound on a winch drum unless special measures are taken to prevent the rope from penetrating into lower layers of windings. Winch drums must be grooved.
- 12.19 In the case of winch operation, the control room has to be arranged in such a way that the operator can observe the winding process. The maximum permissible winding diameter has to be monitored.

### Article 13 ENTRY MONITORING

If required by the mode of operation and the risk assessment, entry monitoring devices have to be installed in the stations and, if appropriate, on line structures. Any reduction of speed required has to be monitored in line with the risk assessment.

### Article 14 SHEAVES, ROLLERS AND ROPE DRUMS

- 14.1 The following table shows the minimum diameters for sheaves, rollers and rope drums:

Purpose	Rope type	Place of use	Multiples of rope diameter at the bottom of the groove
Track rope	Locked coil rope	Anchoring drum	60
	Stranded rope	Anchoring drum Sheave with lining	40 120
Haul rope, hauling-carrying rope	Stranded rope	Drive, deflection and return sheave	with lining 60
	Stranded rope 6 x 7	Rollers	10 (min. Ø 150 mm)
	Stranded rope 6 x 19	Rollers	8 (min. Ø 150 mm)
	Stranded rope 6 x 7	Anchoring drum for the haul rope	15
Tensioning rope	Stranded rope	Winch drum	60
		Winch drum	40
		Tension sheave	with lining 40 without lining 50

- 14.2 Ice scrapers have to be mounted on the drive, deflection and return sheaves for haul ropes and carrying-hauling ropes. This requirement may be waived where permitted by the climatic conditions.
- 14.3 The running surfaces in contact with moving ropes have to be provided with a soft liner reducing rope wear. The liner has to be provided with a groove for guiding the rope. The liner's modulus of elasticity must be 5000 N/mm<sup>2</sup> or less.
- 14.4 The total groove depth (distance from the external roller flange to the groove's bottom / 2) has to be at least 1.5 times the rope diameter (haul ropes).
- 14.5 Rollers have to be provided with side plates made of metal.

## Article 15 CARRIERS

- 15.1 The permissible loading mass, the loading instructions required, the permitted number of persons, a no-smoking sign and passenger instructions must be posted clearly and permanently in the carrier.
- 15.2 If passengers are transported in a sitting position in open carriers, the carriers must be lined up to a height of at least 0.40 m above the seats. If passengers are transported in a standing position, the carriers must be lined up to a height of at least 1.20 m above the carrier's floor.
- 15.3 The flooring of the carrier has to be in line with the terms of use. For standing passengers, a minimum floor area of 0.20 m<sup>2</sup> must be provided per person. For seated passengers, a minimum seat width of 0.45 m per person has to be provided.
- 15.4 Open carriers have to be provided with a protective roof. A protective roof has to be mounted on funicular cars if the clearance does not allow passengers to stand up during the journey.
- 15.5 Carriers have to be designed in a way permitting rescue. An anchor point for rescue equipment must be provided. Windows must be made of a shatter-proof material. Windows must only open to such an extent that persons are not endangered near towers and in stations.
- 15.6 Carriers have to be provided with reflectors on the uphill and downhill ends. On two-track ropeways, the carriers have to be numbered.
- 15.7 Carrier doors have to be secured against accidental opening.
- 15.8 The carrier truck has to be provided with an anti-derailment device or the roller rims have to extend at least to the lower edge of the track rope. Snow scrapers have to be fitted to the carrier trucks; they may be omitted where permitted by the climatic conditions.
- 15.9 The haul rope has to be connected to the carrier truck in a way reducing rope wear. It has to be possible to periodically inspect the connection of the haul rope to the carrier trucks. If, as an exception, a connection is used that cannot be checked, the haul rope section connected has to be replaced periodically. Wedge-type sockets may only be used for ropes with a diameter of more than 16 mm in justified cases. Evidence has to be furnished for the quality characteristics of the components of rope connections. Rope end connections have to be dimensioned for the rope's theoretical ultimate load.  
If clamps are used in continuous haul ropes and carrying-hauling ropes, at least triple slip resistance has to be ensured even in the most unfavorable load case and where a reduction of the rope diameter is possible in operation. The incoming and outgoing radii of clamps used on a continuous haul rope have to correspond at least to the fivefold nominal rope diameter. Bracket clips (bolt clamps) must not be used.
- 15.10 The weight of the carrier has to be distributed to the rollers of the carrier truck as evenly as possible. The load on the rollers of the carrier truck must not be relieved by the action of the haul ropes or single-side loading.



- 15.11 The load-bearing parts of carriers as well as their connections must be designed in such a way that their condition can be checked.
- 15.12 If, in special cases, a carrier truck brake is to be provided, it has to comply with the provisions applicable to ropeways used in public transport.
- 15.13 Closed carriers have to be provided with sufficient ventilation.
- 15.14 In the case of winch operation, a device has to be mounted that shuts down the drive when the load is removed from the haul rope. This device should preferably be installed on the carrier

## **Article 16 ELECTROTECHNICAL EQUIPMENT**

- 16.1 Electrical equipment has to be housed in dedicated closed cabinets.
- 16.2 Circuit diagrams have to be kept in the drive station. The electrical equipment must be permanently marked in conformity with the circuit diagrams.
- 16.3 Safety, control and signal circuits located outside the drive station must be operated at protected extra-low voltage (PELV) or safety extra-low voltage (SELV).
- 16.4 Drive station and opposite station, towers and technical equipment have to be provided with lightning protection systems. Control and telecommunication lines have to be provided with overvoltage protection devices where they leave the stations.
- 16.5 Safety devices have to comply with the safety level required by the risk assessment and their conformity has to be demonstrated.
- 16.6 A voice communication system has to connect the two stations.
- 16.7 Depending on the mode of operation and the risk assessment, acoustic signals indicating readiness for departure in the stations and, if appropriate, a stop command to be triggered in the carrier have to be provided.
- 16.8 Equipment that does not belong to the ropeway installation must not be housed in the control cabinet.
- 16.9 The values of important parameters, such as running speed, mains voltage, power consumption of the drive motor and pressures in hydraulic systems must be displayed.
- 16.10 The readiness of the ropeway to start has to be indicated.
- 16.11 If variable-speed drives are used, a stop command has to be issued when the running speed falls below 0.1 m/s.
- 16.12 The triggering of a safety device has to be indicated until the device is reset.
- 16.13 An operating hour counter and a trip counter have to be installed.

## **Article 17 OPERATION**

### 17.1 Modes of operation:

The ropeway has to be operated in one out of the following three modes of operation:

- a) Operation with an occupied control room in one station
- b) Operation with control from the carrier
- c) Operation without operating personnel

### 17.2 Resumption of service after an automatic stop:

On principle, after an automatic stop, the causes of the malfunction have to be clarified and eliminated before the installation may be taken into operation again. The trip may be continued to the station for evacuating the ropeway, if necessary, with some or all safety devices being disabled. The substitute measures required have to be taken in such cases.

## **Article 18 EVACUATION**

18.1 An evacuation plan has to be drawn up for evacuation.

18.2 Evacuation devices have to be available that permit the evacuation of persons from the carriers in case of a failure even under most adverse conditions within a period of time defined in the terms of use.

18.3 The facilities and rescue equipment required according to the evacuation plan have to be available in the carrier.

18.4 An evacuation exercise has to be performed annually.

## **Article 19 OPERATING PERSONNEL**

19.1 An operations manager has to be appointed for managing ropeway operations. If the operations manager is prevented from working, operations may be continued if a deputy operations manager is available. These persons must have the requisite suitability for performing their tasks.

19.2 Further persons may only be appointed by the operations manager if they have been demonstrably trained and are familiar with the ropeway.

## **Article 20 OPERATING REGULATIONS**

20.1 The operation of the ropeway has to be governed by operating regulations.

20.2 In accordance with the terms of use, the operating regulations have to contain provisions on:

- the persons admitted for transport
- the performance of passenger transport
- the tasks of operating personnel
- the loading rules
- the signaling rules
- the keeping of records in the operations log book

- the instructions for starting operations for the day or after special events
- maximum wind speed
- control of the ropeway
- periodic checks
- maintenance
- evacuation
- storage of material or objects in the stations, if applicable
- fire fighting

## Article 21 MAINTENANCE

- 21.1 Maintenance has to be carried out in line with the manufacturers' instructions. These instructions have to be available at the ropeway. The proper functioning of the installation has to be verified by the operations manager in charge at least once a year.
- 21.2 Ropes have to be visually inspected in accordance with the terms of use but at least once a year.
- 21.3 After extraordinary events (suspected lightning strike, catastrophic weather events, rope overthrow, etc.) the rope sections affected have to be inspected immediately.
- 21.4 Track, haul and carrying-hauling ropes have to be submitted to magnetic rope testing in accordance with the terms of use but no later than 12 years after their installation. Based on the results of testing, shorter testing intervals have to be specified, if necessary. In addition, the sections of track ropes that rest on the towers have to be visually inspected. Magnetic rope tests have to be performed by qualified persons or inspection bodies.
- 21.5 Sections of the track rope exposed to elevated stress have to be displaced every 12 years at the latest.
- 21.6 Track, haul and tensioning ropes have to be repaired or discarded in case of impermissible reductions of the cross-section. This is the case if the reduction of the metallic cross-section (broken wires, wear, corrosion, loosening of the structure or other damage) exceeds the following values indicated as a percentage of the reference length:

Locked coil ropes	10% to 200 d	5% to 30 d *)
Stranded ropes	15% to 40 d	6% to 6 d

d.... nominal rope diameter

\*) ... an outer wire break is permitted

If a visual inspection finds that the above values are reached by more than two-thirds, a magnetic rope test has to be performed or the rope has to be repaired or discarded.

- 21.7 An impermissible reduction of the cross-section also exists if:
- a) a locked coil rope has two breaks of adjacent outer wires that are located relative to one another in such a way that they are likely to fall out and repair is not possible anymore;
  - b) more than half the outer wires of one strand are broken at one point in a stranded rope.

- 21.8 Wedge-type sockets of haul ropes have to be visually inspected annually. In a setup providing protection against vibration, the wedge-type sockets have to be displaced every 4 years and, in all other cases, every two years by the length of the socket (8d).
- 21.9 Cast sockets of track ropes have to be replaced every 6 years or, in a setup providing protection against the weather and vibrations, every 12 years. Cast sockets of haul ropes have to be replaced every 4 years.
- 21.10 In endless haul rope loops, haul rope grips have to be opened and displaced by the grip's length annually.

**Article 22 COMMISSIONING**

- 22.1 Before commissioning, the proper functioning and the fitness for use of all ropeway components has to be demonstrated in the course of acceptance testing.
- 22.2 Insurance has to be taken out to cover third-party liability resulting from the ropeway's operation.

**Article 23 TERMS OF USE**

The terms of use lay down:

- General objectives for the use of the ropeway, also called usage requirements,
- Environment of the ropeway,
- Requirements of third parties,
- Requirements for the operation and maintenance of the ropeway,
- Special requirements of the owner,
- Safety objectives and special risks.

**23.1 Topics and information relevant for use and usage requirements**

**23.1.1 Use of the ropeway**

- Operation in the course of the day and the year as well as service life
- Loads to be transported
 

<b>Persons</b>	Ropeway competence and risk acceptance
<b>Animals</b>	Typical behavior, size and compressive forces exerted by feet
<b>Material</b>	Loading and unloading as well as extent of hazards for operations, personnel and the environment

**23.1.2 Service life**

The planned service life has to be specified. Possible reference values are:

- Temporary structures up to 10 years
- Exchangeable components up to 25 years
- Buildings and other structure of normal significance 50 years

### 23.1.3 Construction standard

The construction standard of a ropeway includes:

- Adequate integration/adaptation
- Design
- Reliability
- Economic efficiency
- Robust construction
- Durability
- Quality
- Level of monitoring
- Rescue and evacuation concept
- Conformity (compliance with all legal requirements)

## 23.2 Environment of the ropeway

### 23.2.1 Environmental factors

- |  |  |
|--|--|
| <ul style="list-style-type: none"><li>• Wind</li><li>• Ice</li><li>• Hail</li><li>• Snow</li><li>• Avalanches</li><li>• Water</li><li>• Fire</li><li>• Lightning</li><li>• Temperature</li><li>• Darkness</li><li>• Fog</li><li>• Sunlight</li></ul> | <p>Combination of environmental factors</p> <ul style="list-style-type: none"><li>• Ice/wind</li><li>• Avalanches</li><li>• Mudslides</li><li>• Flooding</li><li>• Rockfalls</li><li>• Landslides</li><li>• Tree falls</li></ul> |
|--|--|

### 23.2.2 Technical requirements

- Useful load
- Properties of the material to be transported
- Transport capacity
- Geometric parameters
  - Fixed points of the ropeway axis
  - Fixed points of the ropeway corridor
  - Loading space
  - Buildings
  - Dimensions of passageways

### 23.2.3 Modes of operation

The three most frequent modes of operation are described in Article 17.

## 23.3 Topics relevant for the environment

- Noise (drive system) (acoustic signals, roller noise)
- Visual appearance
- Vibrations

#### **23.4 Possible requirements of third parties**

- Intermediate station
- Protective scaffolding for traffic routes
- Transit rights
- Building rights
- Forests
- Aviation

#### **23.5 Requirements of operation and upkeep**

- Minimum availability
- Accepted extent of maintenance, additions to Article 21

#### **23.6 Special requirements of the owner**

- Comfort
- Dismantling
- Generator operation (energy recovery)
- Construction period
- Protective measures (corrosion, aging, natural hazards)
- Infrastructure for personnel (staff room, toilet)
- Infrastructure for maintenance (workshop)
- Vandalism (risk, acceptance and measures)
- Fire (risk, acceptance and measures)
- Budget

#### **23.7 Safety objectives and special risks, hazards, damage and residual risk**

- Damage and hazards to personnel (persons)
- Hazards and damage to the environment
- Damage and hazards to third parties
- Damage to first and second parties
- Damage and hazards to power lines crossed
- Hazards to aircrafts
- Hazards to the existing funicular