American National Standard

for Passenger Ropeways – Aerial Tramways, Aerial Lifts, Surface Lifts, Tows and Conveyors – Safety Requirements

ANSI B77.1-2011

Approved American National Standard

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Revision of
ANSI B77.1-2006

American National Standard
for Passenger Ropeways –

Aerial Tramways, Aerial Lifts, Surface Lifts, Tows and Conveyors – Safety Requirements

Secretariat

National Ski Areas Association

Approved May 2, 2011
Editorially revised October 3, 2011

American National Standards Institute, Inc.

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Contents

Page

Foreword iii

1 General requirements 1

1.1 Scope 1

1.2 Purpose 1

1.3 Reference to other codes and standards 2

1.4 Definitions 2

1.5 Quality assurance program 6

2 Aerial tramways 7

2.1 Design and installation 7

2.2 Electrical design and installation 19

2.3 Operation and maintenance 23

3 Detachable grip aerial lifts 31

3.1 Design and installation 31

3.2 Electrical design and installation 50

3.3 Operation and maintenance 54

4 Fixed grip aerial lifts 61

4.1 Design and installation 61

4.2 Electrical design and installation 77

4.3 Operation and maintenance 82

5 Surface lifts 89

5.1 Design and installation 89

5.2 Electrical design and installation 99

5.3 Operation and maintenance 103

6 Tows 109

6.1 Design and installation 109

6.2 Electrical design and installation 115

6.3 Operation and maintenance 118

7 Conveyors 125

7.1 Design and installation 125

7.2 Electrical design and installation 129

7.3 Operation and maintenance 132

8 Normative references 137

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Annexes

A Wire rope and strand requirements (Normative) 139

A.1 Physical properties 139

A.2 Testing 142

A.3 Connections for wire rope and strand 143

A.4 Maintenance and replacement 145

B Wire Rope - Measuring the diameter and formulas for calculating broken wires (Informative) 149

C Loading Conveyors (Normative) 150

D Signs (Normative) 151

E Control button colors (Normative) 158

F Internal combustion engines and fuel handling (Normative) 159

G Chains, welded link (Normative) 165

H Chains, roller and leaf (Informative) 167

I International system of units (SI) metric conversion factors (Informative) 169

Index 171

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Foreword (This foreword is not part of American National Standard ANSI B77.1-2011.)

This standard deals with passenger transportation systems that use cables, ropes, or other flexible elements for power transmission in the system. These systems include aerial tramways, detachable and fixed grip aerial lifts, surface lifts, tows, and conveyors.

This standard is a revision of American National Standard for Passenger Ropeways - Aerial Tramways Aerial Lifts, Surface Lifts, Tows and Conveyors - Safety requirements, ANSI B77.1-2006. Section 1 provides the scope and general definitions for systems covered in this standard. Sections 2 through 7 cover the specific passenger transportation types. Six (6) Normative Annexes and three (3) Informative Annexes are included in the standard. Normative Annexes are considered part of the standard. Informative Annexes are presented for the information provided and are not considered part of this standard.

The B77 standard had its inception in 1956. At that time, the industry dealings with recreational passenger transportation had reached such proportions that safeguards were required for the protection of the public and progress of the industry. At the request of the Eastern Ski Area Operators Association, one of the original sponsors of the project, a general conference was held in New York City. As a result of that conference, the American National Standards Committee B77, composed of operators, users, authorities having jurisdiction, designers, and manufacturers of aerial passenger tramways, was established to develop safety requirements. The first standard was approved by ANSI on June 8, 1960, and revisions were developed and approved in 1970, 1973, 1976, 1982, 1990, 1992, 1999, and 2006.

Because of the diverse nature of the industries that may use this standard, it is recommended that authorities having jurisdiction consider an effective date of one year from the approval date of the standard. The "effective date" of this standard is a criterion selected by the committee and not by the American National Standards Institute.

Suggestions for the improvement of this standard will be welcome. They should be sent to the ASC B77, c/o National Ski Areas Association, 133 South Van Gordon Street, Suite 300, Lakewood, CO 80228 or e-mailed to ascb77@nsaa.org.

This standard was approved for submittal to ANSI by the Accredited Standards Committee (ASC) B77 on Aerial Passenger Ropeways. Committee approval of the standard does not necessarily imply that all the committee members voted for its approval or the approval of every requirement in the standard. At the time this standard was approved, the ASC B77 Committee had the following members:

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American National Standard
for Passenger Ropeways –

Aerial Tramways, Aerial Lifts, Surface Lifts, Tows and Conveyors – Safety Requirements

Section 1
General requirements

1.1 Scope

This document establishes a standard for the design, manufacture, construction, operation, and maintenance of passenger ropeways. For this standard, passenger ropeway categories include:

- aerial tramways (single and double reversible);
- aerial lifts (detachable lifts, chair lifts, and similar equipment);
- surface lifts (T-bar lifts, J-bar lifts, platter lifts, and similar equipment);
- tows (wire rope and fiber rope tows)
- conveyors.

1.2 Purpose

The purpose of this standard is to develop a system of principles, specifications, and performance criteria that will meet the following objectives:

a) reflect the current state-of-the-art in passenger ropeway design, operation, and maintenance;

b) be acceptable for adoption by government agencies and others.

It is recognized that certain dangers and risks are inherent in machines of this type and their operation. It is also recognized that inherent and other risks or dangers exist for those who are in the process of approaching, loading, riding, unloading, and departing from passenger ropeways. This system is intended to result in passenger ropeways that are designed, constructed, operated, and maintained in a manner that helps reduce danger and exposure to risk to passengers and maintenance and operational personnel, and to encourage improvements in productivity, efficiency, development, and progress consistent with the objectives.

Such a system with these stated objectives constitutes a safety standard.

1.2.1 Other ropeway classifications

Passenger ropeway configurations that do not fall within the categories specified in 1.1, but fall within the general category of passenger ropeways, should be evaluated by the authority having jurisdiction based upon the design engineer's specifications and the applicable provisions of this standard.

1.2.2 New materials and methods for passenger ropeways

Adoption of technological improvements in materials and advances in techniques is essential to enable the industry to keep pace with progress. If a designer or manufacturer proposes to use materials or methods not covered by this standard, those materials, methods, or both, shall be clearly identified, and complete design and test information shall be provided to the purchaser or owner and the authority having jurisdiction (see 1.4 – *authority having jurisdiction*).

1.2.3 Exceptions

Strict application of the provisions of this standard may not be appropriate in every instance. Wherever it may be proposed to depart from the provisions of this standard, the authority having jurisdiction may grant exceptions from the literal requirements or permit the use of other devices or methods that provide features comparable to those included in this standard.

1.2.4 Installations

1.2.4.1 Existing installations

Existing installations and those with design review completed by the authority having jurisdiction prior to the effective date of this standard need not comply with the new or revised requirements of this edition, except where specifically required by the authority having jurisdiction.

Operation and maintenance shall be in compliance with those requirements specifically listed (not included by reference) in the operation and maintenance subsection (2.3, 3.3, 4.3, 5.3, 6.3, 7.3) and normative Annexes A , D and F.

NOTE – Additionally, items listed under (2.3.1.1, 3.3.1.1, 4.3.1.1, 5.3.1.1, 6.3.1.1) are considered of special importance. Compliance on ropeways with design review prior to this standard shall be required.

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1.2.4.2 Relocated installations

Existing ropeways, when removed and reinstalled, shall be classified as new installations (see 1.2.4.3).

1.2.4.3 New installations

New installations and those with design review completed by the authority having jurisdiction after the effective date of this standard shall comply with the new or revised requirements of this edition.

1.2.4.4 Ropeway modifications

A ropeway modification shall be defined as an alteration of the current design of the ropeway which results in:

a) a change in the design speed of the system;

b) a change in the rated capacity by changing the number of carriers, spacing of carriers, or load capacity of the carrier;

c) a change in the path of the rope;

d) any change in the type of brakes and/or backstop devices or components thereof;

e) a change in the structural arrangements;

f) a change in power or type of prime mover or evacuation power unit;

g) a change of the control system logic.

Modified ropeways shall be inspected and/or tested to assure compliance with the modified design. Test procedures and inspection criteria shall be provided by the designer or manufacturer

1.2.5 Interpretation of standard

In cases where additional explanation or interpretation of this standard is required, such requests should be referred to the Accredited Standards Committee (ASC) B77, c/o National Ski Areas Association, 133 South Van Gordon Street, Suite 300, Lakewood, CO 80228.

1.3 Reference to other codes and standards

The design, installation, operation, and maintenance of passenger ropeways and their components that are not covered by this standard should conform to applicable standards or codes. To the extent that they are available, applicable codes or standards shall be selected to cover all features, including, but not limited to, allowable unit stresses and properties of materials. Each code or standard should be of the most recent issue, and the designer shall state which code or standard was followed.

Features not covered by this standard shall be handled in accordance with sound engineering judgment to the satisfaction of the authority having jurisdiction.

1.4 Definitions

actual (measured) breaking force: breaking force obtained to part a wire rope or strand during the breaking test.

ADA accessible: Describes a site, building, facility, or portion thereof that complies with ADAAG (Americans with Disabilities Act Accessibility Guidelines).

aerial lift: Ropeways on which passengers are transported in cabins or on chairs and that circulate in one direction between terminals without reversing the travel path.

aerial tramway: Ropeways on which passengers are transported in cable-supported carriers and are not in contact with the ground or snow surface, and in which the carrier(s) reciprocate between terminals. Also called a *reversible.*

approved: The word “approved” means “approved by the authority having jurisdiction.”

attendant: The individual assigned to particular duties or functions in the operation of a ropeway (also see 1.4 – *supervisor*).

authority having jurisdiction: The phrase “authority having jurisdiction” means any government agency empowered to oversee the design, manufacture, construction, operation, maintenance, and use of passenger ropeways. Where no such agency exists, the owner of the ropeway shall be considered the authority having jurisdiction.

auxiliary power unit (APU): Generic term to generally describe a gas or diesel engine generally used as a backup to the prime mover. It can be designated as a prime mover or evacuation power unit depending upon use and configuration. On aerial tramways an APU can power the rescue drive.

Basic Life Support (BLS): Medically accepted non-invasive procedures used to sustain life.

bicable system: A system that uses track cable(s) to support the carriers and separate haul rope(s) to control motion of the carriers (also see 1.4 – *monocable system*).

brake: A device consisting of one or more friction devices which if applied, accomplishes braking.

braking: The process of absorbing energy in order to maintain or reduce the speed of the ropeway.

NOTE – The typical resistances effective in absorbing the energy of a ropeway include:

a) the inherent resistance in the system (e.g., friction);

b) incidental resistance (e.g., slope, gravity, wind);

c) applied resistance (e.g., brake, power unit ramping down).

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bullwheel: A large grooved wheel at a terminal that rotates continuously when the haul rope is moving and deflects the haul rope by an angle of 10 degrees or more.

bullwheel, deflection: A bullwheel that deflects the haul rope at least 10 degrees but less than 150 degrees.

bullwheel, diameter of: Wherever the term *diameter* is used in specifying bullwheels, it refers to the diameter at the bottom of bullwheel grooves (tread diameter)

bullwheel, drive: A bullwheel that delivers power to the haul rope.

bullwheel, fixed return: When acting simply as a fixed return for the haul rope.

bullwheel, tension: A bullwheel that maintains tension in the haul rope by changing its position.

cabin: An enclosed or semi-enclosed compartment for transporting passengers; most often used on aerial tramways and detachable grip aerial lifts.

carrier: The structural and mechanical assemblage in or on which the passenger(s) of a ropeway system are transported. Unless qualified, the carrier includes, for example, the carriage or grip, hanger, and cabin or chair.

chair: An open or semi-open seat used on an aerial lift.

chair height: Chair height (seat height) is the distance between the top surface, including padding, of the chair seat to the loading or unloading point surface. This distance shall take into account the longitudinal swing of the chair which lowers the chair height.

circuit, electrical power: The electrical power circuit is a normally de-energized circuit that when energized provides electrical power to the drive motor, other lift-related electrical power equipment, or both.

circuit(s), bypass: A circuit(s) that partially or entirely circumvents monitoring devices and remote signal inputs of a malfunctioning operating circuit to allow operation of the system, under the specific conditions set forth for each ropeway type.

complex electronic element: An electrical device composed of one or more solid state components for which the failure modes are not well defined or detectable, or for which the behavior of the device under fault conditions cannot be completely determined.

EXAMPLE – A photocell operating a relay to implement a stop gate function.

continuous diagnostic coverage: A test function(s) provided to detect the failure of a complex electronic element at a period of no greater than the minimum time between each required functional operation of the element.

conveyor: An outdoor transportation system wherein passengers are transported uphill on a flexible moving element (conveyor belt).

conveyor belt: The flexible moving element on a conveyor that consists of multiple tread plates or belting.

deropement: The term used when a rope or cable leaves its operating position relative to the groove of a bullwheel, sheave, carriage wheel, or saddle.

design capacity: The number of passengers per hour (pph) established by the designer as the current ultimate operating capability of the facility in the direction specified.

detachable grip lift: A ropeway system on which carriers circulate around the system alternately attaching to and detaching from a moving haul rope(s). The ropeway system may be monocable or bicable.

diesel: A Class II liquid fuel.

drive system: A group or combination of interrelated elements which transmits power, or motion to the haul rope.

emergency shutdown: A stop that when initiated causes one or more brakes (if installed) to be applied and power to be removed from the power unit. An emergency shutdown shall occur when it is detected that the normal stop, or other stops have failed to function properly and takes priority over all other stop functions or devices (also see 1.4 – *normal stop*). Removing power from the power unit shall mean:

– *Electric motor*: Full load rated contactor or circuit breaker disconnect devices operate to shut down the motor;

– *Internal combustion engine*: Engine shuts down.

NOTE – See 2.1.2.5, 3.1.2.5, 4.1.2.5, 5.1.2.5, 6.1.2.5, 7.1.2.5 (Stops and Shutdowns) for specific requirements for each ropeway type.

emergency shutdown circuit: A protection circuit that effects an emergency shutdown.

evacuation power unit: A power unit utilized for the evacuation of a ropeway that once engaged, passenger loading ceases and the ropeway operation is shutdown once the ropeway has been unloaded.

factor of safety (wire rope): The ratio of the nominal breaking strength of the rope and the maximum static design tension of the rope.

fiber rope: A stranded or braided rope made from natural or synthetic fibers.

fixed grip lift: Ropeway system on which carriers remain attached to a haul rope. The ropeway system may be either continuous or intermittently circulating, and either monocable or bicable.

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flue gas temperatures: The temperatures of the flue products at the point or points of passing close to or through combustible materials, whichever is applicable.

foot passenger: Any person utilizing a passenger ropeway who is not a skier (also see 1.4 – *skier*).

gasoline: A Class I liquid fuel.

gondola:

- Name used to describe an aerial lift using cabins;
- A cabin used on an aerial lift.

grips, detachable: Grips that are attached and detached from the moving haul rope at station(s) or terminal(s) during normal operation.

grips, fixed: Grips that remain continuously attached to the haul rope during normal operation.

grips, haul rope: Devices by which carriers are attached to the haul rope.

Ground-Fault Circuit Interrupter (GFCI): A device intended for the protection of personnel that functions to de-energize a circuit or portion thereof within an established period of time when a current to ground exceeds the values established for a Class A device. Class A ground-fault circuit interrupters trip when the current to ground has a value in the range of 4mA to 6mA.

ground fault protection: A system intended to provide protection of equipment from damaging line-to-ground fault currents by operating to cause a disconnecting means to open all ungrounded conductors of the faulted circuit. This protection is provided at current levels less than those required to protect conductors from damage through the operation of a supply circuit overcurrent device.

hanger: Structural element connecting a cabin, chair, or other passenger-carrying device to the track cable carriage or haul rope grip.

haul rope: A wire rope used on a ropeway that provides motion to carrier(s) and is powered by the drive bullwheel.

line: Indicates the path of a wire rope on the up-going or return side of a ropeway

magnetic rope testing (MRT): Non-destructive magnetic rope testing (MRT) is the use of either electromagnetic or permanent magnetic equipment using magnetic-flux and/or magnetic flux leakage principles capable of detecting discontinuities and/or changes in metallic cross-sectional area in ferromagnetic wire ropes and cables.

minimum breaking force: The specified value that the actual (measured) breaking force must meet or exceed in a test.

NOTE – The term “Minimum Breaking Force” has replaced the term “nominal breaking strength” internationally and in the new ASTM Wire Rope Standard.

monocable system: A system that uses a single haul rope to both support and control motion of the carriers.

nominal voltage: A nominal value assigned to a circuit or system. The actual voltage at which a circuit or system operates can vary from the nominal within a range that permits satisfactory operation of the equipment**.**

non-complex element: An electrical element in which the failure modes are well defined and the behavior of the element under fault conditions can be determined.

EXAMPLE – A system comprising one or more limit switches operating one or more contactors or relays to de-energize a motor.

normal stop: A stop in which the prime mover or other systems may be involved in braking and in which the ropeway comes to rest in a controlled manner.

obstacle: Any object that may interfere with the passenger ropeway operation**.**

operation circuit: An electrical circuit that provides power to or controls the ropeway machinery.

operator: The individual in charge of a ropeway (also see 1.4 – *attendant*).

overhauling: An operating condition in which unbalanced loading is sufficient to overcome line and drive system friction and create a torque, acting to produce rotation of the drive bullwheel in either direction when all brakes and the power unit are inactive.

owner: A person who owns, manages, or directs the operations and maintenance of a passenger ropeway. Owner may apply to a state or any political subdivision or instrumentality thereof.

NOTE – The owner is sometimes referred to as the “operator” or “area operator.” Not to be confused with the individual ropeway “operator” as herein used.

passenger: Any person utilizing a passenger ropeway for personal transportation.

passenger ropeway: Includes all devices that carry, pull, or push passengers along a level or inclined path (excluding elevators) by means of a haul rope or other flexible element that is driven by a power unit remaining essentially at a single location.

prime mover: Power unit utilized for the continuous operation of a passenger ropeway.

Programmable Logic Controller (PLC): Any solid-state automatic device that has programmable memory and is used to process input and output logic functions.

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protection circuit: Electrical circuits designed to stop the ropeway in the event of a malfunction or failure of the ropeway system.

Qualified Engineer: An engineer who is registered as a Professional Engineer in the United States of America.

recreational device: Tube, sled, luge, cart, etc., except a skier, which is pulled uphill on the surface with a passenger riding on the device.

rollers: Sheaves of small diameter used to guide or restrain the rope from leaving its proper alignment.

rope: Unless otherwise specified, the term *rope* shall mean wire rope, which consists of several strands twisted together. (The terms *rope*, *wire rope*, and *cable* are interchangeable, except where, by the context, the general term *cable* refers to either a wire rope or strand used as a track cable.)

ropeway: See 1.4 – *passenger ropeway.*

rotation-resistant rope: Wire rope consisting of inner strands laid in one direction covered by a layer of strands laid in the opposite direction. This has the effect of counteracting torque by reducing the tendency of the finished rope to rotate.

shall: This word is to be used to convey a strict requirement, from which the reader/user may not deviate in order to be considered in conformance with the standard.

sheave: Pulley or wheel grooved for rope.

sheave unit: The largest assembly of sheaves that are independently articulated on a common shaft.

sheave, diameter of: Wherever the term *diameter* is used in specifying sheaves, it refers to the diameter at the bottom of sheave grooves (tread diameter).

sheave, tension system: A sheave used in the tension reeving system.

sheaves, haul rope: Haul rope sheaves are sheaves that support or hold down the haul rope at towers or terminals. (The angle of rope deflection is usually small.)

should: This word is to be used to convey a recommendation, describe a recommended practice or procedure, or introduce a related standard (or publication).

skier: A skier is any person utilizing a device that attaches to at least one foot or the lower torso for the purpose of sliding on a slope. The device slides on the snow or other surface of a slope and is capable of being maneuvered and controlled by the person using the device.

stop: A function initiated by a command that decelerates the ropeway and brings it to rest (also see 1.4 – *brake*).

stop gate: A type of automatic stopping device that, when actuated by a passenger's weight, contact, or passage, will automatically stop the ropeway.

strand: Unless otherwise specified, the term *strand* shall mean wire strand, consisting of several wires twisted together (as compared with wire rope, which consists of several strands twisted together).

supervision circuit: Electrical circuits that provide communications, that monitor or supervise the performance of various ropeway systems, and provide the operator with system information.

supervisor: The individual in responsible charge of personnel and operations for one or more passenger ropeways (also see 1.4 – *operator*).

surface lift: Ropeways on which passengers are propelled by means of a circulating overhead wire rope while remaining in contact with the ground or snow surface. Connection between the passengers and the wire rope is by means of a device attached to, and circulating with, the haul rope, known as a "towing device."

tank, atmospheric storage: A storage tank that has been designed to operate at pressures from atmospheric through 0.5 psig measured at the top of the tank. All fuel tanks shall be atmospheric tanks.

tank, day: A fuel tank, located inside a structure that provides fuel to an engine.

tank, integral: A fuel tank furnished by the engine or lift manufacturer and mounted on the engine.

> EXCEPTION – The aerial lift manufacturer or a qualified engineer may supply an integral tank to be mounted on the engine or day tank for mounting on a combined drive tension carriage or an overhead fixed drive terminal.

tank, supply: A separate fuel tank for supplying fuel to the engine or to a day or integral tank.

towing device: A carrier, fixed or detachable, used on surface lifts and tows to pull passengers. Classification or description is by the device configuration and action of the extension element (i.e., handle, button, J-bar, T-bar, platter, etc.).

tow path: The path along which a passenger is towed on a surface lift or tow from the load point to a point beyond the stop gate equal to 150% of the distance required to stop the empty surface lift or tow operating at full speed.

tow, fiber rope: Ropeways that use a fiber or synthetic rope. Passengers grasp the circulating fiber rope or a towing device attached to the rope depending on the configuration and are thus propelled while supported by the ground or snow surface. The haul rope remains adjacent to the tow path at an elevation that permits passengers to maintain their grasp on the rope or towing device throughout the tow path.

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tow, wire rope: Ropeways on which the passengers are pulled by a towing device attached to a circulating wire rope and are propelled in one direction only by that rope while remaining in contact with the ground or snow surface. The haul rope remains adjacent to the tow path at an elevation such that the skier or recreational device remains on the surface throughout the length of the tow path.

track cable saddle: A component designed to directly support a track cable.

track cable: A wire rope or strand used to support a carrier or carriers on a bicable system.

tramway: See 1.4 – *aerial tramway.*

voltage: Voltage of a circuit is the greatest root-mean-square difference of the potential between any two conductors of the circuit.

voltage, low: A voltage limited to 24 volts nominal.

voltage, high: A voltage of more than 600 volts.

wire rope: See 1.4 – *rope*.

1.5 Quality assurance program

Written Quality Assurance (QA) programs shall be developed and utilized to ensure the integrity of the design, manufacture, installation, operation, and maintenance of passenger ropeways. The objective of these QA programs is to assure that passenger ropeways meet the applicable requirements of this standard.

1.5.1 Design

A Qualified Engineer shall design, or be in responsible charge of the design of new and modified passenger ropeways other than fiber rope tows. (see 1.4 – *Qualified Engineer*).

The designer's QA program for new, modified, or relocated ropeways shall include verification and documentation of the design criteria. This program shall include calculations, analysis, and checking procedures.

For relocated ropeways the designer of the relocation shall be responsible for the establishment of the QA program for that installation. The designer shall describe what QA methods were used for the various components of the relocated ropeway. These methods may include sampling procedures, nondestructive testing, and prior satisfactory "in use" service.

1.5.2 Manufacture

The ropeway manufacturer's QA program for ropeways shall include verification and documentation that manufactured parts conform to the design criteria. For relocated ropeways, this requirement is for newly manufactured parts only.

1.5.3 Construction

For new or modified ropeways, other than rope tows, a qualified engineer shall certify to the owner that the construction and installation has been completed in accordance with the final design criteria for such work.

The installer's QA program for all new or modified ropeways, including rope tows, shall include verification and documentation that the ropeways installation conforms to the design criteria.

1.5.4 Operation and maintenance

The owner's QA program for all ropeways shall include verification and documentation that the ropeway is operated and maintained in accordance with the design criteria, including the performance of in-use periodic testing by qualified personnel.

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Section 2
Aerial Tramways

This section covers passenger ropeways on which passengers are transported in cable-supported carriers and are not in contact with the ground or snow surface. Carrier(s) reciprocate between the terminals, propelled and controlled by a haul rope operating through drive and tensioning equipment installed in the terminals.

Aerial tramway systems may have a single carrier, or group of carriers, that move back and forth on a single path of travel; or, two carriers, or groups of carriers, oscillating between terminals on two (usually very nearly parallel) paths of travel. The systems may be monocable or bicable.

Provisions of this section envision a system having a reversible operating mode. Systems using a fixed attachment, individual carrier, grouped carrier, or chair, in a reversing operation (as opposed to continuous or intermittent circulation with stop-to-load feature) shall refer to section 4 for applicable component requirements not covered in section 2.

2.1 Design and installation

2.1.1 General

2.1.1.1 Design passenger weight

For purposes of design, a passenger shall be considered as having a minimum average weight of 170 pounds (77.1 kilograms). It is the owners responsibility to indicate unusual considerations that might affect the design passenger weight.

If a carrier has a floor space greater than 2.5 square feet (0.23 square meter) per passenger, or transports freight or water, a carrier weighing system shall be installed to prevent overloading. The carrier weighing system shall annunciate a warning at 100 percent live load and prevent the carrier from departing the terminal at 110 percent live load. The designer shall determine the maximum design live load combinations for transporting freight and passengers on the aerial tramway.

The operational manual shall document the live load parameters and relevant operational conditions. The operational manual shall also specify procedures to avoid overload conditions if the weighing system is inoperable.

2.1.1.2 Capacity and speed

The designer shall specify the maximum and minimum design capacities and the design loading conditions under which the aerial tramway may be operated. The maximum rope speed shall be that specified by the designer and established as functional by testing and operational performance.

2.1.1.3 Location

In selecting the location and alignment of an installation, consideration shall be given to the following items, and to any others that may be particularly pertinent to the aerial tramway type and location:

a) ADA accessibility;

b) electric power lines and their supports;

c) rock and earth slides, cave-ins, washouts, and the like;

d) snow creep and avalanches;

e) wind action;

f) icing;

g) ski slopes and trails;

h) rivers and gullies;

i) buried installations, including pipelines;

j) control of air space below, above, and adjacent to the installation;

k) crossing or close proximity to other ropeways;

l) carrier height above all surfaces;

m) highways;

n) fire hazard;

o) structures;

p) railways.

2.1.1.4 Clearing envelope

As a minimum there shall be no obstacles, unless allowed in 2.1.1.5, within 5 feet (1.53 meters) of ropes, track cables, and carriers under design operating conditions. Carriers shall not contact any obstacle during operation under design wind conditions. Clearings and contiguous spaces shall be maintained to reduce the risk of washouts, hazard trees, and other obstacles that might endanger the installation (see 2.3.3.1(k)) or interfere with evacuation.

2.1.1.5 Clearances

Terminals and towers shall be designed and installed to provide the clearances as herein specified and to minimize surge of the line under operating conditions. Local wind conditions shall be taken into consideration.

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2.1.1.5.1 Vertical clearances

Along the line between terminal and intermediate station structures, the following minimum vertical clearances shall exist between the lower edge of the carrier or ropes and the terrain or other possible obstacles, including snow pack:

a) 5 feet (1.53 meters) shall exist between the lower edge of the carrier or ropes and the terrain or other possible obstacles, including snow pack;

b) 8 feet (2.44 meters) when foot passenger traffic is permitted under the line;

c) 15 feet (4.57 meters) where skiing or controlled vehicle access is permitted under the line;

d) 25 feet (7.62 meters) where public vehicle transportation is permitted underneath the aerial tramway line (roads, railroads, and the like).

2.1.1.5.2 Horizontal clearances

The minimum clearance between two passing carriers, each inclined 20% from vertical, shall not be less than:

The larger of 3.28 feet (1.0 meter) or 3.28 feet (1.0 meter) plus the following:

0.004(X - 492)(feet) or 0.004(X - 150)(meters)

X = the chord distance, in feet (meters), from the point of the carriers passing to the nearest tower or track cable supporting structure.

The distance between haul ropes (or track cables), for the purpose of these checks, shall be considered as equal to the gauge of the line.

Carriers with track cable brakes having an unobstructed lateral swing clearance of 20% between the cabin and tower do not require guides.

Carriers without track cable brakes shall have an unobstructed lateral swing when passing tower cabin guides. The clearance shall be the greater of the following:

a) 20 %

b) 2.5 X V in % where

V = max normal travel speed crossing towers in m/s.

2.1.1.5.3 (Reserved)

2.1.1.5.4 Track cable saddles (bicable systems)

Towers and terminals shall be arranged so as to keep the track cable in the saddles under the most adverse design operating and nonoperating conditions. Track cable restraining devices or other provisions may be used, as required, at the discretion of the designer. These provisions shall not interfere with any track cable movement or any track cable brake operation. Maximum wind velocity and other design limits used for structures under nonoperating conditions and the limiting values intended for operating conditions shall be specified by the designer.

2.1.1.5.5 Haul rope sheave units (bicable systems)

Haul rope sheave units are generally of the support type. “Depression” or “hold-down” sheave units not covered by this standard shall be subject to the requirements of 1.2.2.

2.1.1.5.6 Rope guidance (bicable systems)

All line sheave units, including both high- and low-tower sheave assemblies, shall be provided with fair leads or guides to accomplish the following:

a) Permit the unobstructed passage of a carrier gripped to the haul rope, independent of the position of the haul rope guided by the fair leads, as the carrier approaches the sheave assembly;

b) Guide the haul rope into the sheave groove when it has been lifted in normal operations or for other reasons;

c) Provide the rope guidance necessary beneath sheave assemblies and adjacent structures to prevent entanglement of the haul rope as it is returned by the carrier to normal operating position from any location that it may assume due to any anticipated operational displacement.

2.1.1.5.7 Intermediate structures (bicable systems)

Auxiliary intermediate structures (i.e., haul rope carriers and slack carriers) shall be provided to support sheave units as required to maintain the minimum clearances specified in 2.1.1.5.1.

2.1.1.6 Structures and foundations

All structures and foundations shall be designed and constructed in conformance with 1.3 and shall be appropriate for the site. Applied design loads shall include dead, live, snow, wind, and dynamic loads due to normal conditions and for foreseeable abnormal conditions.

Structures and foundations located in snow creep areas shall be designed for such conditions and loads, or protective structures shall be provided as required by the conditions.

2.1.1.6.1 Structures

On bicable systems, torsional displacement of towers under the most anticipated design loading conditions shall be limited to a value that will not cause deropement of the track cable from the saddle.

2.1.1.6.2 Foundations

In determining the resistance of the soil to motion of the foundation, the subsoil conditions at the site shall be considered, including any buoyancy due to groundwater

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that may be present. If the resistance of the soil is not practically determinable, the foundation or anchorage should be designed as a gravity anchor, using a coefficient of friction appropriate to the general character of the soil. Bottoms of foundations shall be below the normal frost depth unless resting on non-frost-susceptible soil or solid rock. Foundations on rock shall be firmly anchored to solid rock, unless designed as gravity foundations.

The top of concrete foundations shall not be less than 6 inches (150 mm) above finished grade unless specific direction for the protection of the foundation and structural steel below grade is specified by the designer.

The design shall have a minimum factor of safety of 2 in resisting overturning and, concurrently, 2 against sliding, under dead-load and live-load conditions. The minimum factors shall be 1.5 under these loadings plus wind acting simultaneously.

2.1.1.7 Communications

A permanently installed two-way voice communication system shall be provided between the prime mover and evacuation power unit control point, drive system building, loading stations, and unloading stations. The power for this system shall be independent of the primary power and the communication system shall be functional and audible during a power failure (see 2.2.5(a)).

Audio indicators shall be audible over all ambient noise levels, and visual indicators (e.g., Light Emitting Diodes) shall be visible even in bright sunlight.

An additional system of two-way voice communication from operating room to all carriers and to opposite terminal platform shall be provided where carriers are attended.

2.1.1.8 Combustion engine(s) and fuel handling

Internal combustion engine installation and fuel handling requirements are located in normative Annex F.

2.1.1.9 Loading and unloading areas

Platforms, ramps, and related units comprising the loading and unloading areas of an aerial tramway are integrally related to its operation. They shall be designed and installed in conformance with 1.3.

Platforms shall be provided with sufficient space to accommodate passengers waiting to embark and passengers disembarking the cabins. Provisions for separation of incoming and outgoing passengers shall be made to guide passengers to and from the cabins.

2.1.1.10 Passenger removal from stranded carriers

Aerial tramways shall be provided with means to evacuate passengers from stranded carriers (see 2.3.2.5.7).

2.1.1.10.1 Carrier evacuation

Where carrier height and terrain crossing conditions permit ready access to a shelter area, aerial tramways may depend partially or entirely upon evacuation to lower passengers from stranded carriers. When this method is used, the apparatus employed shall be stored aboard the carrier, or a means of roping up the apparatus shall be stored aboard the carrier.

2.1.1.11 Acceptance inspection and tests

Prior to the acceptance inspection and the acceptance tests, the aerial tramway shall be operated for a minimum of 10-hours. Continuous operation shall include the following:

a) 6-hours on each power unit classified as a prime mover;

b) 1-hour on each power unit classified as an evacuation power unit or rescue system.

Station dwell times shall be minimized to replicate maximum design capacity.

All terminal, line structures, line equipment, and carriages shall be thoroughly checked both before and during the continuous run test to check for overheating of moving parts, excessive vibration or deflection of mechanical or structural components, free movement of tension systems, and other related conditions.

2.1.1.11.1 Acceptance inspection

Before an aerial tramway that is new or relocated or that has not been operated for routine maintenance within the previous 2 years is opened to the public, it shall be given a thorough inspection by qualified personnel to verify compliance with the plans and specifications of the designer.

It shall be the responsibility of the owner to see that the following conditions have been met:

a) tightness of all structural connections;

b) lubrication of all moving parts;

c) alignment and clearances of all open gearing;

d) installation and alignment of all drive system components;

e) position and freedom of movement of counterweights or other tension systems and carriages;

f) haul rope alignment at entrance to bullwheels;

g) operation of all electrical components, including circuit protection and grounding;

h) adjustment of brakes to design deceleration rates and baseline brake torque testing;

i) minimum clearances for carriers, track cable(s), and haul rope sags under the most adverse static loadings;

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j) proper alignment of track cable saddles and haul rope sheave units;

k) proper track cable to saddle angles and unhindered inline motion of track cable in saddles as applicable;

l) actual testing of evacuation equipment and procedures at the most difficult location;

m) proper location of towers and terminals in accordance with the plans and specifications. Terminal and tower rope/cable working points shall be documented by an "as built" survey, and any variation from the design drawings shall be noted and approved by the engineer responsible for design;

n) slip testing of carriage haul rope clamps, if used, for required force (see 2.1.4.4.2.2(h)).

2.1.1.11.2 Acceptance tests

Before an aerial tramway that is new or relocated or that has not been operated for routine maintenance within the previous 2 years is opened to the public, it shall be given thorough tests by qualified personnel to verify compliance with the plans and specifications of the designer. The designer or manufacturer shall propose and submit an acceptance test procedure.

Thorough load and operating tests shall be performed under full loading and any partial loadings that may provide the most adverse operating conditions. Test load per carrier shall be 110% of the design live load. The functioning of all manual and automatic stops, limit switches, deropement switches, and communications shall be checked. Acceleration and deceleration rates shall be confirmed under all loadings (see 2.1.2.4, 2.1.2.5). Motive power and all braking devices (see 2.1.2.6) shall be proved adequate under the most adverse loading conditions.

A plot of rope speed versus time shall be recorded for stops that the manufacturer or Qualified Engineer has designated in the acceptance test procedure. As a minimum, the plot shall show the rope speed every 0.2 seconds from the initiation of the stop to when the rope is stopped.

The final brake system settings and brake force test values shall be documented in the acceptance test results (see also 2.1.2.6).

2.1.2 Terminals and stations

2.1.2.1 Power units

All aerial tramways shall be equipped with at least two power units, one of which, at a minimum, meets the requirements of 2.1.2.1.2.

All power units shall have the capacity to handle the most unfavorable design loading conditions, including the starting and control of the aerial tramway loaded to 110% of capacity in weight.

Where manual multispeed transmissions are used on a power unit, they shall not be shifted when the aerial tramway is moving.

Where bi-directional capability is provided on a power unit for an aerial tramway, provisions shall be made to prevent accidentally changing directions whenever the aerial tramway is operating.

No aerial tramway shall be operated using a single power unit except for unloading passengers or for maintenance purposes.

If changes are made to the drive system components that affect rotational inertia (i.e. removal of electric motor), the resulting stopping distances and deceleration rates shall meet the requirements of 2.1.2.5.

2.1.2.1.1 Prime mover

Power units engaged as a prime mover shall have the systems required in 2.1 and 2.2 functional during operation (see 1.4 – *prime mover*).

2.1.2.1.2 Evacuation power unit

An evacuation power unit with an independent power source shall be provided to move the carrier(s) to a terminal in the event of failure of the primary power unit(s).

The power unit shall be electrically wired to meet the requirements of 2.2.3.1 so that it can be stopped by the Emergency Shutdown Circuit. The evacuation power unit shall not depend upon the mechanical integrity of the prime mover to move the aerial tramway. The prime mover shall be disconnectable in the event of a mechanical lockup.

The evacuation power unit shall be designed to become operational and move the loaded passenger carriers to the terminals within 1 hour from the time of initiating its connection.

2.1.2.1.3 Power unit interlock

System(s) or device(s) shall be installed that prevent two or more power units, which are not designed to operate together, from being actively connected to the drive system while operating. Electrical interlock systems shall comply with 2.2.4.

2.1.2.1.4 Rescue system drive

A separate drive system or a permutation of the Evacuation Drive used to move the rope for a separate rescue car shall be electrically wired to meet the requirements of 2.2.3.1 so that it can be stopped by an Emergency Shutdown Circuit.

2.1.2.2 Speed reducers and gearing

All speed reducers and gearing shall have the capacity for starting an aerial tramway under the most unfavorable design loading conditions without exceeding design rating. They shall have a service factor appropriate for the application.

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2.1.2.3 Bearings, clutches, couplings, and shafting

Bearings, clutches, couplings, shafting and universal joint shafts (cardan shafts) shall be selected on the basis of the manufacturer's published data for the particular use. All shafting shall be designed in accordance with accepted standard practices. Guarding and containment shall be in accordance with the provisions of 2.1.2.7.1.

Provisions shall be made for adjustment and lubrication of all bearings, clutches, and couplings, when required.

2.1.2.4 Acceleration and speed control

The drive equipment shall be designed to accelerate and decelerate the line smoothly and to avoid severe oscillations or undulation under any design loading condition.

In order to avoid discomfort to the passengers caused by undue longitudinal swinging of the carrier or by excessive acceleration or deceleration and in order to start and stop the carriers smoothly, acceleration shall be limited to 1 foot (0.30 meter) per second squared under the most adverse design condition.

The aerial tramway shall be started at its lowest point of speed range after any type of stop.

The drive system shall be capable of moving the unloaded system at reduced speed for rope inspection and equipment maintenance. This reduced-speed operation may be obtained by the use of the evacuation power unit.

In addition, the following requirements shall be incorporated in the design:

a) Provision shall be made for overhauling loads. The system shall always operate at a controlled speed not exceeding design speed by more than 6%. The energy developed by the overhauling load shall be dissipated in a satisfactory manner without using the brakes specified under 2.1.2.6;

b) If the speed of the aerial tramway can exceed the rated speed by more than 10%, an automatic overspeed device shall be provided that will initiate a stop;

c) The controls of the prime mover shall provide sufficiently smooth accelerating and decelerating ramps so that acceleration stays within the allowable limits and excessive swing is not introduced.

2.1.2.5 Stops and shutdowns

Provision shall be made for smooth deceleration of the aerial tramway during a normal stop and when actuating the automatic drive system brakes described in 2.1.2.6. The operation of the bullwheel brake shall not result in deceleration of the aerial tramway that exceeds 8 feet (2.44 meters) per second squared under all anticipated design loading conditions.

Carrier(s) shall be brought to a stop for loading and unloading, and provisions shall be made to keep the carrier(s) stationary during the loading and unloading process.

Normal stop: (see 1.4 – *normal stop*). The service brake shall have been applied by the time the aerial tramway comes to a stop.

Emergency shutdown: In addition to the requirements of 1.4 – *emergency shutdown,* the bullwheel brake shall be applied. The service brake shall have been applied by the time the aerial tramway comes to a stop. The designer shall designate which control functions of the aerial tramway shall initiate an emergency shutdown.

The designer may define stopping modes in addition to normal stops and emergency shutdown. For additional stopping modes, the designer shall specify the method of stopping, including the type and timing of brake(s) that may be applied, and the criteria for initiating such stops.

2.1.2.6 Brakes

The aerial tramway shall have the following friction-type brakes:

- service brake (see 2.1.2.6.1);
- bullwheel brake (see 2.1.2.6.2)

NOTE – For requirements of systems with or without track cable brakes, see 2.1.4.4.2.

All drive braking systems shall be designed and monitored to ensure that:

a) Once the aerial tramway begins movement in the intended direction, the brakes are maintained in the open position;

b) The service brake shall not open prior to the prime mover providing control for the aerial tramway;

c) Multiple brakes or brake systems shall not be simultaneously applied such that excessive deceleration is applied to the aerial tramway under any design loading condition;

d) The failure of one braking system to stop the aerial tramway shall automatically initiate a second braking system, if any.

The service brake and bullwheel brake shall be designed such that failure of one braking system shall not impair the function of the other systems. All brakes shall have the braking force applied by springs, weights, or other approved forms of stored energy.

Hydraulic systems shall be designed to reduce the possibility of oil contaminating the braking surfaces in the event of a failure of a hose, cylinder or fitting.

The service brake and bullwheel brake shall be designed to assure operation under all anticipated conditions.

All drive braking systems shall be capable of operation to comply with the daily inspections and periodic testing.

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The manufacturer or a Qualified Engineer shall furnish a written procedure to be followed and shall specify the auxiliary equipment necessary for periodic testing and adjustment of the holding force of each brake. Direction of travel, speed, percent load, and position of the carriers shall be determined and added to the procedure in the maintenance manual. The procedure shall additionally specify:

e) the minimum and maximum holding force for the service brake and bullwheel brake or other criteria which establishes the acceptable range of holding force, and;

f) the minimum and maximum deceleration rates for the service brake and bullwheel brake.

This baseline procedure shall be performed at the completion of the acceptance test, and then at the frequency specified, in order to demonstrate the ability of each brake to produce the required force (see 2.1.1.11.2).

Testing shall be accomplished as part of normal maintenance. As a minimum, testing shall be performed monthly during the normal operating season(s) of the aerial tramway. Testing shall not be done while the aerial tramway is open for public operation.

If a device is permanently installed to cause a brake to be disabled for testing, it shall be monitored so that the aerial tramway cannot be operated in its normal mode when the brake is so disabled.

2.1.2.6.1 Service brake

The service brake can be located at any point in the drive system such that there is no belt, friction clutch, or similar friction-type device between the brake and the bullwheel. The service brake shall not act on the same braking surface as the bullwheel brake.

The service brake shall be an automatic brake to stop and hold the aerial tramway under the most unfavorable design loading condition. The rate of application of this brake shall be adjustable. This brake shall have the design capability to decelerate the aerial tramway at a rate of 2 feet (0.61 meter) per second squared when operating under the most unfavorable condition of overhauling load and at full speed.

The brake shall be in a normally applied position. It shall be held open for operation of the aerial tramway and shall be applied when the aerial tramway is stopped.

2.1.2.6.2 Bullwheel brake

The bullwheel brake shall operate on any drive terminal bullwheel assembly that meets the requirements of 2.1.2.8.2.

The bullwheel brake shall be an automatic brake to stop and hold the aerial tramway under all anticipated conditions of loading. The rate of application of this brake shall be adjustable. This brake shall have the design capability to decelerate the aerial tramway from full speed, with the design loading condition most unfavorable to stopping, at 1.5 feet (0.46 meter) per second squared and within the parameters specified in 2.1.2.5.

Bullwheel brake controls shall be located and the brake activated in a manner that deceleration will begin within 3 seconds after the operator or attendant reacts to the stimulus to apply the brake.

Application of the bullwheel brake shall automatically disconnect the power source to the power unit in use. This brake shall act automatically when the speed of the haul rope exceeds the design speed by 15% in either direction or if the carriers travel beyond their normal stopping position in either terminal.

2.1.2.7 Location of machinery

2.1.2.7.1 General

Moving machine parts that normally may be in reach of personnel shall be fitted with guards. Where breakage of a power transmission component can result in injury, provisions shall be made for appropriate containment of said components. Guards and containment shall be done in conformance to American National Standard, ANSI/ASME, B15.1-2000 (R2008), *Safety Standard for Mechanical Power Transmission Apparatus*.

Protection against static electricity shall be provided.

Fire-fighting device(s) shall be available (see F.6 in Annex F).

2.1.2.7.2 Machinery not housed in a machine room

Provisions shall be made to keep the public away from the machinery. All machinery and controls shall be rated for use in their intended environment.

2.1.2.7.3 Machinery housed in a machine room

The machine room shall be adequately ventilated. It shall have a permanently installed lighting system, adequate for proper machinery maintenance and to reduce the risk of injury to operating personnel. The arrangement of the machinery shall permit proper maintenance. A door with a suitable lock shall be provided, and the design shall keep the public away from the machinery. When a passageway is provided between machines or machinery and walls, a minimum passageway width of 18 inches (460 mm) shall be maintained. Means shall be provided to heat the machine room unless the designer or manufacturer certifies in writing that the drive machinery is rated for operation in an unheated room.

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2.1.2.8 Bullwheels and sheaves in terminals and stations

2.1.2.8.1 General

All bullwheels and sheaves, including their mountings and frames, shall be designed to withstand static and dynamic loads. Bearings and mountings shall be selected, designed, and installed in accordance with the recommendations of the manufacturers of the bearings.

When unlined grooves are used for wire rope, they should be V-shaped and shall have rounded bottoms with a radius equal to approximately 55% of the rope diameter.

When lined grooves are used, the allowable bearing pressures of the liner material shall not be exceeded.

2.1.2.8.2 Haul rope terminal bullwheels

Provisions shall be incorporated in the terminal design to retain the terminal bullwheels in their approximate normal operating position in the event of failure of the bearings, shaft, or hub.

Means shall be provided to prevent any haul rope deropement on bullwheels.

The minimum diameter of terminal bullwheels shall be 72 times the nominal diameter of the haul rope, provided that no gripping device passes around the bullwheel. The minimum diameter shall be 80 times the nominal haul rope diameter in cases where gripping devices pass around the bullwheel.

Terminal bullwheels that act as driving, braking, or holding bullwheels shall be so designed that the haul rope does not slip in the bullwheel groove. The design coefficient of friction for a particular bullwheel liner shall not exceed the values shown in table 2-1.

Table 2-1 Design coefficient of friction for bullwheel liners

Bullwheel liner	Coefficient of friction
Steel or cast iron grooves	0.070
Leather	0.150
Rubber, neoprene, or others	0.205

Table 2-2 Minimum diameters for sheaves in tension systems not specifically covered elsewhere in this section

Sheave diameter	
Condition A	**Condition B**
38d	20d
NOTE - *d* equals the nominal rope diameter	

2.1.2.8.3 Sheaves in tension systems and sheaves not specifically covered elsewhere in this section

The minimum diameters for these sheaves shall be as indicated in table 2-2.

Condition A: is applicable where bending of the rope with movement during operation is the case. The minimum ratio applies to ropes of 6x19 class flexibility or better and the use of resilient bullwheel liners with a maximum modulus of elasticity E = 1.45x106 psi (10 kN/mm^2). Sheave liners shall be grooved to a depth of at least 0.33d with a radius of not less than 0.5d of the nominal rope diameter.

When unlined metallic sheaves and/or less flexible ropes are used the minimum ratio shall either be increased by 25% or be specified by the wire rope manufacturer.

Condition B: is applicable when bending without movement during operation is the case.

In the case of a locked coil track cable passing over a sheave or roller chain and connected directly to a counterweight, the radius of curvature of the sheave or the roller chain shall not be less than 100 times the cable diameter or 1200 times the greater dimension of the cross section of the largest wire of the cable, whichever is greater.

NOTE – In shaped wire, consider the greater dimension (width or height) not diagonal measurement.

Provisions shall be made to assure that all tension system sheaves rotate freely.

2.1.2.8.4 Haul rope line sheaves

Haul rope line sheaves in station saddles, tower saddles, and slack carriers shall be designed to perform their function under all anticipated design loading and operating conditions. See 2.1.3.3 for rope guidance and retention requirements.

2.1.2.9 Tension bullwheel carriages

The available travel of the tension bullwheel and carriage shall be adequate for the maximum limits of motion produced by the most unfavorable design loading and operating conditions.

2.1.2.9.1 Rigid mounted carriages

For carriage arrangements with vertical motion, guides shall be provided. For all carriage arrangements other than those whose motion is vertical, the mounting that travels under the action of the tension system shall be supported on rigid straight rails by means of wheels. All loads, including torsional loads, due to driving torque and braking shall be considered, and the structure and carriage shall adequately transmit these loads to the foundation.

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2.1.2.10 Tension systems

Counterweights, hydraulic and pneumatic cylinders, or other suitable devices shall be used to provide the tensioning requirements of the particular installation. All devices used to provide the tension shall have sufficient travel to adjust to all normal operating changes in loading and temperature.

The tension for haul ropes and track cables for all modes of operation shall be determined by the design engineer. Tension systems may be active or passive; however, all systems shall have monitoring equipment that will automatically prevent operation outside of design limits (see 2.2.3.3 and 2.2.5(g) for electrical requirements).

Fixed anchorage systems shall have a device or procedure to determine that the ropes and/or cables are within their operating tension range. The manufacturer shall specify the checking procedures and intervals.

Tension systems may be adjustable to provide proper tensions for different modes of aerial tramway operation.

The tension system design shall consider changes, for each mode of operation, in tensions due to rope elongation, friction, and other forces affecting traction on driving bullwheels and braking bullwheels, tower and sheave loading, and maximum vertical loads on grips and clamps to assure that tensions remain within design limits.

2.1.2.10.1 Hydraulic and pneumatic systems

Hydraulic and pneumatic cylinders, when used, shall have sufficient ram travel to accommodate all normal operating changes in loading and temperature. Provisions shall be made to keep the cylinder free from climatic-induced conditions and contaminants that may interfere with free movement.

If the system fails to provide the design operating pressure, the aerial tramway shall be able to be operated to unload passengers.

Cylinders and their attachments shall each have a minimum factor of safety of 5. The factor of safety is equal to the ultimate tensile strength of the cylinder divided by the maximum steady state design tension.

The systems providing operating pressure for the cylinder shall have a minimum factor of safety of 5 unless a high-velocity check-valve or flow-control device is used where the pressure line is connected to the cylinder. The check-valve shall be rated to hold twice the normal operating pressure. The remainder of the system shall not exceed the manufacturer's published working pressure. Provisions shall be made to restrict the movement of pressure lines or hoses should they become severed under pressure. When pneumatic storage cylinders, accumulators, or other similar devices are used, they shall be located so that they cannot be knocked over or damaged.

2.1.2.10.2 Counterweights

Counterweights, when used, shall be arranged to move freely up and down. Enclosures for counterweights shall be provided where necessary to prevent snow, ice, water, and other materials from accumulating under and around the counterweights and interfering with their free movement. Visual access shall be provided to areas beneath and above all counterweights contained in enclosures or pits. When a counterweight is contained in a structural frame, guides shall be provided to protect the frame and to ensure free movement of the counterweight. Where snow enclosures are not required, guardrails or enclosures shall be provided to prevent unauthorized persons from coming in contact with or passing under counterweights.

2.1.2.10.3 Wire ropes in tension systems

Wire ropes in tension systems shall have a minimum factor of safety of 6 when new (see A.1.3.1 in Annex A). On arrangements involving rope reeving, the maximum design static tension with sheave friction taken into account shall be the basis for determining the factor of safety. See A.3 in Annex A for additional requirements. No rotation-resistant ropes shall be used in tension systems (see 1.4 - *rotation-resistant rope*).

Wire ropes in tension systems shall be adjusted so that the counterweight will reach the end of its travel before the attached tension bullwheel carriage comes within 6 inches (150 mm) of the end of its travel. When wire ropes are used with pneumatic or hydraulic cylinders, they shall be adjusted so that connecting devices will not contact the reeving devices before the ram reaches the travel limits of the cylinder.

2.1.2.10.4 Chains in tension systems

Welded link chains may be used in tension systems (see Annex G).

Roller and leaf chains are prohibited for usage as tensioning members on aerial tramways that are classified as new (see Annex H).

2.1.2.10.5 Cable winches or chain adjusting devices

Winches or other mechanical devices that are used for take-up and remain part of the system shall have a minimum factor of safety of 6 against their ultimate capacity. They shall have a positive lock against release. Where this factor cannot be established by manufacturer's endorsement, a device shall be installed on the tension system rope or chain ahead of the winch/device that will keep the tension system intact in the event of a release or failure of the device.

The diameter of the winding drum shall not be less than the specified minimum sheave diameters referenced as Condition B in table 2-2.

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2.1.2.11 Anchoring devices

All anchoring end connections shall be above finished grade. Any portion of an anchorage below ground shall be protected against loss of strength due to corrosion.

Wire ropes or strands and their connections, used to anchor, tension, or otherwise secure terminal and tower structures, shall be designed with a minimum factor of safety of 6. Where adjusting devices are used in the arrangement, the devices shall be capable of being securely locked or removed during operation.

All connections of ropes or cables used in anchoring devices shall be in accordance with the requirements of A.3.2 in Annex A.

2.1.2.12 Terminal entrance and exit guides

Guide rails with curved ends shall be provided so that entrance and exit of carriers to and from the platforms can be accomplished smoothly and with minimum impact when carriers are deflected from the vertical 20% laterally and, simultaneously, 20% longitudinally.

2.1.3 Line structures

Monocable systems shall meet the requirements of 4.1.3.1 through 4.1.3.3.3.

2.1.3.1 Towers (bicable systems)

The design of the tower structure and foundation shall be in accordance with the requirements of 2.1.1.6.

Means shall be provided for ready access from the ground to all tower tops. Work platforms shall be provided to access all line sheave or saddle assemblies atop a tower. Permanently installed lifting frames shall be installed to facilitate lifting haul rope or track cable or both, on all towers.

Permanent anchor points shall be provided on all tower tops for the attachment of fall protection devices.

Towers shall be identified with successive numbers clearly visible to passengers.

2.1.3.2 Tower guides and clearances

Suitable guides shall be provided to prevent the carriers from contacting intermediate towers or other fixed objects.

On bicable systems with track cable brakes, the guides shall be designed to limit swing to that permitted by the relationship between brake and saddle. If open windows are used on the tower side, a clearance of at least 18 inches (460 mm) shall be maintained at the window height when the cabin is swung inward the maximum amount permitted by the design. On unattended cabins, the windows on the tower side shall be kept closed or screened.

On systems without track cable brakes, cabin guides shall be designed for the maximum allowable lateral swing of the carrier (see 2.1.1.5.2). At no time shall any part of a carrier make contact with another part of the tower saddle when passing at the maximum lateral swing angle.

2.1.3.3 Haul rope line sheaves and mounts

The tread diameter of a haul rope sheave shall not be less than 10 times the nominal diameter of the haul rope unless an elastomer liner is used.

The requirements in 2.1.3.3 and 2.1.3.3.1 through 2.1.3.3.3, where applicable, apply generally to sheaves that support or hold down the haul rope at towers on a bi-cable system, These requirements shall apply to both sides of each aerial tramway.

2.1.3.3.1 Maximum allowable sheave load

The maximum allowable load per sheave shall be determined by the aerial tramway designer.

2.1.3.3.2 Sheave and sheave unit design

Sheave flanges shall be as deep as possible, considering other features of the system. At the same time, rope attachments shall be designed in relation to the sheave groove so as not to contact sheave flanges during normal operations, taking into consideration the anticipated amount of wear of the sheave liner groove. Attachments shall be allowed to contact sheave flanges adjacent to the haul rope when the carrier swings, provided that this is considered in the design of the attachments and sheaves. Furthermore, rope attachments, sheave flanges, and hanger guides shall be designed so that hangers cannot be caught behind guides, and so that ropes and attachments cannot be deroped from sheaves if the carrier is swinging within design limits as it approaches or passes the tower.

Suitable guards, of sufficient strength to resist the lateral forces caused by an inside deropement, shall be installed.

Construction of the entire sheave unit shall be such that the rope cannot become entangled in the sheave unit in the event the rope leaves the sheave toward the outside.

A suitable device, or system shall be installed and maintained that will stop the aerial tramway in case of deropement of a sheave unit (see 2.2.3.4).

If the gauge of the haul rope system is varied at any point along the line, the horizontal departure at any one tower shall be provided for in the design so that deropement cannot occur by virtue of such a departure.

Sheave mounts or mounting frames shall be designed to be adjustable, allowing the sheave units to be aligned.

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2.1.3.3.3 Haul rope retention

Provisions shall be made to retain the haul rope in the sheave groove under all anticipated conditions of loading, except as required for carrier passage (bicable system only).

The carrier shall not leave the track cable if the design haul rope tension is increased by 50% or decreased by 33% (bicable system only).

When the haul rope elevation at a tower lies below a straight line joining the haul rope elevations at the adjacent towers, the haul rope shall not leave the group of sheaves when the haul rope tension is 1.5 times its maximum design value at the point, and there are no carriers in adjacent spans.

2.1.3.4 Track cable saddles and mounts

Cable catchers shall be provided on the saddles on both sides of each track cable. Cable catchers are not required if the track cable shoes are designed to reduce the risk of deropement.

The radius of a track cable saddle shall be determined by the one of the following criteria that requires the largest radius:

a) to be large enough to minimize bending stresses in the cable. In any event, the radius shall be equal to at least 1200 times the largest dimension of the outer wire of the cable;

NOTE – In shaped wire, consider the greater dimension (width or height) not diagonal measurement.

b) to be large enough to provide smooth transition of the carriage assembly from span to span;

c) to be large enough to reduce the bearing pressure to a value that will permit proper lubrication of the cable to facilitate sliding in the saddle groove;

d) to be large enough so that the radial acceleration of the carrier is not greater than 6.6 feet (2.0 meters) per second squared calculated as follows:

V^2/R *is not greater than 6.6 feet (2.0 meters) per second squared*

V = Carrier speed in feet (meters) per second
R = Radius of shoe in feet (meters)

The minimum pressure on the saddle shoes shall be not less than 1.5 times the pressure required to hold the rope in contact with the shoes when a wind force of 6 pounds per square foot (290 pascals) is applied upwards on the rope, parallel to the reaction on the tower.

The saddle shall be long enough to ensure that, under maximum design loading conditions, the cable will not come into contact with the end of the saddle groove.

Saddles shall be designed so that the track cable brake, if any, may function at the time the carrier is passing the saddle without deropement of the carriage wheels.

Saddles shall permit free passage of the carriage even when the carrier is swinging laterally to its design limit as it approaches or passes the tower.

If the gauge of the aerial tramway is varied at any point along the line, horizontal departure at any one tower shall be kept to a minimum to avoid deropement of the carriage wheels as they pass over the saddle.

Systems without track cable brakes shall have the saddles encircle the track cables not less than 180 degrees.

2.1.4 Line equipment

2.1.4.1 Haul rope

See Annex A for basic wire rope design and installation requirements.

Means to efficiently pull out a haul rope throw over shall be provided on bicable systems.

2.1.4.1.1 Factor of safety

Haul ropes shall have a minimum static factor of safety of 5 when new. Static factor of safety is equal to the minimum breaking force (see A.1.3 in Annex A) divided by the computed maximum tension caused by design loads, including the effects of friction, but excluding dynamic loads, in the section of haul rope that is most highly stressed.

The system design and the positioning of the haul rope splice shall be such that the safety factor for the spliced section shall not be greater than 20.

2.1.4.1.2 Factor of safety for spliced haul rope with an independent wire rope center

Where a spliced haul rope with an independent wire rope center (IWRC) is used, the minimum breaking force of an equivalent wire rope with a fiber core shall be used.

2.1.4.2 Track cable

See Annex A for basic requirements for all track cables. Track cables consisting of one strand made up entirely of round wires (commonly called *smooth coil track strand*) shall not be permitted. Wire rope, if used as track cables, shall have an independent wire rope or strand center.

2.1.4.2.1 Track cable factor of safety

Track cables shall have a minimum static factor of safety of 3 and a minimum dynamic factor of safety of 2.5, when new. Dynamic loads shall include the load imposed upon the track cable due to application of track cable brakes.

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2.1.4.2.2 Track cable installation

The designer of the aerial tramway shall provide detailed information concerning handling and installation of the track cable. These instructions shall be consistent with the track cable manufacturer's recommendations. Any handling after installation shall be in accordance with this advice.

2.1.4.3 Carriers

The carrier and all components shall be designed by Qualified Engineers in accordance with accepted practices of design. If the design has not had prior successful use for passenger transportation, its adequacy shall be verified by test loadings, trial operations, and tests under repeated loadings. The maximum capacity of each cabin shall be specified by the aerial tramway designer.

2.1.4.3.1 Grip (monocable)

Haul rope attachment grips, used on monocable systems, shall conform to the requirements of 4.1.4.3 and 4.3.4.3.

2.1.4.3.2 Hanger

The hanger shall be securely attached to the carriage or haul rope attachment and to the cabin in such a manner that it cannot work loose.

The hanger shall be of sufficient vertical length that, under the worst design condition (excluding application of track cable brake) of longitudinal swing, the top of the cabin cannot strike the haul rope, the track cables, or the bottom of a tower saddle. In any event, the carrier shall be able to swing longitudinally without interference to the greater of the following:

a) 20°

b) $\text{atang} \left\{ \frac{3A \cos \beta}{9.81} \right\}$

A = greatest system deceleration in m/s^2.
β = most unfavorable track slope in degrees.
9.81 = gravity in m/s^2

Sway dampers designed to reduce the longitudinal sway of the carrier shall be used if recommended by the aerial tramway designer. Where used, they shall operate smoothly and without danger of deropement of the carriage wheels or the haul rope.

2.1.4.3.3 Cabin

Fully enclosed passenger cabins shall be ventilated. They shall be equipped with doors that fill the entire entrance opening. The minimum clearance width opening shall be 32 inches (815 mm). Each door shall be provided with a lock located in such a manner that it can be unlocked only by authorized persons or by automatic means.

Where the cabin door can be opened from the inside the following shall apply:

a) A door not closed and locked will prevent the start of a trip;

b) A door opened during a trip will initiate a stop;

c) A cabin door key shall be placed under glass, posted to prohibit use except under specified emergency conditions.

The horizontal gap between the cabin door opening floor edge and platform edge shall not be greater than 1 inch (25.4 mm). The height of the cabin floor and the platform shall be within ±½ inch (±12.7 mm). Where it is not operationally or structurally feasible to meet these requirements, platform devices, vehicle devices, or bridge plates shall be provided for independent loading.

All windows shall be of shatter-resistant material.

Means of emergency evacuation of passengers shall be provided.

The maximum capacity of each cabin, both in pounds and kilograms and the approximate number of passengers, shall be posted in a conspicuous place in each cabin (see table D-1(r)) in Annex D).

Cabin floor space available to passengers shall not be less than 2.5 square feet (0.23 square meter) per person for the first 15 passengers and 2 square feet (0.19 square meter) for each passenger thereafter. A minimum clear floor space of 48 inches by 30 inches (1220 mm x 760 mm) for passengers using wheelchairs shall be provided. Floor surfaces shall be slip resistant.

2.1.4.4 Carriage (Bicable systems)

2.1.4.4.1 Carriage wheels

On bicable systems, the weight of the loaded carrier and haulage rope reactions shall be distributed to carriage wheels so that the load on any wheel shall not exceed that recommended for the track cable or the wheel liner material for the wheel diameter selected. In no event shall the load per wheel exceed 1/80 of the minimum design tension in the track cable when track strand is used with unlined wheels or 1/60 with resilient liner material. If wire rope is used as a track cable, the load per wheel shall not exceed 1/40 of the minimum design tension in the track cable.

The carriage shall be equipped with a device that will, as far as possible, hold the carriage on the track cable in the event of a deropement of the wheels. In areas where icing conditions may exist, the carriage shall be equipped with ice scraping devices that cannot contact the track cable under normal anticipated operating conditions.

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2.1.4.4.2 Track cable brakes

Each carrier on a reversible aerial tramway using the bicable system shall be equipped with a brake that will grip the track cable (see 2.1.4.4.2.1) Track Cable Brakes may be omitted if the design requirements of 2.1.4.4.2.2 are met.

2.1.4.4.2.1 Carriers with track cable brakes

The track cable brake shall be designed to stop the carrier while reducing the risk of damage to the track cable, carrier, or structures under all anticipated design loading conditions (see 2.1.1.5.4). Application of the track cable brake shall automatically effect an emergency shutdown (see 2.2.3(i)).

The track cable brake shall be capable of manual activation by the attendant in the cabin.

The brake shall be applied by springs or other approved forms of stored energy. The brake shall be capable of stopping the carrier automatically considering but not limited to the following:

- travel speed;
- loading of carrier(s);
- slope of track;
- remaining rope tensions on carrier(s);
- failure of rope at different locations;
- closing time of brakes;
- wear of brake liners;
- friction of brake liners on track cables;
- lift off the track effect of carrier at the instant of rope failure.

2.1.4.4.2.2 Carriers without track cable brakes

Bicable aerial tramways without track cable brakes shall meet the following provisions:

a) two track cables per track;

b) the haul rope shall be a continuous spliced loop;

c) the minimum haul rope diameter shall be 0.78 inch (20 mm);

d) the carriage(s) shall be connected to the haul rope with a minimum of 2 completely independent spring-loaded clamps. The total of the clamps shall have the capacity to provide a calculated slipping force of not less than 3 times the downward force component of a fully loaded carrier at the steepest gradient with the haul rope at nominal diameter and properly lubricated;

e) the clamps shall be made of steel;

f) the maximum design friction factor between the clamp and the rope shall be 0.16 A test of the actual force required to slip the clamps shall be performed at the acceptance test;

g) the clamps shall be designed to slip the haul rope prior to reducing the haul rope factor of safety below 2.5 based on a coefficient of friction of 0.16. During the test of the clamp slippage force, the haul rope safety factor shall not be less than 2.0;

h) the slippage force of the haul rope in the clamps must be verified at the site. These tests shall be repeated at intervals not exceeding 6 years and each time the clamps are overhauled;

i) any slipping of the haul rope in the clamps must be identifiable by visual inspection;

j) provisions for securing the carriers in the station during the clamp relocation and haul rope inspection process shall be provided;

k) the clamps shall be relocated on the haul rope at an interval in cycles specified by the manufacturer. The haul rope shall be moved in the same direction at each relocation;

l) the haul rope shall be relocated a minimum distance of 2 times the contact length of the clamps and guides to the haul rope plus 2 lay lengths;

m) after the clamps have been relocated and secured the aerial tramway shall be operated through its normal full cycle to verify the approach supervision and pull-in distances prior to passenger operation;

n) the splice must be located uphill of the carrier(s) and a minimum distance from the carriers(s) equal to 1.5 times the longest stopping distance;

o) the entire length of the haul rope shall have an MRT inspection within 200 hours of operation after installation for a base line. Thereafter, MRT inspections shall be done at yearly intervals or as specified by the designer;

p) a 10% change in the nominal haul rope diameter shall not change the clamping force on the haul rope by more than 25%;

q) not less than 50% design clamping force on the haul rope shall be maintained at a 20% reduction of the nominal haul rope diameter;

r) the exit and entry of the haul rope clamp shall be such that any rope-bending radius is large enough as not to affect the life of the haul rope.

2.1.5 Provisions for operating personnel

Operator and attendant work positions shall be located to provide visual surveillance of the station and the line in the vicinity of the work position. The operator's controls and communicating devices shall be within reach without leaving their position.

Station work positions, when enclosed, shall be heated, ventilated, and lighted as required to perform the function of the work position. When enclosed, work positions shall include:

a) the communications and controls required of the work position;

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b) the operating instructions and emergency procedures;

c) a fire extinguisher (see F.6 in Annex F);

d) provisions to be locked to prevent unauthorized entry when unattended.

This does not preclude additional communications and controls to be located at other areas of the aerial tramway.

The control room shall contain, in full view of the operator, indicators that will show the location of the carrier(s) at all times.

2.1.6 Operational and maintenance manuals

2.1.6.1 Operational manual

The designer of each new or relocated aerial tramway shall prepare an operational manual in English for that installation. The manual shall describe the function and operation of the components and provide instructions for the correct usage of the installation.

2.1.6.2 Maintenance manual

The designer of each new or relocated aerial tramway shall provide with delivery of the aerial tramway, a maintenance manual in English, for that installation. The manual shall describe recommended maintenance and testing procedures, including:

a) types of lubricants required and frequency of application;

b) definitions and measurements to determine excessive wear;

c) recommended frequency of service to specific components;

d) carrier testing procedures and acceptance criteria;

e) brake testing and adjustment;

f) dynamic testing procedure.

2.2 Electrical design and installation

2.2.1 General design and installation testing

Prior to operation of newly installed aerial tramways or after any modification thereafter of the electrical system, the electrical system shall be tested and shown to meet the requirements of this standard and the test results shall be recorded. Design of all electronic controls and drives shall consider minimum sensitivity to electrical noise and electrical emissions, such as noise spikes from power lines and lightning, radio transmitters, thyristors (SCR), or solenoid or relay noise at levels and frequencies that could initiate loss of control.

2.2.1.1 Applicable codes

All electrical systems shall comply with American National Standard, ANSI/NFPA 70-2011, *National Electrical Code* and the Institute of Electrical and Electronics Engineers, IEEE C2-2007, *National Electrical Safety Code*.

2.2.1.2 Location

All electrical power transmission wiring located near or proposed to cross over aerial tramways shall comply with the applicable requirements of IEEE C2-2007.

2.2.1.3 Protection

All electrical equipment with operating voltages above 24 volts nominal shall be marked conspicuously with letters/numbers that are no smaller than ¼ inch (6 mm) in height designating the greatest voltage that may be in the equipment, the number of phases and whether the voltage is alternating or direct current. All electrical equipment rated over 600 volts shall be marked with conspicuous warning signs stating “Danger High Voltage”.

EXCEPTIONS – 120 volt single phase lighting circuits and convenience outlets.

All power equipment shall be protected against overloads by circuit breakers or fuses.

In locations where electrical equipment, including batteries, is likely to be exposed to physical damage, enclosures or guards shall be so arranged and of such strength as to prevent such damage.

2.2.1.4 Overhead cables

Only signal, communication, control circuit cables and wire rope associated with rescue systems may be supported between towers that support the aerial lift. Voltage shall be limited to low voltage, 24 volts nominal.

EXCEPTION – Circuits for telephone systems may exceed the low voltage requirements.

Overhead cables shall be positioned in such a way that they do not contact the haul rope, track rope, or carriers under normal aerial tramway operating conditions. If a cable parts and displaces from its normal position, the aerial tramway shall stop (see 2.2.5(d)).

2.2.1.5 Wiring

All wiring shall be in accordance with the designer’s specifications and applicable codes.

2.2.1.5.1 Control wiring classification

All control wiring shall be Class 1 in accordance with Article 725 of ANSI/NFPA 70-2011.

EXCEPTION – Overhead cables (see 2.2.1.4).

2.2.1.5.2 Communication wiring

All communication wiring and systems are exempted from the requirements in Article 800 of ANSI/NFPA 70-2011.

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2.2.1.5.3 Insulation

All control wiring is exempted from the requirements of Article 725.49, Part B of ANSI/NFPA 70-2011. The designer shall specify conductor size, type, and insulation suitable for the electrical and mechanical requirements of the application.

2.2.1.5.4 Exterior lighting and snowmaking circuits

All ungrounded exterior lighting and snowmaking circuits, mounted on or within 60 feet (18.3 meters) of the aerial tramway centerline, shall have ground fault protection (see 1.4 – *ground fault protection*).

2.2.1.5.5 Ground fault circuit interrupter protection for personnel

All 120-volt single phase, 15 and 20 ampere receptacles in areas where electrical diagnostic equipment, electrical hand tools, or portable lighting equipment may be used shall have ground-fault circuit interrupter protection for personnel (see 1.4 – *ground-fault circuit interrupter*).

EXCEPTION – Receptacles dedicated to permanently mounted devices need not comply with this requirement.

2.2.1.6 Grounding

2.2.1.6.1 Structures

All metallic structures shall be bonded to form a grounding electrode system as defined in Article 250 of ANSI/NFPA 70-2011. Electrical continuity of all metal parts of the structures shall be assured by mechanical connection and shall be electrically bonded to the common bonding conductor.

2.2.1.6.2 Drive terminal structure

The drive terminal structure shall have one point referred to as the grounding electrode as defined in ANSI/NFPA 70-2011. All dc and ac electrical systems shall be referenced to this point. If an electrical prime mover is used, the electric service grounding conductor shall terminate at this point, as well as the structure's ground referenced in 2.2.1.6.1. Under the worst-case conditions, the resistance from the grounding electrode to any grounded point within the aerial tramway system shall not exceed 50 ohms, for the purpose of grounding the electrical circuit. The grounding system for the aerial tramway shall not be used as a grounding system for any other system not related to the aerial tramway system.

To ensure that the 50-ohm grounding requirement is met under all conditions of soil, moisture, temperature, and circulating ground and air currents, all terminal and line structures shall be bonded together with a bonding conductor.

2.2.1.6.3 Haul rope grounding

Grounding sheaves with conductive liners or equivalent means should be provided at one location for the purpose of grounding haul ropes and track cables, as applicable, for static electrical discharge. For the haul rope on bicable systems or monocable systems with an isolated or insulated haul rope incorporated in the operating circuitry, no means of grounding are required when the operating circuit takes into consideration static electrical discharge.

2.2.1.6.4 Lightning protection

If lightning protection is provided, it shall follow ANSI/NFPA 780-2008, *Standard for the Installation of Lightning Protection Systems.*

2.2.2 Electrical system circuit design and classification

The designer or aerial tramway manufacturer responsible for the design shall identify and classify any new electrical circuits not already classified as protection circuits, operation circuits, or supervision circuits.

2.2.2.1 Circuit priority

Protection circuits shall have priority over all other circuits. Operation circuits shall have priority over supervision circuits. If any circuit's function is connected to circuits of a higher level of protection, it shall be classified at the higher level.

2.2.3 Protection circuits

Electrical circuits designed to stop the aerial tramway in the event of a malfunction or failure of the aerial tramway system shall be classified protection circuits. All aerial tramway systems shall contain two or more protection circuit(s) at least one of which shall be designated the emergency shutdown circuit (see 2.2.3.1) Protection circuits shall be energized to permit system operation and when de-energized shall initiate a stop, or shall be of such design to provide the equivalent level of protection.

A protection circuit may include one or more non-complex elements (see 1.4 – *non-complex elements*) and/or complex electronic elements (see 1.4 – *complex electronic elements*). The designer shall make use through continuous diagnostic coverage (see 1.4 – *continuous diagnostic coverage*) that the failure of a complex electronic element will cause the aerial tramway to stop or prevent the next departure unless another element in the protection circuit is performing the same function (redundancy). If functional redundancy is implemented, the failure of the first element must be annunciated, at a minimum, at the beginning of operations on a daily basis.

The designer or manufacturer shall develop procedures and frequency for testing protection circuits. As a minimum, all protection circuits shall be calibrated and tested annually.

Protection circuits include, but are not limited to:

a) emergency shutdown (see 2.2.3.1);

b) carriage overtravel detection device (see 2.2.3.2);

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c) tension system fault (see 2.2.3.3);

d) deropement circuit(s) (see 2.2.3.4);

e) brake system (see 2.2.3.5);

f) overspeed (see 2.2.3.6);

g) speed regulation check points (see 2.2.3.8);

h) cabin door fault (see 2.1.4.3.3);

i) track cable brake application detection (see 2.1.4.4.2.1).

2.2.3.1 Emergency shutdown circuit

All aerial tramway systems shall include at least one protection circuit labeled “emergency shutdown circuit” (see 1.4 – *emergency shutdown*). The shutdown shall have priority over all other control stops or commands. If, for any reason, the operator has lost control of the aerial tramway while using the operating control circuitry, the controls shall include an emergency shutdown circuit allowing the operator/attendant to stop the aerial tramway. Any one of the following conditions is considered a loss of control of an aerial tramway:

a) Aerial tramway will not SLOW DOWN when given the command to do so;

b) Aerial tramway will not STOP when given the command to do so;

c) Aerial tramway OVERSPEEDS beyond control settings and/or maximum design speed;

d) Aerial tramway ACCELERATES faster than normal design acceleration;

e) Aerial tramway SELF-STARTS or SELF-ACCELERATES without the command to do so;

f) Aerial tramway REVERSES direction unintentionally and without the command to do so.

2.2.3.2 Carriage overtravel

An overtravel sensing device shall be installed that will stop the system if a carriage travels beyond its normal stopping location.

2.2.3.3 Tension system

Active tension systems, (i.e. counterweight, hydraulic, etc.) shall have a protection device(s) that will stop the aerial tramway when the tension system exceeds its range of normal operation.

EXCEPTION – Track cable counterweight overtravel switches can be programmed to allow the trip to continue and lock out the next trip. Activation of the switch shall be continuously annunciated at the operator’s position.

2.2.3.4 Deropement detection

Bicable systems shall have a system or device that will initiate a stop if the following is detected:

a) the haul rope comes in contact with the track cable(s), other ropes, communication lines, or grounded equipment;

b) the track cable leaves the saddle into the cable catcher.

2.2.3.5 Braking system

Braking systems must meet the requirements of 2.1.2.6.

2.2.3.6 Overspeed

If the rope speed at the drive terminal exceeds the design speed by 10%, the service brake shall slow and stop the aerial tramway automatically.

A system or device shall be installed that will automatically apply the bullwheel brake when the speed of the haul rope exceeds the design value by 15% in either direction.

2.2.3.7 Reserved

2.2.3.8 Speed regulation check points

A redundant device or system shall initiate a stop in the event manual or automatic speed regulation fails to reduce aerial tramway speeds to the designed values in the station and tower approach zones.

2.2.4 Operation circuits

An operation circuit is a circuit that provides power to or controls the aerial tramway machinery.

The designer or manufacturer shall identify the operation circuits that require periodic testing and develop procedures and frequency for testing. At a minimum, all operation circuits shall be tested and calibrated annually.

Operation circuits include, but are not limited to:

a) power circuits;

b) drive fault circuits;

c) normal stop (see 1.4 – *normal stop* and 2.1.2.5);

d) speed command circuits (i.e., fast, slow, etc.);

e) power unit interlock (see 2.1.2.1.3);

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2.2.5 Supervision circuits

Supervision circuits include all communications systems. In addition, supervision circuits may be provided to monitor or supervise the performance of various aerial tramway systems or provide the aerial tramway operator with system information.

The designer or manufacturer shall identify supervision circuits that require periodic testing and develop procedures and frequency for testing supervision circuits. At a minimum, all supervision circuits shall be calibrated and tested annually.

Supervision circuits may include, but are not limited to:

a) telephone and sound powered systems (see 2.1.1.7);

b) information display circuits;

c) audible warning devices (see 2.2.10);

d) overhead cable supervision (see 2.2.1.4);

e) wind speed and direction sensors and display units;

f) gearbox oil pressure, oil flow and temperature;

g) pneumatic and hydraulic tension system pressure (see 2.2.5.1);

h) unauthorized passenger on platform detection;

i) acceleration/deceleration error (see 2.2.5.2).

2.2.5.1 Pneumatic and hydraulic tension systems

When pneumatic or hydraulic tension systems are used, pressure-sensing devices shall also be incorporated that will stop the aerial tramway system in case the operating pressure goes above or below the design pressure range. Such pressure-sensing devices shall be located close to the actual tensioning device. It shall not be possible to isolate the pressure sensor from the actual tensioning device.

2.2.5.2 Acceleration and speed monitoring

The rate of acceleration and deceleration of the aerial tramway shall be monitored. In the event that the acceleration or deceleration exceeds the provisions of 2.1.2.4, the aerial tramway shall stop and annunciate the error.

2.2.6 Bypass circuits

A temporary circuit may be installed for the purpose of bypassing failed electrical circuits. The use of bypass circuits must meet the requirements of 2.3.2.5.9.

2.2.7 Electrical prime mover

All aerial tramway systems equipped with electrical prime movers (electrical motors) shall have phase-loss protection on all power phases and under-voltage protection or over-voltage protection, or both, when speed regulation can be adversely affected by such voltage variations.

2.2.8 Electronic speed-regulated drive monitoring

All electronic speed-regulated drives and electric motors shall shut down in the event of:

a) field loss (dc motors);

b) overspeed;

c) speed feedback loss, if applicable;

d) overcurrent.

2.2.9 Manual control devices

All automatic and manual stop and shutdown devices shall be of the manually reset type. An exception to this requirement is allowed for magnetic or optically operated automatic stop devices, if the operating circuit is such that it indicates that such devices initiated the stop and the circuit is of the manually reset type.

Manual stop switches (push button) shall be positively opened mechanically and their opening shall not be dependent upon springs.

Manual control devices shall be installed at all conductor and operator work positions, control rooms, machine rooms, and out-of-doors in proximity to all loading and unloading areas.

As a minimum, each operator and conductor work position shall include an emergency shutdown device and a Normal Stop device. All manual control devices located in or on a control cabinet shall be mounted so that they are in the same plane or face of the cabinet.

The devices listed in normative Annex E shall be conspicuously and permanently marked with the proper function and color code.

2.2.10 Safety of operating and maintenance personnel

Provision shall be incorporated in the aerial tramway design to render the system inoperable when necessary for Lock-out Tag-out protection of personnel working on the aerial tramway.

The sign “Personnel Working on Aerial Tramway - Do Not Start” or a similar warning sign shall be hung on the main disconnect switch or at control points for starting the prime mover or evacuation power unit when persons are working on the aerial tramway.

The aerial tramway shall incorporate an audible warning device that signals an impending start of the aerial tramway. After the start button is pressed, the device shall sound an audible alarm for a minimum of 2 seconds and shall continue until the ropeway drive system begins to move. The audible device shall be heard inside and outside all terminals and machine rooms above the ambient noise level.

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2.2.11 Electrical system acceptance tests

Upon completion of the acceptance test and before public operation of the aerial tramway, the function of software and/or relay logic shall be certified by a Qualified Engineer. The certification shall be included in the acceptance test report. Any modifications made to the electrical design shall be clearly marked on the on-site documentation and signed by a Qualified Engineer (see 2.1.1.11.2).

2.2.12 Software security

The “as built” documents shall include a procedure, developed by the aerial tramway manufacturer or Qualified Engineer, to ensure the security of the software logic and operating parameters that will control the aerial tramway. Upon completion of the acceptance testing this procedure shall be implemented in a manner that will prevent unauthorized personnel from making changes to the software logic or operating parameters. All programmable logic and parameters shall be documented.

2.2.13 Night operations

For nighttime operation, operating aerial tramways shall be provided with lighting systems. Lighting shall be provided at loading and unloading areas.

2.2.13.1 Illumination

Lights shall be located in a manner to provide generally uniform illumination.

2.2.13.2 Types

Lamps shall be of a type suitable and rated for minimum temperatures of the location. Fixtures shall be designed to maintain proper lamp-operating characteristics.

2.2.13.3 Location

Lights shall be mounted on substantial poles or standards. Aerial tramway towers and terminal structures may be used for supporting lights, subject to the following requirements:

a) Approval shall be obtained from a Qualified Engineer;

b) The service conductors to each aerial tramway tower or terminal structure shall be underground or in rigid raceways. No wiring shall be supported between towers and no open wiring shall pass over or under the aerial tramway;

c) A separate enclosed disconnect and ground fault protection shall be required for each tower or terminal structure;

d) All metallic raceways on a tower or terminal structure shall be grounded;

e) The lighting installation shall not conflict with other requirements of this standard and shall not interfere with operations of the aerial tramway in any manner.

2.2.13.4 Emergency lighting

Emergency lighting shall be provided in the event of electric power failure to permit:

a) regular unloading of aerial tramway facilities;

b) emergency evacuation of carriers;

c) operation of the evacuation or rescue drive.

2.3 Operation and maintenance

This subsection covers the requirements for operation and maintenance of aerial tramways. Many requirements are listed elsewhere in Section 2 and referenced Annexes, since they also regulate installation and design. It is imperative that operating and maintenance personnel be familiar with applicable provisions of this section and the aerial tramway operational and maintenance manuals (see 2.1.6).

2.3.1 General and personnel safety

Operation and maintenance of aerial tramway equipment can be dangerous to personnel performing these tasks. Procedures for performing these functions shall require precautionary measures necessary to reduce the risks for the personnel involved. Implementation of the procedures intended for the protection of the public and operating and maintenance personnel shall be the responsibility of the owner, supervisor, and the individual worker.

Passengers and operating personnel shall be cautioned or prevented, as required, from transporting objects or materials that may encroach upon limitations of carrier clearances or design live loads.

2.3.1.1 Applicable design requirements

The following design requirements shall be met by the effective date listed:

– No new items listed for aerial tramways in this standard

The following items were listed in the ANSI B77.1-2006 Standard and are required:

- 2.1.1.7 Communications (Nov. 1, 2007)
- 2.1.2.1.2 Evacuation power unit (Nov 1, 2008)

2.3.1.2 Signs

See normative Annex D for public sign requirements.

See 2.2.1.3 for electrical warnings.

The sign “Personnel Working on Aerial Tramway - Do Not Start” or a similar warning sign shall be posted as required by 2.2.10.

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2.3.2 Operation

The requirements of this subsection are a basis for operations of a reversible aerial tramway. The number of personnel at each level may be increased and the required duties of the operating personnel can be redistributed to meet the requirements of the manufacturer and unique specifics of the aerial tramway operations requirements. These revisions shall be specified in the documented aerial tramway operating procedures.

2.3.2.1 Personnel and supervision

Aerial tramways shall be operated by trained personnel, and the owner shall be responsible for their supervision and the training to perform the duties listed in 2.3.2.3. Procedures for monitoring the operation and use of the aerial tramway and for advising and assisting passengers, including passengers with common adaptive equipment, shall be included in the training. One or more persons familiar with emergency procedures shall be on the site at all times when the aerial tramway is in operation. All personnel shall practice good housekeeping. Personnel shall comply with the operational procedures and regulations for the aerial tramway. Persons performing the duties of the aerial tramway personnel may exchange assignments as directed by the supervisor; provided they are trained for each assignment undertaken.

2.3.2.1.1 Supervisor

An individual shall be designated to oversee the aerial tramways operating practices and operating personnel for the purpose of public use. The designated supervisor may delegate some authority to others, but shall oversee the operation and operating personnel of the aerial tramway, as called for by the owner as part of the operation and maintenance quality assurance plan (see 1.5.4).

2.3.2.1.2 Operator

An individual(s) shall be designated the operator and shall be in responsible charge of each aerial tramway. The operator(s) shall be trained and experienced in normal operational and emergency procedures, and such training shall be documented.

2.3.2.1.3 Attendants

Attendant(s) shall be assigned to particular duties under direction of the operator. The attendant shall be trained in operations and emergency procedures pertaining to their assignments, and such training shall be documented.

If a cabin attendant is provided, they shall be trained for duty in connection with enclosed cabins, including loading and unloading procedures, communications, and the use of door locks and keys. The cabin attendant shall be familiar with load limits and applicable safety regulations, well versed in the use of any manual control device under his/her control, and trained in the use of emergency evacuation equipment and procedures, and such training shall be documented.

2.3.2.1.4 First aid

One or more persons trained to provide first aid/emergency care at the Basic Life Support (BLS) level, including CPR, shall be available at all times when an aerial tramway is operating and transporting passengers. There shall be ready access to first aid/emergency care supplies and equipment, including provisions for transporting an injured person to an enclosed and, if required, heated shelter.

2.3.2.2 Minimum operating personnel

The following personnel are the minimum that shall be required for public operations:

a) a supervisor shall be in charge of the aerial tramway operation and personnel. The individual may serve concurrently as an operator if the additional role doesn't interfere with the duties of the supervisor;

b) an operator shall be in charge of the aerial tramway during the trip cycle. The individual may serve concurrently as an attendant if the additional role doesn't interfere with the duties of the operator and approved by the supervisor;

c) an attendant shall be on duty at each loading/unloading platform or station. Personnel assigned to a cabin may also act as a platform or station attendant;

d) one or more trained and competent persons shall be available, consistent with the operational procedures, to evaluate and address abnormal operational conditions.

In addition, the staffing requirements (if any) specified by the aerial tramway manufacturer shall be observed.

2.3.2.3 Duties of operating personnel

All personnel shall use reasonable care while performing their duties.

2.3.2.3.1 Supervisor

The duties of the individual designated as the supervisor include:

a) to oversee practices that will determine that the aerial tramways is operational and that all operating personnel are trained, equipped, and capable of performing their duties prior to public operation;

b) to discontinue operations of the aerial tramway due to physical, weather, personnel, or other reasons;

c) to oversee operational procedures and adherence to applicable regulations pertaining to the aerial tramway.

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2.3.2.3.2 Operator

The duties of the individual designated as the operator include:

a) to be knowledgeable of operational and emergency procedures and the related equipment needed to perform the assigned duties;

b) to assume responsible charge of the aerial tramway;

c) to assign and supervise all attendants on their aerial tramway;

d) to verify that the preoperational inspection (see 2.3.2.4.2) is completed and documented before public operation;

e) to start the aerial tramway while operating for the public (see 2.3.2.5.2);

f) to maintain an operational log as required in 2.3.5.1;

g) to deny access to the aerial tramway to any person using procedures and criteria provided;

h) to advise the supervisor of observed abnormal or unusual conditions that may adversely affect the safety of the operation;

i) to terminate passenger operations (see 2.3.2.5.8).

2.3.2.3.3 Attendant

The duties of an attendant include:

a) to be knowledgeable of operational and emergency procedures and the related equipment needed to perform the assigned duties;

b) to monitor the passengers' use of the aerial tramway, including observing, advising and assisting them while they are in the attendant's work area as they embark on or disembark from the aerial lift; and to respond to unusual occurrences or conditions, as noted. The attendant should respond by choosing an appropriate action, which may include any of the following.

1) assisting the passenger;

2) slowing the aerial tramway (if applicable);

3) stopping the aerial tramway;

4) continuing operation and observation.

c) to deny access to the aerial tramway to any person; using procedures and criteria provided;

d) to advise the operator of observed abnormal or unusual conditions that may adversely affect the safety of the operation.

2.3.2.4 Operational procedures

Operational procedures may supplement the designer's operational manual (see 2.1.6.1) and the owner's quality assurance program (see 1.5.4).

2.3.2.4.1 Control of passengers

Each aerial tramway shall have a definite method for marshaling passengers for loading and unloading. Fences, gates, and alternate access and/or loading methods may be required to implement the system for individuals/groups.

2.3.2.4.2 Daily preoperational inspection

Prior to public operations, a daily preoperational inspection shall be performed and documented. As a minimum, the inspection shall consist of the following:

a) a visual inspection of each terminal, station, and the entire length of the aerial tramway;

b) assurance that the tension system is functional and that tension system devices (counterweights, cylinders, carriages, and the like) have adequate travel with appropriate clearances at both ends;

c) operation of manual and automatic switches in terminals, stations, work positions, cabins, and loading and unloading areas, per manufacturer's instructions;

d) operation of all drive braking systems;

NOTE – The designer of the aerial tramway system may specify that this inspection is to take place while the aerial tramway is not moving.

e) operation of communication systems;

f) operation of the aerial tramway, including a visual inspection of all ropes and carriers;

g) for those aerial tramways having primary power internal combustion engines, determining that the fuel quantity is sufficient to conduct the anticipated period of operation without refueling. For those installations having internal combustion engines used as evacuation power units, the fuel supply shall be adequate to unload the aerial tramway. During refueling, power units shall be shut down.

Aerial tramways having internal combustion engines shall have the engine(s) checked during this inspection and operated at least once each week. The aerial tramway shall be operated using each internal combustion engine for at least 30 minutes per month;

h) inspecting the loading and unloading facilities and, if necessary, clearing them of ice and snow to permit the ingress and egress of passengers;

i) inspecting and checking the mechanical features of the carriers for correct operation;

j) assurance that applicable horizontal and vertical clearances are maintained (see 2.1.1.4 and 2.1.1.5).

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2.3.2.4.3 Access to facilities

While in operation, entrances to all machinery, operators' and attendants' rooms shall be restricted to authorized personnel only. All entrances shall have the signs required in Table D-1 (u) in Annex D.

While not in operation, entrances to all machinery, operators', and attendants' rooms shall be locked. To provide shelter and emergency telephone access for public safety, specified entrances may remain unlocked provided the aerial tramway equipment cannot be operated by unauthorized personnel.

2.3.2.5 Operational requirements

2.3.2.5.1 General

The owner and supervisor of each aerial tramway shall review the requirements of Section 2 and referenced Annexes of this standard to ascertain that original design and installation conditions have not been altered in a manner so as to violate the requirements of the standard.

2.3.2.5.2 Starting

Following procedural clearances, the aerial tramway shall be started by the operator or at the direction of the operator.

2.3.2.5.3 (Reserved)

2.3.2.5.4 Stops

After any stop of an aerial tramway, the operator shall determine the cause of the stop, and not restart until clearance has been obtained from all attended stations.

2.3.2.5.5 Damage to carriers

Should any carrier become damaged or otherwise rendered unfit for passenger transportation during normal operation, it shall be clearly and distinctively marked, and not used for passengers until repaired or replaced. It shall be removed or repaired as soon as feasible.

2.3.2.5.6 Hazardous conditions

When wind or icing conditions are such that operation is hazardous to passengers or equipment, according to predetermined criteria based upon the area's operational experience and the designer's design considerations, the aerial tramway shall be unloaded and the operation discontinued. If necessary under the predetermined criteria, device(s) shall be installed at appropriate location(s) to ascertain wind velocity and direction when aerial tramways are operated. No aerial tramway shall operate when there is an electrical storm in the immediate vicinity. Should such conditions develop while the aerial tramway is in operation, loading of passengers shall be terminated, and operation shall be continued only as long as necessary to unload all passengers. When such shutdown has been caused by an electrical storm, grounding of control circuits and haul ropes that are used as conductors in communication systems is permissible. Such grounding shall be removed prior to resumption of passenger operations.

2.3.2.5.7 Evacuation

A plan for evacuation of passengers from each aerial tramway shall be developed and documented. The plan shall include:

a) the definition of the line of authority in the event of an evacuation. This line of authority shall list:

1) the positions responsible for determining the need for and ordering an evacuation by use of the evacuation power unit or evacuation from carriers;

2) the personnel responsible for performing the evacuation, for first aid, and for ground care of evacuated passengers.

b) a description of the equipment necessary for evacuation and where it will be stored;

c) provisions for adequate training in the functions performed in the evacuation process at least once each operating season. Such drills are to be recorded in the operational log of each aerial tramway (see 2.3.5.1);

d) an estimate of the time necessary for the total evacuation of each aerial tramway;

e) a description of unusual terrain conditions and how each of these conditions will be dealt with during an evacuation;

f) an estimate of when the evacuation should begin in the event the aerial tramway becomes inoperable;

g) provisions for communications with passengers of an inoperable aerial tramway, the frequency of such communication, how soon after the aerial tramway becomes inoperable such communication to the passengers will start, and the frequency of communications thereafter;

h) the methods of evacuation to be used for the typical passenger and the methods to be used for incapacitated passengers and non-ambulatory passengers;

i) provisions for communication with the evacuation teams;

j) provisions for suspending the evacuation in the event that the aerial tramway is made operable during the evacuation;

k) provisions for control and assistance of evacuated persons until released;

l) provisions for a post-evacuation report.

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All nonmetallic rope used for evacuation shall be of nylon or polyester (Dacron) fiber of either laid or braided construction. Laid rope of nylon shall be of a hard lay. These ropes shall be either of a static rescue type or a dynamic mountaineering type. Breaking strength, when new, shall be at least 15 times the maximum expected operating load, but in no case less than 4000 pounds (17.8 kilonewtons). No natural fiber or polypropylene ropes shall be used.

These ropes shall be carefully stored when not in use and shall be examined after each completed aerial tramway evacuation and prior to each season of operation, both summer and winter, to ascertain that they are in satisfactory condition.

Carabiners, if used, shall be of the locking type.

2.3.2.5.8 Termination of daily operations

Procedures shall be established for terminating daily operations in such a manner that passengers will not be left on the aerial tramway after it has been shut down. Loading ramps, as required, shall be closed and so signed.

When either loading or unloading portions of an intermediate station are not in operation, it shall be so signed and the loading station shall be closed to public access.

2.3.2.5.9 Bypass requirements

The use of temporary circuits that have been installed for the purpose of bypassing failed electrical circuit(s) (see 2.2.6) shall meet these requirements in the following order:

a) The condition that the circuit indicated is in default shall be thoroughly inspected to ensure an electrical operating circuit malfunction, rather than the indicated condition, actually exists;

b) The bypass shall be authorized only by the aerial tramway supervisor or his/her designated representative;

c) When a bypass is in operation, the function bypassed shall be under constant, close visual observation;

d) The use of a bypass circuit shall be logged and shall indicate when, who authorized, and for what duration, a bypass was used;

e) The operator control panel shall indicate that a bypass is in use.

2.3.3 Maintenance

2.3.3.1 General

Foundations and structural, mechanical, and electrical components, shall be inspected regularly and kept in a state of good repair. The maintenance and testing requirements of the designer or a Qualified Engineer (see 2.1.6.2) shall be followed. Maintenance and testing logs shall be kept (see 2.3.5.2).

A written schedule for systematic maintenance shall be developed and followed. The schedule shall establish specific frequencies for periodic lubrication, adjustment, inspection, and. testing. The schedule shall include, but not be limited to, the following:

a) all wire rope, track cable, (see Annex A);

b) line sheave units, sheaves, bearings, and liners;

c) bullwheels, bearings, and liners;

d) tension systems;

e) drive system, including bearings and couplings;

f) braking systems;

g) electrical control systems;

h) communication systems;

i) carriers;

j) structures;

k) aerial tramway line (see 2.1.1.4).

2.3.3.2 Maintenance personnel

Aerial tramways shall be maintained by trained and competent personnel. The owner shall be responsible for their supervision and training, and such training shall be documented. All personnel shall practice good housekeeping, with particular emphasis on avoiding the development of any condition that might contribute to personal injury. Personnel shall comply with the operational rules and regulations of the specific aerial tramway.

2.3.4 Inspections and testing

2.3.4.1 General inspection

Each aerial tramway shall be inspected annually by an aerial tramway specialist independent of the owner. The inspection shall verify preservation of original design integrity and cover the requirements of this standard for maintenance, operation, required self-inspections, and record keeping. Items found either deficient or in noncompliance shall be noted. A report signed by the specialist shall be filed with the owner.

2.3.4.2 Wire rope, track cable, and chain inspection

Inspection shall comply with the following:

- Wire rope (A.4.1 in Annex A)
- Track cable (A.4.2 in Annex A)
- Welded link chain (Annex G)

For existing roller and leaf chain, see Annex H.

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2.3.4.3 Carrier testing

All carriages, hangers, and cabins shall be tested against acceptance criteria established by the designer or manufacturer; or in cases in which the designer or manufacturer is no longer in business and the original criteria are no longer applicable, by a Qualified Engineer.

Each carriage, hanger, and cabin shall be uniquely identified by the manufacturer or the owner. If any defects are found, the designer/manufacturer/Qualified Engineer shall be consulted. Units failing to meet the acceptance criteria shall not be placed back into service until their defects are corrected.

If the carriages, hangers, or cabins are tested by an agency other than the original equipment manufacturer, then the original aerial tramway manufacturer shall receive a copy of the test procedure and results. In all cases, the owner shall receive a copy of the test procedure and the test results.

2.3.4.4 Dynamic testing

Dynamic testing shall be performed at intervals not exceeding seven (7) years.

A written schedule for systematic dynamic testing shall be developed and followed. The owner shall provide experienced personnel to develop and conduct the dynamic test. The schedule shall establish specific frequencies and conditions for dynamic testing. The testing shall simulate or duplicate inertial loadings. The test load shall be equivalent to the design live load. The results of the testing shall be documented in the maintenance log.

The testing shall include, but not be limited to the following:

a) braking systems;

b) evacuation power units;

c) tension system;

d) electrical systems.

2.3.5 Records

2.3.5.1 Operational log

A log shall be maintained for each aerial tramway. Daily entries shall be made giving the following minimum information:

a) date;

b) names and work positions of operating personnel;

c) operating hours and purpose of operations;

d) temperature, wind, and weather conditions;

e) record of compliance with daily operational inspection including loading and unloading platforms and ramps;

f) position and condition of the tension carriage, counterweights, or other tension system devices;

g) accidents, malfunctions, or abnormal occurrences during operation;

h) signature of operator;

i) record of aerial tramway evacuations and evacuation drills (see 2.3.2.5.7(c)).

2.3.5.2 Maintenance log

A signed complete log shall be maintained wherein the actual execution of maintenance work shall be recorded. The log shall state the components serviced and the condition of the components. A record shall be kept of replacement of components.

2.3.5.3 Wire rope, and track cable log

A log shall be maintained for each aerial tramway giving the following information on each wire rope and strand.

a) specification (see A.1.1 in Annex A);

b) copy of certified test report;

c) date installed;

d) splicing certificate for each splice or laid-in strand;

e) record of lubrication, including type of lubricant and date applied;

f) record of maintenance inspections;

g) inspection reports of wire rope, track cable, and their connections (see Annex A.4.1.2, A.4.2.2 and A.4.3 in Annex A);

h) report of accidents or injury to wire rope or track cable.

2.3.5.4 Chain log

A log shall be maintained for each aerial tramway giving the following information on each chain used as a tension element:

a) specification (see Annex G and Annex H);

b) copy of certified test report;

c) date installed;

d) record of lubrication, including type of lubricant and date applied;

e) record of maintenance inspections;

f) report of accidents or injury to the chain.

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2.3.6 Passenger conduct and responsibilities

2.3.6.1 Passenger responsibilities

It is recognized that certain dangers and risks are inherent in machines of this type, and their operation. It is also recognized that inherent and other risks or dangers exist for those who are in the process of embarking, riding, or disembarking from aerial tramways (see 1.2). Passengers accept the risks inherent in such participation of which the ordinary prudent person is or should be aware.

Passengers shall use good judgment and act in a responsible manner while using the aerial tramway including:

a) participating in the embarkation, riding and disembarkation processes in such a manner as to reduce risks for themselves and others;

b) obeying all written and oral instructions and warnings;

c) refraining from using the aerial tramway while under the influence of drugs or alcohol;

d) properly use the aerial tramway and equipment provided.

2.3.6.2 Passenger dexterity and ability

All passengers who use an aerial tramway shall be responsible for their own embarkation, riding and disembarkation. They shall be presumed to have sufficient ability, physical dexterity, and/or personal assistance to negotiate and to be evacuated from the aerial tramway safely.

2.3.6.3 Passenger embarkation and disembarkation

A passenger shall get on and get off an aerial tramway at designated areas. No passenger shall embark without first understanding and observing the proper loading, riding, and unloading procedures (see Table D-1 (a) in Annex D).

2.3.6.4 Passenger riding

Passengers, while riding an aerial tramway, shall not throw or expel therefrom any object, nor shall any passenger do any act or thing that shall interfere with the operation of the aerial tramway. Passengers shall not willfully engage in any type of conduct that may contribute to or cause injury to any other person.

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Section 3
Detachable grip aerial lifts

This section covers that class of passenger ropeways on which the carriers circulate around the system, alternately attaching and detaching from the moving haul rope. The carriers travel from one terminal to the other along one path and return along another path, making turns in terminals. This section does not include ropeways wherein the passengers are in contact with the ground or snow during the trip.

The aerial lifts covered by this section are of the monocable, dual cable and bicable type systems. The carriers may be open chairs or cabins.

3.1 Design and installation

3.1.1 General

3.1.1.1 Design passenger weight

For purposes of design, a passenger shall be considered as having a minimum average weight of 170 pounds (77.1 kilograms). It is the owners' responsibility to indicate unusual considerations that might affect the design passenger weight.

If an aerial lift transports freight, the freight shall be weighed and not exceed the design load capacity. The designer shall determine the maximum design live load for transporting freight on the aerial lift. The operational manual shall document the live load parameters and relevant operational conditions.

3.1.1.2 Capacity and speed

The maximum carrier speed relative to the surface of loading and unloading platforms during loading or unloading operations shall not exceed the values shown in table 3-1. The speeds listed in table 3-1 may be increased if an aerial lift is slowed or stopped for loading and unloading. The designer shall specify the maximum and minimum design capacities and carrier spacing in each direction and the design loading conditions under which the aerial lift may be operated. The maximum rope speed shall be that specified by the designer and established as functional by testing and operational performance.

Where the aerial lift is not rated for downhill passenger traffic, the number of loaded carriers shall not exceed the values shown in table 3-2, loaded no more closely than every fourth chair, for the carrying of authorized persons downhill.

For the purpose of this section only, authorized persons are defined to include all persons, whether employees of the aerial lift owner or not, who are authorized by the owner or the owner's representatives to be carried on the aerial lift.

Table 3-2 Allowable Loaded Downhill Carriers

Total number of carriers on lift (both sides)	Maximum number of loaded carriers on downhill rope
Less than 60	2
60 to 120	3
Over 120	4

All installations in which downhill traffic is either limited or not permitted shall be so identified with clearly visible signs at loading or unloading areas (see table D-1(n) in Annex D), and this information shall be further contained in operating instructions posted in these areas.

3.1.1.3 Location

In selecting the location and alignment of an installation, consideration shall be given to the following items, and to any others that may be particularly pertinent to the aerial lift type and location:

a) ADA accessibility;

b) electric power lines and their supports;

c) rock and earth slides, cave-ins, washouts, and the like;

d) snow creep and avalanches;

e) wind action;

f) icing;

g) ski slopes and trails;

h) rivers and gullies;

i) buried installations, including pipelines;

j) control of air space below, above, and adjacent to the installation;

k) crossing or close proximity to other ropeways;

l) carrier height above all surfaces;

m) highways;

n) fire hazard;

o) structures;

p) railways.

Table 3-1 Maximum relative carrier loading/unloading speed for detachable chair lifts

Passenger type	1 – 4 Passenger Chair	6 Passenger Chair	8 Passenger Chairs
Skiers	450 feet/min (2.3 m/s)	425 feet/min (2.2 m/s)	400 feet/min (2.0 m/s)
Foot Passengers	250 feet/min (1.3 m/s)	225 feet/min (1.1 m/s)	200 feet/min (1.0 m/s)

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3.1.1.4 Clearing envelope

As a minimum there shall be no obstacles, unless allowed in 3.1.1.5, within 5 feet (1.53 meters) of ropes, track cables, and carriers under design operating conditions. Carriers shall not contact any obstacle during operation under design wind conditions. Clearings and contiguous spaces shall be maintained to reduce the risk of washouts, hazard trees and other obstacles that might endanger the installation (see 3.3.3.1) or interfere with evacuation.

3.1.1.5 Clearances

Terminals and towers shall be designed and installed to provide the clearances as herein specified and to minimize surge of the line under operating conditions. Local wind conditions shall be taken into consideration.

3.1.1.5.1 Vertical clearances

The following reference points will be used in determining vertical clearances for these carrier/passenger combinations:

a) *For cabins and empty chairs* - Vertical clearances shall be referenced from the lowest point of the carrier.

b) *For chairs carrying foot passengers* - Vertical clearances shall be referenced from a point 2 feet (0.61 meters) below the top of the chair seat.

c) *For chairs carrying skiers* - Vertical clearances shall be referenced from a point 5 feet (1.53 meters) below the top of the chair seat.

Along the line between terminals, the following vertical clearances shall exist between the above carrier reference points and the terrain or other obstacles, including maximum design snow depth:

d) Where skiing is permitted beneath the aerial lift, a minimum of 8 feet (2.44 meters) shall be maintained;

e) Where the clearance is less than 8 feet (2.44 meters), provisions shall be made to prevent access by unauthorized persons to the area beneath the aerial lift;

Under the most adverse design loading conditions, while the aerial lift is being operated, a minimum space of 5 feet (1.53 meters) shall be maintained between the lowest point of the carrier(s) or rope(s) and the terrain, vehicles, or other possible obstacles, including snow.

When aerial lifts cross one another, the following conditions shall be met:

f) Under the most adverse design loading conditions, the minimum vertical clearance between the uppermost point or obstruction of the lower aerial lift and the lowest point of the carriers or rope(s) of the upper aerial lift shall be 10 feet (3 meters).

g) Any deropement of the upper or lower aerial lift that reduces the vertical clearance (including dynamic effects) to less than 20 feet (6.1 meters) shall cause both aerial lifts to stop (see 3.2.3.4)

3.1.1.5.2 Horizontal clearances

3.1.1.5.2.1 Line clearances

The minimum distance between passing carriers, each swung 10 degrees inward from the vertical, shall be the greater of the following:

a) 30 inches (760 mm); or

b) 1/2% of the span length (applies to gondolas only).

The distance between haul ropes (or track cables), for the purpose of these checks, shall be considered as equal to the gauge of the line.

There shall be no contact between any tower machinery or obstruction and any part of a carrier when a carrier is swung in any of the following conditions:

c) 15 degrees laterally from vertical or 15 degrees longitudinally from vertical;

d) the combination of 15 degrees lateral and 15 degrees longitudinal;

e) the combination of the lateral angle α (alpha) and 15 degrees longitudinal, where α is equal to 5 degrees plus the angle created by a 250-pound (113-kilogram) passenger positioned in the passenger chair seat causing the greatest angle of inclination, in a static condition, in any direction.

3.1.1.5.2.2 Special clearance requirements for chair lifts used for skiing

The following clearance requirements shall be met to prevent entanglement of skis with the tower structure. Clearance is herein defined to mean the distance between the inner limit of the passenger seat and the clearance line or surface of the tower.

With the carrier swinging laterally 10 degrees from the vertical position, if clearance is less than 24 inches (610 mm) from any open frame tower or 18 inches (460 mm) from any closed tubular tower, ski tip deflectors shall be provided on each side where skiers are allowed, to reduce the risk of skis being caught in the structure. Such deflectors shall be at least 6 feet (1.83 meters) in height, extending 36 inches (915 mm) above and 36 inches (915 mm) below average foot level.

A tubular tower with permanent ladder rungs shall be considered as an open-frame tower, unless it can be demonstrated that ski tips cannot be caught in the ladder. In this case, the tower may be considered as a closed-tubular tower.

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3.1.1.5.2.3 Terminal clearances

Posts, obstructions, or structures shall have at least 4 feet (1.22 meters) of clearance from the edge of an open carrier passenger seat or open cabin body (measured from the outermost attachments on, or the parts of, the carrier, while the carrier is hanging in a vertical position). The following exceptions shall be permitted in terminal areas:

a) Control consoles shall have at least 18 inches (460 mm) of clearance when the carrier is constrained by the carrier guidance system;

b) Carrier guidage may have unrestricted clearance if measures are taken to protect passengers and operators;

c) Handrails, signage, and their supports that are designed to reduce the risk of injury to passengers and that are located prior to the loading point and after the unloading point may have unrestricted clearance;

d) Structural components of the aerial lift shall have at least 18 inches (460 mm) of clearance when the carrier is constrained by the carrier guidage system. On aerial lifts being used primarily for skiers, terminal structural components shall have 18 inches (460 mm) of clearance when fitted with ski tip deflection guards or 30 inches (760 mm) without such guards.

Carriers as they approach, enter, and exit the terminal areas and their related structures, while attached to the haul rope, shall have the same clearance as required when passing a line structure (see 3.1.1.5.2.1).

3.1.1.5.3 Path of rope adjustment

When terminals, towers, or both, contain provisions for a change in height of the rope or track supports, in order to meet normal changes in operational requirements, such provisions shall be controlled as follows:

a) The designer's operational manual shall provide complete instructions for proper procedures and sequences for making adjustments;

b) Where range of adjustments allows possible adjustment error resulting in improper sheave loading, a system to readily verify the proper profile, without the use of tools, shall be incorporated into the installation.

3.1.1.5.4 Track cable saddles (Bicable systems)

Towers and terminals shall be arranged so as to keep the track cable in the saddles under the most adverse design operating and nonoperating conditions. Track cable restraining devices or provisions may be used, as required, at the discretion of the designer. These provisions shall not interfere with any track cable movement. Maximum wind velocity and other design limits used for structures under nonoperating conditions and the limiting values intended for operating conditions shall be specified by the designer.

3.1.1.5.5 Haul rope sheave units (Bicable systems)

Haul rope sheave units are generally of the support type. "Depression" or "hold-down" sheave units not covered by this standard shall be subject to the requirements of 1.2.2.

3.1.1.5.6 Rope guidance (Bicable systems)

All line sheave units, including both high- and low-tower sheave assemblies, shall be provided with fair leads or guides to accomplish the following:

a) Permit the unobstructed passage of a carrier gripped to the haul rope, independent of the position of the haul rope guided by the fair leads, as the carrier approaches the sheave assembly;

b) Guide the haul rope into the sheave groove when it has been lifted in normal operations or for other reasons;

c) Provide the rope guidance necessary beneath sheave assemblies and adjacent structures to prevent entanglement of the haul rope as it is returned by the carrier to normal operating position from any location that it may assume due to any anticipated operational displacement.

3.1.1.5.7 Intermediate structures (Bicable systems)

Auxiliary intermediate structures (i.e., haul rope carriers and slack carriers) shall be provided to support sheave units as required to maintain the minimum clearances specified in 3.1.1.5.1.

3.1.1.6 Structures and foundations

All structures and foundations shall be designed and constructed in conformance with 1.3 and shall be appropriate for the site. Applied design loads shall include dead, live, snow, wind, and dynamic loads due to normal conditions and for foreseeable abnormal conditions.

Structures and foundations located in snow creep areas shall be designed for such conditions and loads, or protective structures shall be provided as required by the conditions.

3.1.1.6.1 Structures

On bicable systems, torsional displacement of towers under the most adverse design loading conditions shall be limited to a value that will not cause deropement of the track cable from the saddle.

3.1.1.6.2 Foundations

In determining the resistance of the soil to motion of the foundation, the subsoil conditions at the site shall be considered, including any buoyancy due to groundwater

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that may be present. If the resistance of the soil is not practically determinable, the foundation or anchorage should be designed as a gravity anchor, using a coefficient of friction appropriate to the general character of the soil. Bottoms of foundations shall be below the normal frost depth unless resting on non-frost-susceptible soil or solid rock. Foundations on rock shall be firmly anchored to solid rock, unless designed as gravity foundations.

The top of concrete foundations shall not be less than 6 inches (150 mm) above finished grade unless specific direction for the protection of the foundation and structural steel below grade is specified by the designer.

The design shall have a minimum factor of safety of 2 in resisting overturning and, concurrently, 2 against sliding, under dead-load and live-load conditions. The minimum factors shall be 1.5 under these loadings plus wind acting simultaneously.

3.1.1.7 Communications

A permanently installed two-way voice communication system shall be provided between the prime mover, evacuation power unit control point, machinery areas, loading stations, and unloading stations. The power for this system shall be independent of the primary power and the communication system shall be functional and audible during a power failure (see 3.2.5(a)).

Audio indicators shall be audible over all ambient noise levels, and visual indicators (e.g., Light Emitting Diodes) shall be visible even in bright sunlight.

3.1.1.8 Internal combustion engine(s) and fuel handling

Internal combustion engine installation and fuel handling requirements are located in normative Annex F.

3.1.1.9 Loading and unloading areas

Platforms, ramps, corrals, and mazes comprising the loading and unloading areas of an aerial lift are integrally related to its operation. They shall be designed and installed in conformance with 1.3.

A loading conveyor, if installed, shall be designed and installed in conformance with normative Annex C.

Handrails, nets, steps, or ramps shall be provided to reduce the risk of injury to the passengers and maintenance and operating personnel, when required.

Terminals, towers, and other structures or obstacles adjacent to the loading and unloading areas shall be designed or guarded to reduce the possibility of entanglement with these items.

3.1.1.9.1 Loading areas

3.1.1.9.1.1 Loading areas for chair lifts

The loading area length, profile, and loading point shall be installed according to the carrier speed, carrier type, carrier conveyance system, passenger type, and aerial lift design. Load Gates, artificial surfaces, and other loading aids when used shall be designed and installed with regards to all passengers including adaptive. Load Gates shall have an override control to hold them in the open position by the attendant. At least one point of access to the aerial lift shall have a minimum clearance width of 36 inches (915 mm) to accommodate passengers using adaptive equipment.

Approach paths to the loading platform shall be approximately level or slightly downsloped to facilitate passengers moving to the loading point. The approach path shall be such that waiting passengers have a view of the loading area. The maze or corral area shall be approximately level, free of obstructions and marked, roped, or fenced in a manner to guide passengers to the “Wait Here” and “Load Here” markers. The corral and maze should be as straight as possible with gradual turns.

The “Wait Here” point shall be marked. This marker shall be located to provide horizontal clearance between passengers at the “Wait Here” point and passing carriers.

The Loading Point shall be approximately level, marked as to where the passengers are to position themselves using a “Load Here” marker located in/on the platform/snow surface. The width of the “Load Here” marker shall not be greater than the carrier width.

3.1.1.9.1.2 Loading areas for gondolas and chair lifts primarily serving foot passengers

The loading area shall be provided with approximately level load platforms and the necessary handrails, steps, or ramps to provide access, guidance, and passenger control.

3.1.1.9.2 Unloading areas

The unloading area length, profile, unload point, and exit ramp shall be installed according to the carrier speed, carrier type, carrier conveyance system, type of passenger, and aerial lift design.

The approach end of the unloading area shall be fitted with inclined guards as necessary to reduce the risk of passengers or their equipment being entangled with the platform edges.

For chair lifts, the unloading point where the passengers stand up and disembark shall be marked on or near the unloading surface. For unloading skiers on a snow surface, this point shall be at the breakover point where the exit ramp starts. The chair height shall not exceed 22 inches (560 mm). This point shall be signed “Unload Here,” as required in table D-1(j). The exit ramp for skiers shall be sloped downward no more than 30 percent.

For aerial lifts used primarily for foot passengers, there shall be provided approximately level unload platforms and the necessary handrails, steps, or ramps to exit the

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unload area. The exit route for foot passengers shall be designated.

For chair lifts, the width of the unloading path on the unloading platform and the breakover point shall be greater than the carrier width.

For chair lifts, there shall be no impediment to obstruct passengers inadvertently failing to unload at the unload point. Appropriate guards are required to reduce the risk of injury caused by catching equipment of passengers failing to unload and passing the unload point.

3.1.1.9.3 Intermediate stations for chair lifts

Intermediate loading and unloading stations are prohibited unless the carriers are slowed or detached from the haul rope and slowed to within the maximum allowable carrier speeds listed in table 3-1.

3.1.1.10 Provisions for evacuation

Aerial lifts shall be provided with means to evacuate passengers from stranded carriers. Provisions shall be made in the design of the aerial lift for emergency evacuation of common passenger types (see 3.3.2.5.7).

3.1.1.11 Acceptance inspection and tests

Prior to the acceptance inspection and the acceptance tests, the aerial lift shall be continuously operated with empty carriers on the line as follows:

a) 6 hours on each power unit classified as a prime mover;

b) 1 hour on each power unit classified as an evacuation power unit.

Stops shall be minimized to replicate normal operation during the continuous operation.

All terminal, line structures, and line equipment shall be thoroughly checked both before and during the continuous run test to check for overheating of moving parts, excessive vibration or deflection of mechanical or structural components, free movement of tension systems, and other related conditions.

3.1.1.11.1 Acceptance inspection

Before an aerial lift that is new or relocated or that has not been operated for routine maintenance within the previous 2 years is opened to the public, it shall be given a thorough inspection by qualified personnel to verify compliance with the plans and specifications of the designer.

It shall be the responsibility of the owner to see that the following conditions have been met:

a) tightness of all structural connections;

b) lubrication of all moving parts;

c) alignment and clearances of all open gearing;

d) installation and alignment of all drive system components;

e) position and freedom of movement of counterweights or other tension systems and carriages;

f) haul rope alignment at entrance to bullwheels;

g) operation of all electrical components, including circuit protection and grounding;

h) adjustment of brakes for stopping distance and brake torque testing;

i) minimum clearances for carriers, track cable and haul rope sags under the most adverse static loadings;

j) proper alignment of track cable saddles (as applicable) and haul rope sheave units;

k) proper track cable to saddle angles and unhindered inline motion of track cable in saddles as applicable;

l) actual testing of evacuation equipment and procedures at the most difficult location;

m) proper location of towers and terminals in accordance with the plans and specifications. Terminal and tower rope/cable working points shall be documented by an “as built” survey, and any variation from the design drawings shall be noted and approved by the engineer responsible for design.

3.1.1.11.2 Acceptance tests

Before an aerial lift that is new or relocated or that has not been operated for routine maintenance within the previous 2 years is opened to the public, it shall be given thorough tests by qualified personnel to verify compliance with the plans and specifications of the designer. The designer or manufacturer shall propose and submit an acceptance test procedure.

Thorough load and operating tests shall be performed under full loading and any partial loadings that may provide the most adverse operating conditions. Test load per carrier shall be 110% of the design live load. The functioning of all push-button stops, stop cords, automatic stops, limit switches, deropement switches, and communications shall be checked. Acceleration and deceleration rates shall be confirmed under all loadings (see 3.1.2.4, 3.1.2.5). Motive power and all braking and rollback devices (see 3.1.2.6) shall be proved adequate under the most adverse loadings.

On systems operating at 600 feet per minute (3 meters per second) or greater, a plot of rope speed versus time shall be recorded for stops that the manufacturer or Qualified Engineer has designated in the acceptance test procedure. As a minimum, the plot shall show the rope speed every 0.2 seconds from the initiation of the stop to when the rope is stopped. The final brake system settings and brake test values shall be documented in the acceptance test results.

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3.1.2 Terminals and stations

3.1.2.1 Power units

All aerial lifts shall be equipped with at least two power units, one of which, at a minimum, meets the requirements of 3.1.2.1.2.

All power units shall have the capacity to handle the most unfavorable design loading conditions, including the starting of the aerial lift loaded to 110% of capacity in weight. If downhill capacity is desired, the aerial lift shall comply with 3.1.2.4.

Where manual multispeed transmissions are used on a power unit, they shall not be shifted when the aerial lift is moving.

Where reverse capability is provided on a power unit for an aerial lift, provisions shall be made to prevent accidentally shifting into reverse whenever the aerial lift is operating.

No aerial lift shall be operated using a single power unit without a second operable power unit being available except for unloading passengers or for maintenance purposes.

EXCEPTION – An aerial lift may continue loading passengers if the following requirements are met:

1) The power unit in use meets the requirements of a prime mover (see 3.1.2.1.1);

2) Evacuation gear and personnel shall be immediately available in sufficient number and quantity to evacuate the entire aerial lift in a period specified in the evacuation plan (see 3.3.2.5.7).

If changes are made to the drive system components that affect rotational inertia (i.e. removal of electric motor), the resulting stopping distances and deceleration rates shall meet the requirements of 3.1.2.5

3.1.2.1.1 Prime mover

Power units engaged as a prime mover shall have the systems required in subsections 3.1 and 3.2 functional during operation (see 1.4 – *prime mover*)

3.1.2.1.2 Evacuation power unit

An evacuation power unit (see 1.4 – *evacuation power unit*) with an independent power source shall be provided that can readily be used to unload the aerial lift in the event of failure of the prime mover. The evacuation power unit shall not depend upon the mechanical integrity of any other power unit to drive the aerial lift. This unit shall be electrically wired to meet the requirements of 3.2.3.1 so that it can be stopped by the Emergency Shutdown Circuit. As a minimum, the evacuation power unit shall be capable of starting and moving a line with all carriers loaded to 110% of capacity in weight in a forward direction at not less than 100 feet per minute (0.51 meters per second).

The evacuation power unit shall be designed to become operational and move all the carriers to or through terminal areas within 1 hour from the time of initiating its connection.

3.1.2.1.3 Power unit interlock

System(s) or device(s) shall be installed that prevent two or more power units, which are not designed to operate together, from being actively connected to the drive system while operating. Electrical interlock systems shall comply with 3.2.4.

3.1.2.2 Speed reducers and gearing

All speed reducers and gearing shall have the capacity for starting an aerial lift under the most unfavorable design loading conditions without exceeding design rating. They shall have a service factor appropriate for the application.

Table 3-3 Required stopping devices

Aerial lift category	Service Brake	Bullwheel Brake	Rollback device	Retarding device (see 3.1.2.4)
Self braking: A lift that decelerates, stops & remains stopped within the service brake performance requirements without a braking device	Not Required	Required	Not Required	Not Required
Non-overhauling: A lift that will not accelerate in either direction when it is not driven, but is not self-braking	Required	Required	Not Required	Not Required
Overhauling reverse direction: A lift that will accelerate in the reverse direction when it is not driven	Required*	Required	Required	Not Required
Overhauling forward direction: A lift that will accelerate in the forward direction when it is not driven	Required	Required	Not Required	Required
* A service brake is not required if the overhauling, reverse direction aerial lift will meet the service brake stopping requirements under the most unfavorable design loading conditions				

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3.1.2.3 Bearings, clutches, couplings, and shafting

Bearings, clutches, couplings, shafting and universal joint shafts (cardan shafts) shall be selected on the basis of the manufacturer's published data for the particular use. All shafting shall be designed in accordance with accepted standard practices. Guarding and containment shall be in accordance with the provisions of 3.1.2.7.1.

Provisions shall be made for adjustment and lubrication of all bearings, clutches, and couplings, when required.

3.1.2.4 Acceleration and speed control

The drive system shall be designed to accelerate and decelerate the line smoothly and to avoid severe oscillation or undulation under any design loading condition.

The aerial lift shall accelerate smoothly from a stop to the intended speed. After any type of stop is initiated, the stop cannot be canceled and the aerial lift may not be started until it has come to a complete stop.

The maximum average rope acceleration shall not exceed 2.0 feet per second squared (0.61 meters per second squared). The maximum rate of the rope deceleration shall not exceed 5 feet per second squared (1.52 meters per second squared). These rate measurements shall be measured over any one second interval under any operating condition while the carrier is attached to the haul rope and referenced to the rope speed at the drive terminal.

The drive system shall be capable of moving the unloaded system at reduced speed for rope inspection and equipment maintenance. This reduced-speed operation may be obtained by the use of the evacuation power unit.

On installations in which an overhauling forward condition exists:

a) Provisions shall be made for an overhauling load so that the system shall operate at a controlled speed not exceeding maximum design rope speed by more than 6%. The energy developed by the overhauling load shall be dissipated without using the brakes specified under 3.1.2.6. This requirement shall be met during operation with any power unit.

b) Provision shall be made for slowing and stopping the aerial lift drive system automatically if the line speed exceeds the design speed by more than 10%.

NOTE – Design values of line speed pertain to the design speed for the particular condition of operation (that is, skiers or foot passengers).

3.1.2.5 Stops & shutdowns

For all stops, the minimum rate of the rope deceleration shall be 1.0 feet per second squared (0.30 meters per second squared) averaged from the beginning to the end of stop. The maximum rate of the rope deceleration shall be 5 feet per second squared (1.52 meters per second squared). These measurements shall be measured over any one second interval under any operating condition while the carrier is attached to the haul rope and referenced to the rope speed at the drive terminal.

Normal stop: (see 1.4 – *normal stop*). If a service brake is required (see table 3-3), it shall have been applied by the time the aerial lift comes to a stop.

Emergency shutdown: (see 1.4 – *emergency shutdown)* The drive bullwheel brake shall be applied. The service brake, if installed, shall have been applied by the time the aerial lift comes to a stop. The designer shall designate which control functions of the aerial lift system shall initiate an emergency shutdown.

The designer may define other stopping modes other than normal and emergency shutdown. For other stopping modes, the designer shall specify the method of stopping, including the type and timing of brake(s) that may be applied, and the stopping criteria.

3.1.2.6 Brakes and rollback devices

The aerial lift shall have the following friction-type brakes and other devices as specified in table 3-3:

- service brake (see 3.1.2.6.1);
- bullwheel brake (see 3.1.2.6.2);
- rollback device (see 3.1.2.6.3).

All braking systems shall be designed and monitored to ensure that:

a) Once the aerial lift begins movement in the intended direction, the brakes are maintained in the open position;

b) The service brake shall not open prior to the drive system developing sufficient torque to prevent overhauling;

EXCEPTION – For an aerial lift that overhauls only in the reverse direction, a drive train backstop (3.1.2.6.4) may be used in lieu of the above.

c) Multiple brakes or brake systems shall not be simultaneously applied such that excessive deceleration is applied to the aerial lift under any anticipated conditions of loading;

d) The failure of one braking system to properly decelerate the aerial lift shall automatically initiate a second braking system, if any.

The service brake, bullwheel brake, and rollback device shall be designed such that failure of one braking system will not impair the function of the other systems. All brakes shall have the braking force applied by springs, weights, or other approved forms of stored energy.

The service brake, bullwheel brake, and rollback device shall be designed to assure operation under all anticipated conditions.

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Each braking system shall be capable of operation to comply with daily inspections and periodic testing.

The manufacturer or a Qualified Engineer shall furnish a written procedure to be followed and specify the auxiliary equipment necessary for periodic testing and adjustment of the holding force of each brake, rollback, and backstop device.

The procedure shall additionally specify:

e) The minimum and maximum holding force for the service brake and bullwheel brake independently, and;

f) The minimum and maximum stopping distance for the service brake and bullwheel brake independently, with a specified loading condition.

This baseline procedure shall be performed at the completion of the acceptance test and then at the frequency specified in order to demonstrate the ability of each brake to produce the required force (see 3.1.1.11.2).

Testing shall be accomplished as part of normal maintenance during the operating season, but shall not be performed when the aerial lift is open to the public. As a minimum, this testing shall be performed monthly during the operating season.

If a device is permanently installed to cause a brake, or rollback device, to be disabled for testing or reverse rotation, it shall be monitored so that the aerial lift cannot be operated in its normal mode when the brake is so disabled.

3.1.2.6.1 Service brake

The service brake can be located at any point in the drive system such that there is no belt, friction clutch, or similar friction-type device between the brake and the drive bullwheel. The service brake shall not act on the same braking surface as the bullwheel brake.

The service brake shall be an automatic brake to stop and hold the aerial lift under the most unfavorable design loading condition. Deceleration rates specified in 3.1.2.5 shall be achieved by the service brake without the aid of other braking devices or drive regeneration.

The brake shall be in a normally applied position. It shall be held open for operation of the aerial lift and shall be applied when its power is removed or the aerial lift is stopped.

3.1.2.6.2 Bullwheel brake

The bullwheel brake shall operate on any drive terminal bullwheel assembly that meets the requirements of 3.1.2.8.2.

The bullwheel brake shall be an automatic brake to stop and hold the aerial lift under the most unfavorable design loading condition. Deceleration rates specified in 3.1.2.5 shall be achieved by the bullwheel brake without the aid of other braking devices or drive regeneration.

Application of the bullwheel brake shall automatically disconnect the power source to the power unit in use. This brake shall act automatically when the speed of the haul rope exceeds the design value by 15% in either direction.

3.1.2.6.3 Rollback device

The rollback device shall act directly on any drive terminal bullwheel assembly that meets the requirements of 3.1.2.8.2 or on the haul rope. Under the most unfavorable design loading condition, the rollback device shall automatically control reverse rotation of the aerial lift, as defined herein. The rollback device shall bring the aerial lift to a stop if unintentional reverse rotation occurs. The rollback device shall be activated if the haul rope travels in excess of 36 inches (915 mm) in the reverse direction. Electrical detection systems shall comply with 3.2.3.7.

3.1.2.6.4 Drive train backstop

A drive train backstop device may be installed on an aerial lift. If used, it shall conform to the following requirements:

a) A drive train backstop device is a one-way or overrunning clutch device. The drive system shall be so arranged that there is no belt, friction clutch, or similar friction-type device between the backstop device and the drive bullwheel;

b) The backstop device shall be rated for the maximum design load;

c) Under the most unfavorable design loading condition, the backstop device shall automatically prevent reverse rotation of the aerial lift before the aerial lift travels in excess of 36 inches (915 mm) in the reverse direction.

3.1.2.7 Location of machinery

3.1.2.7.1 General

Moving machine parts that normally may be in reach of personnel shall be fitted with guards. Where breakage of a power transmission component can result in injury, provisions shall be made for appropriate containment of said components. Guards and containment shall be done in conformance to American National Standard, ANSI/ASME, B15.1-2000 (R2008), *Safety Standard for Mechanical Power Transmission Apparatus*.

Protection against static electricity shall be provided.

Fire-fighting device(s) shall be available (see F.6 in Annex F).

3.1.2.7.2 Machinery not housed in a machine room

Provisions shall be made to keep the public away from the machinery. All machinery and controls shall be rated for use in their intended environment.

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3.1.2.7.3 Machinery housed in a machine room

The machine room shall be adequately ventilated. It shall have a permanently installed lighting system, adequate for proper machinery maintenance and to reduce the risk of injury to operating personnel. The arrangement of the machinery shall permit proper maintenance. A door with a suitable lock shall be provided, and the design shall keep the public away from the machinery. When a passageway is provided between machines or machinery and walls, a minimum passageway width of 18 inches (460 mm) shall be maintained. Means shall be provided to heat the machine room unless the designer or manufacturer certifies in writing that the drive system is rated for operation in an unheated room.

3.1.2.8 Bullwheels and sheaves in terminals and stations

3.1.2.8.1 General

All bullwheels and sheaves, including their mountings and frames, shall be designed to withstand static and dynamic loads. Bearings and mountings shall be selected, designed, and installed in accordance with the recommendations of the manufacturers of the bearings.

When unlined grooves are used for wire rope, they should be V-shaped and shall have rounded bottoms with a radius equal to approximately 55% of the rope diameter.

When lined grooves are used, the allowable bearing pressures of the liner material shall not be exceeded.

3.1.2.8.2 Haul rope terminal bullwheels

Provisions shall be incorporated in the terminal design to retain the terminal bullwheels in their approximate normal operating position in the event of failure of the bearings, shaft, or hub.

Provisions shall be incorporated in the terminal and rope retention design to control the position of the rope, including possible overhaul, to minimize the effects of its departure from its normal operating position.

The minimum diameter of terminal bullwheels shall be 72 times the nominal diameter of the haul rope. The bullwheel assembly shall be designed to retain the haul rope in the event of a deropement from the bullwheel. A flange extension of 1-1/2 times the rope diameter (measured radially from the bottom of the rope groove) shall be deemed adequate for retention.

Terminal bullwheels that act as driving, braking, or holding bullwheels shall be so designed that the haul rope does not slip in the bullwheel groove. The design coefficient of friction for a particular bullwheel liner shall not exceed the values shown in table 3-4.

3.1.2.8.3 Sheaves in tension systems and sheaves not specifically covered elsewhere in this section

The minimum diameters for these sheaves shall be as indicated in table 3-5.

Condition A: is applicable where bending around a sheave is of major importance. This condition shall be used as a minimum design criterion for track cable counterweight ropes.

Condition B: is applicable where bending around a sheave is important, but some sacrifice in rope life is acceptable to achieve reduction in weight, economy in design, and the like.

Condition C: is applicable to sheaves that are not intended to rotate due to any tension system movement but are intended to rotate only due to tension system adjustment.

In the case of a locked coil track cable passing over a sheave or roller chain and connected directly to a counterweight, the radius of curvature of the bullwheel or the roller chain shall not be less than 100 times the cable diameter or 1200 times the greater dimension of the cross section of the largest wire of the cable, whichever is greater.

NOTE – In shaped wire, consider the greater dimension (width or height) not diagonal measurement.

Provisions shall be made to assure that all tension system sheaves rotate freely.

Table 3-4 Design coefficient of friction for bullwheel liners

Bullwheel liner	Coefficient of friction
Steel or cast iron grooves Leather Rubber, neoprene, or others	0.070 0.150 0.205

Table 3-5 Minimum diameters for sheaves in tension systems and sheaves not specifically covered elsewhere in this section.

Rope Type	Bullwheel diameter		
	Condition A	Condition B	Condition C
6x7 6x19 6x37	72*d* 45*d* 27*d*	42*d* 30*d* 18*d*	24*d* 20*d* 12*d*
NOTE - *d* equals the nominal rope diameter			

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3.1.2.8.4 Haul rope line sheaves

The requirements of 3.1.3.3 are applicable to haul rope line sheaves used in terminals and stations, with the following exceptions:

a) Sheaves that carry no load other than the weight of the rope and carriers;

b) Sheaves that are located in such a way that carriers attached to the cable are not passing onto the sheaves;

c) Sheaves that are located in such a way that the weight of carriers is either wholly or partially supported on tracks or by other means.

In such cases, the design shall be modified to meet the requirements of the particular installation.

3.1.2.9 Tension bullwheel carriages

The available travel of the tension bullwheel and carriage shall be adequate for the maximum limits of motion produced by the most unfavorable design loading and operating conditions.

3.1.2.9.1 Rigid mounted carriages

The bullwheel carriage shall be supported from the ground by a rigid structure. The mounting that travels under the action of the tension system shall be supported on rigid, straight rails by means of wheels or other low friction devices. All design loads including torsional loads due to driving torque, braking torque, or reactions of a rollback device shall be considered, and the structure and carriage shall adequately transmit these loads to the foundations.

3.1.2.9.2 Mechanical stops for rigid mounted carriages

Mechanical stops shall be provided to prevent overtravel of the tension carriage. These stops, and the terminal structure, shall be designed to resist, at normal design stresses, an unbalanced horizontal force on the tension bullwheel applied in the direction of the opposite terminal and equal in magnitude to 30% of the tension system reaction on the tension bullwheel.

3.1.2.10 Tension systems

Counterweights, hydraulic and pneumatic cylinders, or other suitable devices shall be used to provide the tensioning requirements of the particular installation. All devices used to provide the tension shall have sufficient travel to adjust to all normal operating changes in loading and temperature.

The tension for haul ropes and track cables for all modes of operation shall be determined by the design engineer. Tension systems may be active or passive. Active systems shall have monitoring equipment that will automatically prevent operation outside of design limits (see 3.2.3.3 and 3.2.5.1 for electrical requirements).

Passive tension systems, (i.e. fixed anchorage) shall have a system or procedure to determine that the ropes and/or cables are within their operating tension range. The manufacturer or Qualified Engineer shall specify the checking procedures and intervals.

Tension systems may be adjustable to provide proper tensions for different modes of aerial lift operation.

The tension system design shall consider changes, for each mode of operation, in tensions due to rope elongation, friction, and other forces affecting traction on driving, braking, or holding bullwheels, tower and sheave loading, and maximum vertical loads on grips to assure that tensions remain within design limits.

3.1.2.10.1 Hydraulic and pneumatic systems

Hydraulic and pneumatic cylinders, when used, shall have sufficient ram travel to accommodate all normal operating changes in loading and temperature. Provisions shall be made to keep the cylinder free from climatic-induced conditions and contaminants that may interfere with free movement.

If the system fails to provide the design operating pressure, the aerial lift shall be able to be operated to unload passengers.

Cylinders and their attachments shall each have a minimum factor of safety of 5. The factor of safety is equal to the ultimate tensile strength of the cylinder divided by the maximum steady state design tension.

The systems providing operating pressure for the cylinder shall have a minimum factor of safety of 5 unless a high velocity check valve or flow control device is used where the pressure line is connected to the cylinder. The check valve shall be rated to hold twice the normal operating pressure. The remainder of the system shall not exceed the manufacturer's published working pressure. Provisions shall be made to restrict the movement of pressure lines or hoses should they become severed under pressure. When pneumatic storage cylinders, accumulators, or other similar devices are used, they shall be located so that they cannot be knocked over or damaged.

3.1.2.10.2 Counterweights

Counterweights, when used, shall be arranged to move freely up and down. Enclosures for counterweights shall be provided where necessary to prevent snow, ice, water, and other materials from accumulating under and around the counterweights and interfering with their free movement. Visual access shall be provided to areas beneath and above all counterweights contained in enclosures or pits. When a counterweight is contained in a structural frame, guides shall be provided to protect the frame and to ensure free movement of the counterweight. Where snow enclosures are not required, guardrails or enclosures shall be provided to prevent unauthorized persons from coming in contact with or passing under counterweights.

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3.1.2.10.3 Wire ropes in tension systems

Wire ropes in tension systems shall have a minimum factor of safety of 6 when new (see A.1.3.1 in Annex A). On arrangements involving rope reeving, the maximum design static tension with sheave friction taken into account shall be the basis for determining the factor of safety. See A.3 in Annex A for additional requirements. No rotation-resistant ropes shall be used in tension systems (see 1.4 - *rotation-resistant rope*).

Wire ropes in tension systems shall be adjusted so that the counterweight will reach the end of its travel before the attached tension bullwheel carriage comes within 6 inches (150 mm) of the end of its travel. When wire ropes are used with pneumatic or hydraulic cylinders, they shall be adjusted so that connecting devices will not contact the reeving devices before the ram reaches the travel limits of the cylinder.

3.1.2.10.4 Chains in tension systems

Welded link chains may be used in tension systems (see normative Annex G).

Roller and leaf chains are prohibited for tension system usage on aerial lifts that are classified as new (see informative Annex H).

3.1.2.10.5 Cable winches or chain-adjusting devices

Winches or other mechanical devices that are used for take-up and remain part of the system shall have a minimum factor of safety of 6 against their ultimate capacity. They shall have a positive lock against release. Where this factor cannot be established by the manufacturer's endorsement, a device shall be installed on the tension system rope or chain ahead of the winch/mechanical device that will keep the tension system intact in the event of a failure or release of the device.

The diameter of the winding drum shall not be less than the specified minimum sheave diameters referenced in 3.1.2.8.3 - Condition C for rope.

3.1.2.11 Anchoring devices

All anchoring end connections shall be above finished grade. Any portion of an anchorage below ground shall be protected against loss of strength due to corrosion.

Wire ropes or strands and their connections, used to anchor, tension, or otherwise secure terminal structures, shall be designed with a minimum factor of safety of 6. Where adjusting devices are used in the arrangement, the devices shall be capable of being securely locked or removed during operation.

All connections of ropes or cables used in anchoring devices shall be in accordance with the requirements of A.3.2 in Annex A.

3.1.2.12 Terminal entrance and exit guides

From the point where the grip first enters the terminal rails or guides to the point where the grip or carrier is stabilized, provisions shall be made to accept the carriers and the grips into the terminal at the maximum rope speed when the carriers are swung to the limits specified in 3.1.1.5.2.1.

3.1.2.13 Carrier Acceleration/Deceleration/ Spacing system

Smooth acceleration and deceleration of the carrier shall be accomplished to and from the rope at any speed.

> EXCEPTION – Gravity launch/retrieve or similar systems with a single operational speed.

The rate of the carrier's acceleration to, and deceleration from, the maximum rope speed shall not exceed 8 feet per second squared (2.44 meters per second squared) under the most unfavorable accelerating or braking condition.

Upon clamping to the haul rope, the differential of carrier velocity and rope speed shall not unduly affect either passenger comfort or mechanical wear.

Automatic carrier spacers or other suitable systems shall control the interval between carriers. Provisions shall be made to ensure that the carrier spacing shall never be less than the distances specified in the design. Unbalanced loading shall be controlled to the extent required by the design through the use of automatic carrier counters or other suitable systems.

In the case of open carriers, or where mechanical requirements for minimum spacing in the terminals exist, a system to prevent abnormal carrier spacing throughout the terminal carrier conveying system shall be installed (see 3.2.3.9).

Open carriers shall not be allowed to come together in locations where passengers are normally present.

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3.1.3 Line structures

3.1.3.1 Towers

The design of the tower structure and foundation shall be in accordance with the requirements of 3.1.1.6. Where guyed towers are used and guys intersect the ground within or near ski runs, the guys shall be marked for visibility.

Means shall be provided for ready access from the ground to all tower tops. Permanent ladders are required for heights above those accessible by portable ladders. Portable ladders, if used, shall be in at least sufficient quantity to be available at each point where attendants are positioned. Portable ladders extending more than 20 feet (6.10 meters) shall not be used.

Permanent anchor points shall be provided on all tower tops for the attachment of fall protection devices.

Towers shall be identified with successive numbers clearly visible to passengers.

Where towers are designed to permit variations in rope height, sheave unit supports shall be guided and attached so as to prevent misalignment by rotation during normal operation.

3.1.3.2 (Reserved)

3.1.3.3 Haul rope sheaves and mounts

The tread diameter of a haul rope sheave shall not be less than 10 times the nominal diameter of the haul rope unless an elastomer liner is used.

The requirements in 3.1.3.3 and 3.1.3.3.1 through 3.1.3.3.3 apply generally to sheaves that support or hold down the haul rope at towers on a monocable system, but where applicable shall also apply to the haul rope of a bicable system. These requirements shall apply to both sides of each aerial lift.

3.1.3.3.1 Maximum allowable sheave load

The maximum allowable load per sheave shall be determined by the aerial lift designer.

3.1.3.3.2 Sheave and sheave unit design

Sheave flanges shall be as deep as possible, considering other features of the system. At the same time, rope grips shall be designed in relation to the sheave groove so as not to contact sheave flanges during normal operations, taking into consideration the anticipated amount of wear of the sheave liner groove. Grips shall be allowed to contact sheave flanges adjacent to the haul rope when the carrier swings, provided that this is considered in the design of the grips and sheaves. Furthermore, rope grips, sheave flanges, and hanger guides shall be designed so that hangers cannot be caught behind guides, and so that haul ropes and grips cannot be deroped from sheaves if the carrier is swinging within design limits as it approaches or passes the tower.

If the gauge of the haul rope system is varied at any point along the line, the horizontal departure at any one tower shall be provided for in the design so that deropement cannot occur by virtue of such a departure.

Sheave unit design shall include the following features:

a) Suitable guards, of sufficient strength to resist the lateral forces caused by an inside deropement, shall be installed.

b) Construction of the entire sheave unit shall be such that the haul rope cannot become entangled in the sheave unit in the event the rope leaves the sheave toward the outside.

c) Sheave mounts or mounting frames shall be designed to be adjustable, allowing the sheave units to be aligned and held in the plane of the rope.

d) On each sheave unit, rope-catching devices shall be installed to reduce the risk of the haul rope moving excessively in the direction of the load on the sheave unit in the event of deropement. These devices shall be located less than one-half the diameter of the sheaves from the normal operating position of the rope and shall extend a minimum of two rope diameters beyond the sheave flange. Alternatively, when the catcher is located so that the rope cannot move in the direction of the load when it passes from the edge of the sheave to a position in the catcher, the catcher shall extend a minimum of two rope diameters beyond the center of the rope when the rope has reached the point where the deropement switch device initiates a stop.

e) Rope-catching devices shall be designed to permit the passage of the haul rope and grips after deropement. The catcher shall be independent from the sheave.

f) On each sheave unit, suitable deropement switch devices shall be installed and maintained that will stop the lift in case of deropement (see 3.2.4.3).

g) On aerial lifts where the carrier speed exceeds 600 feet per minute (3.0 meters per second), at least one device that senses the position of the rope shall be installed on each sheave unit (see 3.2.5.2).

See also 3.1.1.5 through 3.1.1.5.7 for the effect of tower height and location on sheave units.

3.1.3.3.3 Haul rope retention

Provisions shall be made to retain the haul rope in the line sheave groove under all anticipated conditions of loading. This criterion shall be deemed to have been met if any of the following conditions is fulfilled:

Condition A: Under the most adverse design loading conditions (excluding dynamic effects), the minimum load of the haul rope on a group of support sheaves at a tower shall not be less than the largest of the following values: 100 pounds (445 newtons) per sheave; or 300 pounds (1335 newtons) per tower

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group; or a value in pounds equal to two-thirds the sum of the adjacent span lengths expressed in feet of slope length (a value in newtons equal to 10 times the sum of the adjacent span lengths expressed in meters of slope length).

When the haul rope elevation at a tower lies below a straight line joining the haul rope elevations at the adjacent towers, the haul rope shall not leave the group of sheaves under either of the following conditions:

a) when the haul rope tension is 1.5 times its maximum design value at the point, using no carriers in adjacent spans;

b) when the haul rope is under tension of the tension system alone (bare rope) or with any arrangement or number of empty carriers on the line.

The minimum load of the haul rope on a group of hold-down sheaves at a tower under the most adverse loading conditions shall not be less than the larger of the following values: a value in pounds equal to the dead plus live load of the carrier; or a value in pounds equal to the sum of the adjacent span lengths expressed in feet of slope length (a value in newtons equal to 15 times the sum of the adjacent span lengths expressed in meters of slope length). In no case shall this load be less than 225 pounds (1000 newtons) per passenger.

Condition B: Combination sheave units that incorporate support and hold-down sheaves shall be designed with the retaining sheaves always in contact with the haul rope. When retaining sheaves are mounted to deflect, to allow passage of a carrier grip, such deflection shall not occur until the sheave is loaded to one-half of the maximum design sheave loading. The retaining sheaves shall have the same maximum design loading as the other support or hold-down sheaves on the tower. If the design satisfies loading requirements in Condition A, nothing in this paragraph shall preclude the use of rollers or guides opposite the tower sheaves that do not necessarily contact the rope.

Condition C: For line structures where the carrier is either wholly or partially supported or depressed on tracks, or by other means, in lieu of retaining the haul rope in the sheave groove, the following design criteria shall be fulfilled without exceeding the maximum allowable loads.

Under the most adverse loading conditions, the load of the carrier onto the track when fully engaged shall not be less than the largest of the following values: 450 pounds (2000 newtons); or the design gross load per carrier; or a value in pounds equal to two-thirds of the sum of the adjacent span lengths expressed in feet of slope length (a value in newtons equal to 10 times the sum of the adjacent span lengths expressed in meters of slope length).

The carrier shall not leave the track cable if the design haul rope tension is increased by 50% or decreased by 33%.

3.1.3.4 Track cable saddles and mounts

Cable catchers shall be provided on the saddles on both sides of each track cable.

The radius of a track cable saddle shall be determined by the one of the following criteria that requires the largest radius:

a) to be large enough to minimize bending stresses in the cable. In any event, the radius shall be equal to at least 1200 times the largest dimension of the outer wire of the cable;

NOTE - In shaped wire, consider the greater dimension - width or height - not diagonal measure.

b) to be large enough to provide smooth transition of the carriage assembly from span to span;

c) to be large enough to reduce the bearing pressure to a value that will permit proper lubrication of the cable to facilitate sliding in the saddle groove;

d) to be large enough so that the radial acceleration of the carrier is not greater than 6.6 feet (2.0 meters) per second squared calculated as follows:

V^2/R is not greater than 6.6 feet (2.0 meters) per second squared.

V = Carrier speed in feet (meters) per second
R = Radius of shoe in feet (meters)

The minimum pressure on the saddle shoes shall be not less than 1.5 times the pressure required to hold the rope in contact with the shoes when a wind force of 6 pounds per square foot (290 pascals) is applied upwards on the rope, parallel to the reaction on the tower.

The saddle shall be long enough to ensure that, under maximum loading conditions, the cable will not come into contact with the end of the saddle groove.

Saddles shall permit free passage of the carriage even when the carrier is swinging laterally to its design limit as it approaches or passes the tower.

If the gauge of the aerial lift is varied at any point along the line, horizontal departure at any one tower shall be kept to a minimum to avoid deropement of the carriage wheels as they pass over the saddle.

See also 3.1.1.5 through 3.1.1.5.7 for effect of height and location of towers on saddles.

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3.1.4 Line equipment

3.1.4.1 Haul rope

See Annex A for basic wire rope design and installation requirements.

3.1.4.1.1 Factor of safety

When the slope length of the installation is less than 3000 feet (914 meters), the haul rope shall have a minimum static factor of safety of 5 when new. For slope lengths greater than 3000 feet (914 meters), the haul rope may have a minimum static factor of safety of 4.5 when new. Static factor of safety is equal to the minimum breaking force (see A.1.3 in Annex A) divided by the computed maximum tension caused by design loads, including the effects of friction, but excluding dynamic loads, in the section of the haul rope that is most highly stressed.

3.1.4.1.2 Factor of safety for spliced haul rope with an independent wire rope center

Where a spliced haul rope with an independent wire rope center (IWRC) is used, the minimum breaking force of an equivalent wire rope with a fiber core shall be used.

3.1.4.2 Track cable

See Annex A for basic requirements for all track cables. Track cables consisting of one strand made up entirely of round wires (commonly called smooth coil track strand) shall not be permitted. Wire rope, if used as track cables, shall have an independent wire rope or strand center.

3.1.4.2.1 Track cable factor of safety

Track cables shall have a minimum static factor of safety of 3 and a minimum dynamic factor of safety of 2.5 when new.

3.1.4.2.2 Track cable installation

The designer of the aerial lift shall provide detailed information concerning handling and installation of the track cable. These instructions shall be consistent with the track cable manufacturer's recommendations. Any handling after installation shall be in accordance with this advice.

3.1.4.3 Haul rope grip

3.1.4.3.1 Haul rope grip design

The haul rope grip shall be of a type that has been approved by a Qualified Engineer.

The manufacturer shall permanently affix a unit identification, serial number(s) and nominal rope size marking to each grip. Each grip shall be nondestructively tested before public use, and such testing shall be documented.

The design of the haul rope grip shall incorporate the following:

a) a specification sheet for each grip design that as a minimum specifies materials, fabrication methods, allowable rope sizes, allowable rope constructions, carrier weight, maximum rope angle, maximum line sheave load, operational temperature range, production inspection criteria and design operating tolerances;

b) the rope grip shall be designed to pass the rope catchers in the event of a deropement;

c) when the grip is loaded in its normal operating position to a value equal to the dead load plus six (6) times the live load, no part of the grip shall be stressed to a value greater than the ultimate strength of the material;

d) grip parts whose stress is not changed by application of live load shall be designed on the basis of an allowable stress of not more than the yield point of the material divided by 3.0;

e) in the design of springs, where used, the allowable stress may be increased if fatigue tests are conducted and independently certified to provide assurances that the fatigue life of the actual spring is adequate for the various applied loads;

f) grips shall be designed to resist, with a minimum factor of safety of 3.6 with respect to the yield point of the material(s) the stresses resulting from horizontal loads including centrifugal force, grip capture forces, and terminal guide rail forces;

g) the grip material shall be selected for optimum impact resistance;

h) the grip clamping mechanism shall not reach its mechanical limit of travel with a 10% combined reduction from nominal haul rope diameter and total allowable grip wear;

I) a change of rope diameter of plus or minus 10% from nominal shall not cause a reduction of grip force by more than 25% for a new grip;

j) at the nominal rope diameter the minimum factor of safety for the slipping force shall be 3. Slipping force is defined as P sin α where P is the dead plus live load of the carrier and α is the maximum rope angle produced by any design loading condition;

k) the opening of the grip jaws shall accommodate, without contact, a coupling with a haul rope of 10% above nominal diameter;

l) no wedging on the haul rope by gravity may be incorporated in the design of the rope-to-jaw interface. Wedging on the haul rope by spring force may be incorporated in the design of the rope-to-jaw interface provided jaw wear is limited as a retirement criterion to maintain wedge effect;

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m) if energy storage devices produce the gripping force, the failure of one device shall not reduce the slipping force factor of safety below 1.5 for haul ropes between 90% and 110% of nominal rope diameter;

n) the edges of the grip jaw shall enclose the haul rope so that the distance between the jaws does not exceed 75% of the nominal haul rope diameter for a minimum distance of 1.5 times the nominal haul rope diameter;

o) the designer shall consider required pluck forces in the design of the grip. Pluck forces shall be tested and recorded for each new grip design. Pluck force is force perpendicular to the rope applied at the center of each grip;

p) the carrier swing angles under worst design conditions of longitudinal swing shall not result in reaching any mechanical limit of travel. In any event, the minimum carrier swing angles without reaching any mechanical limit of travel shall be the sum of the maximum rope angle plus 15 degrees;

q) grip parts shall be finished to resist corrosion.

3.1.4.3.2 Grip testing requirements

Grip testing shall be performed to confirm design calculations. Grip tests shall simulate as a minimum the maximum design loads for the range of haul rope diameters, carrier loads, and maximum rope angle allowed.

Grips that are new in design or have had their specifications revised shall have the following tests performed and independently certified:

a) Fatigue testing shall be performed using one of the two methods listed in table 3-6:

b) Grips shall be tested to 500,000 clamping/unclamping cycles on a rope or equivalent. Manufacturers recommended maintenance and parts replacement may be performed during this test.

c) Grips shall be tested to 15,000 terminal entry/exit cycles, 5,000 of which to be fully loaded with maximum transverse swing.

d) Carrier swing angles without reaching any mechanical limit of travel between grip and hanger shall be tested and documented.

Failure of any grip component, while testing, is defined as permanent deformation, wear on component parts or initiation of any stress related crack that exceeds design operating tolerances. In addition, the grip, at the conclusion of above testing, shall meet the provisions of 3.1.4.3.1. If failure occurs, the grip shall be redesigned and the above Grip Testing Requirements shall be repeated.

The manufacturer's quality control provisions shall assure that the grips produced and their parts meet the designer's specifications and would pass the foregoing testing requirements. Testing documents for each produced grip shall include serial number(s), NDT testing, slip force testing, and final assembly inspection.

3.1.4.3.3 Lift/Grip interface

3.1.4.3.3.1 Maximum loads

The maximum total vertical load on a single grip shall not exceed 1/14 of the minimum tension in the haul rope.

Where two grips are used for a single carrier, the foregoing requirement may be applied to each grip, provided that:

a) The two grips are independent of each other (that is, articulated in such a manner that they are independently loaded);

b) The clear length of haul rope between the two grips equals or exceeds one-half rope lay.

3.1.4.3.3.2 Attachment

At each carrier launching position, devices shall be installed that will stop the aerial lift if any grip incorrectly attaches to the haul rope (see 3.1.4.3.4.3 and 3.2.3.11).

3.1.4.3.4 Lift/Grip Interface Testing

3.1.4.3.4.1 Slippage Testing

The grip shall maintain 3 times the force required to move a loaded carrier along a properly lubricated haul rope at nominal diameter at the steepest incline.

The aerial lift designer shall specify the force below which the grip will not slip and the required testing equipment and procedures. As a minimum the grip shall be tested after each grip is removed for periodic nondestructive testing and maintenance. When testing, the grip shall not move more than 25% of the nominal rope diameter.

3.1.4.3.4.2 Grip force

The design of the aerial lift shall include provisions that check the grip's ability to produce the force required to meet the minimum grip force equivalent to the slippage force defined above at least once for each revolution of the grip through the system (see 3.2.3.10).

If the gripping force of the grip falls below the minimum required, the design of the system shall include provisions to stop the aerial lift. Passengers shall not be loaded on those carriers until it is verified that the grip in question is producing the minimum required force (see 3.2.3.10).

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Table 3-6 Grip fatigue testing

METHOD #1

Sometimes referred to as signature testing, actual data is used to determine what testing is required for fatigue testing. Determine by testing and with independent certification the dynamic stress range and mean frequency of the frequencies produced by operation of a grip on actual installations:

The following tests shall be performed on the same grip so that the test grip will receive a total of 5 million cycles.

Test #1	**Test #2**	**Test #3**
- Upper Limit - Maximum stress produced by a loaded carrier. - Lower Limit - minimum stress produced by a loaded carrier. Test for two million (2,000,000) cycles at developed frequency between Upper Limit and Lower Limit with grip simulating 0% slope.	- Upper Limit – Maximum stress produced by a loaded carrier. - Lower Limit – Minimum stress produced by a loaded carrier. Test for two million (2,000,000) cycles at developed frequency between Upper Limit and Lower Limit at the maximum specified rope angle for grip.	- Upper Limit - Maximum stress produced by an empty carrier. - Lower Limit - Minimum stress produced by an empty carrier. Test for one million (1,000,000) cycles at developed frequency between Upper Limit and Lower Limit with grip simulating 0% slope.

METHOD #2

Testing is accomplished by using values assigned or measured weights for the loads to be used in fatigue testing. Measure and record the following weights:

- Grip Weight, Maximum of specified sizes.
- Hanger Weight, Maximum of specified sizes.
- Chair/Cabin Weight, Maximum of specified sizes and extras, (i.e. restraining bar, foot rest, bubble, etc.)
- Passenger Weight, 170 pounds (77.1 kilograms) per passenger to maximum specified capacity of the chair.
- Weight (dead plus live) = Grip Weight + Hanger Weight + Chair/Cabin Weight + Passenger Weight
- Weight (dead)= Grip Weight + Hanger Weight + Chair/Cabin Weight

The following tests shall be performed on the same grip so that the test grip will receive a total of 5 million cycles.

Test #1	**Test #2**	**Test #3**
- Upper Limit 2.5 x Weight (dead plus live) - Lower Limit 0.5 x Weight (dead plus live) Test for two million (2,000,000) cycles at approximately 200 cycles/minute between Upper Limit and Lower Limit with grip simulating 0^o rope angle.	- Upper Limit 2.5 x Weight (dead plus live) - Lower Limit 0.5 x Weight (dead plus live) Test for two million (2,000,000) cycles at approximately 200 cycles/minute between Upper Limit and Lower Limit at the maximum specified rope angle for this grip.	- Upper Limit 2.5 x Weight (dead) - Lower Limit 0.5 x Weight (dead) Test for one million (1,000,000) cycles at approximately 200 cycles/minute between Upper Limit and Lower Limit with grip simulating 0^o rope angle.

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3.1.4.3.4.3 Incorrect Attachment

The designer shall incorporate provisions to stop the grip and carrier in a controlled fashion when a grip is incorrectly attached to the rope.

a) *monocable systems*

The path of the rope from the terminal where passengers are loaded shall be approximately level or inclined upward for a length at least equal to:

$$L\ (feet) = \frac{V^2\ (ft/minute)}{14{,}400} \quad \text{or}$$

$$L\ (meters) = \frac{V^2\ (meter/sec)}{1.22}$$

L = Length of level or inclined upward rope

V = rope speed during passenger loading at that station

An incorrectly attached grip tripping the last checking switch shall cause the rope to stop in a distance not greater than the calculated length “L” or in the case where a greater length of level or inclined upward rope is provided, in a distance not greater than the length provided.

b) *bicable systems*

On bicable systems terminals, the designer shall incorporate provisions to stop in a controlled fashion an incorrectly attached carrier after the grip attachment point.

A sign, visible to the operating personnel in the station requiring the reduced rope speed, is required. It shall state the “maximum rope speed during loading” (see table D-1(s)) if the aerial lift must be slowed below the designed speed to comply with 3.1.4.3.4.3(a).

3.1.4.4 Carriers for detachable aerial lifts

Qualified Engineers shall design the carrier and all components in accordance with accepted practices of design.

The aerial lift designer or manufacturer shall develop a Carrier Inspection Plan (see 3.3.4.3).

3.1.4.4.1 Hanger

The hanger shall be securely attached to the carriage or haul rope grip and to the cabin in such a manner that it cannot work loose.

The hanger shall be of sufficient vertical length that, under the worst condition of longitudinal swing, no portion of the chair or cabin can contact any rope or any tower machinery components. Sway dampers designed to reduce the longitudinal sway of the carrier shall be used if recommended by the aerial lift designer.

3.1.4.4.2 Cabin

Fully enclosed passenger cabins shall be ventilated. They shall be equipped with doors that fill the entire entrance opening. The minimum clearance width opening shall be 32 inches (815 mm). Each door shall be provided with a lock located in such a manner that it can be unlocked only by authorized persons or by automatic means.

The horizontal gap between the cabin door opening floor edge and platform edge shall not be greater than 1 inch (25.4 mm). The height of the cabin floor to the platform shall be within ± ½ inch (±12.7 mm). Where it is not operationally or structurally practical to meet these requirements, platform devices, vehicle devices, system devices, or bridge plates shall be provided for independent loading.

All windows shall be of shatter-resistant material.

Means of emergency evacuation of passengers shall be provided.

The maximum capacity of each cabin, both in pounds and kilograms and the approximate number of passengers, shall be posted in a conspicuous place in each cabin (see table D-1(r)).

The minimum clear floor space in accessible cabins shall be 48 inches by 30 inches (1220 mm x 760 mm). Where special accessible cabins are used, it is recommended the waiting interval should not exceed 10 minutes.

All carriers shall be clearly identified with numbers located on each end of each carrier.

Semi-open carriers shall meet applicable requirements for enclosed cabins and open chairs.

3.1.4.4.3 Track cable carriage wheels (bicable systems)

On bicable systems, the weight of the loaded carrier and haulage rope reactions shall be distributed to carriage wheels so that the load on any wheel shall not exceed that recommended for the track cable or the wheel liner material for the wheel diameter selected. In no event shall the load per wheel exceed 1/80 of the minimum design tension in the track cable when track strand is used with unlined wheels or 1/60 with resilient liner material. If wire rope is used as a track cable, the load per wheel shall not exceed 1/40 of the minimum design tension in the track cable.

The carriage shall be equipped with a device that will, as far as possible, hold the carriage on the track cable in the event of a deropement of the wheels. In areas where icing conditions may exist, the carriage shall be equipped with ice scraping devices that cannot contact the track cable under normal anticipated operating conditions.

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3.1.4.4.4 Chairs

Chair lift carriers shall be designed to support a vertical load 4 times the design load without permanent deformations of the assembly or component parts.

All carriers shall be uniquely identified with numbers visible to the operator and attendant.

Each chair shall be equipped with a railing at each side, to a height of not less than 4 inches (100 mm) above the seat for a distance of not less than 12 inches (305 mm) from the back of the seat.

For aerial lifts operating primarily for skiers, the thickness of the chair seat front, including padding, shall not exceed 5 inches (125 mm) from the top of the seating surface to the bottom of the curl. Tilt back angle of the seat bottom should be a minimum of 7 degrees when loaded. Loaded shall mean an evenly distributed load using load test criteria. Provisions shall be made to keep the tails of skis from passing through and becoming trapped in open spaces between framework, safety restraints and chair seat underside.

For aerial lifts operating primarily for foot passengers, each chair shall be equipped with a restraining device that will not open under forward pressure.

The chair shall be designed to accommodate equipment for the purpose of emergency evacuation of passengers.

3.1.4.5 Carrier testing

Carrier testing shall be performed to confirm design calculations. Carrier tests shall simulate as a minimum the maximum design for carrier loads including restraining bars, foot rests, bubbles, etc.

Carrier tests shall verify the carriers ability to support a vertical load during the testing by arranging loads to simulate individual passenger positions.

Carriers that are new in design or have had their specifications revised shall have the following tests performed, independently certified, and the results included in the aerial lift documents:

a) Fatigue testing shall be performed using one of the two methods shown in table 3-7;

b) Carriers shall be tested to 15,000 terminal entry and exits, 5,000 of which are to be fully loaded with maximum transverse swing;

c) Carriers shall be tested simulating horizontal loads and forces, to verify parts of the assembly have a factor of safety of 3.6 with respect to the yield point of the material(s). Horizontal loads include centrifugal loads, grip capture forces, or guide rail forces that stress the hangers as they enter and pass through the terminals.

Failure of any carrier component, while testing, is defined as permanent deformation, wear on component parts or initiation of any stress related crack that exceeds design operating tolerances. If failure occurs, the carrier shall be redesigned and the above carrier testing requirements shall be repeated.

The manufacturer's quality control provision (see 1.5.2) shall assure that the carrier produced and its parts meet the designer's specifications and would pass the foregoing testing requirements.

3.1.5 Provisions for operating personnel

Operator and attendant work positions shall be located to provide visual surveillance of the station and the line in the vicinity of the station. When the work position is enclosed, they shall be heated, ventilated, and lighted as required to perform the assigned duties. An enclosed work position shall contain inside:

a) the communications and controls required;

b) the operating instructions and emergency procedures;

c) a fire extinguisher (see F.6 in Annex F).

This does not preclude additional communications and controls located outside the work position enclosure.

All primary aerial lift controls and communications shall be immediately available to operating personnel. The physical appearance, operation, and location of emergency shutdown devices shall differentiate them from other operating devices or controls.

Loading and unloading areas shall have manual stopping devices located conveniently to the attendants assigned to those areas (see 3.2.9).

3.1.6 Operational and maintenance manuals

3.1.6.1 Operational manual

The designer of each new or relocated aerial lift shall prepare an operational manual in English for that installation. The manual shall describe the function and operation of the components and provide instructions for the correct usage of the installation.

3.1.6.2 Maintenance manual

The designer of each new or relocated aerial lift shall provide with delivery of the installation, a maintenance manual in English, for that installation. The manual shall describe recommended maintenance and testing procedures, including:

a) types of lubricants required and frequency of application;

b) definitions and measurements to determine excessive wear;

c) recommended frequency of service to specific components;

d) carrier inspection plan (see 3.3.4.3);

e) brake testing and adjustment;

f) dynamic testing procedures.

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Table 3-7 Carrier testing

<table>
<tr><td colspan="2"><u>METHOD #1</u>

Sometimes referred to as signature testing, actual data is used to determine what testing is required for fatigue testing. Determined by testing with independent certification the dynamic stress range and mean frequency of the frequencies produced by operation of a carrier on actual installations.

The following tests shall be performed on the same carrier so that the test carrier will receive a total of 5 million cycles.</td></tr>
<tr><td><u>Test #1</u>

- Upper Limit - Maximum stress produced by a loaded carrier.

- Lower Limit - minimum stress produced by a loaded carrier.

Test for four million (4,000,000) cycles at recorded frequency between Upper Limit and Lower Limit.</td><td><u>Test #2</u>

- Upper Limit - Maximum stress produced by an empty carrier.

- Lower Limit - minimum stress produced by an empty carrier.

Test for one million (1,000,000) cycles at developed frequency between Upper Limit and Lower Limit.</td></tr>
<tr><td colspan="2"><u>METHOD #2</u>

Testing is accomplished by using values assigned or measured weights for the loads to be used in fatigue testing. Measure and record the following weights:

- Grip Weight, Maximum of specified sizes.
- Hanger Weight, Maximum of specified sizes.
- Chair/Cabin Weight, Maximum of specified sizes and extras, i.e. restraining bar, foot rest, bubble, etc.
- Passenger Weight, 170 pounds (77.1 kilograms) per passenger to maximum specified capacity of Chair/Cabin.
- Weight (dead plus live) = Grip Weight + Hanger Weight + Chair/Cabin Weight + Passenger Weight
- Weight (dead) = Grip Weight + Hanger Weight + Chair/Cabin Weight

The following tests shall be performed on the same carrier so that the test carrier will receive a total of 5 million cycles.</td></tr>
<tr><td><u>Test #1</u>

- Upper Limit 2.5 x Weight (dead plus live)
- Lower Limit 0.5 x Weight (dead plus live)

Test for four million (4,000,000) cycles at approximately 200 cycles/minute between Upper Limit and Lower Limits.</td><td><u>Test #2</u>

- Upper Limit 2.5 x Weight (dead)
- Lower Limit 0.5 x Weight (dead)

Test for one million (1,000,000) cycles at approximately 200 cycles/minute between Upper Limit and Lower Limits.</td></tr>
</table>

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3.2 Electrical design and installation

3.2.1 General design and installation testing

Prior to operation of newly installed aerial lifts or after any modification thereafter of the electrical system, the electrical system shall be tested and shown to meet the requirements of this standard and the test results shall be recorded. Design of all electronic controls and drives shall consider minimum sensitivity to electrical noise and electrical emissions, such as noise spikes from power lines and lightning, radio transmitters, thyristors (SCR), or solenoid or relay noise at levels and frequencies that could initiate loss of control.

3.2.1.1 Applicable codes

All electrical systems shall comply with American National Standard, ANSI/NFPA 70-2011, *National Electrical Code* and the Institute of Electrical and Electronics Engineers, IEEE C2-2007, *National Electrical Safety Code*.

3.2.1.2 Location

All electrical power transmission wiring located near or proposed to cross over aerial lifts shall comply with the applicable requirements of IEEE C2-2007.

3.2.1.3 Protection

All electrical equipment with operating voltages above 24 volts nominal shall be marked conspicuously with letters/numbers that are no smaller than ¼ inch (6 mm) in height designating the greatest voltage that may be in the equipment, the number of phases and whether the voltage is alternating or direct current. All electrical equipment rated over 600 volts shall be marked with conspicuous warning signs stating “Danger High Voltage”.

EXCEPTION – 120 volt single phase lighting circuits and convenience outlets.

All power equipment shall be protected against overloads by circuit breakers or fuses.

In locations where electrical equipment, including batteries, is likely to be exposed to physical damage, enclosures or guards shall be so arranged and of such strength as to prevent such damage.

3.2.1.4 Overhead cables

Only signal, communication, and control circuit cables may be supported between towers that support the aerial lift. Voltage shall be limited to low voltage, 24 volts nominal.

EXCEPTION – Circuits for telephone systems may exceed the low voltage requirements.

Overhead cables shall be securely mounted to tower and terminal structures and positioned in such a way that they do not contact the haul rope, track rope, or carriers under normal aerial lift operating conditions. If a cable parts and displaces from its normal position, the aerial lift shall stop (see 3.2.5(d)).

3.2.1.5 Wiring

All wiring shall be in accordance with the designer’s specifications and applicable codes.

3.2.1.5.1 Control wiring classification

All control wiring shall be Class 1 in accordance with Article 725 of ANSI/NFPA 70-2011.

EXCEPTION – Overhead cables (see 3.2.1.4).

3.2.1.5.2 Communication wiring

All communication wiring and systems are exempted from the requirements in Article 800 of ANSI/NFPA 70-2011.

3.2.1.5.3 Insulation

All control wiring is exempted from the requirements of Article 725.49 Part B of ANSI/NFPA 70-2011. The designer shall specify conductor size, type, and insulation suitable for the electrical and mechanical requirements of the application.

3.2.1.5.4 Exterior lighting and snowmaking circuits

All ungrounded exterior lighting and snowmaking circuits, mounted on or within 60 feet (18.3 meters) of the aerial lift centerline, shall have ground fault protection (see 1.4 – *ground fault protection*).

3.2.1.5.5 Ground fault circuit interrupter protection for personnel

All 120-volt single phase, 15 and 20 ampere receptacles in areas where electrical diagnostic equipment, electrical hand tools, or portable lighting equipment may be used shall have ground fault circuit interrupter protection for personnel (see 1.4 – *ground-fault circuit interrupter*).

EXCEPTION – Receptacles dedicated to permanently mounted devices need not comply with this requirement.

3.2.1.6 Grounding

3.2.1.6.1 Structures

All metallic structures shall be bonded to form a grounding electrode system as defined in Article 250 of ANSI/NFPA 70-2011. Electrical continuity of all metal parts of the structures shall be assured by mechanical connection and shall be electrically bonded to the common bonding conductor.

3.2.1.6.2 Drive terminal structure

The drive terminal structure shall have one point referred to as the grounding electrode, as defined in ANSI/NFPA 70-2011. All dc and ac electrical systems shall be referenced to this point. If an electrical prime mover is used, the electric service grounding conductor shall terminate at this point, as well as the structure’s ground referenced in 3.2.1.6.1. Under the worst-case conditions, the resistance from the grounding electrode to any grounded point within the aerial lift system shall not exceed 50 ohms, for the purpose of grounding the

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electrical circuit. The grounding system for the aerial lift shall not be used as a grounding system for any other system not related to the aerial lift system.

To ensure that the 50-ohm grounding requirement is met under all conditions of soil, moisture, temperature, and circulating ground and air currents, all terminals and line structures shall be bonded together with a common bonding conductor. The bonding conductor may be the support or messenger cable of an overhead control cable, the ground shield for an underground control cable, or some other conductor running the full length of the aerial lift system, bonded to each of the terminals and the line structures and shall be of sufficient conductance to meet the 50-ohm requirement.

3.2.1.6.3 Haul rope grounding

Grounding sheaves with conductive liners or equivalent means should be provided at one location for the purpose of grounding haul ropes and track cables, as applicable, for static electrical discharge. For the haul rope on bicable systems or monocable systems with an isolated or insulated haul rope incorporated in the operating circuitry, no means of grounding are required when the operating circuit takes into consideration static electrical discharge.

3.2.1.6.4 Lightning protection

If lightning protection is provided, it shall follow American National Standard, ANSI/NFPA 780-2008, *Standard for the Installation of Lightning Protection Systems*.

3.2.2 Electrical system circuit design and classification

The designer or manufacturer responsible for the design shall identify and classify any new electrical circuits not already classified as protection circuits, operation circuits, or supervision circuits.

3.2.2.1 Circuit priority

Protection circuits shall have priority over all other circuits. Operation circuits shall have priority over supervision circuits. If any circuit's function is connected to circuits of a higher level of protection, it shall be classified at the higher level.

3.2.3 Protection circuits

Electrical circuits designed to stop the aerial lift in the event of a malfunction or failure of the aerial lift system shall be classified protection circuits. All aerial lift systems shall contain two or more protection circuit(s) at least one of which shall be designated the emergency shutdown circuit (see 3.2.3.1). Protection circuits shall be energized to permit system operation and when de-energized shall initiate a stop, or shall be of such design to provide the equivalent level of protection.

A protection circuit may include one or more non-complex elements (see 1.4 – *non-complex elements*) and/or complex electronic elements (see 1.4 – *complex electronic elements*). The designer shall make use through continuous diagnostic coverage (see 1.4 – *continuous diagnostic coverage*) that the failure of a complex electronic element will cause the aerial lift to stop unless another element in the protection circuit is performing the same function (redundancy). If functional redundancy is implemented, the failure of the first element must be annunciated, at a minimum, at the beginning of operations on a daily basis.

The designer or manufacturer shall develop procedures and frequency for testing protection circuits. As a minimum, all protection circuits shall be calibrated and tested annually.

Protection circuits include, but are not limited to:

a) emergency shutdown (see 3.2.3.1);

b) stop gate (see 3.2.3.2);

c) tension system fault (see 3.2.3.3);

d) deropement circuit(s) (see 3.2.3.4);

e) brake system (see 3.2.3.5);

f) overspeed (see 3.2.3.6);

g) rollback detection device (see 3.2.3.7);

h) anti-collision (see 3.2.3.9);

k) grip force fault (see 3.2.3.10);

l) improper grip attachment, detachment (see 3.2.3.11);

m) stop cord.

3.2.3.1 Emergency shutdown circuit

All aerial lift systems shall include at least one protection circuit labeled emergency shutdown circuit (see 1.4 – *emergency shutdown*). The shutdown shall have priority over all other control stops or commands. If, for any reason, the operator has lost control of the aerial lift while using the operating control circuitry, the controls shall include an emergency shutdown circuit allowing the operator/attendant to stop the aerial lift. Any one of the following conditions is considered a loss of control of an aerial lift:

a) Aerial lift will not SLOW DOWN when given the command to do so;

b) Aerial lift will not STOP when given the command to do so;

c) Aerial lift OVERSPEEDS beyond control settings and/or maximum design speed;

d) Aerial lift ACCELERATES faster than normal design acceleration;

e) Aerial lift SELF-STARTS or SELF-ACCELERATES without the command to do so;

f) Aerial lift REVERSES direction unintentionally and without the command to do so.

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3.2.3.2 Stop gates

On aerial lifts using chairs, an automatic stopping device beyond each unloading area shall be installed. The device shall automatically stop the aerial lift in the event a passenger rides beyond the intended point of unloading. The operation of the automatic stop device may be delayed or overridden momentarily by the operator or attendant.

3.2.3.3 Tension system

Active tension systems, (i.e. counterweight, hydraulic, etc.) shall have a protection device(s) that will stop the aerial lift when the haul rope tension carriage exceeds its range of normal operations.

3.2.3.4 Deropement detection

On each sheave unit, suitable deropement detection devices shall be installed and maintained that will stop the lift in case of deropement (see 3.1.3.3.2(f), 3.1.1.5.1(g)).

Bicable systems shall also have a system or device that will initiate a stop if the following is detected:

a) The haul rope comes in contact with the track cable(s), other ropes, communication lines, or grounded equipment;

b) the track cable leaves the saddle into the cable catcher.

3.2.3.5 Braking system

All braking systems shall be designed and monitored to ensure that they meet the requirements of 3.1.2.6 (a) through 3.1.2.6 (d).

3.2.3.6 Overspeed

If the line speed exceeds the design speed by 10%, the service brake, if installed, shall slow and stop the aerial lift automatically.

A system or device shall be installed that will automatically apply the bullwheel brake when the speed of the haul rope exceeds the design value by 15% in either direction.

3.2.3.7 Rollback detection device

The rollback detection device shall activate the rollback device and bring the aerial lift to a stop if unintentional reverse rotation occurs. The rollback device shall be activated if the haul rope travels in excess of 36 inches (915 mm) in the reverse direction.

3.2.3.8 Reserved

3.2.3.9 Anti-collision

A system shall be provided that will prevent carrier collision in the receiving and launching mechanisms. The system shall include devices that will automatically stop the aerial lift before any carriers can come together while they are in the decelerating or accelerating process (see 3.1.2.13).

3.2.3.10 Grip force fault

If the gripping force of the grip falls below the minimum required, the design of the system shall include provisions to stop the aerial lift (see 3.1.4.3.4.2).

3.2.3.11 Improper grip attachment, detachment

a) Device(s) that will stop the aerial lift in the event a carrier grip does not engage properly to the haul rope at every grip attachment point (see 3.1.4.3.3.2).

b) Device(s) that will stop the aerial lift in the event a carrier does not disengage the haul rope properly at every grip disengaging point.

3.2.4 Operation circuits

An operation circuit is a circuit that provides power to or controls the aerial lift machinery.

The designer or manufacturer shall identify the operation circuits that require periodic testing and develop procedures and frequency for testing. At a minimum, all operation circuits shall be tested and calibrated annually.

Operation circuits include, but are not limited to:

a) power circuits;

b) drive fault circuits;

c) normal stop (see 1.4 – *normal stop* and 3.1.2.5);

d) speed command circuits (i.e., fast, slow, etc.);

e) carrier spacing system;

f) internal combustion engine speed control;

g) power unit interlock (see 3.1.2.1.3).

3.2.5 Supervision circuits

Supervision circuits include all communications systems. In addition, supervision circuits may be provided to monitor or supervise the performance of various aerial lift systems or provide the aerial lift operator with system information.

The designer or manufacturer shall identify supervision circuits that require periodic testing and develop procedures and frequency for testing supervision circuits. At a minimum, all supervision circuits shall be calibrated and tested annually.

Supervision circuits may include, but are not limited to:

a) telephone and sound powered systems (see 3.1.1.7);

b) information display circuits;

c) audible warning devices (see 3.2.10);

d) overhead cable supervision (see 3.2.1.4);

e) wind speed and direction sensors and display units;

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f) gearbox oil pressure, oil flow and temperature;

g) pneumatic and hydraulic tension system pressure (see 3.2.5.1);

h) unauthorized passenger detection;

i) rope position detectors (see 3.2.5.2);

j) station carrier spacing system (see 3.2.5.3);

k) acceleration/deceleration error (see 3.2.5.4).

3.2.5.1 Pneumatic and hydraulic tension systems

When pneumatic or hydraulic tension systems are used, pressure-sensing devices shall also be incorporated that will stop the aerial lift system in case the operating pressure goes above or below the design pressure range. Such pressure-sensing devices shall be located close to the actual tensioning device. It shall not be possible to isolate the pressure sensor from the actual tensioning device.

3.2.5.2 Rope position detection

On aerial lifts where the carrier speed exceeds 600 feet per minute (3.0 meters per second), at least one device that senses the position of the rope shall be installed on each sheave unit. The device shall initiate a stop before the rope leaves the sheave in the horizontal direction or when the rope is displaced in the vertical direction by one rope diameter plus the distance that the rope is displaced vertically from the sheave by the grip (see 3.1.3.3.2(g)).

When the device that senses the position of the rope is the only deropement switch, it shall meet the requirements of a protection circuit as described in 3.2.3. An aerial lift system may utilize a rope position detector as a supervision circuit as described in 3.2.5 only if it has another deropement detection system that meets the requirements of a protection circuit.

3.2.5.3 Carrier spacing system

Provisions shall be made to ensure that the station carrier spacing shall never be less that the distances specified by the designer (see 3.1.2.13).

Devices shall be installed that will automatically initiate a stop in the event of abnormal carrier spacing in stations.

3.2.5.4 Acceleration/deceleration monitoring

The rate of acceleration and deceleration of the aerial lift shall be monitored. In the event that the acceleration or deceleration exceeds the provisions of 3.1.2.4, the aerial lift shall stop and annunciate the error.

EXCEPTION – Prime movers equipped with fluid couplings, centrifugal clutches, or wound rotor motors.

3.2.6 Bypass circuits

A temporary circuit may be installed for the purpose of bypassing failed electrical circuits. The use of these bypass circuits shall meet the requirements of 3.3.2.5.9.

3.2.7 Electrical prime mover

All aerial lift systems equipped with electrical prime movers (electrical motors) shall have phase-loss protection on all power phases and under-voltage protection or over-voltage protection, or both, when speed regulation can be adversely affected by such voltage variations.

3.2.8 Electronic speed-regulated drive monitoring

All electronic speed-regulated drives and electric motors shall shut down in the event of:

a) field loss (dc motors);

b) overspeed;

c) speed feedback loss as applicable;

d) overcurrent.

3.2.9 Manual control devices

All automatic and manual stop and shutdown devices shall be of the manually reset type. An exception to this requirement is allowed for magnetic or optically operated automatic stop devices, if the operating circuit is such that it indicates that such devices initiated the stop and the circuit is of the manually reset type.

Manual stop switches (push button) shall be positively opened mechanically and their opening shall not be dependent upon springs.

Manual control devices shall be installed in all attendants' and operators' work positions, in machine rooms, and out-of-doors in proximity to all loading and unloading areas. As a minimum, each of these control locations shall include an Emergency Shutdown device and a Normal Stop device. All manual control devices located in or on a control cabinet shall be mounted so that they are in the same plane or face of the cabinet. The control devices shall not be located in a position that would require the operator or attendant to pass through the path of moving carriers in order to operate the controls.

The devices listed in Annex E shall be conspicuously and permanently marked with the proper function and color code.

A full length stop cord or equivalent shall be provided adjacent to the terminal conveying equipment access ways provided for the inspection and maintenance while equipment is in operation.

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3.2.10 Safety of operating and maintenance personnel

Provision shall be incorporated in the aerial lift design to render the system inoperable when necessary for Lock-out Tag-out protection of personnel working on the aerial lift.

The sign “Personnel Working on Aerial Lift - Do Not Start” or a similar warning sign shall be hung on the main disconnect switch or at control points for starting the power units when persons are working on the aerial lift.

The aerial lift shall incorporate an audible warning device that signals an impending start of the aerial lift. After the start button is pressed, the device shall sound an audible alarm for a minimum of 2 seconds and shall continue until the aerial lift begins to move. The audible device shall be heard inside and outside all terminals and machine rooms above the ambient noise level.

3.2.11 Electrical system acceptance tests

Upon completion of the acceptance test and before public operation of the aerial lift, the function of software and/or relay logic shall be certified by a Qualified Engineer and the certification shall be included in the acceptance test report. Any modifications made to the electrical design shall be clearly marked on the on-site documentation and signed by a Qualified Engineer (see 3.1.1.11.2).

3.2.12 Software security

The “as built” documents shall include a procedure, developed by the aerial lift manufacturer or a Qualified Engineer, to ensure the security of the software logic and operating parameters that will control the aerial lift. Upon completion of the acceptance testing this procedure shall be implemented in a manner that will prevent unauthorized personnel from making changes to the software logic or operating parameters. All programmable logic and parameters shall be documented.

3.2.13 Night operations

For nighttime operation, operating aerial lifts shall be provided with lighting systems. Lighting shall be provided at loading and unloading areas.

3.2.13.1 Illumination

Lights shall be located in a manner to provide generally uniform illumination.

3.2.13.2 Types

Lamps shall be of a type suitable and rated for minimum temperatures of the location. Fixtures shall be designed to maintain proper lamp-operating characteristics.

3.2.13.3 Location

Lights shall be mounted on substantial poles or standards. Aerial lift towers and terminal structures may be used for supporting lights subject to the following requirements:

a) Approval shall be obtained from a Qualified Engineer;

b) the service conductors to each aerial lift tower or terminal structure shall be underground or in rigid raceways. No wiring shall be supported between towers and no open wiring shall pass over or under the aerial lift;

c) a separate enclosed disconnect or circuit breaker shall be required for each tower or terminal structure;

d) all metallic raceways on a tower or terminal structure shall be grounded;

e) the lighting installation shall not conflict with other requirements of this standard and shall not interfere with operations of the aerial lift in any manner.

3.2.13.4 Emergency lighting

Emergency lighting shall be provided in the event of electric power failure to permit:

a) regular unloading of an aerial lift;

b) emergency evacuation of carriers;

c) operation of the evacuation power unit.

3.3 Operation and maintenance

This subsection covers the requirements for operation and maintenance of detachable aerial lifts. Many requirements are listed elsewhere in Section 3 and referenced annexes, since they also regulate installation and design. It is imperative that operating and maintenance personnel be familiar with applicable provisions of this section and the aerial lift operational and maintenance manuals (see 3.1.6).

3.3.1 General and personnel safety

Operation and maintenance of aerial lift equipment can be dangerous to personnel performing these tasks. Procedures for performing these functions shall require precautionary measures necessary to reduce the risks for the personnel involved. Implementation of the procedures intended for the protection of the public and operating and maintenance personnel shall be the responsibility of the owner, supervisor, and the individual worker.

Passengers and operating personnel shall be cautioned or prevented, as required, from transporting objects or materials that may encroach upon limitations of carrier clearances or design live loads.

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3.3.1.1 Applicable design requirements

The following design requirements shall be met by the effective date listed:

– No new items listed for detachable aerial lifts in this standard

The following items were listed in the ANSI B77.1-2006 Standard and are required:

- 3.1.1.7 Communications (Nov. 1, 2007)
- 3.1.2.1.2 Evacuation power unit (Nov 1, 2008)
- 3.1.2.6.3 Rollback device (Nov 1, 2008)
- 3.1.3.3.2(d) Cable catcher (Nov 1, 2008)
- 3.1.3.3.2(f) Deropement switch (Nov 1, 2008)

3.3.1.2 Signs

See normative Annex D for public sign requirements.

See 3.2.1.3 for electrical warnings.

The sign “Personnel Working on Aerial Lift - Do Not Start” or a similar warning sign shall be posted as required by 3.2.10.

3.3.2 Operation

3.3.2.1 Personnel and supervision

Detachable grip aerial lifts shall be operated by trained personnel, and the owner shall be responsible for their supervision and the training to perform the duties listed in 3.3.2.3. Procedures for monitoring the operation and use of the aerial lift and for advising and assisting passengers, including passengers with common adaptive equipment, shall be included in the training. One or more persons familiar with emergency procedures shall be on the site at all times when the aerial lift is in operation. All personnel shall practice good housekeeping. Personnel shall comply with the operational procedures and regulations for the aerial lift. Persons performing the duties of the aerial lift personnel may exchange assignments as directed by the supervisor; provided they are trained for each assignment undertaken.

3.3.2.1.1 Supervisor

An individual shall be designated to oversee the aerial lift’s operating practices and operating personnel for the purpose of public use. The designated supervisor may delegate some authority to others, but shall oversee the operation and operating personnel of the aerial lift as called for by the owner as part of the operation and maintenance quality assurance plan (see 1.5.4).

3.3.2.1.2 Operators

One individual shall be designated as the operator of the aerial lift for the purpose of public use. This operator shall be trained in operational, and emergency procedures and such training shall be documented

3.3.2.1.3 Attendants

Attendants shall be assigned to particular duties under direction of the operator. For public operation, attendants shall be trained in operations and emergency procedures pertaining to their assignments; and such training shall be documented.

3.3.2.1.4 First Aid

One or more persons trained to provide first aid/emergency care at the Basic Life Support (BLS) level, including CPR, shall be available at all times when an aerial lift is operating and transporting passengers. There shall be ready access to first-aid/emergency care supplies and equipment, including provisions for transporting an injured person to an enclosed and, if required, heated shelter.

3.3.2.2 Minimum operating personnel

The following personnel are the minimum that shall be required for public operations:

a) an operator shall be in charge of the aerial lift operation. The individual may serve concurrently as an attendant if the additional role doesn’t interfere with the duties of the operator and approved by the supervisor;

b) an attendant shall be on duty at each loading/unloading platform or station

EXCEPTION – A station that has a combined loading/unloading area may be staffed by a single attendant.

c) one or more persons trained to evacuate the aerial lift using the evacuation power unit shall be available at all times when an aerial lift is in public operation.

In addition, the staffing requirements (if any) specified by the aerial lift manufacturer shall be observed.

3.3.2.3 Duties of operating personnel

All personnel shall use reasonable care while performing their duties.

3.3.2.3.1 Supervisor

The duties of the individual designated as the supervisor include:

a) to oversee practices that will determine that the aerial lift is operational and that all operating personnel are trained, equipped, and capable of performing their duties; prior to public use of the aerial lift;

b) to discontinue operations on any aerial lift due to physical, weather, personnel, or other reasons;

c) to oversee operational procedures and adherence to applicable regulations pertaining to the aerial lift.

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3.3.2.3.2 Operator

The duties of the individual designated as the operator include:

a) to be knowledgeable of operational and emergency procedures and the related equipment needed to perform the assigned duties;

b) to assume responsible charge of the aerial lift;

c) to direct the attendants at their aerial lift;

d) to verify that the preoperational inspection (see 3.3.2.4.2) has been completed and documented before public operation;

e) to start the aerial lift while operating for the public (see 3.3.2.5.2);

f) to maintain an operational log (see 3.3.5.1);

g) to deny access to the aerial lift to any person using procedures and criteria provided.

h) to advise the supervisor of observed abnormal or unusual conditions that may adversely affect the safety of the operation;

i) to terminate passenger operations (see 3.3.2.5.8).

3.3.2.3.3 Attendant

The duties of an attendant include:

a) to be knowledgeable of operational and emergency procedures and the related equipment needed to perform the assigned duties;

b) to monitor the passengers' use of the aerial lift; including observing, advising and assisting them while they are in the attendant's work area as they embark on or disembark from the aerial lift; and to respond to unusual occurrences or conditions, as noted. The attendant should respond by choosing an appropriate action, which may include any of the following.

1) assisting the passenger;

2) slowing the aerial lift (if applicable);

3) stopping the aerial lift;

4) continuing operation and observation.

c) to deny access to the aerial lift to any person using procedures and criteria provided;

d) to advise the operator of observed abnormal or unusual conditions that may adversely affect the safety of the operation.

3.3.2.4 Operational procedures

Operational procedures may supplement the designer's operational manual (see 3.1.6.1) and the owner's quality program (see 1.5.4).

3.3.2.4.1 Control of passengers

Each aerial lift shall have a definite method for marshaling passengers for loading and unloading. Fences, gates, and alternate access and/or loading methods may be required to implement the system for individuals/groups.

3.3.2.4.2 Daily preoperational inspection

Prior to public operation, a daily preoperational inspection shall be performed and documented. As a minimum, the inspection shall consist of the following:

a) a visual inspection of each terminal, station, work position, and the entire length of the aerial lift;

b) assurance that the tension system is functional and that tension system devices (counterweights, cylinders, carriages, and the like) have adequate travel with appropriate clearances at both ends;

c) operation of manual and automatic switches in terminals, work positions, and loading and unloading areas, per manufacturer's instructions;

d) operation of all braking systems;

NOTE – The designer of the aerial lift system may specify that this inspection is to take place while the aerial lift is not moving.

e) operation of communication systems;

f) operation of the aerial lift, including a visual inspection of all ropes and carriers;

g) for those aerial lifts having primary power internal combustion engines, determining that the fuel quantity is sufficient to conduct the anticipated period of operation without refueling. For evacuation internal combustion engines, the fuel supply shall be adequate to unload the aerial lift. During refueling, power units shall be shut down.

Aerial lifts having internal combustion engine(s) shall have the engine(s) checked during this inspection and operated at least once each week. The aerial lift shall be operated using each internal combustion engine(s) for at least 30 minutes per month;

h) inspecting the loading and unloading areas and preparing them for the ingress and egress of passengers;

i) clearing carriers of ice and snow to the extent necessary to permit operation, and inspecting and checking all mechanical features.

j) assurance that applicable horizontal and vertical clearances are maintained (see 3.1.1.4 and 3.1.1.5)

3.3.2.4.3 Access to facilities

While in operation, entrances to all machinery, operators' and attendants' rooms shall be restricted to authorized personnel only. All entrances shall have the signs required in Table D-1 (u) in Annex D).

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While not in operation, entrances to all machinery, operators', and attendants' rooms shall be locked. To provide shelter and emergency telephone access for public safety, specified entrances may remain unlocked provided the aerial lift equipment cannot be operated by unauthorized personnel.

3.3.2.5 Operational requirements

3.3.2.5.1 General

The owner and supervisor of each aerial lift shall review the requirements of section 3 and referenced annexes of this standard to ascertain that original design and installation conditions have not been altered in a manner so as to violate the requirements of the standard.

3.3.2.5.2 Starting

Following procedural clearances, the aerial lift shall be started by the operator or at the direction of the operator. Capability for starting from other locations may be provided for maintenance or emergency operation.

3.3.2.5.3 Loading and unloading platforms

The maze or corral, loading platform surface, breakover point, and the load/unload seat height shall be reasonably maintained according to the prevailing weather conditions and established procedures.

3.3.2.5.4 Stops

After any stop of an aerial lift, the operator shall determine the cause of the stop, and not restart until clearance has been obtained from all attended stations.

3.3.2.5.5 Damage to carriers

Should any carrier become damaged or otherwise rendered unfit for passenger transportation during normal operation, it shall be clearly and distinctively marked and not used for passengers until repaired or replaced. It shall be removed from the line as soon as feasible.

3.3.2.5.6 Hazardous conditions

When wind or icing conditions are such that operation is hazardous to passengers or equipment, according to predetermined criteria based upon the area's operational experience and the designer's design considerations, the aerial lift shall be unloaded and the operation discontinued. If necessary under the predetermined criteria, device(s) shall be installed at appropriate location(s) to ascertain wind velocity and direction when aerial lifts are operated. No aerial lift shall operate when there is an electrical storm in the immediate vicinity. Should such conditions develop while the aerial lift is in operation, loading of passengers shall be terminated, and operation shall be continued only as long as necessary to unload all passengers. When such shutdown has been caused by an electrical storm, grounding of control circuits and haul ropes that are used as conductors in communication systems is permissible. Such grounding shall be removed prior to resumption of passenger operations.

3.3.2.5.7 Evacuation

A plan for evacuation of passengers from each aerial lift shall be developed and documented. The plan shall include:

a) the definition of the line of authority in the event of an evacuation. This line of authority shall list:

1) the positions responsible for determining the need for and ordering of an evacuation by use of the evacuation power unit or evacuation from carriers;

2) the personnel responsible for performing the evacuation, for first aid, and for ground care of evacuated passengers.

b) a description of the equipment necessary for evacuation and where it will be stored;

c) provisions for adequate training in the functions performed in the evacuation process at least once each operating season. Such drills are to be recorded in the operational log of each aerial lift (see 3.3.5.1);

d) an estimate of the time necessary for the total evacuation of each aerial lift;

e) a description of unusual terrain conditions and how each of these conditions will be dealt with during an evacuation;

f) an estimate of when the evacuation should begin in the event the aerial lift becomes inoperable;

g) provisions for communications with passengers of an inoperable aerial lift, the frequency of such communication, how soon after the aerial lift becomes inoperable such communication to the passengers will start, and the frequency of communications thereafter;

h) the methods of evacuation to be used for the typical passenger, incapacitated passenger, common adaptive ski equipment, and non-ambulatory passengers.

i) provisions for communication with the evacuation teams;

j) provisions for suspending the evacuation in the event that the aerial lift is made operable during the evacuation;

k) provisions for control and assistance of evacuated persons until released;

l) provisions for a post-evacuation report.

All nonmetallic rope used for evacuation shall be of nylon or polyester (Dacron) fiber of either laid or braided construction. Laid rope of nylon shall be of a hard lay. These ropes shall be either of a static rescue type or a dynamic mountaineering type. Breaking strength, when

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new, shall be at least 15 times the maximum expected operating load but in no case less than 4000 pounds (17.8 kilonewtons). No natural fiber or polypropylene ropes shall be used.

These ropes shall be carefully stored when not in use and shall be examined after each completed aerial lift evacuation and prior to each season of operation, both summer and winter, to ascertain that they are in satisfactory condition.

Carabiners, if used, shall be of the locking type.

3.3.2.5.8 Termination of daily operations

Procedures shall be established for terminating daily operations in such a manner that passengers will not be left on the aerial lift after it has been shut down. Loading ramps, as required, shall be closed and so marked.

When either loading or unloading portions of an intermediate station are not in operation, it shall be so signed and the loading station shall be closed to public access.

3.3.2.5.9 Bypass requirements

The use of temporary circuits that have been installed for the purpose of bypassing failed electrical circuit(s) (see 3.2.6) shall meet these requirements in the following order:

a) The condition that the circuit indicated is in default shall be thoroughly inspected to ensure an electrical operating circuit malfunction, rather than the indicated condition, actually exists;

b) The bypass shall be authorized only by the aerial lift supervisor or his/her designated representative;

c) When a bypass is in operation, the function bypassed shall be under constant, close, visual observation;

d) The use of a bypass circuit shall be logged and shall indicate when, who authorized, and for what duration a bypass was used;

e) The operator control panel shall indicate that a bypass is in use.

3.3.3 Maintenance

3.3.3.1 General

Foundations, structural, mechanical, and electrical components shall be inspected regularly and kept in a state of good repair. The maintenance and testing requirements of the designer or a Qualified Engineer (see 3.1.6.2) shall be followed. Maintenance logs shall be kept (see 3.3.5.2).

A written schedule for systematic maintenance shall be developed and followed. The schedule shall establish specific frequencies for periodic lubrication, adjustment, inspection, and testing. The schedule shall include, but not be limited to, the following:

a) all wire rope and track cable (see A.4.1, A.4.2 in Annex A);

b) line sheave units, sheaves, bearings, and liners;

c) bullwheels, bearings, and liners;

d) tension systems;

e) drive system, including bearings and couplings;

f) braking systems;

g) electrical control systems;

h) communication systems;

i) carriers;

j) structures;

k) lift line (see 3.1.1.4).

3.3.3.2 Maintenance personnel

Detachable grip aerial lifts shall be maintained by trained and competent personnel. The owner shall be responsible for the supervision and training of such personnel, and such training shall be documented. All personnel shall practice good housekeeping, with particular emphasis on avoiding the development of any condition that might contribute to personal injury. Personnel shall comply with the operational rules and safety regulations of the specific aerial lift.

3.3.4 Inspections and testing

3.3.4.1 General inspection

Each aerial lift shall be inspected annually, or after each 2000 hours of operation, whichever comes first, by an aerial lift specialist independent of the owner. The inspection shall verify preservation of original design integrity and cover the requirements of this standard for maintenance, operation, required self-inspections, and record keeping. Items found either deficient or in noncompliance shall be noted. A report signed by the specialist shall be filed with the owner.

3.3.4.2 Wire rope, track cable, and chain inspection

Inspection shall comply with the following:

- Wire rope (A.4.1 in Annex A)
- Track cable (A.4.2 in Annex A)
- Welded link chain (Annex G)

For existing roller and leaf chain, see Annex H.

3.3.4.3 Carrier inspection

All carriers (grips, hangers, chairs, carriages, and cabins) shall be tested. These components shall be inspected per the carrier inspection plan established by the designer/manufacturer. If the designer/manufacturer is no longer in business an inspection plan shall be developed/reviewed by a Qualified Engineer.

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Personnel performing non-destructive testing (NDT) inspections (i.e. manufacturer, inspection agency, other personnel, or in-house personnel) shall be qualified in accordance with nationally recognized NDT personnel qualifications standards: ANSI/ASNT-CP189, SNT-TC-1A, MIL STD 410, NAS-410, or equivalent.

Personnel performing component inspections shall provide certification of their qualification to perform inspections in accordance with the criteria prescribed by designer/manufacturer or Qualified Engineer.

The designer/manufacturer or qualified engineer shall supply the owner a copy of the carrier inspection plan (see 3.1.4.4 and 3.3.4.3.1). If defects are found, the designer/manufacturer or Qualified Engineer shall be consulted to determine whether an increased sample size or testing frequency is warranted if not specified in original acceptance criteria.

The manufacturer or the owner shall uniquely and permanently mark each component.

Parts failing to meet the acceptance criteria shall not be placed back into service until their defects are corrected in accordance with designer/manufacturer or Qualified Engineer criteria.

3.3.4.3.1 Carrier inspection plan

The carrier inspection plan shall include the following:

a) *Sampling size and frequency* – The inspection plan shall identify the components to be inspected to assure a rotating minimum test sample of 20% of each aerial lifts' carriers (to include at least 10) every year, or after a maximum of 2000 hours of operation, whichever comes first.

b) *Inspection requirements* – Documented inspection criteria shall include:

1) the types and methods of inspections to be performed;

2) inspector qualifications;

3) identification and labeling of critical and non-critical component areas;

4) pre-inspection preparation and post test inspection treatment of components;

5) acceptance criteria;

6) additional sampling and retesting requirements.

3.3.4.3.2 Carrier inspection documentation

After inspection, the testing personnel shall provide written certification to the owner that carrier inspection has been performed in accordance with the current carrier inspection plan. The owner shall receive and maintain a copy of the certification and inspection results in accordance with the following:

a) *General summary/cover letter*:

1) customer identification of installation (name or number);

2) name and address of owner/operator;

3) name and address of inspection agency;

4) name and qualification of inspector(s) in charge;

5) date of inspection completion;

6) total number of carriers in the installation;

b) *Inspection summary*:

1) carrier identification by manufacturer or owner;

2) description of each part listed;

3) inspection method and procedure;

4) total number of parts inspected;

5) total number of parts rejected.

c) *For each rejected or repaired part*:

1) part identification number;

2) description and location of indications according to carrier inspection plan;

3) disposition of rejected parts

- repaired to bring into compliance;

- disposal of parts.

d) *Signature of person responsible*.

3.3.4.4 Dynamic testing

Dynamic testing shall be performed at intervals not exceeding seven (7) years.

A written schedule for systematic dynamic testing shall be developed and followed. The owner shall provide experienced personnel to develop and conduct the dynamic test. The schedule shall establish specific frequencies and conditions for dynamic testing. The testing shall simulate or duplicate inertial loadings. The test load shall be equivalent to the design live load. The results of the testing shall be documented in the maintenance log.

The testing shall include, but not be limited to the following:

a) braking systems;

b) power units;

c) tension system;

d) electrical systems.

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3.3.5 Records

3.3.5.1 Operational log

A log shall be maintained for each aerial lift. Daily entries shall be made giving the following minimum information:

a) date;

b) names and work positions of operating personnel;

c) operating hours and purpose of operations;

d) temperature, wind, and weather conditions;

e) record of compliance with daily operational inspection including loading and unloading platforms, seat height, ramps and signs;

f) position and condition of the tension carriage, counterweights, or other tension system devices;

g) accidents, malfunctions, or abnormal occurrences during operation;

h) signature of operator;

i) record of aerial lift evacuations and evacuation drills (see 3.3.2.5.7(c)).

3.3.5.2 Maintenance log

A signed complete log shall be maintained wherein the actual execution of maintenance work shall be recorded. The log shall state the components serviced and the condition of the components. A log shall be kept of replacement of components.

3.3.5.3 Wire rope and track cable log

A log shall be maintained for each aerial lift, giving the following information on each rope and track cable.

a) specification (see Annex A.1.1 in Annex A);

b) copy of certified test report;

c) date installed;

d) splicing certificate for each splice or laid-in strand;

e) record of lubrication, including type of lubricant and date applied;

f) record of maintenance inspections;

g) inspection reports of wire rope, track cable, and their connections (see Annex A.4.1.2, A.4.2.2 and A.4.3 in Annex A);

h) report of accidents or injury to wire rope or track cable.

3.3.5.4 Chain log

A log shall be maintained for each aerial lift, giving the following information on each chain used as a tension element:

a) specification (see Annex G and Annex H);

b) copy of certified test report;

c) date installed;

d) record of lubrication, including type of lubricant and date applied;

e) record of maintenance inspections;

f) report of accidents or injury to the chain.

3.3.6 Passenger conduct and responsibility

3.3.6.1 Passenger responsibilities

It is recognized that certain dangers and risks are inherent in machines of this type, and their operation. It is also recognized that inherent and other risks or dangers exist for those who are in the process of embarking, riding, or disembarking from detachable aerial lifts.(see 1.2). Passengers accept the risks inherent in such participation of which the ordinary prudent person is or should be aware.

Passengers shall use good judgment and act in a responsible manner while using the aerial lift, including:

a) participating in the embarkation, riding, and disembarkation processes in such a manner as to reduce risks for themselves and others;

b) obeying all written and oral instructions and warnings;

c) refraining from using the aerial lift while under the influence of drugs or alcohol;

d) properly use the aerial lift and equipment provided.

3.3.6.2 Passenger dexterity and ability

All passengers who use an aerial lift shall be responsible for their own embarkation, riding, and disembarkation. They shall be presumed to have sufficient ability, physical dexterity, and/or personal assistance to negotiate and to be evacuated from the aerial lift safely. Passengers shall maintain control of their speed and course while loading and unloading the aerial lift.

3.3.6.3 Passenger embarkation and disembarkation

A passenger shall get on and get off an aerial lift at designated areas. No passenger shall embark without first understanding and observing the proper loading, riding, and unloading procedures (see Table D-1 (a) in Annex D).

3.3.6.4 Passenger riding

Passengers, while riding an aerial lift, shall not throw or expel therefrom any object, nor shall any passenger do any act or thing that shall interfere with the operation of the aerial lift. Passengers shall not willfully engage in any type of conduct that may contribute to or cause injury to any other person.

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Section 4
Fixed grip aerial lifts

This section covers that class of passenger ropeways wherein the carriers circulate around the system, remaining attached to the haul rope. The carriers travel from one terminal to the other along one path and return along another path, making U-turns in both terminals. This section does not include ropeways wherein the passengers are in contact with the ground or snow during the trip.

The aerial lifts covered by this section are of the monocable type. The carriers are open chairs or cabins.

4.1 Design and installation

4.1.1 General

4.1.1.1 Design passenger weight

For purposes of design, a passenger shall be considered as having a minimum average weight of 170 pounds (77.1 kilograms). It is the owners' responsibility to indicate unusual considerations that might affect the design passenger weight.

If an aerial lift transports freight, the freight shall be weighed and not exceed the design load capacity. The designer shall determine the maximum design live load for transporting freight on the aerial lift. The operational manual shall document the live load parameters and relevant operational conditions.

4.1.1.2 Capacity and speed

The maximum carrier speed relative to the surface of loading and unloading platforms during loading and unloading operations shall not exceed the values shown in table 4-1. The designer shall specify the design capacity in each direction. The speeds listed in table 4-1 may be increased if a lift is slowed or stopped for loading and unloading, but in no case shall the speed exceed that specified by the designer and established as functional by testing and operational performance.

Where the aerial lift is not rated for downhill passenger traffic, the number of loaded carriers shall not exceed the values shown in table 4-2, loaded no more closely than every fourth chair, for the carrying of authorized persons downhill. The requirements for a stop gate beyond the downhill unloading area shall be waived.

For the purpose of this section only, authorized persons are defined to include all persons, whether employees of the aerial lift owner or not, who are authorized by the owner or the owner's representatives to be carried on the aerial lift.

Table 4-2 Allowable Loaded Downhill Carriers

Total number of carriers on lift (both sides)	Maximum number of loaded carriers on downhill rope
Less than 60	2
60 to 120	3
Over 120	4

All installations in which downhill traffic is either limited or not permitted shall be so identified with clearly visible signs at loading or unloading areas (see table D-1(n) in Annex D), and this information shall be further contained in operating instructions posted in these areas.

4.1.1.3 Location

In selecting the location and alignment of an installation, consideration shall be given to the following items, and to any others that may be particularly pertinent to the aerial lift type and location:

a) ADA accessibility;

b) electric power lines and their supports;

c) rock and earth slides, cave-ins, washouts, and the like;

d) snow creep and avalanches;

e) wind action;

f) icing;

g) ski slopes and trails;

h) rivers and gullies;

i) buried installations, including pipelines;

j) control of air space below, above, and adjacent to the installation;

k) crossing or close proximity to other ropeways;

l) carrier height above all surfaces;

m) highways;

n) fire hazard;

o) structures;

p) railways.

Table 4-1 Maximum relative carrier speed for chair lifts with fixed grips

Passenger type	Single Chair	Double Chair	Triple Chair	Other Chairs
Skier	600 ft/min (3 m/s)	550 ft/min (2.8 m/s)	500 ft/min (2.5 m/s)	450 ft/min (2.3 m/s)
Foot Passengers	350 ft/min (1.8 m/s)	300 ft/min (1.5 m/s)	275 ft/min (1.4 m/s)	250 ft/min (1.3 m/s)

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4.1.1.4 Clearing envelope

As a minimum there shall be no obstacles, unless allowed in 4.1.1.5, within 5 feet (1.53 meters) of ropes, track cables, and carriers under design operating conditions. Carriers shall not contact any obstacle during operation under design wind conditions. Clearings and contiguous spaces shall be maintained to reduce the risk of washouts, hazard trees, and other obstacles that might endanger the installation (see 4.3.3.1) or interfere with evacuation.

4.1.1.5 Clearances

Terminals and towers shall be designed and installed to provide the clearances as herein specified and to minimize surge of the line under operating conditions. Local wind conditions shall be taken into consideration.

4.1.1.5.1 Vertical clearances

The following reference points shall be used in determining vertical clearances for these carrier/passenger combinations:

a) *For cabins and empty chairs* - Vertical clearances shall be referenced from the lowest point of the carrier;

b) *For chairs carrying foot passengers* - Vertical clearances shall be referenced from a point 2 feet (0.61 meters) below the top of the chair seat;

c) *For chairs carrying skiers* - Vertical clearances shall be referenced from a point 5 feet (1.53 meters) below the top of the chair seat.

Along the line between terminals, the following vertical clearances shall exist between the above carrier reference points and the terrain or other obstacles, including maximum design snow depth:

d) Where skiing is permitted beneath the aerial lift, a minimum of 8 feet (2.44 meters) shall be maintained;

e) Where the clearance is less than 8 feet (2.44 meters), provisions shall be made to prevent access by unauthorized persons to the area beneath the aerial lift.

Under the most adverse design loading conditions, while the aerial lift is being operated, a minimum space of 5 feet (1.53 meters) shall be maintained between the lowest point of the carrier(s) or rope(s) and the terrain, vehicles, or other possible obstacles, including snow.

When aerial lifts cross one another, the following conditions shall be met:

f) Under the most adverse design loading conditions, the minimum vertical clearance between the uppermost point or obstruction of the lower aerial lift and the lowest point of the carriers or rope(s) of the upper aerial lift shall be 10 feet (3 meters);

g) Any deropement of the upper or lower lifts that reduces the vertical clearance (including dynamic affects) to less than 20 feet (6.1 meters) shall cause both lifts to stop (see 4.2.3.4).

4.1.1.5.2 Horizontal clearances

4.1.1.5.2.1 Line clearances

The minimum distance between passing carriers, each swung 10 degrees inward from the vertical, shall be the greater of the following:

a) 30 inches (760 mm); or

b) 1/2% of the span length (applies to gondolas only).

The distance between haul ropes, for the purpose of these checks, shall be considered as equal to the gauge of the line.

There shall be no contact between any tower machinery, guard, or obstruction, and any part of a carrier when a carrier is swung in any of the following conditions:

c) 15 degrees laterally from vertical or 15 degrees longitudinally from vertical;

d) the combination of 15 degrees lateral and 15 degrees longitudinal;

e) the combination of the lateral angle α (alpha) and 15 degrees longitudinal, where α is equal to 5 degrees plus the angle created by a 250-pound (113-kilogram) passenger positioned in the passenger seat causing the greatest angle of inclination, in a static condition, in any direction.

EXCEPTIONS – Towers may be equipped with guards to limit lateral swing to not less than 8 degrees provided the following minimum clearances are maintained:

1) *On chair lifts*: 12 inches (305 mm) between the innermost point on chair structure and the tower clearance line or surface;

2) *On gondola lifts with open windows on the tower side*: 18 inches (460 mm) between the innermost point of cabin and the tower clearance line or surface.

Guards may be placed to limit the swing of carriers between 8 and 15 degrees as required to maintain this clearance.

Guards shall be so shaped and located that a 30-degree lateral swing from vertical shall not place any part of the loaded or empty carrier on the inner side of the guard. Guard configuration shall provide for reversal of carrier travel direction during testing or other special operating conditions and shall preclude entanglement when a carrier is swung laterally 15 degrees.

On all towers, with or without guards, when a carrier is swung longitudinally by 15 degrees, there shall be no contact between any obstruction and any part of the carrier.

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4.1.1.5.2.2 Special clearance requirements for chair lifts used for skiing

The following clearance requirements shall be met to prevent entanglement of skis with the tower structure. Clearance is herein defined to mean the distance between the inner limit of the passenger seat and the clearance line or surface of the tower.

With the carrier swinging laterally 10 degrees from the vertical position, or to the limit permitted by any guards, if clearance is less than 24 inches (610 mm) from any open frame tower or 18 inches (460 mm) from any closed tubular tower, ski tip deflectors shall be provided on each side where skiers are allowed, to reduce the risk of skis being caught in the structure. Such deflectors shall be at least 6 feet (1.83 meters) in height, extending 36 inches (915 mm) above and 36 inches (915 mm) below average foot level.

A tubular tower with permanent ladder rungs shall be considered as an open-frame tower, unless it can be demonstrated that ski tips cannot be caught in the ladder. In this case, the tower may be considered as a closed-tubular tower.

4.1.1.5.2.3 Terminal clearances

In terminal areas, there shall be no contact between any terminal machinery, guide, or other lift structural component and any part of a loaded carrier when the carrier is swung from vertical to plus or minus 15 degrees longitudinally from vertical and/or the greater of:

a) 15 degrees laterally from vertical;

b) laterally 5 degrees plus the angle created by a 250-pound (113.4-kilogram) passenger positioned in the passenger seat causing the greatest angle of inclination, in a static condition, in any direction.

EXCEPTIONS – Guides or similar devices including bullwheel flanges or reaction rings may be provided to limit lateral swing in either or both directions. Such guides or devices shall be designed to engage the carrier smoothly and allow plus or minus 15 degrees of longitudinal swing from vertical. While the carrier is engaged in the guides, the following minimum clearances shall be maintained:

1) *On chair lifts*: 18 inches (460 mm) between any point on the chair structure and any obstacle in the guarded direction;

2) *On gondola lifts with open windows*: 18 inches (460 mm) between any point on the cabin and any obstacle in the guarded direction.

External structures, posts, or obstructions, other than lift structural components, shall have at least 4 feet (1.22 meters) of clearance from either edge of a loaded open carrier passenger seat or open cabin body (measured from the outermost attachments on or parts of the carrier while the carrier is hanging in a vertical position).

EXCEPTION – Control consoles may have a clearance of 30 inches (760 mm).

4.1.1.5.3 Path of rope adjustment

When terminals, towers, or both, contain provisions for a change in height of the rope in order to meet normal changes in operational requirements, such provision shall be controlled as follows:

a) The designer's operational manual shall provide complete instructions for proper procedures and sequences for making adjustments;

b) Where range of adjustments allows possible adjustment error resulting in improper sheave loading, a system to readily verify the proper profile, without the use of tools, shall be incorporated into the installation.

4.1.1.6 Structures and foundations

All structures and foundations shall be designed and constructed in conformance with 1.3 and shall be appropriate for the site. Applied design loads shall include dead, live, snow, wind, and dynamic loads due to normal conditions and for foreseeable abnormal conditions.

Structures and foundations located in snow creep areas shall be designed for such conditions and loads, or protective structures shall be provided as required by the conditions.

4.1.1.6.1 (Reserved)

4.1.1.6.2 Foundations

In determining the resistance of the soil to motion of the foundation, the subsoil conditions at the site shall be considered, including any buoyancy due to groundwater that may be present. If the resistance of the soil is not practically determinable, the foundation or anchorage should be designed as a gravity anchor, using a coefficient of friction appropriate to the general character of the soil. Bottoms of foundations shall be below the normal frost depth unless resting on non-frost-susceptible soil or solid rock. Foundations on rock shall be firmly anchored to solid rock, unless designed as gravity foundations.

The top of concrete foundations shall not be less than 6 inches (150 mm) above finished grade unless specific direction for the protection of the foundation and structural steel below grade is specified by the designer.

The design shall have a minimum factor of safety of 2 in resisting overturning and, concurrently, 2 against sliding, under dead-load and live-load conditions. The minimum factors shall be 1.5 under these loadings plus wind acting simultaneously.

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4.1.1.7 Communications

A permanently installed two-way voice communication system shall be provided between the prime mover and evacuation power unit control point, drive system building, loading stations, and unloading stations. The power for this system shall be independent of the primary power and the communication system shall be functional and audible during a power failure (see 4.2.5(a)).

Audio indicators shall be audible over all ambient noise levels, and visual indicators (e.g., Light Emitting Diodes) shall be visible even in bright sunlight.

4.1.1.8 Combustion engine(s) and fuel handling

Internal combustion engine installation and fuel handling requirements are located in normative Annex F.

4.1.1.9 Loading and unloading areas

Platforms, ramps, corrals, and mazes comprising the loading and unloading areas of an aerial lift are integrally related to its operation. They shall be designed and installed in conformance with 1.3.

A loading conveyor, if installed, shall be designed and installed in conformance with normative Annex C.

Handrails, nets, steps, or ramps shall be provided to reduce the risk of injury to the passengers and maintenance and operating personnel, when required.

Terminals, towers, and other structures or obstacles adjacent to the loading and unloading areas shall be designed or guarded to reduce the possibility of entanglement with these items.

Carriers passing loading and unloading areas shall not vary in height above the platform surfaces by more than 4 inches (100 mm) under the most adverse conditions of carrier design loadings and rope tensions. The haul rope shall approximately parallel the platform.

Intermediate unloading and loading stations located in tandem to allow simultaneous unloading and loading shall have the unloading point and loading point separated by a distance in feet (meters) no less than 8 times the maximum rope speed in feet (meters) per second.

When either the loading or unloading area of an intermediate station is not in operation, it shall be so signed (see table D-1 (k, l) in Annex D). The loading station shall be closed to public access at the loading platform entrance.

4.1.1.9.1 Loading areas

The loading area length, profile, and loading point shall be installed according to the aerial lift's speed, terminal bullwheel location, and carrier type, such as to minimize carrier swing while loading passengers. Load gates, artificial surfaces, and other loading aids when used, shall be designed and installed with regard to all passengers including adaptive. Load gates shall have an override control to hold them in the open position by the lift attendant. At least one point of access to the lift shall have a minimum clearance width of 36 inches (915 mm) to accommodate passengers using adaptive equipment.

Approach paths to the loading platform shall be approximately level or slightly down sloped to facilitate passengers moving to the loading point. The approach paths shall be such that waiting passengers have a view of the loading area. The maze or corral area shall be approximately level, free of obstructions and marked, roped, or fenced in a manner to guide passengers to the "Wait Here" and "Load Here" markers. The corral and maze should be as straight as possible with gradual turns.

For aerial lifts used primarily by foot passengers, the loading area shall be provided with approximately level load platforms and the necessary handrails, steps, or ramps to provide access, guidance and public control.

The "Wait Here" point shall be marked. This marker shall be located to provide horizontal clearance between passengers at the "Wait Here" point and passing carriers.

The loading point shall be approximately level, marked as to where the passengers are to position themselves using a "Load Here" marker located on/in the platform/snow surface. The width of the "Load Here" marker shall not be greater than the carrier width.

4.1.1.9.2 Unloading areas

The unloading area length, profile, unload point, and exit ramp shall be installed according to the aerial lift's speed, terminal bullwheel location, and carrier type.

The approach end of the unloading area shall be fitted with inclined guards as necessary to reduce the risk of passengers or their equipment from being entangled with the platform edges. The rope gradient shall not be more than 10 percent upward or downward.

For chair lifts, the unloading point where the passengers stand up and disembark shall be marked on or near the unloading surface. For unloading skiers on a snow surface, this point shall be at the breakover point where the exit ramp starts. The chair height shall not exceed 22 inches (560 mm). This point shall be signed "Unload Here," as required in table D-1 (j) in Annex D. An exit ramp for skiers shall not be sloped downward more than 30 percent.

Foot passengers shall be provided with approximately level unload platforms and the necessary handrails, steps, or ramps to exit the unload area. The exit route for foot passengers shall be designated.

The width of the unloading path on the unloading platform and the breakover point shall be greater than the carrier width.

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For chair lifts, there shall be no impediment to obstruct passengers inadvertently failing to unload at the unload point. Appropriate guards are required to reduce the risk of injury caused by catching equipment or passengers failing to unload and passing the unload point.

When an aerial lift is designed for skiers to unload in close proximity to the haul rope terminal bullwheel, normally designated as bullwheel unloading, the following requirements shall be met:

a) The unloading point and exit ramp shall be so located in relation to the point of tangency of the bullwheel that the unloading passengers skiing down the ramp shall be able to accelerate away from their carrier;

b) The automatic stop device (stop gate) required in 4.2.3.2 shall be located to stop the aerial lift in the event a passenger fails to unload. Provisions shall be made to unload such passengers from the carrier onto an unload platform without lift reversal or carrying passengers beyond the platform.

4.1.1.10 Provisions for evacuation

Aerial lifts shall be provided with means to evacuate passengers from stranded carriers. Provisions shall be made in the design of the aerial lift for emergency evacuation of common passenger types (see 4.3.2.5.7).

4.1.1.11 Acceptance inspection and tests

Prior to the acceptance inspection and the acceptance tests, the aerial lift shall be continuously operated with empty carriers on the line as follows:

a) 6-hours on each power unit classified as a prime mover;

b) 1-hour on each power unit classified as an evacuation power unit.

Stops shall be minimized to replicate normal operation during the continuous operation.

All terminal equipment, line structures, and line equipment shall be thoroughly checked both before and during the continuous run test to check for overheating of moving parts, excessive vibration or deflection of mechanical or structural components, free movement of tension systems, and other related conditions.

4.1.1.11.1 Acceptance inspection

Before an aerial lift that is new or relocated or that has not been operated for routine maintenance within the previous 2 years is opened to the public, it shall be given a thorough inspection by qualified personnel to verify compliance with the plans and specifications of the designer.

It shall be the responsibility of the owner to see that the following conditions have been met:

a) tightness of all structural connections;

b) lubrication of all moving parts;

c) alignment and clearances of all open gearing;

d) installation and alignment of all drive system components;

e) position and freedom of movement of counterweights or other tension systems and carriages;

f) haul rope alignment at entrance to bullwheels;

g) operation of all electrical components, including circuit protection and grounding;

h) adjustment of brakes for stopping distance and brake torque testing;

i) minimum clearances for haul rope sags under the most adverse static loadings;

j) proper alignment of haul rope sheave units;

k) actual testing of evacuation equipment and procedures at the most difficult location;

l) proper location of towers and terminals in accordance with the plans and specifications. Terminal and tower rope working points shall be documented by an “as built” survey, and any variation from the design drawings shall be noted and approved by the engineer responsible for design.

4.1.1.11.2 Acceptance tests

Before an aerial lift that is new or relocated or that has not been operated for routine maintenance within the previous 2 years is opened to the public, it shall be given thorough tests by qualified personnel to verify compliance with the plans and specifications of the designer. The designer or manufacturer shall propose and submit an acceptance test procedure.

Test load per carrier shall be 110% of the design live load. Thorough load and operating tests shall be performed under full loading and any partial loadings that may provide the most adverse operating conditions. The functioning of all push-button stops, automatic stops, limit switches, deropement switches, and communications shall be checked. Acceleration and deceleration rates shall be satisfactory under all loadings (see 4.1.2.4). Motive power and all braking and rollback devices (see 4.1.2.6) shall be proved adequate under the most adverse loadings.

On systems operating at 600 feet per minute (3 meters per second) or greater, a plot of rope speed versus time shall be recorded for stops that the manufacturer or Qualified Engineer has designated in the acceptance test procedure. As a minimum, the plot shall show the rope speed every 0.2 seconds from the initiation of the stop to when the rope is stopped. The final brake system settings and brake test values shall be documented in the acceptance test results.

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4.1.2 Terminals and stations

4.1.2.1 Power units

All aerial lifts shall be equipped with at least two power units, one of which, at a minimum, meets the requirements of 4.1.2.1.2.

All power units shall have the capacity to handle the most unfavorable design loading conditions, including the starting of the aerial lift loaded to 110% of capacity in weight. If downhill capacity is desired, the aerial lift shall comply with 4.1.2.4.

Where manual multispeed transmissions are used on a power unit, they shall not be shifted when the aerial lift is moving.

Where reverse capability is provided on a power unit for an aerial lift, provisions shall be made to prevent accidentally shifting into reverse whenever the aerial lift is operating.

No aerial lift shall be operated using a single power unit, except for unloading passengers or for maintenance purposes.

EXCEPTION – An aerial lift may continue loading passengers if the following requirements are met:

a) The power unit in use meets the requirements of a prime mover (see 4.1.2.1.1);

b) Evacuation gear and personnel shall be immediately available in sufficient number and quantity to evacuate the entire aerial lift in a period specified in the evacuation plan (see 4.3.2.5.7).

If changes are made to the drive system components that effect rotational inertia (i.e. removal of electric motor), the resulting stopping distances and deceleration rates shall meet the requirements of 4.1.2.5.

4.1.2.1.1 Prime mover

Power units engaged as a prime mover shall have the systems required in 4.1 and 4.2 functional during operation (see 1.4 – *prime mover*).

4.1.2.1.2 Evacuation power unit

An evacuation power unit (see 1.4 – *evacuation power unit*) with an independent power source shall be provided that can readily be used to unload the lift in the event of failure of the prime mover. The evacuation power unit shall not depend upon the mechanical integrity of any other power unit to drive the aerial lift. This unit shall be electrically wired to meet the requirements of 4.2.3.1 so that it can be stopped by the Emergency Shutdown Circuit. As a minimum, the evacuation power unit shall be capable of starting and moving a line with all carriers loaded to 110% of capacity in weight in a forward direction at not less than 100 feet per minute (0.51 meters per second).

The evacuation power unit shall be designed to become operational and move all the carriers to or through terminal areas within 1 hour from the time of initiating its connection.

4.1.2.1.3 Power unit interlock

System(s) or device(s) shall be installed that prevent two or more power units, which are not designed to operate together, from being actively connected to the drive system while operating. Electrical interlock systems shall comply with 4.2.4.

4.1.2.2 Speed reducers and gearing

All speed reducers and gearing shall have the capacity for starting an aerial lift under the most unfavorable design loading conditions without exceeding design rating. They shall have a service factor appropriate for the application.

4.1.2.3 Bearings, clutches, couplings, and shafting

Bearings, clutches, couplings, shafting and universal joint shafts (cardan shafts) shall be selected on the basis of the manufacturer's published data for the particular use. All shafting shall be designed in accordance with accepted standard practices. Guarding and containment shall be in accordance with the provisions of 4.1.2.7.

Provisions shall be made for adjustment and lubrication of all bearings, clutches, and couplings, when required.

4.1.2.4 Acceleration and speed control

The drive system shall be designed to accelerate and decelerate the line smoothly and to avoid severe oscillation or undulation under any design loading condition.

The aerial lift shall accelerate smoothly from a stop to the intended speed. After any type of stop is initiated, the stop cannot be canceled and the aerial lift may not be started until it has come to a complete stop.

The maximum average rope acceleration shall not exceed 2.0 feet per second squared (0.61 meters per second squared). The maximum rate of the rope deceleration shall not exceed 5 feet per second squared (1.52 meters per second squared). These rates measurements shall be measured over any one second interval under any operating condition and referenced to the rope speed at the drive terminal.

The drive system shall be capable of moving the unloaded system at reduced speed for rope inspection and equipment maintenance. This reduced-speed operation may be obtained by the use of the evacuation power unit.

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On installations in which an overhauling forward condition exists:

a) Provisions shall be made for an overhauling load so that the system shall operate at a controlled speed not exceeding maximum design rope speed by more than 6%. The energy developed by the overhauling load shall be dissipated in a satisfactory manner by an energy absorbing retarding device without using the brakes specified under 4.1.2.6. This requirement shall be met during operation with any power unit.

b) Provision shall be made for slowing and stopping the aerial lift drive system automatically if the line speed exceeds the design speed by more than 10%.

NOTE – Design values of line speed pertain to the design speed for the particular condition of operation (that is, skiers or foot passengers).

4.1.2.5 Stops and shutdowns

For all stops, the minimum average rate of the rope deceleration shall be 1.0 feet per second squared (0.30 meters per second squared) averaged from the beginning to the end of stop. The maximum rate of the rope deceleration shall be 5 feet per second squared (1.52 meters per second squared). These rates measurements shall be measured over any one second interval under any operating condition and referenced to the rope speed at the drive terminal.

See table 4-3 for minimum and maximum stopping times and distances.

Normal stop (see 1.4 – *normal stop*). If a service brake is required (see table 4-4), it shall have been applied by the time the aerial lift comes to a stop.

Emergency shutdown: (see 1.4 – *emergency shutdown*). If a service brake is required (see table 4-4), it shall have been applied by the time the aerial lift comes to a stop. The designer shall designate which control functions of the aerial lift system shall initiate an emergency shutdown.

The designer may define other stopping modes other than normal and emergency shutdown. For other stopping modes, the designer shall specify the method of stopping, including the type and timing of brake(s) that may be applied, and the stopping criteria.

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Table 4-3 Minimum and Maximum Stopping Times and Distances

Speed In Meters/Second

Speed	Time		Distance	
m/s	Seconds		Meters	
	Max.	Min.	Max.	Min.
1.2	4.00	0.79	2.40	0.47
1.3	4.33	0.86	2.82	0.56
1.4	4.67	0.92	3.27	0.64
1.5	5.00	0.99	3.75	0.74
1.6	5.33	1.05	4.27	0.84
1.7	5.67	1.12	4.82	0.95
1.8	6.00	1.18	5.40	1.07
1.9	6.33	1.25	6.02	1.19
2.0	6.67	1.32	6.67	1.32
2.1	7.00	1.38	7.35	1.45
2.2	7.33	1.45	8.07	1.59
2.3	7.67	1.51	8.82	1.74
2.4	8.00	1.58	9.60	1.89
2.5	8.33	1.64	10.42	2.06
2.6	8.67	1.71	11.27	2.22
2.7	9.00	1.78	12.15	2.40
2.8	9.33	1.84	13.07	2.58
2.9	9.67	1.91	14.02	2.77
3.0	10.00	1.97	15.00	2.96
3.1	10.33	2.04	16.02	3.16
3.2	10.67	2.11	17.07	3.37
3.3	11.00	2.17	18.15	3.58
3.4	11.33	2.24	19.27	3.80
3.5	11.67	2.30	20.42	4.03
3.6	12.00	2.37	21.60	4.26
3.7	12.33	2.43	22.82	4.50
3.8	12.67	2.50	24.07	4.75
3.9	13.00	2.57	25.35	5.00
4.0	13.33	2.63	26.67	5.26
4.1	13.67	2.70	28.02	5.53
4.2	14.00	2.76	29.40	5.80
4.3	14.33	2.83	30.82	6.08
4.4	14.67	2.89	32.27	6.37
4.5	15.00	2.96	33.75	6.66
4.6	15.33	3.03	35.27	6.96
4.7	15.67	3.09	36.82	7.27
4.8	16.00	3.16	38.40	7.58
4.9	16.33	3.22	40.02	7.90
5.0	16.67	3.29	41.67	8.22
5.1	17.00	3.36	43.35	8.56
5.2	17.33	3.42	45.07	8.89
5.3	17.67	3.49	46.82	9.24
5.4	18.00	3.55	48.60	9.59
5.5	18.33	3.62	50.42	9.95
5.6	18.67	3.68	52.27	10.32
5.7	19.00	3.75	54.15	10.69
5.8	19.33	3.82	56.07	11.07
5.9	19.67	3.88	58.02	11.45
6.0	20.00	3.95	60.00	11.84

Speed In Feet/Minute

Speed	Time		Distance	
ft/min	Seconds		Feet	
	Max.	Min.	Max.	Min.
240.0	4.00	0.80	8.00	1.60
260.0	4.33	0.87	9.39	1.88
280.0	4.67	0.93	10.89	2.18
300.0	5.00	1.00	12.50	2.50
320.0	5.33	1.07	14.22	2.84
340.0	5.67	1.13	16.06	3.21
360.0	6.00	1.20	18.00	3.60
380.0	6.33	1.27	20.06	4.01
400.0	6.67	1.33	22.22	4.44
420.0	7.00	1.40	24.50	4.90
440.0	7.33	1.47	26.89	5.38
460.0	7.67	1.53	29.39	5.88
480.0	8.00	1.60	32.00	6.40
500.0	8.33	1.67	34.72	6.94
520.0	8.67	1.73	37.56	7.51
540.0	9.00	1.80	40.50	8.10
560.0	9.33	1.87	43.56	8.71
580.0	9.67	1.93	46.72	9.34
600.0	10.00	2.00	50.00	10.00
620.0	10.33	2.07	53.39	10.68
640.0	10.67	2.13	56.89	11.38
660.0	11.00	2.20	60.50	12.10
680.0	11.33	2.27	64.22	12.84
700.0	11.67	2.33	68.06	13.61
720.0	12.00	2.40	72.00	14.40
740.0	12.33	2.47	76.06	15.21
760.0	12.67	2.53	80.22	16.04
780.0	13.00	2.60	84.50	16.90
800.0	13.33	2.67	88.89	17.78
820.0	13.67	2.73	93.39	18.68
840.0	14.00	2.80	98.00	19.60
860.0	14.33	2.87	102.72	20.54
880.0	14.67	2.93	107.56	21.51
900.0	15.00	3.00	112.50	22.50
920.0	15.33	3.07	117.56	23.51
940.0	15.67	3.13	122.72	24.54
960.0	16.00	3.20	128.00	25.60
980.0	16.33	3.27	133.39	26.68
1000.0	16.67	3.33	138.89	27.78
1020.0	17.00	3.40	144.50	28.90
1040.0	17.33	3.47	150.22	30.04
1060.0	17.67	3.53	156.06	31.21
1080.0	18.00	3.60	162.00	32.40
1100.0	18.33	3.67	168.06	33.61
1120.0	18.67	3.73	174.22	34.84
1140.0	19.00	3.80	180.50	36.10
1160.0	19.33	3.87	186.89	37.38
1180.0	19.67	3.93	193.39	38.68
1200.0	20.00	4.00	200.00	40.00

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4.1.2.6 Brakes and rollback device

The aerial lift shall have the following friction-type brakes and other devices as specified in table 4-4:

- service brake (see 4.1.2.6.1);
- bullwheel brake (see 4.1.2.6.2);
- rollback device (see 4.1.2.6.3);
- drive train backstop (see 4.1.2.6.4).

All braking systems shall be designed to ensure that:

a) Once the aerial lift begins movement in the intended direction, the brakes are maintained in the open position;

b) The service brake shall not open prior to the drive system developing sufficient torque to prevent overhauling;

EXCEPTION – For an aerial lift that overhauls only in the reverse direction, a drive train backstop may be used in lieu of the above.

c) Multiple brakes or brake systems shall not be simultaneously applied such that excessive deceleration is applied to the aerial lift under any anticipated conditions of loading;

d) The failure of one braking system to properly decelerate the aerial lift shall automatically initiate a second braking system, on an overhauling forward direction aerial lift.

The service brake, bullwheel brake, rollback device, and drive train backstop device shall be designed such that failure of one system will not impair the function of the other systems. All brakes shall have the braking force applied by springs, weights, or other approved forms of stored energy.

The service brake, bullwheel brake, rollback, and drive train backstop devices shall be designed to assure operation under all anticipated conditions.

Each braking system shall be capable of operation to comply with daily inspections and periodic testing.

The manufacturer or a Qualified Engineer shall furnish a written procedure to be followed, and specify the auxiliary equipment necessary for periodic testing and adjustment of the holding force of each brake and backstop device. The procedure shall additionally specify:

e) The minimum and maximum holding force for the service brake and bullwheel brake independently;

f) The minimum and maximum stopping distance for the service brake and bullwheel brake independently, with a specified loading condition.

This baseline procedure shall be performed at the completion of the acceptance test and then at the frequency specified in order to demonstrate the ability of each brake to produce the required force (see 4.1.1.11.2).

Testing shall be accomplished as part of normal maintenance during the operating season, but shall not be performed when the aerial lift is open to the public. As a minimum, this testing shall be performed monthly during the operating season.

If a device is permanently installed to cause a brake, rollback, or drive train backstop device to be disabled for testing, it shall be monitored so that the aerial lift cannot be operated in its normal mode when the brakes are so disabled.

Table 4-4 Required stopping devices

Aerial lift category	Service Brake	Bullwheel brake	Rollback device	Drive Train backstop	Retarding device (see 4.1.2.4)
Self braking: A lift that decelerates, stops & remains stopped within the service brake performance requirements without a braking device	Not Required*	Required	Not Required	Not Required	Not Required
Non-overhauling: A lift that will not accelerate in either direction when it is not driven, but is not self-braking	Required	Required	Not Required	Not Required	Not Required
Overhauling reverse direction: A lift that will accelerate in the reverse direction when it is not driven	Required*	Required	Required	Required	Not Required
Overhauling forward direction: A lift that will accelerate in the forward direction when it is not driven	Required	Required	Not Required	Not Required	Required
* A service brake is not required if the overhauling, reverse direction aerial lift will meet the service brake stopping requirements under the most unfavorable design loading conditions					

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4.1.2.6.1 Service brake

The service brake shall be located at any point in the drive system such that there is no belt, friction clutch, or similar friction-type device between the brake and the drive bullwheel. The service brake shall not act on the same braking surface as the bullwheel brake.

The service brake shall be an automatic brake to stop and hold the aerial lift under the most unfavorable design loading condition. The deceleration rate or stopping distance specified in 4.1.2.5 shall be achieved by the service brake without the aid of other braking devices or drive regeneration.

The brake shall be in a normally applied position. It shall be held open for operation of the aerial lift and shall be applied when the aerial lift is stopped.

4.1.2.6.2 Bullwheel brake

The bullwheel brake shall operate on any drive terminal bullwheel assembly that meets the requirements of 4.1.2.8.2.

The bullwheel brake shall be capable of being activated both manually and automatically to stop and hold the aerial lift under the most unfavorable design loading condition. Deceleration rates or stopping distances specified in 4.1.2.5 shall be achieved by the bullwheel brake without the aid of other braking devices or drive regeneration.

On an aerial lift that is categorized as non-overhauling or self braking (see table 4-4), the bullwheel brake shall act automatically on a reverse direction rotation exceeding 36 inches (915 mm).

On an aerial lift that is categorized as overhauling reverse direction (see table 4-4), the bullwheel brake shall act automatically as follows:

a) A reverse direction rotation exceeding that which normally activates the rollback device (see 4.1.2.6.3);

b) The speed of the haul rope exceeds the maximum design rope speed by 15% in the reverse direction.

Note – Based on passenger loading, a lift can be categorized as overhauling reverse direction, overhauling forward direction, or both.

On an aerial lift that is categorized as overhauling forward direction (see table 4-4), the bullwheel brake shall act automatically when the speed of the haul rope exceeds the maximum design rope speed by 15% in the forward direction.

Application of the bullwheel brake shall automatically disconnect the power source to the power unit in use.

4.1.2.6.3 Rollback device

The rollback device shall act directly on the drive bullwheel assembly or on the haul rope. When it has been determined that under the most unfavorable design loading condition, haul rope slippage will not occur, the rollback device may be located at the return bullwheel assembly. However, the rollback device shall not be located at other than the drive station, unless its location will not decrease the factor of safety of the haul rope below the minimum permissible value whenever the rollback device is statically engaged.

Under the most unfavorable design loading condition, the rollback device shall automatically stop reverse rotation of the aerial lift before the haul rope travels in excess of 36 inches (915 mm) in the reverse direction (see 4.2.3.7 for electrical requirements).

4.1.2.6.4 Drive train backstop

A drive train backstop device shall conform to the following requirements:

a) A drive train backstop device is a one-way or overrunning clutch device. The drive train shall be so arranged that there is no belt, friction clutch, or similar friction-type device between the backstop device and the drive bullwheel;

b) The backstop device shall be rated for the maximum design load;

c) Under the most unfavorable design loading condition, the backstop device shall automatically prevent reverse rotation of the aerial lift before the aerial lift travels in excess of 36 inches (915 mm) in the reverse direction.

4.1.2.7 Location of machinery

4.1.2.7.1 General

Moving machine parts that normally may be in reach of personnel shall be fitted with guards. Where breakage of a power transmission component can result in injury, provisions shall be made for appropriate containment of said components. Guards and containment shall be done in conformance to American National Standard, ANSI/ASME B15.1-2000 (R2008), *Safety Standard for Mechanical Power Transmission Apparatus*.

Protection against static electricity shall be provided.

Fire-fighting device(s) shall be available (see F.6 in Annex F).

4.1.2.7.2 Machinery not housed in a machine room

Provisions shall be made to keep the public away from the machinery. All machinery and controls shall be rated for use in their intended environment.

4.1.2.7.3 Machinery housed in a machine room

The machine room shall be adequately ventilated. It shall have a permanently installed lighting system, adequate for proper machinery maintenance and to reduce the risk of injury to operating personnel. The arrangement of the machinery shall permit proper maintenance. A door with a suitable lock shall be

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provided, and the design shall keep the public away from the machinery. When a passageway is provided between machines or machinery and walls, a minimum passageway width of 18 inches (460 mm) shall be maintained. Means shall be provided to heat the machine room unless the designer or manufacturer certifies in writing that the drive system machinery is rated for operation in an unheated room.

4.1.2.8 Bullwheels and sheaves in terminals and stations

4.1.2.8.1 General

All bullwheels and sheaves, including their mountings and frames, shall be designed to withstand static and dynamic loads. Bearings and mountings shall be selected, designed, and installed in accordance with the recommendations of the manufacturers of the bearings.

When unlined grooves are used for wire rope, they should be V-shaped and shall have rounded bottoms with a radius equal to approximately 55% of the rope diameter.

When lined grooves are used, the allowable bearing pressures of the liner material shall not be exceeded.

4.1.2.8.2 Haul rope terminal bullwheels

Provisions shall be incorporated in the terminal design to retain the terminal bullwheels in their approximate normal operating position in the event of failure of the bearings, shaft, or hub.

Provisions shall be incorporated in the terminal and rope retention design to control the position of the rope, including possible overhaul, to minimize the effects of its departure from its normal operating position.

The minimum diameter of terminal bullwheels shall be 80 times the nominal diameter of the haul rope. The bullwheel assembly or related structures shall be designed to minimize the probability of a deropement. A flange extension of 1-1/2 times the rope diameter (measured radially from the bottom of the rope groove) shall be one acceptable means of minimizing the probability of deropement when in full compliance with the provisions of 4.1.2.8.4.

Haul rope terminal bullwheels that act as driving, braking, or holding bullwheels shall be so designed that the haul rope does not slip in the bullwheel groove. The design coefficient of friction for a particular bullwheel liner shall not exceed the values shown in table 4-5.

Table 4-5 Design coefficient of friction for bullwheel liners

Bullwheel liner	Coefficient of friction
Steel or cast iron grooves	0.070
Leather	0.150
Rubber, neoprene, or others	0.205

4.1.2.8.3 Sheaves in tension systems and sheaves not specifically covered elsewhere in this section

The minimum diameters for these sheaves shall be as indicated in table 4-6.

Condition A: is applicable where bending around a sheave is of major importance.

Condition B: is applicable where bending around sheave is important, but some sacrifice in rope life is acceptable to achieve reduction in weight, economy in design, and the like.

Condition C: is applicable to sheaves that are not intended to rotate due to any tension system movement but are intended to rotate only due to tension system adjustment.

Provisions shall be made to assure that all tension system sheaves rotate freely.

4.1.2.8.4 Haul rope line sheaves

The requirements of 4.1.3.3 are applicable to haul rope line sheaves used in terminals and stations, with the following exceptions:

a) Sheaves that carry no load other than the weight of the rope and carriers;

b) Sheaves that are located in such a way that carriers attached to the cable are not passing onto the sheaves.

In such cases, the design shall be modified to meet the requirements of the particular installation.

Guide sheaves shall be located in order to prevent misalignment of rope entering and leaving the drive and return bullwheels. Such sheaves shall be as close as practicable to the drive and return bullwheels, but not farther than one diameter of the drive or return bullwheel from the point of tangency. Shoes, rollers, or sheaves shall be placed on the opposite side of the rope adjacent thereto, to prevent deropement in that direction.

These requirements apply to all installations except floating tension bullwheel carriages (see 4.1.2.9.3).

Table 4-6 Minimum diameters for sheaves in tension systems and sheaves not specifically covered elsewhere in this section

Rope Type	Sheave diameter		
	Condition A	Condition B	Condition C
6x7	72*d*	42*d*	24*d*
6x19	45*d*	30*d*	20*d*
6x37	27*d*	18*d*	12*d*
NOTE: - *d* equals the nominal rope diameter			

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4.1.2.9 Tension bullwheel carriages

The available travel of the tension bullwheel and carriage shall be adequate for the maximum limits of motion produced by the most unfavorable design loading and operating conditions.

4.1.2.9.1 Rigid mounted carriages

The bullwheel carriage shall be supported from the ground by a rigid structure. The mounting that travels under the action of the tension system shall be supported on rigid, straight rails by means of wheels or other low friction devices. All design loads including torsional loads due to driving torque, braking torque, or reactions of a rollback device shall be considered, and the structure and carriage shall adequately transmit these loads to the foundations.

4.1.2.9.2 Mechanical stops for rigid mounted carriages

Mechanical stops shall be provided to prevent overtravel of the tension carriage. These stops, and the terminal structure, shall be designed to resist, at normal design stresses, an unbalanced horizontal force on the tension bullwheel applied in the direction of the opposite terminal and equal in magnitude to 30% of the tension system reaction on the tension bullwheel.

4.1.2.9.3 Floating tension bullwheel carriages

The bullwheel mounting shall be installed and operated in such a manner that the haul rope, in every case, considering every possibility of overloading, remains in the center of the bullwheel groove. The lateral tilt of the bullwheel shall not exceed 2 degrees from the horizontal when in a stationary position, and when the up-going and down-going unloaded carriers are equidistant from the bullwheel.

To prevent excessive lateral tilt in case a loaded carrier passes around the bullwheel, the tension system or anchor cables shall be connected to at least two points on the mounting frame of the bullwheel. The connections of the tension system or anchor cables to the bullwheel frame and the support points of the cables shall be spaced a minimum of 70% of the pitch diameter of the bullwheel and increased as necessary to limit the allowable lateral tilt of the bullwheel to a maximum of 6 degrees from the static position when passing a carrier with full design load.

The design shall incorporate provision for adjustment to control the position of the haul rope entering the terminal bullwheel.

4.1.2.10 Tension systems

Counterweights, hydraulic and pneumatic cylinders, or other suitable devices shall be used to provide the tensioning requirements of the particular installation. All devices used to provide the tension shall have sufficient travel to adjust to all normal operating changes in loading and temperature.

The tension for haul ropes for all modes of operation shall be determined by the design engineer. Tension systems may be active or passive. Active systems shall have monitoring equipment that will automatically prevent operation outside of design limits (see 4.2.3.3 and 4.2.5.1 for electrical requirements).

Passive tension systems, (i.e. fixed anchorage) shall have a system or procedure to determine that the ropes and/or cables are within their operating tension range. The manufacturer or Qualified Engineer shall specify the checking procedures and intervals.

Tension systems may be adjustable to provide proper tensions for different modes of aerial lift operation.

The tension system design shall consider changes, for each mode of operation, in tensions due to rope elongation, friction and other forces affecting traction on driving, braking, or holding bullwheels, tower and sheave loading, and maximum vertical loads on grips to assure that tensions remain within design limits.

4.1.2.10.1 Hydraulic and pneumatic systems

Hydraulic and pneumatic cylinders, when used, shall have sufficient ram travel to accommodate all normal operating changes in loading and temperature. Provisions shall be made to keep the cylinder free from climatic-induced conditions and contaminants that may interfere with free movement.

If the system fails to provide the design operating pressure, the aerial lift shall be able to be operated to unload passengers.

Cylinders and their attachments shall each have a minimum factor of safety of 5. The factor of safety is equal to the ultimate tensile strength of the cylinder divided by the maximum steady-state design tension.

The systems providing operating pressure for the cylinder shall have a minimum factor of safety of 5 unless a high-velocity check-valve or flow-control device is used where the pressure line is connected to the cylinder. The check-valve shall be rated to hold twice the normal operating pressure. The remainder of the system shall not exceed the manufacturer's published working pressures. Provisions shall be made to restrict the movement of pressure lines or hoses should they become severed under pressure. When pneumatic storage cylinders, accumulators, or other similar devices are used, they shall be located so that they cannot be knocked over or damaged.

4.1.2.10.2 Counterweights

Counterweights, when used, shall be arranged to move freely up and down. Enclosures for counterweights shall be provided where necessary to prevent snow, ice, water, and other materials from accumulating under and around the counterweights and interfering with their free movement. Visual access shall be provided to areas beneath and above all counterweights contained in enclosures or pits. When a counterweight is contained in

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a structural frame, guides shall be provided to protect the frame and to ensure free movement of the counterweight. Where snow enclosures are not required, guardrails or enclosures shall be provided to prevent unauthorized persons from coming in contact with or passing under counterweights.

4.1.2.10.3 Wire ropes in tension systems

Wire ropes in tension systems shall have a minimum factor of safety of 6 when new (see A.1.3.1 in Annex A). On arrangements involving rope reeving, the maximum design static tension with sheave friction taken into account shall be the basis for determining the factor of safety. See A.3 in Annex A for additional requirements. No rotation-resistant ropes shall be used in tension systems (see 1.4 - *rotation-resistant rope*).

Wire ropes in tension systems shall be adjusted so that the counterweight will reach the end of its travel before the attached tension bullwheel carriage comes within 6 inches (150 mm) of the end of its travel. When wire ropes are used with pneumatic or hydraulic cylinders, they shall be adjusted so that connecting devices will not contact the reeving devices before the ram reaches the travel limits of the cylinder.

4.1.2.10.4 Chains in tension systems

Welded link chains may be used in tension systems (see normative Annex G).

Roller and leaf chains are prohibited for tension system usage on aerial lifts that are classified as new (see informative Annex H).

4.1.2.10.5 Cable winches or chain adjusting devices

Winches or other mechanical devices that are used for take-up and remain part of the system shall have a minimum factor of safety of 6 against their ultimate capacity. They shall have a positive lock against release. Where this factor cannot be established by the manufacturer's endorsement, a device shall be installed on the tension system rope or chain ahead of the winch/mechanical device that will keep the tension system intact in the event of failure or release of the device.

The diameter of the winding drum shall not be less than the specified minimum sheave diameters referenced in 4.1.2.8.3 - Condition C for rope.

4.1.2.11 Anchoring devices

All anchoring end connections shall be above finished grade. Any portion of an anchorage below ground shall be protected against loss of strength due to corrosion.

Wire ropes or strands and their connections, used to anchor, tension, or otherwise secure terminal structures, shall be designed with a minimum factor of safety of 6. Where adjusting devices are used in the arrangement, the devices shall be capable of being securely locked or removed during operation.

All connections of ropes or cables used in anchoring devices shall be in accordance with the requirements of A.3.2 in Annex A.

4.1.3 Line structures

4.1.3.1 Towers

The design of the tower structure and foundation shall be in accordance with the requirements of 4.1.1.6. Where guyed towers are used and guys intersect the ground within or near ski runs, the guys shall be marked for visibility.

Means shall be provided for ready access from the ground to all tower tops. Permanent ladders are required for heights above those accessible by portable ladders. Portable ladders, if used, shall be in at least sufficient quantity to be available at each point where attendants are stationed. Portable ladders extending more than 20 feet (6.10 meters) shall not be used.

Permanent anchor points shall be provided on all tower tops for the attachment of fall protection devices.

Towers shall be identified with successive numbers clearly visible to passengers.

Where towers are designed to permit variations in rope height, sheave unit supports shall be guided and attached so as to prevent misalignment by rotation during normal operation.

4.1.3.2 (Reserved)

4.1.3.3 Haul rope sheaves and mounts

The tread diameter of a haul rope sheave shall not be less than 10 times the nominal diameter of the haul rope unless an elastomer liner is used.

The requirements in 4.1.3.3 and 4.1.3.3.1 through 4.1.3.3.3 apply generally to sheaves that support or hold down the haul rope at towers on a monocable system. These requirements shall apply to both sides of each aerial lift.

4.1.3.3.1 Maximum allowable sheave load

The maximum allowable load per sheave shall be determined by the aerial lift designer.

4.1.3.3.2 Sheave and sheave unit design

Sheave flanges shall be as deep as possible, considering other features of the system. At the same time, rope grips shall be designed in relation to the sheave groove so as not to contact sheave flanges during normal operations, taking into consideration the anticipated amount of wear of the sheave liner groove. Grips shall be allowed to contact sheave flanges adjacent to the haul rope when the carrier swings, provided that this is considered in the design of the grips

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and sheaves. Furthermore, rope grips, sheave flanges, and hanger guides shall be designed so that hangers cannot be caught behind guides, and so that haul ropes and grips cannot be deroped from sheaves if the carrier is swinging within design limits as it approaches or passes the tower.

If the gauge of the haul rope system is varied at any point along the line, the horizontal departure at any one tower shall be provided for in the design so that deropement cannot occur by virtue of such a departure.

Sheave unit design shall include the following features:

a) Suitable guards, of sufficient strength to resist the lateral forces caused by an inside deropement, shall be installed;

b) Construction of the entire sheave unit shall be such that the haul rope cannot become entangled in the sheave unit in the event the rope leaves the sheave toward the outside;

c) Sheave mounts or mounting frames shall be designed to be adjustable, allowing the sheave units to be aligned and held in the plane of the rope;

d) On each sheave unit, rope-catching devices shall be installed to reduce the risk of the haul rope moving excessively in the direction of the load on the sheave unit in the event of deropement. These devices shall be located less than one-half the diameter of the sheaves from the normal operating position of the rope and shall extend a minimum of two rope diameters beyond the sheave flange. Alternatively, when the catcher is located so that the rope cannot move in the direction of the load when it passes from the edge of the sheave to a position in the catcher, the catcher shall extend a minimum of two rope diameters beyond the center of the rope when the rope has reached the point where the deropement switch device initiates a stop;

e) Rope-catching devices shall be designed to permit the passage of the haul rope and grips after deropement. The catcher shall be independent from the sheave;

f) On each sheave unit, suitable deropement switch devices shall be installed and maintained that will stop the lift in case of deropement (see 4.2.3.4);

g) On lifts where the carrier speed exceeds 600 feet per minute (3.0 meters per second), at least one device that senses the position of the rope shall be installed (see 4.2.5.2).

See also 4.1.1.5 through 4.1.1.5.3 for the effect of tower height and location on sheave units.

4.1.3.3.3 Haul rope retention

Provisions shall be made to retain the haul rope in the line sheave groove under all anticipated conditions of loading. This criterion shall be deemed to have been met if any of the following conditions is fulfilled:

Condition A: Under the most adverse design loading conditions (excluding dynamic effects), the minimum load of the haul rope on a group of support sheaves at a tower shall not be less than the largest of the following values: 100 pounds (445 newtons) per sheave; or 300 pounds (1335 newtons) per tower group; or a value in pounds equal to two-thirds the sum of the adjacent span lengths expressed in feet of slope length (a value in newtons equal to 10 times the sum of the adjacent span lengths expressed in meters of slope length).

When the haul rope elevation at the tower lies below a straight line joining haul rope elevations at the adjacent towers, the haul rope shall not leave the group of sheaves under either of the following conditions:

a) when the haul rope tension is 1.5 times its maximum design value at the point, using unloaded carriers in adjacent spans;

b) when a haul rope is under tension of the tension system alone (bare rope) or with any arrangement or number of empty carriers on the line.

The minimum load of the haul rope on a group of hold-down sheaves at a tower under the most adverse design loading conditions shall not be less than the larger of the following values: a value in pounds equal to the dead plus live load of the carrier; or a value in pounds equal to the sum of the adjacent span lengths expressed in feet of slope length (a value in newtons equal to 15 times the sum of the adjacent span lengths expressed in meters of slope length). In no case shall this load be less than 225 pounds (1000 newtons) per passenger.

Condition B: Combination sheave units that incorporate support and hold-down sheaves shall be designed with the retaining sheaves always in contact with the haul rope. When retaining sheaves are mounted to deflect, to allow passage of a carrier grip, such deflection shall not occur until the sheave is loaded to one-half of the maximum design sheave loading. The retaining sheaves shall have the same maximum design loading as the other support or hold-down sheaves on the tower. If the design satisfies loading requirements in Condition A, nothing in this paragraph shall preclude the use of rollers or guides opposite the tower sheaves that do not necessarily contact the rope.

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4.1.4 Line equipment

4.1.4.1 Haul rope

See Annex A for basic wire rope design and installation requirements.

4.1.4.1.1 Factor of safety

When the slope length of the installation is less than 3000 feet (914 meters), the haul rope shall have a minimum static factor of safety of 5 when new. For slope lengths greater than 3000 feet (914 meters), the haul rope may have a minimum static factor of safety of 4.5 when new. Static factor of safety is equal to the minimum breaking force (see A.1.3 in Annex A) divided by the computed maximum tension caused by design loads, including the effects of friction, but excluding dynamic loads, in the section of the haul rope that is most highly stressed.

4.1.4.1.2 Factor of safety for spliced haul rope with and independent wire rope center

Where a spliced haul rope with an independent wire rope center (IWRC) is used, the minimum breaking force of an equivalent wire rope with a fiber core shall be used.

4.1.4.2 (Reserved)

4.1.4.3 Haul rope grip

4.1.4.3.1 General

The haul rope grip shall be of a type that has been approved by a Qualified Engineer. Grips shall be tested and manufactured using accepted engineering and quality practices. The manufacturer shall permanently affix a unit identification and size marking to each grip. Each grip shall be nondestructively tested before public use, and such testing shall be documented.

The haul rope grip shall be designed to pass smoothly over and under line sheaves that have flanges of adequate height to discourage the haul rope from leaving the sheaves.

The design shall incorporate provisions to accommodate a 10% reduction in haul rope diameter. The designer's instructions shall provide details for the proper initial setting of the grip and a method to assure an operator or inspector that the grip has not reached an operational limit of the clamping components.

4.1.4.3.2 Slippage

The haul rope grip shall be designed and maintained during use so as to resist a force that tends to slide it along the haul rope that is a minimum of 3 times the force required to move a carrier along a properly lubricated haul rope at its steepest incline, under the most adverse conditions of carrier loading. The grip shall automatically adjust to maintain this gripping force with a 3% reduction in haul rope diameter.

The grip designer shall specify the proper grip installation and testing procedures, and for clamping type grips, the minimum force below which the grip should not slip on the rope and a maximum force above which the grip should slip on the rope.

4.1.4.3.3 Strength

The strength of the grip shall be based upon the following criteria:

a) A factor of safety of 6 shall exist in all parts of the grip wherein stress is proportional to the dead and live load of the carrier. This factor of safety is defined as follows: With the grip in its operating condition (gripping the rope or equivalent), a load applied in the usual direction (that is, downward when grip is in the operating position), equal to the dead load of the carrier plus 6 times the design live load, shall not cause any part of the grip to fail;

b) Those parts whose stress is not changed by application of live load shall be designed on the basis of an allowable stress of not more than the yield point divided by 3.0. In the design of springs, where used, the allowable stress may be increased if load tests are conducted by an approved testing laboratory to provide assurances that the fatigue life of the actual spring is more than ample for the various applied loads;

c) For stresses caused by lateral loading, such as centrifugal force, the provisions of 4.1.4.5.2 shall apply;

d) The material of which the grip is made shall be selected or selected and treated to obtain optimum impact resistance;

e) Special attention shall be paid to fatigue considerations. A grip that has not been proved in service should be subjected to fatigue tests.

The manufacturer's quality control provision shall assure that the grips and their parts meet the designer's specifications and the foregoing criteria.

4.1.4.3.4 Maximum loads

The maximum total vertical load on a single grip shall not exceed 1/14 of the minimum tension in the haul rope.

Where two grips are used for a single carrier, the foregoing requirement may be applied to each grip, provided that:

a) the two grips are independent of each other (that is, articulated in such a manner that they are independently loaded);

b) the clear length of haul rope between the two grips equals or exceeds one-half rope lay.

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4.1.4.4 Carriers for fixed grip gondolas

The carrier and all components shall be designed by Qualified Engineers in accordance with accepted practices of design. If the design has not had prior successful use for passenger transportation, its adequacy shall be verified by test loadings, trial operations, and tests under repeated loadings.

The aerial lift designer or manufacturer shall develop a Carrier Inspection Plan (see 4.3.4.3).

4.1.4.4.1 Hanger

The hanger shall be securely attached to the haul rope grip and to the cabin in such a manner that it cannot work loose.

The hanger shall be of sufficient vertical length that, under the worst condition of longitudinal swing, no portion of the cabin can strike the haul rope. In any event, the carrier shall be able to swing longitudinally without interference to an angle of 15 degrees from the vertical at the most adverse locations.

Sway dampers designed to reduce the longitudinal sway of the carrier shall be used if recommended by the aerial lift designer. Where used, they shall operate smoothly and without danger of deropement of the haul rope.

4.1.4.4.2 Cabin

Fully enclosed passenger cabins shall be ventilated. They shall be equipped with doors that fill the entire entrance opening. The minimum clearance width opening shall be 32 inches (815 mm). Each door shall be provided with a lock located in such a manner that it can be unlocked only by authorized persons or by automatic means.

The horizontal gap between the cabin door opening floor edge and platform edge shall not be greater than 1 inch (25.4mm). The height of the cabin floor and the platform shall be within ± ½ inch (±12.7mm). Where it is not operationally or structurally practical to meet these requirements, platform devices, vehicle devices, system devices, or bridge plates shall be provided for independent loading.

All windows shall be of shatter-resistant material.

Means of emergency evacuation of passengers shall be provided.

The maximum capacity of each cabin, both in pounds and kilograms and number of passengers, shall be posted in a conspicuous place in each cabin (see Annex D).

The minimum clear floor space in accessible cabins shall be 48 inches by 30 inches (1220 mm X 760 mm). Where special accessible cabins are used, it is recommended the waiting interval should not exceed 10 minutes.

All carriers shall be clearly identified with numbers located on each end of each carrier.

Semi-open carriers shall meet applicable requirements for enclosed cabins and open chairs.

4.1.4.5 Carriers for fixed grip chair lifts

4.1.4.5.1 Vertical loads

With respect to vertical loads, chair lift carriers shall be designed to support a vertical load 4 times the design load without permanent deformations of the assembly or component parts.

4.1.4.5.2 Horizontal loads

With respect to horizontal loads, such as centrifugal loads that stress the hangers as they pass around terminal bullwheels, the parts of the assembly, including hangers and grips, shall be designed with a factor of safety of 3.6 for an empty carrier with respect to the yield point of the material(s). For this purpose, the applied load is to be taken as the computed force considered as a static load.

When safety stops are not provided to prevent the passage of loaded chairs around the bullwheels, lift components such as chairs, hangers, grips, bullwheels, guides, and the like, shall be designed to withstand, with a factor of safety of 2 (with respect to the yield point of the materials involved), the stresses developed when a loaded carrier passes around the bullwheel at full speed. Certification of a test shall be provided by the manufacturer that a loaded carrier with twice the design load had been passed around the bullwheel at full speed of a chair of identical design and fabrication without any yielding of the chair tested.

4.1.4.5.3 Identification

All carriers shall be clearly identified with successive numbers visible to the operator and attendant.

4.1.4.5.4 Chair safety details

Each chair shall be equipped with a railing at each side, to a height of not less than 4 inches (100 mm) above the seat for a distance of not less than 12 inches (305 mm) from the back of the seat.

For aerial lifts operating primarily for skiers, the thickness of the chair seat front, including padding, shall not exceed 5 inches (125 mm) from the top of the seating surface to the bottom of the curl. Tilt back angle of the seat bottom should be a minimum of 7 degrees when loaded. Loaded shall mean an evenly distributed load using load test criteria. Provisions shall be made to keep the tails of skis from passing through and becoming trapped in open spaces between framework, safety restraints and chair seat underside.

For aerial lifts operating primarily for foot passengers, each chair shall be equipped with a restraining device that will not open under forward pressure.

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4.1.4.5.5 Hanger and carrier testing

The aerial lift designer or manufacturer shall develop a Carrier Inspection Plan (see 4.3.4.3). Such information shall be made a part of the aerial lift maintenance manual (see 4.1.6.2).

4.1.5 Provisions for operating personnel

Operator and attendant work positions shall be located to provide visual surveillance of the station and the line in the vicinity of the station. When the work position is enclosed, they shall be heated, ventilated, and lighted as required to perform the assigned duties. An enclosed work position shall contain inside:

a) the communications and controls required of the station;

b) the operating instructions and emergency procedures;

c) a fire extinguisher (see F.6 in Annex F).

This does not preclude additional communications and controls located outside the work position enclosure.

All primary aerial lift controls and communications shall be immediately available to him/her. The physical appearance, operation, and location of emergency shutdown devices shall differentiate them from other operating devices or controls.

Loading and unloading areas shall have manual stopping devices located conveniently to the attendants assigned to those areas (see 4.2.9).

4.1.6 Operational and maintenance manuals

4.1.6.1 Operational manual

The designer of each new or relocated aerial lift shall prepare an operational manual in English for that installation. The manual shall describe the function and operation of the components and provide instructions for the correct usage of the installation.

4.1.6.2 Maintenance manual

The designer of each new or relocated aerial lift shall provide with delivery of the installation, a maintenance manual in English for that installation. The manual shall describe recommended maintenance and testing procedures including:

a) types of lubricants required and frequency of application;

b) definitions and measurements to determine excessive wear;

c) recommended frequency of service to specific components, including relocation of fixed grips;

d) Carrier Inspection Plan;

e) brake testing and adjustment;

f) dynamic testing procedure.

4.2 Electrical design and installation

4.2.1 General design and installation testing

Prior to operation of newly installed aerial lifts or after any modification thereafter of the electrical system, the electrical system shall be tested and shown to meet the requirements of this standard and the test results shall be recorded. Design of all electronic controls and drives shall consider minimum sensitivity to electrical noise and electrical emissions, such as noise spikes from power lines and lightning, radio transmitters, thyristors (SCR), or solenoid or relay noise at levels and frequencies that could initiate loss of control.

4.2.1.1 Applicable codes

All electrical systems shall comply with American National Standard, ANSI/NFPA 70-2011, *National Electrical Code* and the Institute of Electrical and Electronics Engineers, IEEE C2-2007, *National Electrical Safety Code*.

4.2.1.2 Location

All electrical power transmission wiring located near or proposed to cross over aerial lifts shall comply with the applicable requirements of IEEE C2-2007.

4.2.1.3 Protection

All electrical equipment with operating voltages above 24 volts nominal shall be marked conspicuously with letters/numbers that are no smaller than ¼ inch (6 mm) in height designating the greatest voltage that may be in the equipment, the number of phases and whether the voltage is alternating or direct current. All electrical equipment rated over 600 volts shall be marked with conspicuous warning signs stating “Danger High Voltage”.

EXCEPTION – 120-volt single-phase lighting circuits and convenience outlets.

All power equipment shall be protected against overloads by circuit breakers or fuses.

In locations where electrical equipment, including batteries, is likely to be exposed to physical damage, enclosures or guards shall be so arranged and of such strength as to prevent such damage.

4.2.1.4 Overhead cables

Only signal, communication, and control circuit cables may be supported between towers that support the aerial lift. Voltage shall be limited to low voltage, 24 volts nominal.

EXCEPTION – Circuits for telephone systems may exceed the low voltage requirements.

Overhead cables shall be securely mounted to tower and terminal structures and positioned in such a way that they do not contact the haul rope, track rope, or carriers under normal aerial lift operating conditions. If a cable parts and displaces from its normal position, the aerial lift shall stop (see 4.2.5(d)).

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4.2.1.5 Wiring

All wiring shall be in accordance with the designer's specifications and applicable codes.

4.2.1.5.1 Control wiring classification

All control wiring shall be Class 1 in accordance with Article 725 of ANSI/NFPA 70-2011.

EXCEPTION – Overhead cables (see 4.2.1.4).

4.2.1.5.2 Communication wiring

All communication wiring and systems are exempted from the requirements in Article 800 of ANSI/NFPA 70-2011.

4.2.1.5.3 Insulation

All control wiring is exempted from the requirements of Article 725.49 Part B of ANSI/NFPA 70-2011. The designer shall specify conductor, type, and insulation suitable for the electrical and mechanical requirements of the application.

4.2.1.5.4 Exterior lighting and snowmaking circuits

All ungrounded exterior lighting and snowmaking circuits, mounted on or within 60 feet (18.3 meters) of the aerial lift centerline, shall have ground fault protection (see 1.4 – *ground fault protection*).

4.2.1.5.5 Ground fault circuit interrupter protection for personnel

All 120-volt single phase, 15 and 20 ampere receptacles in areas where electrical diagnostic equipment, electrical hand tools, or portable lighting equipment may be used shall have ground fault circuit interrupter protection for personnel (see 1.4 – *ground-fault circuit interrupter*).

EXCEPTION – Receptacles dedicated to permanently mounted devices need not comply with this requirement.

4.2.1.6 Grounding

4.2.1.6.1 Structures

All metallic structures shall be bonded to form a grounding electrode system as defined in Article 250 of ANSI/NFPA 70-2011. Electrical continuity of all metal parts of the structures shall be assured by mechanical connection and shall be electrically bonded to the common bonding conductor.

4.2.1.6.2 Drive terminal structure

The drive terminal structure shall have one point referred to as the grounding electrode, as defined in ANSI/NFPA 70-2011. All dc and ac electrical systems shall be referenced to this point. If an electrical prime mover is used, the electric service grounding conductor shall terminate at this point, as well as the structure's ground referenced in 4.2.1.6.1. Under the worst-case conditions, the resistance from the grounding electrode to any grounded point within the aerial lift system shall not exceed 50 ohms, for the purpose of grounding the electrical circuit. The grounding system for the aerial lift shall not be used as a grounding system for any other system not related to the aerial lift system.

To ensure that the 50-ohm grounding requirement is met under all conditions of soil, moisture, temperature, and circulating ground and air currents, all terminal and line structures shall be bonded together with a common bonding conductor. The bonding conductor may be the support or messenger cable of an overhead control cable, the ground shield for an underground control cable, or some other conductor running the full length of the aerial lift system, bonded to each of the terminals and the line structures and shall be of sufficient conductance to meet the 50-ohm requirement.

4.2.1.6.3 Haul rope grounding

Grounding sheaves or equivalent means shall be provided at one location for the purpose of grounding haul ropes, as applicable, for static electrical discharge. For systems with an isolated or insulated haul rope incorporated in the operating circuitry, no means of grounding are required when the operating circuit takes into consideration static electrical discharge.

4.2.1.6.4 Lightning protection

If lightning protection is provided, it shall follow ANSI/NFPA 780-2008, *Standard for the Installation of Lightning Protection Systems.*

4.2.2 Electrical system circuit design and classification

The designer or lift manufacturer responsible for the design shall identify and classify any new electrical circuits not already classified as protection circuits, operations circuits, or supervision circuits.

4.2.2.1 Circuit priority

Protection circuits shall have priority over all other circuits. Operation circuits shall have priority over supervision circuits. If any circuit's function is connected to circuits of a higher level of protection, it shall be classified at the higher level.

4.2.3 Protection circuits

Electrical circuits designed to stop the aerial lift in the event of a malfunction or failure of the aerial lift system shall be classified protection circuits. All aerial lift systems shall contain two or more protection circuit(s) at least one of which shall be designated the emergency shutdown circuit (see 4.2.3.1). Protection circuits shall be energized to permit system operation and when de-energized shall initiate a stop, or shall be of such design to provide the equivalent level of protection.

A protection circuit may include one or more non-complex elements (see 1.4 – *non-complex element*) and/or complex electronic elements (see 1.4 – *complex electronic element*). The designer shall make use through continuous diagnostic coverage (see 1.4 –

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continuous diagnostic coverage) that the failure of a complex electronic element will cause the aerial lift to stop unless another element in the protection circuit is performing the same function (redundancy). If functional redundancy is implemented, the failure of the first element must be annunciated, at a minimum, at the beginning of operations on a daily basis.

The designer or manufacturer shall develop procedures and frequency for testing protection circuits. As a minimum, all protection circuits shall be calibrated and tested annually.

Protection circuits include, but are not limited to:

a) emergency shutdown (see 4.2.3.1);

b) stop gate (see 4.2.3.2);

c) tension system fault (see 4.2.3.3);

d) deropement circuit(s) (see 4.2.3.4);

e) brake system (see 4.2.3.5);

f) overspeed (see 4.2.3.6 and 4.2.8(b));

g) rollback detection device (see 4.2.3.7);

h) stop cord (see 4.2.9) as applicable.

4.2.3.1 Emergency shutdown circuit

All aerial lift systems shall include at least one protection circuit labeled emergency shutdown circuit (see 1.4 – *emergency shutdown*). The shutdown shall have priority over all other control stops or commands. If, for any reason, the operator has lost control of the aerial lift while using the operating control circuitry, the controls shall include an emergency shutdown circuit allowing the operator/attendant to stop the aerial lift. Any one of the following conditions is considered a loss of control of an aerial lift:

a) Aerial lift will not SLOW DOWN when given the command to do so;

b) Aerial lift will not STOP when given the command to do so;

c) Aerial lift OVERSPEEDS beyond control settings and/or maximum design speed;

d) Aerial lift ACCELERATES faster than normal design acceleration;

e) Aerial lift SELF-STARTS or SELF-ACCELERATES without the command to do so;

f) Aerial lift REVERSES direction unintentionally and without the command to do so.

4.2.3.2 Stop gates

On lifts using chairs, an automatic stopping device beyond each unloading area shall be installed. The device shall automatically stop the aerial lift in the event a passenger rides beyond the intended point of unloading. The location of the stop device shall be in accordance with the following:

a) *Intermediate stations*: Required only when traffic is not permitted beyond the intermediate station. The device shall automatically stop the aerial lift in the event a passenger rides beyond the intended point of unloading;

b) *Terminal unloading areas – Uphill and downhill:* If danger to passengers or equipment would result in the event the passenger entered or passed around a terminal at full speed, the device shall be so located that the distance from the stopping device to the first obstruction or tangent of the bullwheel, whichever is less, is 150% of the distance required to stop with the aerial lift operating at maximum speed and the most unfavorable loading condition;

For actuating device(s) of the suspended type, the suspended portion shall be strong enough to cause release of the actuating devices in use under the most adverse conditions, and each side shall be detachable and shall interrupt the operating circuit when detached.

4.2.3.3 Tension system

Active tension systems, (i.e. counterweight, hydraulic, etc.) shall have a protection device(s) that will stop the aerial lift when the haul rope tension carriage exceeds its range of normal operations.

4.2.3.4 Deropement switches

4.2.3.4.1 Sheave unit

On each sheave unit, suitable deropement detection devices shall be installed and maintained that will stop the lift in case of deropement (see 4.1.3.3.2(f), 4.1.1.5.1(g)).

4.2.3.4.2 Bullwheel

Device(s) to stop the aerial lift if the haul rope departs the bullwheel from its normal running position.

4.2.3.5 Braking system

All braking systems shall be designed to ensure that they meet the requirements of 4.1.2.6(a) through 4.1.2.6(d).

4.2.3.6 Overspeed

If the line speed exceeds the design speed by 10% on an overhauling lift, the service brake, if installed, shall slow and stop the aerial lift automatically.

A system or device shall be installed that will automatically apply the bullwheel brake on an overhauling lift when the speed of the haul rope exceeds the design speed by 15% in either direction.

4.2.3.7 Rollback detection device

The rollback detection device shall activate the rollback device and bring the aerial lift to a stop if unintentional reverse rotation occurs. The rollback device shall automatically stop reverse rotation of the aerial lift before

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the haul rope travels in excess of 36 inches (915 mm) in the reverse direction (see 4.1.2.6.3).

4.2.4 Operation circuits

An operation circuit is a circuit that provides power to or controls the aerial lift machinery.

The designer or manufacturer shall identify the operation circuits that require periodic testing and develop procedures and frequency for testing. As a minimum, all operation circuits shall be tested and calibrated annually.

Operation circuits include, but are not limited to:

a) power circuits;

b) drive fault circuits;

c) normal stop (see 1.4 – *normal stop* and 4.1.2.5);

d) speed command circuits (i.e., fast, slow, etc.);

e) internal combustion engine speed control;

f) power unit interlock (see 4.1.2.1.3);

4.2.5 Supervision circuits

Supervision circuits include all communications systems. In addition, supervision circuits may be provided to monitor or supervise the performance of various aerial lift systems or provide the aerial lift operator with system information.

The designer or manufacturer shall identify supervision circuits that require periodic testing and develop procedures and frequency for testing supervision circuits. As a minimum, all supervision circuits shall be calibrated and tested annually.

Supervision circuits may include, but are not limited to:

a) telephone and sound powered systems (see 4.1.1.7);

b) information display circuits;

c) audible warning devices (see 4.2.10);

d) overhead cable supervision (4.2.1.4);

e) wind speed and direction sensors and display units;

f) gearbox oil pressure, oil flow and temperature;

g) pneumatic and hydraulic tension system pressure (see 4.2.5.1);

h) unauthorized passenger detection;

i) rope position detectors (see 4.2.5.2);

j) acceleration/deceleration error (see 4.2.5.3).

4.2.5.1 Pneumatic and hydraulic tension systems

When pneumatic or hydraulic tension systems are used, pressure-sensing devices shall also be incorporated that will stop the aerial lift system in case the operating pressure goes above or below the design pressure range. Such pressure-sensing devices shall be located close to the actual tensioning device. It shall not be possible to isolate the pressure sensor from the actual tensioning device.

4.2.5.2 Rope Position Detection

On lifts where the carrier speed exceeds 600 feet per minute (3.0 meters per second), at least one device that senses the position of the rope shall be installed on each sheave unit. The device shall initiate a stop before the rope leaves the sheave in the horizontal direction or when the rope is displaced in the vertical direction by one rope diameter plus the distance that the rope is displaced vertically from the sheave by the grip (see 4.1.3.3.2(g)).

When the device that senses the position of the rope is the only deropement switch, it shall meet the requirements of a protection circuit as described in section 4.2.3. A aerial lift system may utilize a rope position detector as a supervision circuit as described in section 4.2.5 only if it has another deropement detection system that meets the requirements of a protection circuit.

4.2.5.3 Acceleration/deceleration monitoring.

The rate of acceleration and deceleration of the aerial lift shall be monitored. In the event that the acceleration or deceleration exceeds the provisions of 4.1.2.4, the aerial lift shall stop and annunciate the error.

EXCEPTION: Prime movers equipped with fluid couplings, centrifugal clutches, or wound rotor motors.

4.2.6 Bypass circuits

A temporary circuit may be installed for the purpose of bypassing failed electrical circuits. These bypass circuits when used must meet the requirements of 4.3.2.5.9.

4.2.7 Electrical prime mover

All aerial lift systems equipped with electrical prime movers (electrical motors) shall have phase-loss protection on all power phases and under-voltage protection or over-voltage protection, or both, when speed regulation can be adversely affected by such voltage variations.

4.2.8 Electronic speed-regulated drive monitoring

All electronic speed-regulated drives and electric motors shall shut down in the event of:

a) field loss (dc motors);

b) overspeed;

c) speed feedback loss as applicable;

d) overcurrent.

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4.2.9 Manual control devices

All automatic and manual stop and shutdown devices shall be of the manually reset type. An exception to this requirement is allowed for magnetic or optically operated automatic stop devices, if the operating circuit is such that it indicates that such devices initiated the stop and the circuit is of the manually reset type.

Manual stop switches (push button) shall be positively opened mechanically and their opening shall not be dependent upon springs.

Manual control devices shall be installed in all attendants' and operators' work positions, in machine rooms, and out-of-doors in proximity to all loading and unloading areas. As a minimum, each of these control locations shall include an Emergency Shutdown device and a Normal Stop device. All manual control devices located in or on a control cabinet shall be mounted so that they are in the same plane or face of the cabinet. The control devices shall not be located in a position that would require the operator or attendant to pass through the path of moving carriers in order to operate the controls.

The devices listed in Annex E shall be conspicuously and permanently marked with the proper function and color code.

4.2.10 Safety of operating and maintenance personnel

Provision shall be incorporated in the aerial lift design to render the system inoperable when necessary for the Lock-out Tag-out protection of personnel working on the aerial lift.

The sign "Personnel Working on Lift - Do Not Start" or a similar warning sign shall be hung on the main disconnect switch or at control points for starting the power unit(s) when persons are working on the aerial lift.

The aerial lift shall incorporate an audible warning device that signals an impending start of the aerial lift. After the start button is pressed, the device shall sound an audible alarm for a minimum of 2 seconds and shall continue until the aerial lift begins to move. The audible device shall be heard inside and outside all terminals and machine rooms above the ambient noise level.

4.2.11 Electrical system acceptance tests

Upon completion of the acceptance test and before public operation of the aerial lift, the function of software and/or relay logic shall be certified by the Qualified Engineer. The certification shall be included in the acceptance test report. Any modifications made to the electrical design shall be clearly marked on the on-site documentation and signed by a Qualified Engineer (see 4.1.1.11.2).

4.2.12 Software security

The "as built" documents shall include a procedure, developed by the lift manufacturer or a Qualified Engineer, to ensure the security of the software logic and operating parameters that will control the aerial lift. Upon completion of the acceptance testing this procedure shall be implemented in a manner that will prevent unauthorized personnel from making changes to the software logic or operating parameters. All programmable logic and parameters shall be documented.

4.2.13 Night operations

For nighttime operation, operating aerial lifts shall be provided with lighting systems. Lighting shall be provided at loading and unloading areas.

4.2.13.1 Illumination

Lights shall be located in a manner to provide generally uniform illumination.

4.2.13.2 Types

Lamps shall be of a type suitable and rated for minimum temperatures of the location. Fixtures shall be designed to maintain proper lamp-operating characteristics.

4.2.13.3 Location

Lights shall be mounted on substantial poles or standards. Aerial lift towers and terminal structures may be used for supporting lights subject to the following requirements:

a) Approval shall be obtained from a Qualified Engineer;

b) The service conductors to each aerial lift tower or terminal structure shall be underground or in rigid raceways. No wiring shall be supported between towers and no open wiring shall pass over or under the aerial lift;

c) A separate enclosed disconnect or circuit breaker shall be required for each tower or terminal structure;

d) All metallic raceways on a tower or terminal structure shall be grounded;

e) The lighting installation shall not conflict with other requirements of this standard and shall not interfere with operations of the aerial lift in any manner.

4.2.13.4 Emergency lighting

Emergency lighting shall be provided in the event of electric power failure to permit:

a) regular unloading of an aerial lift;

b) emergency evacuation of carriers;

c) operation of the evacuation drive.

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4.3 Operation and maintenance

This subsection covers the requirements for operation and maintenance of fixed grip aerial lifts. Many requirements are listed elsewhere in Section 4 and referenced annexes, since they also regulate installation and design. It is imperative that operating and maintenance personnel be familiar with applicable provisions of this section and the aerial lift operational and maintenance manuals (see 4.1.6).

4.3.1 General and personnel safety

Operation and maintenance of aerial lift equipment can be dangerous to personnel performing these tasks. Procedures for performing these functions shall require precautionary measures necessary to reduce the risks for the personnel involved. Implementation of the procedures intended for the protection of the public and operating and maintenance personnel shall be the responsibility of the owner, supervisor, and the individual worker.

Passengers and operating personnel shall be cautioned or prevented, as required, from transporting objects or materials that may encroach upon limitations of carrier clearances or design live loads.

4.3.1.1 Applicable design requirements

The following design requirements shall be installed by the effective date listed:

- 4.1.2.6.2 Bullwheel Brake (Nov 1, 2012)

The following items were listed in the ANSI B77.1-2006 Standard and are required:

- 4.1.1.7 Communications (Nov. 1, 2007)
- 4.1.2.1.2 Evacuation power unit (Nov 1, 2008)
- 4.1.2.6.3 Rollback Device (Nov 1, 2008)
- 4.1.3.3.2(d) Cable Catcher (Nov 1, 2008)
- 4.1.3.3.2(f) Deropement switch (Nov 1, 2008)

4.3.1.2 Signs

See normative Annex D for public sign requirements

See 4.2.1.3 for electrical warnings.

The sign “Personnel Working on Lift - Do Not Start” or a similar warning sign shall be posted as required by 4.2.10.

4.3.2 Operation

4.3.2.1 Personnel and supervision

Aerial lifts shall be operated by trained personnel, and the owner shall be responsible for their supervision and the training to perform the duties listed in 4.3.2.3. Procedures for monitoring the operation and use of the aerial lift and for advising and assisting passengers, including passengers with common adaptive equipment, shall be included in the training. One or more persons familiar with emergency procedures shall be on the site at all times when the aerial lift is in operation. All personnel shall practice good housekeeping. Personnel shall comply with the operational procedures and regulations for the aerial lift. Persons performing the duties of the aerial lift personnel may exchange assignments as directed by the supervisor; provided they are trained for each assignment undertaken.

4.3.2.1.1 Supervisor

An individual shall be designated to oversee the aerial lift’s operating practices and operating personnel for the purpose of public use. The designated supervisor may delegate some authority to others, but shall oversee the operation and operating personnel of the aerial lift as called for by the owner as part of the operation and maintenance quality assurance plan (see 1.5.4).

4.3.2.1.2 Operator

One individual shall be designated as the operator of the aerial lift for the purpose of public use. This operator shall be trained in operational, and emergency procedures and such training shall be documented.

4.3.2.1.3 Attendants

Attendants shall be assigned to particular duties under direction of the operator. For public operation, attendants shall be trained in operations and emergency procedures pertaining to their assignments; and such training shall be documented.

4.3.2.1.4 First aid

One or more persons trained to provide first aid/emergency care at the Basic Life Support (BLS) level, including CPR, shall be available at all times when an aerial lift is operating and transporting passengers. There shall be ready access to first-aid/emergency care supplies and equipment, including provisions for transporting an injured person to an enclosed and, if required, heated shelter.

4.3.2.2 Minimum operating personnel

The following personnel are the minimum that shall be required for public operations:

a) An operator shall be in charge of the aerial lift operation. The individual may serve concurrently as an attendant if the additional role doesn’t interfere with the duties of the operator and approved by the supervisor;

b) An attendant shall be on duty at each loading/unloading platform or station

Intermediate stations shall be staffed if there is less than 5 feet (1.53 meters) of clearance for skiers or 30 inches (760 mm) for foot passengers from the chair seat to the platform surfaces when the aerial lift is in public operation but the station is not in use (see Table D-1, k and l in Annex D).

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c) One or more persons trained to evacuate the aerial lift using the evacuation power unit shall be available at all times when an aerial lift is in public operation.

In addition, the staffing requirements (if any) specified by the aerial lift manufacturer shall be observed.

4.3.2.3 Duties of operating personnel

All personnel shall use reasonable care while performing their duties.

4.3.2.3.1 Supervisor

The duties of the individual designated as the supervisor include:

a) to oversee practices that will determine that the aerial lift is operational and that all operating personnel are trained, equipped, and capable of performing their duties prior to public use of the lift;

b) to discontinue operations on any aerial lift due to physical, weather, personnel, or other reasons;

c) to oversee operational procedures and adherence to applicable regulations pertaining to the aerial lift.

4.3.2.3.2 Operator

The duties of the individual designated as the operator include:

a) to be knowledgeable of operational and emergency procedures and the related equipment needed to perform the assigned duties;

b) to assume responsible charge of the aerial lift;

c) to direct the attendants at their aerial lift;

d) to verify that the preoperational inspection (see 4.3.2.4.2) has been completed and documented before public operation;

e) to start the aerial lift while operating for the public (see 4.3.2.5.2);

f) to maintain an operational log (see 4.3.5.1);

g) to deny access to the aerial lift to any person using procedures and criteria provided;

h) to advise the supervisor of observed abnormal or unusual conditions that may adversely affect the safety of the operation;

i) to terminate passenger operations (see 4.3.2.5.8)

4.3.2.3.3 Attendant

The duties of an attendant include:

a) to be knowledgeable of operational and emergency procedures and the related equipment needed to perform the assigned duties;

b) to monitor the passengers' use of the aerial lift; including observing, advising and assisting them while they are in the attendant's work area as they embark on or disembark from the aerial lift; and to respond to unusual occurrences or conditions, as noted. The attendant should respond by choosing an appropriate action, which may include any of the following.

1) assisting the passenger;

2) slowing the aerial lift (if applicable);

3) stopping the aerial lift;

4) continuing operation and observation.

c) to deny access to the aerial lift to any person using procedures and criteria provided;

d) to advise the operator of observed abnormal or unusual conditions that may adversely affect the safety of the operation.

4.3.2.4 Operational procedures

Operational procedures may supplement the designer's operational manual (see 4.1.6.1) and the owner's quality program (see 1.5.4).

4.3.2.4.1 Control of passengers

Each aerial lift shall have a definite method for marshaling passengers for loading and unloading. Fences, gates, and alternate access and/or loading methods may be required to implement the system for individuals/groups.

4.3.2.4.2 Daily preoperational inspection

Prior to public operation, a daily preoperational inspection shall be performed and documented. As a minimum, the inspection shall consist of the following:

a) a visual inspection of each terminal, station, work position, and the entire length of the aerial lift;

b) assurance that the tension system is functional and that tension system devices (counterweights, cylinders, carriages, and the like) have adequate travel with appropriate clearances at both ends;

c) operation of all manual and automatic switches in terminals, stations, work positions, and loading and unloading areas, per manufacturer's instructions;

d) operation of all braking systems;

NOTE – The designer of the aerial lift system may specify that this inspection is to take place while the aerial lift is not moving.

e) operation of communication systems;

f) operation of the aerial lift, including a visual inspection of all ropes and carriers;

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g) for those aerial lifts having primary power internal combustion engines, determining that the fuel quantity is sufficient to conduct the anticipated period of operation without refueling. For evacuation internal combustion engines, the fuel supply shall be adequate to unload the aerial lift. During refueling, power units shall be shut down.

Aerial lifts having internal combustion engine(s) shall have the engine(s) checked during this inspection and operated at least once each week. The aerial lift shall be operated using each internal combustion engine(s) at least 30 minutes per month;

h) inspecting the loading and unloading areas and preparing them for the ingress and egress of passengers;

i) clearing carriers of ice to the extent necessary to permit operation, and inspection and checking of all mechanical features.

j) assurance that applicable horizontal and vertical clearances are maintained (see 4.1.1.4 and 4.1.1.5).

4.3.2.4.3 Access to facilities

While in operation, entrances to all machinery, operators' and attendants' rooms shall be restricted to authorized personnel only. All entrances shall have the signs required in Table D-1 (u) in Annex D).

While not in operation, entrances to all machinery, operators', and attendants' rooms shall be locked. To provide shelter and emergency telephone access for public safety, specified entrances may remain unlocked provided the aerial lift equipment cannot be operated by unauthorized personnel.

4.3.2.5 Operational requirements

4.3.2.5.1 General

The owner and supervisor of each aerial lift shall review the requirements of Section 4 and referenced annexes of this standard to ascertain that original design and installation conditions have not been altered in a manner so as to violate the requirements of the standard.

4.3.2.5.2 Starting

Following procedural clearances, the aerial lift shall be started by the operator or at the direction of the operator. Capability for starting from other locations may be provided for maintenance or emergency operation.

4.3.2.5.3 Loading and unloading platforms

The maze or corral, loading platform surface, breakover point, and the load/unload seat height shall be reasonably maintained according to the prevailing weather conditions and established procedures.

4.3.2.5.4 Stops

After any stop of an aerial lift, the operator shall determine the cause of the stop, and not restart until clearance has been obtained from all attended stations.

4.3.2.5.5 Damage to carriers

Should any carrier become damaged or otherwise rendered unfit for passenger transportation during normal operation, it shall be clearly and distinctively marked and not used for passengers until repaired or replaced. It shall be removed from the line as soon as feasible.

4.3.2.5.6 Hazardous conditions

When wind or icing conditions are such that operation is hazardous to passengers or equipment, according to predetermined criteria based upon the area's operational experience and the designer's design considerations, the aerial lift shall be unloaded and the operation discontinued. If necessary under the predetermined criteria, device(s) shall be installed at appropriate location(s) to ascertain wind velocity and direction when aerial lifts are operated. No aerial lift shall operate when there is an electrical storm in the immediate vicinity. Should such conditions develop while the aerial lift is in operation, loading of passengers shall be terminated, and operation shall be continued only as long as necessary to unload all passengers. When such shutdown has been caused by an electrical storm, grounding of control circuits and haul ropes that are used as conductors in communication systems is permissible. Such grounding shall be removed prior to resumption of passenger operations.

4.3.2.5.7 Evacuation

A plan for evacuation of passengers from each aerial lift shall be developed and documented. The plan shall include:

a) the definition of the line of authority in the event of an evacuation. This line of authority shall list:

1) the positions responsible for determining the need for and ordering an evacuation by use of the evacuation power unit or evacuation from individual carriers;

2) the personnel responsible for performing the evacuation, for first aid, and for ground care of evacuated passengers.

b) a description of the equipment necessary for evacuation and where it will be stored;

c) provisions for adequate training in the functions performed in the evacuation process at least once each operating season. Such drills are to be recorded in the operational log of each aerial lift (see 4.3.5.1);

d) an estimate of the time necessary for the total evacuation of each aerial lift;

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e) a description of unusual terrain conditions and how each of these conditions will be dealt with during an evacuation;

f) an estimate of when the evacuation should begin in the event the aerial lift becomes inoperable;

g) provisions for communications with passengers of an inoperable aerial lift, the frequency of such communication, how soon after the aerial lift becomes inoperable such communication to the passengers will start, and the frequency of communications thereafter;

h) the methods of evacuation to be used for the typical passenger, incapacitated passenger, passengers using common adaptive ski equipment, and non-ambulatory passengers;

i) provisions for communication with the evacuation teams;

j) provisions for suspending the evacuation in the event that the aerial lift is made operable during the evacuation;

k) provisions for control and assistance of evacuated persons until released;

l) provisions for a post-evacuation report.

All nonmetallic rope used for evacuation shall be of nylon or polyester (Dacron) fiber of either laid or braided construction. Laid rope of nylon shall be of a hard lay. These ropes shall be either of a static rescue type or a dynamic mountaineering type. Breaking strength, when new, shall be at least 15 times the maximum expected operating load but in no case less than 4000 pounds (17.8 kilonewtons). No natural fiber or polypropylene ropes shall be used.

These ropes shall be carefully stored when not in use and shall be examined after each completed aerial lift evacuation and prior to each season of operation, both summer and winter, to ascertain that they are in satisfactory condition.

Carabiners, if used, shall be of the locking type.

4.3.2.5.8 Termination of daily operations

Procedures shall be established for terminating daily operations in such a manner that passengers will not be left on the aerial lift after it has been shut down. Loading ramps, as required, shall be closed and so marked.

When either loading or unloading portions of an intermediate station are not in operation, it shall be so signed and the loading station shall be closed to public access.

4.3.2.5.9 Bypass requirements

The use of temporary circuits that have been installed for the purpose of bypassing failed electrical circuit(s) (see 4.2.6) shall meet these requirements in the following order:

a) The condition that the circuit indicated is in default shall be thoroughly inspected to ensure an electrical operating circuit malfunction, rather than the indicated condition, actually exists;

b) The bypass shall be authorized only by the aerial lift supervisor or his/her designated representative;

c) When a bypass is in operation, the function bypassed shall be under constant, close visual observation;

d) The use of a bypass circuit shall be logged and shall indicate when, who authorized, and for what duration a bypass was used;

e) The operator control panel shall indicate that a bypass is in use.

4.3.3 Maintenance

4.3.3.1 General

Foundations, structural, mechanical, and electrical components shall be inspected regularly and kept in a state of good repair. The maintenance and testing requirements of the designer or a Qualified Engineer (see 4.1.6.2) shall be followed. Maintenance logs shall be kept (see 4.3.5.2).

A written schedule for systematic maintenance shall be developed and followed. The schedule shall establish specific frequencies for periodic lubrication, adjustment, inspection, and testing. The schedule shall include, but not be limited to, the following:

a) all wire rope, and track cable, (see A.4.1 and A.4.2 in Annex A);

b) line sheave units, sheaves, bearings, and liners;

c) bullwheels, bearings, and liners;

d) tension systems;

e) drive system, including bearings and couplings;

f) braking systems;

g) electrical control systems;

h) communication systems;

i) carriers;

j) structures;

k) lift line (see 4.1.1.4).

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4.3.3.2 Maintenance personnel

Fixed grip aerial lifts shall be maintained by trained and competent personnel. The owner shall be responsible for the supervision and training of such personnel, and such training shall be documented. All personnel shall practice good housekeeping, with particular emphasis on avoiding the development of any condition that might contribute to personal injury. Personnel shall comply with the operational rules and safety regulations of the specific aerial lift.

4.3.3.3 Rope grips

The initial installation and each relocation of a clamp-type grip shall be field-checked by a method established by the designer to provide assurance that the requirement of the first sentence of 4.1.4.3.2 has been met and that the maximum slippage resistance is not exceeded. All grips shall be moved at least once every 24 calendar months. The grips should be moved a uniform distance each time and in the same direction. A grip should never be installed or allowed to migrate closer than a distance of 20 haul rope diameters from a splice tuck or rope repair tuck. The designer's instructions shall be followed if they are more restrictive than these requirements. Movements shall be recorded in the maintenance records (see 4.3.5.2 and 4.3.5.3).

As each grip is relocated, the haul rope shall be examined for deterioration at or near the grip location. The initial location and each subsequent relocation shall be marked by a spray paint or other marking on the rope to identify slippage. A Qualified Engineer shall supply information to the operator to enable him/her to identify excessive slippage.

4.3.4 Inspections and testing

4.3.4.1 General inspection

Each aerial lift shall be inspected annually, or after each 2000 hours of operation, whichever comes first, by an aerial lift specialist independent of the owner. The inspection shall verify preservation of original design integrity and cover the requirements of this standard for maintenance, operation, required self-inspections, and record keeping. Items found either deficient or in noncompliance shall be noted. A report signed by the specialist shall be filed with the owner.

4.3.4.2 Wire rope, track cable, and chain inspection

Inspection shall comply with the following:

- Wire rope (A.4.1 in Annex A);
- Track cable (A.4.2 in Annex A);
- Welded link chain (Annex G);

For existing roller and leaf chain, see Annex H.

4.3.4.3 Carrier inspection

All carriers (grips, clips, hangers, chairs, carriages, and cabins) shall be tested. These components shall be inspected per the carrier inspection plan established by the designer/manufacturer. If the designer/manufacturer is no longer in business an inspection plan shall be developed/reviewed by a Qualified Engineer.

Personnel performing non-destructive testing (NDT) inspections (i.e., manufacturer, inspection agency, other personnel, or in-house personnel) shall be qualified in accordance with nationally recognized NDT personnel qualifications standards: ANSI/ASNT-CP189, SNT-TC-1A, MIL STD 410, NAS-410, or equivalent.

Personnel performing the component inspection shall provide certification of their qualification to perform inspection in accordance with the criteria prescribed by designer/manufacturer or Qualified Engineer.

The designer/manufacturer or qualified engineer shall supply the owner a copy of carrier inspection plan (see 4.1.4.4. and 4.3.4.3.1). If defects are found, the designer/manufacturer or Qualified Engineer shall be consulted to determine whether an increased sample size or testing frequency is warranted if not specified in original acceptance criteria.

The manufacturer or the owner shall uniquely and permanently mark each component.

Parts failing to meet the acceptance criteria shall not be placed back into service until their defects are corrected in accordance with designer/manufacturer or Qualified Engineer criteria.

4.3.4.3.1 Carrier inspection plan

The carrier inspection plan shall include the following:

a) Sampling size and frequency – The inspection plan shall identify the components to be inspected to assure a rotating minimum test sample of 20% of each aerial lifts' carriers (to include at least 10) every year, or after a maximum of 2000 hours of operation, whichever comes first.

b) Inspection requirements – The documented inspection criteria shall include:

1) types and methods of inspections to be performed;

2) inspector qualifications;

3) identification and labeling of critical and non-critical component areas;

4) pre-inspection preparation and post test inspection treatment of components;

5) acceptance criteria;

6) additional sampling and retesting requirements.

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4.3.4.3.2 Carrier inspection documentation

After inspection, the testing personnel shall provide written certification to the owner that carrier inspection has been performed in accordance with the current carrier inspection plan. The owner shall receive and maintain a copy of the certification and inspection results in accordance with the following:

a) general summary/cover letter:

1) customer identification of installation (name or number);

2) name and address of owner/operator;

3) name and address of inspection agency;

4) name and qualification of inspector(s) in charge;

5) date of inspection completion;

6) total number of carriers in the installation.

b) inspection Summary:

1) carrier identification by manufacturer or owner;

2) description of each part listed;

3) inspection method and procedure;

4) total number of parts inspected;

5) total number of parts rejected.

c) for each rejected or repaired part:

1) part identification number;

2) description and location of indications according to carrier inspection plan;

3) disposition of rejected parts:

- repaired to bring into compliance

- disposal of parts

d) signature of person responsible.

4.3.4.4 Dynamic testing

Dynamic testing shall be performed at intervals not exceeding seven (7) years.

A written schedule for systematic dynamic testing shall be developed and followed. The owner shall provide experienced personnel to develop and conduct the dynamic test. The schedule shall establish specific frequencies and conditions for dynamic testing. The testing shall simulate or duplicate inertial loadings. The test load shall be equivalent to the design live load. The results of the testing shall be documented in the maintenance log.

The testing shall include, but not be limited to the following:

a) braking systems;

b) power units;

c) tension system;

d) electrical systems.

4.3.5 Records

4.3.5.1 Operational log

A log shall be maintained for each aerial lift. Daily entries shall be made giving the following minimum information:

a) date;

b) names and work positions of operating personnel;

c) operating hours and purpose of operations;

d) temperature, wind, and weather conditions;

e) record of compliance with daily operational inspection including loading and unloading platforms, seat height, ramps and signs;

f) position and condition of the tension carriage, counterweights, or other tension system devices;

g) accidents, malfunctions, or abnormal occurrences during operation;

h) signature of operator;

i) record of aerial lift evacuations and evacuation drills (see 4.3.2.5.7(c));

j) record of intermediate station use (see 4.3.2.5.8).

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4.3.5.2 Maintenance log

A signed complete log shall be maintained wherein the actual execution of maintenance work shall be recorded. The log shall state the components serviced and the condition of the components. A record shall be kept of replacement of components.

4.3.5.3 Wire rope, and track cable

A log shall be maintained for each aerial lift, giving the following information on each rope and track cable:

a) specification (see A.1.1 in Annex A);

b) copy of certified test report;

c) date installed;

d) splicing certificate for each splice or laid-in strand;

e) record of lubrication, including type of lubricant and date applied;

f) record of maintenance inspections;

g) inspection reports of wire rope, track cable, and their connections (see A.4.1, A 4.2.2, and A.4.3 in Annex A);

h) report of accidents or injury to wire rope or track cable.

4.3.5.4 Chain log

A log shall be maintained for each aerial lift, giving the following information on each chain used as a tension element:

a) specification (see Annex G and Annex H);

b) copy of certified test report;

c) date installed;

d) record of lubrication, including type of lubricant and date applied;

e) record of maintenance inspections;

f) report of accidents or injury to the chain.

4.3.6 Passenger conduct and responsibility

4.3.6.1 Passenger responsibilities

It is recognized that certain dangers and risks are inherent in machines of this type, and their operation. It is also recognized that inherent and other risks or dangers exist for those who are in the process of embarking, riding or disembarking from fixed grip aerial lifts (see 1.2). Passengers accept the risks inherent in such participation of which the ordinary prudent person is or should be aware.

Passengers shall use good judgment and act in a responsible manner while using the aerial lift, including:

a) participating in the embarkation, riding, and disembarkation processes in such a manner as to reduce risks for themselves and others.

b) obeying all written and oral instructions and warnings;

c) refraining from using the aerial lift while under the influence of drugs or alcohol;

d) properly use the aerial lift and equipment provided.

4.3.6.2 Passenger dexterity and ability

All passengers who use an aerial lift shall be responsible for their own embarkation, riding, and disembarkation. They shall be presumed to have sufficient ability, physical dexterity, and/or personal assistance to negotiate and to be evacuated from the aerial lift safely. Passengers shall maintain control of their speed and course while loading and unloading the aerial lift.

4.3.6.3 Passenger embarkation and disembarkation

A passenger shall get on and get off an aerial lift at designated areas. No passenger shall embark without first understanding and observing the proper loading, riding, and unloading procedures (see Table D-1 (a) in Annex D).

4.3.6.4 Passenger riding

Passengers, while riding an aerial lift, shall not throw or expel therefrom any object, nor shall any passenger do any act or thing that shall interfere with the operation of the aerial lift. Passengers shall not willfully engage in any type of conduct that may contribute to or cause injury to any other person.

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Section 5
Surface lifts

This section covers the class of passenger ropeway wherein passengers or passengers on recreational devices are transported on the surface by means of towing devices propelled by a main overhead traveling wire rope. Surface lifts are normally monocable type, and the haul rope is usually supported on intermediate towers on both the uphill and downhill side. Either fixed or detachable grips may be used.

Surface lifts include T-bars, J-bars, and platters.

T-bar lifts are those surface lifts on which the device between the haul rope and passengers forms the shape of an inverted "T," propelling passengers located on both sides of the stem of the "T."

J-bar lifts are those surface lifts on which the device between the haul rope and passenger is in the general form of a "J," propelling a single passenger located on the one side of the stem of the "J."

Platter lifts are those surface lifts on which the device between the haul rope and passenger is a single stem with a platter (or disk) attached to the lower end of the stem, propelling the passenger astride the stem of the platter (or disk).

5.1 Design and installation

5.1.1 General

5.1.1.1 Design passenger weight

For purposes of design, a passenger shall be considered as having a minimum average weight of 170 pounds (77.1 kilograms). It is the owners' responsibility to indicate unusual considerations that might affect the design passenger weight.

5.1.1.2 Capacity and speed

The speed of the surface lift and the spacing of the towing devices shall be such that the minimum loading intervals designated in 5.1.1.2.1 and 5.1.1.2.2 are maintained.

For surface lifts with detachable grips, means shall be provided to maintain the minimum distance between successive passengers that was used in the design of the surface lift. Passengers shall not be loaded until the passenger(s) ahead has traveled this minimum distance from the loading point. Automatic launching devices shall meet these requirements when timed to release to meet the minimum loading interval.

5.1.1.2.1 Single-passenger carriers

The minimum loading interval shall be 3 seconds plus the time required to extend the towing device to such a point that the passenger starts to move.

5.1.1.2.2 Multiple-passenger carriers

The minimum loading interval shall be 4 seconds plus the time required to extend the towing device to such a point that the passengers start to move.

5.1.1.3 Location

In selecting the location and alignment of an installation, consideration shall be given to the following items, and to any others that may be particularly pertinent to the surface lift type and location:

a) ADA accessibility;

b) electric power lines and their supports;

c) rock and earth slides, cave-ins, washouts, and the like;

d) snow creep and avalanches;

e) wind action;

f) icing;

g) ski slopes and trails;

h) rivers and gullies;

i) buried installations, including pipelines;

j) control of air space below, above, and adjacent to the installation;

k) crossing or close proximity to other ropeways;

l) highways;

m) fire hazard;

n) structures.

5.1.1.3.1 Tow path gradient

The maximum permissible grade of the tow path shall be 100% for surface lifts using single passenger towing devices and 80% for surface lifts using towing devices for more than one passenger. Reverse grades along the tow path shall be limited to very low gradients.

5.1.1.3.2 Cross slope

The cross slope of a tow path shall not exceed 5% for surface lifts using towing devices for more than one passenger, except at unloading areas. For single-passenger surface lifts, the cross slope shall not exceed 5% except at towers and unloading areas. The cross slope at towers shall not exceed 10% and shall slope down and away from the centerline of the surface lift.

For surface lifts used to transport recreational devices, the tow path shall be designed to minimize the risk of an inadvertently detached towing device from sliding into another towing device or the surface lift.

5.1.1.3.3 Tow path crossing

No recreational device traffic shall be allowed to cross the uphill tow path (see 1.4 - *tow path*). Skier traffic may cross at designated locations.

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5.1.1.4 Clearing envelope

As a minimum there shall be no obstacles, unless allowed in 5.1.1.5, within 5 feet (1.53 meters) of ropes and carriers under design operating conditions. Carriers shall not contact any obstacle during operation under design wind conditions. Clearings and contiguous spaces shall be maintained to reduce the risk of washouts, hazard trees, and other obstacles that might endanger the installation (see 5.3.3.1).

5.1.1.4.1 Tow path clearing width

The tow path width shall be cleared and maintained in such a manner that no rocks, stumps, or other obstructions project above the tow path surface. The minimum total tow path clearing width shall be 30 inches (760 mm) times the design number of passengers per carrier. In no case shall the tow path clearing width be less than 6 feet (1.83 meters).

5.1.1.5 Clearances

Terminals and towers shall be designed and installed to provide the clearances as herein specified and to minimize surge of the line under operating conditions. Local wind conditions shall be taken into consideration.

5.1.1.5.1 Vertical clearances

Terminals and towers shall be located so that, under the most adverse design loading conditions, the towing device will not lift a passenger from the snow surface. Also, under the most adverse conditions, the haul rope shall be a minimum of 8 feet (2.44 meters) above the surface on which the passenger is towed, and high enough to keep empty down-coming towing devices clear of the snow.

The towers shall be of such a height and so located that if the up-going haul rope comes off the supporting sheaves of one tower, the towers (or terminal) on either side will support the rope clear of the design tow path by a minimum of 24 inches (610 mm).

When a towing device is swung longitudinally by 15 degrees from the vertical position, or when it is in its most extreme operating condition, whichever is more severe, there shall be clearance in the vertical plane between the towing device or hanger and any obstruction, such as sheaves, guards, and the like.

5.1.1.5.2 Horizontal clearances

A minimum clearance of 36 inches (915 mm) shall be maintained between the tower at uphill tow path surface and the vertical plane of the upward traveling haul rope cable. With respect to the downward traveling haul rope, a minimum clearance of 24 inches (610 mm) shall be provided between the towing device in its normal position and the tower. When recreational devices are used, a minimum clearance of 24 inches (610 mm) shall be maintained between the recreational device and the tower.

5.1.1.5.3 Path of rope adjustment

When varying snow depths of the uphill tow path require changing of sheave heights, these changes shall be controlled within minimum and maximum tolerances established by the designer. This control shall be provided as prescribed below.

When terminals, towers, or both contain provisions for a change in height of the haul rope in order to meet normal changes in operational requirements, such provision shall be controlled as follows:

a) The designer's operational manual shall provide complete instructions for proper procedures and sequences for making adjustments;

b) Where range of adjustments allows possible adjustment error resulting in improper sheave loading, a system to readily verify the proper profile, without the use of tools, shall be incorporated into the installation.

5.1.1.6 Structures and foundations

All structures and foundations shall be designed and constructed in conformance with 1.3 and shall be appropriate for the site. Applied design loads shall include dead, live, snow, wind, and dynamic loads due to normal conditions and for foreseeable abnormal conditions.

Structures and foundations located in snow creep areas shall be designed for such conditions and loads, or protective structures shall be provided as required by the conditions.

5.1.1.6.1 (Reserved)

5.1.1.6.2 Foundations

In determining the resistance of the soil to motion of the foundation, the subsoil conditions at the site shall be considered, including any buoyancy due to groundwater that may be present. If the resistance of the soil is not practically determinable, the foundation or anchorage should be designed as a gravity anchor, using a coefficient of friction appropriate to the general character of the soil. Bottoms of foundations shall be below the normal frost depth unless resting on non-frost-susceptible soil or solid rock. Foundations on rock shall be firmly anchored to solid rock, unless designed as gravity foundations.

The top of concrete foundations shall not be less than 6 inches (150 mm) above finished grade unless specific direction for the protection of the foundation and structural steel below grade is specified by the designer.

The design shall have a minimum factor of safety of 2 in resisting overturning and, concurrently, 2 against sliding, under dead load and live-load conditions. The minimum factors shall be 1.5 under these loadings plus wind acting simultaneously.

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5.1.1.7 Communications

A permanently installed two-way voice communication system shall be provided between the prime mover control point, drive system building if any, loading stations, and unloading stations. The communication system shall be functional and audible during operation. (see 5.2.5(c)).

Audio indicators shall be audible over all ambient noise levels, and visual indicators (e.g., Light Emitting Diodes) shall be visible even in bright sunlight.

NOTE – Voice communication systems are not required for those surface lifts qualifying for operation by a single operator, as defined in 5.3.2.2.

5.1.1.8 Combustion engine(s) and fuel handling

Internal combustion engine installation and fuel handling requirements are located in normative Annex F.

5.1.1.9 Loading and unloading areas

Platforms, ramps, corrals, and mazes comprising the loading and unloading areas of a surface lift are integrally related to its operation. They shall be designed and installed in conformance with 1.3.

Terminals, towers, and other structures or obstacles adjacent to the loading and unloading areas shall be designed or guarded to reduce the possibility of entanglement with these items.

5.1.1.9.1 Loading areas

The loading area length, profile, and loading point shall be installed according to the surface lift's speed, terminal bullwheel location, and carrier type to provide a smooth transition from standing, to the towing device pulling the passenger, at full line speed. Load gates, artificial surfaces, and other loading aids when used shall be designed and installed with regards to all passengers including adaptive. At least one point of access to the lift shall have a minimum clearance width of 36 inches (915 mm) to accommodate passengers using adaptive equipment.

Approach paths to the loading zone shall be approximately level or slightly downgraded to facilitate passengers moving to the loading point. The approach paths shall be such that waiting passengers have a view of the loading area. The maze or corral area shall be approximately level, free of obstructions and marked, roped, or fenced in a manner to guide passengers to the "Wait Here" and "Load Here" markers. The maze or corral should be as straight as practical.

The "Wait Here" point shall be marked. This marker shall be located to provide horizontal clearance between passengers and passing towing devices.

The loading point shall be marked as to where passengers are to stand using a loading marker located in/on the platform/snow surface.

5.1.1.9.2 Unloading areas

The unloading area length, profile, unload point, and exit ramp shall be installed according to the surface lift's speed, terminal bullwheel location, and carrier type. Unloading areas shall have an approximately level area followed by a downgrade to assist the passenger in releasing the towing device and exiting the surface lift.

The distance between the unload point and the terminal guides shall be sufficient to allow towing devices to become retracted and permit their oscillations to diminish before entering the terminal or the terminal shall be designed to allow a partially retracted towing device to pass in a controlled manner. This distance is further determined by the location of the stop gate and surface lift stopping distance (see 5.2.3.2).

5.1.1.10 (Reserved)

5.1.1.11 Acceptance inspection and tests

Prior to the acceptance inspection and the acceptance tests, the surface lift shall be operated for a period of continuous, full-speed operation, with empty towing devices, of sufficient duration to check for overheating of moving parts, excessive vibration or deflection of mechanical or structural components, free movement of tension systems, and other related conditions.

5.1.1.11.1 Acceptance inspection

Before a surface lift that is new, relocated, or that has not been operated for routine maintenance within the previous 2 years is opened to the public, it shall be given a thorough inspection by qualified personnel to verify compliance with the plans and specifications of the designer.

It shall be the responsibility of the owner to see that the following conditions have been met:

a) tightness of all structural connections;

b) lubrication of all moving parts;

c) alignment and clearances of all open gearing;

d) installation and alignment of all drive system components;

e) position and freedom of movement of counterweights or other tension systems and carriages;

f) haul rope alignment at entrance to bullwheels;

g) operation of all electrical components, including circuit protection and grounding;

h) adjustment of brake(s)and/or rollback devices if installed;

i) haul rope sags;

j) proper alignment of haul rope sheave units;

k) retraction of towing devices;

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l) proper location of towers, bents, and terminals in accordance with the plans and specifications. Terminal and tower haul rope working points shall be documented by an “as built” survey, and any variation from the design drawings shall be noted and approved by the engineer responsible for design.

5.1.1.11.2 Acceptance tests

Before a surface lift that is new or relocated, or that has not been operated for routine maintenance within the previous 2 years is opened to the public, it shall be given thorough tests by qualified personnel to verify compliance with the plans and specifications of the designer. The designer or manufacturer shall propose and submit an acceptance test procedure.

The functioning of all push-button stops, automatic stops, stop gates, limit switches, deropement switches, and communication devices shall be checked. Acceleration and deceleration rates shall be satisfactory under all loadings (see 5.1.2.4). Braking shall be proved adequate (see 5.1.2.6).

5.1.2 Terminals and stations

5.1.2.1 Power units

All power units shall have the capacity to handle the most unfavorable design loading conditions, including the starting of a fully loaded surface lift.

Where manual multispeed transmissions are used on a power unit, they shall not be shifted when the surface lift is moving.

Where reverse capability is provided on a power unit for a surface lift, provisions shall be made to prevent accidentally shifting into reverse whenever the surface lift is operating.

5.1.2.1.1 Prime mover

Power units engaged as a prime mover shall have the systems required in subsections 5.1 and 5.2 functional during operation (see 1.4 – *prime mover*).

5.1.2.1.2 Evacuation power unit

An evacuation power unit shall not be required.

5.1.2.2 Speed reducers and gearing

All speed reducers and gearing shall have the capacity for starting a surface lift under the most unfavorable design loading conditions without exceeding design rating. They shall have a service factor appropriate for the application.

5.1.2.3 Bearings, clutches, couplings, and shafting

Bearings, clutches, couplings, shafting and universal joint shafts (cardan shafts) shall be selected on the basis of the manufacturer’s published data for the particular use. All shafting shall be designed in accordance with accepted standard practices.

Guarding and containment shall be in accordance with the provisions of 5.1.2.7.1.

Provision shall be made for adjustment and lubrication of all bearings, clutches, and couplings, when required.

5.1.2.4 Acceleration and speed control

Acceleration of a drive shall be regulated with regard to surface lift type, profile, speed, and use.

After any type of stop is initiated, the stop shall not be canceled and the lift shall not be started until it has come to a complete stop.

The lift is to be started at its lowest point of speed range after any type of stop.

5.1.2.5 Stops and shutdowns

Normal stop (see 1.4 – *normal stop*): If a service brake is required it shall have been applied by the time the surface lift comes to a stop.

Emergency shutdown (see 1.4 – *emergency shutdown)*: If a service brake is required (see 5.1.2.6.1), it shall have been applied by the time the surface lift comes to a stop. The designer shall designate which control functions of the surface lift system shall initiate an emergency shutdown.

The designer may define other stopping modes other than normal and emergency shutdowns. For other stopping modes, the designer shall specify the method of stopping, including the type and timing of brake(s) that may be applied, and the stopping criteria.

5.1.2.6 Brakes and rollback device

Each surface lift shall have the brakes and devices as designated in 5.1.2.6.1 and 5.1.2.6.3.

Installed braking systems shall be capable of operation to comply with daily inspections and periodic testing.

5.1.2.6.1 Service brake

Unless an unloaded surface lift operating at maximum speed will stop in 25 feet (7.62 meters) or the distance $d = V^2/18\,000$ where d is the stopping distance in feet and V is the surface lift speed in feet per minute, ($d = 0.66V^2$ where d is stopping distance in meters and V is the surface lift speed in meters per second) whichever is greater, an automatic brake shall be provided to assure this stopping distance.

This brake shall be applied by springs, weights, or other approved forms of stored energy when any stop circuit is interrupted. When the motive power is an internal combustion engine, a positive system shall be provided to stop the surface lift. If the prime mover is an internal combustion engine, the compression of the engine may serve as a brake when this unit is not declutched by activation of the stop circuit.

5.1.2.6.2 (Reserved)

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5.1.2.6.3 Rollback device

A rollback device shall be provided to automatically prevent reverse rotation of the surface lift under maximum load.

The rollback device, if required, shall be so arranged that there is no single belt, friction clutch, or similar friction-type device between the backstop device and the drive bullwheel.

5.1.2.7 Location of machinery

5.1.2.7.1 General

Moving machine parts that normally may be in reach of personnel shall be fitted with guards. Where breakage of a power transmission component can result in injury, provisions shall be made for appropriate containment of said components. Guards and containment shall be done in conformance with American National Standard, ANSI/ASME, B15.1-2000 (R2008), *Safety Standard for Mechanical Power Transmission Apparatus*.

Protection against static electricity shall be provided.

Fire-fighting device(s) shall be available (see F.6 in Annex F).

5.1.2.7.2 Machinery not housed in a machine room

Provisions shall be made to keep the public away from the machinery. All machinery and controls shall be rated for use in their intended environment.

5.1.2.7.3 Machinery housed in a machine room

The machine room shall be adequately ventilated. It shall have a permanently installed lighting system, adequate for proper machinery maintenance and to reduce the risk of injury to operating personnel. The arrangement of the machinery shall permit proper maintenance. A door with a suitable lock shall be provided, and the design shall keep the public away from the machinery. When a passageway is provided between machines or machinery and walls, a minimum passageway width of 18 inches (460 mm) shall be maintained. Means shall be provided to heat the machine room unless the designer or manufacturer certifies in writing that the drive system machinery is rated for operation in an unheated room.

5.1.2.8 Bullwheels and sheaves in terminals and stations

5.1.2.8.1 General

All bullwheels and sheaves, including their mountings and frames, shall be designed to withstand static and dynamic loads. Bearings and mountings shall be selected, designed, and installed in accordance with the recommendations of the manufacturers of the bearings.

When unlined grooves are used for wire rope, they should be V-shaped and shall have rounded bottoms with a radius equal to approximately 55% of the rope diameter.

When lined grooves are used, the allowable bearing pressures of the liner material shall not be exceeded.

5.1.2.8.2 Haul rope terminal bullwheels

Provisions shall be incorporated in the terminal design to retain the terminal bullwheels in their approximate normal operating position in the event of failure of the bearings, shaft, or hub.

Provisions shall be incorporated in the terminal and rope retention design to control the position of the rope, including possible overhaul, to minimize the effects of its departure from its normal operating position.

The minimum diameter of terminal bullwheels shall be 72 times the nominal diameter of the haul rope. The bullwheel assembly and related structures shall be designed to minimize the probability of a deropement. A flange extension of 1-1/2 times the rope diameter (measured radially from the bottom of the rope groove) shall be one acceptable means of minimizing the probability of deropement when in full compliance with the provisions of 5.1.2.8.4.

5.1.2.8.3 Sheaves in tension systems and sheaves not specifically covered elsewhere in this section

The minimum diameters for these sheaves shall be as indicated in table 5-1.

Condition A: is applicable where bending around sheave is of major importance.

Condition B: is applicable where bending around sheave is important, but some sacrifice in rope life is acceptable to achieve reduction in weight, economy in design, and the like.

Condition C: is applicable to sheaves that are not intended to rotate due to any tension system movement but are intended to rotate only due to tension system adjustment.

Provisions shall be made to assure that all tension system sheaves rotate freely.

Table 5-1 Minimum diameters for sheaves in tension systems and sheaves not specifically covered elsewhere in this section

Rope Type	Sheave diameter		
	Condition A	Condition B	Condition C
6x7 6x19 6x37	72*d* 45*d* 27*d*	42*d* 30*d* 18*d*	24*d* 20*d* 12*d*
NOTE: - *d* equals the nominal rope diameter			

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5.1.2.8.4 Haul rope line sheaves

The requirements of 5.1.3.3 are applicable to haul rope line sheaves used in terminals and stations, with the following exceptions:

a) Sheaves that carry no load other than the weight of the rope and towing devices;

b) Sheaves that are located in such a way that the weight of towing device is either wholly or partially supported on tracks or by other means;

c) Sheaves that are located in such a way that towing devices attached to the haul rope are not passing onto the sheaves.

In such cases, the design shall be modified to meet the requirements of the particular installation.

Guide sheaves shall be located in order to prevent misalignment of rope entering and leaving the drive and return bullwheels. Such sheaves shall be as close as practicable to the drive and return bullwheels, but not farther than one diameter of the drive or return bullwheel from the point of tangency. Shoes, rollers, or sheaves shall be placed on the opposite side of the rope adjacent thereto, to prevent deropement in that direction.

These requirements apply to all installations except floating tension bullwheel carriages (see 5.1.2.9.3).

5.1.2.9 Tension bullwheel carriages

The available travel of the tension bullwheel and carriage shall be adequate for the maximum limits of motion produced by the most unfavorable design loading and operating conditions.

5.1.2.9.1 Rigid mounted carriages

The bullwheel carriage shall be supported from the ground by a rigid structure. The mounting that travels under the action of the tension system shall be supported on rigid, straight rails by means of wheels or other low friction devices. All design loads including torsional loads due to driving torque, braking torque, or reactions of a rollback device shall be considered, and the structure and carriage shall adequately transmit these loads to the foundations.

5.1.2.9.2 Mechanical stops for rigid mounted carriages

Mechanical stops shall be provided to prevent overtravel of the tension carriage. These stops, and the terminal structure, shall be designed to resist, at normal design stresses, an unbalanced horizontal force on the tension bullwheel applied in the direction of the opposite terminal and equal in magnitude to 30% of the tension system reaction on the tension bullwheel.

5.1.2.9.3 Floating tension bullwheel carriages

A floating tension bullwheel carriage may be used and operated with a lateral tilt of more than 6 degrees if it is of the type that has proved to give satisfactory service in the industry and is approved by a Qualified Engineer. Otherwise, the provisions of 5.1.2.9.1 shall apply. In any event, adequate control measures shall be taken to prevent the rope from riding on the flanges or deropement from the terminal bullwheel and the tower sheaves on the nearest line tower.

5.1.2.10 Tension systems

Counterweights, hydraulic and pneumatic cylinders, or other suitable devices shall be used to provide the tensioning requirements of the particular installation. All devices used to provide the tension shall have sufficient travel to adjust to all normal operating changes in loading and temperature.

The tension for haul ropes for all modes of operation shall be determined by the design engineer. Tension systems may be automatic or manual; however, all systems shall have monitoring equipment that will automatically prevent operation outside of design limits (see 5.2.3.3 and 5.2.5.1 for electrical requirements).

Passive tension systems, (i.e. fixed anchorage) shall have a system or procedure to determine that the ropes and/or cables are within their operating tension range. The manufacturer or Qualified Engineer shall specify the checking procedures and intervals.

Tension systems may be adjustable to provide proper tensions for different modes of surface lift operation.

The tension system design shall consider changes, for each mode of operation, in tensions due to rope elongation, friction, and other forces affecting traction on driving, braking, or holding bullwheels, tower, and sheave loading, and maximum vertical loads on grips to assure that tensions remain within design limits.

5.1.2.10.1 Hydraulic and pneumatic systems

Hydraulic and pneumatic cylinders, when used, shall have sufficient ram travel to accommodate all normal operating changes in loading and temperature. Provisions shall be made to keep the cylinder free from climatic-induced conditions and contaminants that may interfere with free movement.

Cylinders and their attachments shall each have a minimum factor of safety of 5. The factor of safety is equal to the ultimate tensile strength of the cylinder divided by the maximum steady state design tension.

The systems providing operating pressure for the cylinder shall have a minimum factor of safety of 5 unless a high-velocity check valve or flow control device is used where the pressure line is connected to the cylinder. The check valve shall be rated to hold twice the normal operating pressure. The remainder of the system shall not exceed the manufacturer's published working pressure. Provisions shall be made to restrict the movement of pressure lines or hoses should they become severed under pressure. When pneumatic storage cylinders, accumulators, or other similar devices

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are used, they shall be located so that they cannot be knocked over or damaged.

5.1.2.10.2 Counterweights

Counterweights, when used, shall be arranged to move freely up and down. Enclosures for counterweights shall be provided where necessary to prevent snow, ice, water, and other materials from accumulating under and around the counterweights and interfering with their free movement. Visual access shall be provided to areas beneath and above all counterweights contained in enclosures or pits. When a counterweight is contained in a structural frame, guides shall be provided to protect the frame and to ensure free movement of the counterweight. Where snow enclosures are not required, guardrails or enclosures shall be provided to prevent unauthorized persons from coming in contact with or passing under counterweights.

5.1.2.10.3 Wire ropes in tension systems

Wire ropes in tension systems shall have a minimum factor of safety of 6 when new (see A.1.3.1 in Annex A). On arrangements involving rope reeving, the maximum design static tension with sheave friction taken into account shall be the basis for determining the factor of safety. See A.3 in Annex A for additional requirements. No rotation-resistant ropes shall be used in tension systems (see 1.4 – *rotation-resistant rope*).

Wire ropes in tension systems shall be adjusted so that the counterweight will reach the end of its travel before the attached tension bullwheel carriage comes within 6 inches (150 mm) of the end of its travel. When wire ropes are used with pneumatic or hydraulic cylinders, they shall be adjusted so that connecting devices will not contact the reeving devices before the ram reaches the travel limits of the cylinder.

5.1.2.10.4 Chains in tension systems

Welded link chains may be used in tension systems (see Annex G).

Roller and leaf chains are prohibited for tension system usage on lifts that are classified as new (see Annex H).

5.1.2.10.5 Cable winches or chain adjusting devices

Winches or other mechanical devices that are used for take-up and remain part of the system shall have a minimum factor of safety of 6 against their ultimate capacity. They shall have a positive lock against release. Where this factor cannot be established by the manufacturer's endorsement, a device shall be installed on the tension system rope or chain ahead of the winch/mechanical device that will keep the tension system intact in the event of failure or release of the device.

The diameter of the winding drum shall not be less than the specified minimum sheave diameters referenced as Condition C in 5.1.2.8.3 for rope.

5.1.2.11 Anchoring devices

All anchoring end connections shall be above finished grade. Any portion of an anchorage below ground shall be protected against loss of strength due to corrosion.

Wire ropes or strands and their connections, used to anchor, tension, or otherwise secure terminal structures, shall be designed with a minimum factor of safety of 6. Where adjusting devices are used in the arrangement, the devices shall be capable of being securely locked or removed during operation.

All connections of ropes or cables used in anchoring devices shall be in accordance with the requirements of A.3.2 in Annex A.

5.1.3 Line structures

5.1.3.1 Towers

The design of the tower structure and foundation shall be in accordance with the requirements of 5.1.1.6. Where guyed towers are used and guys intersect the ground within or near public areas, the guys shall be marked for visibility.

Means shall be provided for ready access from the ground to all tower tops. Permanent ladders are required for heights above those accessible by portable ladders. Portable ladders, if used, shall be in at least sufficient quantity to be available at each point where attendants are positioned. Portable ladders extending more than 20 feet (6.10 meters) shall not be used.

Permanent anchor points shall be provided on all tower tops for the attachment of fall protection devices.

Towers shall be identified with successive numbers clearly visible to passengers when looking up the surface lift line.

Where towers are designed to permit variations in rope height, sheave unit supports shall be guided and attached so as to prevent misalignment by rotation during normal operation.

5.1.3.2 Tower guards and clearances

If unloading is permitted ahead of any intermediate tower, the layout of the unloading area shall satisfy the requirements of 5.1.1.9, and the tower shall be so guarded as to prevent the released towing devices from becoming entangled with it.

5.1.3.3 Haul rope sheaves and mounts

The tread diameter of a haul rope sheave shall not be less than 10 times the nominal diameter of the haul rope unless an elastomer liner is used.

The requirements in 5.1.3.3 and 5.1.3.3.1 through 5.1.3.3.4 apply generally to sheaves that support or hold down the haul rope at towers on a monocable system. These requirements shall apply to both sides of each surface lift.

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5.1.3.3.1 Maximum allowable sheave load

The maximum allowable load per sheave shall be determined by the surface lift designer.

5.1.3.3.2 Sheave and sheave unit design

Sheave flanges shall be as deep as possible, considering other features of the system. At the same time, rope grips shall be designed in relation to the sheave groove so as not to contact sheave flanges during normal operations, taking into consideration the anticipated amount of wear of the sheave liner groove. Grips shall be allowed to contact sheave flanges adjacent to the haul rope when the carrier swings, provided that this is considered in the design of the grips and sheaves. Furthermore, rope grips, sheave flanges, and hanger guides shall be designed so that hangers cannot be caught behind guides, and so that haul ropes and grips cannot be deroped from sheaves if the carrier is swinging within design limits as it approaches or passes the tower.

If the gauge of the haul rope system is varied at any point along the line, the horizontal departure at any one tower shall be provided for in the design so that deropement cannot occur by virtue of such a departure.

Sheave unit design shall include the following features:

a) Suitable guards, of sufficient strength to resist the lateral forces caused by an inside deropement, shall be installed;

b) Construction of the entire sheave unit shall be such that the haul rope cannot become entangled in the sheave unit in the event the rope leaves the sheave toward the outside;

c) Sheave mounts or mounting frames shall be designed to be adjustable, allowing the sheave units to be aligned and held in the plane of the rope;

d) On each sheave unit, rope-catching devices shall be installed to reduce the risk of the haul rope moving excessively in the direction of the load on the sheave unit in the event of deropement. These devices shall be located less than one-half the diameter of the sheaves from the normal operating position of the rope and shall extend a minimum of two rope diameters beyond the sheave flange;

e) Rope catching devices shall be designed to permit the passage of the rope and grips after deropement;

f) On each sheave unit, suitable deropement switch devices shall be installed and maintained that will stop the surface lift in case of deropement (see 5.2.3.4).

See also 5.1.1.5 through 5.1.1.5.1 for the effect of tower height and location on sheave units.

5.1.3.3.3 Haul rope retention

Provisions shall be made to retain the haul rope in the line sheave groove under all anticipated conditions of loading. This criterion shall be met if any of the following conditions is fulfilled:

Condition A: Under the most adverse design loading conditions (excluding dynamic effects), the minimum load of the haul rope on a group of support sheaves at a tower shall not be less than the largest of the following values: 100 pounds (445 newtons) per sheave; or 300 pounds (1335 newtons) per tower group; or a value in pounds equal to two-thirds the sum of the adjacent span lengths expressed in feet of slope length (a value in newtons equal to 10 times the sum of the adjacent span lengths expressed in meters of slope length).

When the haul rope elevation at a tower lies below a straight line joining the haul rope elevations at the adjacent tower, the haul rope shall not leave the group of sheaves under either of the following conditions:

a) when the haul rope tension is 1.5 times its maximum design value at the tower working point, using unloaded carriers in adjacent spans or, in the case of detachable systems, no carriers in adjacent spans;

b) when a haul rope is under tension of the tension system alone (bare rope) or with any arrangement or number of empty towing devices on the line.

The minimum load of the haul rope on a group of hold-down sheaves at a tower under the most adverse design loading conditions shall not be less than the larger of the following values: a value in pounds equal to the dead plus live load of the carrier; or a value in pounds equal to the sum of the adjacent span lengths expressed in feet of slope length (a value in newtons equal to 15 times the sum of the adjacent span lengths expressed in meters of slope length). In no case shall this load be less than 225 pounds (1000 newtons) per passenger.

Condition B: Combination sheave units that incorporate support and hold-down sheaves shall be designed with the retaining sheaves always in contact with the haul rope. When retaining sheaves are mounted to deflect, to allow passage of a carrier grip, such deflection shall not occur until the sheave is loaded to one-half of the maximum design sheave loading. The retaining sheaves shall have the same maximum design loading as the other support or hold-down sheaves on the tower. If the design satisfies loading requirements in Condition A, nothing in this paragraph shall preclude the use of rollers or guides opposite the tower sheaves that do not necessarily contact the rope.

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5.1.3.3.4 Additional requirements

When single sheaves are used for other than guide sheaves, which normally carry no load other than the weight of the rope and towing devices, the sheave diameter should not be less than 20 times the nominal rope diameter. The sheaves for the return rope shall be installed in a manner to prevent a passenger from contacting the rope or being hit by one of the returning towing devices. All line sheaves shall be so guarded that towing devices cannot become entangled in the sheaves or sheave supports while traveling in either a forward or reverse direction.

5.1.4 Line equipment

5.1.4.1 Haul rope

See Annex A for basic wire rope design and installation requirements.

5.1.4.1.1 Factor of safety

When the slope length of the installation is less than 3000 feet (914 meters), the haul rope shall have a minimum static factor of safety of 5 when new. For slope lengths greater than 3000 feet (914 meters), the haul rope may have a minimum static factor of safety of 4.5 when new. Static factor of safety is equal to the nominal breaking force (see A .1.3.1 in Annex A) divided by the computed maximum tension caused by design loads, including the effects of friction, but excluding dynamic loads, in the section of the haul rope that is most highly stressed.

5.1.4.1.2 Factor of safety for spliced haul rope with an independent wire rope center

Where a spliced haul rope with an independent wire rope center (IWRC) is used, the nominal breaking force of an equivalent wire rope with a fiber core shall be used.

5.1.4.2 Reserved

5.1.4.3 Fixed and detachable haul rope grips

5.1.4.3.1 General

The haul rope grip shall be of a type that has been approved by a Qualified Engineer. Grips shall be tested and manufactured using accepted engineering and quality practices. The manufacturer shall permanently affix a unit identification and size marking to each grip. Each grip shall be nondestructively tested before public use, and such testing shall be documented.

The rope grip shall be designed to pass smoothly over and under line sheaves that have flanges of adequate height to discourage the haul rope from leaving the sheaves.

The design shall incorporate provisions to accommodate a 10% reduction in haul rope diameter. The designer's instructions shall provide details for the proper initial setting of the grip and a method to assure an operator or inspector that the grip has not reached an operational limit of the clamping components.

5.1.4.3.2 Slippage

The rope grip shall be designed and installed so as to resist a force which tends to slide it along the haul rope, and which is a minimum of 2 times the force required to move a carrier along a properly lubricated haul rope at its steepest incline, under the most adverse conditions of carrier loading.

The grip designer shall specify the proper grip installation and testing procedures, and for clamping type grips, the minimum force below which the grip should not slip on the rope and a maximum force above which the grip should slip on the rope.

5.1.4.3.3 Strength

The strength of the grip shall be based upon the following criteria:

a) A minimum factor of safety of 6 shall exist in all parts of the grip wherein stress is proportional to the dead and live load of the carrier. This factor of safety is defined as follows: With the grip in its operating position (gripping the rope or equivalent), a downward load, equal to the dead load of the carrier plus 6 times the design live load, shall not cause any part of the grip to fail;

b) Those parts whose stress is not changed by application of live load shall be designed on the basis of an allowable stress of not more than the yield point divided by 3.0. In the design of springs, where used, the allowable stress may be increased if load tests are conducted by an approved testing laboratory to provide assurances that the fatigue life of the actual spring is more than ample for the various applied loads;

c) The material of which the grip is made shall be selected or selected and treated to obtain optimum impact resistance;

d) Special attention shall be paid to fatigue considerations. A grip that has not been proved in service should be subjected to fatigue tests.

The manufacturer's quality control provision shall assure that the grips and their parts meet the designer's specifications and the foregoing criteria.

5.1.4.3.4 Maximum loads

The maximum total vertical load on a single grip shall not exceed 1/14 of the minimum tension in the haul rope.

5.1.4.3.5 (Reserved)

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5.1.4.3.6 Positive attachment of detachable grips

A detachable grip shall be designed and constructed in such a manner that it grips the haul rope positively without damaging the haul rope and in such a manner that it cannot become accidentally uncoupled, even by haul rope vibrations.

Provision shall be made to preclude a grip attaching to the haul rope at the splice unless the designer stipulates that the grip will function properly at that point and gives maximum and minimum permissible rope diameter variations through the splice length including the point of splice tucks.

5.1.4.4 Carriers

5.1.4.4.1 General

The bar, platter, or other device in contact with the skier shall be so designed that the passenger can embark and disembark. Devices that envelop the passenger, such as a strap, are prohibited.

The length of the towing device shall permit the shortest passenger to remain in firm contact with the tow path and to satisfy the requirements of 5.1.1.5.1.

5.1.4.4.2 Loads

With respect to vertical loads, the surface lift carriers shall be designed to support a vertical load 4 times the design load without permanent deformations of the assembly or component parts.

5.1.4.4.3 Additional requirements for retractable towing devices

Retraction of a towing device shall be so controlled that it may be released from a fully extended position without causing injury to passengers or damage to the towing device, or causing such violent oscillations as to expose any part of the towing device to entanglement with the haul rope, sheaves, other structures, or equipment.

5.1.4.4.4 Towing Devices for Recreational Devices

The connection between the towing device and a recreational device shall be designed to minimize inadvertent detachment due to line surges including stops and starts and should not be detached by passenger movements without their reaching the towing device.

The designer shall specify the following relative to any towing device:

a) The allowable loading to which the towing device may be subjected;

b) the specifications relating to how the towing device is to be used, (i.e., if it is designed for use with a recreational device.);

c) the characteristics of the connection details appropriate for the connection of the recreational device to the towing device.

5.1.5 Provisions for operating personnel

Operator and attendant work positions shall be located to provide visual surveillance of the station and the tow path in the vicinity of the station. When the work position is enclosed, they shall be heated, ventilated, and lighted as required to perform the assigned duties. An enclosed work position shall contain inside:

a) the communications and controls required of the station;

b) the operating instructions and emergency procedures;

c) a fire extinguisher (see F.6 in Annex F).

This does not preclude additional communications and controls located outside the work position enclosure.

All primary surface lift controls and communications shall be immediately available to them. The physical appearance, operation, and location of emergency shutdown devices shall differentiate them from other operating devices or controls.

Loading and unloading areas shall have manual stopping devices located conveniently to the attendants assigned to those areas (see 5.2.9).

5.1.6 Operational and maintenance manuals

5.1.6.1 Operational manual

The designer of each new or relocated surface lift shall prepare an operational manual in English for that installation. The manual shall describe the function and operation of the components and provide instructions for the correct usage of the installation.

5.1.6.2 Maintenance manual

The designer of each new or relocated surface lift shall provide with delivery of the installation, a maintenance manual in English for that installation. The manual shall describe recommended maintenance and testing procedures, including:

a) types of lubricants required and frequency of application;

b) definitions and measurements to determine excessive wear;

c) recommended frequency of service to specific components, including relocation of fixed grips, if applicable;

d) brake testing and adjustment.

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5.2 Electrical design and installation

5.2.1 General design and installation testing

Prior to operation of newly installed surface lifts or after any modification thereafter of the electrical system, the electrical system shall be tested and shown to meet the requirements of this standard and the test results shall be recorded. Design of all electronic controls and drives shall consider minimum sensitivity to electrical noise and electrical emissions, such as noise spikes from power lines and lightning, radio transmitters, thyristors (SCR), or solenoid or relay noise at levels and frequencies that could initiate loss of control.

5.2.1.1 Applicable codes

All electrical systems shall comply with American National Standard, ANSI/NFPA 70-2011, *National Electrical Code* and the Institute of Electrical and Electronics Engineers, IEEE C2-2007, *National Electrical Safety Code*.

5.2.1.2 Location

All electrical power transmission wiring located near or proposed to cross over surface lifts shall comply with the applicable requirements of ANSI C2-2007.

5.2.1.3 Protection

All electrical equipment with operating voltages above 24 volts nominal shall be marked conspicuously with letters/numbers that are no smaller than ¼ inch (6 mm) in height designating the greatest voltage that may be in the equipment, the number of phases and whether the voltage is alternating or direct current. All electrical equipment rated over 600 volts shall be marked with conspicuous warning signs stating “Danger High Voltage”.

EXCEPTION – 120 volt single phase lighting circuits and convenience outlets.

All power equipment shall be protected against overloads by circuit breakers or fuses.

In locations where electrical equipment, including batteries, is likely to be exposed to physical damage, enclosures or guards shall be so arranged and of such strength as to prevent such damage.

5.2.1.4 Overhead cables

Only signal, communication, and low voltage control circuit cables may be supported between towers that support the surface lift. Voltage shall be limited to low voltage, 24 volts nominal.

EXCEPTION – Circuits for telephone systems may exceed the low voltage requirements.

Overhead cables shall be securely mounted to tower and terminal structures and positioned in such a way that they do not contact the haul rope or towing devices under normal surface lift operating conditions. The surface lift shall stop if a cable parts, causing the cable to displace from its normal position (see 5.2.5(d)).

5.2.1.5 Wiring

All wiring shall be in accordance with the designer’s specifications and applicable codes.

5.2.1.5.1 Control wiring classification

All control wiring shall be Class 1 in accordance with Article 725 of ANSI/NFPA 70-2011

EXCEPTION – Overhead cables (see 5.2.1.4).

5.2.1.5.2 Communication wiring

All communication wiring and systems are exempted from the requirements in Article 800 of ANSI/NFPA 70-2011.

5.2.1.5.3 Insulation

All control wiring is exempted from the requirements of Article 725.49 Part B of ANSI/NFPA 70-2011. The designer shall specify conductor size, type, and insulation suitable for the electrical and mechanical requirements of the application.

5.2.1.5.4 Exterior lighting and snowmaking circuits

All ungrounded exterior lighting and snowmaking circuits, mounted on or within 60 feet (18.3 meters) of the surface lift centerline, shall have ground fault protection.

5.2.1.5.5 Ground fault circuit interrupter protection for personnel

All 120-volt single phase, 15 and 20 ampere receptacles in areas where electrical diagnostic equipment, electrical hand tools, or portable lighting equipment may be used shall have ground fault circuit interrupter protection for personnel.

EXCEPTION – Receptacles dedicated to permanently mounted devices need not comply with this requirement.

5.2.1.6 Grounding

5.2.1.6.1 Structures

All metallic structures shall be bonded to form a grounding electrode system as defined in Article 250 of ANSI/NFPA 70-2011. Electrical continuity of all metal parts of the structures shall be assured by mechanical connection and shall be electrically bonded to the common bonding conductor.

5.2.1.6.2 Drive terminal structure

The drive terminal structure shall have one point referred to as the grounding electrode as defined in ANSI/NFPA 70-2011. All dc and ac electrical systems shall be referenced to this point. If an electrical prime mover is used, the electric service grounding conductor shall terminate at this point as well as the structure’s ground referenced in 5.2.1.6.1. Under the worst-case conditions, the resistance from the grounding conductor to any grounded point within the surface lift system shall not exceed 50 ohms, for the purpose of grounding the

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electrical circuit. The grounding system for the surface lift shall not be used as a grounding system for any other system not related to the surface lift system.

To ensure that the 50-ohm grounding requirement is met under all conditions of soil, moisture, temperature, and circulating ground and air currents, all terminal and line structures shall be bonded together with a common bonding conductor. The bonding conductor may be the support or messenger cable of overhead control cable, the ground shield for underground control cable, or some other conductor running the full length of the surface lift system, bonded to each of the terminals and the line structures and of sufficient conductance to meet the 50-ohm requirement.

5.2.1.6.3 Haul rope grounding

Grounding sheaves or equivalent means shall be provided at one location for the purpose of grounding haul ropes, as applicable, for static electrical discharge.

5.2.1.6.4 Lightning protection

If lightning protection is provided, it shall follow ANSI/NFPA 780-2008, *Standard for the Installation of Lightning Protection Systems.*

5.2.2 Electrical system circuit design and classification

The designer or lift manufacturer responsible for the design shall identify and classify any new electrical circuits not already classified as protection circuits, operation circuits, or supervision circuits.

5.2.2.1 Circuit priority

Protection circuits shall have priority over all other circuits. Operation circuits shall have priority over supervision circuits. If any circuit's function is connected to circuits of a higher level of protection, it shall be classified at the higher level.

5.2.3 Protection circuits

Electrical circuits designed to stop the surface lift in the event of a malfunction or failure of the surface lift system shall be classified protection circuits. All surface lift systems shall contain one or more protection circuit(s) at least one of which shall be designated the emergency shutdown circuit (see 5.2.3.1). Protection circuits shall be energized to permit system operation and when de-energized shall initiate a stop, or shall be of such design to provide the equivalent level of protection.

A protection circuit may include one or more non-complex elements (see 1.4 – *non-complex element*) and/or complex electronic elements (see 1.4 – *complex electronic element*). The designer shall make use through continuous diagnostic coverage (see 1.4 – *continuous diagnostic coverage*) that the failure of a complex electronic element will cause the surface lift to stop unless another element in the protection circuit is performing the same function (redundancy). If functional redundancy is implemented, the failure of the first element must be annunciated, at a minimum, at the beginning of operations on a daily basis.

The designer or manufacturer shall develop procedures and frequency for testing protection circuits. As a minimum, all protection circuits shall be calibrated and tested annually.

Protection circuits include but are not limited to:

a) emergency shutdown (see 5.2.3.1);

b) stop gate (see 5.2.3.2);

c) tension system fault (see 5.2.3.3);

d) deropement circuit(s) (see 5.2.3.4);

e) brake system (if installed);

f) overspeed (if installed)

g) rollback detection device (if electrical).

5.2.3.1 Emergency shutdown circuit

All surface lift systems shall include at least one protection circuit labeled emergency shutdown circuit (see 1.4 - *emergency shutdown*). The shutdown shall have priority over all other control stops or commands. If, for any reason, the operator has lost control of the surface lift while using the operating control circuitry, the controls shall include an emergency shutdown circuit allowing the operator/attendant to stop the surface lift. Any one of the following conditions is considered a loss of control of a surface lift:

a) Surface lift will not SLOW DOWN when given the command to do so;

b) Surface lift will not STOP when given the command to do so;

c) Surface lift OVERSPEEDS beyond control settings and/or maximum design speed;

d) Surface lift ACCELERATES faster than normal design acceleration;

e) Surface lift SELF-STARTS or SELF-ACCELERATES without the command to do so;

f) Surface lift REVERSES direction unintentionally and without the command to do so.

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5.2.3.2 Stop gates

Automatic stopping device(s) shall be installed beyond each unloading area to stop the surface lift if actuated by a person's passage.

For actuating device(s) of the suspended type, the suspended portion shall be strong enough to cause release of the actuating devices in use under the most adverse conditions, and each side shall be detachable and shall interrupt the operating circuit when detached. The location of the device(s) shall be in accordance with the following:

a) *Intermediate unloading stations:* Required only when passengers are not permitted beyond the intermediate unloading station. The device shall automatically stop the surface lift in the event a passenger or an unretracted towing device passes beyond the intended point of unloading;

b) *Terminal unloading areas:* Always required. The device shall automatically stop the surface lift in the event a passenger or an unretracted towing device passes beyond the stop gate. The stop gate shall be so located that the distance from the stop gate to the first obstruction is 150% of the distance required to stop the empty surface lift operating at maximum speed.

In no case may the grip travel more than two-thirds (2/3) of the distance from its position at the time the stop gate is tripped to the point where it would begin to pull a passenger in the reverse direction.

A device shall be installed on the down side of surface lifts to stop the surface lift in the event a towing outfit fails to retract. This device shall be located as near to the upper terminal as practical, but in no event be further downhill than opposite to the unloading area.

5.2.3.3 Tension system

Active tension systems, (i.e. counterweight, hydraulic, etc.) shall have a protection device(s) that will stop the lift when the haul rope tension carriage exceeds its range of normal operations.

5.2.3.4 Deropement switches

On each sheave unit, suitable deropement detection devices shall be installed and maintained that will stop the surface lift in case of deropement (see 5.1.3.3.2(f)).

5.2.4 Operation circuits

An operation circuit is a circuit that provides power to or controls the surface lift machinery.

The designer or manufacturer shall identify operation circuits that require periodic testing and develop procedures and frequency for testing. As a minimum, all operation circuits shall be tested and calibrated annually.

Operation circuits include, but are not limited to:

a) power circuits;

b) drive fault circuits;

c) normal stop (see 1.4 – *normal stop* and 5.1.2.5);

d) speed command circuits (i.e., fast, slow, etc.);

e) internal combustion engine speed control.

5.2.5 Supervision circuits

Supervision circuits include all communications systems. In addition, supervision circuits may be provided to monitor or supervise the performance of various surface lift systems or provide the surface lift operator with system information.

The designer or manufacturer shall identify supervision circuits that require periodic testing and develop procedures and frequency for testing supervision circuits. As a minimum, all supervision circuits shall be calibrated and tested annually.

Supervision circuits may include, but are not limited to:

a) telephone and sound powered systems (see 5.1.1.7);

b) information display circuits;

c) audible warning devices (see 5.2.10);

d) overhead cable supervision (5.2.1.4);

e) wind speed and direction sensors and display units;

f) gearbox oil pressure, oil flow, and temperature;

g) pneumatic and hydraulic tension system pressure (see 5.2.5.1).

5.2.5.1 Pneumatic and hydraulic tension systems

When pneumatic or hydraulic tension systems are used, pressure-sensing devices shall also be incorporated that will stop the surface lift system in case the operating pressure goes above or below the design pressure range. Such pressure-sensing devices shall be located close to the actual tensioning device. It shall not be possible to isolate the pressure sensor from the actual tensioning device.

5.2.6 Bypass circuits

A temporary circuit may be installed for the purpose of bypassing failed electrical circuits. The use of these bypass circuits shall meet the requirements of 5.3.2.5.9.

5.2.7 Electrical prime mover

All surface lift systems equipped with electrical prime movers (electrical motors) shall have phase-loss protection on all power phases and under voltage protection or over voltage protection, or both, when speed regulation can be adversely affected by such voltage variations.

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5.2.8 Electronic speed-regulated drive monitoring

All electronic speed-regulated drives and electric motors shall shut down in the event of:

a) field loss (dc motors);

b) overspeed;

c) speed feedback loss as applicable;

d) overcurrent.

5.2.9 Manual control devices

All automatic and manual stop and shutdown devices shall be of the manually reset type. An exception to this requirement is allowed for magnetic or optically operated automatic stop devices, if the operating circuit is such that it indicates that such devices initiated the stop and the circuit is of the manually reset type.

Manual stop switches (push button) shall be positively opened mechanically and their opening shall not be dependent upon springs.

Manual control devices shall be installed at all attendants' and operators' work positions, in machine rooms, and out-of-doors in proximity to all loading and unloading areas. As a minimum, each of these control locations shall include an Emergency Shutdown device. All manual control devices located in or on a control cabinet shall be mounted so that they are in the same plane or face of the cabinet. The control devices shall not be located in a position that would require the operator or attendant to pass through the path of moving carriers in order to operate the controls.

The devices listed in Annex E shall be conspicuously and permanently marked with the proper function and color code.

5.2.10 Safety of operating and maintenance personnel

Provision shall be incorporated in the surface lift design to render the system inoperable when necessary for Lock-out Tag-out protection of personnel working on the surface lift.

The sign "Personnel Working on Lift - Do Not Start" or a similar warning sign shall be hung on the main disconnect switch or at control points for starting the power unit(s) when persons are working on the surface lift.

The surface lift shall incorporate an audible warning device that signals an impending start of the surface lift. After the start button is pressed, the device shall sound an audible alarm for a minimum of 2 seconds and shall continue until the surface lift begins to move. The audible device shall be heard inside and outside all terminals and machine rooms above the ambient noise level.

5.2.11 Electrical system acceptance tests

Upon completion of the acceptance test and before public operation of the surface lift, the function of software and/or relay logic shall be certified by a Qualified Engineer. The certification shall be included in the acceptance test report. Any modifications made to the electrical design shall be clearly marked on the on-site documentation and signed by a Qualified Engineer (see 5.1.1.11.2).

5.2.12 Software security

The "as built" documents shall include a procedure, developed by the lift manufacturer or a Qualified Engineer, to ensure the security of the software logic and operating parameters that will control the surface lift. Upon completion of the acceptance testing this procedure shall be implemented in a manner that will prevent unauthorized personnel from making changes to the software logic or operating parameters. All programmable logic and parameters shall be documented.

5.2.13 Night operations

For nighttime operation, operating surface lifts shall be provided with lighting systems. The entire tow path shall be lit.

5.2.13.1 Illumination

Lights shall be located in a manner to provide generally uniform illumination.

5.2.13.2 Types

Lamps shall be of a type suitable and rated for minimum temperatures of the location. Fixtures shall be designed to maintain proper lamp-operating characteristics.

5.2.13.3 Location

Lights shall be mounted on substantial poles or standards. Surface lift towers and terminal structures may be used for supporting lights subject to the following requirements:

a) Approval shall be obtained from a Qualified Engineer;

b) The service conductors to each surface lift tower or terminal structure shall be underground or in rigid raceways. No wiring shall be supported between towers and no open wiring shall pass over or under the surface lift;

c) A separate enclosed disconnect or circuit breaker shall be required for each tower or terminal structure;

d) All metallic raceways on a tower or terminal structure shall be grounded;

e) The lighting installation shall not conflict with other requirements of this standard and shall not interfere with operations of the surface lift in any manner.

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5.2.13.4 Emergency lighting

Emergency lighting shall be provided in the event of electric power failure to permit regular unloading of the surface lift.

5.3 Operation and maintenance

This subclause covers the requirements for operation and maintenance of all types of surface lifts. Many requirements are listed elsewhere in Section 5 and referenced annexes, since they also regulate installation and design. It is imperative that operating and maintenance personnel be familiar with applicable provisions of this section and the surface lift operational and maintenance manuals (see 5.1.6).

5.3.1 General and personnel safety

Operation and maintenance of surface lift equipment can be dangerous to personnel performing these tasks. Procedures for performing these functions shall require precautionary measures necessary to reduce the risks for the personnel involved. Implementation of the procedures intended for the protection of the public and operating and maintenance personnel shall be the responsibility of the owner, supervisor, and the individual worker.

Passengers and operating personnel shall be cautioned or prevented, as required, from transporting objects or materials that may encroach upon limitations of towing device clearances or design live loads.

5.3.1.1 Applicable design requirements

The following design requirements shall be met by the effective date listed:

– No new items listed for surface lifts in this standard

The following items were listed in the ANSI B77.1-2006 Standard and are required:

- 5.1.1.7 Communications (Nov. 1, 2007).
- 5.1.2.6.3 Rollback Device (Nov 1, 2008).
- 5.1.3.3.2(d) Cable Catcher (Nov 1, 2008).
- 5.1.3.3.2(f) Deropement switch (Nov 1, 2008).

5.3.1.2 Signs

See normative Annex D for public sign requirements.

See 5.2.1.3 for electrical warnings.

The sign “Personnel Working on Lift - Do Not Start” or a similar warning sign shall be posted as required by 5.2.10.

5.3.2 Operation

5.3.2.1 Personnel and supervision

Surface lifts shall be operated by trained personnel, and the owner shall be responsible for their supervision and the training to perform the duties listed in 5.3.2.3. Procedures for monitoring the operation and use of the surface lift and for advising and assisting passengers, including passengers with common adaptive equipment, shall be included in the training. One or more persons familiar with emergency procedures shall be on the site at all times when the surface lift is in operation. All personnel shall practice good housekeeping. Personnel shall comply with the operational procedures and regulations for the surface lift. Persons performing the duties of the surface lift personnel may exchange assignments as directed by the supervisor provided they are trained for each assignment undertaken.

5.3.2.1.1 Supervisor

An individual shall be designated to oversee the surface lift’s operating practices and operating personnel for the purpose of public use. The designated supervisor may delegate some authority to others, but shall oversee the operation and operating personnel of the surface lift(s) unless modified by the owner as part of the operation and maintenance quality assurance plan (see 1.5.4).

5.3.2.1.2 Operator

One individual shall be designated as the operator of the surface lift for the purpose of public use. This operator shall be trained in operational, and emergency procedures and such training shall be documented

5.3.2.1.3 Attendants

Attendants shall be assigned to particular duties under direction of the operator. For public operation, attendants shall be trained in operational and emergency procedures pertaining to their assignments; and such training shall be documented.

5.3.2.1.4 First Aid

One or more persons trained to provide first aid/emergency care at the Basic Life Support (BLS) level, including CPR, shall be available at all times when a surface lift is operating and transporting passengers. There shall be ready access to first-aid/emergency care supplies and equipment, including provisions for transporting an injured person to an enclosed and, if required, heated shelter.

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5.3.2.2 Minimum operating personnel

While operating for public use, an operator shall be present. The individual may serve concurrently as an attendant when authorized by the supervisor.

One attendant's work position shall be at each loading area.

One attendant's work position shall be at each unloading area.

The above requirements for minimum operating personnel may be modified as follows:

a) surface lifts may be operated by a single individual at the loading area who will serve concurrently as the operator and the attendant. The following conditions shall be met:

1) the length of the surface lift tow path, shall not exceed 800 feet (244 meters);

2) the entire tow path and the entire haul rope system shall be visible to the operator;

3) the surface lift shall have a clearly identified stop switch located at the unloading area, in addition to the required stop gate;

4) the operator shall have all surface lift controls immediately available;

5) the restarting of the surface lift following actuation of an automatic or manual stopping device shall be restricted until clearance is assured and the actuated automatic or manual stopping device(s) has been reset by an authorized person;

6) there shall be no obstructions at the top bullwheel area that could come into contact with a passenger who might fail to unload.

b) surface lifts provided with video surveillance of sections of the tow path and designated unloading stations not visible to the operator do not require an unloading attendant, provided conditions (3) through (6) are enforced and the unloading areas of the surface lift meet the requirements of 5.1.1.9.

NOTE – When specifically approved, platter lifts with single-passenger hangers do not require either an unloading attendant or video surveillance providing conditions (3) through (6) are enforced and the unloading area of the platter lift meets all manufacturer's design specifications.

In addition, the staffing requirements (if any) specified by the surface lift manufacturer shall be observed.

5.3.2.3 Duties of operating personnel

All personnel shall use reasonable care while performing their duties.

5.3.2.3.1 Supervisor

The duties of the individual designated as the supervisor include:

a) to oversee practices that will determine that the surface lift is operational and that all operating personnel are trained, equipped, and capable of performing their duties; prior to public use of the lift;

b) to discontinue operations on any surface lift due to physical, weather, personnel, or other reasons;

c) to oversee operational procedures and adherence to applicable regulations pertaining to the surface lift.

5.3.2.3.2 Operator

The duties of the individual designated as the operator include:

a) to be knowledgeable of operational and emergency procedures and the related equipment needed to perform the assigned duties;

b) to assume responsible charge of the surface lift;

c) to direct the attendants at his/her surface lift;

d) to verify that the preoperational inspection (see 5.3.2.4.2) has been completed and documented before public operation;

e) to start the surface lift while operating for the public (see 5.3.2.5.2);

f) to maintain an operational log (see 5.3.5.1);

g) to deny access to the surface lift to any person using procedures and criteria provided;

h) to advise the supervisor of observed abnormal or unusual conditions that may adversely affect the safety of the operation;

i) to terminate passenger operations (see 5.3.2.5.8)

5.3.2.3.3 Attendant

The duties of an attendant include:

a) to be knowledgeable of operational and emergency procedures and the related equipment needed to perform the assigned duties;

b) to monitor the passengers' use of the surface lift; including observing, advising and assisting them while they are in the attendant's work area as they embark on or disembark from the surface lift; and to respond to unusual occurrences or conditions, as noted. The attendant should respond by choosing an appropriate action, which may include any of the following.

1) assisting the passenger

2) slowing the surface lift (if applicable);

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3) stopping the surface lift;

4) continuing operation and observation.

c) to deny access to the surface lift to any person using procedures and criteria provided;

d) to advise the operator of observed abnormal or unusual conditions that may adversely affect the safety of the operation.

5.3.2.4 Operational procedures

Operational procedures may supplement the designer's operational manual (see 5.1.6.1) and the owner's quality program (see 1.5.4).

5.3.2.4.1 Control of passengers

Each surface lift shall have a definite method for marshaling passengers for loading and unloading. Fences, gates, and alternate access and/or loading methods may be required to implement the system. Passengers shall not attach or detach recreational devices from the towing device.

5.3.2.4.2 Daily preoperational inspection

Prior to public operation, a daily preoperational inspection shall be performed and documented. As a minimum, the inspection shall consist of the following:

a) a visual inspection of each terminal, station, and the entire length of the surface lift;

b) assurance that the tension system is functional and that tension system devices (counterweights, cylinders, carriages, and the like) have adequate travel with appropriate clearances at both ends;

c) operation of all manual and automatic switches in terminals, stations, work positions, and loading and unloading areas, per manufacturer's instructions;

d) operation of all braking systems;

NOTE – The designer of the surface lift system may specify that this inspection is to take place while the surface lift is not moving.

e) operation of communication systems;

f) operation of the surface lift, including a visual inspection of all ropes and towing devices;

g) checking each control circuit for circuit continuity and integrity at its most remote terminal on a daily basis;

h) for those surface lifts having internal combustion engines, determining that the fuel quantity is sufficient to conduct the anticipated period of operation without refueling. During refueling, power units shall be shut down;

I) inspecting the loading and unloading areas and preparing them for the ingress and egress of passengers. The tow path shall be inspected and, if necessary, tracks shall be established. Tracks shall be established beyond the stop gate for a distance necessary for passengers to stop should the passenger pass through the stop gate (see 5.2.3.2). The towing devices shall be cleared of ice to the extent necessary to permit operation;

j) assurance that applicable horizontal and vertical clearances are maintained (see 5.1.1.4 and 5.1.1.5).

5.3.2.4.3 Access to facilities

While in operation, entrances to all machinery, operators' and attendants' rooms shall be restricted to authorized personnel only. All entrances shall have the signs required in Table D-1 (u) in Annex D.

While not in operation, entrances to all machinery, operators', and attendants' rooms shall be locked. To provide shelter and emergency telephone access for public safety, specified entrances may remain unlocked provided the surface lift equipment cannot be operated by unauthorized personnel.

5.3.2.5 Operational requirements

5.3.2.5.1 General

The owner and supervisor of each surface lift shall review the requirements of Section 5 and referenced annexes of this standard to ascertain that original design and installation conditions have not been altered in a manner so as to violate the requirements of the standard.

5.3.2.5.2 Starting

Following procedural clearances, the surface lift shall be started by the operator or at the direction of the operator. Capability for starting from other locations may be provided for maintenance or emergency operation.

5.3.2.5.3 Tow path maintenance

For skiers, a minimum tow path surface width of 30 inches (760 mm) times the design number of passengers per carrier, but not less than 4 feet (1.22 meters), shall be maintained through the length of the tow path. The tow path, including the loading and unloading areas shall be maintained to the range of contours specified by the designer or a Qualified Engineer.

For recreational devices, the minimum tow path surface width shall be 24 inches (610 mm) plus the width of the recreational device. It shall be maintained to minimize the risk of an inadvertently detached towing device from sliding into another towing device or lift component. Surface irregularities that could contribute to inadvertent detachment of a recreational device shall be minimized.

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No recreational devices traffic shall be allowed to cross the tow path (see 1.4 – tow path). Skier traffic may cross at designated locations.

5.3.2.5.4 Stops

After any stop of a surface lift, the operator shall determine the cause of the stop, and not restart until clearance has been obtained from all attended stations.

5.3.2.5.5 Damage to towing devices

Should any towing device become damaged or otherwise rendered unfit for passenger transportation during normal operation, it shall be clearly and distinctively marked and not used for passengers until repaired or replaced. It shall be removed from the line as soon as feasible.

5.3.2.5.6 Hazardous conditions

When conditions are such that operation is hazardous to passengers or equipment based upon the area's operational experience and the designer's design considerations, the surface lift shall be unloaded and the operation discontinued. No surface lift shall operate when there is an electrical storm in the immediate vicinity. Should such conditions develop while the surface lift is in operation, loading of passengers shall be terminated, and operation shall be continued only as long as necessary to unload all passengers. When such shutdown has been caused by an electrical storm, grounding of control circuits and haul ropes that are used as conductors in communication systems is permissible. Such grounding shall be removed prior to resumption of passenger operations.

5.3.2.5.7 (Reserved)

5.3.2.5.8 Termination of daily operations

Procedures shall be established for terminating daily operations in such a manner that those passengers will not be left on the surface lift after it has been shut down. Loading ramps, as required, shall be closed during off-hours and so marked.

5.3.2.5.9 Bypass requirements

The use of temporary circuits that have been installed for the purpose of bypassing failed electrical circuit(s) (see 5.2.6) shall meet these requirements in the following order:

a) The condition that the circuit indicated is in default shall be thoroughly inspected to ensure an electrical operating circuit malfunction, rather than the indicated condition, actually exists;

b) The bypass shall be authorized only by the surface lift supervisor or his/her designated representative;

c) When a bypass is in operation, the function bypassed shall be under constant, close visual observation;

d) The use of a bypass circuit shall be logged and shall indicate when, who authorized, and for what duration a bypass was used;

e) The operator control panel shall indicate that a bypass is in use.

5.3.3 Maintenance

5.3.3.1 General

Foundations and all structural, mechanical, and electrical components shall be inspected regularly and kept in a state of good repair. The maintenance requirements of the designer (see 5.1.6.2) shall be followed. Maintenance logs shall be kept (see 5.3.5.2).

A written schedule for systematic maintenance shall be developed and followed. The schedule shall establish specific frequencies for periodic lubrication, adjustment, inspection, and testing. The schedule shall include, but not be limited to, the following:

a) all wire rope, and strand, (see A.4 in Annex A);

b) line sheave units, sheaves, bearings, and liners;

c) bullwheels, bearings, and liners;

d) tension system;

e) drive system, including bearings and couplings;

f) braking systems;

g) electrical control systems;

h) communication systems;

I) towing devices;

j) structures;

k) tow path (see 5.1.1.4 and 5.3.2.5.3).

5.3.3.2 Maintenance personnel

Surface lifts shall be maintained by trained and competent personnel. The owner shall be responsible for the supervision and training of such personnel, and such training shall be documented. All personnel shall practice good housekeeping, with particular emphasis on avoiding the development of any condition that might contribute to personal injury. Personnel shall comply with the operational rules and safety regulations of the specific surface lift.

5.3.3.3 Rope grips

5.3.3.3.1 Fixed rope grips – Additional requirements

All fixed grips shall be moved at least once every 24 calendar months. The grips should be moved a uniform distance each time and in the same direction. A fixed grip should never be installed or allowed to migrate closer than a distance of 20 haul rope diameters from a splice tuck or rope repair tuck. The designer's instructions shall be followed if they are more restrictive

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than these requirements. Movements shall be recorded in the maintenance records (see 5.3.5.2 and 5.3.5.3).

As each grip is relocated, the haul rope shall be examined for deterioration at or near the grip location. A Qualified Engineer shall supply information to the owner to enable him/her to identify excessive slippage.

5.3.3.3.2 Detachable rope grips – Additional requirements

Detachable rope grips shall be disassembled for inspection, adjustment, and replacement of worn parts at intervals not to exceed those recommended by the designer.

5.3.4 Inspections

5.3.4.1 General inspection

Each surface lift shall be inspected annually, or after each 2000 hours of operation, whichever comes first, by a surface lift specialist independent of the owner. The inspection shall verify preservation of original design integrity and cover the requirements of this standard for maintenance, operation, required self-inspections, and record keeping. Items found either deficient or in noncompliance shall be noted. A report signed by the specialist shall be filed with the owner.

5.3.4.2 Wire rope inspection

Inspection of wire rope shall comply with A.4.1.2 in Annex A.

5.3.5 Records

5.3.5.1 Operational log

A log shall be maintained for each surface lift. Daily entries shall be made giving the following minimum information:

a) date;

b) names and work positions of operating personnel;

c) operating hours and purpose of operations;

d) temperature, wind, and weather conditions;

e) record of compliance with daily operational inspection including loading and unloading platforms, ramps, tow path and signs;

f) position and condition of the tension carriage, counterweights, or other tension system devices;

g) accidents, malfunctions, or abnormal occurrences during operation;

h) signature of operator.

5.3.5.2 Maintenance log

A signed complete log shall be maintained wherein the actual execution of maintenance work shall be recorded. The log shall state the components serviced and the condition of the components. A record shall be kept of replacement of components.

5.3.5.3 Wire rope log

A log shall be maintained for each surface lift giving the following information on each rope:

a) specification (see A.1.1 in Annex A);

b) copy of certified test report;

c) date installed;

d) splicing certificate for each splice or laid-in strand;

e) record of lubrication, including type of lubricant and date applied;

f) record of maintenance inspections;

g) inspection reports of wire rope and their connections (see A.4.1 and A.4.3 in Annex A);

h) report of accidents or injury to wire rope or strand.

5.3.5.4 Chain log

A log shall be maintained for each surface lift, giving the following information on each chain used as a tension element:

a) specification (see Annex G and Annex H);

b) copy of certified test report;

c) date installed;

d) record of lubrication, including type of lubricant and date applied;

e) record of maintenance inspections;

f) report of accidents or injury to the chain.

5.3.6 Passenger conduct and responsibility

5.3.6.1 Passenger responsibilities

It is recognized that certain dangers and risks are inherent in machines of this type, and their operation. It is also recognized that inherent and other risks or dangers exist for those who are in the process of embarking, riding, or disembarking from surface lifts (see 1.2). Passengers accept the risks inherent in such participation of which the ordinary prudent person is or should be aware.

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Passengers shall use good judgment and act in a responsible manner while using the surface lift, including:

a) participating in the embarkation, riding, and disembarkation processes in such a manner as to reduce risks for themselves and others;

b) obeying all written and oral instructions and warnings;

c) refraining from using the surface lift while under the influence of drugs or alcohol;

d) properly use the surface lift and equipment provided.

5.3.6.2 Passenger dexterity and ability

All passengers who use a surface lift shall be responsible for their own embarkation, riding, and disembarkation. They shall be presumed to have sufficient ability, physical dexterity, and/or personal assistance to negotiate and to be evacuated from the surface lift safely. Passengers shall maintain control of their speed and course while loading and unloading the surface lift.

5.3.6.3 Passenger embarkation and disembarkation

A passenger shall get on and get off a surface lift at designated areas. No passenger shall embark without first understanding and observing the proper loading, riding, and unloading procedures (see Table D-1 (a) in Annex D).

5.3.6.4 Passenger riding

Passengers, while riding a surface lift, shall not throw or expel therefrom any object, nor shall any passenger do any act or thing that shall interfere with the operation of the surface lift. Passengers shall not willfully engage in any type of conduct that may contribute to or cause injury to any other person.

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Section 6
Tows

This section covers that class of passenger ropeways wherein passengers grasp a circulating fiber haul rope or a towing device attached to a circulating wire or fiber rope and are propelled uphill. Passengers riding on recreational devices are also propelled uphill. On a tow, the uphill rope spans without intermediate support from the loading to the unloading area. The downhill rope may have intermediate supports.

6.1 Design and installation

6.1.1 General

6.1.1.1 Design passenger weight

For purposes of design, a passenger shall be considered as having a minimum average weight of 170 pounds (77.1 kilograms). It is the owners' responsibility to indicate unusual considerations that might affect the design passenger weight.

6.1.1.2 Capacity and speed

The loading interval and capacity shall be stated by the designer and regulated to suit the design limitations of the equipment as well as the slope gradient and the ability of the passengers to load and unload the tow.

6.1.1.2.1 Speed (Fiber rope tows)

The rope speed shall not exceed 1500 feet per minute (7.6 meters per second) when skiers grasp the circulating haul rope. The speed shall not exceed 400 feet per minute (2.0 meters per second) when towing devices are attached to the haul rope or passengers are riding recreational devices.

6.1.1.2.2 Speed (Wire rope tows)

The rope speed shall not exceed 400 feet per minute (2.0 meters per second).

6.1.1.3 Location

In selecting the location and alignment of an installation, consideration shall be given to the following items, and to any others that may be particularly pertinent to the tow type and location:

a) ADA accessibility;

b) electric power lines and their supports;

c) rock and earth slides, cave-ins, washouts, and the like;

d) snow creep and avalanches;

e) wind action;

f) icing;

g) ski slopes and trails;

h) rivers and gullies;

i) buried installations, including pipelines;

j) control of air space below, above, and adjacent to the installation;

k) crossing or close proximity to other ropeways;

l) highways;

n) fire hazard;

m) structures;

6.1.1.3.1 Tow path gradient

The maximum grade of a tow path shall be regulated for the use intended. In no case shall the grade exceed that recommended by the tow design engineer or the manufacturer. Reverse grades shall be permitted at loading and unloading areas. Gradual reverse grades will be permitted along the tow path for tows used by skiers.

6.1.1.3.2 Tow path cross slope

The cross slope of a tow path for skiers shall not exceed 5% except at unloading areas. On wire rope tows, any cross slope shall be away from the centerline of the tow.

For tows used to transport recreational devices, the tow path shall be designed to minimize the risk of an inadvertently detached towing device from sliding into another towing device or the tow.

6.1.1.4 Clearing envelope

As a minimum there shall be no obstacles, unless allowed in 6.1.1.5, within 5 feet (1.53 meters) of ropes and carriers under design operating conditions. Carriers shall not contact any obstacle during operation under design wind conditions. Clearings and contiguous spaces shall be maintained to reduce the risk of washouts, hazard trees and other obstacles that might endanger the installation (see 6.3.3.1).

6.1.1.4.1 Tow path clearing width

A minimum tow path surface clearing width shall be cleared on each side of the centerline of the tow path and maintained in such a manner that no rocks, stumps, or other obstructions project above the surface as follows:

a) 36 inches (915 mm) for skiers or;

b) 18 inches (460 mm) plus one-half the width of the recreational device.

6.1.1.5 Clearances

Terminals and supports shall be designed and installed to provide the clearances as herein specified and to minimize surge of the line under operating conditions. Local wind conditions shall be taken into consideration.

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6.1.1.5.1 Vertical clearances

At no point along the tow path shall the rope exert a downward force greater than 35 pounds (156 newtons), or an upward force greater than 30 pounds (133 newtons), when held at a height of 24 inches (610 mm) above the snow surface by a single passenger.

EXCEPTION – For tows used to transport recreational devices, the upward force of 30 pounds (133 newtons) may be exceeded at the unloading area for a distance not exceeding 20 feet (6.10 meters) (see 6.1.1.9).

When the down-coming rope is less than 7 feet (2.14 meters) above the tow path, protective fencing or other means shall be provided to prevent persons from coming in contact with the down-coming rope.

Towing devices shall not contact the ground or snow surface at any point along the tow path.

6.1.1.5.2 Horizontal clearances

The following minimum distances shall be maintained along the tow path:

a) 36 inches (915 mm) between the up-going rope and any support;

b) 18 inches (460 mm) from a recreational device and any support.

6.1.1.5.3 Other clearances

The clearances for up-going and down-coming ropes shall be:

a) *Tows without towing devices:* There shall be a minimum distance of 5 feet (1.53 meters) between the up-going rope and downhill intermediate supports for 50 feet (15.25 meters) uphill of the loading area.

b) *Tows with towing devices:* At all points, the distance between the up-going and down-coming ropes shall exceed twice the projection of any towing device attached to the haul rope. In no event, shall the distance be less than 4 feet 6 inches (1.38 meters). The uphill tow path shall be so located that a passenger cannot be struck by a down-coming towing device (see 6.1.3.2).

6.1.1.6 Structures and foundations

All structures and foundations shall be designed and constructed in conformance with 1.3 and shall be appropriate for the site. Applied design loads shall include dead, live, snow, wind, and dynamic loads due to normal conditions and for foreseeable abnormal conditions.

Structures and foundations located in snow creep areas shall be designed for such conditions and loads, or protective structures shall be provided as required by the conditions.

6.1.1.6.1 (Reserved)

6.1.1.6.2 Foundations

In determining the resistance of the soil to motion of the foundation, the subsoil conditions at the site shall be considered, including any buoyancy due to groundwater that may be present. If the resistance of the soil is not practically determinable, the foundation or anchorage should be designed as a gravity anchor, using a coefficient of friction appropriate to the general character of the soil. Bottoms of foundations shall be below the normal frost depth unless resting on non-frost-susceptible soil or solid rock. Foundations on rock shall be firmly anchored to solid rock, unless designed as gravity foundations.

The top of concrete foundations shall not be less than 6 inches (150 mm) above finished grade unless specific direction for the protection of the foundation and structural steel below grade is specified by the designer.

The design shall have a minimum factor of safety of 2 in resisting overturning and, concurrently, 2 against sliding, under dead-load and live-load conditions. The minimum factors shall be 1.5 under these loadings plus wind acting simultaneously.

6.1.1.6.3 Anchorages

All structures shall be supported on sills or other supports that, however temporary, are capable of carrying the loads imposed by structural and machine elements under static or operating conditions without shifting or settlement that will impair the operation of the tow.

Anchors may be natural objects or devices installed in a manner capable of withstanding tensions and uplift imposed by tow installation (see 6.1.2.11).

The design shall have a factor of safety of 2 in resisting overturning, sliding, or withdrawal under dead and live load.

6.1.1.7 Communications

A permanently installed two-way voice communication system shall be provided between the prime mover control point, drive system building if any, loading stations, and unloading stations. The communication system shall be functional and audible during operation.

Audio indicators shall be audible over all ambient noise levels, and visual indicators (e.g., Light Emitting Diodes) shall be visible even in bright sunlight.

NOTE – Voice communication systems are not required for those tows qualifying for operation by a single operator, as defined in 6.3.2.2.

6.1.1.8 Combustion engine(s) and fuel handling

Internal combustion engine installation and fuel handling requirements are located in normative Annex F.

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6.1.1.9 Loading and unloading areas

Platforms, ramps, corrals, and mazes comprising the loading and unloading areas of a tow are integrally related to its operation. They shall be designed and installed in conformance with 1.3.

6.1.1.9.1 Loading areas

Loading areas shall be approximately level. The area shall be free of obstructions and fenced in a manner to guide passengers to the loading point. Load gates, artificial surfaces, and other loading aids when used shall be designed and installed with regards to all passengers including adaptive. At least one point of access to the tow shall have a minimum clearance width of 36 inches (915 mm) to accommodate passengers using adaptive equipment.

6.1.1.9.2 Unloading areas

The unloading areas length, profile, and exit pathway shall be installed in accordance with the tow's speed, usage and manufacturer's recommendations. The exit pathway should be inclined downward in the direction of travel and outward from the line of the uphill tow path to provide passenger movement away from the tow.

6.1.1.10 (Reserved)

6.1.1.11 Acceptance inspection and tests

Prior to the acceptance inspection and the acceptance tests, the tow shall be operated for a period of continuous, full-speed operation, with empty towing devices, of sufficient duration to check for overheating of moving parts, excessive vibration or deflection of mechanical or structural components, free movement of tension systems, rope twist, and other related conditions.

6.1.1.11.1 Acceptance inspection

Before a tow that is new or relocated or that has not been operated for routine maintenance within the previous 2 years is opened to the public, it shall be given a thorough inspection by qualified personnel to verify compliance with the plans and specifications of the designer.

It shall be the responsibility of the owner to see that the following conditions have been met:

a) tightness of all structural connections;

b) lubrication of all moving parts;

c) alignment and clearances of all open gearing;

d) installation and alignment of all drive system components;

e) position and freedom of movement of counterweights or other tension systems and carriages;

f) haul rope alignment at entrance to bullwheels;

g) operation of all electrical components, including circuit protection and grounding;

h) horizontal and vertical clearances (see 6.1.1.5.1 through 6.1.1.5.3);

i) terminals for correct location and installation in accordance with plans and specifications;

j) condition of haul rope splice.

6.1.1.11.2 Acceptance tests

Before a tow that is new or relocated or that has not been operated for routine maintenance within the previous two years is opened to the public, it shall be given thorough tests by qualified personnel to verify compliance with the plans and specifications of the designer. The designer or manufacturer shall propose and submit an acceptance test procedure.

The functioning of all push-button stops, stop gates, etc. shall be checked. Braking shall be proved adequate (see 6.1.2.6.1 and 6.1.2.6.3). The tests shall include full-speed operation for as long as required to check for overheating of moving parts, excessive vibration or deflection of mechanical or structural components, free movement of tensioning systems, rope twist or spiraling verified to conform with 6.1.4.1.1, and other related conditions.

6.1.2 Terminals and stations

6.1.2.1 Power units

All power units shall have the capacity to handle the most unfavorable design loading conditions, including the starting of a fully loaded tow.

Where manual multi-speed transmissions are used on a power unit, they shall not be shifted when the tow is moving.

Where reverse capability is provided on a power unit for a tow, provisions shall be made to prevent accidentally shifting into reverse whenever the tow is operating.

6.1.2.1.1 Prime mover

Power units engaged as a prime mover shall have the systems required in 6.1 and 6.2 functional during operation (see 1.4 – *prime mover*).

6.1.2.1.2 Evacuation power unit

An evacuation power unit shall not be required.

6.1.2.2 Speed reducers and gearing

All speed reducers and gearing shall have the capacity for starting a tow under the most unfavorable design loading conditions without exceeding design rating. They shall have a service factor appropriate for the application.

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6.1.2.3 Bearings, clutches, couplings, and shafting

Bearings, clutches, couplings, shafting and universal joint shafts (cardan shafts) shall be selected on the basis of the manufacturer's published data for the particular use. All shafting shall be designed in accordance with accepted standard practices. Guarding and containment shall be in accordance with the provisions of 6.1.2.7.1.

Provision shall be made for adjustment and lubrication of all bearings, clutches, and couplings, when required.

6.1.2.4 Acceleration and speed control

Acceleration of a drive system shall be regulated with regard to tow type, profile, speed, and use.

After any type of stop is initiated, the stop shall not be canceled and the tow shall not be started until it has come to a complete stop.

The tow is to be started at its lowest point of speed range after any type of stop.

6.1.2.5 Stops & shutdowns

Normal stop (see 1.4 – *normal stop*): If a service brake is required (see 6.1.2.6.1), it shall have been applied by the time the tow comes to a stop.

Emergency shutdown (see 1.4 – *emergency shutdown)*: If a service brake is required (see 6.1.2.6.1), it shall have been applied by the time the tow comes to a stop. The designer shall designate which control functions of the tow system shall initiate an emergency shutdown.

The designer may define other stopping modes other than normal stop and emergency shutdown. For other stopping modes, the designer shall specify the method of stopping, including the type and timing of brake(s) that may be applied, and the stopping criteria.

6.1.2.6 Brakes and rollback device

Each tow shall have the brakes and devices as designated in 6.1.2.6.1 and 6.1.2.6.3.

Installed braking systems shall be capable of operation to comply with daily inspections and periodic testing.

6.1.2.6.1 Service brake

Unless an unloaded tow operating at maximum speed will stop in 25 feet (7.62 meters) or less, an automatic brake shall be provided to assure this stopping distance.

This brake shall be applied by springs, weights, or other approved forms of stored energy when any stop circuit is interrupted. When the motive power is an internal combustion engine, a positive system shall be provided to stop the tow.

6.1.2.6.2 (Reserved)

6.1.2.6.3 Rollback device

A device to automatically prevent reverse rotation of the tow shall be on all tows having an average grade in excess of 15%. If it can be demonstrated that the tow will not roll back (if declutched) under the most adverse loading, a rollback device shall not be necessary.

The rollback device, if required, shall be so arranged that there is no single belt, friction clutch, or similar friction-type device between the backstop device and the drive bullwheel.

6.1.2.7 Location of machinery

6.1.2.7.1 General

Moving machine parts that normally may be in reach of personnel shall be fitted with guards. Where breakage of a power transmission component can result in injury, provisions shall be made for appropriate containment of said components. Guards and containment shall be done in conformance to American National Standard, ANSI/ASME, B15.1-2000 (R2008), *Safety Standard for Mechanical Power Transmission Apparatus*.

Protection against static electricity shall be provided.

Fire-fighting device(s) shall be available (see F.6 in Annex F).

6.1.2.7.2 Machinery not housed in a machine room

Provisions shall be made to keep the public away from the machinery. All machinery and controls shall be rated for use in their intended environment.

6.1.2.7.3 Machinery housed in a machine room

The machine room shall be adequately ventilated. It shall have a permanently installed lighting system, adequate for proper machinery maintenance and to reduce the risk of injury to operating personnel. The arrangement of machinery shall permit proper maintenance. A door with a suitable lock shall be provided, and the design shall keep the public away from the machinery. When a passageway is provided between machines or machinery and walls, a minimum passageway width of 18 inches (460 mm) shall be maintained. Means shall be provided to heat the machine room unless the designer or manufacturer certifies in writing that the drive system machinery is rated for operation in an unheated room.

6.1.2.8 Bullwheels and sheaves in terminals and stations

6.1.2.8.1 General

All bullwheels and sheaves, including their mountings and frames, shall be designed to withstand static and dynamic loads. Bearings and mountings shall be selected, designed, and installed in accordance with the recommendations of the manufacturers of the bearings.

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When unlined grooves are used for wire rope, they should be V-shaped and shall have rounded bottoms with a radius equal to approximately 55% of the rope diameter.

When lined grooves are used, the allowable bearing pressures of the liner material shall not be exceeded.

6.1.2.8.2 Haul rope terminal bullwheels

6.1.2.8.2.1 Wire rope tow bullwheels

Haul rope terminal bullwheel frames shall be designed to retain the rope in the event of the failure of the shaft or mounting. In instances where the bullwheel is cantilevered, the design working stresses shall not be more than 60% of those otherwise allowable.

The minimum diameter of terminal bullwheels shall be 72 times the nominal diameter of the haul rope, provided that no towing device passes around the bullwheel. The minimum diameter shall be 80 times the nominal haul rope diameter in cases where towing devices pass around the bullwheel. In the latter case, means shall be provided to guide towing devices into, around, and out of terminal bullwheels and to prevent the towing devices from swinging excessively while passing around the bullwheel. The bullwheel assembly shall be designed to retain the haul rope in the event of a deropement from the bullwheel.

Haul rope terminal bullwheels that act as driving, braking, or holding bullwheels shall be so designed that the haul rope does not slip in the bullwheel groove.

Provisions shall be made to permit adjustment of the terminal bullwheels to control the rotation of the haul rope and towing devices.

6.1.2.8.2.2 Fiber rope tow bullwheels and sheaves

Bullwheels and sheaves shall be designed and arranged to prevent unnecessary stress, wear, or disfigurement of the fiber haul rope. They shall be of sufficient strength and properly balanced to prevent excessive vibration at any operating speed. A suitable method shall be provided to retain the rope in the terminal in the event of a deropement.

6.1.2.8.3 (Reserved)

6.1.2.8.4 Haul rope line sheaves

The requirements of 6.1.3.3 are applicable to haul rope line sheaves used in terminals and stations, except sheaves that carry no load other than the weight of the rope and towing devices.

In the event auxiliary terminal guide sheaves are required, they shall be sized and located, have sufficient guides, and be otherwise designed to present no operational hazard to passengers, operating personnel, or mechanical elements of the tow.

6.1.2.9 Tension bullwheel carriages

The available travel of the tension bullwheel and carriage shall be adequate for the maximum limits of motion under normal operation.

The idler terminal bullwheel may be supported by a rigid structure or carried in a floating manner. The assembly shall not be subject to collapse in the event of deropement and the subsequent retaining of the haul rope by the structure or bullwheel mounting.

6.1.2.10 Tension systems

Counterweights, hydraulic and pneumatic cylinders, or other suitable devices shall be used to provide the tensioning requirements of the particular installation.

6.1.2.10.1 Tensioning devices for wire rope tows

A mechanical or hydraulic tensioning system shall be provided to ensure that the haul rope tension does not exceed a value of one-fifth its minimum breaking force under the most unfavorable accumulation of stress due to loading, operating, temperature, and like considerations. A visual means of verifying this restriction shall be provided.

6.1.2.10.2 Tensioning devices for fiber rope tows

All installations shall have provisions for adjusting and maintaining proper rope tension.

6.1.2.10.3 Wire ropes in tension systems

Wire ropes in tension systems shall have a minimum factor of safety of 6 when new (see A.1.3.1 in Annex A). On arrangements involving rope reeving, the maximum design static tension with sheave friction taken into account shall be the basis for determining the factor of safety. See A.3 in Annex A for additional requirements. No rotation-resistant ropes shall be used in tension systems (see 1.4 - *rotation-resistant rope*).

6.1.2.10.4 Chains in tension systems

Welded link chains may be used in tension systems (see Annex G).

Roller and leaf chains are prohibited for tension system usage on lifts that are classified as new (see Annex H).

6.1.2.10.5 Cable winches or chain adjusting devices

Winches or other mechanical devices that are used for take-up and remain part of the system shall have a minimum factor of safety of 6 against their ultimate capacity. They shall have a positive lock against release. Where this factor cannot be established by the manufacturer's endorsement, a device shall be installed on the tension system rope or chain ahead of the winch/mechanical device that will keep the tension system intact in the event of failure or release of the device.

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6.1.2.11 Anchoring devices

All anchoring end connections shall be above finished grade. Any portion of an anchorage below ground shall be protected against loss of strength due to corrosion.

Wire ropes or strands and their connections, used to anchor, tension, or otherwise secure terminal structures, shall be designed with a minimum factor of safety of 6. Where adjusting devices are used in the arrangement, the devices shall be capable of being securely locked or removed during operation.

All connections of ropes or cables used in anchoring devices shall be in accordance with the requirements of A.3.2.4 in Annex A.

6.1.3 Return Line structures

6.1.3.1 Supports

Line supports will be permitted between the unloading and loading areas to carry the return rope only; provisions of 6.1.1.5.3 are applicable. Guyed towers shall be permitted if these towers and their guys are clearly marked, conform to the clearance requirements of 6.1.1.5.2, and are protected from public access.

There shall be no spikes, hooks, or other projections on a tower for a distance of 7 feet (2.14 meters) above the snow surface.

6.1.3.2 Guards and clearances

Moving parts (other than the up-going haul rope and towing devices) that are less than 7 feet (2.14 meters) above the snow surface shall be guarded in such a manner as to prevent accidental contact by the public or passengers using the tow. Adequate clearance or guards shall be provided between opposing haul ropes and towing devices to prevent accidental contact by the public or passengers. Persons shall be prevented from passing under the counterweight or tensioning system, or contacting any attachments thereto, by fences or guards.

6.1.3.3 Haul rope sheaves and mounts

The tread diameter of a haul rope sheave shall not be less than 10 times the nominal diameter of the haul rope unless an elastomer liner is used.

The sheave mountings shall be sufficiently strong to prevent failure under the most adverse design load conditions. If the vertical component of the rope tension is not sufficient to hold the rope in the sheave groove at all times, then a device shall be used to prevent deropement from the sheave. This applies to both sheaves supporting the rope and those holding it down.

6.1.4 Line equipment

6.1.4.1 Haul rope

Bullwheel and/or sheave adjustment or other means shall be provided to regulate rotation of the up-going rope and limit spiraling to one complete revolution in 200 feet (61.0 meters) of travel and to a maximum of 3 revolutions over the total length of the tow.

6.1.4.1.1 Factor of safety for wire rope

Haul ropes shall have a minimum static factor of safety of 5, when new. Static factor of safety is equal to the minimum breaking force (see A.1.3 in Annex A) divided by the computed maximum tension caused by design loads, including the effects of friction, but excluding dynamic loads, in the section of rope that is most highly stressed. See Annex A for basic wire rope design and installation requirements.

6.1.4.1.2 Factor of safety for spliced haul rope with an independent wire rope center

Where a spliced haul rope with an independent wire rope center (IWRC) is used, the minimum breaking force of an equivalent wire rope with a fiber core shall be used.

6.1.4.1.3 Requirements for haul ropes for fiber rope tows

The haul rope shall be natural- or synthetic-fiber rope having a special lay or braid to minimize twist and manufactured for use with a tow for skiing. Fiber ropes shall be reeled in a manner that minimizes twist, and the manufacturer's instructions for unreeling and installation shall be followed.

Splices shall be made by qualified personnel in accordance with the manufacturer's recommendations.

The minimum factor of safety shall be 5, based upon the manufacturer's catalog breaking strength of the new rope divided by the maximum full-load static tension in the haul rope.

6.1.4.2 (Reserved)

6.1.4.3 Towing devices

Rope grippers for skiers shall not be permitted. Towing devices shall be allowed on tows operating at 400 feet per minute (2.0 meters per second) or less.

Towing devices shall be designed to prevent sliding along the haul rope when subject to twice the pull required to move a passenger along the tow path at the steepest point. The towing device shall be designed to preclude entangling gloves or clothing, or pinching fingers between the towing device and the haul rope. Attaching the towing device to the haul rope shall in no way impair the strength of the haul rope.

The connection between the towing device and a recreational device shall be designed to minimize inadvertent detachment due to line surges including stops and starts and should not be detached by passenger movements without their reaching the towing device.

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The designer shall specify the following relative to any towing device:

a) The allowable loading to which the towing device may be subjected;

b) The specifications relating to how the towing device is to be used, i.e. if it is designed for use with a recreational device;

c) The characteristics of the connection details appropriate for the connection of the recreational device to the towing device.

6.1.5 Provisions for operating personnel

Operator and attendant work positions shall be located to provide visual surveillance of the station and the tow path in the vicinity of the station. Work positions shall not be located between the uphill and downhill haul ropes. When the work position is enclosed, they shall be heated, ventilated, and lighted as required to perform the assigned duties. An enclosed work position shall contain inside:

a) the communications and controls required;

b) the operating instructions and emergency procedures;

c) a fire extinguisher (see F.6 in Annex F).

This does not preclude additional communications and controls located outside the enclosed work position.

When the tow is operated by an operator without the use of other attendants, the operator shall be located where they can observe the full length of the tow path. All primary tow controls and communications shall be immediately available to them.

When attendants are on duty at a tow, loading and unloading areas shall have manual stopping devices located convenient to the attendants assigned to those areas.

6.1.6 Operational and maintenance manuals

6.1.6.1 Operational manual

The designer of each new or relocated tow shall prepare an operational manual in English for that installation. The manual shall describe the function and operation of the components and provide instructions for the correct usage of the installation.

6.1.6.2 Maintenance manual

The designer of each new or relocated tow shall provide with delivery of the installation, a maintenance manual in English for that installation. The manual shall describe recommended maintenance and testing procedures, including:

a) types of lubricants required and frequency of application;

b) definitions and measurements to determine excessive wear;

c) recommended frequency of service to specific components, including relocation of fixed grips, if applicable.

6.2 Electrical design and installation

6.2.1 General design and installation testing

Prior to operation of newly installed tows, or after any modification thereafter of the electrical system, the electrical system shall be tested and shown to meet the requirements of this standard and the test results shall be recorded. Design of all electronic controls and drives shall consider minimum sensitivity to electrical noise and electrical emissions, such as noise spikes from power lines and lightning, radio transmitters, thyristors (SCR), or solenoid or relay noise at levels and frequencies that could initiate loss of control.

6.2.1.1 Applicable codes

All electrical systems shall comply with American National Standard, ANSI/NFPA 70-2011, *National Electrical Code* and the Institute of Electrical and Electronics Engineers, IEEE C2-2007, *National Electrical Safety Code*.

6.2.1.2 Location

All electrical power transmission wiring located near or proposed to cross over tows shall comply with the applicable requirements of IEEE C2-2007.

6.2.1.3 Protection

All electrical equipment with operating voltages above 24 volts nominal shall be marked conspicuously with letters/numbers that are no smaller than ¼ inch (6 mm) in height designating the greatest voltage that may be in the equipment, the number of phases and whether the voltage is alternating or direct current. All electrical equipment rated over 600 volts shall be marked with conspicuous warning signs stating “Danger High Voltage”.

EXCEPTION – 120 volt single phase lighting circuits and convenience outlets.

All power equipment shall be protected against overloads by circuit breakers or fuses.

In locations where electrical equipment, including batteries, is likely to be exposed to physical damage, enclosures or guards shall be so arranged and of such strength as to prevent such damage.

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6.2.1.4 Overhead cables

Only signal, communication, and control circuit cables may be supported between towers that support the tow. Voltage shall be limited to low voltage, 24 volts nominal.

EXCEPTION – Circuits for telephone systems may exceed the low voltage requirements.

Overhead cables shall be securely mounted to tower and terminal structures and positioned in such a way that they do not contact the haul rope or towing devices under normal tow operating conditions. If a cable parts and displaces from its normal position, the tow shall stop (see 6.2.5(d)).

6.2.1.5 Wiring

All wiring shall be in accordance with the designer's specifications and applicable codes.

6.2.1.5.1 Control wiring classification

All control wiring shall be Class 1 in accordance with Article 725 of ANSI/NFPA 70-2011.

EXCEPTION – Overhead cables (see 6.2.1.4).

6.2.1.5.2 Communication wiring

All communication wiring and systems are exempted from the requirements in Article 800 of ANSI/NFPA 70-2011.

6.2.1.5.3 Insulation

All control wiring is exempted from the requirements of Article 725.49 Part B of ANSI/NFPA 70-2011. The designer shall specify conductor size, type, and insulation suitable for the electrical and mechanical requirements of the application.

6.2.1.5.4 Exterior lighting and snowmaking circuits

All ungrounded exterior lighting and snowmaking circuits, mounted on or within 60 feet (18.3 meters) of the tow centerline, shall have ground fault protection (see 1.4 – *ground fault protection*).

6.2.1.5.5 Ground fault circuit interrupter protection for personnel

All 120-volt single phase, 15 and 20 ampere receptacles in areas where electrical diagnostic equipment, electrical hand tools, or portable lighting equipment may be used shall have ground fault circuit interrupter protection for personnel (see 1.4 – *ground-fault circuit interrupter*).

EXCEPTION – Receptacles dedicated to permanently mounted devices need not comply with this requirement.

6.2.1.6 Grounding

6.2.1.6.1 (Reserved)

6.2.1.6.2 Terminal structure

The drive terminal structure shall have one point referred to as the grounding electrode as defined in ANSI/NFPA 70-2008. All dc and ac electrical systems shall be referenced to this point. If an electrical prime mover is used, the electric service grounding conductor shall terminate at this point. Under the worst-case conditions, the resistance from the grounding electrode to any grounded point within the tow system shall not exceed 50 ohms for the purpose of grounding the electrical circuit. The grounding system for the particular tow shall not be used as a grounding system for any other system not related to the tow system.

6.2.1.6.3 Haul rope grounding

Grounding sheaves or equivalent means shall be provided at one location for the purpose of grounding metallic haul ropes, as applicable, for static electrical discharge.

6.2.1.6.4 Lightning protection

If lightning protection is provided, it shall follow ANSI/NFPA 780-2008, *Standard for the Installation of Lightning Protection Systems.*

6.2.2 Electrical system circuit design and classification

The designer or tow manufacturer responsible for the design shall identify and classify any new electrical circuits not already classified as protection circuits, operation circuits, or supervision circuits

6.2.2.1 Circuit priority

Protection circuits shall have priority over all other circuits. Operation circuits shall have priority over supervision circuits. If any circuit's function is connected to circuits of a higher level of protection, it shall be classified at the higher level.

6.2.3 Protection circuits

Electrical circuits designed to stop the tow in the event of a malfunction or failure of the tow system shall be classified protection circuits. All tow systems shall contain one or more protection circuit(s) at least one of which shall be designated the emergency shutdown circuit (see 6.2.3.1). Protection circuits shall be energized to permit system operation and when de-energized shall initiate a stop, or shall be of such design to provide the equivalent level of protection.

A protection circuit may include one or more non-complex elements (see 1.4 – *non-complex element*) and/or complex electronic elements (see 1.4 – *complex element*). The designer shall make use through continuous diagnostic coverage (see 1.4 – *continuous diagnostic coverage*) that the failure of a complex electronic element will cause the tow to stop unless another element in the protection circuit is performing the same function (redundancy). If functional redundancy is implemented, the failure of the first element must be annunciated, at a minimum, at the beginning of operations on a daily basis.

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The designer or manufacturer shall develop procedures and frequency for testing protection circuits. As a minimum, all protection circuits shall be calibrated and tested annually.

Protection circuits include, but are not limited to:

a) emergency shutdown (see 6.2.3.1);

b) stop gate (6.2.3.2);

c) tension system fault (if installed);

d) overspeed (see 6.2.8).

All automatic and manual stop and shutdown devices shall be of the manually reset type. An exception to this requirement is allowed for magnetic or optically operated automatic stop devices, if the operating circuit is such that it indicates that such devices initiated the stop and the circuit is of the manually reset type.

Manual stop switches (push button) shall be positively opened mechanically and their opening shall not be dependent upon springs.

6.2.3.1 Emergency shutdown circuit

All tow systems shall include at least one protection circuit labeled emergency shutdown circuit (see 1.4 - *emergency shutdown*). The shutdown shall have priority over all other control stops or commands. If, for any reason, the operator has lost control of the tow while using the operating control circuitry, the controls shall include an emergency shutdown circuit allowing the operator/attendant to stop the tow. Any one of the following conditions is considered a loss of control of a tow:

a) Tow will not SLOW DOWN when given the command to do so;

b) Tow will not STOP when given the command to do so;

c) Tow OVERSPEEDS beyond control settings and/or maximum design speed;

d) Tow ACCELERATES faster than normal design acceleration;

e) Tow SELF-STARTS or SELF-ACCELERATES without the command to do so;

f) Tow REVERSES direction unintentionally and without the command to do so.

6.2.3.2 Stop gates

Automatic stop device(s) shall be installed at each terminal and beyond each unloading area to stop the tow if actuated by a person's passage.

For actuating device(s) of the suspended type, the suspended portion shall be strong enough to cause release of the actuating devices in use under the most adverse conditions, and each side shall be detachable and shall interrupt the operating circuit when detached. The device shall be in accordance with the following as applicable:

a) *Intermediate unloading areas:* Required only when passengers are not permitted beyond the intermediate unloading area;

b) *Terminal areas:* Installed on the incoming side so that the distance from the stop gate to the first obstruction is more than 150% of the distance required to stop the empty tow operating at maximum speed. The stop device shall extend across the tow beneath the incoming rope and insofar as is practical the outgoing rope;

c) *Fiber rope tows:* Additionally, at unloading areas a device shall encircle the incoming fiber rope.

6.2.4 Operation circuits

An operation circuit is a circuit that provides power to or controls the tow machinery.

The designer or manufacturer shall identify operation circuits that require periodic testing and develop procedures and frequency for testing. As a minimum, all operation circuits shall be tested and calibrated annually.

Operation circuits include, but are not limited to:

a) power circuits;

b) drive fault circuits;

c) normal stop (see 1.4 – *normal stop* and 6.1.2.5);

d) speed command circuits (i.e., fast, slow, etc.).

6.2.5 Supervision circuits

Supervision circuits include all communications systems. In addition, supervision circuits may be provided to monitor or supervise the performance of various tow systems or provide the tow operator with system information.

The designer or manufacturer shall identify supervision circuits that require periodic testing and develop procedures and frequency for testing supervision circuits. As a minimum, all supervision circuits shall be calibrated and tested annually.

Supervision circuits may include, but are not limited to:

a) telephone and sound powered systems (see 6.1.1.7);

b) information display circuits;

c) Audible warning devices;

d) overhead cable supervision (6.2.1.4).

6.2.6 Bypass circuits

A temporary circuit may be installed for the purpose of bypassing failed electrical circuits. The use of these bypass circuits shall meet the requirements of 6.3.2.5.9.

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6.2.7 Electrical prime mover

All tow systems equipped with electrical prime movers (electrical motors) shall have phase-loss protection on all power phases and under-voltage protection or over-voltage protection, or both, when speed regulation can be adversely affected by such voltage variations.

6.2.8 Electronic speed-regulated drive

All electronic speed-regulated drives and electric motors shall shut down in the event of:

a) field loss (dc motors);

b) overspeed;

c) speed feedback loss as applicable;

d) overcurrent.

6.2.9 Manual control devices

Manual control devices shall be installed at all attendants' and operators' work positions, in machine rooms, and out-of-doors in proximity to all loading and unloading areas. As a minimum, each of these control locations shall include an Emergency Shutdown device. All manual control devices located in or on a control cabinet shall be mounted so that they are in the same plane or face of the cabinet. The control devices shall not be located in a position that would require the operator or attendant to pass through the path of moving carriers in order to operate the controls.

The devices listed in Annex E shall be conspicuously and permanently marked with the proper function and color code.

6.2.10 Safety of operating and maintenance personnel

Provision shall be incorporated in the tow design to render the system inoperable when necessary for Lock-out Tag-out protection of personnel working on the tow.

The sign "Personnel Working on Tow - Do Not Start" or a similar warning sign shall be hung on the main disconnect switch or at control points for starting the power unit(s) when persons are working on the tow.

6.2.11 (Reserved)

6.2.12 (Reserved)

6.2.13 Night operations

For night time operation, operating tows shall be provided with lighting systems. The entire tow path and operational areas shall be lighted.

6.2.13.1 Illumination

Lights shall be located in a manner to provide generally uniform illumination.

6.2.13.2 Types

Lamps shall be of a type suitable and rated for minimum temperatures of the location. Fixtures shall be designed to maintain proper lamp operating characteristics.

6.2.13.3 Location

Lights shall be mounted on substantial poles or standards. Tow towers and terminal structures may be used for supporting lights subject to the following requirements:

a) Approval shall be obtained from a Qualified Engineer;

b) The service conductors to each tow tower or terminal structure shall be underground or in rigid raceways. No wiring shall be supported between towers and no open wiring shall pass over or under the tow;

c) A separate enclosed disconnect or circuit breaker shall be required for each tower or terminal structure;

d) All metallic raceways on a tower or terminal structure shall be grounded;

e) The lighting installation shall not conflict with other requirements of this standard and shall not interfere with operations of the tow in any manner.

6.2.13.4 Emergency lighting

Emergency lighting shall be provided in the event of electric power failure to permit unloading of the tow.

6.3 Operation and maintenance

This subsection covers the requirements for operation and maintenance of all types of tows. Many requirements are listed elsewhere in Section 6 and referenced annexes, since they also regulate installation and design. It is imperative that operating and maintenance personnel be familiar with applicable provisions of this section and the tow operational and maintenance manuals (see 6.1.6).

6.3.1 General and personnel safety

Operation and maintenance of tow equipment can be dangerous to personnel performing these tasks. Procedures for performing these functions shall require precautionary measures necessary to reduce the risks of the personnel involved. Implementation of the procedures intended for the protection of the public and operating and maintenance personnel shall be the responsibility of the owner, supervisor, and the individual worker.

Work positions shall not be located between the uphill and downhill haul ropes.

Passengers and operating personnel shall be cautioned or prevented, as required, from transporting objects or materials that may encroach upon limitations of clearances or design live loads.

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6.3.1.1 Applicable design requirements

The following design requirements shall be met by the effective date listed:

– No new items listed for tows in this standard

The following items were listed in the ANSI B77.1-2006 Standard and are required:

– 6.1.1.7 Communications (Nov. 1, 2007)
– 6.1.2.6.3 Rollback Device (Nov 1, 2008)

6.3.1.2 Signs

See normative Annex D for public sign requirements.

See 6.2.1.3 for electrical warnings.

The sign “Personnel Working on Tow - Do Not Start” or a similar warning sign shall be posted as required by 6.2.10.

6.3.2 Operation

6.3.2.1 Personnel and supervision

Tows shall be operated by trained personnel, and the owner shall be responsible for their supervision and the training to perform the duties listed in 6.3.2.3. Procedures for monitoring the operation and use of the tow and for advising and assisting passengers, including passengers with common adaptive equipment, shall be included in the training. One or more persons familiar with emergency procedures shall be on the site at all times when the tow is in operation. All personnel shall practice good housekeeping. Personnel shall comply with the operational procedures and regulations for the tow. Persons performing the duties of the tow personnel may exchange assignments as directed by the supervisor; provided they are trained for each assignment undertaken.

6.3.2.1.1 Supervisor

An individual shall be designated to oversee the tow’s operating practices and operating personnel for the purpose of public use. The designated supervisor may delegate some authority to others, but shall oversee the operation and operating personnel of the tow(s) unless modified by the owner as part of the operation and maintenance quality assurance plan (see 1.5.4).

6.3.2.1.2 Operator

One individual shall be designated as the operator of the tow for the purpose of public use. This operator shall be trained in operational, and emergency procedures and such training shall be documented.

6.3.2.1.3 Attendants

Attendants shall be assigned to particular duties under direction of the operator. For public operation, attendants shall be trained in operational and emergency procedures pertaining to their assignments; and such training shall be documented.

6.3.2.1.4 First aid

One or more persons trained to provide first aid/emergency care at the Basic Life Support (BLS) level, including CPR, shall be available at all times when a tow is operating and transporting passengers. There shall be ready access to first aid/emergency care supplies and equipment, including provisions for transporting an injured person to an enclosed and, if required, heated shelter.

6.3.2.2 Minimum operating personnel

While operating for public use, an operator shall be present. The individual may serve concurrently as an attendant when authorized by the supervisor.

One attendant’s work position shall be at each loading area.

One attendant’s work position shall be at each unloading area.

The above requirements for minimum operating personnel may be modified as follows:

a) tows may be operated by a single individual at the loading area who will serve concurrently as the operator and the attendant. The following conditions shall be met:

1) recreational devices are not used;

2) the length of the tow path shall not exceed 800 feet (244 meters);

3) the entire tow path is clearly visible to the operator;

4) the operator can start the tow while maintaining the surveillance required in condition (3);

5) the restarting of the tow following actuation of an automatic or manual stopping device(s) shall be restricted until clearance is assured and the actuated automatic or manual stopping device(s) has been reset by an authorized person;

6) when video surveillance of the uphill tow path and the unattended loading or unloading area is provided, conditions (2) and (3) need not apply;

7) when conditions (2), (3), and (4) are met, one operator can operate more than one tow providing both tows stop when any stopping device is activated on either tow, and the stopping and starting controls for each tow are clearly marked and within his/her reach.

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b) One attendant may be permitted to serve the unloading of more than one tow where such an attendant is normally required by other subsections of this standard, provided the following conditions are met:

1) all unloading areas from the unload point to the end of the tow path shall be visible to the attendant and shall be within a 90-degree cone of sight of the attendant's station;

2) the distance from the attendant's station to the uphill end of each tow path shall not exceed 100 feet (30.5 meters) and shall be readily accessible;

3) whenever the attendant must leave his/her work position, all tows under the attendant's surveillance shall be stopped;

4) the attendant cannot serve as an operator on any of these tows;

5) all stop gates shall be effective and shall comply with the requirements of 6.2.3.2;

6) recreational devices are automatically detached from the towing device.

In addition, the staffing requirements (if any) specified by the tow manufacturer shall be observed.

6.3.2.3 Duties of operating personnel

All personnel shall use reasonable care while performing their duties.

6.3.2.3.1 Supervisor

The duties of the individual designated as the supervisor include:

a) to oversee practices that will determine that the tow is operational and that all operating personnel are trained, equipped, and capable of performing their duties prior to public use of the tow;

b) to discontinue operations on any tow due to physical, weather, personnel, or other reasons;

c) to oversee operational procedures and adherence to applicable regulations pertaining to the tow.

6.3.2.3.2 Operator

The duties of the individual designated as the operator include:

a) to be knowledgeable of operational and emergency procedures and the related equipment needed to perform the assigned duties;

b) to assume responsible charge of the tow;

c) to direct the attendants at his/her tow;

d) to verify that the preoperational inspection (see 6.3.2.4.2) has been completed and documented before public operation;

e) to start the tow while operating for the public (see 6.3.2.5.2);

f) to maintain an operational log (see 6.3.5.1);

g) to deny access to the tow to any person using procedures and criteria provided;

h) to advise the supervisor of observed abnormal or unusual conditions that may adversely affect the safety of the operation;

i) to terminate passenger operations (see 6.3.2.5.8).

6.3.2.3.3 Attendant

The duties of an attendant include:

a) to be knowledgeable of operational and emergency procedures and the related equipment needed to perform the assigned duties;

b) to monitor the passengers' use of the tow; including observing, advising and assisting them while they are in the attendant's work area as they embark on or disembark from the tow; and to respond to unusual occurrences or conditions, as noted. The attendant should respond by choosing an appropriate action, which may include any of the following:

1) assisting the passenger;

2) slowing the tow (if applicable);

3) stopping the tow;

4) continuing operation and observation.

c) to deny access to the tow to any person using procedures and criteria provided;

d) to advise the operator of observed abnormal or unusual conditions that may adversely affect the safety of the operation;

6.3.2.4 Operational procedures,

Operational procedures may supplement the designer's operational manual (see 6.1.6.1) and the owner's quality program (see 1.5.4).

6.3.2.4.1 Control of passengers

Each tow shall have a definite method for marshaling passengers for loading and unloading. Fences and gates may be required to implement the system. Passengers shall not attach or detach the recreational device from the towing device.

On a tow with towing devices connected to recreational devices, the path of the haul rope and the recreational devices shall be coordinated in such a manner that at all times between the load point and the unload point the passenger may avoid inadvertent contact with the haul rope.

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6.3.2.4.2 Daily preoperational inspection

Prior to public operation, a daily preoperational inspection shall be performed and documented. As a minimum, the inspection shall consist of the following:

a) a visual inspection of each terminal, work position, station, and the entire length of the tow;

b) assurance that the tension system is functional and that tension system devices (counterweights, cylinders, carriages, and the like) have adequate travel with appropriate clearances at both ends;

c) operation of all manual and automatic switches in terminals, stations, work positions, and loading and unloading areas, per manufacturer's instructions;

d) operation of all braking systems.

NOTE – The designer of the tow system may specify that this inspection is to take place while the tow is not moving;

e) operation of communication systems;

f) operation of the tow, including a visual inspection of all ropes and towing devices;

g) for those tows having internal combustion engines, determining that the fuel quantity is sufficient to conduct the anticipated period of operation without refueling. During refueling, power units shall be shut down;

h) inspecting the loading and unloading areas and preparing them for the ingress and egress of passengers. The tow path shall be inspected and, if necessary, tracks shall be established. Tracks shall be established beyond the stop gate for a distance necessary for passengers to stop should the passenger pass through the stop gate (see 6.1.1.3.1).

i) the haul rope twist shall be verified daily prior to operation for the public and shall comply with that specified in 6.1.4.1. Verification shall be noted in the daily operational log.

6.3.2.4.3 Access to facilities

While in operation, entrances to all machinery, operators' and attendants' rooms shall be restricted to authorized personnel only. All entrances shall have the signs required in Table D-1 (u) in Annex D.

While not in operation, entrances to all machinery, operators', and attendants' rooms shall be locked. To provide shelter and emergency telephone access for public safety, specified entrances may remain unlocked provided the Tow equipment cannot be operated by unauthorized personnel.

6.3.2.5 Operational requirements

6.3.2.5.1 General

The owner and supervisor of each tow shall review the requirements of Section 6 and referenced Annexes of this standard to ascertain that original design and installation conditions have not been altered in a manner so as to violate the requirements of the standard.

6.3.2.5.2 Starting

Following procedural clearances, the tow shall be started by the operator or at the direction of the operator.

6.3.2.5.3 Tow path maintenance

The following minimum tow path widths shall be maintained and free of obstructions for the length of the tow path:

a) 4 feet (1.22 meters) for skiers;

b) 24 inches (610 mm) plus the width of the recreational device for passengers on recreational devices.

For tows used to transport recreational devices, the tow path shall be maintained to minimize the risk of an inadvertently detached towing device from sliding into another towing device or the tow. Surface irregularities that could contribute to inadvertent detachment of a recreational device shall be minimized.

6.3.2.5.4 Stops

After any stop of a tow, the operator shall determine the cause of the stop, and not restart until clearance has been obtained from all attended stations.

6.3.2.5.5 Damage to towing devices

Should any towing device become damaged or otherwise rendered unfit for passenger transportation during normal operation, it shall be clearly and distinctively marked, and not used for passengers until repaired or replaced. It shall be removed from the line as soon as feasible.

6.3.2.5.6 Hazardous conditions

No tow shall operate when wind or icing conditions may endanger passengers or equipment or when there is an electrical storm in the immediate vicinity. Should such conditions develop while the tow is in operation, loading of passengers shall be terminated, and operation shall be continued only as long as necessary to discharge all passengers.

6.3.2.5.7 (Reserved)

6.3.2.5.8 Termination of daily operations

Procedures shall be established for terminating daily operations.

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6.3.2.5.9 Bypass requirements

The use of temporary circuits that have been installed for the purpose of bypassing failed electrical circuit(s) (see 6.2.6) shall meet these requirements in the following order:

a) The condition that the circuit indicated is in default shall be thoroughly inspected to ensure an electrical operating circuit malfunction, rather than the indicated condition, actually exists;

b) The bypass shall be authorized only by the tow supervisor or his/her designated representative;

c) When a bypass is in operation, the function bypassed shall be under constant, close visual observation;

d) The use of a bypass circuit shall be logged and shall indicate when, who authorized, and for what duration a bypass was used;

e) The operator control panel shall indicate that a bypass is in use.

6.3.3 Maintenance

6.3.3.1 General

Foundations, structural, mechanical, and electrical components shall be inspected regularly and kept in a state of good repair. The maintenance requirements of the designer (see 6.1.6.2) shall be followed. Maintenance logs shall be kept (see 6.3.5.2).

A written schedule for systematic maintenance shall be developed and followed. The schedule shall establish specific frequencies for periodic lubrication, adjustment, inspection, and testing. The schedule shall include, but not be limited to, the following:

a) all fiber ropes, wire ropes (see A.4.1 in Annex A);

b) line sheave units, sheaves, bearings, and liners;

c) bullwheels, bearings, and liners;

d) tensioning systems;

e) drive system, including bearings and couplings;

f) braking systems;

g) electrical control systems;

h) communication systems;

i) towing devices;

j) structures;

k) tow path (see 6.1.1.4 and 6.3.2.5.3).

6.3.3.2 Maintenance personnel

Tows shall be maintained by trained and competent personnel. The owner shall be responsible for the supervision and training of such personnel, and such training shall be documented. All personnel shall practice good housekeeping, with particular emphasis on avoiding the development of any condition that might contribute to personal injury. Personnel shall comply with the operational rules and safety regulations of the specific tow.

6.3.3.3 Additional requirements for towing devices

All wire rope towing devices shall be moved at least once annually. The towing devices should be moved a uniform distance each time and in the same direction. The designer's instructions shall be followed if they are more restrictive than these requirements. Movements shall be recorded in the maintenance records (see 6.3.5.3).

As each towing device is relocated, the haul rope shall be examined for deterioration at or near the towing device location.

6.3.3.4 Fiber rope

Operation and replacement of fiber ropes shall be in accordance with 6.1.4.1 and 6.1.4.1.3.

6.3.3.5 Wire rope

No haul rope shall be permitted to remain in service when broken wires are visible on the exterior portions of the strands.

6.3.4 Inspection

Each tow shall be inspected annually, or after each 2000 hours of operation, whichever comes first, by a tow specialist independent of the owner. The inspection shall verify preservation of original design integrity and cover the requirements of this standard for maintenance, operation, required self-inspections, and record keeping. Items found either deficient or in noncompliance shall be noted. A report signed by the specialist shall be filed with the owner.

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6.3.5 Records

6.3.5.1 Operational log

A log shall be maintained for each tow. Daily entries shall be made giving the following minimum information:

a) date;

b) names and work positions of operating personnel;

c) operating hours and purpose of operations;

d) temperature, wind, and weather conditions;

e) record of compliance with daily operational inspection including loading and unloading platforms, ramps, tow path, rope twist, and signs;

f) position and condition of the tension carriage, counterweights, or other tension systems;

g) accidents, malfunctions, or abnormal occurrences during operation;

h) signature of operator.

6.3.5.2 Maintenance log

A signed complete log shall be maintained wherein the actual execution of maintenance work shall be recorded daily. The log shall state the components serviced and the condition of the components. A record shall be kept of replacement of components.

6.3.5.3 Wire Rope Log

A log shall be maintained for each tow using a wire rope giving the following information on the haul rope.

a) copy of certified test report;

b) date installed;

c) splicing certificate for each long splice or laid-in strand or, record of installation of mechanical splice (splice grip or pressed sleeve connector);

d) record of maintenance inspections;

e) inspection reports of wire rope, and their connections (see A.4.1.2 and A.4.3 in Annex A);

f) report of accidents or injury to wire rope.

6.3.6 Passenger conduct and responsibilities

6.3.6.1 Passenger responsibilities

It is recognized that certain dangers and risks are inherent in machines of this type, and their operation. It is also recognized that inherent and other risks or dangers exist for those who are in the process of embarking, riding, or disembarking from tow (see 1.2). Passengers accept the risks inherent in such participation of which the ordinary prudent person is or should be aware.

Passengers shall use good judgment and act in a responsible manner while using the tow, including:

a) participating in the embarkation, riding, and disembarkation processes in such a manner as to reduce risks for themselves and others;

b) obeying all written and oral instructions and warnings;

c) refraining from using the tow while under the influence of drugs or alcohol;

d) properly use the tow and equipment provided.

6.3.6.2 Passenger dexterity and ability

All passengers who use a tow shall be responsible for their own embarkation, riding, and disembarkation. They shall be presumed to have sufficient ability, physical dexterity, and/or personal assistance to negotiate the tow safely. Passengers shall maintain control of their speed and course while loading, riding, and unloading the tow.

6.3.6.3 Passenger embarkation and disembarkation

A passenger shall get on and get off a tow at designated areas. No passenger shall embark without first understanding and observing the proper loading, riding, and unloading procedures (see Table D-1 (a) in Annex D).

6.3.6.4 Passenger riding

Passengers, while riding a tow, shall not throw or expel therefrom any object, nor shall any passenger do any act or thing that shall interfere with the operation of the tow. Passengers shall not willfully engage in any type of conduct that may contribute to or cause injury to any other person.

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Section 7
Conveyors

This section covers that class of outdoor transportation wherein skiers, or passengers with recreational devices, are transported uphill on a flexible moving element. The circulating, flexible moving element (conveyor belt) travels uphill on one path and generally returns underneath the uphill portion.

7.1 Design and installation

7.1.1 General

7.1.1.1 Design passenger weight

For purposes of design, a passenger shall be considered as having a minimum average weight of 170 pounds (77.1 kilograms). It is the owners' responsibility to indicate unusual considerations that might affect the design passenger weight.

7.1.1.2 Capacity and speed

The loading interval and capacity shall be stated by the manufacturer to suit the design limitations of the equipment as well as the slope gradient and the ability of passengers to load and leave the conveyor. Maximum conveyor speed shall be 160 feet per minute (0.8 meters per second).

7.1.1.3 Location

In selecting the location and alignment of an installation, consideration shall be given to the following items, and to any others that may be particularly pertinent to the conveyor type and location:

a) ADA accessibility;

b) electric power lines and their supports;

c) rock and earth slides, cave-ins, washouts, and the like;

d) snow creep and avalanches;

e) wind action;

f) icing;

g) ski slopes and trails;

h) rivers and gullies;

i) buried installations, including pipelines;

j) control of air space below, above, and adjacent to the installation;

k) crossing or close proximity to other ropeways;

l) highways;

m) structures;

n) fire hazard.

7.1.1.3.1 Conveyor gradient

The maximum grade of a conveyor shall be maintained within the design limits.

7.1.1.3.2 Cross slope

The cross slope of the conveyor shall not exceed 5 percent.

7.1.1.4 Configuration

7.1.1.4.1 Conveyor belt dimensions

The conveyor system length shall be the exposed conveyor belt surface to the next whole inch or centimeter measured from the outgoing transition point to the incoming transition point.

The width of the conveyor shall be the width of the exposed conveyor belt to the next whole inch or centimeter. The minimum conveyor belt width shall be 21 inches (534 mm).

> EXCEPTION – The belt width may be reduced in the unloading area except where multiple units are connected for extended length.

The surface of the belt used for dimensional measurements is the lowest surface of the belt a passenger contacts.

7.1.1.4.2 Path width

Decking with an appropriate surface for the intended use shall be located on each side of the belt. The decking shall have a minimum clear width of 12 inch (305 mm) on each side. The decking shall approximate the plane of the belt surface.

The slope grading from the outer edge of the decking to 5 feet (1.53 meters) shall not exceed 2 horizontal to 1 vertical. A fence or other structure may be used in lieu of slope grading as long as the surface between the edge of the decking and the fence approximates the plane of the belt surface.

7.1.1.4.3 Clearing envelope

At a minimum there shall be no obstacles, unless allowed in 7.1.1.5, within 5 feet (1.53 meters) horizontally and 10 feet (3.05 meters) vertically from the edge of the conveyor belting. Vegetation may extend over the conveyor belting provided it does not obscure the operator's and/or attendant's view of the conveyor. Clearings and contiguous spaces shall be maintained to reduce the risk of washouts, hazard trees, and other obstacles that might endanger the installation (see 7.3.3.1).

7.1.1.5 Clearances

7.1.1.5.1 Vertical clearances

The minimum headroom shall be 7 feet (2.14 meters) measured vertically from the conveyor belt surface.

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7.1.1.5.2 Horizontal clearances

There shall be a minimum distance of 18 inches (460 mm) between the exposed edge of the belt and any obstruction located between the loading and discharge zones.

A fence, enclosure, or other structure shall be considered an obstruction (see 7.1.1.4.2) and it shall be designed to reduce the risk of entanglement.

7.1.1.6 Structures and foundations

All structures and foundations shall be designed and constructed in conformance with 1.3 and shall be appropriate for the site. Applied design loads shall include dead, live, snow, wind and dynamic loads due to normal conditions and for foreseeable abnormal conditions.

Structures and foundations located in snow creep areas shall be designed for such conditions and loads, or protective structures shall be provided as required by the conditions.

7.1.1.6.1 (Reserved)

7.1.1.6.2 Foundations

In determining the resistance of the soil to motion of the foundation, the subsoil conditions at the site shall be considered, including any buoyancy due to groundwater that may be present. If the resistance of the soil is not practically determinable, the foundation or anchorage should be designed as a gravity anchor, using the coefficient of friction appropriate to the general character of the soil. Foundations on rock shall be firmly anchored to solid rock, unless designed as gravity foundations.

The top of concrete foundations shall not be less than 6 inches (150 mm) above finished grade unless specific direction for the protection of the foundation and structural steel below grade is specified by the designer.

The design shall have a minimum factor of safety of 2 in resistance to overturning and, concurrently, 2 against sliding, under dead-load and live-load conditions; the minimum factors shall be 1.5 under these loadings plus wind acting simultaneously.

7.1.1.6.3 Anchorages

All structures that are supported on sills or other supports, however temporary, shall be capable of carrying the loads imposed by structural and machine elements under static or operating conditions without shifting or settlement that will impair the operation of the conveyor.

Anchors may be natural objects or devices installed in a manner capable of withstanding tensions and sliding loads imposed by the conveyor installation.

The design shall have a safety factor of 2 in resisting overturning, sliding, or withdrawal under dead and live load.

7.1.1.7 Communications

A permanently installed two-way voice communication system shall be provided between the prime mover control point, drive machinery building, if any, and the loading and unloading areas. The communications system shall be functional and audible during operation.

Audio indicators shall be audible over all ambient noise levels, and visual indicators (e.g., Light Emitting Diodes) shall be visible even in bright sunlight.

NOTE – Voice communications systems are not required on those conveyors qualifying for operation by a single operator, as defined in 7.3.2.2.

7.1.1.8 Internal combustion engine installation

Internal combustion engines shall not be used on a conveyor.

7.1.1.9 Loading and unloading areas

Platforms, ramps, corrals, and mazes comprising the loading and unloading areas of a conveyor are integrally related to its operation. They shall be designed and installed in conformance with 1.3.

7.1.1.9.1 Loading areas

Loading areas shall be approximately level. The area shall be free of obstructions and may be fenced in a manner to guide passengers to the load point. Load gates, artificial surfaces, and other loading aids, when used, shall be designed and installed with regards to all passengers including adaptive. At least one point of access to the conveyor shall have a minimum clearance width of 36 inches (915 mm) to accommodate passengers using adaptive equipment.

7.1.1.9.2 Unloading areas

The transition stop device, profile, exit pathway and length of the unloading area shall be maintained in accordance with the manufacturer's recommendations. When used primarily by skiers, the exit pathway shall be inclined downward in the direction of travel and away from the line of the uphill conveyor path to provide passenger movement away from the conveyor.

7.1.1.10 (Reserved)

7.1.1.11 Acceptance inspection and tests

7.1.1.11.1 Acceptance inspection

Before a conveyor that is new, relocated or that has not been operated for routine maintenance within the previous 2 years is opened to the public, it shall be given a thorough inspection by qualified personnel to verify compliance with the plans and specifications of the designer.

It shall be the responsibility of the owner to see that the following conditions have been met:

a) tightness of all structural connections;

b) lubrication of all moving parts;

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c) installation and alignment of all drive system components;

d) proper function of belt tensioning components;

e) conveyor belt alignment;

f) conveyor belt splice (see 7.1.4.1);

g) operation of all electrical components including circuit protection and grounding;

h) path width and clearances (see 7.1.1.4.2, 7.1.1.5);

i) conveyor installed in accordance with plans and specifications;

j) if installed, adjustment of brake(s) for stopping distance and/or rollback device tested.

7.1.1.11.2 Acceptance tests

Before a conveyor that is new or relocated or that has not been operated for routine maintenance within the previous 2 years is opened to the public, it shall be given thorough tests by qualified personnel to verify compliance with the plans and specifications of the designer. The designer or manufacturer shall propose and submit an acceptance test procedure.

The functioning of all push-button stops, automatic stops, limit switches, and communications shall be checked. Braking shall be proved adequate (see 7.1.2.6.1 and 7.1.2.6.3). The test shall include full-speed operation for as long as required to check for overheating of moving parts, excessive vibration and deflection of mechanical or structural components.

7.1.2 Drive system

7.1.2.1 Power units

All power units shall have the capacity to handle the most unfavorable design loading conditions, including the starting of the conveyor loaded to 110% of capacity in weight.

Where manual multispeed transmissions are used on a power unit, they shall not be shifted when the conveyor is moving.

Where reverse capability is provided on a power unit for a conveyor, provisions shall be made to prevent accidentally shifting into reverse whenever the conveyor is operating.

7.1.2.1.1 Prime Mover

Power units engaged as a prime mover shall have the systems required in 7.1 and 7.2 functional during operation (see 1.4 – *prime mover*).

7.1.2.1.2 Evacuation power unit

An evacuation power unit shall not be required.

7.1.2.2 Speed reducers and gearing

All speed reducers and gearing shall have the capacity for starting a conveyor under the most unfavorable design loading conditions without exceeding design rating. They shall have a service factor appropriate for the application. They shall be located such that no belt, friction clutch, or similar friction-type device is between the speed reducer and drive drum.

7.1.2.3 Bearings, clutches, couplings and shafting

Bearings, clutches, couplings, shafting and universal joint shafts (cardan shafts) shall be selected on the basis of the manufacturer's published data for the particular use. All shafting shall be designed in accordance with accepted standard practices. Guarding and containment shall be in accordance with the provisions of 7.1.2.7.1.

Provisions shall be made for adjustment and lubrication of all bearings, clutches, and couplings, when required.

7.1.2.4 Acceleration and speed control

The designer shall determine the acceleration of the drive with regard to the conveyor type, profile, speed and use. The maximum stopping distance for an unloaded conveyor operating at maximum design speed shall be 28 inches (711 mm) or less during a normal stop. See 7.2.3.3(g) Belt transition stop device for additional requirements.

The stopping distance for a normal stop (see 1.4 normal stop) shall not be less than the distance shown in Table 7.1.

Table 7-1 Minimum distance

Belt Speed		Distance	
Feet per minute	**Meters per second**	**Inches**	**Millimeters**
160 - 140	0.8 -.0 7	8.5	220
140 - 120	0.7 - 0.6	6.5	170
120 - 100	0.6 - 0.5	5.0	120
100 - 80	0.5 – 0.4	3.5	90
Less than 80	Less than 0.4	NA	NA

After any type of stop is initiated, the stop shall not be canceled and the conveyor shall not be started until it has come to a complete stop.

The conveyor is to be started at its lowest point of speed range after any type of stop.

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7.1.2.5 Stops and shutdowns

Normal stop (see 1.4 – *normal stop*): If a service brake is required (see 7.1.2.6.1), it shall have been applied by the time the conveyor comes to a stop.

Emergency shutdown (see 1.4 – *emergency shutdown*): If a service brake is required (see 7.1.2.6.1), it shall have been applied by the time the conveyor comes to a stop. The designer shall designate which control functions of the conveyor system shall initiate an emergency shutdown.

The designer may define other stopping modes other than normal stop and emergency shutdown. For other stopping modes, the designer shall specify the method of stopping, including the type and timing of brake(s) that may be applied, and the stopping criteria.

7.1.2.6 Brakes and rollback devices

Each conveyor shall have the brakes and devices as designated in 7.1.2.6.1 and 7.1.2.6.3.

7.1.2.6.1 Service brake

A service brake shall be required if the stopping distance, including dynamic braking by the drive, exceeds the maximum specified in 7.1.2.4.

If installed, the service brake shall be located at any point in the drive train such that there is no belt, friction clutch, or similar friction-type device between the brake and the drive drum. This brake shall be applied by springs, weights, or other approved forms of stored energy when any stop circuit is interrupted.

7.1.2.6.2 (Reserved)

7.1.2.6.3 Rollback device

A rollback device shall be required unless it can be demonstrated that the conveyor will not roll back (if declutched) under the most adverse design loading condition.

The rollback device, if required, shall be so arranged that there is no single belt, friction clutch, or similar friction-type device between the backstop device and the drive drum.

7.1.2.7 Location of machinery

7.1.2.7.1 General

Moving machine parts that normally may be in reach of personnel shall be fitted with guards. Where breakage of a power transmission component can result in injury, provisions shall be made for appropriate containment of said components. Guards and containment shall be done in conformance to American National Standard, ANSI/ASME B15.1-2000 (R2008), *Safety Standard for Mechanical Power Transmission Apparatus*.

Protection against static electricity shall be provided.

Fire-fighting device(s) shall be available (see F.6 in Annex F).

7.1.2.7.2 Machinery not housed in a machine room

Provisions shall be made to keep the public away from the machinery. All machinery and controls shall be rated for use in their intended environment.

7.1.2.7.3 Machinery housed in a machine room

The machine room shall be adequately ventilated. It shall have a permanently installed lighting system, adequate for proper machinery maintenance and to reduce the risk of injury to operating personnel. The arrangement of the machinery shall permit proper maintenance. A door with a suitable lock shall be provided, and the design shall keep the public away from the machinery. When a passageway is provided between machines or machinery and walls, a minimum passageway width of 18 inches (460 mm) shall be maintained. Means shall be provided to heat the machine room unless the designer or manufacturer certifies in writing that the drive machinery is rated for operation in an unheated room.

7.1.2.8 Drums and rollers

All drums, sprocket drums, and conveyor belt support rollers, including their mountings and frames, shall be designed to withstand static and dynamic loads. Drums, roller bearings and their mountings shall be selected, designed, and installed in accordance with the recommendations of the manufacturers.

7.1.2.9 Tension drums or rollers

The available travel of tensioning drums or rollers shall be adequate to properly tension the conveyor belt during normal operations.

7.1.2.10 Tension systems

The system providing tension to the conveyor belt shall provide adequate belt tensioning for normal operations taking into consideration changing load and weather conditions.

7.1.3 Line structure(s)

The design of structures supporting conveyor belting, the drive roller, idler roller and intermediate conveyor belt guide rollers shall be in accordance with the requirements of 7.1.1.6.

7.1.4 Line equipment

7.1.4.1 Conveyor belt

Conveyor belting and its splice(s) shall be based on the material rating of the manufacturer considering the most adverse design loading conditions.

Splices and alternate treads on adjacent surfaces shall intermesh so that there is no continuous transverse gap between the surfaces. Splicing of the conveyor belt shall be made in such a manner as to result in a continuous conveyor belt surface.

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7.1.4.2 Supports

Where the conveyor belt load side is supported on a series of load carrying rollers, the combination of roller spacing, belt tension, and belt stiffness shall be such that the deflection of the conveyor belt surface, midway between load carrying rollers, shall not exceed the quantity 0.094 in (2.4 mm) plus 0.004 times the center-to-center distance of the rollers in inches (millimeters) when measured as follows:

The conveyor belt surface shall be loaded midway between rollers with a 25-pound (11.3-kg) weight concentrated on a cylindrical foot piece 2 inches (51mm) long by 1 inch (25.4 mm) in diameter placed with its long axis across the belt. Deflection of this foot piece from its unloaded position shall not exceed the above quantity.

7.1.5 Provisions for operating personnel

Operator and attendant work positions shall be located to provide visual surveillance of the station and the conveyor in the vicinity of the station. When the work position is enclosed, they shall be heated, ventilated, and lighted as required to perform the assigned duties. An enclosed work position shall contain inside:

a) the communications and controls required;

b) the operating instructions and emergency procedures;

c) a fire extinguisher (see F.6 in Annex F).

This does not preclude additional communications and controls located outside the enclosed work position.

Loading and unloading areas shall have conveyor stopping devices located convenient to the operator or attendants assigned to those areas (see 7.2.9).

7.1.6 Operational and maintenance manuals

7.1.6.1 Operational manual

The designer of each new or reinstalled conveyor shall provide an operational manual in English for each installation. The manual shall describe the function and operation of the components and provide instructions for the correct usage of the installation.

7.1.6.2 Maintenance manual

The designer of each new or relocated conveyor shall prepare a maintenance manual in English for each installation. The manual shall describe recommended maintenance and testing procedures, including:

a) types of lubricants required and frequency of application;

b) definitions and measurements to determine excessive wear;

c) recommended frequency of service to specific components.

7.2 Electrical design and installation

7.2.1 General design and installation testing

Prior to operation of newly installed conveyors, or after any modification thereafter of the electrical system, the electrical system shall be tested and shown to meet the requirements of this standard and the test results shall be recorded. Design of all electronic controls and drives shall consider minimum sensitivity to electrical noise and electrical emissions, such as noise spikes from power lines and lightning, radio transmitters, thyristors (SCR), or solenoid of relay noise at levels and frequencies that could initiate loss of control.

7.2.1.1 Applicable codes

All electrical systems shall comply with American National Standard, ANSI/NFPA 70-2011, *National Electrical Code* and the Institute of Electrical and Electronics Engineers, IEEE C2-2007, *National Electrical Safety Code*.

7.2.1.2 Location

All electrical power transmission wiring located near or proposed to cross over conveyors shall comply with the applicable requirements of IEEE C2-2007.

7.2.1.3 Protection

All electrical equipment with operating voltages above 24 volts nominal shall be marked conspicuously with letters/numbers that are no smaller than ¼ inch (6 mm) in height designating the greatest voltage that may be in the equipment, the number of phases and whether the voltage is alternating or direct current. All electrical equipment rated over 600 volts shall be marked with conspicuous warning signs stating “Danger High Voltage”.

EXCEPTION – 120 volt single phase lighting circuits and convenience outlets.

All power equipment shall be protected against overloads by circuit breakers or fuses.

In locations where electrical equipment, including batteries, is likely to be exposed to physical damage, enclosures or guards shall be so arranged and of such strength as to prevent such damage.

7.2.1.4 (Reserved)

7.2.1.5 Wiring

All wiring shall be in accordance with the designer's specifications and applicable codes.

7.2.1.5.1 Control wiring classification

All control wiring shall be Class 1 in accordance with Article 725 of ANSI/NFPA 70-2011.

7.2.1.5.2 Communications wiring

All communications wiring and systems are exempted from the requirements in Article 800 of ANSI/NFPA 70-2011.

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7.2.1.5.3 Insulation

All control wiring is exempted from the requirements of Article 725.49 Part B of ANSI/NFPA 70-2011. The designer shall specify conductor size, type, and insulation suitable for the electrical and mechanical requirements of the application.

7.2.1.5.4 Exterior lighting and snowmaking circuits

All ungrounded exterior lighting and snowmaking circuits, mounted on or within 60 feet (18.3 meters) of the conveyor centerline, shall have ground fault protection (see 1.4 – *ground fault protection*).

7.2.1.5.5 Ground fault circuit interrupter protection for personnel

All 120-volt single phase, 15 and 20 ampere receptacles in areas where electrical diagnostic equipment, electrical hand tools, portable lighting equipment, or heating/snowmelt mats may be used shall have ground fault circuit interrupter protection for personnel (see 1.4 – *ground-fault circuit interrupter*).

EXCEPTION – Receptacles dedicated to permanently mounted devices need not comply with this requirement.

7.2.1.5.6 Power supply cords

Placement of wires shall also take into consideration snow grooming, skiers, and other equipment that may pass over temporary power supply cords. The power supply cords shall have ground fault circuit interrupter protection.

7.2.1.6 Grounding

7.2.1.6.1 (Reserved)

7.2.1.6.2 Conveyor structure

The conveyor structure shall have one point at the drive end referred to as the grounding electrode, as defined in ANSI/NFPA 70-2008. All dc and ac electrical systems shall be referenced to this point. The electrical service shall terminate at the electrical prime mover. Under the worst-case conditions, the resistance for the grounding electrode to any part of the conveyor system shall not exceed 50 ohms for the purpose of grounding the conveyor control circuit. The grounding system for the conveyor shall not be used as a grounding system for any other system not related to the conveyor system.

7.2.1.6.3 (Reserved)

7.2.1.6.4 Lightning protection

If lightning protection is provided, it shall follow ANSI/NFPA 780-2008, *Standard for the Installation of Lightning Protection Systems.*

7.2.2 Electrical system circuit design and classification

The designer or manufacturer responsible for the design shall identify and classify any new electrical circuits not already classified as Protection Circuits, Operations Circuits, or Supervision Circuits

7.2.2.1 Circuit priority

Protection circuits shall have priority over all other circuits. Operations circuits shall have priority over supervision circuits. If any circuit's function is connected to circuits of a higher level of protection, it shall be classified at the higher level.

7.2.3 Protection circuits

Electrical circuits designed to stop the conveyor in the event of a malfunction or failure of the conveyor system shall be classified protection circuits. All conveyor systems shall contain one or more protection circuit(s) at least one of which shall be designated the emergency shutdown circuit (see 7.2.3.1). Protection circuits shall be energized to permit system operation and when de-energized shall initiate a stop, or shall be of such design to provide the equivalent level of protection.

A protection circuit may include one or more non-complex elements (see 1.4 – *non-complex element*) and/or complex electronic elements (see 1.4 – *complex electronic element*). The designer shall make use through continuous diagnostic coverage (see 1.4 – *continuous diagnostic coverage*) that the failure of a complex electronic element will cause the conveyor to stop unless another element in the protection circuit is performing the same function (redundancy). If functional redundancy is implemented, the failure of the first element must be annunciated, at a minimum, at the beginning of operations on a daily basis.

The designer or manufacturer shall develop procedures and frequency for testing protection circuits. As a minimum, all protection circuits shall be calibrated and tested annually.

Protection circuits include, but are not limited to:

a) emergency shutdown (see 7.2.3.1);

b) stop gate (if installed see 7.2.3.2);

c) tension system fault (if installed see 7.1.2.10);

d) belt transition stop device (see 7.2.3.3).

7.2.3.1 Emergency shutdown circuit

All conveyor systems shall include at least one protection circuit labeled emergency shutdown circuit (see 1.4 – *emergency shutdown*). The shutdown shall have priority over all other control stops or commands. If, for any reason, the operator has lost control of the conveyor while using the operating control circuitry, the controls shall include an emergency shutdown circuit allowing the operator/attendant to stop the conveyor. Any one of the following conditions is considered a loss of control of a conveyor:

a) Conveyor will not SLOW DOWN when given the command to do so;

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b) Conveyor will not STOP when given the command to do so;

c) Conveyor OVERSPEEDS beyond control settings and/or maximum design speed;

d) Conveyor ACCELERATES faster than the normal design acceleration;

e) Conveyor SELF-STARTS or SELF-ACCELERATES without the command to do so;

f) Conveyor REVERSES direction unintentionally without the command to do so.

7.2.3.2 Stop gate

A stop gate, if installed, shall be located 5 feet (1.53 meters) plus 150% of the distance required to stop the empty conveyor operating at maximum speed from the leading edge of the belt transition stop device.

7.2.3.3 Belt transition stop device

A belt transition stop device shall be provided. If an object continues to follow the belt past the belt transition stop device, the device shall move to relieve the pinch point and initiate the stop.

As a minimum, the belt transition stop device shall have the following features:

a) the leading edge of the device shall be marked with yellow and black warning stripes;

b) the device shall be designed to limit the maximum opening size between the leading edge of the device and the belt to 2.5 inches (64 mm);

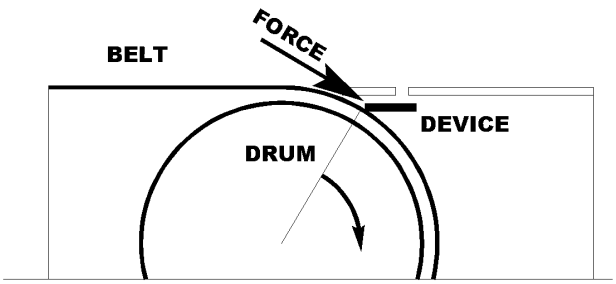
c) a stop shall be initiated by a force on the transition device not to exceed 30 pounds (133 newtons). The activating force shall be applied tangentially to the belt surface at the leading edge of the belt transition stop device. See Figure 7-1;

d) the design of the device shall allow the operator to readily remove entangled objects. The conveyor shall be inoperable if the relief system is in use;

e) the distance between the belt surface and the belt transition device shall be minimized in the normal operating position;

f) the stop shall be initiated before the leading edge of the device moves 5/8 inch (15 mm) in the direction of its travel;

Figure 7-1 Force Angle



g) if the belt transition stop device is activated, the conveyor belt must stop within a belt travel distance of 12 inches (305 mm). At no time may the stopping distance be greater than ½ of the circumference of the drum;

h) there shall be no obstruction within 2.5 inches (64 mm) of the exposed top surface of the belt beyond the transition stop device for the distance equal to the lesser of 12 inches (305 mm) or ½ of the circumference of the drum.

7.2.4 Operation circuits

An operation circuit is a circuit that provides power to or controls the conveyor machinery.

The designer or manufacturer shall identify operation circuits that require periodic testing and develop procedures and frequency for testing. As a minimum, all operation circuits shall be tested and calibrated annually.

Operation circuits include, but are not limited to:

a) power circuits;

b) drive fault circuits;

c) normal stop (see 1.4 – *normal stop* and 7.1.2.5);

d) speed command circuits (i.e., fast, slow, etc.).

7.2.5 Supervision circuits

Supervision circuits include all communications systems. In addition, supervision circuits may be provided to monitor or supervise the performance of various conveyor systems or provide the conveyor operator with system information.

The designer or manufacturer shall identify supervision circuits that require periodic testing and develop procedures and frequency for testing supervision circuits. As a minimum, all supervision circuits shall be calibrated and tested annually.

Supervision circuits may include, but are not limited to:

a) telephone and sound powered systems (see 7.1.1.7);

b) information display circuits;

c) audible warning devices.

7.2.6 Bypass circuits

No temporary bypass circuit may be installed for malfunctions of operating control circuitry.

7.2.7 Electrical prime mover

All conveyor systems equipped with electrical prime movers (electrical motors) shall have phase-loss protection on all power phases and under-voltage protection or over-voltage protection, or both, when speed regulation can be adversely affected by such voltage variations.

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7.2.8 Electronic speed-regulated drive monitoring

All electronic speed-regulated drives and electric motors shall shut down in the event of:

a) field loss (dc motors);

b) overspeed;

c) speed feedback loss as applicable;

d) overcurrent.

7.2.9 Manual control devices

All automatic and manual stop and shutdown devices shall be of the manually reset type. An exception to this requirement is allowed for magnetic or optically operated automatic stop devices, if the operating circuit is such that it indicates that such devices initiated the stop and the circuit is of the manually reset type.

Manual stop switches (push button) shall be positively opened mechanically and their opening shall not be dependent upon springs.

Manual control devices that will initiate a stop shall be installed at all attendants' and operators' work position, in machine rooms, machine compartments, access points to crawl spaces, and out-of-doors in proximity to all loading and unloading areas.

The devices listed in Annex E shall be conspicuously and permanently marked with the proper function and color code.

7.2.10 Safety of operating and maintenance personnel

Provision shall be incorporated in the conveyor design to render the system inoperable when necessary for Lock-out Tag-out protection of personnel working on the conveyor.

The sign “Personnel Working on Conveyor - Do Not Start” or a similar warning sign shall be hung on the main disconnect switch or at control points for starting the power unit(s) when persons are working on the conveyor.

7.2.11 Electrical system acceptance tests

Upon completion of the acceptance test and before public operation of the surface lift, the function of software and/or relay logic shall be certified by a Qualified Engineer. The certification shall be included in the acceptance test report. Any modifications made to the electrical design shall be clearly marked on the on-site documentation and signed by a Qualified Engineer (see 7.1.1.11.2).

7.2.12 Software security

The “as built” documents shall include a procedure, developed by the conveyor manufacturer or a Qualified Engineer, to ensure the security of the software logic and operating parameters that will control the conveyor. Upon completion of the acceptance testing this procedure shall be implemented in a manner that will prevent unauthorized personnel from making changes to the software logic or operating parameters. All programmable logic and parameters shall be documented.

7.2.13 Night operation

For nighttime operations, operating conveyors shall be provided with lighting systems. The entire conveyor belt surface including the loading and unloading areas shall be lighted.

7.2.13.1 Illumination

Lights shall be located in a manner to provide generally uniform illumination.

7.2.13.2 Types

Lamps shall be of a type suitable and rated for minimum temperatures of the location. Fixtures shall be designed to maintain proper lamp operating characteristics.

7.2.13.3 Location

Lights shall be mounted on substantial poles or standards.

7.2.13.4 Emergency lighting

Emergency lighting shall be provided in the event of electric power failure to permit unloading of the conveyor.

7.3 Operation and maintenance

This subsection covers the requirements of operation and maintenance of conveyors. Many requirements listed here are listed elsewhere in Section 7 and referenced annexes, since they also regulate installation and design. It is imperative that operating and maintenance personnel be familiar with applicable provisions of this section and the conveyor operational and maintenance manual (see 7.1.6).

7.3.1 General and personnel safety

Operation and maintenance of conveyor equipment can be dangerous to personnel performing these tasks. Procedures for performing these functions shall require precautionary measures necessary to reduce the risk for the personnel involved. Implementation of the procedures intended for the protection of the public and operating and maintenance personnel shall be the responsibility of the owner, supervisor, and the individual worker.

Passengers and operating personnel shall be cautioned or prevented, as required, from transporting objects or materials that may encroach upon limitations of clearance or design live loads.

7.3.1.1 (Reserved)

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7.3.1.2 Signs

See normative Annex D for public sign requirements.

See 7.2.1.3 for electrical warnings.

The sign “Personnel Working on Conveyor - Do Not Start” or a similar warning sign shall be posted as required by 7.2.10.

7.3.1.3 Operational plan for the transportation of recreational equipment

Each owner shall have an operational plan that has procedures for transportation of sports equipment and recreational devices by passengers. This plan shall be consistent with the manufacturer’s specifications and instructions, if any.

7.3.2 Operation

7.3.2.1 Personnel and supervision

Conveyors shall be operated by trained personnel, and the owner shall be responsible for their supervision and the training to perform the duties listed in 7.3.2.3. Procedures for monitoring the operation and use of the conveyor and for advising and assisting passengers, including passengers with common adaptive equipment, shall be included in the training. One or more persons familiar with emergency procedures shall be on the site at all times when the conveyor is in operation. All personnel shall practice good housekeeping. Personnel shall comply with the operational procedures and regulations for the conveyor. Persons performing the duties of the conveyor personnel may exchange assignments as directed by the supervisor; provided they are trained for each assignment undertaken.

7.3.2.1.1 Supervisor

An individual shall be designated to oversee the conveyor’s operating practices and operating personnel for the purpose of public use. The designated supervisor may delegate some authority to others, but shall oversee the operation and operating personnel of the conveyor(s) unless modified by the owner as part of the operations and maintenance quality assurance plan (see 1.5.4).

7.3.2.1.2 Operator

One individual shall be designated as the operator of the conveyor for the purpose of public use. This operator shall be trained in operational, and emergency procedures; and such training shall be documented.

7.3.2.1.3 Attendants

Attendants shall be assigned to particular duties under direction of the operator. For public operation, attendants shall be trained in operational and emergency procedures pertaining to their assignments; and such training shall be documented.

7.3.2.1.4 First aid

One or more persons trained to provide first aid/emergency care at the Basic Life Support (BLS) level, including CPR, shall be available at all times when a conveyor is operating and transporting passengers. There shall be ready access to first aid/emergency care supplies and equipment, including provisions for transporting an injured person to an enclosed and, if required, heated shelter.

7.3.2.2 Minimum operating personnel

While operating for public use, an operator shall be present. The individual may serve concurrently as an attendant when authorized by the supervisor.

One attendant’s work position shall be at each loading area.

One attendant’s work position shall be at each unloading area.

The above requirements for minimum operating personnel may be modified as follows:

Conveyors may be operated by a single individual at the unloading area who serves concurrently as the operator and the attendant. The following conditions shall be met:

a) the conveyor system length shall not exceed 400 feet (122.0 meters);

b) the travel length of the conveyor is clearly visible to the operator during operation, including the exit belt transition pinch point;

c) the operator can start the conveyor while maintaining the surveillance required in condition (b);

d) the restarting of the conveyor following the actuation of an automatic or manual stopping device(s) shall be restricted until clearance is assured and the actuated automatic or manual stopping device(s) have been reset by an authorized person.

In addition, the staffing requirements (if any) specified by the conveyor manufacturer shall be observed.

7.3.2.3 Duties of operating personnel

All personnel shall use reasonable care while performing their duties.

7.3.2.3.1 Supervisor

The duties of the individual designated as the supervisor include:

a) to oversee practices that will determine that the conveyor is operational and that all operating personnel are trained, equipped, and capable of performing their duties prior to public use of the conveyor;

b) to discontinue operations on the conveyor due to physical, weather, personnel, or other reasons;

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c) to oversee operational procedures and adherence to applicable regulations pertaining to the conveyor.

7.3.2.3.2 Operator

The duties of the individual designated as the operator include:

a) to be knowledgeable of operational and emergency procedures and the related equipment needed to perform the assigned duties;

b) to assume responsible charge of the conveyor;

c) to direct any attendants at his/her conveyor;

d) to verify that the preoperational inspection (see 7.3.2.4.2) has been completed and documented before public operation;

e) to start the conveyor while operating for the public (see 7.3.2.5.2);

f) to maintain an operational log (see 7.3.5.1);

g) to deny access to the conveyor to any person using procedures and criteria provided;

h) to advise the supervisor of observed abnormal or unusual conditions that may adversely affect the safety of the operation;

i) to terminate passenger operations (see 7.3.2.5.8).

7.3.2.3.3 Attendant

The duties of an attendant include:

a) to have knowledge of the operational and emergency procedures, and the related equipment, needed to perform the assigned duties;

b) to monitor the passengers' use of the conveyor; including observing, advising and assisting them while they are in the attendant's work area as they embark on or disembark from the conveyor; and to respond to unusual occurrences or conditions, as noted. The attendant should respond by choosing an appropriate action, which may include any of the following.

1) assisting the passenger;

2) slowing the conveyor (if applicable);

3) stopping the conveyor;

4) continuing operation and observation.

c) to deny access to the conveyor to any person using procedures and criteria provided;

d) to advise the operator of observed abnormal or unusual conditions that may adversely affect the safety of the operation.

7.3.2.4 Operational procedures

Operational procedures may supplement the designer's operational manual (see 7.1.6.1) and the owner's quality program (see 1.5.4).

7.3.2.4.1 Control of passengers

Each conveyor shall have a definite method for marshaling passengers for loading and unloading. Fences, gates and alternate access may be required to implement the system.

7.3.2.4.2 Daily preoperational inspection

Prior to public operation, a daily preoperational inspection shall be performed and documented. As a minimum, the inspection shall consist of the following:

a) a visual inspection of each end, and the entire length of the conveyor belt;

b) assurance that the conveyor belt is properly tensioned and operates smoothly;

c) operation of manual and automatic switches in terminals, work positions, and loading and unloading areas, per manufacturer's instructions;

d) operation of all braking systems if installed:

NOTE – The designer of the conveyor system shall specify whether the inspection is to take place while the conveyor is moving.

e) operation of the communications system;

f) operation of the conveyor;

g) inspection of the loading and unloading areas and preparing them for ingress and egress of passengers;

h) condition and preparation of the clear surface beyond each exposed edge (see 7.1.1.4.2).

7.3.2.4.3 Access to facilities

While in operation, entrances to all machinery, operators' and attendants' rooms shall be restricted to authorized personnel only. All entrances shall have the signs required in Table D-1 (u) in Annex D.

While not in operation, entrances to all machinery, operators', and attendants' rooms shall be locked. To provide shelter and emergency telephone access for public safety, specified entrances may remain unlocked provided the conveyor equipment cannot be operated by unauthorized personnel.

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7.3.2.5 Operational requirements

7.3.2.5.1 General

The owner and supervisor of each conveyor shall review all the requirements of Section 7 and referenced annexes of this standard to ascertain that original design and installation conditions have not been altered in a manner as to violate the requirements of the standard.

7.3.2.5.2 Starting

Following procedural clearances, the conveyor shall be started by the operator or at the direction of the operator.

7.3.2.5.3 (Reserved)

7.3.2.5.4 Stops

After any stop of a conveyor, the operator shall determine the cause of the stop, and not restart until clearance has been obtained from all attended stations.

7.3.2.5.5 (Reserved)

7.3.2.5.6 Hazardous conditions

No conveyor shall be operated when wind or icing conditions may endanger passengers or equipment or when there is an electrical storm in the immediate vicinity. Should such conditions develop while the conveyor is in operation, loading of passengers shall be terminated, and operation shall be continued only as long as necessary to discharge all passengers.

7.3.2.5.7 (Reserved)

7.3.2.5.8 Termination of daily operation

Procedures shall be established for terminating daily operations.

7.3.2.5.9 Bypass requirements

No temporary bypass circuit may be installed for malfunctions of operating control circuitry.

7.3.3 Maintenance

7.3.3.1 General

Foundation and all structural, mechanical, and electrical components shall be inspected regularly and kept in a state of good repair. The maintenance requirements of the designer (see 7.1.6.2) shall be followed. Maintenance logs shall be kept (see 7.3.5.2).

A written schedule for systematic maintenance shall be developed and followed. The schedule shall establish specific frequencies for periodic lubrication, adjustment, inspection, and testing. The schedule shall include, but not be limited to, the following:

a) conveyor belting;

b) drums and rollers;

c) conveyor belt tensioning system;

d) braking systems;

e) electrical control systems;

f) communications systems;

g) structures.

7.3.3.2 Maintenance personnel

Conveyors shall be maintained by trained and competent personnel. The owner shall be responsible for the supervision and training of such personnel, and such training shall be documented. All personnel shall practice good housekeeping, with particular emphasis on avoiding the development of any condition that might contribute to personal injury. Personnel shall comply with the operational rules and safety regulations of the specific conveyor.

7.3.4 Inspection

Each conveyor shall be inspected annually, or after each 2,000 hours of operation, whichever comes first, by a conveyor specialist independent of the owner. The inspection shall verify preservation of the original design integrity and cover the requirements of this standard for maintenance, operation, required self-inspections, and record keeping. Items found either deficient or in noncompliance shall be noted. A report signed by the specialist shall be filed with the owner.

7.3.5 Records

7.3.5.1 Operational log

A log shall be maintained for each conveyor. Daily entries shall be made giving the following minimum information:

a) date;

b) names and work position of operating personnel;

c) operating hours and purpose of operations;

d) temperature, wind, and weather conditions;

e) record of compliance with daily operational inspection including signs, loading and unloading zones;

f) accidents, malfunctions, or abnormal occurrences during operation;

g) signature of the operator.

7.3.5.2 Maintenance log

A signed complete log shall be maintained wherein the actual execution of maintenance work shall be recorded. The log shall state the components serviced and the condition of the components. A record shall be kept of replacement of components.

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7.3.6 Passenger conduct and responsibilities

7.3.6.1 Passenger responsibilities

It is recognized that certain dangers and risks are inherent in machines of this type, and their operation. It is also recognized that inherent and other risks or dangers exist for those who are in the process of embarking, riding, or disembarking from conveyors (see 1.2). Passengers accept the risks inherent in such participation of which the ordinary prudent person is or should be aware.

Passengers shall use good judgment and act in a responsible manner while using the conveyor, including:

a) participating in the embarkation, riding, and disembarkation processes in such a manner as to reduce risks for themselves and others;

b) remaining standing/upright while riding the conveyor;

c) obeying all written and oral instructions and warnings;

d) refraining from using the conveyor while under the influence of drugs or alcohol;

e) properly use the conveyor and equipment provided.

7.3.6.2 Dexterity and ability

All passengers who use a conveyor shall be responsible for their own embarkation, riding, and disembarkation. They shall be presumed to have sufficient ability, physical dexterity, and/or personal assistance to negotiate the conveyor safely. Passengers shall maintain control of their speed and course while loading, riding, and unloading the conveyor

7.3.6.3 Embarkation and disembarkation

A passenger shall get on and get off a conveyor at designated areas. No passenger shall embark without first understanding and observing the proper loading, riding, and unloading procedures (see Table D-1 (a) in Annex D).

7.3.6.4 Passenger riding

Passengers, while riding a conveyor, shall not throw or expel therefrom any object, nor shall any passenger do any act or thing that shall interfere with the operation of the conveyor. Passengers shall not willfully engage in any type of conduct that may contribute to or cause injury to any other person.

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Section 8

Normative references

The following standards contain provisions, which through reference in this text, constitute provisions of this American National Standard. All standards are subject to revision, and parties to agreements based on this American National Standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below.

ANSI/NFPA 30-2008, *Flammable and Combustible Liquids Code*

ANSI/NFPA 70-2011, *National Electrical Code*

ANSI/NFPA 780-2008, *Standard for the Installation of Lightning Protection Systems*

ANSI/NFPA 10-2007, *Standard for Portable Fire Extinguishers*

ANSI/NFPA 58-2008, *Liquefied Petroleum Gas Code*

ANSI/NFPA 72-2010, *National Fire Alarm Code*

ASME B15.1-2000 (R2008), *Safety Standard for Mechanical Power Transmission Apparatus*

IEEE C2-2007, *National Electrical Safety Code*

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Annex A
(Normative)

Wire rope and strand requirements

A.1 Physical properties

A.1.1 Specifications

Wire rope or strand used as tension members, shall be specified by the lift designer.

This specification shall state that the rope or strand members shall comply with the rope or strand provisions of A.1.

Only wire rope and strand that are the subject of, and in compliance with, the specification shall be installed on a passenger ropeway.

The ropeway designer or wire rope manufacturer shall prescribe the frequency and methods for any additional maintenance or inspections of wire rope or strand not covered in this section.

Copies of the specification shall be furnished to the ropeway manufacturer, owner, and authority having jurisdiction.

A.1.1.1 Wire rope specification

The specification for wire rope shall include the following:

a) nominal diameter;

b) number and arrangement of wires;

c) strength grade;

d) type of core;

e) lay of wire rope;

f) minimum breaking force;

g) type of lubrication.

For relocated wire rope, the wire rope inspector shall be supplied with the service history, perform a visual wire rope inspection, and perform an internal inspection of the rope at several random locations to determine its condition. An MRT examination shall be performed in conjunction with the visual inspections on wire ropes to be used on aerial tramways and aerial lifts. A Qualified Engineer shall determine whether the rope meets the requirements of this standard and the ropeway specifications. Copies of the test and the inspections shall be furnished to the owner and authority having jurisdiction.

A.1.1.2 Track strand specification

The specification for track strand shall include the following:

a) nominal diameter and tolerances;

b) number, type/profile, and arrangement of wires;

c) minimum values for tensile strength, torsion and ductility for wires;

d) lay length (outside wires) of track strand;

e) minimum breaking force;

f) type of lubrication.

A.1.2 Diameter tolerance

A.1.2.1 Wire rope

Wire rope shall have a diameter tolerance of +5%, -0%. Measurements shall be made on new wire rope when the rope is tensioned between 10% and 20% of its minimum breaking force.

A.1.2.2 Track strand

The diameter tolerances of track strand shall be as listed on the specification.

NOTE – The prescribed method for measuring the rope or strand diameter and ascertaining the actual dimensions shall be in accordance with the wire rope or strand manufacturer's recommendations.

A.1.3 Minimum breaking force

In a test, an acceptable wire rope or strand shall not break under a tension less than its specified minimum breaking force (see A.2.1.3).

A.1.3.1 Wire rope

The strength of the wire rope upon which the designer shall base the ropeway calculations including design factor of safety shall not be more than the minimum breaking force (see 1.4 –*minimum breaking force*) listed in the manufacturer's published catalog or table A-1 for the diameter, classification, and strength grade selected by the designer.

The factor of safety is the ratio of the minimum breaking force of the rope and the maximum static design tension of the rope.

A.1.3.2 Track strand

The strength of track strand on which the designer shall base all calculations shall not be more than the minimum breaking force shown on the specification. The aggregate tensile strength for individual wires shall not be exceeded when calculating the minimum breaking force of the track strand.

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Table A.1 Wire Rope Minimum Breaking Force *(Nominal Breaking Strength)*

DIAMETER		6 x 7 FC		6X19 AND 6X36 FC						6X19 AND 6X36 IWRC						DIAMETER RANGE (see A.1.2.1)	
		IPS	1770	IPS	1770	EIP	1960	EEIP	2160	IPS	1770	EIP	1960	EEIP	2160		
in.	mm	tons	kN	tons	kN	tons	kN	tons	kN	tons	kN	tons	kN	tons	kN	Min.-in.	Max.-in.
	6		21.2		21		23.3		25.7		22.7		25.1		27.7	0.236	0.250
1/4		2.64		2.74		3.01				2.94		3.40				0.250	0.265
	7		28.8		28.6		31.7		34.9		30.9		34.2		37.7	0.276	0.292
5/16		4.1		4.26		4.69				4.58		5.27				0.313	0.331
	8		37.6		37.4		41.4		45.6		40.3		44.7		49.2	0.315	0.331
	9		47.6		47.3		52.4		57.7		51.0		56.5		62.3	0.354	0.372
3/8		5.86		6.1		6.71		7.38		6.56		7.55		8.30		0.375	0.394
	10		58.8		58.4		64.7		71.3		63.0		69.8		76.9	0.394	0.413
	11		71.1		70.7		78.3		86.2		76.2		84.4		93.0	0.433	0.455
7/16		7.93		8.27		9.1		10		8.89		10.2		11.2		0.438	0.459
	12		84.6		84.1		93.1		103		90.7		100		110.7	0.472	0.496
1/2		10.3		10.7		11.8		12.9		11.5		13.3		14.6		0.500	0.525
	13		99.3		98.7		109		120		106		118		130	0.512	0.537
	14		115		114		127		140		124		137		151	0.551	0.579
9/16		13		13.5		14.9		16.3		14.5		16.8		18.5		0.563	0.591
5/8		15.9		16.7		18.4		20.2		17.7		20.6		22.7		0.625	0.656
	16		150		150		166		182		161		179		197	0.630	0.661
	18		190		189		210		231		204		226		249	0.709	0.744
	19		212		211		233		257		227		252		278	0.748	0.785
3/4		22.7		23.8		26.2		28.8		25.6		29.4		32.4		0.750	0.788
	20		235		234		259		285		252		279		308	0.787	0.827
	22		284		283		313		345		305		338		372	0.866	0.909
7/8		30.7		32.2		35.4		39.0		34.6		39.8		43.8		0.875	0.919
	24		338		336		373		411		363		402		443	0.945	0.922
1		39.7		41.8		46		50.6		44.9		51.7		56.9		1.000	1.050
	26		397		395		437		482		426		472		520	1.024	1.075
	28		461		458		507		559		494		547		603	1.102	1.157
1 1/8		49.8		52.6		57.9		63.6		56.5		65.0		71.5		1.125	1.181
1 1/4		61		64.6		71.1		78.2		69.4		79.9		87.9		1.250	1.313
	32		602		598		662		730		645		715		787	1.260	1.323
1 3/8		73.1		77.7		85.5		94.0		83.5		96.0		106		1.375	1.444
	36		762		757		838		924		817		904		997	1.417	1.488
1 1/2		86.2		92		101		111		98.9		114		125		1.500	1.575
	40				935		1035		1140		1008		1116		1230	1.575	1.654
1 5/8				107		118		129		115		132		146		1.625	1.706
	44				1131		1252		1380		1220		1351		1489	1.732	1.819
1 3/4				124		136		150		133		153		169		1.750	1.838
1 7/8				141		155		171		152		174		192		1.875	1.969
	48				1346		1490		1642		1452		1608		1772	1.890	1.984
2				160		176		194		172		198		217		2.000	2.100
	52				1579		1749		1927		1704		1887		2079	2.047	2.150
2 1/8				179		197		217		192		221		243		2.125	2.231
	56				1832		2028		2235		1976		2188		2411	2.205	2.315
2 1/4				200		220		242		215		247		272		2.250	2.363
	60				2103		2328		2566		2268		2512		2768	2.362	2.480
2 3/8				222		2344		269		239		274		301		2.375	2.494

NOTES –

Tons = 2000 lbs

1770, 1960, 2160 = Grade in SI units.

Table A-2 Torsion values for wires

Wire Diameter (inch)	Revolutions in a gauge length of 8 inches*		
	Improved plow steel	**Extra-improved plow steel**	**Extra-extra improved plow steel**
Wires tested prior to fabrication of rope 0.000-0.079 0.080-0.159	(2.36/*d*) - 2 (2.36/d) - 2	(2.20/*d*) - 2 (1.92/d) - 2	(2.20/*d*) - 2 (1.92/d) - 2
Wires removed from rope after fabrication All Diameters	(2.24/*d*) - 2	(2.16/*d*) - 8	(2.16/*d*) - 8

NOTE – d equals diameter of wire in inches
* To convert to torsions (revolutions) in 100d, multiply values by 12.5d

Table A-3 Tensile force on wires during torsion test

Wire Diameter		**Tensile Force**	
From (in)	**To** (in)	**Minimum** (lb)	**Maximum** (lb)
0.000	0.009	0.5	1.0
0.010	0.014	1.0	2.0
0.015	0.019	1.5	3.0
0.020	0.029	2.0	4.0
0.030	0.039	3.0	6.0
0.040	0.049	4.0	8.0
0.050	0.059	5.0	10.0
0.060	0.069	6.0	12.0
0.070	0.079	7.0	14.0
0.080	0.089	8.0	16.0
0.090	0.099	9.0	18.0
0.100	0.109	10.0	20.0
0.110	0.119	11.0	22.0
0.120	0.129	12.0	24.0
0.130	0.139	13.0	26.0
0.140	0.149	14.0	28.0
0.150	0.159	15.0	30.0
0.160	and up	16.0	32.0

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A.1.4 Tensile strength requirements

A.1.4.1 Wire Rope Requirements

NOTE – A wire rope may be made up of several different tensile strength wires. The original wire tensile strengths of the rope are important for wire rope replacement on an aerial ropeway.

A.1.4.2 Wire tensile strength for track strand

The actual tensile breaking force of a single wire shall not vary from the tensile strength listed in the specification by more than +12% or -2.5%.

A.1.5 Torsion requirements

A.1.5.1 Wire torsion values for wire rope

Wires shall meet the applicable torsion values shown in table A-2.

Wire torsion tests are not required for wire ropes in tension systems.

A.1.5.2 Wire torsion values for track strand

Round wire torsions and profile wire ductility values shall meet or exceed values listed in the specification.

A.2 Testing - Wire rope and track strand

Before operation, a certified test report in English covering the tests required herein shall be provided from an experienced, qualified testing laboratory. Unless otherwise specified, the manufacturer of the wire rope or track strand is responsible for all testing requirements in this standard.

Copies of the test reports shall be furnished to the owner, lift manufacturer, and the authority having jurisdiction.

A.2.1 Testing procedures

A.2.1.1 Sampling

A sample long enough to provide 9 feet (2.75 meters) of free length shall be cut from each manufactured length to be used for the actual rope or strand ultimate strength test and diameter measurement.

If tensile and torsion tests are to be performed on wires removed from the finished rope or strand, a second sample, 36 inches (915 mm) long, shall be cut.

From each short sample, a minimum of one specimen of each size of main wires from each strand shall be taken. The total number of specimens shall not be less than 15% of the total number of main wires.

When wires are tested prior to fabrication, the same density of sampling shall be employed. Records shall be kept by the manufacturer to enable identification of such wires with the actual rope or strand produced.

A.2.1.2 Examination of diameter

The diameter shall be measured on the long sample, 9 feet (2.75 meters), at the center of its length, and 36 inches (915 mm) on each side of center (see A.1.2). The average of these three measurements shall be the diameter of the wire rope or track strand being inspected.

A.2.1.3 Breaking force test

An actual (measured) breaking force test shall be made on a complete rope or strand. The tests shall be made on the long sample (see A.2.1.1). The actual (measured) breaking force must meet or exceed the minimum breaking force specified for the wire rope or strand.

A.2.1.4 Wire tensile test

Samples for wire rope shall not be less than six wires of each size in the rope except for the center wires. At least two samples of the center wire will be tested.

The free length of wire shall not be less than 10 inches (255 mm). The speed of the head during the test shall not be more than 1 inch (25 mm) per min. The results shall be listed in the test report.

For track strand, the density and test parameters shall be negotiated with the strand manufacturer and stated in the specification.

A.2.1.5 Wire torsion tests

Wire torsion value shall be determined by either of the two following methods:

a) Wires shall be tested prior to fabrication into rope or strand;

b) Wires shall be removed from a rope or strand after fabrication and be tested.

A.2.1.5.1 Torsion test procedure

Wires for the torsion test shall be hand straightened. The free length of wires in the testing machine, before the test, shall be 8 inches + 1/16 inch (203.2 mm + 1.6 mm). One clamp in the testing machine shall be movable parallel to the axis of the tested wire, and an axial tensile force in accordance with table A-3 shall be applied to keep the tested wire straight during the test. The tested wire shall be twisted by either of two methods: Both clamps may be rotated in opposite directions or one clamp may be rotated while the other is held stationary at a uniform rate of not more than 60 revolutions per minute. In either case, the total rotations will be counted and reported.

A.2.1.5.2 Alternate test procedure

Because the number of revolutions in the torsion test is proportional to the free length, a free length before the test may be 4 inches + 1/16 inch (101.6 mm +1.6 mm) for wires up to 0.040 inch (1.02 mm) in diameter or 6 inches + 1/16 inch (152.4 mm + 1.6 mm) for wires not more than 0.060 inch (1.52 mm) in diameter. The wire specimens with a free length of 4 inches (101.6 mm) shall not break when twisted one-half the number of revolutions shown in table A-2. The wire specimens with

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a free length of 6 inches (152.4 mm) shall not break when twisted three-fourths the number of revolutions shown in table A-2. Testing shall be done in the same manner as described in A.2.1.5.1.

A.2.1.6 Ductility test for track strand wires

Wires for track strand shall withstand one 90-degree bend over a round mandrel. The wire shall not split or crack during the following tests:

a) *Round wires:* The mandrel diameter shall be three times the wire diameter;

b) *Shaped wires:* The mandrel diameter shall be three times the greater dimension of width or height. The bending plane is the plane allowing the smallest possible distance between the chucks for properly holding the profile wires (see Figure A-1).



Figure A-1 – Profile wire in chucks

A.2.2 Test reports

A.2.2.1 Wire rope

The test reports for wire rope shall include the following:

a) complete description of wire rope furnished for the test, including cross-sectional metallic area; grade; type of core; minimum breaking force of the rope. The number, diameter, arrangement, and cross-sectional metallic area of wires.

b) actual rope diameter (see A.1.2.1);

c) actual (measured) breaking force (see A.2.1.3);

d) results of wire tension tests (see A.2.1.4);

e) results of torsion testing including the size of wires tested (see A.2.1.5).

A.2.2.2 Track strand

The test reports for track strand shall include the following:

a) complete description of track strand furnished for the test, including cross-sectional metallic area; grade and minimum breaking force of the strand. The number, diameter/profile, shape, arrangement, and cross-sectional metallic area of wires.

b) actual strand diameter (see A.1.2.2);

c) actual (measured) breaking force (see A.2.1.3);

d) actual tensile breaking force, sizes, and description of the wires tested (see A.2.1.4);

e) results of torsion testing including the size and description of wires tested (see A.2.1.5);

f) results of ductility testing including the size and description of wires tested (see A.2.1.6).

A.2.3 Rejects and retests

A.2.3.1 Rejects

If only one test sample is supplied from a manufactured length, and any test specimens taken from this sample fail to pass any specified tests, all reels or coils of strand or rope from that manufactured length shall be rejected.

If a separate test sample is furnished from each piece of strand or rope that is reeled or coiled for shipment, failure of any test specimens to pass any specified tests shall be cause for rejection of only the particular reel or coil from which the faulty specimens have been taken.

A.2.3.2 Retests

In the ultimate breaking force test of the wire rope or track strand, if the measured breaking force falls below the requirement, one retest shall be made on a sample from the same reel or coil. If the measured breaking force meets or exceeds the requirement, this shall pass for acceptance.

Where the test specimen breaks in the jaws of the machine or at a termination, the results may be discarded and another specimen tested without considering it a retest.

In tensile and torsion tests of wires, one wire may fall below the requirement, but by not more than 20% below. In such a case, six additional wires of the same size will be tested, all of which shall pass.

A.3 End connections and splices for wire rope and strand

The ropeway designer, wire rope manufacturer, fitting manufacturer, or a Qualified Engineer shall specify parameters for installation, inspection, maintenance, repair, or replacement of end connections and splices not covered in this section.

End connections and splices shall be performed by or under the supervision of a competent facility or person and in accordance with instructions approved by the ropeway designer, fitting manufacturer, wire rope manufacturer, or Qualified Engineer.

Documentation shall be provided by the facility or person performing any splice or end connection stating that it has been accomplished in accordance with the provisions of this standard. The name, date, and signature of the person performing the splice or end connections shall be included in this documentation.

These parameters, instructions, and the documentation of end connections and splices shall become part of the wire rope log and be updated as necessary.

A.3.1 Splices

A.3.1.1 Haul ropes

The minimum length of the splice shall be 1200 times

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the nominal rope diameter. The tails, or lengths of the rope strands tucked into the center of the rope on splicing, shall be a minimum of 30 times the nominal rope diameter in length.

When two or more contiguous long splices occur in a rope, they shall be separated by an undisturbed length of rope that is a minimum of 2400 times the nominal rope diameter.

No type of connection other than the conventional "long" splice shall be used to join two ends of a haul rope together.

EXCEPTION – For ropeways using wire rope and meeting the requirements of Section 6, sleeve-type splices or wedge type splice handles are permitted when installed in accordance with the tow manufacturer's instructions. This splice shall be replaced annually.

Splicing of haul ropes on bi-cable systems shall not be permitted, with the following exceptions:

a) circulating systems;

b) when two haul ropes are used, either of which would sustain the maximum load with a static design factor of 5 if the other haul rope were broken;

c) the infrequent case that this rule would result in a shipping package that is too large to handle by existing means of transportation.

Where splice(s) are used on bi-cable ropeways, care shall be taken to avoid the adverse effects on the splice produced by rope twist.

A.3.1.2 Track cables

Track cable couplings shall not be used where carriage wheels may roll over the coupling. No splices shall be permitted in wire rope or strand used as track cables.

A.3.1.3 Ropes used in tension systems

No splices shall be permitted in tension system ropes.

A.3.2 End connections

A.3.2.1 Haul ropes (bi-cable systems)

End connections shall be capable of withstanding the maximum static design tension of the haul rope multiplied by the applicable design factor of safety and shall be in accordance with A.3.2.5.

A.3.2.2 Track cables

The method of end attachment shall be one currently in practice or established by tests, and shall develop at least 90% of the minimum breaking force of the cable and shall be in accordance with A.3.2.5.

A.3.2.3 Wire ropes used in tension systems

End connections shall be designed to not fail or slip under a tension equal to 80% of the minimum breaking force of the rope and shall be in accordance with A.3.2.5.

When wire ropes in tension systems are attached directly to track cable(s), the transfer of torsion to the track cable(s) shall be limited.

A.3.2.4 Anchoring devices

When rope or strands are used as guys or anchors to structures, both rope or strand and their end connections must have a factor of safety of 6.

A.3.2.5 Types and methods

Rope and cable sockets (poured, swaged, mechanical, and clamping) shall be designed so that they shall not be stressed beyond the yield point of the material used when the ropes or cables they anchor are under tensions equal to the design working load of the ropeway multiplied by the applicable design factor of safety.

NOTE – An acceptable method of establishing the competence of a facility or person to make a poured, swaged, mechanical, and clamping socket end connections is to perform a breaking force test of a length of wire rope or strand similar to and prepared in the manner that will be used in the working assembly. The test specimen shall not fail below the minimum breaking force of the wire rope or strand tested. The purpose of this test is to establish the ability of the facility or person to make a proper connection.

Some common end attachments and information concerning their attachment follow:

A.3.2.5.1 Poured sockets

Zinc sockets shall have documentation of all pertinent data including chemical composition of the material used in the socket, temperature of pouring material and preheated socket body.

Resin sockets shall have documentation of all pertinent data including the cleaning process and the material used in the socket.

A.3.2.5.2 Mechanical and Clamping sockets

Mechanical and clamping sockets shall have documentation of all of the pertinent data including the baseline measurements of rope and socket positions after tension is applied (seating in the housing); subsequent measurements and/or inspections required during initial running.

A.3.2.5.3 Swaged sockets

Swaged sockets shall be attached by a competent person or facility (see A.3.2.5 - NOTE) using fittings of a design in general acceptance and in common use by wire rope manufacturers and with attention to the following minimum particulars:

a) Rope shall be inserted to the bottom of the hole;

b) The bottom of the hole shall be one rope diameter beyond the swaged section;

c) Critical dimensions are as follows: Outside diameter before swaging, outside diameter after swaging, inside diameter, depth of hole;

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d) Swaged sockets shall be applied only to wire rope having a steel core in the section of rope inserted to the bottom of the hole. Fiber core rope shall have the core removed from this section and a strand of IWRC of the proper diameter installed before swaging.

A.3.2.5.4 Wire rope clips and thimbles

Wire rope clips and thimbles shall be used as follows:

a) limited to bi-cable haul ropes, ropes used in tension systems, anchors, and guys;

b) wire rope clips shall be of forged steel. Malleable wire rope clips shall not be used;

c) used in the number and the spacing stipulated by the wire rope clip manufacturer;

d) wire rope clips of the single saddle type shall be installed with the U-bolt against the “dead end” and the saddle against the “live end”;

e) torque values and retightening procedures shall conform to the wire rope clip manufacturer’s instructions;

f) the radius of curvature of the rope in combination with the correct clip application shall be designed to achieve a minimum attachment efficiency of 80%.

A.3.2.5.5 Mechanical thimble splices

Two types of mechanical thimble splices shall be permitted:

a) flemish thimble splices with swaged metal sleeve(s);

b) fold-back, or return loop, with thimble and swaged metal sleeve(s).

A.3.2.5.6 Bollards

The following are minimum bollard diameters:

a) haul ropes (Reserved);

b) track cables shall be secured with a minimum of three wraps on the bollard and two clamps plus a gage clamp. The diameter of a drum for track cable anchorage shall not be less than:

1) 65 times the cable diameter; or

2) 600 times the greater of height or width dimension of the outside wire.

A.4 Maintenance, inspections, and replacement

The ropeway designer, wire rope or strand manufacturer shall prescribe the frequency and methods for any additional maintenance or inspections of wire rope or strand in the specification (see A.1.1) that is not covered in this section.

A.4.1. Wire rope

A.4.1.1 Lubrication

The type of lubricant and frequency as recommended by the rope manufacturer or designer shall be used. Ropes that have little or no motion, such as wire ropes in tension systems, anchors, and guys, require special consideration for protection against corrosion;

A.4.1.2 Inspection

All ropes shall be subject to detailed visual inspections at regularly established intervals, not to exceed 1 year, or immediately after any accident possibly affecting the integrity of the wire rope.

The visual and MRT inspections shall be made by a qualified wire rope inspector. A qualified wire rope inspector is a person who by his/her knowledge, experience, and training in the field of wire rope application is capable of judging the current condition of the wire rope.

Inspection of the entire rope, end connections, and splices including measurements of diameter, lay, and rope length (as determined by counterweight or tension carriage position with reference to temperature and loading) is required as a minimum.

During visual inspection, the inspector shall be positioned sufficiently close to the rope to observe and physically examine it. In the case of moving haul ropes, the inspection shall be made by slowly moving the rope past a fixed inspection station. Frequent stops shall be made to permit detailed inspection and make necessary measurements.

Splices and grip locations shall be given close attention in haul ropes. The haul rope shall be stopped to examine each splice in detail. End connections require close attention.

In addition, MRT inspections of haul ropes shall be required for these cases:

a) when the ratio of the bull wheel diameter to the haul rope diameter (D/d) on aerial lifts is less than 80

b) when the design factor of safety of the haul rope for an aerial ropeway is less than 5;

c) haul ropes on bicable ropeways;

d) detachable grip aerial lifts operating over 600 fpm (3 meters/second).

When MRT inspections are required, a base line inspection shall be performed within the first year. Additional MRT inspections shall be performed at a minimum of 3-year intervals. Visual assessment of rope in the area of MRT indications is required.

NOTE – See 2.1.4.4.2.2(o) for additional MRT requirements on aerial tramways having carriers without track rope brakes.

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The wire rope inspector may require more frequent visual or MRT inspections due to (e.g. condition of the wire rope, specific ropeway configuration, operational conditions, etc).

Records shall be retained by the owner including the name of the inspector, method of inspection, date, measurements (including location taken), observed anomalies, condition of the rope, and condition of the splice and/or end connections.

The inspector shall verify that the rope(s) have not met the replacement criteria in A.4.1.3. A written and signed report stating that the rope is satisfactory for continued use shall be filed with the owner. The report shall be included in the wire rope log (see 2.3.5.3, 3.3.5.3, 4.3.5.3, 5.3.5.3, 6.3.5.2) and be available to the general inspector (see 2.3.4, 3.3.4, 4.3.4, 5.3.4, 6.3.4).

A.4.1.3 Repair/replacement of wire rope

The following shall be applied to the entire length of the wire rope excluding any sections in end connections or splices. For areas in end connections or splices, see A.4.3.

No wire rope is allowed to remain in service when, in the opinion of a qualified wire rope inspector, the rope has been reduced to less than 80% of its minimum breaking force as a result of broken wires, wear, and corrosion.

The cross sectional metallic area repair/discard criteria of the wire rope due to broken wires shall be in accordance with the values given in Table A-4.

Table A-4 Loss of cross section metallic area
d = nominal wire rope diameter

Maximum permissible loss of metallic area	Reference Length
7.5%	6d
10%	30d
25% (*one strand)*	6d
NOTE: When calculating the number of broken wires from the metallic cross sectional area, the results will be rounded down to the next whole wire. See Annex B for examples of how to calculate the number of broken wires allowed.	

The wire rope inspector shall consider the items listed in A.4.1.3.1 in addition to Table A-4 to determine the repair or replacement of a wire rope. As a result of the visual inspection of the wire rope, the inspector may require that, “opening of the rope”, or more frequent inspections including MRT be performed.

If an inspection indicates that a rope is damaged so as to make it unusable, the rope shall be repaired or replaced. Repair of wire rope shall conform to the requirements of A.4.1.4.

A.4.1.3.1 Criteria

The following items should be considered by the wire rope inspector in determination of the continued use of the wire rope. Observed anomalies should be included in the wire rope inspection report:

a) general condition, lubrication, and history of the wire rope;

b) more than one valley break in one rope lay may indicate some abnormal condition, possibly fatigue and breakage of other wires not readily visible;

c) abrasion, scrubbing, or peening causing loss of the original diameter of the outside wires reducing the cross sectional metallic area of the rope;

d) evidence of rope deterioration from corrosion;

e) severe kinking, severe crushing, or other damage resulting in distortion of the rope structure;

f) evidence of any heat damage. (Sources could be a burn from a torch, or an arc caused by contact with electrical wires, natural electrical charges or fires of any nature);

g) reduction of rope diameter under tension system tension to a diameter less than 94% of the original nominal rope diameter. This procedure includes wear of the outer wires;

h) significant localized increase in the lay length after the rope has broken in;

i) significant increase in the rate of rope stretch after original constructional stretch has been removed. This is determined from records showing the movement of the counterweights or tension carriage. This final stretching indicates deterioration of the wire rope and is accompanied by a further reduction in wire rope diameter and a further increase in lay length;

j) increase of uniform wire breakage rate due to fatigue for anomalous conditions approaching 25% in 500d not including localized mechanical damage.

A.4.1.3.2 Accidental damage

When damage to a rope is accidental and is a non-repetitive event, wire breaks in excess of those stated in Table A-4 may exist provided that:

a) the area is inspected by a qualified wire rope inspector;

b) the damaged area has not been reduced to less than 80% of the minimum breaking force or nominal cross sectional metallic area of the wire rope;

c) details of the cause are apparent and identifiable;

d) the cause is corrected;

e) the area is appropriately marked and observed at intervals required by the wire rope inspector;

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f) written documentation shall continue to be entered into the wire rope log until the damage is repaired or the wire rope is replaced.

A.4.1.4 Repairs of wire rope

If the haul rope damage is local, it is permissible to splice in a section of rope of the same size, grade, and construction. Repairs shall conform to requirements of A.3.1.1.

In the event that damage occurs to the haul rope and such damage is confined only to one or two strands of the rope, replacement of the damaged strand or strands will be permitted and the rope may be continued in service under the following conditions:

a) A competent wire rope splicer shall advise the owner, prior to the rope's being placed back in operation, that a suitable replacement strand was available and that all other conditions were such that he/she was able to make a proper repair to the rope by use of this method;

b) The minimum length of the new piece of strand shall be at least 360 times the nominal rope diameter and the length of the tail tucked into the core at each end shall be at least 30 times the nominal rope diameter;

c) When the repair involves laying-in two strands, the tuck position for one strand shall be at least 96 times the nominal rope diameter from the tuck position of the second strand. If the calculated distance from the closest tuck of a laid-in strand, or strands, is less than 96 times the nominal rope diameter distance from the closest tuck in an existing splice, the laid-in strand, or strands, shall be run into the splice;

d) The repaired area shall be inspected at the completion of the repair and once weekly for a period of 6 weeks of operation to ensure that there is no interference with the grips and the newly laid-in strand, or strands, during grip migration. Thereafter, it shall be subject to routine wire rope inspection. The wire rope shall be removed from operation immediately if core collapse, pulling, high stranding, or other significant distortions occur;

e) Documents showing splice diagrams and diagrams of laid-in strand, or strands, shall be prepared by the splicer, dated, and signed for the owner. A copy shall be placed in the wire rope log for that rope.

A.4.2 Track cable

A.4.2.1 Lubrication

The type and frequency shall be as recommended by the track cable manufacturer or ropeway designer. Lubrication at saddles and other points of support or guidance require special consideration.

A.4.2.2 Inspection

All track cables shall be subject to detailed inspections at regularly established intervals, not to exceed one year, or immediately after any accident possibly affecting the integrity of the cable.

Visual inspection of the entire cable including end connections, measurements of diameter, lay, and cable length (as determined by tension system position with reference to temperature and loading) is required as a minimum.

MRT methods are required with visual assessment of the cable in the area of MRT indications. A MRT inspection shall be performed the first year of operation, and every six (6) years afterwards. The track cable manufacturer and/or inspector, due to the operational cycles and general condition of the track cable, may require additional inspections.

When a track cable is relocated so as to place a different section on the saddles, each section moved off a saddle shall be given an additional detailed inspection prior to operation for the public.

These inspections shall be made by a competent track cable inspector. A competent inspector is a person who by his/her knowledge, experience, and training in the field of track cable application is capable of judging the current condition of the track cable.

Records shall be retained by the owner including the name of the inspector, method of inspection, date, measurements (including location taken), anomalies, condition of the cables, and condition of the end connections.

The inspector shall verify that the track cable(s) have not met the replacement criteria in A.4.2.3. A written and signed report stating that the cable is satisfactory for continued use shall be filed with the owner. The report shall be included in the track cable log (see 2.3.5.3, 3.3.5.3) and be available to the general inspector (see 2.3.4, 3.3.4).

NOTE – When wire rope is used as track cable, refer to A.4.1.3 and A.4.1.3.1.

A.4.2.3 Repair/replacement of track strand

If an exterior wire in a track strand is broken, the strand or ropeway manufacturer shall be contacted immediately, and an opinion shall be obtained regarding repair or other corrective action.

If two adjacent exterior wires within one lay are broken, the ropeway shall be shut down. The strand shall be replaced or repaired to the satisfaction of the strand manufacturer, ropeway manufacturer, or a Qualified Engineer.

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If more than two broken exterior wires occur within one lay, the ropeway shall be shut down. The track strand shall be replaced or repaired to the satisfaction of the strand manufacturer, ropeway manufacturer, or a Qualified Engineer.

Any repairs shall be in accordance with explicit instructions from the strand manufacturer.

Track strand shall be retired from service when there is any indication that the exterior wire may come out of lock or when the reduction in nominal metallic cross section due to wire breaks, wear, or any corrosion amounts to 10% in any length of 200 strand diameters or 5% in any length of 30 strand diameters. Repeated breaks in the same wire shall count as a single break.

A.4.2.4 Relocation

The distance to be moved and the frequency of moving shall be performed as recommended by the track cable manufacturer or ropeway designer.

A.4.3 Connections

A.4.3.1 Splices

Damage within splices can often be corrected by proper repair.

Splices shall be retired or repaired if any of the following conditions exist:

a) the cross sectional metallic area of broken wires at a tuck exceeds the values given in table A-1. Leading and trailing tuck strands shall be considered independent of one another when making this evaluation;

b) any sign of slippage;

c) significant distortion of the rope at the tucks has occurred;

d) the rope diameter measures less than 90% of the original nominal diameter except at the strand tuck;

NOTE – The acceptable minimum diameter for proper grip attachment shall be as per lift manufacturer's recommendations.

A.4.3.2 End connections

Cracked, deformed or excessively worn attachments shall be replaced. End connections shall be re-terminated or replaced if any of the following conditions exist:

a) more than one broken wire at the connection;

b) connection is installed improperly;

c) slippage of attachment fitting outside of design parameters;

d) evidence of deterioration from corrosion;

e) does not meet the parameters specified in A.3.2.

Sections of rope permanently deformed or damaged by the application of wire rope clips, or bent around thimbles, sheaves, or other anchoring devices not meeting the minimum diameters specified in Condition B in 2.1.2.8.3 and Condition C of 3.1.2.8.3, 4.1.2.8.3, 5.1.2.8.3 shall not be relocated and reused as part of the rope section under load.

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Annex B
(Informative)

Wire Rope – Measuring the diameter

It is easy and not uncommon to mismeasure the diameter of a wire rope. Figure B-1 shows the correct method to measure the diameter of a wire rope. Figure B-2 shows the incorrect method.

An average diameter for a 6-strand wire rope at a single location is obtained by taking three (3) measurements between the three sets of opposite strands using the method shown in figure B-1. The three measurements are added together and divided by 3 to obtain an average value for the diameter. Four (4) measurements would be taken at one location for an 8-strand rope and the total of the measurements divided by 4.

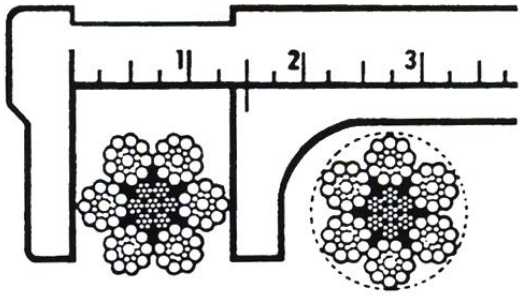


Figure B-1 – Correct method for measuring

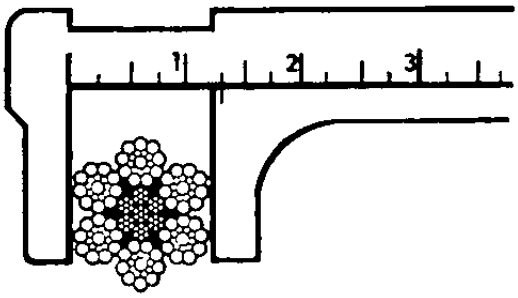


Figure B-2 – Incorrect method of measuring

Wire rope – Formulas for calculating allowable broken wires

The size and actual number of outside wires has a great influence on the number of allowable broken wires when using a percentage based on different rope constructions and sizes.

Each rope must have the calculations done based on the data from the wire rope specifications and test reports due to variations between manufacturers. (See A.2.2 in Annex A.)

7.5% of rope in 6d

$$\frac{\text{Cross Sectional Metallic Area of Rope} \times 0.075}{\text{Cross Sectional Area of Outer Wire}} = \text{Broken Wires}$$

10% of rope in 30d

$$\frac{\text{Cross Sectional Metallic Area of Rope} \times 0.1}{\text{Cross Sectional Area of Outer Wire}} = \text{Broken Wires}$$

25% of one strand in 6d

$$\frac{\text{Cross Sectional Metallic Area of Rope} \times 0.25}{\text{Cross Sectional Area of Outer Wire} \times 6} = \text{Broken Wires}$$

NOTE:
1. All calculated values for broken wires are rounded down to the next whole wire.
2. An “outside” broken wire should be measured to verify the diameter (and cross-sectional metallic area) as listed in the wire rope specifications and/or wire rope test report.
3. For specialty ropes such as 8-stand, refer to the formulas provide by the wire rope manufacturer.

Figure B-3 – Wire Rope log sample chart for calculated broken wires allowances

Diameter / Rope Construction	Cross Sectional Metallic Area of rope	Outside wire diameter	Cross Sectional Metallic Area of outside wire	Number of Broken Wires		
				7.5% of rope in 6d	10% of rope in 30d	25% of one strand in 6d

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Annex C
(Normative)

Loading Conveyors

C.1 General design and installation

Wire rope or strand used as tension members, shall be specified by the lift designer.

This section covers endless belts that assist in loading ropeway passengers. The circulating moving element (conveyor belt) travels in one path and generally returns underneath.

Loading Conveyors are considered integral to the aerial lift. They shall meet the applicable requirements for the aerial lift (see 3.1.1.9.1 and 4.1.1.9.1) unless superseded by Annex C requirements.

The Loading Conveyor design shall incorporate devices to prevent entanglement of passengers between the Loading Conveyor belt, components, and coverings.

C.1.1 Speed

The speed of the Loading Conveyor belt shall vary directly with that of the carriers' haul rope and shall not exceed 200 feet per minute (1.0 meter per second) for skiers and 160 feet per minute (0.8 meters per second) when used primarily for foot passengers.

When operating for the public, the Loading Conveyor shall not operate in reverse.

C.1.2 Conveyor belt dimensions

The width of the Loading Conveyor belt for chairlifts shall exceed the inside width of the carrier seat by at least 4 inches (100 mm) on each side. The loading conveyor lanes shall be marked according to the design capacity of the chair seat (one lane per seat position).

C.1.3 Loading conveyor access

Loading Conveyor access shall be in the direction of the motion of the Loading Conveyor and shall be controlled by an automatic access regulating device. The operation of this device is controlled by the position of the carriers. If the automatic access regulating device fails, operation of the Loading Conveyor is not permitted.

The surface and slope at the automatic access regulating device shall promote forward movement when the device opens.

The Loading Conveyor shall be accessible by foot passengers and adaptive passengers.

It shall be possible to maintain ropeway operation even when the passenger Loading Conveyor is not operating. When the Loading Conveyor is not in operation, lift speed will be regulated by Table 3-1 for detachable lifts and Table 4-1 for fixed grip lifts.

C.1.4 Index loading (detachable grip carriers)

The loading point shall be parallel to the chair seat.

The length of the load area, beyond the end of the Loading Conveyor belt, shall be at least 6.6 feet (2 meters) in length.

C.1.5 Differential loading (fixed grip carriers)

The position of the automatic access regulating device and its control shall ensure that the earliest possible loading for any carrier is located after the carrier has passed around the terminal bullwheel. The end of the loading zone shall be at least 3.3 feet (1 meter) before the end of the Loading Conveyor belt.

The "loading zone" does not require a "load here" sign when the Loading Conveyor is operating.

C.1.6 Ropeway Speed

The maximum speed of the carrier is limited to the speed listed in Table 4-1 with the use of a Loading Conveyor. .

Note: An increase in ropeway speed is a modification (see 1.2.4.4).

C.2 Controls

The following electrical interfaces shall be installed:

a) stopping the Loading Conveyor shall also cause the ropeway to stop and vice versa;

b) the automatic access regulating device must be able to be held closed by the attendant;

c) speed feedback loss from the rope/bullwheel or the loading conveyor shall stop the lift;

d) a full length stop cord or equivalent shall be provided in the vault adjacent to the conveying equipment passageways provided for inspection and maintenance while the equipment is in operation.

C.3 Operation and maintenance

The manufacturer's required tolerances for belt guides shall be maintained (see C.1).

Maintenance and operations personnel shall be aware of any particular issues with confined space, personnel egress, etc. for the loading Conveyor.

C.4 Preoperational Inspection

The manufacturer's preoperational inspection requirements will be added to the preoperational inspection requirements of the aerial lift (see 3.3.2.4.2, 4.3.2.4.2). Prior to transporting passengers, the daily preoperational inspection of the loading conveyor shall be performed and documented.

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Annex D
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Signs

D.1 Signs on Ropeways

See the sign subclause (2.3.1.2, 3.3.1.2, 4.3.1.2, 5.3.1.2, 6.3.1.2, 7.3.1.2) for operational warnings and postings.

D.1.1 Required Signs

All signs for instruction, information or prohibition of the public shall be bold in design with wording short, simple, and to the point. All such signs shall be prominently placed, and those pertaining to the ropeway operations shall be adequately lighted for night operation. Additional signs, deemed necessary by the owner, may be posted but should not detract attention from any required sign.

Table D-1 is a chart used to determine sign requirements on a ropeway. Signs are listed in the left column with location and related designs. Ropeway types are listed across the top by section number and other characteristics. Required signs for each ropeway type are indicated by a ⊗ marked in the column.

D.1.2 Designs

All required signs shall be produced in the colors and designs shown in the attached figures. Minimum letter heights are listed in table D-1.

Representative signs are displayed in figures D-1 – D-23.

> EXCEPTION: For ropeways used exclusively for foot passengers/non-snow operations, the colors shown in the attached figures may be deviated from provided contrast with background and adjacent elements do not adversely affect readability.

D.1.3 Sign groupings

Signs marked with a ‡ or a # in table D-1 may be grouped together in one location and may appear as one sign. The borders and indicated colors for individual signs are not required provided contrast with background and adjacent elements does` not adversely affect readability.

Signs for inside cabins, table D-1 (r) and (t) may be grouped together The borders and indicated colors for individual signs are not required. Text and pictograms must be legible.

Signs marked with a * in table D-1, Sections 5, 6, and 7 shall be visible to users facing up and downhill while using recreational devices.

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Table D-1 Required Signs

	Sign Wording **Required for lift type Sections marked ⊗** **Signs for wording shown in "*italics*" may be modified for local conditions.**	Function **These signs are intended to communicate specific information to ropeway users, in particular:**	Location	Sign Example	Minimum height of letters in mm
(a)	*Instructions and Warnings for use of the ropeway. May include the duties and obligations of the passenger as well as the "Responsibility Code"* ‡	how to embark, ride and disembark the specific ropeway.	At the waiting area, before the "Wait Here" sign.	D-1	20
(b)	"No Loose Scarves" "No Loose Clothing" "No Long Hair Exposed" ‡	concerning specific articles which are prohibited.	At the waiting area, before the "Wait Here" sign.	D-2	20
(c)	"Remove Ski Pole Straps from Wrists Until Unloaded" ‡	ski pole straps are to be removed while using ropeway.	At the waiting area, before the "Wait Here" sign.	D-3	20
(d)	"Check for Loose Clothing and Equipment" ‡	to check that they are not entangled.	At two locations: 1. At or before the "Wait Here" sign. ‡ 2. Vicinity of "Prepare to Unload" sign.	D-4	 20 50
(e)	" Loading Seat Height ____ ± 2 Inches" ‡	the seat height is within a specific height range for use by adaptive skiers.	In the vicinity of the instructions for the use of the ropeway sign.	D-9	20
(f)	"Wait Here"	to wait at this location for the appropriate time to proceed to loading platform.	At the point where passengers should wait for the carrier to pass before moving to the loading point.	D-6	20
(g)	"Load Here"	to stand at this location to embark the ropeway.	At the load point of the loading platform. *(See ** note)*	D-7	20
(h)	"Keep Tips Up"	that users are to keep ski/snowboard tips up.	Ahead of any point where skier users may come in contact with a platform or the snow surface.	D-12	50
(i)	A) "Prepare to Unload" *or* B) "Prepare to Unload – *Raise Restraining Bar"*	that they are approaching a disembarkation area and should be ready.	Ahead of the unloading area. If ropeway is equipped with a manual restraining device, wording B is to be	D-13 or D-14	50
(j)	"Unload Here"	to disembark from the ropeway at this point.	On the unloading platform for foot users and at the breakover point of the unload platform for skier users. (See 3.1.1.9.2)	D-8	50
(k)	"Do Not Unload Here"	to prohibit unloading at this station, at this time.	Intermediate Station if not in use (See 4.1.1.9).	D-15	50
(l)	"Do Not Load Here"	to prohibit loading at this station, at this time.	Intermediate Station: if not in use (See 4.1.1.9).	D-16	20
(m)	"Stop Gate" or "Hit to Stop Lift"	that this device will stop the ropeway if a user strikes it.	If applicable, at the location of the stop gate device.(not applicable with electronic detection of user).	D-17, D-18, or D-19	20
(n)	"*No Downhill Loading*" or "*Downhill Capacity*" if limited#	to prohibit downhill loading or state carrier loading parameters	If applicable, in the vicinity of the downhill platform area.	D-22 D-23	20
(o)	"Remain Standing"	to stay standing, not sitting.	At the loading area.	D-5	50
(p)	"Stay in Tow Path"	to remain within the tow path.	In at least one location adjacent to the track, beyond the loading area.	D-10	50
(q)	"Cross Surface Lift Here Proceed When Clear"	that this is an designated crossing area.	At designated tow path crossings.	D-11	20
(r)	*The maximum capacity of each cabin in pounds and kilograms and the approximate number of passengers*#	to signify the maximum weight that this cabin is allowed to carry.	At two locations: 1. in a location visible prior to boarding; 2. posted inside each cabin.	D-20	 20 6
(s)	*The maximum rope speed during loading*#	as required by 3.1.4.3.4.3	At terminal requiring speed reduction, visible to the operator/attendant .	D-21	14
(t)	*Instructions for procedures in emergencies*	to signify what to do in an emergency.	Prominently posted inside each cabin.	D-24	3.5
(u)	*A sign to exclude the entry of unauthorized persons.*	to prohibit the entry of unauthorized persons.	At entrances to machine, operators and attendants rooms.	D-25	20

‡ # May be grouped together in one location as one sign.

* Signs marked with this symbol in Sections 5, 6, and 7 shall be visible to users facing up and downhill while using recreational devices.

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Ropeway Category and Usage											
Sec. 2	Sec. 3 – Detachable Grip			Sec. 4 – Fixed Grip			Sec. 5		Sec. 6		Sec. 7
Tramway	**Chair** *Skier*	**Chair** *Foot Passenger*	**Gondola**	**Chair** *Skier*	**Chair** *Foot Passenger*	**Gondola**	**Surface** *Skier*	**Surface** *Recreational Device*	**Tow** *Skier*	**Tow** *Recreational Device*	**Conveyor**
⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗
									⊗	⊗	⊗
	⊗			⊗			⊗				
	⊗	⊗		⊗	⊗		⊗				
	⊗			⊗							
	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗			
	⊗	⊗		⊗**	⊗**		⊗	⊗	⊗	⊗	⊗
	⊗			⊗							
	⊗	⊗		⊗	⊗		⊗	⊗*	⊗	⊗*	⊗*
	⊗	⊗		⊗	⊗		⊗	⊗*	⊗	⊗*	⊗*
	⊗	⊗		⊗	⊗						
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** "Load Here" sign not required on a Section 4 fixed grip chairlift when a Loading Conveyor is in use.

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Fig. D-1



Fig. D-2



Fig. D-3



Fig. D-4



Fig. D-5

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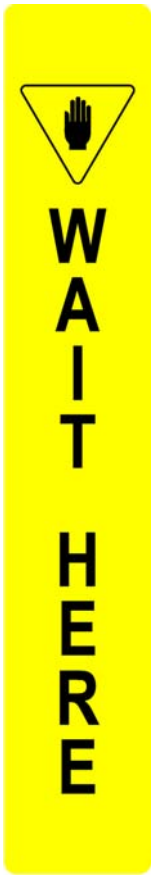


Fig. D-6

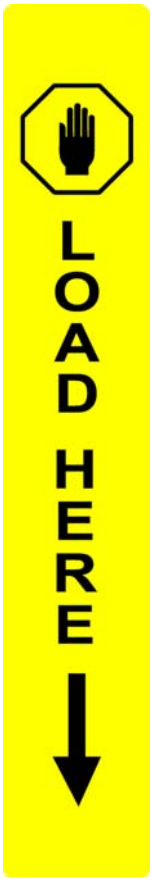


Fig. D-7

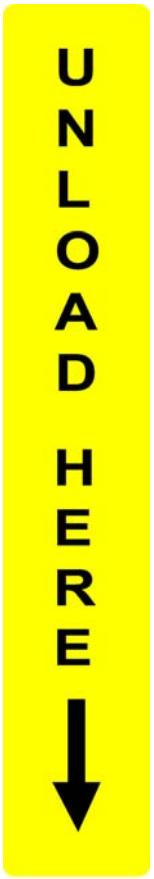


Fig. D-8

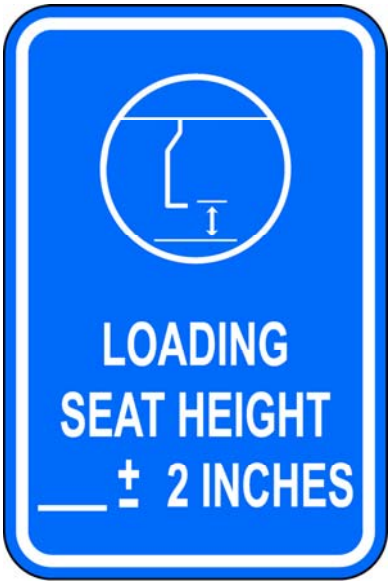


Fig. D-9



Fig. D-10



Fig. D-11



Fig. D-12

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Fig. D-13



Fig. D-14



Fig. D-15



Fig. D-16



Fig. D-17



Fig. D-18

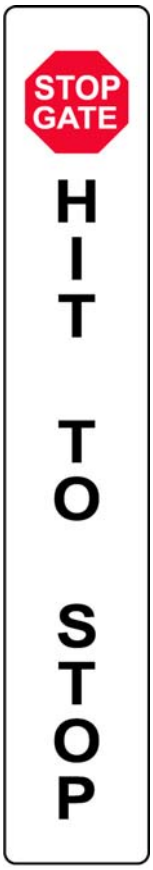


Fig. D-19

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Fig. D-20

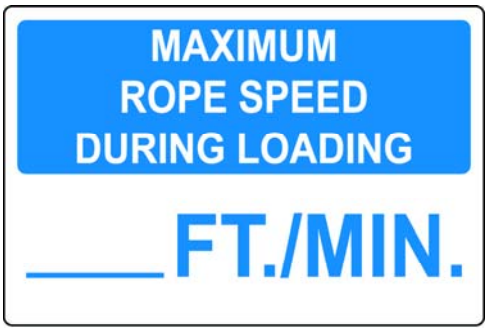


Fig. D-21



Fig. D-22



Fig. D-23



Fig. D-24



Fig. D-25

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Annex E
(Normative)

Operator control devices

Table E-1 – Device function and characteristics

FUNCTION	COLOR	LABEL	FEATURES
Normal Stop	RED	STOP	Mushroom actuator with a minimum diameter of 1-3/8 inches (38 mm)
Emergency Shutdown	RED	EMERGENCY SHUTDOWN	Actuator must be visible but shielded to prevent inadvertent operation. *Exception: Shield is not required if the circuit is the only stop circuit on the ropeway*

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Annex F
(Normative)

Combustion engine(s) and fuel handling

F.1 Combustion engines

Engines shall be situated so that they are accessible for maintenance, repair and fire fighting.

F.1.1 Engine room

Engine rooms must be of noncombustible or fire-resistive construction. If a combustion engine is enclosed within a structure, provisions shall be made for adequate ventilation to prevent a hazardous accumulation of flammable vapors or gasses, both when the engine is operating or shut down.

F.1.2 Engine rooms located within structures

Engine rooms located within structures shall have interior walls, floors, and ceilings of at least 1-hour fire-resistive rating.

EXAMPLE – One layer on walls and two layers on ceiling of properly installed 5/8" Type X gypsum wallboard, or its equivalent, covering all combustible wall and ceiling members would meet this requirement.

Openings in the engine room that open into other mixed occupancy sections of the structure shall be provided with automatic or self-closing fire doors or dampers to contain a fire to the engine room.

F.1.3 Air supply

Provisions shall be made to supply sufficient air for combustion, proper cooling, and adequate ventilation. The air supply requirements will vary with the types and sizes of engines, the driven equipment and other air-consuming equipment within the engine room.

F.1.4 Flammable materials

No flammable liquids may be stored in the building outside of a UL listed container or storage cabinet, unless such flammable liquids are in the original containers and intended for daily usage. Quantities must be consistent with normal daily usage. Class I or II flammable storage materials shall be limited to 2 gallons in a UL listed container and must be stored either in an outside storage area or in a UL listed cabinet.

F.1.5 Open flames

Gasoline, natural gas or liquid phase LP-gas fueled engines shall not be installed in rooms or locations containing fired equipment or open flames.

F.1.6 Engine support

Engines shall be supported on firm foundations or suitable steel framework and properly secured.

F.2 Electrical installations

F.2.1 Hazardous locations

Engine rooms or other locations shall not be classified as hazardous locations as defined in ANSI/NFPA 70-2011, solely by reason of the engine fuel.

F.2.2 Combustion engine wiring

Wire and insulation materials shall remain flexible over typical engine operating temperature ranges and have the minimum possible absorption of oils, fuels, and other fluids commonly found on or near the engine.

Wiring shall be protected by either fuses or circuit breakers in accordance with its ampacity. Batteries, wiring and electrical protective devices shall be protected against arcing and accidental shorting.

F.3 Combustion engine protective devices

F.3.1 Evacuation power unit

Engines used only for evacuation purposes shall be equipped with the following devices:

a) An automatic engine shutdown device for low lubricating oil pressure or, in the case of a splash lubricated engine, for low oil level;

EXCEPTION – All combustion engines of 50 HP and under.

b) All engines must be wired into the emergency shutdown circuit;

c) If the engine can drive the rope to exceed 100% of design rope speed under the most unfavorable loading conditions, one of the following devices shall be required;

1) **Engine Governor** The governor shall limit the engine speed to a maximum of 100% of the design rope speed;

2) **Overspeed Device** The overspeed device shall initiate an engine shutdown if the line speed exceeds the design speed by more than 10%.

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F.3.2 Prime mover

Engines intended for continuous operation shall have the devices specified in F.3.1 and the following additional protection shall be provided:

a) An automatic engine shutdown device for engine over speed which shall initiate an engine shutdown when the lift speed exceeds the design speed by 10%;

b) An automatic engine shutdown device for high coolant temperature.

F.4 Fuel supply

F.4.1 Structural members used as fuel tanks

Structural members shall not be used as fuel tanks or contain fuel tanks.

F.4.2 Fuel tanks for combustion engines

Fuel tanks shall have adequate capacity to permit uninterrupted operation during the normal operation period.

F.4.3 Integral or day tanks

Integral or day tanks shall be of steel or aluminum with welded or brazed joints.

F.4.4 Outside aboveground or underground fuel supply tanks

Outside aboveground or underground fuel supply tanks, including those incorporating secondary containment, shall be built in accordance with recognized standards of design or approved equivalents. Tanks shall be built, installed, and used within the scopes of their approvals.

F.4.4.1 Location with respect to haul and counterweight rope.

Every aboveground tank at ground level for storage of Class I or Class II liquids shall be located a minimum of 10 feet horizontally from a vertical plane created by the path of the rope(s).

F.4.5 Underground tanks and piping

Underground tanks and piping containing flammable liquids shall comply with all federal, state and local regulations.

F.4.6 Provisions for internal corrosion

When tanks are not designed in accordance with the American Petroleum Institute, American Society of Mechanical Engineers, or the Underwriters Laboratories Inc. Standards, or if corrosion is anticipated beyond that provided for in the design formulas used, additional metal thickness or suitable protective coatings or linings shall be provided to compensate for the corrosive loss expected during the design life of the tank.

F.4.7 Fuel tanks inside structures

F.4.7.1 Integral tanks

Class I fuels Only “integral tanks” of 25 gallons capacity or less are allowed within a structure. Other supply tanks may be located underground or outside of structures.

Class II fuels The fuel storage capacity of an “integral or day tank” shall not exceed 660 gallons per tank.

F.4.7.2 Day or supply tanks

Day or supply tanks within structures shall be securely mounted on substantial noncombustible supports.

F.4.7.3 Supply tanks

Fuel tanks greater than 25 gallons capacity located above grade shall have either a wall, curb or dike having a capacity at least equal to that of the largest surrounded tank, or a wall, curb or dike of lesser capacity equipped with an overflow or drainage system that shall be adequate in size and location to convey any spillage of fuel to a tank (inside or outside the structure) or to a safe area outside the structure.

F.4.7.4 Enclosed fuel tanks

When a structural system is partially or totally enclosing a fuel tank, the structural systems’ exterior surfaces shall be suitably marked to warn personnel of the hazard hidden from view. Markings shall define the limits and contents of the hidden fuel tank.

F.4.8 Fuel flow control

F.4.8.1 Liquid fuel supply systems

Liquid fuel supply systems, including drains from carburetors, shall be designed and installed to minimize as far as practicable the accidental discharge of fuel into the engine room or structure. Adequate alarms, float-controlled valves, and mechanical or remote reading level gauges or protected sight gauges shall be installed to aid personnel in properly operating the fuel system. Stationary powered fuel pumps supplying integral or day tanks shall have “stop” controls sensitive to a tank’s high liquid level.

If a supply tank is located higher than the engine room floor, an anti-siphon device is required.

F.4.8.2 Pumps

Where supplied by pumps, day tanks or integral tanks shall be provided with an overflow return line, a high level alarm, and a high level automatic shutoff. The overflow line shall be continuous piping to the supply tank without valves or traps. Its capacity shall exceed the delivery capacity of the supply lines it serves.

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F.4.8.3 Engine air intake

Overflows, vents, and fuel piping of fuel tanks shall not be located at or near engine air intake, exhaust piping, mufflers or filters.

F.4.9 Filling

F.4.9.1 Fill pipes

Fill pipes located beyond the sides of a building or engine room shall have a locked fuel cap. Fill pipes shall be located to avoid toxic fumes and fire hazard during refueling.

F.4.9.2 Gasoline and diesel fuel tanks

Fuel tanks shall be filled by a closed piping system.

EXCEPTION – Fuel tanks may be filled by other than closed piping systems when engine is shut down and with no passengers on the ropeway. If containers are utilized for filling, they must be UL listed.

F.4.9.3 Fuel quality

A procedure or program shall be established to ensure a liquid fuel's quality is suitable for use in the intended combustion engine.

F.4.10 Fuel piping, valves, venting, piping and fittings

F.4.10.1 Atmospheric storage tanks

Atmospheric storage tanks shall be adequately vented to prevent the development of vacuum or as a result of filling or emptying and atmospheric temperature changes.

EXCEPTION – Integral tanks do not require venting.

F.4.10.2 Normal vents

Normal vents shall be sized in accordance with either:

a) the American Petroleum Institute Standard No. 2000, *Venting Atmospheric and Low-Pressure Storage Tanks,* or;

b) another accepted standard, or shall be at least as large as the filling or withdrawal connection, whichever is larger, but in no case less than 1-1/4 inches (32 mm) nominal inside diameter.

F.4.10.3 Fill or withdrawal connection

If any tank or pressure vessel has more than one fill or withdrawal connection and simultaneous filling or withdrawal can be made, the vent size shall be based on the maximum anticipated simultaneous flow.

F.4.10.4 Pipe outlets

Wherever pipe outlets for tanks storing Class I liquids are adjacent to buildings or public ways, they shall be located so that vapors are released at a safe point outside of buildings and not less than 12 feet above the adjacent ground or normal snow level. In order to aid their dispersion, vapors shall be discharged upwards or horizontally away from closely adjacent walls. Vent outlets shall be located so that flammable vapor will not be trapped by eaves or other obstructions and shall be at least 5 feet (1.53 meters) from building openings.

F.4.10.5 Location and arrangement of vents for class II liquids

Vent pipes from tanks storing Class II liquids shall terminate outside of the building and higher than the fill pipe opening. Vent outlets shall be above normal snow level. They may be fitted with return bends, coarse screens, or other devices to minimize ingress of foreign material.

F.4.10.6 Vent piping for storage

Tank vent pipes and vapor return piping shall be installed without sags or traps in which liquid can collect. Condensate tanks, if utilized, shall be installed and maintained so as to preclude the blocking of the vapor return piping liquid. The vent pipes and condensate tanks shall be located so that they will be protected from physical damage. The tank end of the vent pipe shall enter the tank through the top.

Vent piping for storage tanks storing Class I liquids shall not be manifolded with vent piping for tanks with Class II liquids unless positive means are provided to prevent the vapors from Class I liquids from entering tanks storing Class II liquids. This is to prevent contamination and possible change in classification of the less volatile fuel.

F.4.10.7 Emergency relief venting

Every aboveground storage tank shall have some form of construction or device that will relieve excessive internal pressure caused by exposure to fires.

F.4.10.8 Piping systems

Piping systems shall be substantially supported and protected against physical damage and excessive stresses. The use of approved metallic or nonmetallic flexible connectors for protection against damage caused by settlement, vibration, expansion, contraction or corrosion is acceptable.

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F.4.10.9 Valves

Sufficient valves shall be provided to control flow of liquid fuel in the normal operation and to shut off the flow of fuel in the event of a pipe break. These valves shall be adequately labeled at the valve.

F.4.10.10 Openings for gauging

Openings for gauging on tanks storing Class I liquids shall be provided with a vapor tight cap or cover. The cap or cover shall be closed when not gauging.

F.4.10.11 Fill pipes

Fill pipes that enter the top of a tank other than day or integral tanks shall terminate within 6 inches of the bottom of the tank. Fill pipes shall be installed or arranged so that vibration is minimized.

F.4.11 Transfer of liquid fuel to engines

Liquid fuel shall feed to engines by pumps only. If the fuel tank(s) are located above the engine fuel intake, the fuel tank shall be equipped with an anti-siphon device.

F.5 Exhaust piping

F.5.1 Design and construction

F.5.1.1 Engine exhaust

Engine exhaust discharge systems shall be designed on the basis of flue gas temperatures (see 1.4 – flue gas temperature).

F.5.1.2 Exhaust pipes

Exhaust pipes shall be of wrought iron or steel and of sufficient strength to withstand the service. Fittings of cast iron shall be acceptable.

F.5.1.3 Low points

Low points in the exhaust system shall be provided with suitable means for draining of condensate.

F.5.2 Installation

F.5.2.1 Exhaust pipes

Exhaust pipes shall terminate outside the structure at a point where the hot gases or sparks will be discharged harmlessly and not be directed against combustible material or structures, or into atmospheres containing flammable gases or vapors or combustible dusts. Exhaust pipes shall not terminate under loading platforms or structures, or near ventilation air inlets. Additionally, exhaust pipes shall be adequately supported and shall be connected to the engine or muffler so that emission of sparks, flame or gas within the structure is prevented.

F.5.2.2 Flexible connections

Where necessary, a flexible connector shall be provided in an exhaust pipe from the engine to minimize the possibility of a break in the engine exhaust system because of engine vibration or heat expansion. This connection shall not permit the release of dangerous quantities of gas into the engine room.

F.5.2.3 Exhaust system guards

Exhaust stacks, manifolds and turbochargers within reach of personnel shall be equipped with guards or heat shields for a distance of 8 feet (2.44 meters) above the floor or other walking or working surface, or to the ceiling if less than 8 feet (2.44 meters).

F.5.3 Clearance from combustible materials

F.5.3.1 Exhaust pipes

Exhaust pipes shall be installed with clearances of at least 9 inches (to combustible material), except as provided in F.5.3.2 and F.5.3.3.

F.5.3.2 Exhaust pipes through roofs

Exhaust pipes passing directly through combustible roofs shall be guarded at the point of passage by ventilated metal thimbles that extend not less than 9 inches (230 mm) above and below roof construction and are at least 6 inches (150 mm) in diameter larger than the exhaust pipe.

F.5.3.3 Exhaust pipes through walls

Exhaust pipes passing directly through combustible walls or partitions shall be guarded at the point of passage by one of the following methods:

a) Metal ventilated thimbles not less than 12 inches (305 mm) larger in diameter than the exhaust pipe, or;

b) Metal or burned fire clay thimbles built in brickwork or other approved fireproofing materials providing not less than 8 inches (200 mm) of insulation between the thimble and combustible material.

F.6 Fire protection

F.6.1 Fire extinguishers, classification

F.6.1.1 Low hazard

Structures used for the operation and maintenance of a ropeway which are not designated as a Moderate Hazard shall be classified as Light (Low) Hazard, as defined by NFPA 10-2007. Light (Low) Hazard areas shall be protected by a minimum of a 10-lb. (or two 5-lb.) Dry Chemical ABC fire extinguisher or equivalent.

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F.6.1.2 Moderate hazard

Structures containing a ropeway combustion engine shall be classified as Ordinary (Moderate) Hazard, as defined by NFPA 10-2007.

Ordinary (Moderate) Hazard areas shall be protected by a minimum of a 20 lb. (or two 10-lb. or four 5-lb.) Dry Chemical ABC fire extinguisher or equivalent.

F.6.2 Fire extinguishers, location

Extinguishers shall be conspicuously located where they will be readily accessible and immediately available in the event of fire. Preferably, they shall be located along normal paths of travel, including exits from areas.

F.6.2.1 Obstructions

Extinguishers shall not be obstructed or obscured from view.

F.6.2.2 Mounting

Extinguishers shall be installed in a bracket and protected from dislodgment and physical damage.

F.6.2.3 Travel distances

Travel distances within an engine room for portable extinguishers shall not exceed 30 feet (9.1 meters). Extinguishers should be placed at regular intervals within a engine room so that the maximum walking distance from any point to the nearest extinguisher does not exceed the maximum travel distance.

EXCEPTION – The travel distance between fire extinguishers can be increased to 50 feet (15.25 meters) maximum, if the area is protected with a 20 lb. Dry Chemical ABC fire extinguisher or equivalent.

F.6.3 Inspection and maintenance of fire extinguishers

Each extinguisher shall have a tag or label securely attached that indicates the month and year of inspections, maintenance, recharging and identifies the person performing the following services.

a) Monthly inspections (see F.6.3.1);

b) Annual Maintenance (see F.6.3.2);

c) Recharging (see F.6.3.3).

F.6.3.1 Inspection

F.6.3.1.1 Frequency

Extinguishers shall be inspected when initially placed in service and thereafter at approximately 30-day intervals during ropeway operation and the inspection recorded in the maintenance log.

F.6.3.1.2 Procedures

Periodic inspections shall include a check of at least the following items:

a) Located in designated place;

b) No obstructions to access or visibility;

c) Operating instructions on nameplate legible and facing outward;

d) Seals and tamper indicators not broken or missing;

e) Determine fullness by weighing or “hefting” (CO2);

f) Examine for obvious physical damage, corrosion, leakage, or clogged nozzle;

g) Pressure gauge reading or indicator in the operable range or position.

When an inspection of any rechargeable extinguisher reveals a deficiency in any of the conditions listed in (c), (d), (e), (f), and (g) stated above, it shall be subjected to applicable maintenance procedures. When an inspection of any non-rechargeable dry chemical extinguisher reveals a deficiency in any of the conditions listed in (c), (d), (e), (f), and (g) stated above, it shall be discharged, marked “used” and removed from service.

F.6.3.2 Maintenance of fire extinguishers

F.6.3.2.1 Frequency

Extinguishers shall be subjected to maintenance not more than one year apart or when specifically indicated by an inspection.

F.6.3.2.2 Maintenance

Maintenance procedures shall include a thorough examination of the three basic elements of an extinguisher:

a) mechanical parts;

b) extinguishing agent, and;

c) expelling means.

EXCEPTION – During annual maintenance, it is not necessary to internally examine non-rechargeable extinguishers, carbon dioxide extinguishers, or stored pressure extinguishers except for those types specified in ANSI/NFPA 10, 4-4.1.1. However, such extinguishers shall be thoroughly examined externally in accordance with the applicable item (a) stated above.

Every six years, stored rechargeable pressure extinguishers shall be emptied and subjected to the applicable maintenance procedures. When the applicable maintenance procedures are performed during periodic recharging and hydrostatic testing, the six-year requirement shall begin from that date.

EXCEPTION – Non-rechargeable extinguishers shall not be hydrostatically tested but shall be removed from service at a maximum interval of 12 years from the date of manufacture.

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F.6.3.3 Recharging of fire extinguishers

All rechargeable extinguishers shall be recharged after any use or as indicated by an inspection or when performing maintenance. When performing the recharging, the recommendation of the manufacturer shall be followed. Only those agents specified on the nameplate, or agents proven to have equal chemical composition and physical characteristics shall be used.

F.6.4 Operating instructions of fire extinguishers

Operating instructions shall be located on the front of the extinguisher. Other labels and markings shall not be placed on the front.

EXCEPTION – In addition to manufacturers' labels, other labels that specifically relate to operation, classification, or warning information shall be permitted on the front.

F.6.5 Fire alarms

All machine rooms located beneath the rope of the ropeway (vaulted) shall have a fire detection system conforming to ANSI/NFPA 72-2010. This system shall initiate a visual and audible indication at the operators' station.

F.7 Fuel handling

F.7.1 Liquefied petroleum gases

Gas fuels shall be handled in accordance with the latest edition of the Liquefied Petroleum Gas Code, ANSI/NFPA 58.

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Annex G
(normative)

Welded link chain

G.1 Welded link chain

Only grade 80 Alloy Steel Chain as recognized by the National Association of Chain Manufacturers (NACM) shall be used in supporting live loads on ropeways when in public operation.

For chain used as a tensioning component, where the chain does not pass through or around sprockets, the minimum factor of safety shall be 5. For applications of chain where any sprockets are used, the minimum factor of safety shall be 6. See 2.1.2.10.5, 3.1.2.10.5, 4.1.2.10.5, and 5.1.2.10.5, for adjusting device requirements.

G.1.1 Chain specifications

This specification for welded link chain shall include the following:

a) dimensions;

b) strength grade;

c) nominal breaking strength.

Only chains that are the subject of and in compliance with the specification shall be installed on a passenger ropeway.

There shall be periodic identification along the chain indicating the grade of the chain.

G.1.2 Breaking Strength

The chain breaking strength shall be the minimum ultimate load in pounds (Newtons) at which the new chain will break, as found by representative testing, by applying direct increasing tension to a straight length at a uniform rate of speed in a standard testing machine.

The strength of the chain on which the designer shall base the calculation for factor of safety shall not be greater than the ultimate breaking strength listed by the chain manufacturer.

The factor of safety is equal to the ultimate tensile strength of the chain divided by the maximum static design tension.

G.1.3 Test procedure

A sample section of chain from the same manufactured lot, as that intended for use on the ropeway shall be tested. For the purpose of acceptance testing of chain, a lot shall consist of 1000 feet (305 meters) or fraction thereof.

Welded link chain shall be tested in accordance with NACM specifications for welded carbon steel chain.

G.1.4 Chain test reports

The test reports for chain shall include the following:

a) dimensions of the chain sample tested;

b) strength grade of the chain;

c) proof test load;

d) breaking force;

e) elongation at fracture;

f) metallic content of the sample.

G.2 Inspections

As a minimum, chains shall be inspected visually, at regular intervals for imperfections such as cracks, notches, deformed links, weld splatter, gouges, or other damage.

The chain and its end connections shall be inspected annually or after 2000 hours of operation, whichever comes first, or immediately after any accident possibly affecting the integrity of the chain. This inspection is for wear and elongation and shall be done as specified by the lift designer or chain manufacturer.

As a minimum, the chain shall be checked by comparing lengths of unused chain to sections in service. If elongation exceeds 1.5%, the chain shall be removed from service. Repairing of welded link chain by welding or heating shall not be permitted by anyone other than the chain manufacturer.

Periodically, as specified by the chain manufacturer or lift manufacturer, welded link chains shall be detensioned so that wear surfaces may be inspected.

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A competent mechanic or similarly trained person, who may be an employee of the owner, shall make the chain inspection. A competent mechanic is a person who, by knowledge, experience, and training in ropeway maintenance, is capable of judging the current condition of the chain.

Written and signed inspection reports stating that the chain is satisfactory for continued use shall be retained by the owner in the Chain Log. The reports shall include the name of the inspector, inspection date, measurements taken (including location taken), anomalies, condition of the chain, condition of the sprockets, and condition of the end connections.

G.3 Maintenance

Welded link chain shall be kept clean and free from any coating or deposits that may reduce flexibility. The cleaning process shall not damage the chain, and any solution used in the cleaning process shall be acid free.

The type and frequency of lubrication as recommended by the chain manufacturer shall be used.

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Annex H
(Informative)

Roller and Leaf Chains

H.1 Roller and leaf chains

Roller and leaf chains are prohibited in a tension system as a tension member on ropeways that are classified as new (see 1.2.4.2 and 1.2.4.3). This annex is intended for those existing ropeway systems that have roller or leaf chain installed as a tension member.

For a chain used as a tensioning component, where the chain does not pass through or around sprockets, the minimum factor of safety shall be 5. For applications of chain where any sprockets are used, the minimum factor of safety shall be 6. See 2.1.2.10.5, 3.1.2.10.5, 4.1.2.10.5, 5.1.2.10.5, 6.1.2.10.5 for adjusting device requirements.

H.1.1 Chain specifications

This specification for roller and leaf chains shall include the following:

a) dimensions;

b) strength grade;

c) nominal breaking strength.

Only chains that are the subject of and in compliance with the specification shall be installed on a passenger ropeway.

There shall be periodic identification along the chains indicating the grade of the chains.

H.1.2 Breaking Strength

The chain breaking strength shall be the minimum ultimate load in pounds (Newtons) at which the new chain will break, as found by representative testing, by applying direct increasing tension to a straight length at a uniform rate of speed in a standard testing machine.

The strength of the chain on which the designer shall base the calculation for factor of safety shall not be greater than the ultimate breaking strength listed by the chain manufacturer.

The factor of safety is equal to the ultimate tensile strength of the chain divided by the maximum static design tension.

H.1.3 Test procedure

A sample section of chain from the same manufactured lot, as that intended for use on the ropeway, shall be tested. For the purpose of acceptance testing of chain, a lot shall consist of 1000 feet (305 meters) or fraction thereof.

Roller and leaf chains shall be tested in accordance with NACM specifications.

H.1.4 Chain test reports

The test reports for the chain shall include the following:

a) dimensions of the chain sample tested;

b) strength grade of the chain;

c) proof test load;

d) breaking force;

e) elongation at fracture;

f) metallic content of the sample.

H.2 Inspections

Inspection of the entire chain including end connections shall be conducted annually as prescribed by the chain manufacturer or Qualified Engineer. The inspection shall focus on elongation in the areas where the chain receives the most frequent articulation, turning pins, fatigue cracking of the side plates, stress corrosion cracking of the link plates, and corrosion fatigue. Chains found to be damaged shall be removed from service.

A competent mechanic or similarly trained person, who may be an employee of the owner, shall make the chain inspection. A competent mechanic is a person who, by knowledge, experience, and training in ropeway maintenance, is capable of judging the current condition of the chain.

Written and signed inspection reports stating that the chain is satisfactory for continued use shall be retained by the owner in the Chain Log. The reports shall include the name of the inspector, inspection date, measurements taken (including location taken), anomalies, condition of the chain, condition of the sprockets, and condition of the end connections.

H.3 Maintenance

Repairing of roller and leaf chains by welding or heating shall be prohibited.

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Roller and leaf chains shall be kept clean and free from any coating or deposits that may reduce flexibility. The cleaning process shall not damage the chains, and any solution used in the cleaning process shall be acid free.

The type and frequency of lubrication as recommended by the chain manufacturer shall be used. The initial factory lubrication is an excellent rust and corrosion inhibitor. As a minimum, a good grade SAE 10 or 20-weight non-detergent motor oil should be used annually when the chains are out of tension. Lubrication becomes more critical as the chains age. It is imperative for lubrication penetration that it be applied when the chains are out of tension to inhibit corrosion and reduce internal friction.

Each chain and end connection shall be evaluated and a replacement schedule established. Roller and leaf chains shall be replaced at 20-year intervals or at intervals specified by a Qualified Engineer.

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Annex I
(Informative)

International system of units (SI) metric conversion factors

The ropeway industry is an international industry. Manufacturers and authorities having jurisdiction may be involved in using a variety of dimensional factors in describing their equipment. The following is offered as assistance.

To convert from	To	Multiply by
Acceleration		
feet per second^2	meter per second^2 (m/s^2)	3.048 000 E–01
inches per second^2	meter per second^2 (m/s^2)	2.540 000 E–02
feet per minute^2	meter per minute^2 (m/m^2)	1.828 800 E+00
Angle		
degree (angle)	radian (rad)	1.745 329 E–02
minute (angle)	radian (rad)	2.908 882 E–04
second (angle)	radian (rad)	4.848 137 E–06
Area		
feet^2	meter^2 (m^2)	9.290 304 E–02
inch^2	meter^2 (m^2)	6.451 600 E–04
Bending Moment of Torque		
pound-foot • inch	newton meter (N•m)	1.129 848 E–01
pound-foot • foot	newton meter (N•m)	1.355 818 E+00
Bending Moment or Torque per Unit Length		
pound-foot • foot/inch	newton meter per meter (N•m/m)	5.337 866 E+01
pound-foot • foot/inch	newton meter per meter (N•m/m)	4.448 222 E+00
Force		
kip (1000 lbf)	newton (N)	4.448 222 E+03
pound-force (lbf avoirdupois)	newton (N)	4.448 222 E+00
Force per Unit Length		
pound-foot/foot	newton per meter (N/m)	1.459 390 E+01
pound-foot/inch	newton per meter (N/m)	1.751 268 E+02
Length		
foot	meter (m)	3.048 000 E–01
mile (statute)	meter (m)	1.609 3E+03
inch	meter (m)	2.540 000 E–02

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To convert from	To	Multiply by
Mass		
pound (lb avoirdupois)	kilogram (kg)	4.535 924 E–01
ton (short, 2000 lb)	kilogram (kg)	9.071 847 E+02
Mass per Unit Area		
pound/foot^2	kilogram per meter^2 (kg/m^2)	4.882 428 E+00
pound/inch^2	kilogram per meter^2 (kg/m^2)	7.031 000 E+02
Mass per Unit Length		
pound-foot • inch	kilogram per meter (kg/m)	1.448 164 E+00
pound-foot • foot	kilogram per meter (kg/m)	1.785 797 E+01
Mass per Unit Volume		
pound/foot^3	kilogram per meter^3 (kg/m^3)	1.601 846 E+01
pound/inch^3	kilogram per meter^3 (kg/m^3)	2.767 990 E+04
Temperature		
degree Fahrenheit	degree Celsius (C)	$t°_C = (t°_F – 32)/1.8$
degree Fahrenheit	degree Kelvin (K))	$t_K = (t°_F + 459.67)/1.8$
Velocity		
feet/hour	meter per second (m/s)	8.466 667 E–05
feet/minute	meter per second (m/s)	5.080 000 E–03
feet/second	meter per second (m/s)	3.048 000 E–01
inch/second	meter per second (m/s)	2.540 000 E–02
Volume		
feet^3	meter^3 (m^3)	2.831 685 E–02
gallon (us dry)	meter^3 (m^3)	4.404 884 E–03
inch^3	meter^3 (m^3)	1.638 706 E–05
yard^3	meter^3 (m^3)	7.645 549 E–01
Volume per Unit Time		
feet^3/minute	meter^3 per second (m^3/s)	4.719 474 E–04
feet^3/second	meter^3 per second (m^3/s)	2.831 685 E–02
inch^3/minute	meter^3 per second (m^3/s)	2.731 177 E–07

Multiplication Factor	Prefix	Symbol
$1000 = 10^3$	kilo	k
$100 = 10^2$	hecto	h
$10 = 10^1$	deka	da
$0.1 = 10^{-1}$	deci	d
$0.01 = 10^{-2}$	centi	c
$0.001 = 10^{-3}$	milli	m

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Index

(Numbers refer to sections and annexes in this standard.)

This index is intended as a supplement to the table of contents to aid the reader in finding particular subjects or requirements described in this standard. It is not all-inclusive, but rather is directed to the most commonly encountered topics and most frequently used ropeway terminology.

Subject	*Reversible Aerial Tramways*	*Detachable Grip Aerial Lifts*	*Fixed Grip Aerial Lifts*	*Surface Lifts*	*Tows*	*Conveyors*
A						
acceleration	2.1.2.4	3.1.2.4	4.1.2.4	5.1.2.4	6.1.2.4	7.1.2.4
carrier	-	3.1.2.13	-	-	-	-
monitoring	2.2.3.8	3.2.3.8	4.2.3.8	-	-	-
acceptance (inspection / tests)						
inspection	2.1.1.11.1	3.1.1.11.1	4.1.1.11.1	5.1.1.11.1	6.1.1.11.1	7.1.1.11.1
general	2.1.1.11	3.1.1.11	4.1.1.11	5.1.1.11	6.1.1.11	-
tests	2.1.1.11.2	3.1.1.11.2	4.1.1.11.2	5.1.1.11.2	6.1.1.11.2	7.1.1.11.2
electrical	2.2.11	3.2.11	4.2.11	5.2.11	-	7.2.11
power unit operation requirements	2.1.1.11	3.1.1.11	4.1.1.11	5.1.1.11	6.1.1.11	-
access to facilities	2.3.2.4.3	3.3.2.4.3	4.3.2.4.3	5.3.2.4.3	6.3.2.4.3	7.3.2.4.3
aerial lift, definition of	1.4 – aerial lift					
aerial tramway, definition of	1.4 – aerial tramway					
anchorage (structures)	-	-	-	-	6.1.1.6.3	7.1.1.6.3
anchoring devices	2.1.2.11	3.1.2.11	4.1.2.11	5.1.2.11	6.1.2.11	-
anemometers	2.3.2.5.6	3.3.2.5.6	4.3.2.5.6	-	-	-
anti collision	-	3.2.3.9	-	-	-	-
attendants						
definition of	1.4 – attendant					
duties of	2.3.2.3.3	3.3.2.3.3	4.3.2.3.3	5.3.2.3.3	6.3.2.3.3	7.3.2.3.3
intermediate station	-	3.3.2.2	4.3.2.2	-	-	-
minimum number of	2.3.2.2	3.3.2.2	4.3.2.2	5.3.2.2	6.3.2.2	7.3.2.2
requirements for	2.3.2.1.3	3.3.2.1.3	4.3.2.1.3	5.3.2.1.3	6.3.2.1.3	7.3.2.1.3
authority having jurisdiction	1.4 – authority having jurisdiction					
auxiliary power unit (APU)	1.4 – auxiliary power unit					
B						
backstop, drive train	-	3.1.2.6.4	4.1.2.6.4	-	-	-
bearings	2.1.2.3	3.1.2.3	4.1.2.3	5.1.2.3	6.1.2.3	7.1.2.3
bicable system						
definition of	1.4 – bicable system					
intermediate structures	2.1.1.5.7	3.1.1.5.7	-	-	-	-
rope guidance	2.1.1.5.6	3.1.1.5.6	-	-	-	-
sheave units	2.1.1.5.5	3.1.1.5.5	-	-	-	-
track cable saddles	2.1.1.5.4	3.1.1.5.4	-	-	-	-
brakes						
bullwheel	2.1.2.6.2	3.1.2.6.2	4.1.2.6.2	-	-	-
deceleration rate	2.1.2.5	3.1.2.5	4.1.2.5	-	-	-
design capability	2.1.2.6.2	3.1.2.6.2	4.1.2.6.2	-	-	-
document settings	2.1.1.11.2	3.1.1.11.2	4.1.1.11.2	-	-	-
electrical	2.2.3.5	3.2.3.5	4.2.3.5	-	-	-
general	2.1.2.6	3.1.2.6	4.1.2.6	5.1.2.6	6.1.2.6	7.1.2.6
required devices	2.1.2.6	3.1.2.6	4.1.2.6	5.1.2.6	6.1.2.6	7.1.2.6
	-	Table 3.3	Table 4.4	-	-	-
requirements for	2.1.2.6	3.1.2.6	4.1.2.6	5.1.2.6	6.1.2.6	7.1.2.6
rollback device	-	3.1.2.6.3	4.1.2.6.3	5.1.2.6.3	6.1.2.6.3	7.1.2.6.3
rollback detection (electrical)	-	3.2.3.7	4.2.3.7	-	-	-
service	2.1.2.6.1	3.1.2.6.1	4.1.2.6.1	5.1.2.6.1	6.1.2.6.1	7.1.2.6.1
stopping distance for	-	-	4.1.2.5	5.1.2.5.1	6.1.2.6.1	7.1.2.6.1
design capability	2.1.2.6.1	3.1.2.6.1	4.1.2.6.1	-	-	-
braking, definition of	1.4 – braking					
bullwheel,						
definition of	1.4 – bullwheel					
deflection	1.4 – bullwheel, deflection					
diameter	1.4 – bullwheel, diameter of					
drive	1.4 – bullwheel, drive					
fixed return	1.4 – bullwheel, fixed return					
tension	1.4 – bullwheel, tension					
in terminal and station						
general	2.1.2.8.1	3.1.2.8.1	4.1.2.8.1	5.1.2.8.1	6.1.2.8.1	-
coefficient of friction	2.1.2.8.2	3.1.2.8.2	4.1.2.8.2	5.1.2.8.2	6.1.2.8.2	-
diameter	2.1.2.8.2	3.1.2.8.2	4.1.2.8.2	5.1.2.8.2	6.1.2.8.2	-
retention	2.1.2.8.2	3.1.2.8.2	4.1.2.8.2	5.1.2.8.2	-	-
bullwheel brake	2.1.2.6.2	3.1.2.6.2	4.1.2.6.2	-	-	-
deceleration rate	2.1.2.5	3.1.2.5	4.1.2.5	-	-	-
design capability	2.1.2.6.2	3.1.2.6.2	4.1.2.6.2	-	-	-
bullwheel unloading	-	-	4.1.1.9.2	5.1.1.9.2	-	-

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Subject	*Reversible Aerial Tramways*	*Detachable Grip Aerial Lifts*	*Fixed Grip Aerial Lifts*	*Surface Lifts*	*Tows*	*Conveyors*
				5.2.3.2		
bypass circuits	2.2.6	3.2.6	4.2.6	5.2.6	6.2.6	7.2.6
operational requirements	2.3.2.5.9	3.3.2.5.9	4.3.2.5.9	5.3.2.5.9	6.3.2.5.9	7.3.2.5.9
C						
cabin, definition of	1.4 – cabin					
design	2.1.4.3.3	3.1.4.4.2	4.1.4.4.2	-	-	-
dimensions	2.1.4.3.3	3.1.4.4.2	4.1.4.4.2	-	-	-
cable catchers (see rope catching devices)						
capacity						
design	2.1.1.2	3.1.1.2	4.1.1.2	5.1.1.2	6.1.1.2	7.1.1.2
posting limitations	see – Table D-1 (n) and (r) in Annex D					
carriage (bicable system)	2.1.4.4	3.1.4.4.3	-	-	-	-
wheels	2.1.4.4.1	3.1.4.4.3	-	-	-	-
track cable brake	2.1.4.4.2	-	-	-	-	-
carriages, (tension system)	2.1.2.9	3.1.2.9	4.1.2.9	5.1.2.9	6.1.2.9	-
floating	-	-	4.1.2.9.3	5.1.2.9.3	-	-
rigid	2.1.2.9.1	3.1.2.9.1	4.1.2.9.1	5.1.2.9.1	-	-
mechanical stops	2.1.2.9.2	3.1.2.9.2	4.1.2.9.2	5.1.2.9.2	-	-
carrier, definition of	1.4 – carrier					
acceleration	-	3.1.2.13	-	-	-	-
cabin	2.1.4.3.3	3.1.4.4.2	4.1.4.4.2	-	-	-
carriage (bicable systems)	2.1.4.4	3.1.4.4.3	-	-	-	-
chair details	-	3.1.4.4.4	4.1.4.5.4	-	-	-
damage to	2.3.2.5.5	3.3.2.5.5	4.3.2.5.5	5.3.2.5.5	6.3.2.5.5	-
design of	2.1.4.3	3.1.4.4	4.1.4.4	5.1.4.4	6.1.4.3	-
	-	-	4.1.4.5	-	-	-
entrance and exit guides	2.1.2.12					
grip (see fixed or detachable grip)						
inspection	2.3.4.3	3.3.4.3	4.3.4.3			
inspection plan	-	3.3.4.3.1	4.3.4.3.1	-	-	-
inspection documentation	-	3.3.4.3.2	4.3.4.3.2	-	-	-
horizontal loads	-	-	4.1.4.5.2	-	-	-
hanger	2.1.4.32	3.1.4.4.1	4.1.4.4.1	-	-	-
loading speed	-	Table 3-1	Table 4-1	-	6.1.1.2	-
numbering of						
cabins	-	3.1.1.4.2	4.1.4.4.2	-	-	-
chairs	-	3.1.4.4.4	4.1.4.5.3	-	-	-
spacing of	-	3.1.1.2	4.1.1.2	5.1.1.2	6.1.1.2	-
spacing (in station)	-	3.2.5.3	-	-	-	-
speed of	2.1.1.2	3.1.1.2	4.1.1.2	5.1.1.2	6.1.1.2	-
testing	2.3.4.3	3.1.4.5	4.1.4.4	-	-	-
double load test certification	-	-	4.1.4.5.2	-	-	-
vertical loads	-	-	4.1.4.5.1	-	-	-
chains						
in tension systems	2.1.2.10.4	3.1.2.10.4	4.1.2.10.4	5.1.2.10.4	6.1.2.10.4	-
maintenance log	2.3.5.4	3.3.5.4	4.3.5.4	5.3.5.4	-	
roller & leaf	see – Annex H	Roller and leaf chain				
welded link	see – Annex G	Welded link chain				
chair (see also carrier)						
definition of	1.4 – chair					
safety details for	-	3.1.4.4.4	4.1.4.5.4	-	-	-
test loads	-	3.1.1.11.2	4.1.1.11.2	-	-	-
double load test certification	-	-	4.1.4.5.2	-	-	-
circuit,						
bypass	2.2.6	3.2.6	4.2.6	5.2.6	6.2.6	7.2.6
design and classification	2.2.2	3.2.2	4.2.2	5.2.2	6.2.2	7.2.2
emergency shutdown circuit	2.2.3.1	3.2.3.1	4.2.3.1	5.2.3.1	6.2.3.1	7.2.3.1
priority	2.2.2.1	3.2.2.1	4.2.2.1	5.2.2.1	6.2.2.1	7.2.2.1
lighting	2.2.1.5.4	3.2.1.5.4	4.2.1.5.4	5.2.1.5.4	6.2.1.5.4	7.2.1.5.4
operation	2.2.4	3.2.4	4.2.4	5.2.4	6.2.4	7.2.4
protection	2.2.3	3.2.3	4.2.3	5.2.3	6.2.3	7.2.3
snowmaking	2.2.1.5.4	3.2.1.5.4	4.2.1.5.4	5.2.1.5.4	6.2.1.5.4	7.2.1.5.4
supervision	2.2.5	3.2.5	4.2.5	5.2.5	6.2.5	7.2.5
clearances						
chairs for skiing	-	3.1.1.5.2.2	4.1.1.5.2.2	-	-	-
general	2.1.1.5	3.1.1.5	4.1.1.5	5.1.1.5	6.1.1.5	7.1.1.5
horizontal	2.1.1.5.2	3.1.1.5.2	4.1.1.5.2	5.1.1.5.2	6.1.1.5.2	7.1.1.5.2
machinery	2.1.2.7.3	3.1.2.7.3	4.1.2.7.3	5.1.2.7.3	6.1.2.7.3	7.1.2.7.3
other	-	-	-	-	6.1.1.5.3	
terminal	-	3.1.1.5.2.3	4.1.1.5.2.3	-	-	-
tows (additional)	-	-	-	-	6.1.3.2	-
vertical	2.1.1.5.1	3.1.1.5.1	4.1.1.5.1	5.1.1.5.1	6.1.1.5.1	7.1.1.5.1
clearing, width of	2.1.1.4	3.1.1.4	4.1.1.4	5.1.1.4	6.1.1.4	7.1.1.4.3
clutches	2.1.2.3	3.1.2.3	4.1.2.3	5.1.2.3	6.1.2.3	7.1.2.3
codes and standards, reference to	see – 1.3	Reference to other codes and standards				
combustion engine(s)	2.1.1.8	3.1.1.8	4.1.1.8	5.1.1.8	6.1.1.8	7.1.1.8
	see – Annex F	Combustion engines and fuel handling				
communications	2.1.1.7	3.1.1.7	4.1.1.7	5.1.1.7	6.1.1.7	7.1.1.7
communication wiring	2.2.1.5.2	3.2.1.5.2	4.2.1.5.2	5.2.1.5.2	6.2.1.5.2	7.2.1.5.2

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Subject	*Reversible Aerial Tramways*	*Detachable Grip Aerial Lifts*	*Fixed Grip Aerial Lifts*	*Surface Lifts*	*Tows*	*Conveyors*
complex electronic element, definition of	1.4 – complex electronic element					
conveyor	see – Section 7					
definition of	1.4 – conveyor					
conveyor belt	1.4 – conveyor belt					
cross slope	-	-	-	-	-	7.1.1.3.2
drums/rollers	-	-	-	-	-	7.1.2.8
general	-	-	-	-	-	7.1.4.1
gradient	-	-	-	-	-	7.1.1.3.1
loading	-	3.1.1.9	4.1.1.9	-	-	-
supports	-	-	-	-	-	7.1.4.2
stopping distance	-	-	-	-	-	7.1.2.4
transition stop device	-	-	-	-	-	7.2.3.3
width/length	-	-	-	-	-	7.1.1.4.1
conveyor, loading	see Annex C Loading Conveyors					
counterweights (see also tension systems)						
general	2.1.2.10.2	3.1.2.10.2	4.1.2.10.2	5.1.2.10.2	-	-
bullwheels	2.1.2.8.3	3.1.2.8.3	4.1.2.8.3	5.1.2.8.3	6.1.2.8.3	-
winches	2.1.2.10.5	3.1.2.10.5	4.1.2.10.5	5.1.2.10.5	6.1.2.10.5	-
wire rope	2.1.2.10.3	3.1.2.10.3	4.1.2.10.3	5.1.2.10.3	6.1.2.10.3	-
couplings	2.1.2.3	3.1.2.3	4.1.2.3	5.1.2.3	6.1.2.3	7.1.2.3
D						
definitions	see – 1.4 Definitions					
deropement	see – 1.4 deropement					
deropement switches or devices	2.1.3.3.2	3.1.3.3.2(f)	4.1.3.3.2(f)	5.1.3.3.2(f)	-	-
deropement switch (electrical)	2.2.3.4	3.2.3.4	4.2.3.4	5.2.3.4	-	-
design (electrical)	2.2	3.2	4.2	5.2	6.2	7.2
design (mechanical)	2.1	3.1	4.1	5.1	6.1	7.1
design requirements (degrandfathered)	2.3.1.1	3.3.1.1	4.3.1.1	5.3.1.1	6.3.1.1	-
detachable grip lift, definition of	1.4 – detachable grip lift					
detachable grips						
general requirements	-	3.1.4.3.1	-	5.1.4.3.1	-	-
grip force	-	3.1.4.3.4.2	-	5.1.4.3.2	-	-
incorrect attachment	-	3.1.4.3.3.2 3.1.4.3.4.3 3.2.3.11	-	-	-	-
maintenance	-	3.3.3.3	-	5.3.3.3.2	-	-
maximum loads	-	3.1.4.3.3.1	-	5.1.4.3.4	-	-
positive attachment	-	-	-	5.1.4.3.6	-	-
slippage testing	-	3.1.4.3.1	-	5.1.4.3.2	-	-
strength	-	-	-	5.1.4.3.3	-	-
testing requirements	-	3.1.4.3.2	-	-	-	-
documentation						
training						
attendant	2.3.2.1.3	3.3.2.1.3	4.3.2.1.3	5.3.2.1.3	6.3.2.1.3	7.3.2.1.3
operator	2.3.2.1.2	3.3.2.1.2	4.3.2.1.2	5.3.2.1.2	6.3.2.1.2	7.3.2.1.2
maintenance personnel	2.3.3.2	3.3.3.2	4.3.3.2	5.3.3.2	6.3.3.2	7.3.3.2
testing						
dynamic	2.3.4.4	3.3.4.4	4.3.4.4	-	-	-
carrier	-	3.3.4.3.2	4.3.6.3.2	-	-	-
records (also see log books)	2.3.5	3.3.5	4.3.5	5.3.5	6.3.5	7.3.5
drive system	see – 1.4 drive system					
drive train backstop	-	3.1.2.6.4	4.1.2.6.4	-	-	-
drums/rollers	-	-	-	-	-	7.1.2.8
dynamic testing	2.3.4.4	3.3.4.4	4.3.4.4	-	-	-
E						
electrical						
acceleration monitoring	2.2.3.8	3.2.3.8	4.2.3.8	-	-	-
acceptance test	2.2.11	3.2.11	4.2.11	5.2.11	6.2.11	7.2.11
applicable codes	2.2.1.1	3.2.1.1	4.2.1.1	5.2.1.1	6.2.1.1	7.2.1.1
braking system	2.2.3.5	3.2.3.5	4.2.3.5	-	-	-
circuits						
bypass	2.2.6	3.2.6	4.2.6	5.2.6	6.2.6	7.2.6
design and classification	2.2.2	3.2.2	4.2.2	5.2.2	6.2.2	7.2.2
emergency shutdown circuit	2.2.3.1	3.2.3.1	4.2.3.1	5.2.3.1	6.2.3.1	7.2.3.1
priority	2.2.2.1	3.2.2.1	4.2.2.1	5.2.2.1	6.2.2.1	7.2.2.1
operation	2.2.4	3.2.4	4.2.4	5.2.4	6.2.4	7.2.4
protection	2.2.3	3.2.3	4.2.3	5.2.3	6.2.3	7.2.3
supervision	2.2.5	3.2.5	4.2.5	5.2.5	6.2.5	7.2.5
control voltage	2.2.1.4	3.2.1.4	4.2.1.4	5.2.1.4	6.2.1.4	7.2.1.4
deropement	2.2.3.4	3.2.3.4	4.2.3.4	5.2.3.4	-	-
design and installation	2.2	3.2	4.2	5.2	6.2	7.2
electronic speed-regulated drives	2.2.8	3.2.8	4.2.8	5.2.8	6.2.8	7.2.8
emergency lighting	2.2.13.4	3.2.13.4	4.2.13.4	5.2.13.4	6.2.13.4	7.2.13.4
general	2.2.1	3.2.1	4.2.1	5.2.1	6.2.1	7.2.1
electrical continued:						
ground fault protection	2.2.1.5.4	3.2.1.5.4	4.2.1.5.4	5.2.1.5.4	6.2.1.5.4	7.2.1.5.4
ground fault circuit interrupter (GFCI)	2.2.1.5.5	3.2.1.5.5	4.2.1.5.5	5.2.1.5.5	6.2.1.5.5	7.2.1.5.5

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Subject	*Reversible Aerial Tramways*	*Detachable Grip Aerial Lifts*	*Fixed Grip Aerial Lifts*	*Surface Lifts*	*Tows*	*Conveyors*
grounding						
drive terminal structure	2.2.1.6.2	3.2.1.6.2	4.2.1.6.2	5.2.1.6.2	6.2.1.6.2	7.2.1.6.2
haul rope	2.2.1.6.3	3.2.1.6.3	4.2.1.6.3	5.2.1.6.3	6.2.1.6.3	-
structures	2.2.1.6.1	3.2.1.6.1	4.2.1.6.1	5.2.1.6.1	-	7.2.1.6.2
lightning protection	2.2.1.6.4	3.2.1.6.4	4.2.1.6.4	5.2.1.6.4	6.2.1.6.4	7.2.1.6.4
manual control devices	2.2.9	3.2.9	4.2.9	5.2.9	6.2.9	7.2.9
marking and color	see – Annex E Operator control devices					
night lighting	2.2.13	3.2.13	4.2.13	5.2.13	6.2.13	7.2.13
overhead cables	2.2.1.4	3.2.1.4	4.2.1.4	5.2.1.4	6.2.1.4	-
overspeed	2.2.3.6	3.2.3.6	4.2.3.6	-	-	-
protection	2.2.1.3	3.2.1.3	4.2.1.3	5.2.1.3	6.2.1.3	7.2.1.3
phase loss	2.2.7	3.2.7	4.2.7	5.2.7	6.2.7	7.2.7
safety of personnel	2.2.10	3.2.10	4.2.10	5.2.10	6.2.10	7.2.10
software security	2.2.12	3.2.12	4.2.12	5.2.12	-	7.2.12
speed						
check points	2.2.3.9	-	-	-	-	-
tension system	2.2.3.3	3.2.3.3	4.2.3.3	5.2.3.3	-	-
hydraulic and pneumatic	2.2.5.1	3.2.5.1	4.2.5.1	5.2.5.1		
testing	2.2.11	3.2.11	4.2.11	5.2.11	-	7.2.11
transmission wiring	2.2.1.2	3.2.1.2	4.2.1.2	5.2.1.2	6.2.1.2	7.2.1.2
warnings and marking	2.2.1.3	3.2.1.3	4.2.1.3	5.2.1.3	6.2.1.3	7.2.1.3
wiring	2.2.1.5	3.2.1.5	4.2.1.5	5.2.1.5	6.2.1.5	7.2.1.5
wiring classification	2.2.1.5.1	3.2.1.5.1	4.2.1.5.1	5.2.1.5.1	6.2.1.5.1	7.2.1.5.1
wiring, communication	2.2.1.5.2	3.2.1.5.2	4.2.1.5.2	5.2.1.5.2	6.2.1.5.2	7.2.1.5.2
wiring, insulation	2.2.1.5.3	3.2.1.5.3	4.2.1.5.3	5.2.1.5.3	6.2.1.5.3	7.2.1.5.3
Electromagnetic Wire Rope Testing (EWRT) (see – Magnetic Rope Testing (MRT))						
emergency shutdown						
definition of	1.4 – emergency shutdown					
additional requirements	2.1.2.5	3.1.2.5	4.1.2.5	5.1.2.5	6.1.2.5	7.1.2.5
circuit	2.2.3.1	3.2.3.1	4.2.3.1	5.2.3.1	6.2.3.1	7.2.3.1
engineer, qualified, definition of	1.4 – Qualified Engineer					
evacuation power unit	2.1.2.1.2	3.1.2.1.2	4.1.2.1.2	5.1.2.1.2	6.1.2.1.2	7.1.2.1.2
definition of	1.4 – evacuation power unit					
evacuation						
plan	2.3.2.5.7	3.3.2.5.7	4.3.2.5.7	-	-	-
provisions for	2.1.1.10	3.1.1.10	4.1.1.10	-	-	-
	2.1.1.10.1					
exceptions	see – 1.2.3 Exceptions					
exhaust systems	see – F.5.2.1 in Annex F					
existing installations	see – 1.2.4.1 Existing installations					
exterior lighting & snowmaking circuits	2.2.1.5.4	3.2.1.5.4	4.2.1.5.4	5.2.1.5.4	6.2.1.5.4	7.2.1.5.4
F						
fiber rope, specifications for	-	-	-	-	6.1.4.1.3	-
splicing	-	-	-	-	6.1.4.1.3	
first aid	2.3.2.1.5	3.3.2.1.5	4.3.2.1.5	5.3.2.1.5	6.3.2.1.5	7.3.2.1.5
fire extinguishers	see – F.6.1 in Annex F					
fixed grip lift, definition of	1.4 – fixed grip lift					
fixed grip						
general requirements	2.1.4.3	-	4.1.4.3.1	5.1.4.3	6.1.4.3	-
maintenance	-	-	4.3.3.3	5.3.3.3.1	6.3.3.3	-
maximum loads	-	-	4.1.4.3.4	5.1.4.3.4	-	-
relocation	-	-	4.3.3.3	5.3.3.3.1	6.3.3.3	-
slippage	-	-	4.1.4.3.2	5.1.4.3.2	6.1.4.3	-
strength	-	-	4.1.4.3.3	5.1.4.3.3	-	-
testing criteria	-	-	4.1.4.3.5	-	-	-
testing schedule	-	-	4.3.4.3	-	-	-
floating tension bullwheel carriage	-	-	4.1.2.9.3	5.1.2.9.3	-	-
foot passenger, definition of	1.4 – foot passenger					
foundations						
general	2.1.1.6	3.1.1.6	4.1.1.6	5.1.1.6	6.1.1.6	7.1.1.6
design of	2.1.1.6.2	3.1.1.6.2	4.1.1.6.2	5.1.1.6.2	6.1.1.6.2	7.1.1.6.2
factor of safety	2.1.1.6.2	3.1.1.6.2	4.1.1.6.2	5.1.1.6.2	6.1.1.6.2	7.1.1.6.2
fuel handling	see – F.4 in Annex F					
G						
gear box	2.1.2.2	3.1.2.2	4.1.2.2	5.1.2.2	6.1.2.2	7.1.2.2
gearing	2.1.2.2	3.1.2.2	4.1.2.2	5.1.2.2	6.1.2.2	7.1.2.2
gondola cabin	-	3.1.4.4.2	4.1.4.4.2	-	-	-
gradient, tow path	-	-	-	5.1.1.3.1	6.1.1.3.1	-
grandfather clause	see – 1.2.4.1 Existing Installations					
grip (see Fixed or Detachable Grip)						
ground fault circuit interrupter (GFCI)						
definition of	1.4 – Ground Fault Circuit Interrupter (GFCI)					
requirements for	2.2.1.5.5	3.2.1.5.5	4.2.1.5.5	5.2.1.5.5	6.2.1.5.5	7.2.1.5.5
ground fault protection						
definition of	1.4 – ground fault protection					
requirements for	2.2.1.5.4	3.2.1.5.4	4.2.1.5.4	5.2.1.5.4	6.2.1.5.4	7.2.1.5.4
grounding						
drive terminal structure	2.2.1.6.2	3.2.1.6.2	4.2.1.6.2	5.2.1.6.2	6.2.1.6.2	7.2.1.6.2

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Subject	*Reversible Aerial Tramways*	*Detachable Grip Aerial Lifts*	*Fixed Grip Aerial Lifts*	*Surface Lifts*	*Tows*	*Conveyors*
haul rope	2.2.1.6.3	3.2.1.6.3	4.2.1.6.3	5.2.1.6.3	6.2.1.6.3	-
structures	2.2.1.6.1	3.2.1.6.1	4.2.1.6.1	5.2.1.6.1	6.2.1.6.1	7.2.1.6.2
guards						
for machinery	2.1.2.7.1	3.1.2.7.1	4.1.2.7.1	5.1.2.7.1	6.1.2.7.1	7.1.2.7.1
for towers	2.1.3.2	3.1.3.3.2	4.1.3.3.2	5.1.3.3.2	6.1.3.3.2	-
tows (additional)	-	-	-	-	6.1.3.2	-
H						
hanger	2.1.4.3.2	3.1.4.4.1	4.1.4.4.1	-	-	-
swing requirements	2.1.4.3.2	-	-	-	-	-
testing	-	3.1.4.5.5	4.1.4.5.5	-	-	-
haul rope	2.1.4.1	3.1.4.1	4.1.4.1	5.1.4.1	6.1.4.1	-
factor of safety	2.1.4.1.1	3.1.4.1.1	4.1.4.1.1	5.1.4.1.1	6.1.4.1.1	-
grounding	2.2.1.6.3	3.2.1.6.3	4.2.1.6.3	5.2.1.6.3	6.2.1.6.3	-
retention	2.1.3.3.3	3.1.3.3.3	4.1.3.3.3	5.1.3.3.3	-	-
hazardous operating conditions	2.3.2.5.6	3.3.2.5.6	4.3.2.5.6	5.3.2.5.6	6.3.2.5.6	7.3.2.5.6
I						
illumination for night lighting	2.2.13.1	3.2.13.1	4.2.13.1	5.2.13.1	6.2.13.1	7.2.13.1
inspection						
acceptance	2.1.1.11.1	3.1.1.11.1	4.1.1.11.1	5.1.1.11.1	6.1.1.11.1	7.1.1.11.1
daily pre-operational	2.3.2.4.2	3.3.2.4.2	4.3.2.4.2	5.3.2.4.2	6.3.2.4.2	7.3.2.4.2
general	2.3.4.1	3.3.4.1	4.3.4.1	5.3.4.1	6.3.4	7.3.4
track cable	see – A.4.2.2 in Annex A					
wire rope	see – A.4.1.2 in Annex A					
intermediate stations	-	3.1.1.9.3	4.1.1.9	-	-	-
attendants at	-	3.3.2.2	4.3.2.2	-	-	-
intermediate structures	2.1.1.5.7	3.1.1.5.7	-	-	6.1.3.1	-
internal combustion engine	see – F.1 in Annex F					
exhaust system	see – F.5 in Annex F					
fuel supply	see – F.4 in Annex F					
gear shifts	2.1.2.1	3.1.2.1	4.1.2.1	5.1.2.1	6.1.2.1	-
testing time	2.1.1.11	3.1.1.11	4.1.1.11	5.1.1.11	-	-
interpretation of standard	see – 1.2.5 Interpretation of standard					
L						
leaf chain	see – Annex H Roller and leaf chain					
lighting						
emergency	2.2.13.4	3.2.13.4	4.2.13.4	5.2.13.4	6.2.13.4	7.2.13.4
exterior circuits	2.2.1.5.4	3.2.1.5.4	4.2.1.5.4	5.2.1.5.4	6.2.1.5.4	7.2.1.5.4
night	2.2.13	3.2.13	4.2.13	5.2.13	6.2.13	7.2.13
lightning, circuit protection	2.2.1.6.4	3.2.1.6.4	4.2.1.6.4	5.2.1.6.4	6.2.1.6.4	7.2.1.6.4
line structures (see towers)						
loading areas	2.1.1.9	3.1.1.9	4.1.1.9	5.1.1.9	6.1.1.9	7.1.1.9
	-	3.1.1.9.1	4.1.1.9.1	5.1.1.9.1	6.1.1.9.2	7.1.1.9.1
		3.3.2.5.3	4.3.2.5.3	-	-	-
chair	-	3.1.1.9.1.1	4.1.1.9.1	-	-	-
foot passengers	-	3.1.1.9.1.2	4.1.1.9.1	-	-	-
gondolas	-	3.1.1.9.1.2	4.1.1.9.1	-	-	-
	-	3.3.2.5.3	4.3.2.5.3	-	-	-
loading conveyors	see Annex C Loading Conveyors					
	-	3.1.1.9	4.1.1.9	-	-	-
loading interval						
chairs	-	3.1.1.2	4.1.1.2	5.1.1.2	6.1.1.2	7.1.1.2
multiple passenger towing devices	-	-	-	5.1.1.5.2	-	-
single passenger towing devices	-	-	-	5.1.1.5.1	-	-
location, requirements for	2.1.1.3	3.1.1.3	4.1.1.3	5.1.1.3	6.1.1.3	7.1.1.3
log books						
chain	2.3.5.4	3.3.5.4	4.3.5.4	5.3.5.4	-	-
maintenance	2.3.5.2	3.3.5.2	4.3.5.2	5.3.5.2	6.3.5.2	7.3.5.2
operational log	2.3.5.1	3.3.5.1	4.3.5.1	5.3.5.1	6.3.5.1	7.3.5.1
preoperational log	2.3.2.4.2	3.3.2.4.2	4.3.2.4.2	5.3.2.4.2	6.3.2.4.2	7.3.2.4.2
wire rope, strand, & chain log	2.3.5.3	3.3.5.3	4.3.5.3	5.3.5.3	6.3.5.3	7.3.5.3
M						
machinery						
location of	2.1.2.7	3.1.2.7	4.1.2.7	5.1.2.7	6.1.2.7	7.1.2.7
housed inside room	2.1.2.7.3	3.1.2.7.3	4.1.2.7.3	5.1.2.7.3	6.1.2.7.3	7.1.2.7.3
not housed	2.1.2.7.2	3.1.2.7.2	4.1.2.7.2	5.1.2.7.2	6.1.2.7.2	7.1.2.7.2
clearances	2.1.2.7.3	3.1.2.7.3	4.1.2.7.3	5.1.2.7.3	6.1.2.7.3	7.1.2.7.3
guarding	2.1.2.7.1	3.1.2.7.1	4.1.2.7.1	5.1.2.7.1	6.1.2.7.1	7.1.2.7.1

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Subject	*Reversible Aerial Tramways*	*Detachable Grip Aerial Lifts*	*Fixed Grip Aerial Lifts*	*Surface Lifts*	*Tows*	*Conveyors*
Magnetic Rope Testing (MRT)						
definition of	1.4 – Magnetic Rope Testing					
haul rope	see – A.4.1.2 in Annex A					
testing requirements (additional)	2.1.4.4.2.2(o)	-	-	-	-	-
track cable	see – A.4.2.2 in Annex A					
maintenance						
dynamic testing	2.3.4.4	3.3.4.4	4.3.4.4	-	-	-
general	2.3.3.1	3.3.3.1	4.3.3.1	5.3.3.1	6.3.3.1	7.3.3.1
inspections and testing	2.3.4	3.3.4	4.3.4	5.3.4	6.3.4	7.3.4
log	2.3.5.2	3.3.5.2	4.3.5.2	5.3.5.2	6.3.5.2	7.2.5.2
manual	2.1.6.2	3.1.6.2	4.1.6.2	5.1.6.2	6.1.6.2	7.1.6.2
personnel	2.3.3.2	3.3.3.2	4.3.3.2	5.3.3.2	6.3.3.2	7.3.3.2
schedule and requirements	2.3.3.1	3.3.3.1	4.3.3.1	5.3.3.1	6.3.3.1	7.3.3.1
manual control devices	2.2.9	3.2.9	4.2.9	5.2.9	6.2.9	7.2.9
manuals						
maintenance	2.1.6.2	3.1.6.2	4.1.6.2	5.1.6.2	6.1.6.2	7.1.6.2
operational	2.1.6.1	3.1.6.1	4.1.6.1	5.1.6.1	6.1.6.1	7.1.6.1
modifications	see – 1.2.4.4 Ropeway modifications					
monocable system, definition of	1.4 – monocable system					
motors (see power units)	2.1.2.1	3.1.2.1	4.1.2.1	5.1.2.1	6.1.2.1	7.1.2.1
N						
new materials and methods	see – 1.2.2 New materials and methods					
night operations	2.2.13	3.2.13	4.2.13	5.2.13	6.2.13	7.2.13
night lighting	2.2.13	3.2.13	4.2.13	5.2.13	6.2.13	7.2.13
emergency	2.2.13.4	3.2.13.4	4.2.13.4	5.2.13.4	6.2.13.4	7.2.13.4
grounding	2.2.1.5.4	3.2.1.5.4	4.2.1.5.4	5.2.1.5.4	6.2.1.5.4	7.2.1.5.4
illumination	2.2.13.1	3.2.13.1	4.2.13.1	5.2.13.1	6.2.13.1	7.2.13.1
location	2.2.13.3	3.2.13.3	4.2.13.3	5.2.13.3	6.2.13.3	7.2.13.3
types	2.2.13.2	3.2.13.2	4.2.13.2	5.2.13.2	6.2.13.2	7.2.13.2
normal stop, definition of	1.4 – normal stop					
additional requirements	2.1.2.5	3.1.2.5	4.1.2.5	5.1.2.5	6.1.2.5	7.1.2.5
O						
operating circuits	2.2.4	3.2.4	4.2.4	5.2.4	6.2.4	7.2.4
operating personnel	2.3.2.1	3.3.2.1	4.3.2.1	5.3.2.1	6.3.2.1	7.3.2.1
duties of	2.3.2.3	3.3.2.3	4.3.2.3	5.3.2.3	6.3.2.3	7.3.2.3
number required	2.3.2.2	3.3.2.2	4.3.2.2	5.3.2.2	6.3.2.2	7.3.2.3
provisions for	2.1.5	3.1.5	4.1.5.	5.1.5	6.1.5	7.1.5
safety of	2.2.10	3.2.10	4.2.10	5.2.10.	6.2.10.	7.2.10
work position	2.1.5	3.1.5	4.1.5	5.1.5	6.1.5	7.1.5
operational log	2.3.5.1	3.3.5.1	4.3.5.1	5.3.5.1	6.3.5.1	7.3.5.1
operational manual	2.1.6.1	3.1.6.1	4.1.6.1	5.1.6.1	6.1.6.1	7.1.6.1
operational personnel	2.3.2.1	3.3.2.1	4.3.2.1	5.3.2.1	6.3.2.1	7.3.2.1
operational procedures	2.3.2.4	3.3.2.4	4.3.2.4	5.3.2.4	6.3.2.4	7.3.2.4
operational requirements	2.3.2.5	3.3.2.5	4.3.2.5	5.3.2.5	6.3.2.5	7.3.2.5.9
bypass requirements	2.3.2.5.9	3.3.2.5.9	4.3.2.5.9	5.3.2.5.9	6.3.2.5.9	7.3.2.5.8
damage to carriers	2.3.2.5.5	3.3.2.5.5	4.3.2.5.5	5.3.2.5.5	6.3.2.5.5	-
evacuation plan	2.3.2.5.7	3.3.2.5.7	4.3.2.5.7	-	-	-
hazardous conditions	2.3.2.5.6	3.3.2.5.6	4.3.2.5.6	5.3.2.5.6	6.3.2.5.6	7.3.2.5.6
starting	2.3.2.5.2	3.3.2.5.2	4.3.2.5.2	5.3.2.5.2	6.3.2.5.2	7.3.2.5.2
stops	2.3.2.5.4	3.3.2.5.4	4.3.2.5.4	5.3.2.5.4	6.3.2.5.4	7.3.2.5.4
terminating daily operations	2.3.2.5.8	3.3.2.5.8	4.3.2.5.8	5.3.2.5.8	6.3.2.5.8	7.3.2.5.8
tow path maintenance	-	-	-	5.3.2.5.3	6.3.2.5.3	-
operations	2.3	3.3	4.3	5.3	6.3	7.3
operators						
definition of	1.4 – operator					
at intermediate stations	-	3.3.2.2	4.3.2.2	5.3.2.2	-	-
duties of	2.3.2.3.2	3.3.2.3.2	4.3.2.3.2	5.3.2.3.2	6.3.2.3.2	7.3.2.3.2
minimum number	2.3.2.2	3.3.2.2	4.3.2.2	5.3.2.2	6.3.2.2	7.3.2.2
requirements for	2.3.2.1.2	3.3.2.1.2	4.3.2.1.2	5.3.2.1.2	6.3.2.1.2	7.3.2.2
overhauling, definition of	1.4 – overhauling					
overhauling loads	2.1.2.4(a)	3.1.2.4	4.1.2.4			
overhead cables	2.2.1.4	3.2.1.4	4.2.1.4	5.2.1.4	6.1.2.4	-
overspeed	2.2.3.6	3.2.3.6	4.2.3.6	5.2.3(f)	6.2.3(d)	-
overtravel, carrier	2.2.3.2	-	-	-	-	-
P						
passenger						
control of	2.3.2.4.1	3.3.2.4.1	4.3.2.4.1	5.3.2.4.1	6.3.2.4.1	7.3.2.4.1
foot passenger, definition of	1.4 – foot passenger					
skier, definition of	1.4 – skier					
weight	2.1.1.1	3.1.1.1	4.1.1.1	5.1.1.1	6.1.1.1	7.1.1.1
passenger conduct	2.3.6	3.3.6	4.3.6	5.3.6	6.3.6	7.3.6
dexterity and ability	2.3.6.1	3.3.6.1	4.3.6.1	5.3.6.1	6.3.6.1	7.3.6.1
embarkation and disembarkation	2.3.6.2	3.3.6.2	4.3.6.2	5.3.6.2	6.3.6.2	7.3.6.2
riding	2.3.6.3	3.3.6.3	4.3.6.3	5.3.6.3	6.3.6.3	7.3.6.3
weight, design	2.1.1.1	3.1.1.1	4.1.1.1	5.1.1.1	6.1.1.1	7.1.1.1
passenger ropeway, definition of	1.4 – passenger ropeway					

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Subject	*Reversible Aerial Tramways*	*Detachable Grip Aerial Lifts*	*Fixed Grip Aerial Lifts*	*Surface Lifts*	*Tows*	*Conveyors*
personnel (operations)	2.3.2.1	3.3.2.1	4.3.2.1	5.3.2.1	6.3.2.1	7.3.2.1
personnel (maintenance)	2.3.3.2	3.3.3.2	4.3.3.2	5.3.3.2	6.3.3.2	7.3.3.2
personnel safety						
procedure for	2.3.1	3.3.1	4.3.1	5.3.1	6.3.1	7.3.1
provisions for	2.2.10	3.2.10	4.2.10	5.2.10	6.2.10	7.2.10
portable tow	see – Section 6 Tows					
power units	2.1.2.1	3.1.2.1	4.1.2.1	5.1.2.1	6.1.2.1	7.1.2.1
evacuation power unit	2.1.2.1.2	3.1.2.1.2	4.1.2.1.2	5.1.2.1.2	6.1.2.1.2	7.1.2.1.2
interlock	2.1.2.1.3	3.1.2.1.3	4.1.2.1.3	-	-	-
phase loss (electrical)	2.2.7	3.2.7	4.2.7	5.2.7	6.2.7	7.2.7
prime mover	2.1.2.1.1	3.1.2.1.1	4.1.2.1.1	5.1.2.1.1	6.1.2.1.1	7.1.2.1.1
rescue system drive	2.1.2.1.4	-	-	-	-	-
testing hours	2.1.1.11	3.1.1.11	4.1.1.11	5.1.1.11	6.1.1.11	-
preoperational inspection	2.3.2.4.2	3.3.2.4.2	4.3.2.4.2	5.3.2.4.2	6.3.2.4.2	7.3.2.4.2
prime mover	2.1.2.1.1	3.1.2.1.1	4.1.2.1.1	5.1.2.1.1	6.1.2.1.1	7.1.2.1.1
definition of	1.4 – prime mover					
protection circuits	2.2.3	3.2.3	4.2.3	5.2.3	6.2.3	7.2.3
Q						
Qualified Engineer, definition of	1.4 – Qualified Engineer					
quality assurance program	1.5	1.5	1.5	1.5	1.5	1.5
design	1.5.1	1.5.1	1.5.1	1.5.1	1.5.1	1.5.1
construction	1.5.3	1.5.3	1.5.3	1.5.3	1.5.3	1.5.3
manufacture	1.5.1	1.5.1	1.5.1	1.5.1	1.5.1	1.5.1
operations and maintenance	1.5.4	1.5.4	1.5.4	1.5.4	1.5.4	1.5.4
R						
ramps, inclination of	-	3.1.1.9.2	4.1.1.9.2	5.1.1.9.2	6.1.1.9.2	7.1.1.9.2
recreational device, definition of	1.4 – recreational device					
records (also see log books)	2.3.5	3.3.5	4.3.5	5.3.5	6.3.5	7.3.5
reduction system	2.1.2.2	3.1.2.2	4.1.2.2	5.1.2.2	6.1.2.2	7.1.2.2
relocated installations	see – 1.2.4.2 Relocated installations					
repairs, rope patch	see – A.4.1.4 in Annex A					
replacement or repair of wire rope	see – A.4.1.3 in Annex A					
rescue (see evacuation)						
retention, haul rope	2.1.3.3.3	3.1.3.3.3	4.1.3.3.3	5.1.3.3.3	6.1.2.8.2.1	-
retention, terminal bullwheels	2.1.2.8.2	3.1.2.8.2	4.1.2.8.2	5.1.2.8.2	-	-
retractable towing device	-	-	-	5.1.4.4.3	-	-
rigid mounted tension carriage	2.1.2.9.1	3.1.2.9.1	4.1.2.9.1	5.1.2.9.1	-	-
rollback device						
bullwheel	-	3.1.2.6.3	4.1.2.6.3	5.1.2.6.3	6.1.2.6.3	-
cable	-	3.1.2.6.3	4.1.2.6.3	-	-	-
drum	-	-	-	-	-	7.1.2.6.3
roller chain	see – Annex H Roller and leaf chain					
rollers (see sheaves)						
definition of	1.4 – roller					
ropeway categories	see – 1.1 Scope, 1.2.1 Other ropeway categories					
rope (see wire rope or fiber rope)						
rope catching devices	2.1.3.3.2	3.1.3.3.2(d)	4.1.3.3.2(d)	5.1.3.3.2(d)	-	-
rope grips (see detachable of fixed grips)						
rope grippers	-	-	-	-	6.1.4.3	-
rope guidance (Bicable Systems)	2.1.1.5.6	3.1.1.5.6	-	-	-	-
rope height adjustment	-	3.1.1.5.3	4.1.1.5.3	5.1.1.5.3	-	-
rope position detection	-	3.2.5.2	4.2.5.2	-	-	-
S						
saddles, track cable	2.1.1.5.4	3.1.1.5.4	-	-	-	-
	2.1.3.4	3.1.3.4	-	-	-	-
safety						
facilities	2.3.2.4.3	3.3.2.4.3	4.3.2.4.3	5.3.2.4.3	6.3.2.4.3	7.3.2.4.3
operation & maintenance personnel	2.2.10	3.2.10	4.2.10	5.2.10	6.2.10	7.2.10
personnel	2.3.1	3.3.1	4.3.1	5.3.1	6.3.1	7.3.1
service brake	2.1.2.6.1	3.1.2.6.1	4.1.2.6.1	5.1.2.6.1	6.1.2.6.1	7.1.2.6.1
stopping distance for	-	3.1.2.5	4.1.2.5	5.1.2.6.1	6.1.2.5.1	-
design capability	2.1.2.6.1	3.1.2.6.1	4.1.2.6.1	5.1.2.6.1	6.1.2.5.1	-
shafting	2.1.2.3	3.1.2.3	4.1.2.3	5.1.2.3	6.1.2.3	7.1.2.3
sheaves						
definition of	1.4 – sheaves					
diameter	1.4 – sheave, diameter of					
diameter in tension system	2.1.2.8.3	3.1.2.8.3	4.1.2.8.3	5.1.2.8.3	-	-
haul rope	1.4 – sheaves, haul rope					
line sheaves in stations/saddles	2.1.2.8.4	3.1.2.8.4	4.1.2.8.4	5.1.2.8.4	6.1.2.8.4	-
tension system/other	2.1.2.8.3	3.1.2.8.3	4.1.2.8.3	5.1.2.8.3	-	-

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Subject	*Reversible Aerial Tramways*	*Detachable Grip Aerial Lifts*	*Fixed Grip Aerial Lifts*	*Surface Lifts*	*Tows*	*Conveyors*
sheave unit design	2.1.3.3.2	3.1.3.3.2	4.1.3.3.2	5.1.3.3.2		
bicable	2.1.1.5.5	3.1.1.5.5	-	-	-	-
catcher, haul rope	-	3.1.3.3.2(d)	4.1.3.3.2(d)	5.1.3.3.2(d)	-	-
combination	-	3.1.3.3.3(b)	4.1.3.3.3(b)	5.1.3.3.2	-	-
deropement	2.1.3.3.2	3.1.3.3.2	4.1.3.3.2	5.1.3.3.2	-	-
design	2.1.3.3.2	3.1.3.3.2	4.1.3.3.2	5.1.3.3.2	6.1.3.3	-
diameter	2.1.3.3	3.1.3.3	4.1.3.3	5.1.3.3	6.1.3.3	-
haul rope retention	2.1.3.3.3	3.1.3.3.3	4.1.3.3.3	5.1.3.3.3	-	-
load	2.1.3.3.1	3.1.3.3.1	4.1.3.3.1	5.1.3.3.1	-	-
minimum load	2.1.3.3.3	3.1.3.3.3	4.1.3.3.3	5.1.3.3.3	-	-
switches		3.1.3.3.2(f-g)	4.1.3.3.2(f-g)	5.1.3.3.2(f)	-	-
additional requirements	-	-	-	5.1.3.3.4	-	-
shutdown (see Emergency Shutdown)						
signs	2.3.1.2	3.3.1.2	4.3.1.2	5.3.1.2	6.3.1.2	7.3.1.2
electrical warnings	2.2.1.3	3.2.1.3	4.2.1.3	5.2.1.3	6.2.1.3	7.2.1.3
personnel warnings	2.2.10	3.2.10	4.2.10	5.2.10	6.2.10	7.2.10
requirements	See – Annex D	Signs				
ski tip guards	-	3.1.1.5.2.2	4.1.1.5.2.2	-	-	-
ski track (see tow path)						
skier, definition of	1.4 – skier					
snowmaking circuits	2.2.1.5.4	3.2.1.5.4	4.2.1.5.4	5.2.1.5.4	6.2.1.5.4	7.2.1.5.4
software security	2.2.12	3.2.12	4.2.12	5.2.12	-	7.2.12
speed						
control of	2.1.2.4	3.1.2.4	4.1.2.4	5.1.2.4	6.1.2.4	7.1.2.4
design	2.1.1.2	3.1.1.2	4.1.1.2	5.1.1.2	6.1.1.2	7.1.1.2
line or carrier	2.1.1.2	3.1.1.2	4.1.1.2	5.1.1.2	6.1.1.2	-
speed reducers	2.1.2.2	3.1.2.2	4.1.2.2	5.1.2.2	6.1.2.2	7.1.2.2
spiraling of rope	-	-	-	-	6.1.4.1	-
splices	see – A.3.1 in Annex A					
counterweight rope	see – A.3.1.3 in Annex A					
emergency repairs	see – A.4.1.4 in Annex A					
haul rope	see – A.3.1.1 in Annex A					
fiber rope (tows)	-	-	-	-	6.1.4.1.3	-
standards & codes, reference to	see – 1.3 Reference to other codes and standards					
station (intermediate)	-	3.1.1.9.3	-	-	-	-
stops & shutdowns	2.1.2.5	3.1.2.5	4.1.2.5	5.1.2.5	6.1.2.5	7.1.2.5
stop gate						
definition of	1.4 – stop gate					
requirements for	-	3.2.3.2	4.2.3.2	5.2.3.2	6.2.3.2	7.2.3.2
signs	see – Table D-1 in Annex D					
stop switches						
emergency shutdown circuit	2.2.3.1	3.2.3.1	4.2.3.1	5.2.3.1	6.2.3.1	7.2.3.1
normal stop circuit	2.2.4(c)	3.2.4(c)	4.2.4(c)	5.2.4(c)	6.2.4(c)	7.2.4(c)
stopping devices, required	-	Table 3.3	Table 4.4	-	-	-
strand, definition of	1.4 – strand					
structures						
general	2.1.1.6	3.1.1.6	4.1.1.6	5.1.1.6	6.1.1.6	7.1.1.6
design of	2.1.1.6	3.1.1.6	4.1.1.6	5.1.1.6	6.1.1.6	7.1.1.6
supervision circuits	2.2.5	3.2.5	4.2.5	5.2.5	6.2.5	7.2.5
supervisors						
definition of	1.4 – supervisor					
duties of	2.3.2.3.1	3.3.2.3.1	4.3.2.3.1	5.3.2.3.1	6.3.2.3.1	7.3.2.3.1
requirements for	2.3.2.1.1	3.3.2.1.1	4.3.2.1.1	5.3.2.1.1	6.3.2.1.1	7.3.2.1.1
surface lift, definition of	1.4 – surface lift					
survey, as built	2.1.1.11.1(m)	3.1.1.11.1(m)	4.1.1.11.1(l)	5.1.1.11.1(l)	-	-
T						
tension systems	2.1.2.10	3.1.2.10	4.1.2.10	5.1.2.10	6.1.2.10	7.1.2.10
chains	2.1.2.10.4	3.1.2.10.4	4.1.2.10.4	5.1.2.10.4	6.1.2.10.4	-
counterweights	2.1.2.10.2	3.1.2.10.2	4.1.2.10.2	5.1.2.10.2	-	-
electrical	2.2.3.3	3.2.3.3	4.2.3.3	5.2.3.3	-	-
	2.2.5.1	3.2.5.1	4.2.5.1	5.2.5.1	-	-
fixed anchorage	2.1.2.10	3.1.2.10	4.1.2.10	5.1.2.10	6.1.2.10.1	-
hydraulic	2.1.2.10.1	3.1.2.10.1	4.1.2.10.1	5.1.2.10.1	6.1.2.10.1	-
pneumatic	2.1.2.10.1	3.1.2.10.1	4.1.2.10.1	5.1.2.10.1	-	-
winches	2.1.2.10.5	3.1.2.10.5	4.1.2.10.5	5.1.2.10.5	6.1.2.10.5	-
wire rope	2.1.2.10.3	3.1.2.10.3	4.1.2.10.3	5.1.2.10.3	6.1.2.10.3	-
tension bullwheel carriage	2.1.2.9	3.1.2.9	4.1.2.9	5.1.2.9	6.1.2.9	-
floating	-	-	4.1.2.9.3	5.1.2.9.3	-	-
rigid	2.1.2.9.1	3.1.2.9.1	4.1.2.9.1	5.1.2.9.1	-	-
terminal						
cabin platform interface	2.1.4.3.3	3.1.4.4.2	-	-	-	-
guides	2.1.2.12	3.1.2.12	-	-	-	-
height adjustment	-	3.1.1.5.3	4.1.1.5.3	-	-	-
termination of daily operations	2.3.2.5.8	3.3.2.5.8	4.3.2.5.8	5.3.2.5.8	6.3.2.5.8	7.3.2.5.8

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Subject	*Reversible Aerial Tramways*	*Detachable Grip Aerial Lifts*	*Fixed Grip Aerial Lifts*	*Surface Lifts*	*Tows*	*Conveyors*
testing						
acceptance	2.1.1.11.2	3.1.1.11.2	4.1.1.11.2	5.1.1.11.2	6.1.1.11.2	7.1.1.11.2
backstops	-	3.1.2.6.3	4.1.2.6.3	-	-	-
brakes	2.1.2.6	3.1.2.6	4.1.2.6	5.1.2.6	6.1.2.6	7.1.2.6
dynamic	2.3.4.4	3.3.4.4	4.3.4.4	-	-	-
electrical	2.2.11	3.2.11	4.2.11	5.2.11	-	7.2.11
grips	-	3.1.4.3.2	4.1.4.3.5	-	-	-
hanger	2.1.4.3 2.3.4.3	3.1.4.5 3.3.4.3	4.1.4.5.5 4.3.4.3	-	-	-
towers						
fall protection	2.1.3.1	3.1.3.1	4.1.3.1	5.1.3.1	-	
general	2.1.3.1	3.1.3.1	4.1.3.1	5.1.3.1	6.1.3.1	-
guards	2.1.3.2	-	4.1.3.3.2	5.1.3.2	6.1.3.2	-
height adjustment	-	3.1.1.5.3	4.1.1.5.3	5.1.1.5.3	-	-
ladders for	2.1.3.1	3.1.3.1	4.1.3.1	5.1.3.1	-	-
lifting frames	2.1.3.1	3.1.3.1	4.1.3.1	-	-	-
numbering of	2.1.3.1	3.1.3.1	4.1.3.1	5.1.3.1	-	-
ski tip guards	-	3.1.1.5.2.2	4.1.1.5.2.2	-	-	-
supports, tows	-	-	-	-	6.1.3.1	-
track cable saddles	2.1.1.5.4	3.1.1.5.4 3.1.3.4	-	-	-	-
tow, fiber rope, definition of	1.4 – tow, fiber rope					
tow, wire rope, definition of	1.4 – tow, wire rope					
tow grippers	-	-	-	-	6.1.4.2.1	-
tow path						
definition of	1.4 – tow path					
crossing, slope or trail	-	-	-	5.1.1.3.3	6.1.1.2.3	
cross slope	-	-	-	5.1.1.3.2	6.1.1.2.2	-
gradient,	-	-	-	5.1.1.3.1	6.1.1.2.1	-
surface width	-	-	-	5.1.1.4.1	6.1.1.4.1	-
width clearing	-	-	-	5.1.1.4	6.1.1.4	-
towing device						
definition of	1.4 – towing device					
design of	-	-	-	5.1.4.4.1	6.1.4.3	-
damage to	-	-	-	5.3.2.5.5	6.3.2.5.5	-
track cable	see – Annex A	Wire rope and strand requirements				
definition of	1.4 – track cable					
application	2.1.4.2	3.1.4.2	-	-	-	-
breaking force (strength)	see – A.1.3 and A.1.3.2					
bollards	see – A.3.2.5.6(b)					
diameter measuring	see – Annex B	Measuring the diameter of wire rope				
diameter tolerances	see – A.1.2.2					
end connections	see – A.3.2					
requirements	see – A.3					
counterweight rope	see – A.3.2.3					
track cable	see – A.3.2.2					
types & methods	see – A.3.2.5					
factor of safety	2.1.4.2.1	3.1.4.2.1	-	-	-	-
inspection	see – A.4.2.2					
installation	2.1.4.2.2	3.1.4.2.2	-	-	-	-
log	2.3.5.3	3.3.5.3	4.3.5.3	5.3.5.3	6.3.5.3	-
lubrication	see – A.4.2.1					
maintenance of	see – A.4.2					
MRT	see – A.4.2.2					
relocation	see – A.4.2.4					
repair/replacement criteria	see – A.4.2.3					
criteria	see – A.4.2.3					
repair of	see – A.4.2.3					
end connection	see – A.4.3.2					
specifications for	see – A.1.1					
requirements of	see – A.1.1.2					
testing						
breaking force	see – A.2.1.3					
wire ductility	see – A.2.1.6					
wire tensile	see – A.2.1.4					
wire torsion	see – A.2.1.5					
reports	see – A.2.2.2					
rejects and retests	see – A.2.3					
track cable brakes	2.1.4.4.2	-	-	-	-	-
with track cable brakes	2.1.4.4.2.1	-	-	-	-	-
without track cable brakes	2.1.4.4.2.2	-	-	-	-	-
track cable saddle	2.1.1.3.4	3.1.1.3.4	-	-	-	-

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Subject	*Reversible Aerial Tramways*	*Detachable Grip Aerial Lifts*	*Fixed Grip Aerial Lifts*	*Surface Lifts*	*Tows*	*Conveyors*
training						
attendant						
mechanic						
operator						
supervisor						
tramway, definition of	1.4 – aerial tramways					
transition stop device	-	-	-	-	-	7.2.3.3
U						
unloading area	2.1.1.9	3.1.1.9 3.1.1.9.2	4.1.1.9 4.1.1.9.2	5.1.1.9 5.1.1.9.2	6.1.1.9 6.1.1.9.2	7.1.1.9 7.1.1.9.2
W						
welded link chain	see – Annex G	Welded link chain				
weight, passenger	2.1.1.1	3.1.1.1	4.1.1.1	5.1.1.1	6.1.1.1	7.1.1.1
wheels (see sheaves, line)						
width						
of clearing	2.1.1.4	3.1.1.4	4.1.1.4	5.1.1.4	6.1.1.4	7.1.1.4.3
of tow path	-	-	-	5.1.1.4.1	6.1.1.4.1	-
winches, tension systems	2.1.2.10.5	3.1.2.10.5	4.1.2.10.5	5.1.2.10.5	6.1.2.10.5	-
wind Gauges	2.3.2.5.6	3.3.2.5.6	4.3.2.5.6	-	-	-
wire rope	see – Annex A	Wire rope and strand requirements				
definition of	1.4 - rope					
accidental damage	see – A.4.1.3.2					
breaking force (strength)	see – A.1.3 and A.1.3.1					
bollards	see – A.3.2.5.6(a)					
diameter measuring	see – Annex B	Measuring the diameter of wire rope				
diameter tolerances	see – A.1.2					
end connections	see – A.3.2					
requirements	see – A.3					
counterweight rope	see – A.3.2.3					
haul rope (bicable)	see – A.3.2.1					
types & methods	see – A.3.2.5					
factor of safety for	2.1.4.1.1	3.1.4.1.1	4.1.4.1.1	5.1.4.1.1	6.1.4.1.1	-
factor of safety (IWRC)	2.1.4.1.2	3.1.4.1.2	4.1.4.1.2	5.1.4.1.2	6.1.4.1.2	-
inspection	see – A.4.1.2					
log	2.3.5.3	3.3.5.3	4.3.5.3	5.3.5.3	6.3.5.3	-
lubrication	see – A.4.1.2					
maintenance of	see – A.4.1					
MRT	see – A.4.1.2					
repair/replacement criteria	see – A.4.1.3					
criteria	see – A.4.1.3.1				6.3.3.5	
repair of	see – A.4.1.4					
end connection	see – A.4.3.2					
haul rope	see – A.4.1.3					
splice	see – A.4.3.1					
specifications for	see – A.1.1					
requirements of	see – A.1.1.1					
splices						
requirements	see – A.3					
emergency	see – A.4.1.4					
haul rope	see – A.3.1.1					
tension system	2.1.2.10.3	3.1.2.10.3	4.1.2.10.3	5.1.2.10.3	6.1.2.10.3	-
testing						
breaking force	see – A.2.1.3					
wire tensile	see – A.2.1.4					
wire torsion	see – A.2.1.5					
reports	see – A.2.2.1					
rejects and retests	see – A.2.3					
track cable (see track cable)	-	-	-			
twist (spiraling)	-	-	-	-	6.1.4.1	-

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