



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 N. 25-2

Fundamental safety aspects of bicable reversible aerial ropeways

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.



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ROMA 1957
PARIS 1963
LUZERN 1969
WIEN 1975
MÜNCHEN 1981
GRENOBLE 1987
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O. I. T. A. F.

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Fundamental safety aspects of bicable reversible aerial ropeways

Hazardous situations and Hazardous scenarios which ought to be given due consideration in a safety analysis

SUBSYSTEMS

- 1. Ropes and Rope connections
- 1.1 Ropes

Component	Function	Requirements	Hazardous situation	Hazardous scenario
All ropes	Connect components of a ropeway	Guarantee transmission of energy	Release of energy	Excessive elongation of the rope
			Broken rope	Rope tension calculation error
				Dimensioning error
				Improper rope selection
				Production error
				Damage during the transport of the rope
				Assembly error
				Damage due to contact between ropes (for instance rope cross-over) or impact against solid objects for instance rope reengagement device occurring in conditions of relative simultaneous movement
				Damage due to external action (lightning stroke, falling rock, falling trees, ice)
				Fatigue of materials , alternate bending, pulsating fatigue , torsional strain, compression
				Corrosion
				Excessive thermal stress (fire, lightning stroke, electrical current, friction, welding, socketing, action of the track rope brake
				Excessive wear
		Resistance to torsional stresses resulting from operating conditions	Broken rope Deropement	Rope departs from its regular position, modification of the rope cross section, undue strain and slackening of the rope
		Chemical compatibility of rope lubricants and the contact area	Destruction of the lining	Inadequate rope lubricant (rope deflection, rope supporting contact areas)
Haul rope Counter rope	Haul carriers	Guarantee the transmission of frictional forces of rope fixings (for instance grips, chapeux-de-gendarme	Slippage of carriers along the rope	Insufficient frictional forces
		To maintain unchanged the rope geometry	Slippage of the carrier along the rope	Rope diameter is either too big or too small

				Loose external wires sticking out of the rope structure
			Broken rope	Coiling damage of winch rope
		Guarantee the transmission of peripheral forces onto the driving sheave (haul rope)	Loss of driving capacity	Inadequate rope lubricant
		To maintain unchanged the required rope geometry	Failure of components	Excessive vibrations
			Deropement	Rope diameter too small or too big
		Capacity to take up additional loads	Broken rope	Loose external wires sticking out of the rope structure
Track rope	Carry and support carriers	Adequate bearing capacity	Broken rope	The actuation of the track rope brake or failure of the redundant action of the haul rope cause the rope to be subjected to an excessive stress
		Capacity to take up the load of carriers	Broken rope	Rope subjected during operation to excessive stress in specific highly stressed points, for instance carrier truck intake or run off points of the saddle, rope bearing area
		Capacity to take up the action of brakes	Broken rope	Insufficient lubrication of rope contact areas
	Provide guidance of carrier truck rollers	Maintain unchanged the rope geometry	Derailment of the carrier	Excessive transverse load
			Failure of components	Rope subjected to excessive stress due to the action of the track rope brake
Tension rope	Transmission of tensile forces	Capacity to take up forces	Broken rope	External wires sticking out of the rope structure
				Failure of components
Control rope	Transmission of signals	Carrying capacity	Failure of signal transmission	Rope subjected during operation to excessive stresses in highly stressed points (for instance deflection or return points)
				Poor load balance
				Overstressed rope

Signal rope Contact rope			Broken rope	Overstressed rope
Guy rope	Back up structures	Adequate bearing and supporting capacity	Broken rope	Rope subjected during operation to excessive stress in specific highly stressed points (for instance bearing points)
				Rope anchoring point subjected to excessive stress (for instance constrained forces due to constrained or excessive movement)
Evacuation rope	Haul the rescue carrier	Like requirements as for the haul and counter rope	Like hazardous situations as for the haul and the counter rope	Like hazardous scenarios as for the haul and the counter rope
		Adequate carrying capacity	Broken rope	Rope entanglement
Winch rope	To haul the rescue carrier	Alike requirements for the haul and the counter rope	Alike hazardous situations of the haul and the counter rope	Alike hazardous scenarios of the haul and the counter rope

1.2 Rope connections

Component	Function	Requirement	Hazardous situation	Hazardous scenario
All rope connections	Like general functions as for ropes and specific functions of haul and counter ropes	Like general requirements as for ropes and specific requirements for haul and counter ropes	Like general hazardous situations as for ropes and specific hazardous situations of haul and counter ropes	Like general hazardous scenarios as for ropes and specific hazardous scenarios of haul and counter ropes
Splice	To connect rope ends	Transmission of the tensile force of one rope to the next one	Splice failure	Strand slippage
				Failure in the splice knot or splice area surrounding tuck ends
				Insufficient or excessive tensile force
				Broken wires (for instance contact between strands)
Poured socket (socket and cone)	To connect a rope end to the carrier or with another component	Transmission of the tensile force to fastening points	Failure of the poured socket	Improper introduction of forces (points or direction)
				Rope slipping out of the cone due to a manufacturing error (for instance inappropriate wire preshaping, incorrect wire pretreatment, inadequate pouring material, ill-chosen temperature)
				Unconstrained rotation of the poured socket
				Assembly error
Anchoring drum (without clamp)	Connection between rope and carrier or another component	Transmission of tensile forces to fastening points	Failure of the anchoring	Material fatigue due to vibrations at the rope inlet point
				Dimensioning error (for instance failure of the load bearing structure)
				Improper point and direction of introduction of forces into the connection
				Insufficient frictional adherence between rope and drum
Splice	To connect rope ends	Smooth passage of splices over sheaves and rollers	Splice failure	Failure of the drum lining material
				Excessive stress due to a drum diameter which is too small
				Material fatigue due to vibrations at the rope inlet point

				Excessive thermal stress (fire, lightning stroke, electrical current, friction, welding and socketing)
			Corrosion of the rope	Corrosion due to inadequate selection of the lining material
Clamping plate	Connection between rope and carrier or another component	Transmission of the tensile force of the rope to fastening points	Failure of the clamping plate	Dimensioning error (for instance too high design coefficient of friction between rope and clamping plate which is too high, excessive compression
			Failure of the connection	Excessive reduction of the rope diameter
		Conservative and heedful working conditions of the rope	Rope damage	Material fatigue due to vibrations at the rope inlet point
Wedge socket	Connection between rope and carrier or another component	Transmission of the tensile force of the rope onto fastening points	Failure of the wedge socket	Improper point and direction of introduction of forces into the connection
		Frictional take up of forces	Rope slippage	Improper geometry of the wedge socket fitting
		Conservative and heedful working condition of the rope	Rope damage	Failure due to loss of rope tension
Wedge type coupling	Connection between rope and carrier or another component	Transmission of the tensile force of the rope onto the fastening point	Failure of the wedge type coupling	Improper geometry of the wedge socket fitting
			Failure of the wedge type coupling	Improper geometry of the wedge socket fitting
			Rope slippage	Failure due to loss of rope tension
				Improper geometry of the wedge socket fitting
		Conservative and heedful working conditions of the rope	Rope damage	Material fatigue due to vibrations at the rope inlet point
			Loss of load bearing capacity	Material fatigue due to vibrations at the rope inlet point
				Disorder of the rope geometry at the rope inlet point

2 Drives and brakes

Component	Function	Requirement	Hazardous situation	Hazardous scenario
All drives and brakes	Hauling and braking of the ropeway	Ensure concurrent action of all components of the driving system	Failure of the driving and braking systems	Loss of the safe and regular position of ropes due to an excessive deceleration
		Guarantee the availability of the ropeway	Immobility of the ropeway	Failure of a driving mode
Driving motor and power supply	Hauling and braking of the ropeway	Provide the necessary performance and torque for the intended use of the ropeway	Failure of the driving system	Motor subjected to overload exceeding the limits of the performance which is required for its intended purpose
			Uncontrolled movement of the ropeway	Outage of power supply
				Blocked motor
		Controlled and monitored performance of the ropeway	Uncontrolled movement of the ropeway	Insufficient driving and braking performance
				Excessive oscillations of the rope
		Driving modes which are independent one from another	Failure of driving units	Overspeed
Clutch (fast and slow shaft) Reduction gear	Hauling and braking of the ropeway	Transmission of the motor torque to the driving sheave	Failure of the clutch	Simultaneous actuation of several driving modes
			Uncontrolled movement of the ropeway	Blocked reduction gear
				Coupling subjected to excessive stress
				Interrupted transmission of the force
Driving sheave with bearing	Hauling and braking of the ropeway	Provide guidance and carrying capacity	Deropement	Damage or impairment due to vibrations
				Broken driving sheave
				Blocked driving sheave (failure of the bearing)
				failure, displacement or deformation of the driving sheave
		Transmission of the force from sheave to rope	Rope slippage	Inadequate groove geometry or insufficient height of flanges
				Insufficient frictional adherence of the rope (for instance inadequate lining material, groove geometry, rope lubricant, contamination or ice on contact area, loss of lining components)
			Slippage of the lining on the drive sheave	Unacceptable geometry
Winch			Derailment of carrier truck or deropement	Insufficient frictional adherence
			Broken winch	

	Hauling and braking of the ropeway	Provide guidance and braking capacity		Blocked winch drum (failure of the bearing)
				Failure, displacement or deformation of the winch drum
				Inadequate groove geometry or insufficient height of drum flanges
				Rope run off by jerks and jolts due to defective coiling
		Transmission of forces from drive to rope	Rope slippage	Insufficient frictional adherence (for instance inadequate lining material, rope lubricant, contamination or ice on the contact surface, loss of lining components)
Mechanical brake	Bring the ropeway to a standstill and maintain it	To decelerate the ropeway till standstill with the specified rate of deceleration	Insufficient deceleration	Insufficient fastening of the end fixing of the haul rope
				Loss of pressure (for instance mechanical failure of a component of the brake, malfunction of brake controls, blocked pressure transmitting element)
				Reduced pressure (for instance failure of the brake spring, increased internal friction, wear of the brake lining)
				Increase of the brake reaction time (for instance due to contamination in the brake piping, extremely viscous pressure transmitting fluid)
				Reduced coefficient of friction (for instance inadequate friction material, contaminated or iced contact surfaces, heating up of brake lining)
				Unacceptable load condition
		Maintain standstill of the ropeway	Excessive deceleration	Excessive force (for instance over dimensioned brake, malfunction of brake controls, accidental simultaneous application of several brakes, loss of the flywheel mass)
			Accidental movement of the ropewayx	Insufficient retention force
		Possibility to open brakes deliberately	Immobility of the ropeway	Prevented opening of the brake

3 Mechanical devices

3.1 Rope tensioning equipment

Component	Function	Requirement	Hazardous situation	Hazardous scenario
All rope tensioning devices	Apply and maintain the tension of the rope	Maintain the rope tension within the specified range of tensions	Failure of the tensioning device	Dimensioning error
			Components subjected to excessive stress (for instance ropes, splice, rope connection, supporting elements)	Excessive or insufficient rope tension
			Unacceptable variation of the rope configuration or of the load carrying stretch of the line	Excessive or insufficient rope tension (for instance clearance, rope pressure, deropement, occurrence of dangerous rope swinging)
			Haul rope slippage on the drive sheave	Insufficient rope tension
Mobile rope tensioning device	To apply and maintain the tension of the rope	Mobility of the rope tensioning device	Unacceptable increase or drop of the rope tension	Reduced clearance, (travel of the tensioning lorry) or blocked tensioning device
			Rope vibrations	Jerky and jolting movement of the tensioning device
Hydraulic tensioning device	To apply and maintain the tension of the rope	Maintain the rope tension within the specified range of rope tensions	Components subjected to excessive stresses (for instance rope, splice, end fixings, supporting structures)	Excessive or insufficient hydraulic pressure
			Failure of the tensioning function	Contaminated hydraulic oil, for instance, water, dirt) or clogged pipes
				Use of inadequate media (for instance range of temperatures)
				Missing indication of the low level of oil
				Defective components (for instance valves, defective controls or their incorrect regulation)
				Leakage or broken pipe
			Unacceptable increase or drop of the rope tension	Slow regulation (for instance insufficient pipe diameter, insufficient pumping output)
				Incorrect measurement of the rope tension (for instance due to the use of unsuited or defective measuring devices)
			Fire hazard, combustible load	Hydraulic oil leakage

			Oil fouling of other components	Hydraulic oil leakage
Counterweight tensioning device	To apply and maintain the rope tension	Maintain the rope tension within the specified range of rope tensions	Rope vibrations	Unacceptable dynamic behaviour of the whole system

3.2 Mechanical equipment of stations

Component	Function	Requirement	Hazardous Situation	Hazardous scenario
Rope saddle	Support the track rope	Adequate carrying capacity	Deropement	Dimensioning error
			Broken rope	Overstressing (for instance due to excessive bending)
		Guiding capacity	Deropement	Inadequate rope saddle (for instance groove, saddle radius or saddle lining)
				Insufficient rope pressure
				Iced groove inlet point
			Entrapped carrier	Insufficient carrier clearance (for instance application of the carrier truck brake)
			Hindrance or constraint of the longitudinal movement of the track rope	Dimensioning error
Roller and roller shaft	To guide the haul rope and support its load	Support the load of the haul rope	Deropement	Track rope blocked by the saddle
		Adequate guidance of the haul rope	Deropement	Dimensioning error
				Failure of the component (for instance insufficient lining prestressing)
				Insufficient clearance for the carrier roller cut sawn by the rope
				Inadequate roller (for instance groove, flange)
				Excessive lateral forces (for instance wind, widening of the track)
Track rope deflection	Rope deflection,		Deropement causing the carrier to crash down to the ground	Excessive lateral forces (for instance wind, track widening)
				Skew rollers
				Loss of function due to icing
				Dimensioning error

	take up the additional load of the track rope	Capacity to deflect and support the load of the rope	Broken rope	Overstressing (for instance excessive curvature) Insufficient lubrication of contact surfaces with the rope
		Adequate guidance	Deropement	Inadequate rope saddle (for instance groove, saddle radius or saddle lining) Insufficient rope pressure Icing of rope inlet points of the saddle
			Entrapped carrier	Insufficient carrier clearance (for instance due to the application of the carrier truck brake)
			Hindrance or constraint of the free movement of the track rope	Dimensioning error
			Release of energy (lift off by fits and starts))	Track rope blocked by the track rope saddle (for instance insufficient lubrication)
Mobile track rope deflection devices (for instance deflection sheave or roller chain with bearing)	To support and guide the rope	Provide adequate support	Deropement	Failure of the mobile rope deflection device (for instance broken sheaves, rollers or roller chains) Displacement or deformation of the mobile deflection device or crashing down to the ground
			Release of elastic energy (lift off by fits and starts))	Blocked mobile deflection device (for instance failure of the bearing)
		Provide guidance	Deropement	Inadequate guidance (for instance groove, flange)
			Broken rope	Fatigue of the rope material due to inadequate geometry of the bearing Fatigue of the rope material due to the variable bending of the rope in the deflection area
Supporting structure of mechanical devices	Support the live load (for instance of vehicles, roof)	Provide adequate bearing capacity	Failure of the supporting structure	Insufficient load carrying capacity Insufficient fatigue strength Failure of connections Insufficient ultimate serviceability state
			Entrapped carriers	Insufficient carrier clearance
End of track buffer	Limit the travel of the ropeway	Capacity to take up the impact	Overshooting the regular stop. Sudden release of energy. Uncontrolled movement of the haul rope and of the carrier	Dimensioning error

		Capacity to cushion the impact	Excessively strong impact. Lift off of the carrier truck. Carrier crashing down to the ground	No adequate cushioning of the impact
Haul rope return and deflection sheaves with bearings	Guide the haul rope and support its load	Adequate load carrying capacity	Deropement	Broken rollers
				Blocked rollers (for instance failure of the bearing)
				Sheave displaced deformed or crashing down
		Provide adequate guidance	Deropement	Improper roller geometry (for (instance grooves, flanges
			Broken rope	Damaged rope
Rope guiding rollers, deflection rollers	To support and guide the rope	Provide adequate bearing capacity	Deropement	Insufficient load bearing capacity
				Failure of flanges
				Failure of roller securing elements
				Failure of the bearing (for instance rolling bearing)
		Provide adequate guidance	Deropement	Inadequate roller (for instance grooves, flanges)
				Incorrect alignment

3.3 Mechanical equipment of line structures

Component	Function	Requirement	Hazardous situation	Hazardous scenario
Line saddles	Support track rope	Provide adequate load bearing capacity	Deropement	Dimensioning error
			Broken rope	Overstressing (for instance excessive bending).
		Provide adequate guidance	Deropement	Inadequate saddle (for instance groove, saddle radius, or saddle lining)
				Insufficient rope pressure
				Groove icing at the rope inlet point
			Entrapped carrier	Insufficient carrier clearance (for instance due to the application of the carrier truck brake

			Hindrance or constraint of the longitudinal movement of the track rope	Dimensioning error
			Release of energy (lift off by fits and starts)	Track rope blocked by the track rope saddle
Roller and roller shaft	Guide the haul rope and support its load	Support the load of the haul rope	Deropement	Dimensioning error
				Failure of the component (for instance insufficiently prestressed the lining insert
		Adequate guidance of the haul rope	Deropement	Insufficient carrier clearance
				Roller cut by the rope
				Inadequate roller (for instance groove, flange)
				Excessive lateral forces (for instance wind, broader track
				Skew rollers
				Loss of function due to icing
Rope catching device	To catch ropes that have gone off their regular track	Provide adequate catching capacity	Rope crashing down to the ground	Failure to hold back the rope that has gone off the track
		Capacity to hold back the rope that has gone off the track	Rope crashing down to the ground	Dimensioning error
		Provide adequate guidance of the rope that has gone off the track	Rope crashing down to the ground	Unacceptable deformation
			Entrapped carrier	Insufficient carrier clearance
Haul rope reengagement device	To guide the haul rope	Provide adequate guidance	Deropement	Dimensioning error
				Unacceptable geometry
			Entrapped carrier	Insufficient carrier clearance
Haul rope reengagement derailleur	Guidance of the haul rope that has gone off the track	Provide adequate guidance	Entrapped carrier	Insufficient carrier clearance
Intermediate haul rope reengagement device for double track ropes	Guarantee the necessary space and clearance	Guarantee the necessary clearance	Entrapped or derailed carrier	Insufficient carrier clearance
				Collision of the closed carrier truck brake with the intermediate reengagement device
	Transfer the load of the haul rope onto the track rope	Conservative and heedful fastening to the track rope	Entrapped carrier by projecting broken wires	Track rope subjected to oversteering

	Maintain the necessary distance between both track ropes	Provide the necessary transmission of forces to both ropes	Derailed carrier or carrier crashing down to the ground	Modification of the track
	Hanging device suspended on the haul rope in a point of the rope span (for instance used to reduce the sag of the rope or the haul rope load exerted on the carrier)	Guarantee an appropriate support of the haul rope	Inadmissible position of the haul rope, overstressing of the rope connection with the carrier	Failure of the intermediate haul rope reengagement device
		Provide adequate guidance of the haul rope	Damaged haul rope	Haul rope entrapped at the level of the intermediate reengagement device
			Deropement at the level of the intermediate reengagement device, entrapped carrier	Excessive lateral force (for instance wind, vibrations of the haul rope exceeding the limits of the guiding capacity of rollers)

4 Carrier

4.1 Cabin

Component	function	Requirement	Hazardous situation	Hazardous scenario
All cabins	Carry loads	Adequate load bearing capacity	Failure of the load bearing structure	Insufficient load bearing capacity
				Insufficient fatigue strength
				Use exceeding the limits of the intended purpose
				Damage due to accumulation of water or snow in the voids
				The application of the carrier truck brake causes the carrier to hit for instance the rope
				Excessive deceleration causes persons or loads to be hit or collide
				Failure of connecting elements
				Thermal overstress (fire, lightning stroke)
	Guarantee the necessary availability of space	Necessary clearance	Rope swinging	Excessive wind sensitivity
			Entrapped or derailed carrier	Insufficient clearance in stations
				Insufficient clearance along the line
Floor, walls, ceiling and windows, hook, straps and other contrivances for passengers to hold themselves	Accommodate passengers	Adequate carrying capacity	Failure of the load bearing structure	Dimensioning error
				Failure of connecting elements
				Action of the weather (corrosion, embrittlement, chemical action, temperature

			Persons stumbling and falling	Inadequate surface finish of the cabin floor (skid proof floor)
				Inadequate or missing contrivances for passengers to hold themselves
Windows	Visibility	Visibility	Persons or objects falling out of the cabin	Openings which are too big
			Injured persons	Arms, legs, head stretching out of the cabin
				Insufficient illumination of the inside of the cabin
				Brittle material
Ventilation	Air supply	Adequate air supply	Oxygen deficiency	Insufficient air supply
Cabin door	Open and close the cabin	Adequate opening function	Injured passengers	Doors are too small
		Adequate closing function	Injured passengers	Squeezing or shearing of members of the body
			Persons or objects falling out through the door	Doors open during the travel

4.2 Hanger

Component	Function	Requirement	Hazardous situation	Hazardous scenario
All hangers	Connection between carrier truck and cabin	Adequate load bearing capacity	Failure of load bearing structures	Insufficient load bearing capacity
				Insufficient fatigue strength
				Conditions exceeding the limits of the intended use
				Failure of connecting elements
				Damage due to the accumulation of water and snow in the voids
				Action of weather conditions (for instance corrosion)
		Adequate clearance	Entrapped or derailed carrier	Insufficient clearance in the station
				Insufficient clearance along the line

4.3 Carrier truck

Component	Function	Requirement	Hazardous situation	Hazardous scenario
Carrier truck	Guidance and carriage of carriers	Adequate load bearing capacity	Failure of load bearing structures	Insufficient load bearing capacity
				Insufficient fatigue strength
				Failure of connecting elements (for instance weldings)
				Exceeding the limits of the intended use
				Damage due to the accumulation of water or snow in the voids
		Adequate guidance	Carrier truck derailment	Excessive snow load on track rope
			Lift off of the carrier truck, carrier truck crashing against the rope or fixed structures	Failure of the longitudinal swing damper
				Excessive centripetal acceleration of the carrier truck when passing over the line structure
		Adapt itself to the track curve	Carrier truck derailment	Excessively stiff structure
	Clearance		Entrapped or derailed carrier	Insufficient clearance in the station (for instance longitudinal swinging clearance)
				Insufficient clearance along the line (for instance deceleration due to the application of brakes, clearance)
	Take up of forces at the end of the track (station buffer)	Take up and transmission of the reaction force of the buffer	Failure of load bearing structures	Insufficient load bearing capacity
Carrier truck brake	In the case of breakage of the haul rope or counter rope or failure of rope end fixings bring to a standstill and maintain the standstill of the carrier gripped to the track rope.	Guarantee the standstill of the carrier	Insufficient deceleration	Failure of the rope pressure (for instance mechanical failure of a component of the brake, malfunction of brake controls, blocked braking pressure transmitting media)
				Drop of braking force (for instance failure of brake springs, increased internal friction, wear of brake lining)
				Longer reaction time of the brake (for instance contamination of brake piping, excessively viscous pressure transmitting fluid)

				Drop of the coefficient of friction (for instance inadequate friction material, contamination or icing of the contact surface, inadequate rope lubricant, heating up of the brake lining)
				Inadequate load conditions
			Excessive deceleration (causing the carrier to strike the track rope or the line support structure)	Excessive braking pressure (for instance overdimensioned brake, malfunction of braking controls)
			Carrier derailment	Actuated brake getting stuck against the track rope saddle
			Lift off of the carrier truck	Malfunction of brake controls
		Maintain the standstill of the carrier	Accidental movement of the carrier	Insufficient carrier retaining capacity

4.4 Connection with the rope

Component	Function	Requirement	Hazardous situation	Hazardous situation
Grip	To connect rope with carrier	Transmission of the tensile force	Uncontrolled movement of the carrier (grip slippage along the haul rope, carrier crashdown)	Dimensioning error
				Breakage of components which transmit forces
				Reduced coefficient of friction between rope and brake shoe
				Insufficient clamping pressure (for instance variation of the internal friction, broken spring or fatigue of the spring, internal blockage)
	To support the haul rope	Adequate load bearing capacity	Carrier crashing down	Dimensioning error, breakage of components which transmit forces
Poured socket (socket and cone)	Cf chapter 1.2 (rope connections)			
Anchoring drum (without clamp)				

Clamping plate	
Wedge type coupling	

5 Electrotechnical devices (are not being dealt with in this recommendation)

6 Recovery and evacuation devices

Foreword

The choice of the rescue equipment very much depends on the type of the ropeway installation for which it is used, as well as on the local conditions of the site. There are also several types of rescue devices which are not considered as specific rescue devices of the ropeway industry, such as for instance platforms designed to lift persons or motor turntable ladders. Neither have been covered in this document the different rescue systems the use of which also depends on local conditions. (for instance the use of helicopters).

Component	Function	Requirement	Hazardous situation	Hazardous scenario
All recovery and evacuation devices	Rescue persons	Rescue and recover passengers within an acceptable lapse of time	Injury to the health of persons	Inadequate rescue system
				Inexperienced rescue team
				Insufficient recovery and evacuation devices
				Damage or injury due to weather conditions (for instance wind, cold, heat)
		Safe, fast and ergonomic operating conditions	Persons falling down to the ground	Insufficient facilities of access, exit or crossing over
				Insufficiency of safeguarding facilities for persons to be rescued
				Operation exceeding the limits of the intended field of application
				Insufficient load bearing capacity
				Failure of connecting elements
			Injured persons	Excessive stress
				Poor light conditions
				Missing or insufficient stepboards, hanging and holding contrivances or personal protection equipment
				Inadequate maintenance of recovery and evacuation devices

				Insufficient information of passengers
				Accidental movement or start of the ropeway (for instance mobile ropes, rollers)
				Missing or insufficient access and floor space
Recovery and evacuation ropeway	See general functions listed in this document			
	Evacuation of persons along the rope line	Safe, fast and ergonomic operating conditions	Injured persons	Inexperienced starting operation of the ropeway
				Rescue carrier or vehicle docking with an excessively high speed the main ropeway carrier
	Sufficient clearance for the inoperative main ropeway installation	Adequate clearance	Collision with the main ropeway	Insufficient ropeway clearance
Rope travel devices	Transport the rescue team by means of a carrier travelling on the rope	Safe, fast and ergonomic operating conditions	Injured persons	Dimensioning error
				Derailment of the transportation facility
				Uncontrolled travel on the rope
				Blocked or entrapped transportation facility
				Carrier cross over error
				Mistaken cross-over behaviour from and onto the transportation facility
				Complex and physically extremely stressing operation
Abseil devices	To abseil, i.e. with the help of a rope lower persons down to an adequate floor space	Safe, fast and ergonomic working conditions	Injured persons	Dimensioning error
				Failure of the vertical rescue device, broken rope, excessive build up of heat during the abseiling operation
				Excessive speed of impact on the floor space
				Inexperienced behaviour of passengers to be rescued
				Impossibility to rescue persons who are handicapped by restrained mobility

INFRASTRUCTURE

6 Line structures

Component	Function	Requirement	Hazardous situation	Hazardous scenario
All line structures	Resist to permanent, variable and accidental actions and provide (indirect) guidance of loads	Preserve unchanged the rope configuration	Deropement	Changed rope configuration (for instance insufficient clearance, line structures, ropes and rope supporting structures subjected to excessive stress)
		Adequate load bearing capacity	Failure of the load bearing structure	Dimensioning error, insufficient load bearing capacity
				Failure of connecting elements
				Neglect of constrained actions (for instance displacement of layers of grillage foundations, temperature)
Transverse top member of line support structures	Resist to permanent, variable and accidental actions	Provide adequate load bearing capacity	Failure of the load bearing structure	Insufficient fatigue strength
				Insufficient carrier clearance
				Damage due to the accumulation of water or snow in the voids
			Deropement	Damage due to climatic conditions (for instance corrosion)
Shaft of the line support structure	Resist to permanent, variable and accidental actions	Adequate load bearing capacity	Failure of the load bearing structure	Inadmissible vibrations or deformations
				Insufficient fatigue strength
				Insufficient carrier clearance
				Damage due to external action (for instance load of the snow, avalanches, wind, earthquake, water, falling rock)
				Damage due to accumulation of water or snow in voids
Foundations of line support structures	Resist to permanent, variable or accidental actions	Adequate load bearing capacity	Failure of the load bearing structure	Damage due to climatic conditions (for instance corrosion)
				Deropement
				Inadmissible vibrations or deformation
Foundations of line support structures	Resist to permanent, variable or accidental actions	Adequate load bearing capacity	Failure of the load bearing structure	Ground gliding, drifting or subjected to excessive strain
				Loss of ground resistance (for instance, surcharge of the soil, slope failure, washout of the soil)

				Damage due to external action (for instance load of the snow, avalanches, wind, earthquake, water, falling rock)
				Neglect of constrained stresses (for instance non uniform shift of layers of grillage foundations, temperatures)
			Deropement	Excessive or non uniform settlement
Rope lifting and placing equipment	Bear the load of lifted ropes and rope placing equipment	Load bearing capacity	Failure of the load bearing structure	Usage which is not conform to the intended purpose
				Unbalanced load distribution of combined line support and compression structures
				Damage due to accumulation of water and snow in voids
				Damage due to climatic conditions (for instance corrosion)
				Anchoring points subjected to excessive stress (for instance inadequate lifting device and oblique pull)
Footboards and work platforms	Resist to permanent, variable or accidental actions	Adequate load bearing capacity	Failure of the load bearing structure	Overstressing due to vibrations in operation
Carrier guiding systems	To guide carriers	Provide safe guidance of carriers	Uncontrolled movement of carriers (for instance skew carriers, dangerous transverse and longitudinal swinging)	Entrapped carriers
			Carrier derailment	Carriers getting stuck or bottomed

7 Station structures

Component	Function	Requirement	Hazardous situation	Hazardous scenario
All structures	Resist to permanent, variable and accidental actions	Adequate load bearing capacity	Failure of the load bearing structure	Dimensioning error, insufficient load bearing capacity
				Failure of connecting elements
				Constrained stresses (for instance, non uniform shift of layers of grillage foundations, temperature
				Insufficient fatigue strength

				Damage due to external action (for instance load of the snow, avalanches, wind, earthquake, water, falling rock)
				Damage due to the accumulation of water or snow in voids
				Damage due to climatic conditions (for instance corrosion)
				Insufficient carrier clearance
			Deropement	Inadmissible vibrations or deformation
Foundations of stations	Resist to permanent, variable and accidental actions	Adequate load bearing capacity	Failure of load bearing structure	Soil gliding, overturning and subjected to excessive stress
				Loss of the natural resistance of the soil (for instance surcharge of the earth, slope failure, washout of the soil)
				Damage due to external action (for instance load of the snow, avalanches, wind, earthquake, water, falling rock)
			Deropement	Excessive or uneven settlement
Assembly equipment	Resist to applied loads	Provide adequate load bearing capacity	Failure of load bearing structures	Usage non conform to the intended purpose
				Damage due to climatic conditions (for instance corrosion)
				Anchoring points subjected to excessive stress (for instance inadequate assembly equipment, oblique pull)
Work platforms and footboards	Carry the useful load	Adequate load bearing capacity	Failure of the load bearing structure	Excessive stress due to inadmissible vibrations during operation
Maintenance access and exit passage ways (for instance ladders)	Carry the useful load	Adequate load bearing capacity	Persons falling down to the ground	Missing or insufficient guards
Station facing	Protection against action of climatic conditions	Adequate load bearing capacity	Failure of the load bearing structure	Falling components
		Adequate tightness	Malfunction of the electrical or mechanical equipment	Damage due to the penetration of water or snow
Carrier guiding system	Guide and stabilize carriers	Safe guidance and stabilization of carriers	Uncontrolled movement of carriers (for instance skew position of carriers, dangerous transverse and longitudinal swinging)	Carrier entrapment

			Carrier derailment	Carrier getting stuck or bottomed
Carrier guidance at entry into the station	To carry carriers	Transmission of the driving force	Carrier crashing down to the ground	Insufficient load bearing capacity
				Insufficient fatigue strength
				Failure of connecting elements
	Guidance of the carrier	Take hold of the carrier	Failure to take hold of the carrier	Inadmissible geometry of carrier guides
				Damage due to impact dents and edges
				Incorrect regulation
	Attenuate swinging movement	Provide adequate guidance	Failure to take hold of the carrier	Insufficient carrier clearance
		To cushion the swinging movement of carriers at their entry into the station	Excessive swinging movement of carriers	Design error of the cushioning system
				Failure of connecting elements (for instance screwed connections)

OPERATION

8 Hazardous scenarios of operating conditions and procedures

Subject matter	Function	Requirement	Hazardous situation	Hazardous scenario
Staff	Manager, conductor, ropeway operating staff	Guarantee adequate surveillance and control	Injured persons	No surveillance of embarking and disembarking passengers
				Presence of uncontrolled persons in the premises of the ropeway
				Collision with incoming or outgoing carriers
				Improper loading of carriers (for instance overloading)
				Inexperienced operation of protection guards against falling
				Operating errors (of the travelling platform)
				Insufficient assistance of passengers handicapped by their restricted mobility
				Transportation of passengers showing signs of likely unreasonable behaviour (for instance drunk passengers)

		Surveillance and control of operating conditions of the ropeway	Injured persons	Failure to reveal existing disorders due to Insufficient controls before starting and during operation of the ropeway (for instance verification of clearance gauge limits)
				Falling objects within the premises of the station and along the line
				Missing protection guards
				External wires projecting out of the rope construction
				Persons entrapped and dragged away at rope intake points
				Incorrect behaviour of persons (disregard of instructions for passengers, disregard of service instructions)
				Transportation of dangerous goods (for instance explosives, gas cylinders) while the ropeway is opened to public service
				Inexperienced storage of fire loads
				Inadmissible simultaneous transportation of persons and goods in one and the same carrier
				Insufficient clearance between carriers and objects in the station
				Collision between carriers and objects in the station
				Insufficient communication
				Disregard of operating instructions
		Surveillance and control to be carried out when the ropeway is out of operation	Injured persons	Non revealed unsafe maintenance conditions (for instance servicing, inspection, repair)
		Provide suitable and safe traffic routes	Injured persons	Disregard of instructions for the use and maintenance
				Stumbling and slippery points of traffic routes
				Insufficient guiding instructions in access and exit areas
				Falling snow or ice
Passengers	Transport passenger	Reasonable behaviour	Injured persons	Objects thrown out of the carrier

				Disregard of the operating staff's instructions for passengers
				Passengers causing the carrier to swing
Operational organisation	Organize the ropeway service	Establish behaviour rules for the staff	Injured persons	Missing or insufficient organization of the ropeway service
				Missing or insufficient service information
				Employment of unsuited persons (for instance insufficient instruction and training, unsuitable and unreliable persons)
				Insufficient staff
				Missing or insufficient equipment and spare pieces
Servicing and maintenance instructions	Provide precise instructions for the execution of servicing and maintenance assignments	Establishment of rules for the execution of the servicing and of the maintenance responsibilities	Injured persons	Poor assignment of responsibilities
				Missing or insufficient instruction of the servicing and maintenance staff
				Missing or insufficiently precise indications regarding the servicing and maintenance

9 Operational infrastructure

9.1 Traffic routes

Subject matter	Function	Requirement	Hazardous situation	Hazardous scenario
Traffic routes for passengers and the staff	Access and exit possibilities	Provide safe access and exit routes	Injured persons	Unsuitable route surface
				Stumbling points and objects persons might bump against
				Dangerous obstacles
				Missing guards
				Insufficient illumination
				Extremely narrow traffic routes
				Falling of deposits of snow and or ice
				Malfunction of automatic doors

	Access and exit area	Provide adequate embarking and disembarking conditions	Injured persons	Persons getting entrapped between carriers and fixed structural members
				Extremely big gap between carrier and platform
				Untimely opening and closing of automatic doors
Travelling platform	Possibility to move station platforms	Provide an embarking and disembarking area	Injured persons	Persons caused to fall, getting entrapped, squeezed and cut by the travelling platform
			Persons falling	Missing of adequate guards to protect persons on the fixed platform when the travelling platform moves away
		Provide an adequate carrier guidance	Collision of an incoming carrier with the travelling platform	Insufficient clearance

9.2 The line

Geometrical criteria	Function	Requirement	Hazardous situation	Hazardous scenario
general clearance gauge limit criteria of the ropeway	Guarantee the required space	Clearance	Collision	Insufficient clearance between the ropeway and the surrounding ground and likely layers of snow
				Insufficient clearance between structures and objects which are an integral part of the ropeway Installation (for instance line structures)
				Insufficient clearance between structures and objects which are not an integral part of the ropeway installation (for instance buildings, power mains, agricultural vehicles, ski run grooming machines)
				Insufficient clearance between vehicles and persons on public traffic routes
				Insufficient clearance between the ropeway and other ropeway installations
			Contact or cross over of ropes	Insufficient clearance between ropes of the concerned ropeway and ropes of other ropeways

			Damage due to other ropeways and injured persons	Falling objects
Track gauge of the rope span	Guarantee the required lateral space of the ropeway	Clearance between carriers travelling uphill and those travelling downhill	Carrier collision	Excessive lateral wandering (for instance transverse swinging, lateral wind action)
Ground	Guarantee the required space for vertical rescue	Guarantee the conveyance of rescued persons	Injured persons	Unfavourable conditions of the ground (for instance declivities, trees, stretches of water, ice, drifting snow)
				Dangerous transport conditions to adequate usable traffic areas

10 External action

Component		Requirement	Hazardous situation	Hazardous scenario
Ropeway installation	Fire	Prevent any fire in the area occupied by the ropeway	Failure of components (for instance ropes, line support structures, carriers) and / or injuries suffered by persons (fire, heat and / or smoke, panicking)	Simultaneous occurrence of several sources of ignition (for instance open fire, static discharge, frictional heat, short circuit) and combustible materials (for instance oil, grease, fuel)
		To prevent the propagation of fire in the area of the ropeway installation	Failure of components (for instance ropes, line support structures, carriers) and / or damage caused to persons (fire, heat and / or smoke, panicking)	Propagation of fire due to the presence of inflammable materials (for instance storage and transportation), use of inadequate materials
	Explosion	Prevent explosions in the area of the ropeway installation	Failure of components (for instance ropes, line support structures, carriers) and / or damage suffered by persons	Explosions due to explosible materials (for instance explosives, gas, liquids)
	Wind	Prevent dangerous operating situations	Damage suffered by persons or goods	Dangerous action of the wind
	Falling trees	Prevent trees falling on the ropeway	Failure of components	Unstable trees falling on components and equipment of the ropeway
	Aircrafts	To signal the presence of ropeways which might constitute an obstacle	Failure of components	Collision of aircrafts and the ropeway
	Electricity	Prevent power flashover	Damage suffered by persons or goods	Risk to approach a power main

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