
**Safety of amusement rides and
amusement devices —**

**Part 1:
Design and manufacture**

*Sécurité des manèges et des dispositifs de divertissement —
Partie 1: Conception et fabrication*

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO document should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

ISO draws attention to the possibility that the implementation of this document may involve the use of (a) patent(s). ISO takes no position concerning the evidence, validity or applicability of any claimed patent rights in respect thereof. As of the date of publication of this document, ISO had not received notice of (a) patent(s) which may be required to implement this document. However, implementers are cautioned that this may not represent the latest information, which may be obtained from the patent database available at www.iso.org/patents. ISO shall not be held responsible for identifying any or all such patent rights.

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 254, *Safety of amusement rides and amusement devices*.

This second edition cancels and replaces the first edition (ISO 17842-1:2015), which has been technically revised.

The main changes are as follows:

- the normative references have been updated;
- the terms and definitions have been revised;
- alignment with EN 13814 series from 2019;
- the general risk assessment has been supplemented by the operator-side risk assessment;
- the safety distances of passenger units have been fundamentally revised;
- the requirements for personal restraint systems have been supplemented by additional monitoring;
- new [Annex I](#) contains the acceleration effects on passengers to align with ASTM F2291-21.

A list of all parts in the ISO 17842 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Safety of amusement rides and amusement devices —

Part 1: Design and manufacture

1 Scope

This document specifies the minimum requirements necessary to ensure the safe design, calculation, manufacture and installation of mobile, temporary or permanently installed amusement ride machinery and structures, which are intended for use by persons as a leisure activity. The amusement rides and amusement devices include for example, roundabouts, swings, boats, Ferris wheels, roller coasters, chutes, booths, side shows and structures for artistic aerial displays. They are intended to be installed both repeatedly without degradation or loss of integrity, and temporarily or permanently in fairgrounds and amusement parks or any other locations.

This document is not applicable to grandstands, construction site installations, scaffolding, removable agricultural structures, simple coin operated children's amusement devices, carrying up to three children, and recreational devices like waterslides or summer toboggan runs, playground equipment, rope courses, climbing wall, inflatable, trampolines, swimming pool equipment, etc.

NOTE For all the equipment not covered by the requirements of ISO 17842-1, the relevant standards apply.

Nevertheless, this document can be used in the design of any similar structural or passenger carrying amusement device not explicitly mentioned herein.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 898-1, *Mechanical properties of fasteners made of carbon steel and alloy steel — Part 1: Bolts, screws and studs with specified property classes — Coarse thread and fine pitch thread*

ISO 1141, *Fibre ropes — Polyester — 3-, 4-, 8- and 12-strand ropes*

ISO 1181, *Fibre ropes — Manila and sisal — 3-, 4- and 8-strand ropes*

ISO 1346, *Fibre ropes — Polypropylene split film, monofilament and multifilament (PP2) and polypropylene high-tenacity multifilament (PP3) — 3-, 4-, 8- and 12-strand ropes*

ISO 2307, *Fibre ropes — Determination of certain physical and mechanical properties*

ISO 3834-2, *Quality requirements for fusion welding of metallic materials — Part 2: Comprehensive quality requirements*

ISO 3834-3, *Quality requirements for fusion welding of metallic materials — Part 3: Standard quality requirements*

ISO 3834-4, *Quality requirements for fusion welding of metallic materials — Part 4: Elementary quality requirements*

ISO 4014, *Fasteners — Hexagon head bolts — Product grades A and B*

ISO 4016, *Fasteners — Hexagon head bolts — Product grade C*

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- ISO 4017, *Fasteners — Hexagon head screws — Product grades A and B*
- ISO 4018, *Fasteners — Hexagon head screws — Product grade C*
- ISO 4032, *Fasteners — Hexagon regular nuts (style 1)*
- ISO 4413, *Hydraulic fluid power — General rules and safety requirements for systems and their components*
- ISO 4414, *Pneumatic fluid power — General rules and safety requirements for systems and their components*
- ISO 5817, *Welding — Fusion-welded joints in steel, nickel, titanium and their alloys (beam welding excluded) — Quality levels for imperfections*
- ISO 9554, *Fibre ropes — General specifications*
- ISO 9606-1, *Qualification testing of welders — Fusion welding — Part 1: Steels*
- ISO 9606-2, *Qualification test of welders — Fusion welding — Part 2: Aluminium and aluminium alloys*
- ISO 9692-1, *Welding and allied processes — Types of joint preparation — Part 1: Manual metal arc welding, gas-shielded metal arc welding, gas welding, TIG welding and beam welding of steels*
- ISO 9692-2, *Welding and allied processes — Joint preparation — Part 2: Submerged arc welding of steels*
- ISO 9692-3, *Welding and allied processes — Types of joint preparation — Part 3: Metal inert gas welding and tungsten inert gas welding of aluminium and its alloys*
- ISO 10042, *Welding — Arc-welded joints in aluminium and its alloys — Quality levels for imperfections*
- ISO 10325, *Fibre ropes — High modulus polyethylene — 8-strand braided ropes, 12-strand braided ropes and covered ropes*
- ISO 10474:2013, *Steel and steel products — Inspection documents*
- ISO 10547, *Polyester fibre ropes — Double braid construction*
- ISO 10554, *Polyamide fibre ropes — Double braid construction*
- ISO 10556, *Fibre ropes of polyester/polyolefin dual fibres*
- ISO 10572, *Mixed polyolefin fibre ropes*
- ISO 12100:2010, *Safety of machinery — General principles for design — Risk assessment and risk reduction*
- ISO 13854:2017, *Safety of machinery — Minimum gaps to avoid crushing of parts of the human body*
- ISO 13849-1, *Safety of machinery — Safety-related parts of control systems — Part 1: General principles for design*
- ISO 13849-2, *Safety of machinery — Safety-related parts of control systems — Part 2: Validation*
- ISO 13857, *Safety of machinery — Safety distances to prevent hazard zones being reached by upper and lower limbs*
- ISO 14118, *Safety of machinery — Prevention of unexpected start-up*
- ISO 14119, *Safety of machinery — Interlocking devices associated with guards — Principles for design and selection*
- ISO 14120, *Safety of machinery — Guards — General requirements for the design and construction of fixed and movable guards*
- ISO 14731, *Welding coordination — Tasks and responsibilities*

- ISO 14732, *Welding personnel — Qualification testing of welding operators and weld setters for mechanized and automatic welding of metallic materials*
- ISO 17635:2016, *Non-destructive testing of welds — General rules for metallic materials*
- ISO 17842-2:2022, *Safety of amusement rides and amusement devices — Part 2: Operation and use*
- ISO 17842-3, *Safety of amusement rides and amusement devices — Part 3: Requirements for inspection during design, manufacture, operation and use*
- IEC 60204-1:2005, *Safety of machinery — Electrical equipment of machines — Part 1: General requirements*
- IEC 60204-32, *Safety of machinery — Electrical equipment of machines — Part 32: Requirements for hoisting machines*
- IEC 60364-4-41, *Low-voltage electrical installations — Part 4-41: Protection for safety — Protection against electric shock*
- IEC 60364-5-54, *Electrical Installation of buildings — Part 5-54: Selection and erection of electrical equipment — Earthing arrangements, protective conductors and protective bonding conductors*
- IEC 60364-7-740, *Electrical Installation of buildings — Part 7-740: Requirements for special installations or locations — Temporary electrical installations for structures, amusement devices and booths at fairgrounds, amusement parks and circuses*
- IEC 61558-1, *Safety of power transformers, power supplies, reactors and similar products — Part 1: General requirements and tests*
- IEC 61800-5-2, *Adjustable speed electrical power drive systems — Part 5-2: Safety requirements — Functional*
- IEC 62061, *Safety of machinery — Functional safety of safety-related electrical, electronic and programmable electronic control systems*
- IEC 62305 (all parts), *Protection against lightning*
- EN 818 (all parts), *Short link chain for lifting purposes — Safety*
- EN 1069-1+A1, *Water slides — Part 1: Safety requirements and test methods*
- EN 1090-2, *Execution of steel structures and aluminium structures — Part 2: Technical requirements for steel structures*
- EN 1090-3, *Execution of steel structures and aluminium structures — Part 3: Technical requirements for aluminium structures*
- EN 1090-3:2008, *Execution of steel structures and aluminium structures — Part 3: Technical requirements for aluminium structures*
- EN 1261, *Fibre ropes for general service — Hemp*
- EN 1677 (all parts), *Components for slings — Safety*
- EN 1993-1-1, *Eurocode 3: Design of steel structures — Part 1-1: General rules and rules for buildings*
- EN 1993-1-8, *Eurocode 3: Design of steel structures — Part 1-8: Design of joints*
- EN 1993-1-9:2005, *Eurocode 3: Design of steel structures — Part 1-9: Fatigue*
- EN 1999-1-1, *Eurocode 9: Design of aluminium structures — Part 1-1: General structural rules*
- EN 12195-2, *Load restraint assemblies on road vehicles — Safety — Part 2: Web lashing made from man-made fibres*

EN 12385 (all parts), *Steel wire ropes — Safety*

EN 13411 (all parts), *Terminations for steel wire ropes — Safety*

EN 13889+A1, *Forged steel shackles for general lifting purposes — Dee shackles and bow shackles — Grade 6 — Safety*

EN 14399 (all parts), *High-strength structural bolting assemblies for preloading*

EN 50172, *Emergency escape lighting systems*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at <https://www.iso.org/obp>

— IEC Electropedia: available at <https://www.electropedia.org/>

**3.1
amusement device**
arrangement of equipment that produces the desired effect of amusement or entertainment when the *patron* (3.26) moves through it or on it primarily by his or her own action, or any other system that is not covered by the term *amusement ride* (3.2)

Note 1 to entry: In this document, the term “amusement device” is used to refer to an amusement device or *amusement ride* (3.2).

**3.2
amusement ride**
device that is designed to entertain the *passengers* (3.26) during motion including the consequence of biomechanical effect

Note 1 to entry: In this document, the term “amusement device” is used to refer to an *amusement device* (3.1) or amusement ride.

Note 2 to entry: See ISO/TS 17929 for the definition of biomechanical effect.

**3.3
attendant**
competent person (3.6) appointed to work under the supervision of an *operator* (3.25), to assist in the operation of a device available for use by the public

**3.4
barrier**
device intended to prevent the user from falling and from passing beneath a barrier

Note 1 to entry: A barrier can also be used as a fence.

**3.5
closed restraint**
restraint in a position in which the *restraint* (3.35) is intended to remain during the operation of the amusement device in order to restrain the *passenger* (3.26)

**3.6
competent person**
person who can demonstrate the knowledge and skills acquired through training, qualifications or experience, or a combination of all, enabling that person to perform a specified task

3.7**controller**

person or organisation having overall control of an *amusement device* (3.1)

Note 1 to entry: This may be either an individual or corporate body owning an *amusement device* (3.1) or the concessionaire or lessee who has been granted control of the amusement device, by the owner, for a specified period.

3.8**design review**

document detailing the review of all the applicable design documents to determine the suitability for use of an *amusement device* (3.1)

3.9**design risk assessment****DRA**

document produced by the *designer* (3.10) as a tool to ensure a safe design within the agreed scope of supply

3.10**designer****engineer**

person or body responsible for the design of an *amusement device* (3.1) (or modifications thereof), including, but not limited to, establishing and describing the configuration of the *amusement ride* (3.2) or *amusement device* (3.1), conducting appropriate risk assessment(s), establishing strength (including fatigue strength), designing and specifying electrical/electronic control systems, defining the acceptable quality level for production, defining inspection criteria and including the provision of the necessary documentation

3.11**amusement device log**

book and/or electronic data file containing all the necessary information about the use and history of any *amusement device* (3.1)

3.12**fail safe**

characteristic of a system, component or device the failure of which maintains a safe state

3.13**fence**

structure designed to restrict or prevent movement across a boundary without change of elevation

3.14**gate**

section of *fence* (3.13) or *barrier* (3.4) that can be opened to provide access or egress

3.15**guardrail**

rail intended to prevent a user from falling

3.16**guest**

person who interacts with an *amusement device* (3.1)

3.17**handrail**

rail intended to assist the user to balance

3.18

initial approval

design and calculation review process, including verification, examinations and tests executed by the inspecting body before an *amusement ride* (3.2) is first made available for public use

3.19

latching restraint

restraint (3.35) which is held secure against opening except by intentional action of the *passenger* (3.26) or the *operator* (3.25)

Note 1 to entry: This can include *restraints* (3.35) (e.g. drop bars) held in place by gravity, detents or other means.

3.20

locking restraint

restraint (3.35) which is held secure against opening except by intentional action of the *operator* (3.25) or other means not accessible by the *passenger* (3.26)

3.21

machinery component

component which forms part of an assembly in which at least one component moves (excluding vibration and deformation)

3.22

major modification

safety-related alteration to the hardware or software of an *amusement device* (3.1), including the introduction of a new *safety-related component* (3.39) or the substitution of a *safety-related component* (3.39), which results in a deviation from the current design specification

3.23

manufacturer

individual or commercial entity responsible for a product with the view to placing it on the market under his/her own name

Note 1 to entry: Any commercial operator that either places a product on the market under his/her own name or trademark or modifies a product in such a way that conformity with applicable requirements is affected, should be considered as the manufacturer and should assume the obligations of the manufacturer.

3.24

operation and use risk assessment

OURA

document produced by the *controller* (3.7) that details all of the considered risks inherent during all modes of *amusement device* (3.1) operation and the means taken to mitigate against them

Note 1 to entry: This term is explained in detail in 5.1.2.2.

3.25

operator

competent person appointed by the *controller* (3.7) to be in charge of the operation of an *amusement device* (3.1) when it is available to the public

3.26

passenger

patron

person using an *amusement device* (3.1)

3.27

passenger containment

components (e.g. seating, foot wells, handrails, passenger restraints) designed to prevent *passengers* (3.26) from moving outside a predetermined area on a ride either as a result of biomechanical effects, the ride forces or the reasonably foreseeable behaviour of the *passenger* (3.26)

3.28**passenger reach envelope
reach envelope**

physical space around a *passenger* (3.26) during a ride cycle while properly positioned, as defined by the ride analysis, in the *amusement ride* (3.2) or *amusement device* (3.1) and limited only by the vehicle, seat geometry and restraint system

3.29**passenger unit
PU**

part or parts of an *amusement ride* (3.2) in or on which the *passengers* (3.26) are intended to ride

3.30**permit**

authorization to operate an *amusement device* (3.1) in a particular state granted by the legally authorized body after successful approval and/or examination

3.31**platform**

horizontal or slightly inclined surface raised above the level of an adjacent area

3.32**reasonably foreseeable misuse**

use of an *amusement device* (3.1) in a way not intended by the *designer* (3.10), but which can result from readily predictable human behaviour

Note 1 to entry: [Annex F](#) gives a non-exhaustive list of guest behaviour.

[SOURCE: ISO 12100:2010, 3.24, modified — "machine" has been replaced with "amusement device", Note 1 to entry has been added.]

3.33**redundancy**

application of more than one device or system, or part of a device or system, with the objective of ensuring that in the event of one failing to perform its function, another will perform that function

3.34**repair**

restoration of components or assemblies to a technically acceptable condition

Note 1 to entry: See also ISO 17842-2:2022, 4.3.8.3.

3.35**restraint**

system, device, or characteristic that is intended to inhibit or restrict the body movement and/or maintain the body position to allow the *passenger* (3.26) to tolerate accelerations while on the *amusement ride* (3.2) or *amusement device* (3.1)

3.36**safe stop**

stop of an *amusement ride* (3.2) in a safe way and in a final safe stable position

3.37**safety envelope
clearance envelope**

area in which *passengers* (3.26) are prevented from being injured while moving in an *amusement ride* (3.2) or *amusement device* (3.1)

Note 1 to entry: This is the *passenger reach envelope* (3.28) plus a suitable margin as defined in [Annex H](#).

3.38

safety-related control system

SRCS

assembly of components that can be electronic, electric, electro-mechanical, hydraulic, pneumatic or mechanical combined to monitor and control a device so as to reduce risks to *guests* (3.15)

3.39

safety-related component

component of an *amusement device* (3.1) on which the safety of the *passengers* (3.26) is dependent as identified in the *design risk assessment* (3.9) and/or the *operation and use risk assessment* (3.24)

3.40

service

replacement or replenishment and check of conditions of components, including fluids which are designated to be replaced or replenished and/or checked at specified intervals

3.41

sideshow

booth or similar enclosed structure containing shows, activities or games for the entertainment of the public, where the *guest* (3.15) is not transported in any way by the structure

3.42

spectator

person in the vicinity of an *amusement device* (3.1), either watching the operation of the *amusement device* (3.1) or waiting to access to the use the *amusement device* (3.1)

3.43

structural component

calculated load bearing part which has not been classified as *machinery components* (3.21) by the *designer* (3.10)

3.44

sustained acceleration

acceleration with duration greater than or equal to 200 ms

Note 1 to entry: See [Annex I](#).

3.45

temporarily installed amusement device

amusement device (3.1) designed to be installed and uninstalled and whose installation period does not exceed more than three months

3.46

thorough examination

procedures and investigations necessary for the inspection body to decide whether the *amusement device* (3.1) can continue to be operated safely or whether it requires defects to be remedied immediately or within a specified time

3.47

trial run

proving run of an *amusement device* (3.1) during which no *passengers* (3.26) are carried

4 Requirements for design analysis and examination

4.1 Design documents

4.1.1 General

The construction documents include all the documents required for the assessment of the stability and operational safety of the device, including the Design Risk assessment (DRA). They shall be available for any subsequent approval by the inspection bodies. These documents shall encompass all the design conditions pertaining to the operation of the amusement devices or structures. A description of the construction, operation and operational safety, design drawings and a comprehensive stress, fatigue and stability analysis as specified in [5.1.4](#) are required for this purpose.

4.1.2 Design risk assessment

See [5.1.2.1](#).

4.1.3 Description of design and operation of an amusement device

The amusement device, in particular its design, modes of operation and its structure shall be explained in this description. Adequate details of mechanical (hydraulic, pneumatic), electrical and electronic equipment, including the control system shall be listed. The description shall include details of the particular features of the device and of any alternative modes of installation which may exist. Also details of the main dimension and of motion spaces extending beyond these dimensions, limitations, design particulars and materials, motion systems, types of drive, velocities, accelerations, electrical equipment, work cycle and operating sequence and of any restrictions regarding the circle of users which may exist, shall be described.

4.1.4 Design and manufacturing drawings

Design and manufacturing drawings are required for all assemblies, subassemblies and individual components, the fracture or failure of which can endanger the stability or operational safety of the amusement device. The drawings shall feature all the dimensions and cross-section values required for testing and approval, including details of materials, structural components, fasteners, connectors, and also relevant velocities.

The drawings shall include as a minimum, as applicable:

- general drawings in plan view, elevation and sections, in a legible scale, depending on the size of the device; indication of the necessary clearance around the moving parts;
- detail drawings showing all the structural subassemblies which are not clearly discernible on the general drawings, as well as detail drawings of connections and individual items of a structural, mechanical or electrical nature, which can affect the safety of the amusement device and its operation, shall be drawn to a larger scale. Illustrations of the following items may be necessary for this purpose:
 - slewing gear, hoisting and swivelling mechanisms, including their support arrangements, drives and controls, lifting and swivelling ranges;
 - carriages, gondolas and similar, illustrated in all the required views and cross sections, with details of the overall dimensions, the internal dimensions of importance to the passengers (seats, side and back rests, leg and foot room), hand and foot holds and locking and securing devices;
 - motion gear with details of load, guide, and upstop wheels, bearings, axles, shafts and their attachment, freedom of movement in relation to the vehicle, steering and control, anti-rollback

devices, safety devices against derailment and overturning, buffers, trailer devices, protection devices, drives and brakes and anchoring to the foundation;

- pneumatic and hydraulic circuits, and electrical and electronic wiring diagrams.

4.1.5 Principles of analysis

All calculated load bearing parts can be classified as either structural components or machinery components.

The designer shall formalize the classification of all calculated load bearing parts before beginning the analysis.

All design calculations for a particular component shall be consistent with a defined design base standard. The respective manufacturing requirements of design standards shall be taken into account.

This classification guides the designer towards the appropriate analysis methods which can be used.

Verification shall comprise the following:

- a) ultimate limit states analysis;
- b) fatigue limit states analysis;
- c) stability limit states analysis: i.e. bar buckling, plate, shell and torsional buckling;
- d) if required, verification of deformation limit states;
- e) verification of safety against overturning, sliding and lifting off;
- f) dynamic analysis (excluding seismic analysis).

The afore-mentioned verifications shall include at least the following details:

- design loads, taking into account the possible operating conditions or alternative installations. In the case of moving parts, the velocity or the rotational speed and acceleration shall be stated. Special loads imposed during erection (e.g. parts walked on which are not designed for that purpose) should be specified and separately listed;
- main dimensions and cross-section values of all load bearing structural components and details relating to the assessment of the fatigue strength;
- details of materials and components;
- determination of the most unfavourable (maximum/minimum stress and stress range) stresses and details relating to the strength of the load bearing structural components and fasteners. If calculation seems insufficient to evaluate limit states of assemblies, the analysis may be replaced by testing to the relevant testing standard. The testing laboratory shall conduct the appropriate number of tests, prepare samples, the testing procedure, the reporting according to the relevant European Standards or in absence of those to equivalent national standards;
- details of elastic deformations (flexure, torsion), when such details affect the stability or operating safety of the device;
- details of those structural components which require special examination and inspection in accordance with [4.7](#).

4.2 Selection of materials

4.2.1 General

Only materials in respect of which design data are featured in international and/or national standards may be used.

Unless other materials have been established and proven for their serviceability, the designer shall give special consideration to structural joints which are to be welded and the weldability of the selected metals.

4.2.2 Recommended steels

4.2.2.1 General

Steel grades for which standardized technological material data (mechanical and chemical properties) are featured may be used.

4.2.2.2 Steels for structural components

Steels used for structural components should be in accordance with EN 10025.

Minimum values are:

Yield:	$R_{eH} = 235 \text{ MPa}$
Ultimate:	$R_m = 350 \text{ MPa}$
Notch impact energy:	$K = 27 \text{ J at } T = +20^\circ\text{C}$, Charpy V specimen

Depending on the loads (impact and fatigue), the temperature and the thickness, the notch impact energy will possibly need to be increased, e.g. $K = 27 \text{ J at } T = -20^\circ\text{C}$, Charpy V specimen.

Other steel grades for which technological material data (mechanical and chemical properties) is available may also be used.

4.2.2.3 Steels for machinery and mechanisms

The steels shall comply with available technological material data (mechanical and chemical properties) or guidelines, which meet the design requirements.

4.2.3 Aluminium alloys

Aluminium alloys shall be selected in accordance with international and/or national standards and internationally accepted guidelines.

EN 1999-1-1 can be suitable.

Aluminium alloys with an elongation (rupture) of $\varepsilon < 8 \%$ should be avoided for dynamically loaded structures.

4.2.4 Timber

Selection of timber shall be in accordance with international and/or national standards or internationally accepted guidelines.

EN 1995-1-1 can be suitable.

4.2.5 Plastic composites

Plastic composites for which technological material data (mechanical and chemical properties) are featured and the use can be approved in a traceable way may also be used.

4.2.6 Concrete

The selection of concrete grade shall be in accordance with international and/or national standards. EN 1992-1-1 can be suitable.

4.2.7 Fasteners for structural components

Bolts, screws and studs shall be in accordance with ISO 898-1 and EN 14399.

Property class 12.9 shall not be used.

For machinery and mechanisms, other bolts according to appropriate international and/or national standards can be used.

Rivets and blind rivets can be used when their capacity for the assigned purpose is experimentally proven in accordance with EN 1993-1-8 and [4.1.5](#).

4.2.8 Standards relating to ropes, chains, safety devices, connectors and adapters

4.2.8.1 General

In addition to the calculation of the load-bearing capacity of materials or accessories, which relate directly to the safety of passengers or public, certificates, manufacturer's markings or testing results shall also be provided.

When ropes, chains, safety devices, connectors and adapters are used, the following standards in particular shall be referred to.

4.2.8.2 Steel ropes

Steel wire ropes: EN 12385.

Termination for steel wire ropes — Safety: EN 13411.

Clamps for wire ropes: EN 13411.

Components for slings: EN 1677 (all parts).

Shackles: EN 13889.

4.2.8.3 Fibre ropes

Fibre ropes for general service — Determination of certain physical and mechanical properties: ISO 2307.

Fibre ropes for general service — General specifications: ISO 9554.

4.2.8.3.1 Synthetic fibre ropes

Polyamide fibre ropes. Double braid construction: ISO 10554.

Polyester fibre ropes. Double braid construction: ISO 10547.

Polyester 3- 4- and 8-strand ropes: ISO 1141.

Fibre ropes of polyester/polyolefin dual fibres: ISO 10556.

Mixed polyolefin fibre ropes: ISO 10572.

Fibre ropes — Polypropylene split film, monofilament and multifilament and polypropylene high tenacity 3-, 4- and 8-strand ropes: ISO 1346.

Fibre ropes — High modulus polyethylene. 8-strand braided ropes, 12-strand braided ropes and covered ropes: ISO 10325.

4.2.8.3.2 Natural fibre ropes

Fibre ropes. Manila and sisal. 3-, 4- and 8-strand ropes: ISO 1181.

Fibre ropes for general service — Hemp: EN 1261.

4.2.8.4 Chains

Short link chain for lifting purposes — Safety: EN 818.

4.3 Design loads

4.3.1 General

In general actions, load, design as well as any structural assumptions for load bearing parts of devices shall be chosen in the following sequence:

- a) according to the provisions of this document;
- b) to an official national standard of the country of use of the device, only if superseding local conditions (e.g. wind, seismic) require it.

The following prevailing detailed rules, adjustments and considerations in relation to building and structural standards, shall be used in all general applications, due to the special nature of amusement rides and devices.

4.3.2 Permanent actions

For amusement rides and devices the load assumption for permanent actions shall be determined.

Where variations can occur, the values $G_{k,sup}$ and $G_{k,inf}$ shall be taken into account when assessing the most probable structural response. Elsewhere a single characteristic value G_k is sufficient. The values are defined as follows:

- G_k characteristic value of permanent action;
- $G_{k,sup}$ upper characteristic value;
- $G_{k,inf}$ lower characteristic value.

The actual dead load of the load bearing structure, the accessories and the technical equipment required for the operation, including cladding, fabrics and other decorative elements are included in the above values. The wet and dry condition of material is accounted for in $G_{k,sup}$ and $G_{k,inf}$.

The actual weight of machine components, electrical equipment, and passenger units like carriages or gondolas shall be verified.

4.3.3 Variable actions

4.3.3.1 Imposed loads

4.3.3.1.1 General

Imposed loads consist of the external loads and imposed deformations (e.g. imposed loads, gyroscopic loads, dynamic loads, wind and snow loads, temperature or settlement) acting on a structural component, which can vary in magnitude, direction and point of application (variation in time and space) during normal operation.

4.3.3.1.2 Vertically imposed loads

4.3.3.1.2.1 Passenger-carrying units

On passenger-carrying units (vehicles, cars, gondolas), the following loads shall be assumed.

Vertically imposed loads (Q_k) for each person over 10 years of age:

- where Q_k is 0,75 kN for all fatigue calculations;
- where Q_k is 0,75 kN for static calculations for more than four passengers per compartment;
- where Q_k is $1,35 \text{ kN} - (n - 1) \times 0,15 \text{ kN}$ where $1 \leq n \leq 4$ for static calculation only and the load transferring members from the seat into centre assemblies for individually supported or suspended seats with $n = 1$ to 4 passengers per single compartment.

These static loads are not an operational and general weight limit or requirement and shall not be used for overall calculations (e.g. sliding, overturning) of the compartment or ride itself.

The above-mentioned values of load assumptions shall be corrected when using special compartments for larger persons.

NOTE 1 The designer can consider higher weight depending on the seat configuration and type of ride.

For each person of 10 years or less:

$Q_k = 0,40 \text{ kN}$ in both fatigue and static cases.

Where the reduced loadings for a person of 10 years or less are used, the restrictions shall be clearly indicated at the ride and in the manual.

4.3.3.1.2.2 Other vertical loads

The following vertical imposed loads (where q_k is an area load) shall be applied for any area designed for access by foot.

Open to public access:

- | | |
|----------------------------|---|
| $q_k = 3,5 \text{ kN/m}^2$ | for floors, stairways, landings, ramps, entrances, exits and other similar features in rides and facilities; |
| $q_k = 5,0 \text{ kN/m}^2$ | for grandstands and their stairways and landings with fixed seats; and a superior value, if particularly dense crowds are anticipated for the above-mentioned categories; |
| $q_k = 7,5 \text{ kN/m}^2$ | for grandstands and their stairways and landings without seats or non-fixed seats; and a superior value, if particularly dense crowds are anticipated for the above-mentioned categories; |

$q_k = 2,0 \text{ kN/m}^2$	for the revolving or boom area walked on by the public during operation (load and unload); or twice the full passenger load of all passenger units and carriages according to 4.3.3.1.2.1 , whichever is the more unfavourable, in order to make the necessary allowance for change of passengers;
$Q_k = 1,0 \text{ kN/step}$	for stairs; alternatively, an area load as listed above, whichever is the more unfavourable;
$q_k = 1,5 \text{ kN/m}^2$	for seat boards of rows of seats per seat run and for floors between fixed rows of seats, unless higher loads result from the application of area loads ($q_k = 3,5 \text{ kN/m}^2$).

Not open to public access:

$q_k = 1,5 \text{ kN/m}^2$	for all floors, platforms, ramps, staircases, catwalks, stages and other areas which are walked over by individual person, or
$Q_k = 1,5 \text{ kN}$	for individual loads,

whichever is the more unfavourable.

4.3.3.1.2.3 Horizontal imposed loads

The following horizontal imposed loads shall be applied for:

- for raised platforms designed for access by foot, use 10 % of vertical imposed loads as stated in [4.3.3.1.2.2](#);
- barriers, parapets, fences, railings, wall panels, and other similar features.

When bounding floors intended for public access designed for $q_k = 3,5 \text{ kN/m}^2$:

$p_k = 0,5 \text{ kN/m}$	at hand rail height;
$p_k = 0,1 \text{ kN/m}$	at intermediate rail height.

When bounding floors intended for public access designed for $q_k = 5,0 \text{ kN/m}^2$ and $q_k = 7,5 \text{ kN/m}^2$:

$p_k = 1 \text{ kN/m}$	at hand rail height;
$p_k = 0,15 \text{ kN/m}$	at intermediate rail height.

When bounding floors not intended for public access designed for $q_k = 1,50 \text{ kN/m}^2$:

$p_k = 0,30 \text{ kN/m}$	at hand rail height;
$p_k = 0,10 \text{ kN/m}$	at intermediate rail height.

For wall panels where there is no special handrail, the above values shall be applied at handrail height, but, where appropriate, not higher than 1,2 m.

4.3.3.2 Driving forces and braking forces

Driving forces and braking forces shall be calculated for the drive and brake selected (e.g. d.c. motor, three-phase a.c. motor, hydraulic drive), and they shall be used in the calculation. In the case of hydraulic cylinders, the influences arising from start-up and braking shall be kept within manageable limits by suitable design measures, and shall be taken into account in the calculation.

In general, the braking and starting forces, B , shall be calculated according to the actual brake and motor performance (acceleration/deceleration):

$$B = a_b \times (m_v + m_p) \quad (1)$$

where

- a_b is the braking/starting acceleration;
- m_v is the mass of moving parts without passengers;
- m_p is the total mass of passengers according to [4.3.3.1.2.1](#).

In the case of circular movements, the appropriate parameters shall be applied in [Formula \(1\)](#). Care needs to be taken to allow for speed reduction units (e.g. transmissions, gearboxes). An eventual impact factor shall be taken into account (see [4.3.5.2](#)).

In the case of speeds not exceeding 3 m/s, the driving forces and braking forces can be derived with $a_b = 0,7 \text{ m/s}^2$, if a more precise evaluation is not carried out.

Emergency stop (E-Stop) is a static load case.

4.3.3.3 Bracing and restraint loads

Bracing and restraint loads shall be taken into account when designing passenger restraints and containment, handrail or guardrail and bracing devices the passenger unit. All significant situations during the ride cycle including loading, unloading and emergency situations shall be considered. Allowance shall also be made for the forces caused by passengers bracing themselves against restraints and other parts of the containment (e.g. footrests). The magnitudes of maximum bracing forces are dependent upon the detailed design of the containment and as a result of passenger's deliberate actions. However, forces used in any calculations should never be less than 500 N per person.

4.3.3.4 Wind loads

4.3.3.4.1 General

In general, standards for wind actions on buildings and structures shall be chosen in the following sequence:

- a) according to the provisions of this document;
- b) to an official national standard of the country of use of the device, only if superseding local conditions (e.g. wind, seismic) require it.

NOTE Dynamic effects due to wind can occur on flexible structures.

4.3.3.4.2 Wind loads out of service

The wind loads for permanently installed amusement devices shall be taken from the local wind code.

EN 1991-1-4 can be applied.

The wind loads (out of service) for temporarily installed amusement devices may be reduced by applying the following factor on the basic wind speed:

- $c_{\text{prob}} = 0,85$ if the installation period is shorter than three months.

Additional shelter and/or strengthening means may be specified by the designer. In this case, the designer shall provide detailed shelter and/or strengthening procedures and corresponding wind speeds.

4.3.3.4.3 Wind loads in service

The wind loads for permanently installed amusement devices in operating state (in service) shall be taken from the local wind code, considering a basic 10 min wind speed of $v_{b,0} = 15$ m/s and a gust wind speed (3 s gust) of 21 m/s, measured at a height of 10 m.

For temporarily installed rides, [Table 1](#) shall be applied:

Table 1 — Gust wind speeds and pressures for temporarily installed rides

H (height) m	q velocity pressure kN/m ²	V wind speed m/s
0 < 8	0,20	17,89
8 < 20	0,30	21,9
20 < 35	0,35	23,7
35 < 50	0,40	25,3

The wind load area from the imposed load (e.g. the passengers' envelope) shall be taken into account in the calculation.

4.3.3.5 Snow loads

Snow loads shall be applied in accordance with an official national standard of the country or international standards.

Snow loads shall not be taken into account for amusement devices if they are:

- installed in areas where there is no likelihood of snow or operated at a time of the year where the likelihood of snow can be discounted;
- designed and operated so that snow settling on the device is prevented;
- operated while adopting preventative action which stops snow from settling on the device.

This last condition can be achieved if all of the following conditions are met:

- sufficient heating equipment is installed and is ready for use;
- the heating is started prior to snow fall;
- the device is heated in such a way, that the roof cladding has an external surface temperature of not less than +2 °C on all parts.

A reduced snow load of 0,2 kN/m² can be applied for devices on the overall roof area, where a snow depth not exceeding $h = 8$ cm can be ensured at any time by removing snow.

The above restrictions concerning snow loads shall be stated in the device log.

4.3.3.6 Inertia forces (centrifugal forces, gyroscopic forces and Coriolis forces)

Inertia forces shall be determined according to the prevailing circumstances in each case.

4.3.3.7 Intentional collision during operation

The effects of collision loads shall only be taken into consideration in respect of the structural components directly affected and their associated fixings.

Collision shall be assumed to occur at the most unfavourable point of the structural component concerned, and the calculation shall be based on the mass of the fully occupied vehicle, m_{tot} , except

when intentional collision only can occur with empty vehicles. If collision can only occur at angles $\alpha \leq 90^\circ$, the collision force F (in Newtons) shall be assumed to be

$$F = 9,81 \times m_{\text{tot}} \times \sin \alpha \quad (2)$$

where

m_{tot} is the mass of the fully occupied vehicle, in kg;

α is the angle between the vehicle and the structure.

But in any case, the value for the calculation shall be not less than

$$F = 9,81 \times m_{\text{tot}} \times 0,3 \quad (3)$$

Alternatively, a dynamic analysis can be performed.

Where collision is not intended to be part of the ride design or purpose, collision shall be assumed to be an accidental action (see [4.3.6.3](#)).

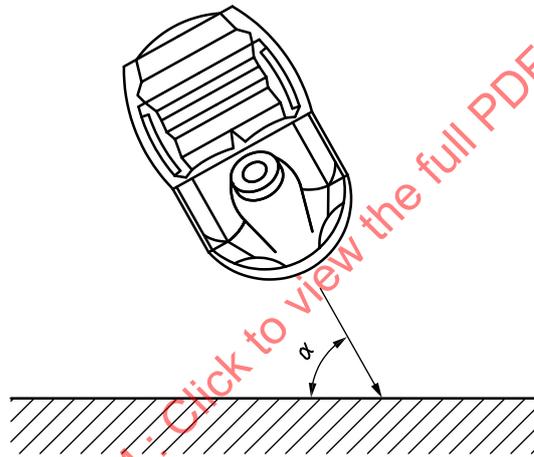


Figure 1 — Angle of collision (α)

4.3.4 Seismic forces

Seismic forces shall only be considered by special requests; they shall not be combined with wind load cases.

The need to consider seismic forces shall be documented in the DRA.

Seismic forces shall be applied in accordance with an official national standard of the country or international standards.

4.3.5 Applicable coefficients

4.3.5.1 General

Moving and/or varying loads induced by track bound passenger units for example, may amplify the stresses of directly loaded structural parts. Therefore, load amplifying factors/coefficients for individual or combined impact and vibrating effects shall be considered.

4.3.5.2 Impacts

If impact forces are likely to arise in the structure or their individual parts during the travel motion (for example from the rail joints or from abrasive wear), then the moving loads under consideration (dead load and imposed load) shall be multiplied by an impact factor of not less than

$$\varphi_1 = 1,2$$

unless the type of structure demands an even higher value. If substantially greater impact forces (e.g. due to rail joints) are ascertained during trial runs on the completed structures, and if these impact forces cannot be reduced to their design value by construction, then the impact factor shall be increased accordingly in a revised calculation.

Forces arising from start-up and braking, e.g. in the case of hydraulic cylinders, are not considered to be impact forces (but normal imposed loads); see also [4.3.3.2](#) in this respect.

4.3.5.3 Vibration of structural track components

In general, as a result of the vibration response of structural track components, e.g. the track of a roller coaster, all resultant stresses shall be multiplied by the vibration coefficient $\varphi_2 = 1,2$.

If proof can be provided, a lower coefficient, $1,0 \leq \varphi_2 \leq 1,2$, may be adopted. The following items may be calculated without taking into account the vibration coefficient:

- supports or suspensions of the structural components directly travelled over;
- ground pressures;
- settling;
- stability and resistance to sliding.

Additional structural measures for certain structures can be required in order to reduce or attenuate inadmissible vibrations (e.g. resonance).

4.3.5.4 Combined impact and vibration factors

One coefficient for combination impact and vibration effects can be used in the special case when both effects do not occur at the same time and location. The internal member forces or stresses of all directly loaded structural parts shall be multiplied by a combined impact-vibration factors of not less

$$\varphi_{1\&2} = 1,2$$

(e.g. rail tracks).

If the impact influence is known to be greater than 1,2, the individual impact factors φ_1 shall be applied with the realistic value.

4.3.6 Load combinations

4.3.6.1 General

The assessment of limit states for amusement devices shall be made using the following combinations and partial safety factors.

4.3.6.2 Fundamental combinations

The design values of the actions shall be combined according to [Formulae \(4\)](#) and [\(5\)](#):

$$\sum \gamma_G G_k = \sum 1,35 \cdot G_k \quad (4)$$

$$\sum \gamma_G G_k + \sum \gamma_Q Q_{k,i} = \sum 1,1 \cdot G_k + \sum 1,35 \cdot Q_{k,i} \quad (5)$$

Both cases shall be checked,

where

- $\gamma_G = 1,35$ is the partial safety factor for permanent actions only (no variable actions);
- $\gamma_G = 1,10$ is the partial safety factor for permanent actions together with one or more variable actions;
- $\gamma_G = 0,90$ is the partial safety factor for favourably acting permanent actions;
- $\gamma_Q = 1,35$ is the partial safety factor for variable actions;
- G_k is the characteristic value of permanent actions;
- $Q_{k,i}$ is the characteristic value of the variable actions.

The permanent actions shall be taken into account with a superior and an inferior value, if the permanent action is variable.

4.3.6.3 Accidental combination

$$1,0 \cdot G_k + A_d + \sum 1,0 \cdot Q_{k,i} \quad (6)$$

where

- $Q_{k,i}$ is the characteristic value of the variable actions;
- A_d is the design value of the accidental actions.

Accidental actions (e.g. seismic forces) only need to be considered by special requests. In such cases, [Formula \(7\)](#) shall be applied.

4.3.7 Fatigue combinations

Each partial stress range contributing to a complete design stress spectrum of the respective individual part to be dimensioned shall be introduced in the verification by a partial safety factor for fatigues actions

$$\gamma_{Ff} \geq 1,00$$

No combination factors shall be applied.

4.4 Structural analysis — Principles

4.4.1 General

The structural analysis shall prove that the limit states shall never be reached due to any individual and combined action given in [4.3](#). The limit states are defined by the design resistances.

It shall be verified that the design value of internal forces or moments does not exceed the corresponding design resistance of the respective part and that the ultimate and serviceability limit states are not exceeded. For tests, see 4.1.5. Special consideration shall be given to the limit state verification regarding deformation and stability for structures, where the deformation limit can be a decisive value. Any favourable effect using the methods of the theory of the 2nd order (non-linear calculation of the system on the deformed system) may be taken into account.

All verifications shall be performed for the most unfavourable loading. In this respect, the permanent, variable and accidental actions, as well as the dynamic (inertia) forces, shall always be assumed to have the position and magnitude which result in the most unfavourable limit states for the structural and mechanical components to be analysed. For structural, mechanical components and items of equipment which are not permanent fixtures, it shall also be ascertained as to whether more unfavourable conditions are likely to arise when such items are displaced or removed.

Non-standard formulae shall be recorded in writing with the symbols. The sources of such formulae shall be stated if these sources are publicly available. In other cases, the derivations of the formulae shall be presented to such an extent that their validity can be verified.

If computer processing for calculation is used, special consideration shall be given to the requirements for the review of computer calculations during the design approval. Clear information concerning for example the software, formulae and units shall be submitted. Input and output data of importance for design shall be printed in their entirety. The review of such calculations shall be performed by independent parallel calculations and/or independent software. The correctness of the assumptions regarding the input and the output data shall be comprehensively reviewed during design approval.

Design resistance, R_d , shall be evaluated according to [Formula \(7\)](#).

$$R_d = \frac{R_k}{\gamma_M} \quad (7)$$

where

- R_k is the characteristic value of the resistance (e.g. material property);
- $\gamma_M = 1,10$ is the partial safety factor of the resistance in static load combinations (e.g. material property);
- γ_{Mf} is the partial safety factor of the resistance in fatigue load combinations (see [Table 5](#), e.g. material property);
- $\gamma_{Ma} = 1,00$ is the partial safety factor of the resistance (e.g. material property) in accidental combinations.

For materials other than steel the values for the available γ_M shall be used.

4.4.2 Analysis principles for various types of devices

4.4.2.1 Conditions for calculating rotating type devices

Amusement rides and devices shall be calculated in operative, inoperative, fully loaded, partially loaded and unbalanced conditions. One-sided loading shall be considered when only seats situated on 1/4 or 3/4 of the perimeter are occupied. The verification of the ultimate limit state shall be carried out for these one-sided loading conditions.

The overturning moment caused by one-sided loading when seats on at least 1/6th of the perimeter are occupied shall not exceed the stability moment in existence at that time, without taking the anchor ties into consideration. For this one-sided loading, the fatigue strength shall be verified. This shall be done also for a one-sided loading on 5/6th of the perimeter. The corresponding sector portions shall be

selected for the most unfavourable case, and the seats situated at the edge of the sector concerned shall be included in the count.

An analogous procedure shall be adopted for multi-seated gondolas in lieu of single seats. If there are 18 or more seats uniformly distributed around the perimeter, a higher one-sided loading may be the determining factor in respect of an adequate safety against overturning in certain cases. In this regard it shall be assumed that the ratio between $M_{Rk,stab}$ (stabilizing moment) and $M_{Ek,dst}$ (overturning destabilizing moment) takes into account the partial safety factors according to [Table 2](#).

If a device is also intended by design to rotate in reverse, then both directions of travel shall be taken into consideration when dimensioning the components of the device.

4.4.2.2 Design and analysis principles for passenger-carrying units

The seats and gondolas shall be sized by taking into account the forces resulting from dead loads, imposed loads and motion. If seats are mounted on pin joints, they shall be arranged in such a way that no constraints can arise.

The fastening of the seats onto outriggers shall also be designed for these forces.

The arm rests, back rests, safety straps, chains, ropes and associated locking devices shall be capable of absorbing the aforementioned forces arising from the passenger load. The structure of seats and gondolas shall be designed and analysed in such a way that the forces arising (e.g. start-up and braking forces, impact forces, out-of-balance forces and forces exerted from the passengers onto restraints and railings) are securely transmitted into the structure and fatigue problems are excluded.

4.4.2.3 Roundabouts with several motions

4.4.2.3.1 General

For roundabouts, in which the moving parts are rotated about several axes in different planes, all the forces which arise shall be determined. This shall be done by considering, as a minimum, the angular velocities, centrifugal forces, Coriolis forces due to the change of direction of one or more of the rotational axes, gyroscopic forces, starting and braking forces and any impact forces which can arise.

4.4.2.3.2 Roundabout with planar motion only

Where the roundabout undergoes planar motion with constant speed rotation about two parallel axes only, the absolute velocities and accelerations (taking into account the relative motions and Coriolis' accelerations) shall be calculated.

4.4.2.3.3 Roundabouts with outriggers running on rail tracks

4.4.2.3.3.1 Roundabouts with arms centrally guided, with internal or external location of drive unit

On such roundabouts, due attention shall be paid to possible constraints and the bending and torsion moments in the arms which arise from the type of attachment of the gondolas or seats. The rails or running track shall be sized in such a way that the deflection due to wheel load does not exceed 1/500 of the span between track supports.

4.4.2.3.3.2 Roundabouts without a central guide

Safety against overturning of the cars shall be ensured by banking of the rails or by safety rollers and the like, or if necessary by both these precautions. In the first step the calculation of the safety against overturning of the substructure with a total partial safety factor of at least $\gamma = 1,0$, the anchorage in the foundation soil shall not be taken into consideration. In order to reach safety against overturning with

partial safety factors in accordance with [4.5.1](#), the anchorage may be taken into consideration in the calculation.

4.4.2.3.3.3 Roundabouts with undulating track

On these installations, the inertial forces arising from the movement in space of the gondolas shall be taken into consideration.

4.4.2.3.3.4 Roundabouts with several rotation gears

On these installations, particular attention shall be paid to the effects of the Coriolis and Gyration forces on the structure.

In the case of rotary motions which are not positively actuated (i.e. either free spinning or passenger actuated or both), the effects of the individual rotation of the individual rotation gears shall be investigated. For boom type roundabouts (e.g. round-ups, twisters, hully-gullies), where gondolas can rise, the effects of the forces arising during vertical movement, starting up and braking, shall be taken into account, with due consideration for any unfavourable effects of impact forces and centrifugal forces.

In this context, the effects of the above-mentioned forces on each outrigger, on the complete roundabout and on the safety against overturning of the roundabout shall be investigated for the most unfavourable position in each case under static load combinations. The general out of balance load assumptions of [4.3.3](#) shall be considered. Fatigue calculations in accordance with [4.7.3](#) shall be carried out.

The telescopic jacks shall be supported without constraint and shall be sized adequately to withstand buckling.

The same applies, if appropriate, for lift roundabouts. Unavoidable accelerations on the telescopic jack at the beginning and at the end of a lifting stroke shall be taken into consideration by making a suitable allowance for increased loading when the roundabout components are being sized, unless these accelerations are attenuated with damping elements.

If the pressure lines of the lifting cylinders fail, the lowering speed shall not exceed twice the normal operational lowering speed and in any case no more than 1,0 m/s. The requirements of [5.3.2.7](#) shall be applied.

4.4.2.4 Roller coasters with rail track-bound vehicles

4.4.2.4.1 General (dynamics)

The longitudinal gradient of the rail shall be limited in such a way that the resultant force at angles perpendicular to it does not fall below 0,2 g. This value also applies for the passenger unit with the highest speed in the case of trains. If the resultant force falls below the above value, the passengers shall be secured against lift-off in accordance with [5.1.7.2.2](#).

The maximum transverse inclination of the rail, at the spots at which the car is likely to come to a full stop for operational reasons (e.g. at safety brakes), shall be limited to a maximum value of 25° unless the design of the passenger containment system and the biomechanical effects analysis allow for a higher value. The path of the rail track shall be designed in such a way, that the instantaneous theoretical step in acceleration is limited to 2 g. This is related to the centre of mass and does not exclude the necessity for other calculations to be made for accelerations on passengers' bodies. The velocity, accelerations and forces can be determined for the centre of mass. The overall centre of mass may be used where there are multiple coupled cars.

A simulation of the motion over the time shall be carried out in order to determine speed, accelerations and forces.

Because the friction coefficients are subject to considerable variations in magnitude as a result of the running in time, the design, the surface finish of the rail and the weather, it is necessary to carry out a measurement of the actual velocity and accelerations. The data of the measurement shall be in the limit of design.

To determine the individual wheel forces, additional calculations are necessary.

For high speed track having tight loops or helices, the need for rigid body dynamics shall be considered.

4.4.2.4.2 Supporting framework

Effects of settlement shall not be taken into account for fatigue calculations.

For exposed support columns without cladding anchored by the continuous rail in the overall structure, the assessment of the wind load may be ignored for the verification of the stability and of the safety against sliding.

The safety of the installation against overturning, when it is subjected to wind load need not be verified as a general rule, unless exceptionally large horizontal forces are likely to arise, as a result of a particularly unfavourable shape, exceptionally large wind load areas of the framework components (decorations, lighting strips), or as a result of partial or total cladding of the framework or track.

4.4.2.4.3 Passenger units

All forces arising in the chassis and superstructures shall be followed in the calculation from their point of origin, down to the supports. Thus, for example, in the case of passenger units with one oscillating and one rigid axle, the moments from forces transverse to the car above the oscillating axle, can only be absorbed by the rigid axle.

Forces transverse to the car, for example, can only be transmitted through wheels which run against the side of the rail.

If the load wheels are not designed in such a way that they are also capable of absorbing lateral forces, then special guide rollers shall be provided for this purpose.

The vehicles shall be equipped with devices for the prevention of derailment and lift-off. Safety devices against lift-off (rollers or claws) shall in any case be calculated for the actual forces acting on them. As a minimum they shall be sized for 50 % of the fully loaded vehicle weight, even when there is no lift-off.

4.4.2.4.4 Brakes

Each stopping or speed regulation brake (at the end of a descent, stopping after each journey) shall be designed in such a way that the braking deceleration does not exceed a maximum value of 5,0 m/s². Greater deceleration is permitted on condition that special devices for the protection (e.g., lap bars) of the passenger are provided; see [5.1.7.2](#).

Safety brakes shall be arranged for the planned minimum distance between successive cars or trains in such a way that there will always be sufficient braking elements between any two cars or trains to prevent collision.

Each safety brake shall be designed in such a way that the braking deceleration does not exceed a maximum value of 7,0 m/s², unless a greater deceleration is permitted in which case special devices for the protection (e.g., lap bars) of the passenger shall be provided; see [5.1.7.2](#).

Fatigue need not be considered for safety brakes, which are only operated in emergency cases. The maximum deceleration shall be assessed by using the highest attainable friction coefficient for the selected brake surface materials with the minimum load.

With regard to the sizing of the effective deceleration length, it shall be assumed that the car is still able to come to a full stop, when applying a safety factor of 1,2 (related to the friction coefficient), to

the minimum friction coefficient experienced due to weather influences, wear, maximum speed and load. The limiting values shall be checked on the finished installation. During such tests the minimum friction and maximum speed shall be produced as far as possible using wet rails, wet brake elements and wet fins.

Speed regulation brakes shall be calculated by using fatigue load cases.

4.4.2.4.5 Anti-rollback devices

Installations, on which the cars or trains are conveyed on the ascent ramp by means of chains, ropes, friction wheels or by self-propulsion, shall be provided with either safety devices to prevent running back, or with automatically acting brakes to prevent running back.

When several cars or trains are planned to be at the same time on the section of track situated between the end of the lift or ascent ramp and the station, or the brake situated before the station, then safety devices to prevent running back shall also be fitted in the uphill sections of the track after the valleys.

However, if a passenger unit or train is intended to be able to travel backwards along the track and through the station then safety devices against running back can be omitted from the ascent ramps.

When several cars or trains are on the track, safety devices against running back on the uphill sections may be dispensed with, on condition that the individual track sections are safeguarded by a fail safe block-zone system, with automatically controlled brakes.

When it is intended by design that only one single car or one single train be on the track one at a time, safety devices against running back can be omitted from the uphill stretches after the valleys or when the car is intended to roll backwards.

The fatigue strength need not be verified for the anti-rollback devices. If the car is stopped by the anti-rollback device with a sudden impact, an impact factor shall be assumed for dimensioning purposes. This value shall be at least one half of the vertical maximum running back height [h in centimetres (cm)], if no exact verification is carried out, and in any case shall not to be less than 2,0. A load of $\varphi \times Q$ shall be assumed for dimensioning purposes where Q is defined as the dead load of the car plus the live load of passengers (fully loaded roller coaster car).

$$\varphi \geq 0,5 \times h$$

$$2,0 \leq \varphi$$

The two conditions above shall be satisfied.

If the deflection is known or can be determined reliably, the [Formula \(8\)](#) shall be applied:

$$\varphi \geq 1 + \sqrt{1 + \frac{2h}{\delta_0 \sin \alpha}} \quad (8)$$

where

δ_0 is the total deflection of the centre of mass along the slope;

α is the slope angle (see [Figure 1](#));

h is the height (see [Figure 1](#)).

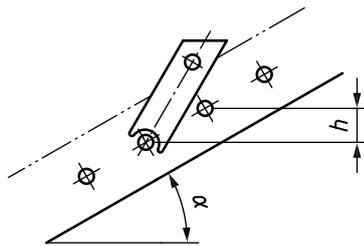


Figure 2 — Impact factor/running back elevation

Measured data and/or dynamic analysis can also be used to determine impact forces.

4.4.3 Other railways with track-bound vehicles

4.4.4 Conventional railways

Conventional railways are, for example, children's railways, children's traffic gardens, ghost railways and similar installations, with both conventional and suspended vehicles.

The requirements outlined in [4.4.3](#) shall apply for dimensioning and for the operating safety, as far as applicable.

If track girders and supports form an integral part of the roofing structure, fatigue loading due to oscillating loads shall be taken into account during the design.

Ghost railways which have more than one level shall have anti-rollback devices in the rising sections. In all inclined sections, the necessary brake device to control velocity and de-railing shall be provided.

4.4.5 Suspended railways (or coasters)

An analysis of the dynamic behaviour of track-bound rides having suspended cars with one (or more) degree(s) of freedom to swing or rotate, shall be conducted.

For suspended railways, free spaces of an order of magnitude of the calculated swinging motion, with an added safety margin, shall be provided both to the excursion side and to the opposite side, in addition to the clearance for rail track-bound vehicles specified in [5.1.7.1](#).

The added safety margin shall be not less than 20 % of the calculated angle of swing, with a minimum value of 10°. The oscillation behaviour shall be taken into consideration when calculating the angle of swing. The accelerations arising from the oscillatory motion of the gondola shall be taken into account in the calculations for the vehicle, the rail and the supports.

If the lateral oscillations of pendulum gondolas are damped, and if the clearance is inadequate for an undamped oscillation, pendulum movement limitations shall be provided. This pendulum movement limitation may be provided by suitably designed and documented redundant dampers.

At the beginning of route sections in which pendulum gondolas are guided (e.g. in the region of passenger transfers) guides shall be provided, which are capable of grasping the gondolas at least twice the value of the calculated angle of swing, and of guiding them in as smoothly as possible while taking into consideration the travelling speed.

The DRA shall determine the method, if required, of locking pendulum gondolas for the purpose of passenger transfers (e.g. suitable dampers).

4.5 Verification of stability

4.5.1 General

Proof shall be provided of safety against overturning (see 4.5.2), sliding (see 4.5.3) and lifting (see 4.5.4) of amusement devices and their components. Favourably acting imposed loads and dead loads of components and accessories which are not always present shall not be taken into account, when providing proof of safety against overturning, sliding and lifting. Only the lowest value of continuously acting favourable influences including material variations (e.g. G_{sup} , G_{inf}) shall be taken into account.

For foundations, official available data shall be applied to the prevailing rules of 4.5.1. A frost-free foundation for amusement devices is only required in cases where lifting or lowering/settling due to frost can lead to damage or failure.

Only the lowest value of continuously acting favourable influences shall be taken into account.

If an adequate degree of safety cannot be achieved by virtue of the dead load of a structure alone, then further additional steps shall be taken to ensure it, such as counterweights, anchors and buttresses.

As the weight of amusement devices can be determined and verified accurately, the safety factors can be determined more precisely as defined in Table 2).

Table 2 — Safety factor against overturning, sliding and lifting

Loading ^a		γ
1	Favourably acting proportions of the dead load	1,0
2	Unfavourably acting proportions of the dead load	1,1
3	Unfavourably acting wind loads	1,2 ^b
4	Accidental combinations	1,0
5	Unfavourably acting proportions of loads other than the loads listed in items 2, 3 and 4.	1,3

^a If loads are resolved into components, then these components shall be multiplied by the same value of γ .

^b For devices higher than 20 m, $\gamma = 1,2$ shall be replaced by $\gamma = 1,2 + 0,3 \times (h - 20)/40$ where h is the total height of device in metres. For devices higher than 60 m $\gamma = 1,5$ shall be used as a minimum.

4.5.2 Overturning

The safety against overturning shall be calculated using Formula (9):

$$\sum \gamma M_{Rk, stb} \geq \sum \gamma M_{Ek, dst} \quad (9)$$

where

γ are the partial safety factors in accordance with Table 2;

$M_{Rk, stb}$ are the stabilizing moment proportions;

$M_{Ek, dst}$ are the overturning destabilizing moment proportions.

Care shall be taken to ensure that the loads entered in the calculation can be accommodated by the shear stiffness of the structure.

4.5.3 Sliding

The safety against sliding shall be calculated using Formula (10):

$$\mu \cdot \sum \gamma N_k \geq \sum \gamma H_k \quad (10)$$

where

- γ are the partial safety factors in accordance with [Table 2](#);
- N_k are the vertical load components;
- H_k are the horizontal load components;
- μ is the coefficient of friction in accordance with [Table 3](#).

The coefficients of friction in [Table 3](#) may be assumed for the determination of the frictional forces, unless higher values determined by tests are available in individual cases, or unless the effect of moisture requires the adoption of lower values.

Table 3 — Coefficient of friction μ

	Wood	Steel	Concrete
Wood	0,40	0,40	0,60
Steel	0,40	0,10	0,20
Concrete	0,60	0,20	0,50
Clay ^a	0,25	0,20	0,25
Loam ^a	0,40	0,20	0,40
Sand and gravel	0,65	0,20	0,65

^a Of consistency of stiffness at least in accordance with ISO 14688-2.

It shall be taken into consideration that loosening by vibration can occur in the case of supports subject to vibrating stress.

If stability is not obtained by static friction alone, then the structure shall be anchored in the ground. In such cases, the safety against sliding shall be calculated in conjunction with the action of soil anchors. Under these conditions, the coefficients of friction in accordance with [Table 2](#) shall only be entered in the calculation at 70 % of the listed values.

$$\bar{\mu} \cdot \sum \gamma N_k + Z_{h,d} \geq \sum \gamma H_k \tag{11}$$

where

- $\bar{\mu} = 0,7\mu$ and μ is the coefficient of friction in accordance with [Table 3](#);
- $Z_{h,d}$ is the horizontal design load bearing capacity of the anchor (see [4.6](#)).

4.5.4 Lifting

The safety against lifting shall be calculated using [Formula \(12\)](#):

$$\sum \gamma N_{Rk,stab} \geq \sum \gamma N_{Ek,dst} \tag{12}$$

where

- γ is the partial safety factor in accordance with [Table 2](#);
- $N_{Rk,stab}$ are the vertical stabilizing load components;
- $N_{Ek,dst}$ are the vertical lifting destabilising load components.

With anchor ties, the following relationship shall be applied:

$$\sum \gamma N_{Rk,stab} + Z_{v,d} \geq \sum \gamma N_{Ed,dst} \quad (13)$$

where $Z_{v,d}$ is the vertical design load bearing capacity of the anchor (see 4.6).

4.6 Ground anchorages

4.6.1 General

Varying soil conditions and the type of loading require the following experimentally assessed values for anchor ties to be applied, which already include inherent partial safety factors. The following calculation principles shall be used. [Subclause 4.6](#) is applicable and restricted to:

- weight anchors, e.g. ballast bodies placed on the surface of the ground or buried;
- rod anchors, e.g. metal rods fitted with eyelets or with an upset head, not permitted in long-term installations.

Concerning special anchors such as wing anchors, folding anchors, screw anchors and sectional steel anchors, the determination of their load bearing capacities requires loading tests.

Where rod anchors shorter than 80 cm are used for subordinate devices and are required from the results of a calculation, loading tests or other acceptable evidence shall be provided.

4.6.2 Design load bearing capacity of weight anchors

When calculating the design load bearing capacity of fully or partially buried anchors, the passive earth pressure shall only be taken into account on the condition that the anchor is capable of performing small displacements and rotations without any danger to the structure, and that the foundation soil characteristics are known sufficiently.

4.6.3 Design load bearing capacity of rod anchors

The design load bearing capacity of simple rod anchors with a circular cross section and with a minimum driving-in depth of 80 cm shall be determined in accordance with the empirical formulae given in [Table 4](#).

Table 4 — Design load bearing capacity of anchors Z_{Rd}

Angle of acting tensile force to the vertical β	Design load bearing capacity of rod anchors Z_{Rd} N
$\beta = 0^\circ$	$Z_{Rd} \hat{=} f_{load} \cdot dl' = 6,5dl'$ for stiff cohesive and for dense cohesionless soils
$\beta = 0^\circ$	$Z_{Rd} \hat{=} f_{load} \cdot dl' = 8,0dl'$ for very stiff cohesive soils
$\beta \geq 45^\circ$	$Z_{Rd} \hat{=} f_{load} \cdot dl' = 10,0dl'$ for cohesive soils of at least medium to stiff consistency
$\beta \geq 45^\circ$	$Z_{Rd} \hat{=} f_{load} \cdot dl' = 17,0dl'$ for dense cohesionless soils
$0^\circ < \beta < 45^\circ$	The load bearing capacity for the soil types shall be determined by interpolation (see Figure 3 and Figure 4).

The symbols used in [Table 4](#), [Formula \(14\)](#) and [Formula \(15\)](#) and [Figure 2](#) and [Figure 3](#) are:

- $Z_{Rd} = Z_u / \gamma_M$ is the design load bearing capacity of the anchor, in N (Newtons);
- Z_u is the lowest value of the test due to [4.6.4](#);
- $\gamma_M = 1,5$ is the partial safety factor for a material property, also accounting for model uncertainties and dimensional variations;
- $Z_{h,Rd}$ is the horizontal design load bearing capacity of anchor, in N;
- $Z_{v,Rd}$ is the vertical design load bearing capacity of anchor, in N;
- d is the anchor diameter, in cm;
- l' is the depth of penetration (minimum length 80 cm);
- α is the angle of penetration;
- β is the angle of acting tensile force to the vertical;
- f_{load} is the factor for determining the load bearing capacity of rod anchors.

The formulae in [Table 4](#) are only valid on the condition that the anchor will “pull” when driven in. For $\beta = 0^\circ$ the friction shall be effective along the entire length of the rod; for $\beta \geq 45^\circ$, the angle of penetration α shall be 90° . At this driving-in angle, the obliquely loaded anchor will reach its maximum design load bearing capacity. In order to prevent any bending of anchors subjected to shear loading, the following minimum diameter shall be respected, for simple round steel rod anchors:

$$d_{min} = 0,025l' + 0,5 \tag{14}$$

with l' in cm.

The point of application of the force on rod anchors subjected to bending stress shall be situated either as close to the ground surface as possible, or beneath it.

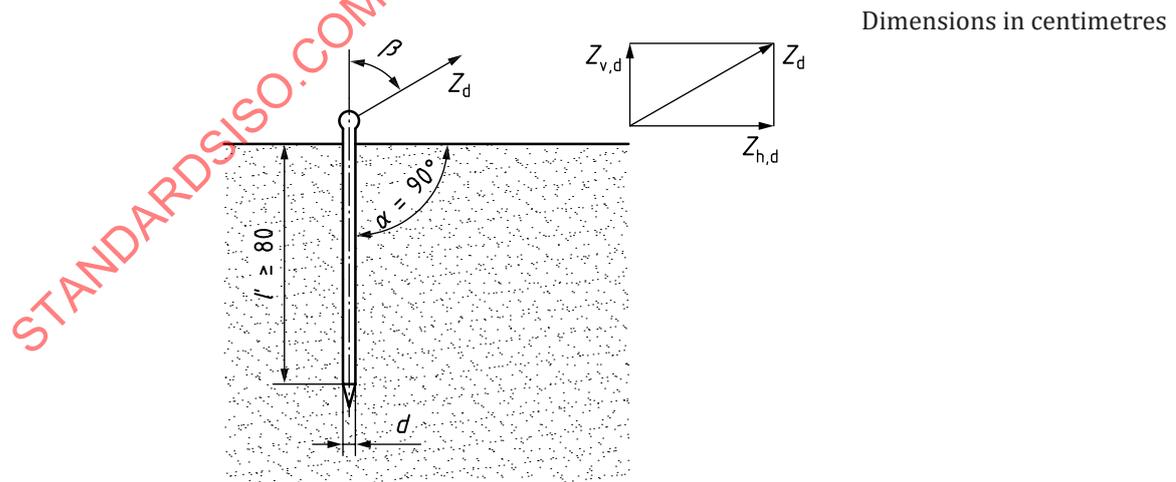
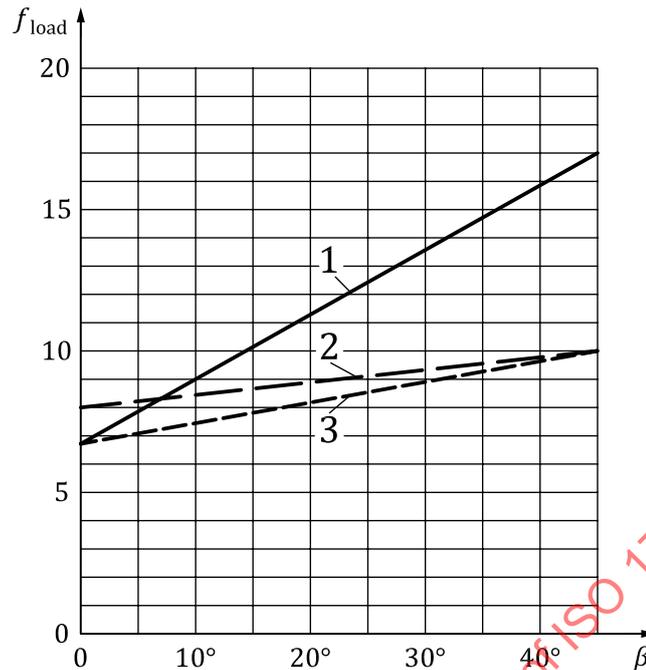


Figure 3 — Rod anchor

**Key**

- 1 dense cohesionless soils
- 2 very stiff cohesive soils
- 3 stiff cohesive soils

Figure 4 — Factors for determining the load bearing capacity of rod anchors

4.6.4 Testing of anchors (numbering)

The calculated design load bearing capacities may be exceeded, if this can be substantiated by loading tests, or if experimental data relating to the installation site are available. When test loading an anchor, at least three tests shall be carried out. A safety factor of $\gamma = 1,5$ shall be applied to the lowest test value (Z_u) in order to determine the design capacity (Z_{Rd}) in subsequent calculation. The design load bearing capacity determined in this manner shall not result in anchor movement which can result in stresses, deformations or instability which cannot be accommodated by the structure.

If the foundation conditions are comparable, loading tests carried out in another location may be adopted for substantiation purposes.

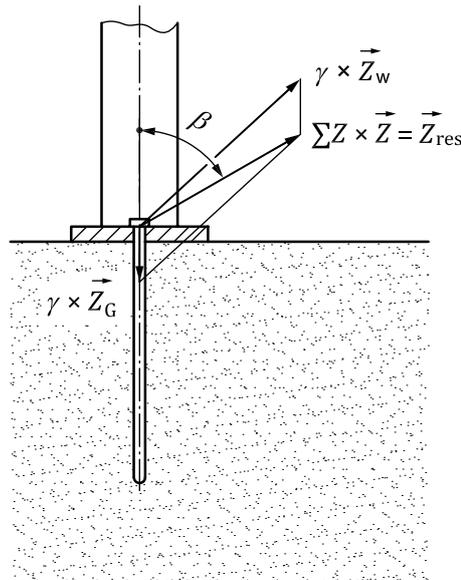
The safety factors featured in [Table 2](#) shall be taken into consideration when determining the permissible load.

4.6.5 Calculation of loads on anchors

The resulting load Z_{res} acting on the anchorage shall be determined by vector summation, taking into account the partial safety factors as shown in [Table 2](#). This load Z_{res} shall be less than the permissible loading of the anchorage according to [4.6.3](#):

$$Z_{res} \sum \gamma Z \leq Z_{Rd} \quad (15)$$

See also [Figure 5](#).



Key

- Z_G favourably acting resultant of permanent actions;
- Z_W unfavourably acting portion of variable actions;
- γ safety factor in accordance with [Table 2](#);
- β angle of acting tensile force to the vertical.

Figure 5 — Anchor loading

4.6.6 Further requirements

When displacements in excess of 2 cm occur on loaded rod anchors or similar devices, the load bearing capacity of the anchor is no longer fully ensured. An increase of the resistance against pull-out failure can be achieved either by means of additional anchors or by driving in wooden wedges. In the case of pure tensile stress in the direction of the axis of the rod anchor, the danger of a complete failure of the anchor arises when very small movements occur.

The foot of the anchor (pointed tip) shall not exhibit any widening of the cross section in the case of rod anchors, so as to prevent any reduction of the skin friction in the zone of the anchor shank.

After the driving in of a rod anchor, the soil on the surface shall be tamped against the anchor, as far as practicable, in order to prevent the infiltration of surface water.

If groups of anchors are used, each individual anchor may only be assessed in the calculation at its full, calculated load bearing capacity on the condition that the spacing between adjoining anchors amounts to not less than five times the anchor diameter. Dynamic loads can lead to the loosening of an anchorage, consequently, repeated checks of the anchors are essential. For groups of anchors consisting of more than six anchors, the load bearing capacity of such groups of anchors has to be verified by calculation. Without further verification, an angle of excavation of 45° starting from the outer anchor can be assumed for this calculation.

4.6.7 Ground support for packing

Only small contact stresses are permitted for packing, because of the lack of embedding in the soil and also because of the relatively small bearing widths used in practice. Packing is subject to sink into the soil and cause considerable settlements. Packing shall be kept under observation when placed on particularly yielding soils. In the event of yielding or loosening, an underlay shall be provided and the bearing surfaces shall be enlarged as necessary.

For a foundation soil with a low load bearing capacity, additional measures shall be adopted. If several elements are laid side by side without any gaps in order to increase the bearing widths, an interconnection shall be created, e.g. by cross-stacking.

For a foundation soil which can be travelled over (e.g. by trucks), the following design soil pressures can be used in the calculation for square and rectangular packing with dimensions:

$$1 \leq l/b \leq 3$$

where

l is the length of packing in the ground contact zone;

b is the width of packing in the ground contact zone;

$b = 20 \text{ cm}$: $P = 100 \text{ kN/m}^2$;

$b = 30 \text{ cm}$: $P = 150 \text{ kN/m}^2$;

$b \geq 40 \text{ cm}$: $P = 200 \text{ kN/m}^2$;

p is the design value of the allowable soil pressure (resistance).

Interpolation should be conducted for intermediate values.

For installation on strengthened (consolidated) locations, higher design soil pressures can be considered.

NOTE When using the design soil pressure value, all the partial load factors are set to $\gamma_M = 1,0$ and $\gamma_f = 1,0$.

4.7 Verification of strength

4.7.1 General

A distinction shall be made between predominantly static stress and predominantly fluctuating stress. Fluctuating stress occurs both in the form of pulsating stress (stress which fluctuates within two limiting values without any change of sign,) and in the form of alternating stress (stress which fluctuates between two limiting values and changes its sign). For both situations, the stress range $\Delta\sigma = \max \sigma - \min \sigma$ is significant for the calculation.

Fatigue calculation of welded structural items shall be performed based on the stress range $\Delta\sigma$ concept. If the minimum life time requirements in [4.7.3.1.4](#) are applied and a partial safety factor according to [Table 5](#) at 95 % survival probability or equivalent is maintained, EN 1993-1-9, EN 13001-3-1+A2 or other equivalent standards can be used.

The resistance of notch details shall be determined as statistical value with 95 % of survival probability and confidence interval of 75 %.

The resistance of welded notch details may be improved (only weld transitions) by post-weld treatment (e.g. TIG dressing, hammer peening or grinding).

The minimum life time requirements in [4.7.3.1.4](#) with at least the partial safety factors of [Table 5](#) shall be considered.

Structures subjected to fluctuating stress which are likely to be exposed to more than $n = 10^4$ stress cycles during their expected service life, shall be dimensioned by calculation of fatigue strength.

NOTE Recognized state of art literature such as the Forschung Kuratorium MaschinBau Analytical strength assessment of components in mechanical engineering (FKM) guideline can be used.

4.7.2 Predominantly static stress

Permissible stresses of materials used for structural components shall be taken from 4.2.

With regard to general stress analysis of machinery components made of steel, including components which act simultaneously as structural components, [Formulae \(16\)](#) and [\(17\)](#) shall apply:

$$R_d \leq \frac{R_{eH}}{\gamma_{M0}} \tag{16}$$

and

$$R_d \leq \frac{R_m}{\gamma_{M2}} \tag{17}$$

where

- R_d is the design material resistance;
- R_{eH} is the yield strength;
- R_m is the ultimate strength;
- $\gamma_{M0} = 1,1$ is the partial safety factor for elastic strength resistance (yield);
- $\gamma_{M2} = 1,5$ is the partial safety factor for ultimate strength resistance when $R_{eH}/R_m < 0,75$;
- $\gamma_{M2} = 2,0$ is the partial safety factor for ultimate strength resistance when $R_{eH}/R_m > 0,75$.

The smaller of the two R_d values above shall be used.

4.7.3 Fluctuating stress

4.7.3.1 Fatigue assessment of structural components

4.7.3.1.1 General

An assessment of fatigue life as a result of repeated fluctuation of stress shall be carried out.

4.7.3.1.2 Partial safety factors for fatigue where EN 1993-1-9 is specified

For fatigue loads, a partial safety factor shall be applied:

$$\gamma_{Ff} = 1,0$$

The following values for the partial safety factors for steel shall be applied:

Table 5 — Partial safety factor for fatigue resistance in stress range concept

Examination and access	Rupture will not affect collapse	Rupture will affect collapse
Structural part accessible during regular thorough examination	$\gamma_{Mf} = 1,0$	$\gamma_{Mf} = 1,1$
Structural part not accessible during regular thorough examination	$\gamma_{Mf} = 1,05$	$\gamma_{Mf} = 1,15$

4.7.3.1.3 Fatigue loads

When calculating $\Delta\sigma$ or $\Delta\tau$, the influence of dead loads which do not change in position, the components of variable actions which do not vary in time and position, snow loads, temperature loads, loads due to assembly and wind loads (without induced oscillation) need not be considered.

In the case where wind loads induce oscillation, the wind pressure can be set to 50 % of the in-service-wind loads (4.3.3.4.3), if there is no other calculated critical value of the wind pressure due to the wind speed, at the natural frequency. An investigation of wind induced oscillation shall be performed to evaluate additional fatigue loads.

When calculating $\Delta\sigma$ or $\Delta\tau$, the following actions shall be taken into account as a minimum:

- a) dead loads with change of position;
- b) moving imposed loads;
- c) driving and braking forces according to 4.3.3.2;
- d) load coefficients for impact and vibrations of parts directly travelled over;
- e) intentional collision forces;
- f) inertia forces;
- g) centrifugal and Coriolis force;
- h) gyroscopic effect.

Where there is movement of dead loads, when assessing $\Delta\sigma$ or $\Delta\tau$ (e.g. for lifted booms), the maximum and minimum stresses shall be calculated including dead loads according to [Formulae \(18\)](#) and [\(19\)](#):

$$\Delta\sigma = \sigma_{\max} - \sigma_{\min} \quad (18)$$

$$\Delta\tau = \tau_{\max} - \tau_{\min} \quad (19)$$

For amusement devices with a similar periodic loading, such as roller coasters tracks, roundabouts, ferris wheels, the amplitude stress $\Delta\sigma$ can be assumed as equivalent constant amplitude stress $\Delta\sigma_E$ according to EN 1993-1-9.

If unbalanced load conditions have to be considered the stress range due to 1/6 and 5/6 one-sided load according to [4.4.2.1](#) shall be assumed for 100 % of fatigue life.

NOTE E.g. rotational rides, Ferris wheels and carousels.

4.7.3.1.4 Number of load cycles

The fatigue assessment of load bearing parts shall consider the following number of load cycles, if no more precise calculation about load cycles and life time can be provided.

- a) Fatigue limit at 35 000 h: At least 35 000 operating hours shall be assumed in the fatigue calculation of amusement devices not including loading and unloading time. The number of load cycles shall be determined for each specific amusement device and its components.
- b) Endurance limit: Safety-related components shall be designed for endurance limit. In this context, the stress range $\Delta\sigma_D$ is understood to be the constant amplitude fatigue limit. When no stress range is higher than $\Delta\sigma_D$ for the respective detail category, infinite fatigue life can be assumed. If no detail calculation of the load cycles will be provided endurance limit life calculation shall be used.
- c) Standard products: Mass-produced replaceable safety-related machinery components used as structural parts (e.g. bearings and slewing rings) for which company standards are available, are

excluded. These shall be dimensioned for at least 5 000 operating hours. The replacement frequency of components shall be based on the calculated lifetime in hours or number of cycles. A theoretical lifetime calculation shall be submitted. Any safety related standard product item with a wear limit of less than 5 000 operating hours shall be mentioned in the manual.

4.7.3.2 Fatigue assessment of machine component (welded and non-welded)

Machine components are, for example, axles, pins, shafts, wheel bogies, coupling bars and restraint bars.

Assessment of welded parts may also follow the procedure given in [4.7.3.1](#) or international standards or guidelines, e.g. FKM or FEM 1.001 (Fédération Européenne de la Manutention).

Fatigue assessment is requested for parts with more than 10 000 load cycles.

Vehicles and trains for track-bound amusement devices shall be analysed by using the full, imposed load for the complete fatigue life.

4.7.3.2.1 Fatigue resistance

The fatigue resistance shall take into account:

- a) material strength;
- b) construction parameters;
- c) size effects;
- d) shape effects;
- e) corrosion influence;
- f) surface influence;
- g) alternate strength;
- h) endurance limit strength;
- i) service strength.

The strength values shall consider notch case and stress ratio.

4.7.3.2.2 Fatigue stress

Nominal stress or structural stress shall be used for fatigue assessment. Stresses shall be determined in accordance with the general principles of stress analysis.

Nominal stress method can be used for beam like systems. Nominal stresses σ , τ shall be investigated.

Structural stress methods and notch stress methods based on finite element analysis are possible for shell or volume investigations. Minimum and maximum principal stresses may require investigation.

4.7.3.2.3 Partial safety factor

The partial safety factor depends on the standard or guideline used.

4.7.4 Bolts

Bolts conforming to ISO 898-1, ISO 4014, ISO 4016, ISO 4017 or ISO 4018, nuts conforming to ISO 4032 and bolt and nut assemblies to EN 14399 (all parts), assigned to property classes 4.6, 5.6, 8.8 and 10.9 shall be used.

The calculation of limit states shall be made in accordance with EN 1993-1-1.

Where EN 1993-1-1 is not applied, the following shall be used for bolts assigned to the property grades referred to in [Table 6](#) and [Table 7](#).

- Bolted connections with bolts subject to vibrating forces normal to the axis of the bolt shall provide means to inhibit transverse displacements of the connecting parts either by the provision of shear keys, pins, cotter pins, bushes or by using tight-fit bolts or by providing a friction-type connection considering a friction coefficient of $2/3 \min. \mu$.
- The value to be adopted for $\min. \mu$ shall be the lowest coefficient of friction, which can occur in operation under the most unfavourable conditions.
- In the case of single-shear joints, the eccentricity shall be taken into consideration.
- Permissible shear strengths in accordance with [Table 6](#).
- Permissible calculated pressure on the face of the bolt hole for shear bearing pressure joints in accordance with EN 1993 (all parts) (or in absence of this with equivalent national standards) for non-prestressed bolts.
- Permissible additional transmissible tensile force in the direction of the bolt axis per prestressed bolt or fitted bolt in accordance with [Table 7](#); with F_v in accordance with [Table 6](#); a partial safety factor of $\gamma_G = \gamma_Q = \gamma_{F,f} = 1,0$ can be applied.
- Permissible pre-stressing force and tightening torques in accordance with [Table 6](#).

Bolts in connections designed for transport or dismantling may be used again on the condition that they have not been stressed beyond the yield point.

The torque values shall be confirmed by the bolt manufacturer or the supplier.

For detachable joints of structural devices other bolts with the same material properties may be used.

Table 6 — Design shear stress τ_m for a predominantly static stress per bolt, and for a shearing area perpendicular to the axis of the bolt

Property class	8.8	10.9
Design shear stress, τ_m , N/mm ²	300	360

Table 7 — Pre-stressing forces and tightening torques for bolts — ISO 4014, ISO 4017, ISO 4032, and EN 14399-3, EN 14399-4, EN 14399-6

Thread size	Pre-stressing force F_v (kN) for property class		Tightening torque M_a (Nm) for property class		Tightening torque M_a (Nm) for property class	
			Bolting assemblies according to EN 14399-3, EN 14399-4 and EN 14399-6		Bolts according to ISO 4014, ISO 4017 and ISO 4032	
			Surface condition: hot galvanised and MoS2 lubricated nut or as built and MoS2 lubricated nut $\mu = 0,10$		Slightly oiled $\mu = 0,14$ (as built)	
	8.8	10.9	8.8	10.9	8.8	10.9
M 12 ^a	35	50	70	100	80	120
M 16 ^a	70	100	170	250	210	300
M 20 ^a	110	160	300	450	410	590
M 22 ^a	130	190	450	650	520	760
M 24 ^a	150	220	600	800	660	970
M 27 ^a	200	290	900	1 250	1 000	1 450
M 30 ^a	245	350	1 200	1 650	1 370	1 950
M 36 ^a	355	510	2 100	2 800	2 350	3 380
M 42 ^b		710		4 500		
M 48 ^b		930		6 500		
M 56 ^b		1 280		10 000 ^a		
M 64 ^b		1 680		15 000 ^a		

^a Values are taken from EN 1993-1-8:2005.
^b See References [12], [21] and [24].

In general, the resistance forces of bolts according to Table 7 shall be determined according to EN 1993-1-8 and the fatigue resistance should consider the fluctuating stress in the pre-stressed connection. Bolt resistances of a pre-stressed connection can be determined according to Table 8, if sufficient compression body can be established.

Table 8 — Simplified definition of bolt resistances

Predominantly static stress	Vibrating stress
$N_{R,d} = 0,8 F_v$	$N_{R,FAT} = 0,6 F_v$

4.7.5 Ropes, chains, safety devices, connectors and adapters

4.7.5.1 Ropes, chains, belts and straps

4.7.5.1.1 Partial safety factor calculation

The partial safety factor will depend on the intended application. The relationship as given in Formula (20) shall apply:

$$Z_{Rd} \geq \gamma Z_k \tag{20}$$

where

- Z_{Rd} is the minimum load at fracture;
- Z_k is the maximum characteristic load;
- γ is the partial safety factor.

It is possible that other limit states may also need to be checked.

Wire rope with diameters smaller than 4 mm shall be avoided for amusement devices. Rope clamps shall not be used for fastenings onto drive mechanisms or impact loaded safety devices.

4.7.5.1.2 Ropes and chains under fluctuating loads (suspension of passenger-carrying devices e.g. chairs, gondolas)

For steel chains, a partial safety factor of $\gamma = 6$ shall be used.

For steel wire ropes the values for permissible stresses are given in [Table 9](#). Extrapolation of the permissible stress values in [Table 9](#) for higher nominal strength categories is not allowed. If individual wires with a nominal strength category exceeding 1 570 MPa are used, the permissible stress shall be assessed independently.

For other materials than steel, special investigation shall be required.

This does not apply however to safety equipment in accordance with [4.7.5.2](#).

Table 9 — Design stress for wire ropes for suspension of structural components made from individual wires of 1 570 MPa nominal strength category, for the purpose of verification of fatigue strength

Diameter of wire rope d mm	Permissible stress σ_f for wire ropes N/mm ²
$4 \leq d \leq 5^a$	$540 + 67 \kappa$
$5 < d \leq 20$	$337 + 270 \kappa$
$20 < d \leq 30$	$270 + 337 \kappa$
$30 < d \leq 40$	$202 + 405 \kappa$

^a For design reasons, wire rope diameters smaller than 4 mm shall be avoided.

κ is defined in [Formula \(21\)](#) as

$$\kappa = \frac{\min \sigma}{\max \sigma}; 0 \leq \kappa \leq 1 \quad (21)$$

Verifications shall be done with the factor $\gamma = 1,0$ on the load side and are compared directly with the values in [Table 9](#).

4.7.5.1.3 Ropes and chains under predominantly non-fluctuating load

Ropes and chains under predominantly non-fluctuating load are, for example, guy ropes, stay ropes, anchoring ropes and chains.

For steel chains, a partial safety factor of $\gamma = 4,0$ shall be used.

For wire ropes made from individual wires with a nominal strength category of 1 570 MPa, a partial safety factor of $\gamma = 3,0$ shall be taken for the general stress analysis.

For web lashing made from man-made fibres according to EN 12195-2 under predominantly non-fluctuating loads, an additional partial safety factor of $\gamma = 2,0$ on lashing capacity (LC) shall be used.

Regarding fibre ropes made from natural and/or synthetic fibres, the values given in [Table 10](#) shall apply.

Table 10 — Partial safety factors for natural or synthetic fibre ropes

Rope diameter mm	Partial safety factor γ
12	4,0
14	3,3
16	3,3
18	2,7
20 and thicker	2,7

The respective partial safety factors γ_f shall be taken into account and be compared with the respective breaking load divided by the partial safety factor.

4.7.5.2 Passenger safety devices

A total safety factor of $\gamma_M = 6$ shall be adopted for safety devices such as safety belts and safety harnesses in loop-the-loop swings. The ultimate limit state is based on the fracture load.

For foot strap buckles in loop-the-loop swings, the following minimum sizes shall be adopted for roller buckles:

- steel buckles: belt width not less than 25 mm;
- aluminium alloy buckles: belt width not less than 30 mm.

In any case the minimum design strength shall not be less than 2 kN for foot strap buckles in loop-the-loop swings.

4.7.5.3 Connectors and adapters

In the absence of International Standards for hooks and eyelets of turnbuckles, connectors and adapters can be used in accordance with national standards. Their permissible loading shall be determined with the aid of the partial safety factors for steel chains (where $\gamma = 4$ or 6) in accordance with [4.7.5.1.1](#).

The permissible loadings for approved load data may be trebled for statically stressed shackles. For dynamically stressed shackle for approved load data shall apply. Shackle pins shall be secured against loosening in dynamically loaded connections.

4.8 Structural design and construction

4.8.1 Arrangement, accessibility

Structural components which are designed in accordance with [Table 5](#), Row 1 (partial safety factor $\gamma_{Mf} = 1,1$ or 1,0) shall be made accessible for checking, if necessary in dismantled conditions.

4.8.2 Locking and safety devices for fasteners

Bolts, nuts, tapered washers and other fasteners, the slackening of which, as a result of fluctuating stresses, can result in incident or injury, shall be secured by well recognized methods, e.g. pre-stressing, cotter pin, retaining compound, counter nut, self-lock nut, spring washers, toothed lock washers, fan type (serrated) lock washers.

On pre-stressed bolts (according to [Table 7](#)), the pre-stressing is considered as security against loosening.

However, as pre-stressed screwed connections are also subject to loosen, particularly in the initial stages as a result of settlement, for example in the case of ball bearing slewing gear, a reference shall be made in the assembly and operating instruction manual to carry out the necessary checks.

4.8.3 Joints intended for regular dismantling

Spring washers, toothed lock washers, fan type (serrated) lock washers and similar locking devices are not permitted on screwed connections fitted with bolts assigned to property class 8.8 and 10.9.

If open hooks are used, it is necessary to assess the consequences of unhooking. Hooks with a safety catch are not considered to be open hooks.

As a general rule, it shall be taken into consideration that any modification of timber members resulting in weakening the timber section shall be avoided. This applies in particular to timbers exposed to impacts or subjected to alternating or pulsating stresses. Drill holes in timber components for connecting bolts, which are subjected to alternating and pulsating loads or on which the bolts are regularly removed during assembly and dismantling operations, shall be relieved from stress by the provision of suitable load spreading plates or dowel pins.

Tensile forces in drill holes acting at right angles to or obliquely to the direction of the grain, which can lead to the splitting or tearing of the wood, shall be absorbed by load spreading (wrap-around) plates on either side of the drilled holes, or by other suitable means. Bolted connections which are not protected in such a way, shall be provided with washers. Appropriate measures such as steel plates or enlarged washers shall be used to prevent damage to timber due to compression under bolt head or nuts. Star washers and similar devices (toothed insert dowels) shall not be used in timber joints which can be dismantled.

Rope connections shall be formed in such a way that there is neither a possibility of kinks or knots arising, nor of excessive stressing of individual wires.

Ropes of any kind shall not bear on sharp edges.

4.8.4 Designing of components subject to fluctuating loads

Abrupt transitions in cross section (sudden changes in stiffness) and notches shall be avoided in components subject to fluctuating stresses.

4.8.5 Supports

Extendable columns and jack screws (pot jacks and similar) which transmit loads onto the surface of the ground shall, if necessary, be cross-braced or secured in another way to take applied horizontal forces.

4.8.6 Central masts

Central masts subject to fluctuating stresses shall not be made of wood.

4.8.7 Prevention of corrosion and rot

Prevention of corrosion and rot shall be provided for steel components, light alloy components and timber components according EN 1090, EN 1993, EN 1999 and EN 1995.

5 Requirements for design and manufacture of rides and structures

5.1 Risk reduction by prevailing design and safety measures

5.1.1 General

The majority of devices in [Clause 5](#) has been categorised in order to unify design approval, examination and safety precautions. The groups are intended to highlight the relevant additional precautions required. Any single device can fall into more than one category, e.g. dark rides, which include rail-guided devices travelling through water.

5.1.2 Risk assessment

5.1.2.1 General

The DRA and OURA are keystone documents, paramount to the total safety management of the amusement device and also considered as dynamic documents. They are required to be reviewed periodically and to follow any relevant change to the design or operation of the amusement device.

These risk assessments shall assess the hazards that the amusement device can pose, the likelihood of those hazards causing a risk and the control measures that are necessary to control those risks adequately. The risk assessments shall identify hazards, estimate and evaluate the risk to which guests, spectators, and operational and maintenance staff are exposed.

5.1.2.2 Design risk assessment (DRA)

The DRA shall be produced by the designer of every device. It shall be used to guide the designer into making the correct decisions in the total design ethos (e.g. material selection, PLC program, ergonomic characteristics, biomechanical effects) so that an acceptable level of risk resides (residual risk) from each design decision. Although not an operation and use risk assessment, the DRA shall be used to guide the structure and content of the operating and maintenance procedures.

5.1.2.3 Operation and use risk assessment (OURA)

The OURA shall be produced by the controller and operator of every device. It shall be used to guide the operator and controller into making the correct decisions in the total operation ethos (e.g. age/height limit, loading/offloading of passengers, foreseeable misuse) so that an acceptable level of residual risk from each hazard is analysed. It shall be elaborated in close consultation with the designer and the DRA and shall demonstrate the management of residual risks highlighted in the DRA. See [Figure 6](#).

5.1.2.4 Hazard analysis

For guidance on general principles, see ISO 12100 and the specific applicable hazards for the amusement devices listed in [Annex E](#).

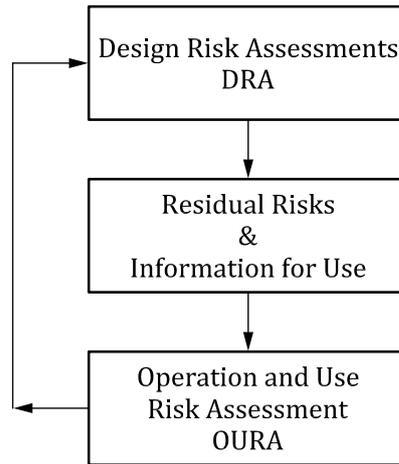


Figure 6 — Risk assessments

5.1.3 Risk reduction for platforms, ramps, floors, stairs and walkways

5.1.3.1 General

The requirements in this section only apply to public use. Permanent access for non-public use (e.g. maintenance) is covered by ISO 14122.

All surface areas of platforms, walkways, ramps and stairs accessible to the public can be tested according to CEN/TS 16165 to evaluate the slip resistance.

All surface areas of platforms, walkways, ramps and stairs accessible to the public shall be free from

- tripping points,
- openings allowing a ball of 12 mm in diameter to fall through, and
- nip or pinch points.

Where the public are intended to pass underneath, further measures are required to protect from falling objects. Any change in elevation of platform levels should be clearly marked in order to avoid any hazard for the public.

Also, the same basic rules given for stair steps in [5.1.3.3](#) shall be followed. This shall not apply to those items which are intentionally designed for the purpose of amusement in funhouses or similar amusement devices, which do not conform to the requirements in [Clause 5](#) and for which special precautions shall be taken in accordance with [5.2.10](#).

Where maintenance equipment is used for emergency evacuation, a specific risk assessment is required.

5.1.3.2 Platforms and ramps

The slope of platforms where the public stand shall not exceed 1 in 8 – 12,5 %.

Ramps for the general public shall not have a slope greater than 1 in 6 – 16,7 %.

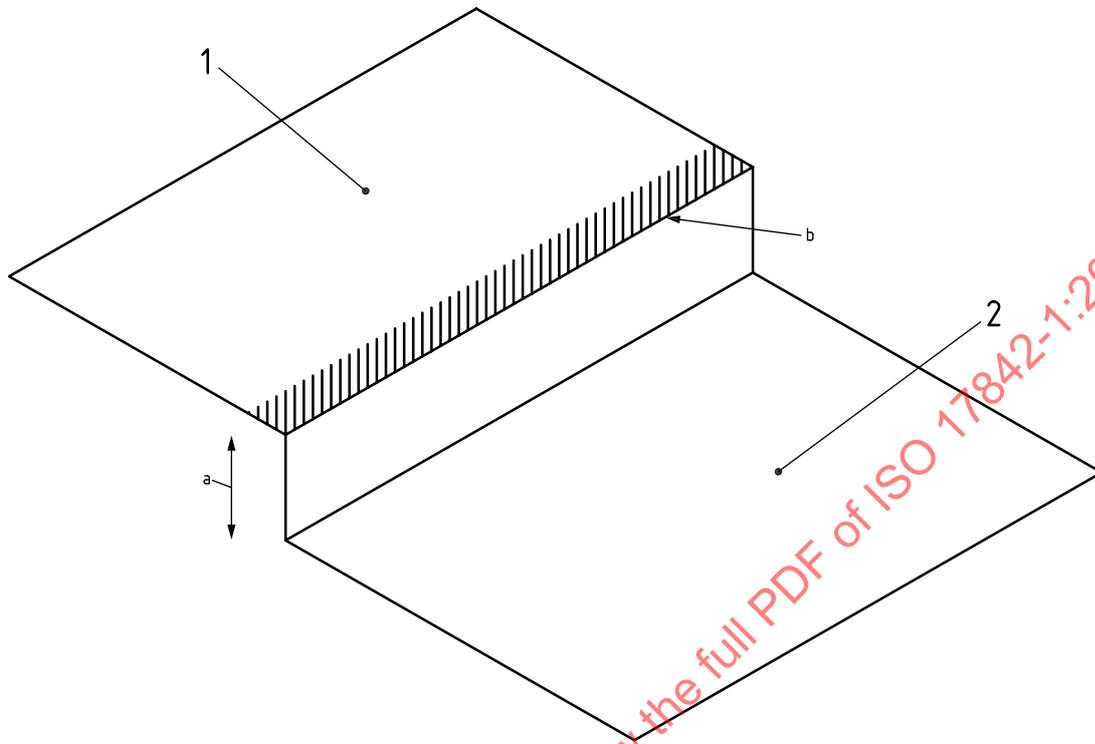
When individual cross battens (anti-slip step) are fitted across the full width of the ramp at a distance of no more than 0,40 m, the slope can be increased to 1 in 4 – 25 %.

The cross battens with rectangular sections shall be maximum 4 mm high so as not to create a trip hazard and no more than 50 mm wide.

Lesser slopes or other means can be required to accommodate patrons using mobility aids.

Where there are adjacent platforms at different heights, unless the difference is between 0,10 m and 0,24 m, stairs or ramps are required.

See [Figure 7](#).



Key

- 1 platform 1
- 2 platform 2
- a Difference in height between 1 and 2 (between 0,10 and 0,24 m).
- b Any change in elevation of platforms should be clearly marked.

Figure 7 — Difference in platform height

5.1.3.3 Stairs

Stairs which are used by the public shall be at least 0,90 m in width. Evacuation stairs and catwalks which are intended for use by a maximum number of six passengers at a time that can be adequately supervised, shall be at least 0,60 m in width.

Stairs shall be no more than 2,50 m in width, except when they surround the amusement device and they do not have more than 10 steps or 2,00 m difference in height. Where central handrails are fitted, each section can be considered as an individual stair.

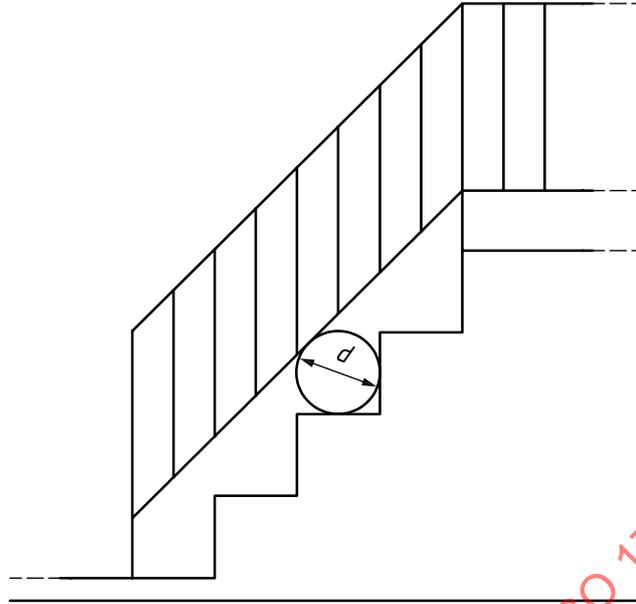
The going and the rise of the steps in any stairways shall be uniform throughout its length. The maximum slope of any stair measured on the centre line shall not exceed 45°.

Flights of stairs for public access and egress shall not exceed 15 steps. Landings at least 0,80 m in depth shall be provided between consecutive flights of stairs.

Evacuation stairs may be without landings if this is not physically possible (e.g. in roller coaster lifts).

The minimum vertical clearance above any step shall be of 2,30 m for public access.

Where the public has access below a stairway, protection from falling objects is required.

**Key**

d diameter of sphere (150 mm)

Figure 8 — Stairway guardrail clearance

The minimum distance between pairs of handrails or between handrails and inner edges of the stair shall be 0,90 m or 0,60 m depending on the type of stair. The 0,60 m width is only for single file use. Where the stairway is 0,90 m or greater in width, there shall be a handrail on both sides. A sphere with a diameter more than 150 mm shall not pass between the step and the lower bar of the barrier, see [Figure 8](#). The going shall be at least 0,24 m except for spiral or curved stairs.

The step height shall be between 0,14 m and 0,24 m. The overlap of the steps for open stairs shall be ≥ 10 mm.

Steps shall have slip resistant surfaces.

The going on spiral or curved stairways shall be:

- a) in accordance with [Figure 9 a\)](#) for stairways which are either a means of access between two levels or intended for attendant assisted evacuation;
- b) in accordance with [Figure 9 b\)](#) where the stairway is to be specified as part of an emergency escape route.

Inclined treads are not allowed.

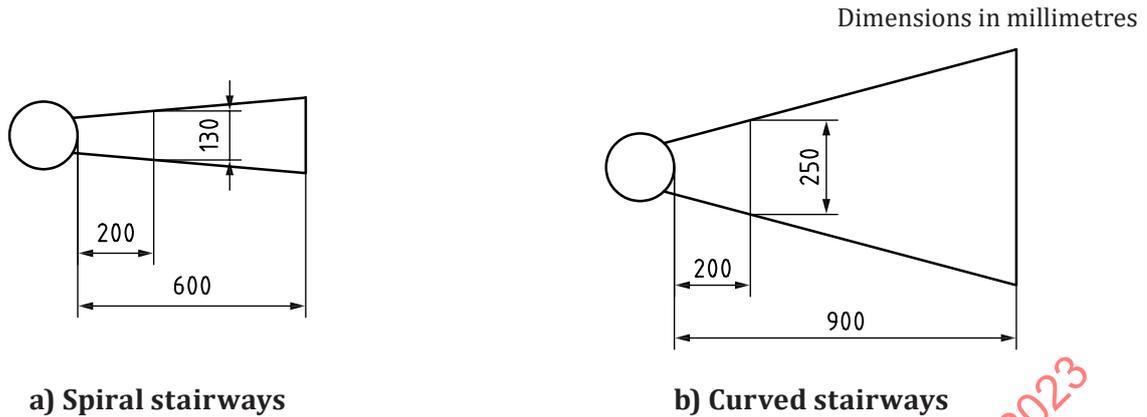


Figure 9 — Dimensions for stairways

5.1.3.4 Moving walkways, travelators and similar

The belt of moving walkways or travelators shall be either seamless or have not more than one joint which shall not protrude.

Handrail shall be provided if required by risk assessment.

The maximum clearance between the belt and a toe board shall not exceed 4 mm.

The slope of a moving walkway or travelator shall not exceed 1 in 6 unless moving handrails are provided, in which case the slope shall not exceed 1 in 4.

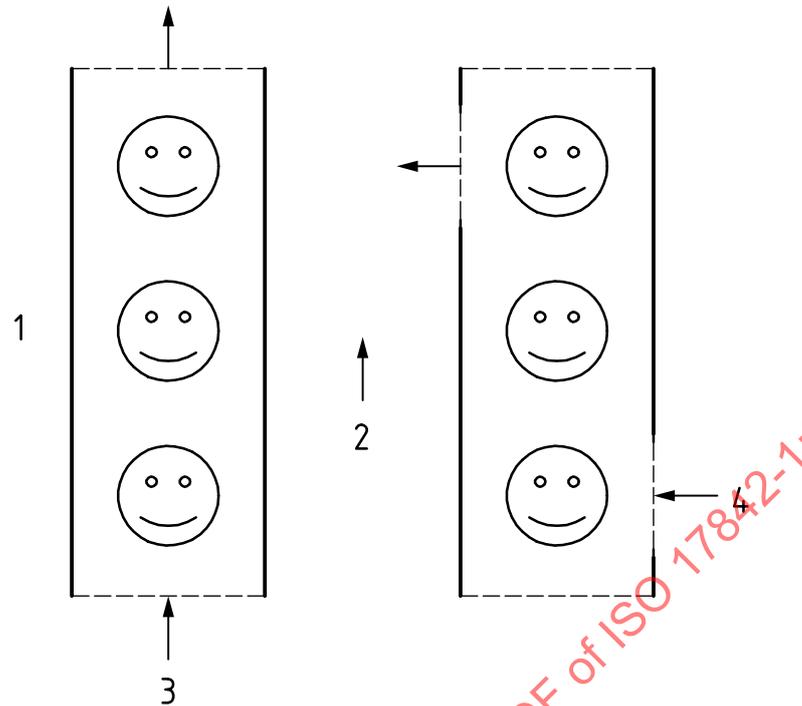
In case of a perpendicular egress from the moving walkway or travelator, the end of the moving walkway shall be guarded with a final handrail and an intermediate rail at 45° with respect to the direction of motion. Additionally, a trip board, or an equivalent system which can interrupt the power in case a passenger is pushed against the final handrail, shall be provided. The access to such a moving walkway shall be controlled by automatic or manual means to avoid danger due to congestion. An emergency stop button shall be fitted at both ends. The emergency stop shall stop the moving walkway in the shortest distance possible without causing users to fall, and then remove power.

Provisions shall be made to protect the end of moving walkways or travelator to prevent trapping or pinching. The end return and tension rollers shall be suitably protected. If such protection is not possible due to the type of surface, perpendicular egress shall be provided.

The maximum relative speed shall not exceed 0,75 m/s with parallel egress from the stationary platform, and 0,5 m/s with perpendicular egress. If the walkway or travelator is used as part of the amusement device itself then higher speeds can be accepted. See [Figure 10](#).

Effective brakes shall stop and hold the walkway in case of any interruption of the power supply.

The minimum width of the travelator shall not be less than 0,60 m.

**Key**

- 1 boundary of travelator
- 2 direction of travelator
- 3 example of arrow depicting parallel access/egress from travelator
- 4 example of arrow depicting perpendicular access/egress from travelator

Figure 10 — Travelator directions in relation to passenger access/egress

5.1.4 Risk reduction using barriers, fencing and guarding

5.1.4.1 Protection against falls from one level to another

5.1.4.1.1 General

Barriers, guardrails or other suitable means shall be provided where a person can fall due to a difference in the height of adjacent levels. In general fall prevention means should not be required up to 0,40 m. Where there is a difference in levels from 0,40 m up to 0,60 m the risk assessment should determine if any area separation system is required.

NOTE Risk assessment should consider e.g. the type of impacted surface, free fall space, presence of hazardous parts in impacted surfaces, potential crowding etc. EN 1176-1 and EN 1177 provide useful information on fall protection.

Barriers for this purpose are specified in [5.1.4.3](#). Railings shall as a minimum consist of two guard rails (a top rail and an intermediate rail).

In addition, where the fall height is more than 1,0 m, a toe board of 100 mm height shall be fitted in order to protect people from passing underneath.

Barriers in accordance with [5.1.4.3](#) a) or other suitable means are required to prevent falls from a height of 2 m or more in public areas.

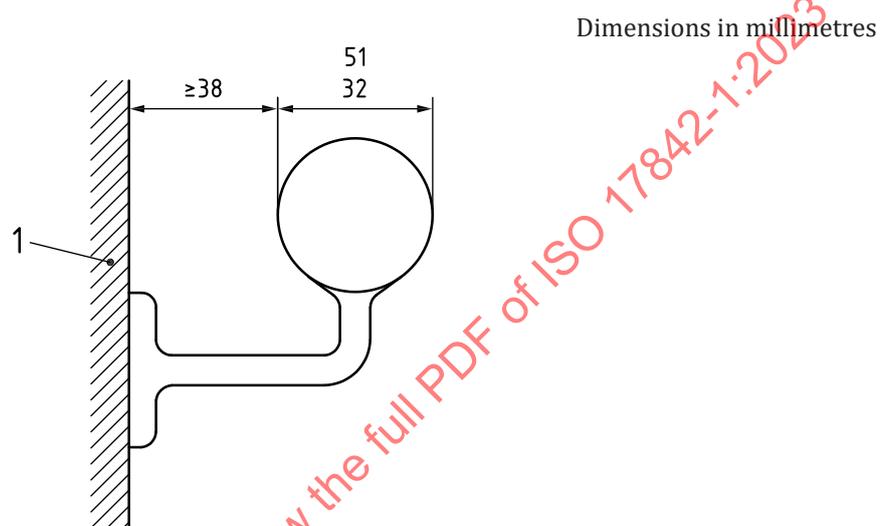
Where there is a low probability of serious injury (not giving direct access to moving machinery, nor falling from heights of more than 2 m) decorative fences in accordance with [5.1.4.3](#) b) are also allowed.

In this case chains and ropes for the top and intermediate rails are also permitted, if they withstand the forces defined in 4.3.3.1.2.3 with a maximum deflection of 30 mm. Untensioned chains, ropes or other non-rigid materials are not permitted.

The design of the top of the barrier or guardrail should not encourage children to stand or sit on them, nor should any infilling encourage climbing.

5.1.4.1.2 Handrail design

Handrails shall have a free space around them of 38 mm and the grip shall be more than 32 mm and less than 51 mm. For handrails only for children, the grip can be reduced to a min. of 16 mm. See Figure 11.



Key
1 wall

Figure 11 — General handrail clearances

5.1.4.2 Protection against crushing, impact or entanglement

5.1.4.2.1 Public access areas

The design of devices shall be such that the risk of passengers and people being injured by entanglement, crushing or impact with the moving ride or its parts is minimised by design. Where such conditions are not fulfilled, area separation systems shall be provided to prevent access of passengers or waiting passengers to parts of the device unsuitable for public access (e.g. moving parts) due to the likelihood of injury or incident.

5.1.4.2.2 Area separation systems

Where an area separation inside or outside the device is required (see 5.2), it shall be designed and positioned in such a way that no one outside the area is within reach of any moving part of the device. The location (distance) of such separation systems depends on:

- the height above the floor of a source of danger;
- the height of the separating device (fence);
- the shortest distance between the edge of the separated area and the source of danger. The minimum safety distance shall be 500 mm. To avoid injuries, the distances defined in ISO 13857 shall be used;
- the relative speed of passenger units — and the reach of the passengers (motion safety envelope).

5.1.4.2.3 Classification of area separation systems

Area separation systems are classified as follows:

- J1 — predominantly visual area separation systems: coloured stripes on the floor or fixed steps, poles, cones or equivalent.
- J2 — physical area separation systems: flexible devices, such as ropes, chains, cords which need not withstand horizontal forces.
- J3 — physical area separation systems: rigid devices, such as fencing, barriers or guardrails which can withstand horizontal forces.

5.1.4.2.4 Classification of access and egress openings in fences, barriers, handrail guardrails

The number of openings in fences barriers, handrail, and guardrails shall be limited to the number and width necessary for safe access and egress. Each opening shall not be more than 2,5 m wide. The access and egress openings are classified as follows:

- K1 — openings without any direct control;
- K2 — openings controlled by attendants;
- K3 — openings provided with barriers or gates indicating the access to a restricted zone by limiting the flow of persons, (e.g. mechanical gates, turnstiles);
- K4 — openings provided with barriers or gates where the locking and unlocking are actuated by the operator or attendant;
- K5 — openings provided with barriers or gates; the closed position enables the ride to start and the opened position causes the ride to stop.

For each defined category of rides, or for each group or single ride being in the same ride category and having the same specific features, the minimum requirements for access and egress openings are expressed by the classification defined above and the requirements in 5.2. shall also apply.

5.1.4.3 Fences and barriers

5.1.4.3.1 General

Fences and barriers shall be designed using the load assumptions given in 4.3.3. Fences shall be at least 1,1 m high above any standing position and shall be constructed so that neither adults nor children can get through or underneath them. They shall be constructed so that people cannot trap their heads in the fence and the barrier and thus protecting them from a significant hazard. Two categories of fence and barrier are allowed for that purpose.

The elements shall not have sharp edges.

For amusement rides used solely by children less than 10 years of age, the separated area can have a reduced height of 0,85 m for both types of fence if the difference in height level is less than 0,4 m.

5.1.4.3.2 Conventional fences and barriers

Fences and barriers with predominantly vertical internal elements are shown in [Figure 12](#). The distance between two adjacent elements shall not be more than 0,10 m or fences provided with mesh as an internal element (see [Figure 13](#)). The size of the mesh shall be in accordance with [Figure 13](#).

5.1.4.3.3 Decorative fences and barriers

Fences and barriers provided with decorative internal elements are shown in [Figure 14](#). The distances between two adjacent elements shall be as shown in [Figure 14](#).

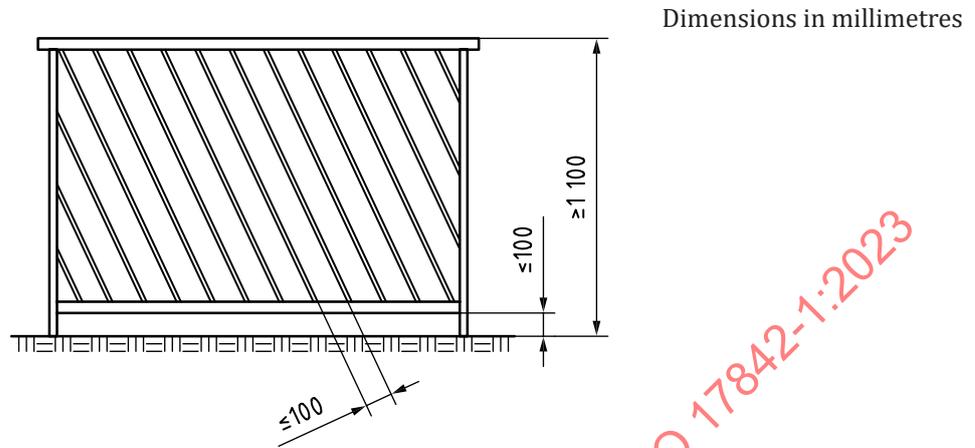


Figure 12 — Examples of fences and barriers with predominantly vertical internal elements

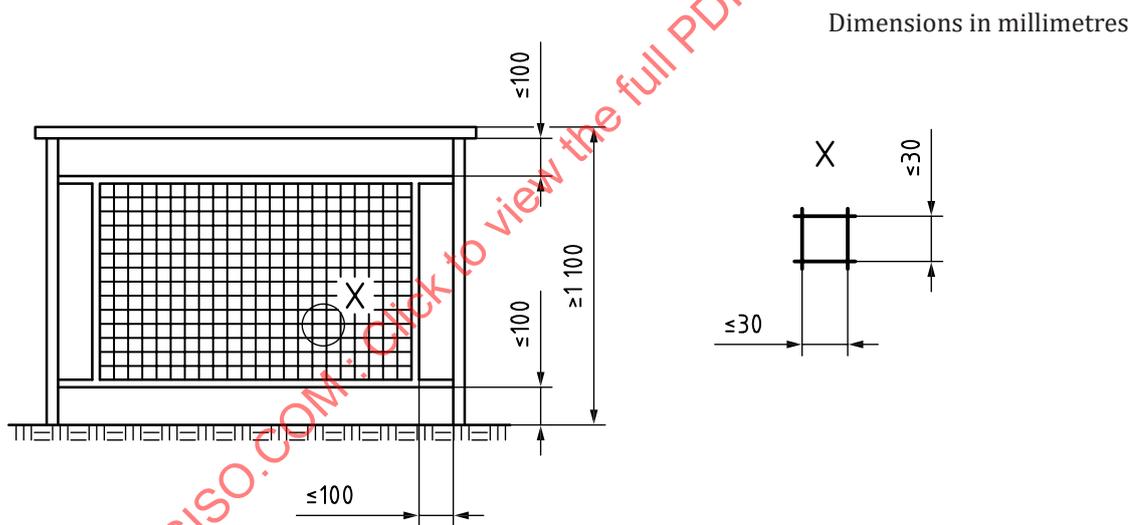


Figure 13 — Examples of fences and barriers provided with mesh or panels as an internal element

Dimensions in millimetres

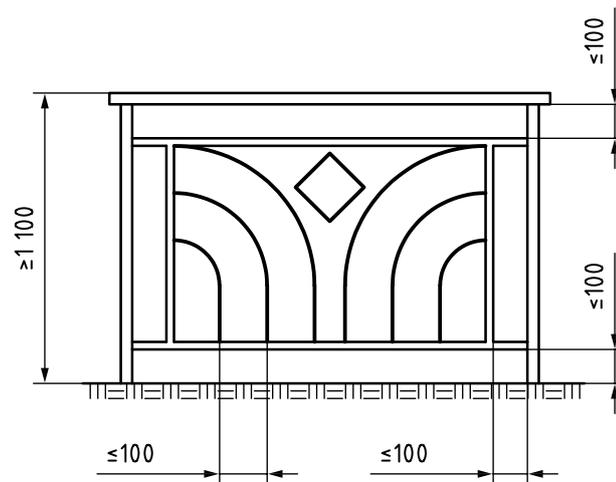


Figure 14 — Examples of fences and barriers with decorative internal elements

5.1.5 Guarding of machinery parts

Any hazardous machinery on an amusement device where there is risk to passengers or personnel shall be guarded in accordance with ISO 14119 and ISO 14120.

5.1.6 Risk reduction in the case of access and egress

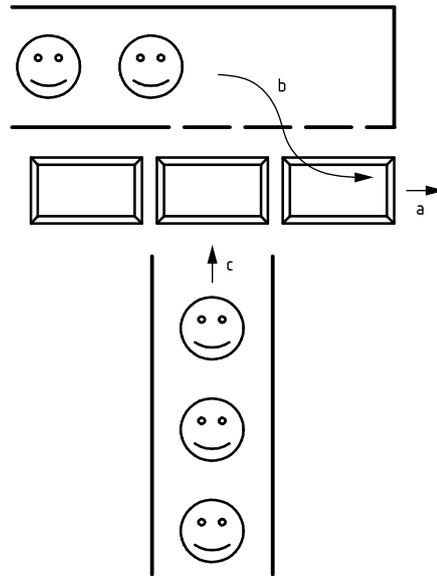
5.1.6.1 Access to and egress from passenger units

5.1.6.1.1 General

Amusement devices carrying passengers shall be designed so as that the risk of people being injured from falls while gaining access to or egress from the amusement device is minimized. The access to and the egress from passenger units is in general gained from platforms and ramps according to 5.1.3. Stairs are admitted only if their position and size, related to the passenger unit features, are designed so that the risk of any admitted passenger experiencing a slip or fall during access or egress is minimized. The access to passenger units such as cars and gondolas shall be not more than 0,40 m above or below the access platform or ramp if unaided (aid can be in the form of handholds or physical assistance). Between 0,40 m and 0,60 m, a specific detailed DRA shall be conducted. Where movements of passenger units during access or egress can produce a hazard, means shall be provided to retain it in a stationary position. Such means shall not lose their retaining capability even in case of a power loss. In certain cases (e.g. carousel), this is not possible and a specific detailed DRA shall be conducted to establish what suitable protection is required.

If access or egress from a passenger unit is provided during the passenger unit's motion, the maximum relative speed between the unit and the access or egress platform shall not exceed 0,75 m/s with access parallel to the direction of motion and 0,50 m/s with perpendicular egress.

See [Figure 15](#).



- a Direction of passenger unit.
- b Example of parallel access to moving passenger units (speed limited to 0,75 m/s).
- c Example of perpendicular access to moving passenger units (speed limited to 0,50 m/s).

Figure 15 — Examples of parallel and perpendicular access to a vehicle in motion

5.1.6.1.2 Emergency access and egress

Appropriate means for the safe recovery of passengers who are stranded away from the normal passenger unit loading/unloading area(s), shall be provided. This provision shall include arrangements for rescue personnel to gain safe access.

5.1.6.1.3 Access to and egress from enclosures, sideshows and similar amusement devices

Every booth or similar enclosed structure shall be provided with exits which are commensurate with the number of occupants in relation to their width, number and siting. Emergency exits shall have a height of at least 2,0 m. No exit shall be less than 1,20 m wide. The width of any exit in relation to the number of occupants who have to use it shall be determined by [Table 11](#).

Table 11 — Width of exit

Minimum clear width of exit m	Additional clear width of exit m	Maximum number of people
1,20	0,00	Not more than 200 people
1,20	0,60	For each additional 100 persons

The number of persons shall be calculated with two persons per square metre excluding the areas not open to the public if no other limiting criteria apply. At least one access and one exit shall be suitable for wheelchairs.

The required exits should be evenly distributed around the structure on opposite sides of the enclosure, so that genuine alternative routes are available from all parts. From any part of an enclosure having more than one exit, the travel distance (i.e. the walking distance between any point in a structure and an exit) to the nearest exit shall not be more than 30 m. After the first 6,5 m, the remainder of the route

shall make it possible to reach an alternative exit. In enclosures having only one exit, the travel distance shall not be more than 24 m. If the number of persons exceeds 200, two exits are required.

Furthermore, the specification of local fire department shall be met.

5.1.7 Risk reduction for passenger units

5.1.7.1 Safety distances from passenger units — Safety envelope

5.1.7.1.1 General

The safety distances shall be defined by a safety envelope.

In addition to the following safety envelopes, notices are required to warn passengers to keep all parts of the body inside the cars and to maintain the intended passenger position.

The safety envelope shall be free from any fixed or moving parts relative to the passengers, except the passenger unit and its moving parts.

The dimensions of the safety envelope depend on the DRA.

5.1.7.1.2 Passenger reach envelope

The specific design of patron compartment, including the restraint system if available, shall be taken into account in defining the reach envelope. The reach envelope shall be developed on the basis of distances.

NOTE 1 Basis of distances is specified in ISO 13857, ISO/TS 17929 and other anthropometric standards and guidelines.

NOTE 2 Specific human measures are defined in statistical reports, e.g. ISO 7250-1, ISO/TS 17929, DIN 33402-2, GOST 12.2.049, AS 3533.1.

5.1.7.1.3 Minimum dimensions of safety envelope

To prevent passengers from being injured by stationary, moving objects or objects belonging to passenger units other than that in which they are located, and in the absence of other measures (e.g. ergonomic study, limiting movement of body parts, combination of seat and restraint design) reducing the reach of the passengers, the following minimum general safety distances shall be provided:

- a) for minimum lateral safety distance $\min. y_{lat}$, see [Table 12](#);
- b) 2,00 m (respectively 1,70 m for children up to the age of 10 years) above the floor of the passenger units (see [Figure 16](#));
- c) 1,50 m above the seat (respectively 1,30 m for children up to the age of 10 years) if the passenger is positively restrained from standing up (see [Figure 17](#));
- d) 1,0 m (respectively 0,9 m for children up to the age of 10 years) below the seat in suspended seats (see [Figure 18](#)).

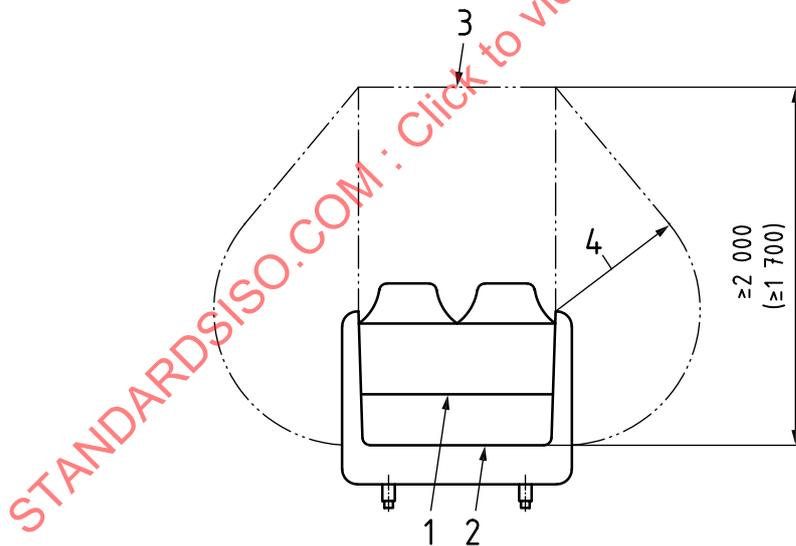
Table 12 — Minimum lateral safety distances in relation to side height of seat, from inside part of seat and if no other hazards (min. y_{lat})

Cat.	Speed, v $\frac{m}{s}$	$h \leq 400$ mm	$400 < h \leq 600$ mm	$h > 600$ mm
A	$v < 3$	700 mm	500 mm	300 mm
B	$3 < v < 10$	900 mm	700 mm	500 mm
C	$10 < v < 20$	1 000 mm (900 mm for children up to the age of 10 years)	900 mm	500 mm
D	$v > 20$	1 000 mm (900 mm for children up to the age of 10 years)	1 000 mm (900 mm for children up to the age of 10 years)	700 mm

If an over-shoulder restraint is used and the lateral movement of the upper body is limited, the min. y_{lat} values similar to a side height of $h > 600$ mm can be used. If the reach envelope is limited by other installations (e.g. cabin) then even less min. y_{lat} values can be adopted.

Any special situation shall be taken into consideration in the definition of the minimum safety distances. Safety distances may be extended due to accelerations, darkness, sharp-edged elements or vice versa.

Dimensions in millimetres



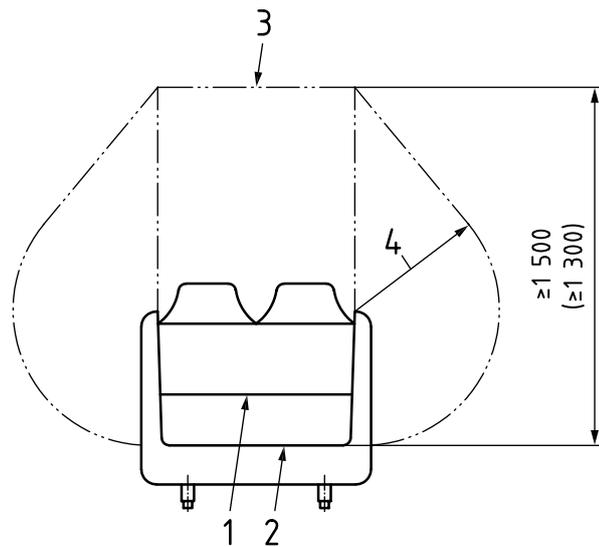
Key

- 1 seat surface
- 2 floor surface
- 3 safety envelope
- 4 for minimum lateral safety distance y_{lat} , see [Table 12](#) beginning with floor surface

NOTE Values for children up to the age of 10 years are given in parentheses.

Figure 16 — Vertical safety distance from the floor and lateral safety distance for passengers

Dimensions in millimetres

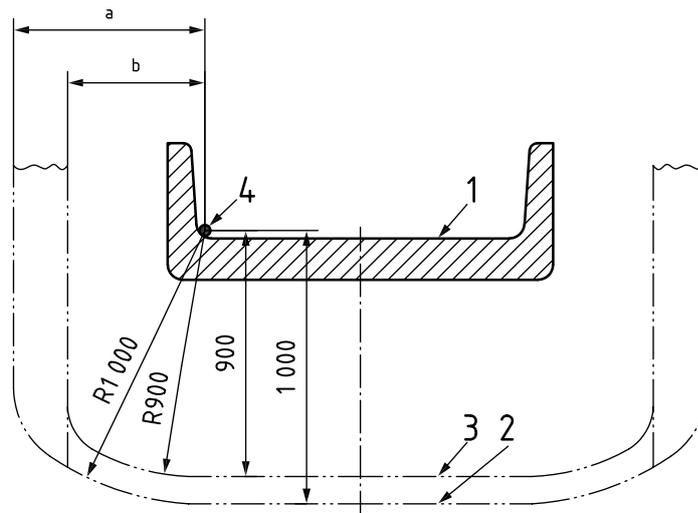
**Key**

- 1 seat surface
- 2 floor surface
- 3 safety envelope
- 4 minimum lateral safety distance y_{lat} , see [Table 12](#)
beginning with floor surface

NOTE Values for children up to the age of 10 years are given in parentheses.

Figure 17 — Vertical safety distance from the seat and lateral safety for passengers

If passenger units are free-ranging and controlled by the passenger, the distance in [5.1.7.1.3 a\)](#) applies only to fixed objects.



Key

- 1 seat surface
- 2 safety envelope
- 3 safety envelope for children up to the age of 10 years
- 4 corner centre radius

a Minimum lateral safety distance y_{lat} . see [Table 12](#).

b Minimum lateral safety distance y_{lat} for children up to age of 10 years, see [Table 12](#) or [Annex H](#).

This may need to be reduced in a station or other low speed area, depending on risk assessment.

Figure 18 — Minimum safety distance for legs in suspended seats

5.1.7.1.4 Minimum safety distances between passenger containments

Additionally, the following distance shall be maintained: 0,12 m from the outside of the unit to any other part at the seat's height of another unit in the most unfavourable operating condition (see [Figure 19](#)). For dodgem/bumper cars, see the minimum safety distances in [Table 14](#).

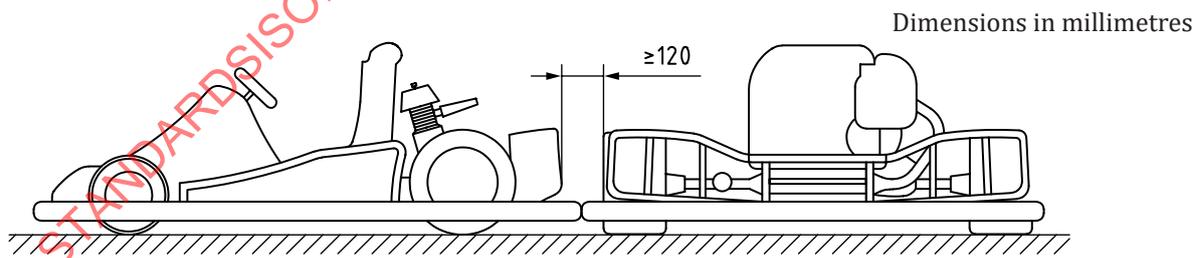
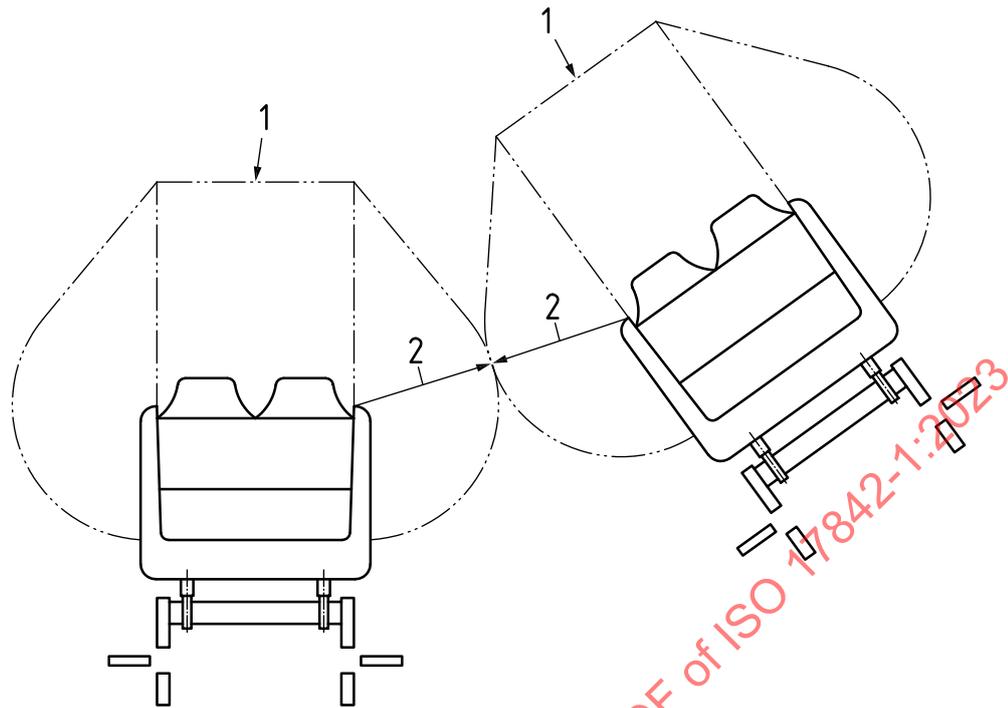


Figure 19 — Safety distance for free ranging vehicles

If the passenger units are not free ranging, the safety envelopes shall not overlap (see [Figure 20](#)) unless it is not possible for both passenger units to be in the overlapping space at the same time.

**Key**

- 1 safety envelope
- 2 minimum lateral safety distance y_{lat}

Figure 20 — Relative position of safety envelopes

5.1.7.2 Restraint devices limiting passenger movement

5.1.7.2.1 General

Passenger restraints and their locking devices shall be designed in such a manner as to prevent trapping and crushing of body parts.

Passenger restraint devices shall have a configuration such as not to act on sensitive and fragile parts of the passenger's body. Even if provided with warning lights and/or acoustic warning, they shall allow a visual and/or physical verification of their correct closing by the attendant.

Powered passenger restraint devices may create additional hazards giving rise to injuries. Their movement shall be slow and the maximum exerted force shall not be more than 0,15 kN (0,08 kN if children are also admitted) measured on the active edge of the device.

Locking and latching devices shall be designed in such a way as to prevent unlocking without a deliberate and intentional action.

Locking devices shall not lose their locking action in the case of malfunction or emergency stop of the ride, unless the DRA or OURA supports a different approach.

5.1.7.2.2 Passenger restraints

Each element of the ride, designated to accommodate passengers (passenger unit), shall be provided with adequate means to restrain passengers within the device, and if necessary, in their places, depending on the nature of the ride and the results of the DRA.

The design of a restraint shall minimize by risk assessment at least the following risks for passengers:

- hitting parts in relative motion or being trapped in between them;
- being injured by contact with any part of the structure of the ride, including passenger restraint;
- being struck by parts of the structure in which they are carried;
- being hit by other passengers resulting from the type of motion induced by the ride.

The design of a restraint shall prevent ejecting or falling from the passenger unit under the condition that passengers do not display any unreasonable behaviour.

In the case of malfunction or emergency stop, when the passengers are maintained in their places by the restraint devices, arrangements shall be made for unlocking the device by the authorized personnel, unless the DRA or OURA supports a different approach.

Passenger restraints shall be provided as determined by the designer based on risk assessment.

This determination shall be based on the passenger restraint and containment analysis performed in accordance with criteria defined in this document and shall take into consideration the nature of the amusement ride or device and the intended adult or child passenger physical characteristics, based on anthropomorphic data such as those given in [Annex C](#).

The passenger restraint and containment analysis shall identify the need for a restraint system for reasons other than simply the acceleration or seat inclination. The analysis shall also evaluate the need for locking or latching functions when restraints are required.

The designer shall take into consideration the evacuation of passengers from any reasonably foreseeable position and/or situation on the ride or device, including emergency stops and stops in unplanned locations. The passenger restraint and containment analysis shall address whether individual or group restraints releases are appropriate.

With the DRA, the designer specifies the state, locked or unlocked, of the restraint system in the event of an unintended stop, e.g. emergency stop or loss of power.

Restraint devices shall be provided in cases where it is reasonably foreseeable that passengers can be lifted or ejected from their seats or riding positions by the acceleration of the amusement ride or device, or by seat inclination, during the ride or device cycle and other reasonably foreseeable situations, e.g. the application of emergency brakes or vehicles stopped in inverted positions.

The restraint diagram shown in [Figure 21](#) shall be used as part of the passenger restraint and containment analysis for determining if a restraint is required, and the type of restraint, if any. The restraint diagram identifies and graphically illustrates five distinct areas of theoretical acceleration. Each of the five distinct areas can require a different class of restraint. The restraint diagram applies for sustained acceleration (as defined in [3.40](#)) levels only. It shall not be applied for impact acceleration.

For the axis convention, refer to [Figure 21](#).

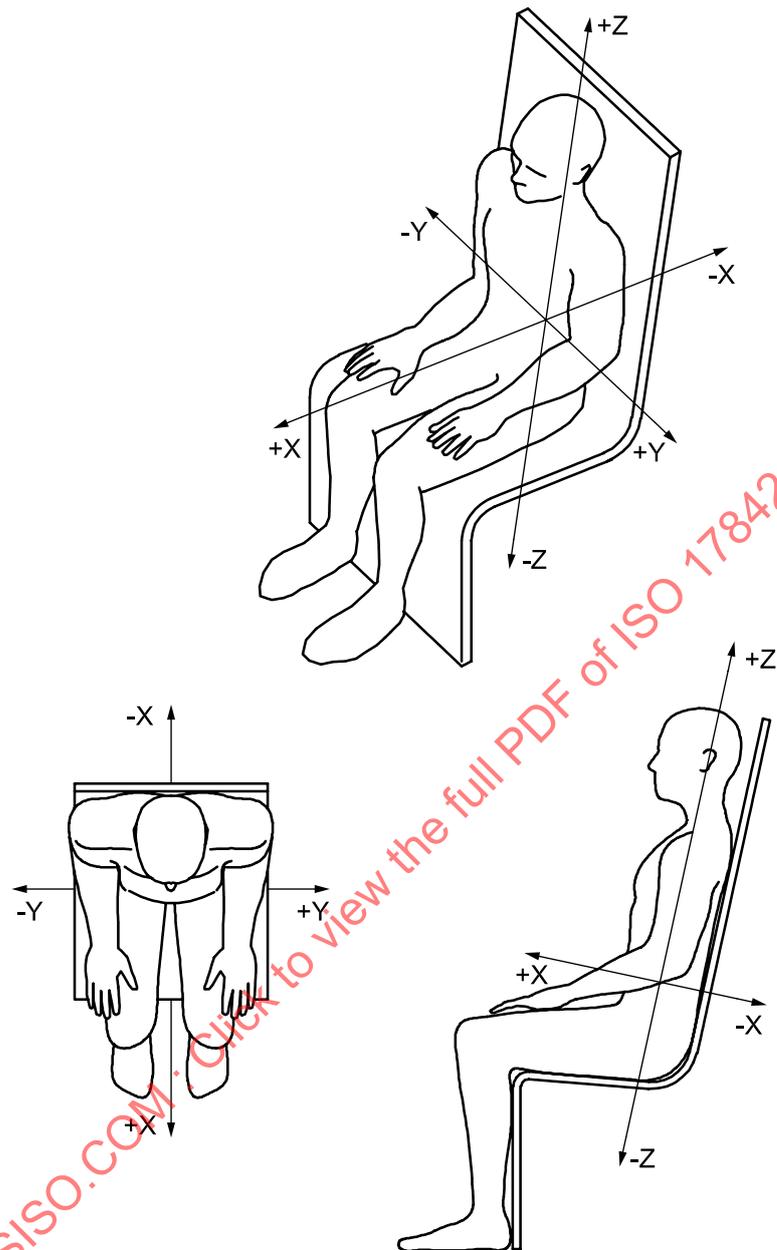


Figure 21 — Body coordinate system

Acceleration is defined in accordance with the following coordinate system:

- $+a_z$ presses the body into the seat downwards, described as “eyes down”.
- $-a_z$ lifts the body out of the seat, described as “eyes up”.
- $+a_y$ presses the body sideward to the right, described as “eyes right”.
- $-a_y$ presses the body sideward to the left, described as “eyes left”.
- $+a_x$ presses the body into the seat backward, described as “eyes back”.
- $-a_x$ pushes the body out of the seat forward, described as “eyes front”.

can require special consideration. In [Figure 22](#), no information on the absolute acceleration limits is given.

At boundary cases the lower category of the restraint class may be chosen.

[Figure 22](#) is a design guide. If [Figure 22](#) is used to validate the choice of restraint by measurements then data shall be filtered to 1 Hz (only for application of this figure) and applying a tolerance of $\pm 0,05$ g.

The DRA (see [5.1.2.2](#)) can require a different class of restraint to be used.

The determination of the class of the restraint, based on [Figure 22](#), is as follows.

5.1.7.2.3 Classification of passenger restraint devices

Restraint devices have the following requirements based on their classification according to [Figure 22](#). See also [Table 13](#).

Class 1: Unrestrained or no restraint at all.

Class 2: A latching restraint device for each individual passenger or a latching collective restraint device for more than one passenger. A Class 2 restraint device shall have at least the following:

- 1) Number of passengers per restraint device – The restraint device can be for an individual passenger or it can be a collective device for more than one passenger.
- 2) Final latching position relative to the passenger – The final latching position can be fixed or adjustable in relation to the passenger.
- 3) Type of latching – The passenger or operator can latch the restraint.
- 4) Type of unlatching – The passenger or operator can unlatch the restraint.
- 5) Restraint position monitoring – In addition to the operator responsibilities no independent restraint position monitoring required.
- 6) Means of activation – The restraint can be manually or automatically (e.g. motorized) opened and closed.
- 7) Redundancy of latching device – Redundancy is not required.

Class 3: A latching restraint device for each individual passenger or a latching collective restraint device for more than one passenger. A Class 3 restraint device shall have at least the following:

- 1) Number of passengers per restraint device – The restraint device can be for an individual passenger or it can be a collective device for more than one passenger.
- 2) Final latching position relative to the passenger – The final latching position shall be adjustable in relation to the passenger, e.g. a bar or a rail with multiple latching positions.
- 3) Type of latching – The passenger or operator can manually latch the restraint or it may be automatically latched. The manufacturer shall provide instructions so that the operator shall verify the restraint device is latched.
- 4) Type of unlatching – The passenger can manually unlatch or the operator can manually or automatically unlatch the restraint.
- 5) Restraint position monitoring – In addition to the operator responsibilities, no independent restraint position monitoring is required. The design shall allow the operator to perform a visual or manual check of the restraint each ride cycle.
- 6) Means of activation – The restraint can be manually or automatically (e.g. motorized) opened and closed.

- 7) Redundancy of latching device – Redundancy shall be provided for the latching device function.
- 8) Monitoring of latching device – The latching device shall be periodically tested prior to be put into operation with guests. The frequency and procedure of such a periodic test shall be determined by the mechanical design (redundancy check).

Class 4: A redundant locking restraint device for each individual passenger. A Class 4 restraint device shall have at least the following:

- 1) Number of passengers per restraint device – A restraint device shall be provided for each individual passenger.
- 2) Final locking position relative to the passenger – The final locking position of the restraint shall be adjustable in relation to the passengers, e.g. a bar or a rail with multiple positions.
- 3) Type of locking – The restraint device shall be automatically locked.
- 4) Type of unlocking – Only the operator shall manually or automatically unlock the restraint.
- 5) Restraint position monitoring – In addition to the operator responsibilities, an independent restraint position monitoring system shall initiate a cycle stop or inhibit cycle start. The design shall allow the operator to perform a visual or manual check of the restraint each ride cycle (redundancy check).

NOTE For some amusement rides, such as roller coasters and freefall towers, the position of the restraint cannot be monitored continuously.

- 6) Means of activation – The restraint can be manually or automatically (e.g. motorized) opened or closed.
- 7) Redundancy of locking device – Redundancy shall be provided for the locking device function.
- 8) Monitoring of locking device – The locking device shall be periodically tested prior to be put into operation with guests. The frequency and procedure of such a periodic test shall be determined by the design.

Class 5: A redundant locking restraint device for each individual passenger. A Class 5 restraint device shall have at least the following:

- 1) Number of passengers per restraint device – A restraint device shall be provided for each individual passenger.
- 2) Final locking position relative to the passenger – The final locking position of the restraint shall be adjustable in relation to the passengers, e.g. a bar or a rail with multiple positions.
- 3) Type of locking – The restraint device shall be automatically locked.
- 4) Type of unlocking – Only the operator shall manually or automatically unlock the restraint.
- 5) Restraint position monitoring — In addition to the operator responsibilities an independent restraint position monitoring system shall initiate a cycle stop or inhibit a cycle start. The design shall allow the operator to perform a visual or manual check of the restraint for each ride cycle.

NOTE For some amusement rides, such as roller coasters and freefall towers, the position of the restraint cannot be monitored continuously.

- 6) Means of activation – The restraint can be manually or automatically (e.g. motorized) opened or closed.
- 7) Redundancy of locking device – Redundancy shall be provided for the locking device function.
- 8) Monitoring of locking device – Direct position monitoring of the locking devices shall be required prior to the start of a new ride cycle. In case of a failure a start shall be inhibited. As an accepted

alternative, the integrity of the redundant locking devices shall be verified within every two ride cycles (redundancy check).

- 9) Restraint configuration – Two restraints, e.g. a shoulder and lap bar per passenger or one fail safe restraint device is required (see 5.1.7.2.4 for secondary restraint device requirements).

NOTE “Shoulder restraint” is also called “Upper torso restraint” in ASTM.

Passenger restraint devices are summarized in Table 13.

Table 13 — Minimum requirements of passenger restraint classes

Class	1	2	3	4	5
No. of passengers per restraint	No restraint	Individual or collective for two or more passengers	Individual or collective for two or more passengers	Individual for each passenger	Individual for each passenger
Final latching/locking position	No restraint	Non-adjustable latching	Adjustable latching to passenger	Adjustable locking to passenger	Adjustable locking to passenger
Latching/locking	No restraint	Manually or automatically latching	Manually or automatically latching	Automatically locking	Automatically locking
Unlatching/unlocking	No restraint	Unlatching by passenger (manually) or operator (manually or automatically)	Unlatching by passenger (manually) or operator (manually or automatically)	Unlocking by operator manually or automatically	Unlocking by operator manually or automatically
Restraint device monitoring	None	None	None	Position of the restraint device	Position of the restraint device
Means of activation	None	Manually or automatically opened or closed	Manually or automatically opened or closed	Manually or automatically opened or closed	Manually or automatically opened or closed
Redundancy	None	None	Latching device	Locking device	Locking device and restraint device
Latching/locking device monitoring	None	None	Redundancy check	Redundancy check	Redundancy check or Direct locking device monitoring

5.1.7.2.4 Secondary restraint device for class 5 restraints (see 5.1.7.2.3, class 5 no. 9)

If, in addition to the primary restraint device which conforms to the above-mentioned requirements, a secondary device is present and necessary, the secondary device shall have at least the following characteristics:

- collective;
- not adjustable;
- manually locked by the passenger;
- manually unlocked by operators or attendants;
- no warning at all;
- redundancy only concerning locking device (functional).

This secondary device may be the containment enclosure or collective cage.

The function of the secondary device shall be independent of the primary device.

5.1.7.3 Doors

When passenger units are provided with doors, measures shall be taken to ensure that doors do not open during operation, or in case of emergency or failure. In general doors shall be fitted with latching and/ or locking devices which prevent unintentional opening during a ride (e.g. safety hooks) and can be opened from the outside only unless the DRA demonstrates that the above measures are not necessary, e.g. door opens inward with respect to the passenger unit, low speed, no risk or low risk of falling.

Powered doors should not be capable of inflicting injuries upon passengers. Their movement shall be slow and the maximum exerted force shall not exceed 150 N measured on the edge of the door.

5.1.7.4 Seats

Seats shall be securely fixed to the structure of the passenger unit and stress analysis shall be carried out for seats and their fixings.

Seats shall be provided with a backrest, when required, at least 0,4 m high and a seat surface with a declivity toward the backrest. The height of the backrest can be reduced to 0,25 m if the risk assessment allows it. The passenger shall have in all cases, a sufficient support from the seat, the back and armrests, and the footrests, so as to be able to counteract the forces which arise during the ride. When sizing and designing the passenger seats and adjacent parts, due attention shall be paid to an adequate height and shape of the backrests, armrests, footrests, and eventual headrests.

Elements such as the shape, size, and the friction between seat surface and passenger clothes and the eventual presence of partial or total upholstery, can greatly affect the effectiveness of the whole restraint system.

Seats suspended by steel wire ropes or link type chains shall have a design, which in the case of the failure of one suspension element, does not result in a dangerous situation (e.g. overturning of the seat).

5.1.7.5 Passenger containment

Recommendations for passenger containment can be found in [Annex C](#).

5.1.8 Requirements for special provisions

5.1.8.1 Body height relative to passenger age

Size body height is the main characteristic used to determine by ergonomics the suitability of a passenger for an amusement device.

The following list gives an approximate correlation between height and age:

- L0) children between 90 cm and 105 cm of height corresponding to approximately 2 and 4 years;
- L1) children between 105 cm and 120 cm of height corresponding to approximately 4 and 6 years;
- L2) children between 120 cm and 130 cm of height corresponding to approximately 6 and 8 years;
- L3) children between 130 cm and 140 cm of height corresponding to approximately 8 and 10 years;
- L4) children between 140 cm and 160 cm of height corresponding to approximately 10 and 14 years;
- L5) adults.

On some amusement devices, it is also important to consider the maturity and cognitive abilities of the child. For further information, see [Annex G](#) and/or ISO/TS 17929.

5.1.8.2 Passengers with special needs

Requirements necessary for the safe use of the ride and any special precaution shall be defined.

For further information, see [Annex G](#) and [Annex H](#).

5.1.8.3 Wind measuring devices

Where there are unacceptable risks associated with the operation of an amusement ride or device in wind gusts exceeding the design wind speed, a wind measuring device (or other reliable indicator) shall be incorporated into the design, and appropriate instructions for use included in the operations manual.

5.2 Supplementary safety requirements for various types of amusement devices

5.2.1 Amusement rides with horizontal and/or vertical axis

5.2.1.1 General

These are amusement devices moving around vertical and/or inclined axes of rotation, with one or more degrees of freedom of the moving frameworks and gondolas. Driving mechanisms permit variation of inclination of the different rotating axes up to movement in vertical planes (see [Figure 23](#) to [Figure 26](#)).

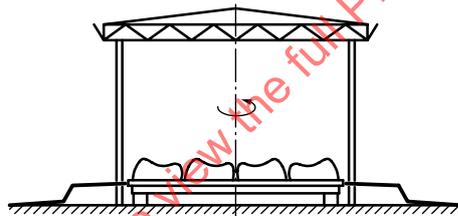


Figure 23 — Vertical axis, one degree of freedom

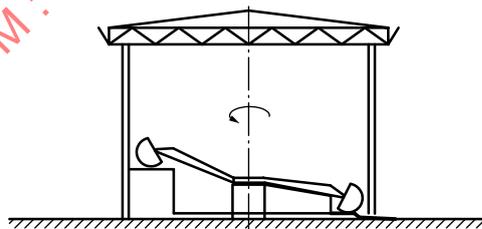


Figure 24 — Vertical axis, more than one degree of freedom

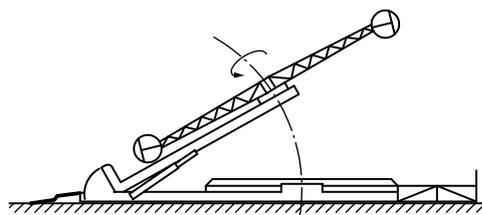


Figure 25 — Variable inclined more than one degree of freedom

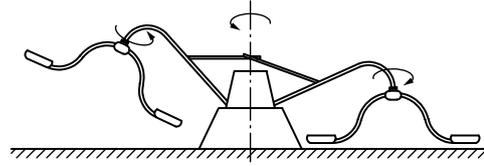


Figure 26 — Variable inclined axis

5.2.1.2 Area separation systems, access and egress openings

If in addition to horizontal and/or vertical movements or another rotation (around a further axis) are also possible, the amusement device shall be provided with a perimeter fence for the general public in accordance with J3 requirements (see 5.1.4.3). If an intermediate area, intended for passengers waiting to access the passenger's unit is provided, this area shall be separated from the dangerous area by means of an area separation system conforming, as a minimum to J2 requirements. Access and egress openings for the general public shall conform to K2 requirements, unless an intermediate area as mentioned above is provided, in which case a compliance with K1 requirement is admissible.

On amusement rides and devices featuring a round rotating platform without protruding elements where the only movement is a rotation around the vertical axis with an angular velocity not exceeding 8 rpm or a peripheral velocity not exceeding 3,0 m/s, no area separation system is required. If the velocity exceeds this value, the area separation system shall conform to J1 requirements unless the risk assessment requires J2 or higher.

If the amusement device consists of a round platform but is provided with protruding parts or isolated passenger units, and the velocity is within the limits specified in the above paragraph, the area separation system shall conform to J2 requirements as a minimum unless the risk assessment allows for J1 requirements. The same requirements shall be conformed to if, in addition to the above-mentioned features, slow vertical movements parallel to the rotation axis and with a vertical velocity not exceeding 0,5 m/s, are present.

For Chair-O-Planes and similar rides with a peripheral velocity not exceeding 3,0 m/s, the area separation system shall conform to J1 unless the risk assessment requires J2 or higher.

For Chair-O-Planes and similar rides with a peripheral velocity exceeding 3,0 m/s, in the absence of an ergonomic study or implementation of alternative safety measures, the minimum vertical distance between the lowest part of the seat and the areas accessible to the public shall be at least 3,7 m during rotation. For rides where the minimum height of the seat is less than 3,7 m during rotation, an area separation system according to J3 requirements, positioned according to Table 12, and access and egress openings conforming to K1 requirements are required, unless other mitigations protect against the access to the area (e.g. steps, or J1/J2 requirements and supervision).

The outside contour of swinging seats or gondolas shall have at least a horizontal distance from fixed objects according to Table 12.

5.2.1.3 Passenger units

Children's rides (circular rotating) shall have a solid rotating platform underneath passenger units, unless passengers are restrained by means of enclosures or restraint devices which limit their movements. The doors of passenger units on merry-go-rounds for children which are intended as a restraining device or, when open, can project outside the perimeter of the rotating platform, shall be fitted with a latching device which can be opened from the outside only.

Gondolas or cars suspended by steel wire ropes or link type chains shall have a suspension system such that the failure of one suspension element shall not result in a dangerous situation.

Access doors in rotor drums shall provide a complete enclosure and shall open inwards only, with the door lock being operated from the outside.

Rotors shall have a closed cylinder wall. The floor and the inner surface of the cylinder wall shall be designed without protruding or indented components. The upper edge of the cylinder wall should not be reachable by the user nor the spectator. The floor (with adjustable height) is to be inserted into the cylinder with a minimum gap and shall be even and follow the direction of the rotation of the cylinder. The doors shall be inserted with only a small gap into the cylinder wall. Rotors shall be designed in such a way that they cannot start turning with open doors.

5.2.2 Amusement rides with horizontal axis

5.2.2.1 General

Amusement rides moving around a horizontal axis are shown in [Figure 27](#) to [Figure 29](#).

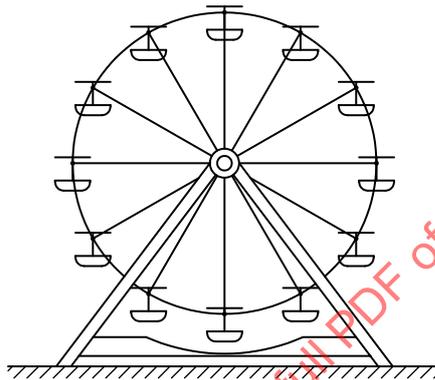


Figure 27 — Main horizontal axis (passenger unit pivoting)

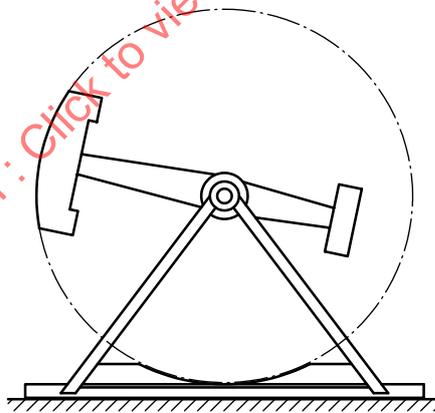


Figure 28 — Main horizontal axis (passenger unit not pivoting and with mechanical drive)

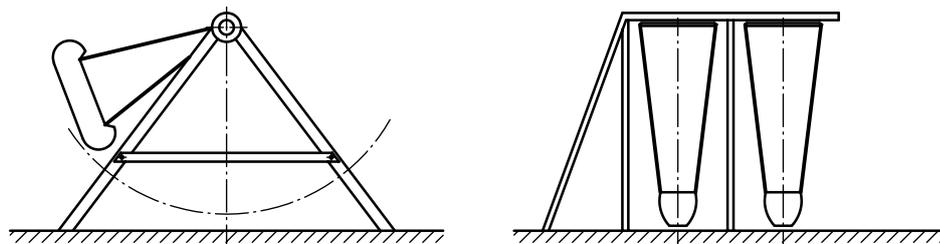


Figure 29 — Main horizontal axis non-energized (passenger unit not pivoting and without mechanical drive)

5.2.2.2 Area separation systems, access and egress openings

Area separation systems for the general public shall conform in general to J3 requirements (see [5.1.4.2.3](#)).

Openings shall conform to K2 requirements (see [5.1.4.2.4](#)) and be able to physically close off (e.g. by chained gates) the entrance to the ride during operation.

Area separation systems for non-energized swings shall conform to J3 requirements, but the type of fence can be as follows:

A hand rail 1,1 m high and an intermediate rail at half height.

The distance from the path of the swing or gondola shall be in accordance with [5.1.7.1.3](#).

Inside the fence, there shall be sufficient room for the operator to avoid body crushing between the fence and passenger unit in accordance with ISO 13854.

Space between parallel swings shall be protected by a fence or barrier in accordance with OURA.

5.2.2.3 Passenger units

Gondolas of swing boats shall have handrails not less than 1,1 m from the floor of the gondola. If the vertical distance between the upper edge of the side wall and the handrail is more than 0,4 m, additional intermediate rails shall be fitted. Gondolas for children only shall have these dimensions reduced to 0,85 m and 0,25 m respectively.

Gondolas of giant wheels if not designed as closed cabins or not conforming to the safety distances stated in [5.1.7.1.3](#) shall have guards to prevent contact with parts having relative motion with respect to passengers (special consideration should be given to prevent long hair from being caught). Barrier of access openings of gondolas shall be a minimum height of 1,1 m. For giant wheels of less than 6 m falling height and for children up to 130 cm height, 0,85m is sufficient. Doors shall be locked and secured against unintended opening, if other standing surfaces are present, further measures shall also be taken. For closed cabins, refer to EN 13796-1.

5.2.2.4 Restraints

Containment belts, foot restraint straps or equivalent means shall be provided in non-powered gondolas where passengers, during rotation, travel upside down. For power operated gondolas where passengers travel temporarily upside-down during rotation and where the vertical (head to foot or +az presses the body into the seat downwards, described as "eyes down") acceleration is less than 0,2 g, refer to [5.1.7.2](#).

5.2.2.5 Miscellaneous

Swing boats shall be provided with brakes, which neither stop the gondolas too abruptly nor lock.

Swings for children of less than 10 years of age shall not have a distance of more than 3 m between the floor of the gondola and the axis of suspension: rotation of the highest seat in a ship shall not pass the horizontal line through the centre and shall be prevented. Brakes are not required if the operator can stop the gondola by hand.

5.2.3 Rail-guided channel or track-bound devices

5.2.3.1 General

See [Figure 30](#).

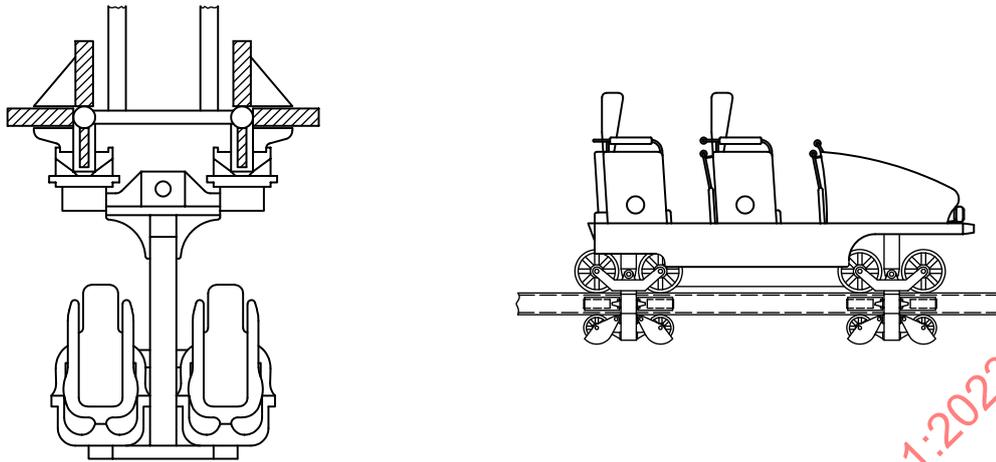


Figure 30 — Track-guided devices

5.2.3.2 Area separation systems, access and egress openings

Area separation systems for the general public shall conform to J3 requirements (see [5.1.4.2.3](#))

Access openings to the loading zones shall conform to K3 requirements (see [5.1.4.2.4](#)) in order to prevent access of passengers until the train comes to a stop. Egress openings shall conform to K3 requirements.

Power operated, rail-guided devices for children where the velocity does not exceed 2,0 m/s and where they are capable of being stopped within 2 m by the operator, shall be provided with an area separation system conforming to J2 requirements. Access and egress openings shall conform to K2 requirements.

Miniature railways do not require an area separation system in amusement parks where all of the following conditions are met:

- train route is clearly isolated from other amusement devices, shops or roads;
- train is driven by an operator;
- train's velocity does not exceed 5 m/s;
- acoustic warnings are provided on the train;
- acoustic and optical warnings are provided on level-crossings.

The station area separation system shall conform to J1 requirements (see [5.1.4.2.3](#)).

5.2.3.3 Passenger units

The passenger units shall be designed in such a way that:

- passengers inside and outside are not likely to come into contact with moving parts;
- passengers' hands or arms are not likely to be crushed or bruised by contact with the cars in front or behind the one they are travelling in;
- the chassis and superstructures of the vehicles have sufficient degrees of freedom and clearance to follow changes in transverse inclination, curves, humps and troughs, even under permissible wear conditions.

Where there is contact between the cars or any guiding elements, the cars shall be fitted with fenders at the front and/or rear, which shall be mounted at the same height. If there is a liability for offset during contact, e.g. as a result of longitudinal or transverse swinging, then the fenders shall have a sufficient height to provide overlap. At least one fender per car shall have shock absorbing properties,

the damping being designed as a response function to the nominal speed. Damping may be dispensed with if the cars are safeguarded against collision by a block-zone system or other means.

5.2.3.4 Restraints

Restraints shall be fitted where necessary in accordance with [5.1.7.2](#).

5.2.3.5 Miscellaneous

The guiding elements of cars and trains shall ensure that contact with the track is maintained under all circumstances, by provision of side guiding wheels, rollers, up stop rollers, or equivalent systems adequate for the purpose. Special provisions shall be taken in the design of guiding elements in order to ensure that, even in the case of loss of one load wheel, side guide wheel or up stop wheel, the car or train cannot leave the rails. Running wheels, guide wheels, up stop wheels are subject to wear. The permissible wear rates shall be specified by precise limits.

Lateral movement of cars and gondolas shall be restricted to prevent collision with cars or gondolas on adjacent tracks or fixed objects. Safety distances shall be considered by using the extreme positions of the cars or gondolas.

Pendulum gondolas, or similar passenger units, shall be provided with devices for limiting lateral or longitudinal oscillations of the gondola, during passenger loading and unloading (see also [5.1.6](#)).

5.2.3.6 Roller coaster track

5.2.3.6.1 Block zone systems

Requirements are given in [Annex C](#).

5.2.3.6.2 Brakes

Safety brake zones shall be arranged in such a way that there are always sufficient braking elements between any two cars/trains.

Safety brake zones shall be fail safe and designed to stop the car or train in the most unfavourable conditions.

Consequently, the brakes shall not lock or jam and shall be applied in a controlled and progressive manner.

A suitable redundancy of independent brake elements shall be provided, and the brake shall stop the train/vehicle for the most unfavourable condition with sufficient safety margin even in the case of a pressure drop in the brake system or a power loss.

The mechanical parts of the brake elements shall be designed and calculated with the appropriate partial safety factors.

In the event of delays during passenger loading, any risk of collision by following cars shall be prevented with certainty by appropriate means.

All functions and operational states of the safety brake system shall be controlled and monitored by a safety related control system.

Operating fluid pressure and the acceptable pressure limits of each brake element shall be kept automatically controlled by the safety related control system.

Operational brakes shall be provided to stop the cars or trains automatically in the shortest practicable stopping distance, taking into account the maximum permissible deceleration (see [4.4.2.4.4](#)).

Maximum deceleration shall not exceed 0,7 g for an emergency and 0,5 g for normal stopping brakes (service brakes) unless special provisions for passengers are installed (e.g. lap bars).

5.2.4 Dodgem/bumper cars

5.2.4.1 General

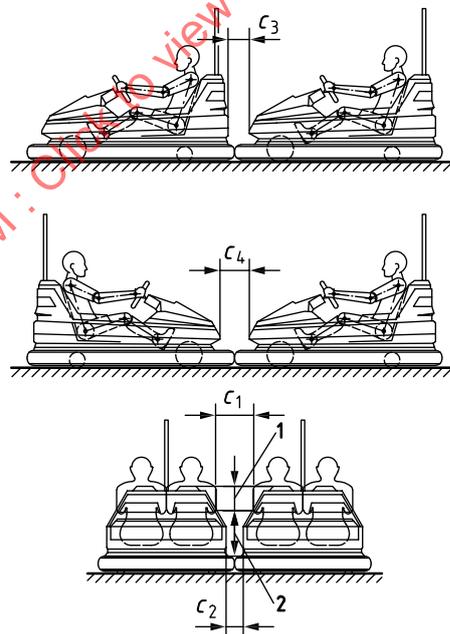
For bumper cars, the minimum safety distances given in Table 14 shall be provided. See Figure 31 and Figure 32.

Table 14 — Distances in mm for dodgem cars

Classes (defined by passenger's height or age)		X	Y	S	R1	R2	C1 ^a	C2 ^a	C3 ^a	C4 ^a
Passengers from 4 to 8 years from 105 cm to 130 cm	min.	70	320	25	175	400	70	45	90	100
	max.	85	400	30	230	515				
Passengers An adult with accompanied child	min.	85	400	30	230	515	85	60	120	150
	max.	100	435	35	275	620				
Passengers ^b	min.	100	435	35	275	620	100	85	140	200
	max.	120	550	50	310	725				

^a C1, C2, C3 and C4 are minimum clearances (empty spaces) between the rigid parts of the bodywork (excluding for example rubber protections which can cause no damage) in a static position.

^b An adult accompanying a small child is also admitted. Seat physical space limiting the weight.

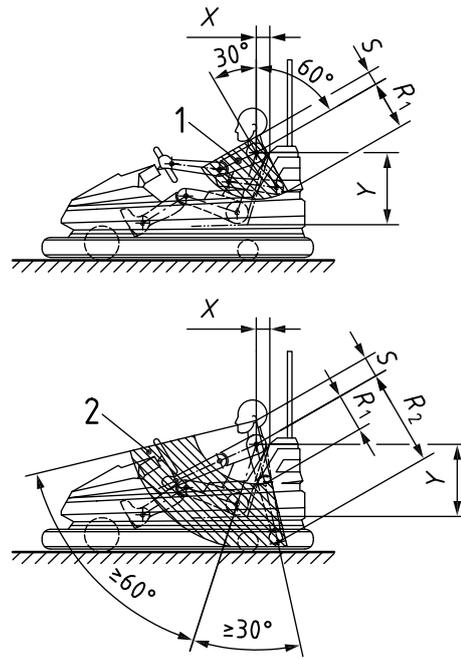


Key

- 1 zone 1
- 2 zone 2

C1 to C4 minimum clearances (see Table 14)

Figure 31 — Dodgem/bumper cars



Key

- 1 zone 1
- 2 zone 2
- X, Y, S, R1, R2 safety distances for dodgem cars (see [Table 14](#))

Figure 32 — Dodgem/bumper cars

5.2.4.2 Area separation system, access and egress openings

Area separation system for the general public to the driving area shall conform to J1 requirements. Access and egress shall conform to K1.

The driving area shall be surrounded by a sill of sufficient height, so as to prevent mounting by the car. The sill shall be strong enough to withstand the impact of the cars at maximum speed.

5.2.4.3 Passenger units

Dodgem car vehicles shall be designed so that passengers cannot fall out. The vehicles shall be surrounded by buffers made of soft material or inflatable tyres, which shall project sufficiently to provide the clearances given in [5.2.4.1](#). The buffers fitted to vehicles which are used on the same ride shall be set at the same height for all vehicles and at the same height as the edge of the sill or barrier.

All moving or other dangerous parts of the vehicles which can cause injury, shall either be

- a) designed so as to remove risk of injury, or
- b) protected so as to minimize injury by impact.

Dodgem cars shall be fitted with safety belts or other equally effective devices which will prevent children from being injured on impact with other vehicles. Where belts are fitted, they shall be at least 25 mm in width.

5.2.4.4 Miscellaneous

The driving area shall be free from discontinuities so as to prevent obstruction to the cars' movement.

Dodgem cars shall be designed in such a way as to minimize the risk of overturning.

The speed of dodgem cars shall not exceed 12 km/h. Cars to be used by unaccompanied children, aged from 8 years to 12 years, shall be limited to a maximum speed of 10 km/h. The driving area shall exclusively be used by unaccompanied children, aged 8 years or less and shall be limited to a maximum speed of 8 km/h. if the risk assessment demonstrates the safe use.

Where high efficiency shock absorbing systems are provided, to ensure that acceptable acceleration levels are not exceeded, the speed may be increased to 14 km/h if the impact forces do not exceed the forces reached in a conventional dodgem car travelling up to 12 km/h. The maximum speed of the vehicles operating on the same track shall not vary by more than 15 %. The mass difference of loaded cars (see 4.3.3.1.2.1) operating on the same track shall not exceed 30 %.

Where high efficiency shock absorbing systems are provided the mass difference may be increased to a value which ensures that acceptable acceleration levels are not exceeded.

The installation shall be fitted with an emergency stop device, which enables the operator to stop all vehicles from his or her control position as quickly as is safely practicable.

5.2.4.5 Electromechanical requirements for dodgem cars

Conducting parts of cars which are not protected from direct touching, shall be powered with a maximum of 25 V AC or 60 V ripple free (max. 10 % ripple) DC supplied by an isolating transformer in accordance with IEC 61558-1 or an equivalent generator.

For those exposed electrical conductors out of normal reach (heights of at least 2,5 m above the floor pan of the vehicle), the maximum voltage shall not be more than 50 V AC or 120 V ripple free DC, i.e. a maximum of 10 % ripple supplied by an isolating transformer in accordance with IEC 61558-1 or an equivalent AC or DC generator.

The overhead current supply net or plate, the collectors on the vehicles and the track shall be designed and built in such a manner that injury is minimized paying particular attention to the eyes as a result of particles and sparks.

For driving areas of up to 200 m² the current supply net or plate shall be securely attached to the power supply at a minimum of two points. For areas greater than 200 m², a minimum of three supply points shall be fitted.

Any current supply net shall be of wire mesh (preferably hexagonal). The diameter of wire should be between 1,0 mm and 1,4 mm. The nominal square hole size of the mesh should not exceed 40 mm × 40 mm.

Steel and other suitable materials (e.g. copper, brass, aluminium) can be used.

Nets shall be tensioned with plates fixed in such a manner that no significant deformation or movement due to the pressure of the collectors occurs.

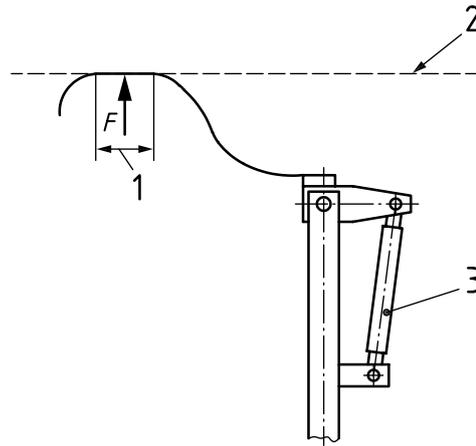
Steel wires shall be galvanised before being joined by the wire wrapping. The current supply net shall be fixed at a uniform distance of not less than 2,5 m above the floor pan of the vehicle.

Any current supply net shall be of galvanised steel or be of a suitable alternative material (e.g. copper, brass, aluminium).

The connections to the net shall be equally spaced around the perimeter of the net or plate.

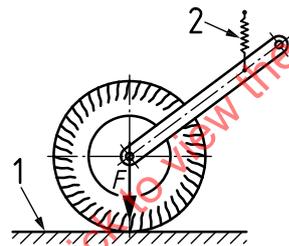
The vehicles shall be equipped with contact brushes made of steel or bronze or the suitable material, which are spring loaded against the floor with a force F of at least 10 N (see Figure 34).

The current collector (see Figure 33) shall be made of a suitable material and formed with the largest radius possible, so as to touch the current collector net at a minimum of three points. It should swivel easily and exert a constant force F on the supply net of at least 10 N.



- Key**
- 1 contact area
 - 2 net
 - 3 spring
 - F contact force

Figure 33 — Example of a typical net current collector



- Key**
- F contact force
 - 1 floor
 - 2 spring

Figure 34 — Contact force of a floor contact brush

The plates which form the track shall be smooth; panels shall have a good electrical contact through the edges or by other means. They shall be connected to the negative pole of the energy source at two opposite points in order to avoid dangerous potential differences.

The plates of the track shall be connected to all metallic surrounding structures.

5.2.5 Speedways/go-karts

These requirements are specific for amusement parks and fairground go-karts.

5.2.5.1 Area separation system, access and egress openings

In order to prevent the general public from walking onto the track, the speedway tracks shall be guarded by a guard rail at least 0,5 m above the sill of the track but in any case at least 1,1 m above the floor level accessible to the public (area separation system conforming to J3 requirements). Access and egress shall conform to K2 requirements. The driving area shall be surrounded by a barrier of

sufficient height so as to prevent mounting by the car. Spring supported barriers are not permitted. The sill shall be strong enough to withstand the impact of the cars at maximum speed.

5.2.5.2 Passenger units

The speedway track and cars shall be designed in such a way as to minimize the risk of overturning. Factors such as speed, inclination, bend radii and width of track shall be taken into consideration. Where overtaking is possible the track shall be at least three times the maximum width of the speedway car.

Speedway cars shall be surrounded by fenders so as to prevent any contact between the respective wheels and/or the frames of the cars.

5.2.5.3 Restraints

Speedway cars shall be provided with adjustable diagonal shoulder belts on each passenger seat of at least 25 mm in width, while respecting the following minimum requirements as defined in [5.1.7.2.2](#).

5.2.5.4 Miscellaneous

The speed of cars running on a speedway shall not exceed 30 km/h.

Cars to be used by unaccompanied children aged 8 years or less shall be limited to a maximum speed of 8 km/h if the risk assessment demonstrates the safe use.

Cars driven by internal combustion engines shall be fitted with a tray beneath the engine and the fuel lines.

The engine shall be positioned so that passengers are not endangered by an engine fire. EN 16230 on fuel-driven engines shall be considered.

The driving area shall be smooth and level and shall be constructed of material appropriate for that purpose.

The installation shall be fitted with a device which enables the operator to stop all vehicles.

5.2.6 Mini-motorbikes for children

5.2.6.1 Area separation system, access and egress openings

To prevent the general public from walking onto the track, the area separation system shall conform to J3 requirements. Access and egress shall conform to K1. The driving area shall be surrounded by a barrier or a sill of sufficient height to prevent mounting by the vehicle. Spring supported barriers are not permitted; special requirements can be given for inflatable barriers. The sill shall be strong enough to withstand the impact of the cars at maximum speed.

5.2.6.2 Passenger units

Mini motorbikes shall be designed in such a way that the risk of overturning is reduced to a minimum.

Mini-motorbikes shall be provided with adequate bumpers, which shall project at least 10 cm beyond the most extreme parts of the vehicle. The bumpers fitted to vehicles which are used on the same ride shall be set at the same height for all vehicles and at the same height as the edge of the sill or barrier.

Careful attention shall be paid to ensure that the motorbike is stable during riding and in case of impacts.

Special precautions shall be taken in order to ensure safe accommodation and protection of passengers. An integrated footrest shall be provided to protect passengers' legs against impact and to prevent passengers from falling.

5.2.6.3 Restraints

There are no special requirements.

5.2.6.4 Miscellaneous

The speed of mini-motorbikes shall not exceed 8 km/h, if the risk assessment demonstrates the safe use.

5.2.7 Boat rides

5.2.7.1 General

Water sports and public transportation are not dealt with in this document.

5.2.7.2 Area separation system, access and egress

On the sides of the waterway there shall be an access area of at least 0,5 m wide at places where the boat is intended to stop.

The landing position shall be clearly marked and shall provide safe and easy access to and egress from the boats by using as a minimum J1 requirements. The gate "K" requirements shall be defined by the risk assessment.

5.2.7.3 Passenger units

See general requirements in [5.1.7](#).

5.2.7.4 Restraints

See general requirements in [5.1.7.2](#).

In water rides, the hazards in case the passenger unit capsizes shall be considered.

5.2.7.5 Miscellaneous

Water depths shall not be greater than technologically necessary. Where water depths exceed 0,7 m, adequate safety measures shall be taken to prevent users from drowning if the boat takes water or capsizes.

Where power driven boats operate in a channel permitting one-way operation only, the speed shall not exceed 15 km/h.

Where free ranging boats operate on an enclosed lake, the number of boats allowed to operate at any one time shall be restricted in accordance with the available water area, in order to ensure safe operation. The following water areas shall be provided as a minimum:

- 15 m²/boat with a maximum speed up to 8 km/h;
- 30 m²/boat with a maximum speed of no more than 15 km/h.

Boats driven by internal combustion engines shall be fitted with a tray beneath the engine and the fuel lines. The engine shall be positioned so that passengers are not endangered by an engine fire. A suitable fire suppression system shall be fitted in the engine compartment.

Facilities shall be provided to recover all boats in case of emergency.

5.2.8 Flume rides

5.2.8.1 Area separation system, access and egress openings

During loading and unloading of passengers, the relative velocity between the boat and the access platform shall not exceed 0,5 m/s.

The minimum distance between the wall of the boat and the wall of the channel shall be 0,12 m, in normal floating conditions (see [Figure 35](#)). In the station area the distance between the wall of the boat and access- respectively egress-platform shall be reduced to approximately 0,05 m. Special consideration shall be given to the change of clearance. The separation system shall meet a minimum of J1 requirements. The K requirements shall be defined by the risk assessment.

The 120 mm requirement is measured when the boat is horizontal. The 120 mm requirement is to avoid the pinch point between the boat and the side of the flume. A risk assessment may show that the reduced clearance can be acceptable. Low risk can be assumed with relative speed up to 3 m/s and mass of the boat. Warning signs and announcements may be acceptable mitigations to warn passengers.

Dimensions in millimetres

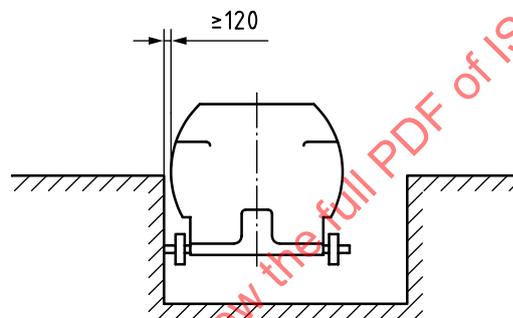


Figure 35 — Minimum distance to channel walls

Normal floating conditions should be measured in straight channel.

5.2.8.2 Passenger units

The boat shall be provided with adequate handrails and footrests in order to allow passengers to brace themselves against forces occurring during boat acceleration and deceleration.

Protection shall be provided in order to prevent damage to passengers seated in the front, if they can be propelled against the front panel.

The gunwale to the seat height is shown in [Figure 36](#).

See also general requirements in [5.1.7](#).

Dimensions in millimetres

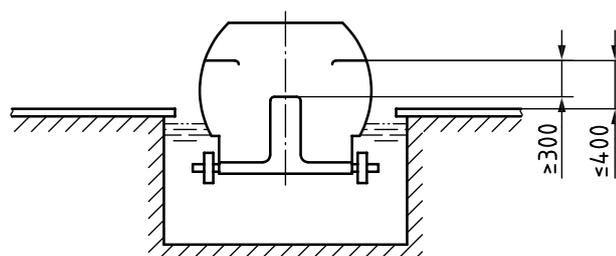


Figure 36 — Minimum and maximum step height and side wall height

5.2.8.3 Restraints

Restraint devices are not allowed on flume ride boats when there is a risk of overturning. If the average longitudinal deceleration during braking does not exceed 0,7 g, the downward slope does not exceed 40° and head-to-foot acceleration is more than +0,2 g in all places, the “restraint rose” (see [Figure 22](#)) shall not be applied.

5.2.8.4 Miscellaneous

Automatic fail safe block-zone systems shall be provided in the channel zones where collisions between boats can injure passengers because of the velocity.

Means shall be provided to prevent collisions at speeds greater than what the bumpers were designed to handle on the lifts or in zones preceding the slopes.

Fail safe means shall be provided to prevent any boat from entering the downward slope block-zone if the minimum water depth necessary for a safe deceleration is not ensured, at the end of the slope.

For general requirements related block-zone systems, see also [5.2.3.6](#).

For block-zone control systems, see [Annex B](#).

Sufficient water quality shall be achieved and kept.

Compliance with EEC directive 2006/7/EC (32006L0007) is recommended.

5.2.9 Helter skelters, slides

5.2.9.1 General

The requirements below are in addition to or prevail over those contained in EN 1176 (all parts). Slides with a height greater than that mentioned in EN 1176-3 are not excluded from being used as amusement devices.

The requirements below are in addition to or prevail over those contained in EN 1176 (all parts) or EN 1069.

5.2.9.2 Area separation system, access and egress openings

In areas where passengers can walk onto the slide area or run out zones area separation systems for the general public shall conform to J3 requirements as a minimum. Access openings to the loading and run out zones shall conform to K2 requirements, in order to prevent crushing of users. Egress openings shall conform to K1 requirements.

5.2.9.3 Passenger units

Means (e.g. sacks, mats, sleds) shall be provided for the user to sit on during the ride, where additional protection is required to protect against splinters and burns.

5.2.9.4 Restraints

There are no special requirements.

5.2.9.5 Miscellaneous

Channels or troughs shall be smooth throughout their entire length. Overlapping is only permitted in the sliding direction. Channel side walls shall be at least 0,45 m high for single channels and well-rounded at the top upper edge.

The end of the slide shall be built in such a way that the user can complete his ride without assistance.

The access platform to the highest part of the slide can deviate from requirements mentioned in [5.1.3.2](#), but the slope shall not exceed the slope of the starting section of the slide (the slide entry). In this area passengers shall walk in single file only.

The longitudinal configuration of the channel shall prevent excessive speeds and account for accelerations exerted on the passenger and the necessary stopping distances. The risk of lift off from the surface shall be reduced to a minimum.

In case of multi-channel slides the internal division (between channels) shall not be less than 10 cm.

5.2.10 Side shows, booths, win-a-prize and sales stands, mazes, halls of mirrors, funhouses, labyrinths, hammers, ring the bell and similar

5.2.10.1 Funhouses

Devices on which users can climb, shall be positioned so that the surroundings take this risk into account. Where falls are foreseeable, e.g. from climbing frames, climbing nets, adventure equipment, in addition to eliminating parts of the structure likely to cause injury, suitable impact absorbing surfaces, shall be provided over a sufficient area.

Where the likelihood of falls is built into the concept, e.g. with inclined rope ladders, especially with swivel retaining devices, then high efficiency absorption material, e.g. deep foam, rubber or inflated mattresses shall be provided.

Smooth and splinter free surfaces (sanded where necessary if wooden) shall be provided to minimize risk of injury. The most favourable materials shall be selected to avoid hostile surfaces, e.g. to avoid material liable to splinter, especially where the body is in close contact with the surface, such as for slides or divisions of slides.

All nails, screws, sharp angled fixtures and fittings shall be recessed, sunken or otherwise protected. Staples holding punchbags, climbing ropes and nets at floor level shall be covered.

Neither hazardous protruding items nor pinch points are allowed. Wherever possible, smooth surfaces shall be provided.

Certain rotating devices, whether power or non-power driven, shall be regulated so as not to exceed the maximum permitted speed. They shall also be provided with a smooth sliding surface and adequate impact absorbing material at the limiting point of travel e.g. on rotating horizontal wheels and cages as well as inclined axis wheels. Any impact absorbing material and the dimensions of the run-out area shall be defined by risk assessment.

Where users transfer from a standing to a sitting position to prepare to descend a slide or inclined tube, adequate safe hand holds shall be fixed at suitable positions and in such a way that they themselves do not cause injury. Loading platforms shall be installed in such places. If the device is only for the use of children up to 10 years of age, minimum dimensions can be found in EN 1176-1).

All power-driven parts of a device shall be analysed for possible trapping or crushing. Emergency stop devices and close operator supervision shall be provided as required. Risks at transitions from moving to stationary surfaces shall be minimized, e.g. by using comb techniques.

Devices not driven by mechanical power, such as roller walkways, horizontal multiple tier rolls, pyramid rolls and rise and fall sections of floor often spring loaded for return, shall have supplementary supports, such as parallel bars for the participants to support themselves. They shall also be provided with additional safeguards so that a person cannot fall through openings in the floor, down stairwells or under rails protecting a gallery. Any foot or toe traps shall be eliminated, especially at any device which is moving under user load.

Devices like swinging platforms or seesaws shall be safeguarded (i.e. fences, area separation) preventing access to their extreme points of travel. Foreseeable abuse of such measures shall be taken into account. Limitation of the arc of travel can be required as well as padding of the extreme ends.

Trampolines and other bouncing devices shall be sited at locations where the surroundings are not likely to produce injuries.

NOTE Supplementary information for trampolines can be found in ASTM F 381 and for inflatables in the ISO 20187 series.

Devices with hinged floors, including those operating by the moving weight of participants require special attention to clearances between their moving edges and the side walls, taking into account the safety of a fallen person, and in particular, children.

Warning notices shall clearly indicate the need to wear footwear on devices such as boardwalks, rocking bridge, stepping stones and steel rollers so as to avoid injuries from splinters, etc.

Warning notices shall clearly indicate “no footwear” devices, such as slides, tubes, rotating barrels, rotating dishes where hard footwear is undesirable as fellow participants can be struck by flailing footwear.

The following legible notice shall be displayed outside such devices:

“This device is only for the use of users in good physical condition and requires sportive actions”.

An essential element of the safe enjoyment of the funhouse environment is an adequate alert supervision. Supervisors shall take immediate action to avoid injury e.g. by stopping a device. He or she shall control unruly behaviour and warn participants of their unsafe acts. Supervision can be supplemented by remote controls such as closed-circuit TV, visual display units or mirrors. Observation points shall be positioned at suitable places which give an overall view of the activities within the funhouse.

5.2.10.2 Hall of mirrors

No steps are permitted in halls of mirrors.

Glass panels shall be made of safety glass.

Neither hazardous protruding items nor pinch points are allowed. Wherever possible, smooth surfaces shall be provided. For additional requirements see also [5.2.10.1](#).

5.2.10.3 Win-a-prize and sales stands

All installations with a ground area of more than 50 m² shall have a minimum of two distinct exits each being at least 1,0 m wide. For more than 100 m² there shall be a minimum of two opposite exits.

Throw a Ball and similar installations shall be equipped with safety nets or walls of sufficient strength so as to protect the general public from injury during operations. The operator's position shall be safeguarded in a similar manner.

5.2.10.4 The hammer, Ring the bell and similar installations

The installation shall be stable or otherwise securely anchored to the ground (see [4.5](#)).

The anvil or striking plate shall be fixed in such a way that it cannot become detached.

The whole amusement device shall be fenced off by means of a perimeter fence. Safety distances from the anvil shall be in accordance with [5.1.4.2.2](#).

Where percussion caps or similar explosive devices are used, adequate protection against splinters and fragments shall be provided around the striking points.

5.2.10.5 Maneges

The ring in circus tents shall be separated from the seating area by a substantially solid barrier at least 40 cm high. For circus tents contrary to 5.1.6.1.3, the admissible number of persons shall be based on the number of seats.

5.2.11 Shooting stands and trailers, shooting devices

5.2.11.1 Area separation system, access and egress openings

Shooting stands shall be completely closed off at the sides and overhead as well as in the direction of shooting. Care shall be taken, by way of structural measures, to ensure that nobody is injured as a result of a shot going astray.

The rear wall of the shooting gallery shall be vertical and of sheet steel at least of 1.5 mm thick.

The side walls and overheads of shooting galleries shall be made from material which can retain the bullets within the gallery.

Steel sheeting shall be firmly fixed to the base on which it is set, and shall show no evidence of being able to move backwards or forwards; screws or nails with domed heads shall not be used. The heads of nails or screws used for fixing the coverings of steel sheet shall be of the countersunk type. Where steel angle is being used, it shall not be inserted in the side turned towards those who are shooting.

For each shooter, a width of at least 80 cm shall be provided. Further area separation systems are not required if the booths or trailers are enclosed as mentioned in the above clauses.

Any access and egress doors in the side walls shall be designed as lockable doors with the same requirements as for the side walls. The maximum angle of opening shall be 90°.

5.2.11.2 Miscellaneous

The lighting shall be adequately protected against erratic or ricochet bullets.

If there are devices for fixing targets in front of the rear wall, means shall be provided to prevent the projectiles from ricocheting (e.g. freely suspended layers of woollen material, tenting material such as twill or jute).

If, however, the target objects are fixed directly onto the rear wall, or there is some other reason why loose layers of material cannot be suspended between the target objects and the rear wall, then the rear wall shall be constructed in such a manner (e.g. using thick steel sheeting, padding at the rear) that dangerous ricochets cannot occur.

Any objects which are suspended, for decorative purposes between the shooting rest and the target, shall be designed or deployed in such a manner that they cannot lead to ricochets; they shall be at a distance of at least 2,5 m from the side of the shooting rest which is turned towards the person who is shooting.

5.2.11.3 Weapons

Only the following types of weapon, which are neither semi-automatic nor fully automatic, shall be used:

- Weapons with a calibre of up to 5,5 mm for which the muzzle energy shall not be more than 7,5 Nm. The trigger shall not be fitted with a hair spring and shall be designed in such a way that the weapon is not discharged as a result of an impact on the barrel or the spring mechanism, or through a relatively small vibration. In the case of those weapons where the gun does not have to be cocked and loaded by hand before further shots can be discharged, the operating personnel shall be able to interrupt the shooting by means of some suitable device.

- Rifles designed for indoor use using rim-firing cartridges of up to 4,5 mm.
- Pistols and other weapons with a length of up to 60 cm may only be used where they are restricted to some fixed field of fire.
- Crossbows for which the kinetic energy of the bolt is not more than 2 Nm.

Weapons can be subject to local regulations.

5.2.11.4 Ammunition

Only the following type of ammunition may be used:

- commercially available soft lead shot, round shot, or diablo shot;
- a 4,5 mm shot rim-fire cartridge with a medium charge as a maximum;
- air rifle ammunition;
- feathered bolts for cross bows.

Ammunition can be subject to local regulations.

5.2.11.5 Targets

Where camera covers and flash bulbs are used in “photo shooting” stands, these shall be designed and fitted in such a way that they cannot burst and so that the shooting pieces cannot ricochet.

The rear wall shall be at least 2,8 m from the shooting rests when using weapons of the compressed air type. The front of the targets shall be at least 2,4 m from the fixed shooting rests.

For live ammunition, the rear wall shall be at least 5,5 m from the fixed shooting rests.

Fittings in shooting galleries onto which tubes for the insertion of flowers and the like are affixed, shall be mounted so that their upper horizontal surfaces are either horizontal or sloped to the rear side. The vertical front side shall be tilted at an angle of at least 20° to the vertical towards the rear, and, where the fitting is not made of steel, it shall be covered with steel sheeting of at least 2 mm in thickness. The distance between the brackets which support them, shall be such that if they are hit by a shot, no vibration occurs.

Fittings in shooting galleries for the purpose of holding targets and the “hit” indicator shall be designed and fitted in such a manner that they can only be brought into action from the shooting rest. The brackets holding the figures used as targets and the devices for supporting these shall be protected from “hits” by suitable constructional measures. The funnel shall be fashioned in such a way that shots which strike it cannot ricochet, even when they strike at an angle. Disc targets and moving targets shall be designed and manufactured in such a manner that shots are not able to ricochet from them, even when they strike at an angle. The targets for feathered bolts shall be of knot free white wood or of a material of equivalent effectiveness.

Shooting stands in which feathered bolts as well as weapons firing soft shots are used, shall be separated into different firing areas by dividing walls.

5.3 Mechanical systems

5.3.1 Hydraulic and pneumatic devices

5.3.1.1 General requirements

The adequate safety of the hydraulic and pneumatic equipment shall be demonstrated by means of construction drawings, calculations, the relevant circuit diagrams and a functional description of the plant.

In case of failure, the devices shall go to a safe state when required by the DRA. A first failure of the system shall be detected. In this case, a subsequent failure shall not be considered in accordance with ISO 4413 and ISO 4414.

5.3.1.2 Design

All rams, cylinders and associated pipework and fittings which are subjected to pressure shall be designed to withstand twice the maximum working pressure for hydraulic equipment and 1,5 times for pneumatic equipment without sustaining permanent distortion or failure. Brittle material shall not be used for cylinders or connecting links. Rams and cylinders shall be mounted so that they are subjected to axial loads only.

Purchased parts off the shelf (e.g. valves) shall be designed in accordance with ISO 4413 and ISO 4414.

5.3.1.3 Travelling limits

Effective means shall be provided to prevent rams from travelling beyond the limits of the cylinder. A separate mechanical stop is not necessarily required.

5.3.1.4 Piping

Piping shall be supported so that undue stresses are eliminated. Particular attention shall be paid to joints, bends and fittings, and at any section of the system subject to vibration.

Piping shall be mounted in such a way as to allow the inspection of the pipe and particularly the joints as much as possible.

5.3.1.5 Hoses

The nominal pressure of the hoses shall be greater than the maximum operating pressure of the system. The burst pressure of the hose shall be five times higher than the nominal pressure. Particular attention shall be paid to joints, bends and fittings, and at any section of the system subject to vibration. The type of hose shall be selected according to the requirements of the system (compatibility with hydraulic fluid used, etc.). Hoses shall be installed so as to prevent sharp bends and chafing or trapping due to moving parts of the machine. The manufacturer shall specify the intervals at which the hoses should be replaced.

5.3.1.6 Reservoir

Reservoirs for hydraulic fluid shall be of rigid construction, having adequate and effective venting to the atmosphere. The inner covering of the reservoir shall withstand the chemical characteristics and temperature range of the fluid.

An air filter, a fluid strainer and a level indicator shall be provided. The reservoir for normal operation shall have at least 10 % more capacity than that necessary to guarantee an uninterrupted flow of the fluid to the pump. A label showing the correct type of hydraulic fluid shall be clearly displayed on the system.

5.3.1.7 Venting

The hydraulic circuits shall permit the release of air and as such can require a purging system.

5.3.1.8 Pressure limits

The hydraulic or pneumatic system shall incorporate a pressure relief valve fitted between the pump and the non-return valve. The relief valve shall be set to a pressure of not more than 10 % (pneumatic) or 20 % (hydraulic) higher than the highest normal working pressure but at a pressure higher than that required to prevent the relief valve blowing off during normal working conditions. The strength of the cylinders shall be calculated using 1,4 times the working load. There shall be a fatigue calculation for cylinders.

5.3.1.9 Fail to safe

If a dangerous situation occurs due to the failure of piping or hoses, a non-return valve, a flow control valve or a pipe break valve shall be fitted directly to the cylinder.

5.3.1.10 Checking

Provisions shall be made in the hydraulic system for the fitting of a pressure gauge to facilitate checking of the working pressure and the setting of the pressure release valve.

5.3.1.11 Lowering

In the event of failure or malfunction of the hydraulic or pneumatic system the maximum lowering speed shall not exceed 0,5 m/sec for any part of the passenger-carrying equipment, unless shock absorbing devices or other equivalent systems are installed to prevent undue shocks to passengers.

5.3.1.12 Protection

All safety related valves shall be protected against unauthorized resetting.

5.3.1.13 Emergency

Where necessary a manually operated emergency system shall be fitted, in order to facilitate the recovery of passengers from a dangerous position in the case of system power supply failure.

5.3.1.14 Cleanliness

All filters shall have a sufficient degree of filtration and shall be mounted on the pressure side of the pump. The mounting of a filter in the piping returning to the reservoir shall be avoided, when a safe position of the system is dependent on an unrestricted flow of the medium back into the reservoir. All fluids shall be filtered, when put into the system. Each system put into operation, shall be of a cleanliness commensurate with the components

5.3.2 Lifting and elevating units being integral part of an amusement ride

5.3.2.1 General

These lifts are an integral part of the amusement devices. If they are required for general lifting purposes, they shall be designed accordingly.

5.3.2.2 Hoist units — Brakes

Hoist units (rope and chain hoists) shall be equipped with effective brakes or other equivalent devices, capable of stopping the movements of the equipment and its loads safely at its rated speed and maintaining it in its stopped position.

In case of power loss all brakes shall adopt a safe state. This can be closed or open, depending on risk assessment.

The hoist unit shall be designed in order to ensure that a single point failure cannot dissociate the brake and the drum or sprocket.

5.3.2.3 Limitation of the lifting and lowering movement

To guard against malfunction of the control system, devices according to IEC 60204-32 shall be provided, and shall include:

- preliminary switches for initiating a controlled stop towards the upper and lower hoist limits;
- operational limit switches which prohibit incorrect hoist drive direction at the hoist travel limits;
- ultimate limit switches of the safety type with direct mechanical actuation, which disconnect the main electrical supply from the hoist. The actuators of these switches shall be independent of other switches;
- mechanical top and bottom limit stops.

5.3.2.4 Overload protection

If there is a danger due to overloading, machines shall be equipped with appropriate overload protection systems. This is not applicable when the number of persons is limited or fixed by the number of seats, rests or places provided.

5.3.2.5 Slack rope or chain protection

The machine shall be equipped with a slack rope or chain detection device which, when actuated, cuts out all operational movement except at creep speed, unless it can be shown that a slack rope or chain cannot occur under any operational condition.

5.3.2.6 Safety devices

Machines with a lifting carriage which is intended to carry people and which can be raised more than 1,5 m shall be equipped with a safety device(s) against over speed caused by failure of the suspension and mechanical units (e.g. chain, rope, drive gear, counterweight) or a redundant system for the lifting device shall be designed:

- The safety system shall operate, by means of an over speed governor, at a speed no higher than 1,4 times the rated speed.
- When there is more than one safety system, their actuators shall be mechanically connected to ensure they operate simultaneously.
- Operation of the safety system shall interrupt power to the hoist unit.
- Slackening or breaking of the over speed governor rope or chain, shall interrupt power to the hoist unit.

For hoist units using power screws, rack and pinion drives, directly acting hydraulic or pneumatic drives equivalent safety means shall be provided (see [5.3.2.7](#) to [5.3.2.10](#)).

The structural, fatigue, control and operational issues and properties of all involved components shall be verified.

5.3.2.7 Suspension elements

Hoist units using rope or chain systems shall be dimensioned in accordance with the load spectrum and operating time class. The ratio between the minimum breaking load of a rope or chain and the maximum force in the rope or chain shall be at least 6 for hoist units intended to carry people and at least 5 for other hoist units.

If a detailed fatigue life calculation taking into account the realistic chain/rope parameters is performed and a sufficient safety factor against the minimum replacement frequency of one year is achieved, the safety factor of the above sentence need not be observed. The application of this method requires visual and non-destructive inspections as determined by the life calculation.

All ropes or chains of one lifting unit shall be of the same size, quality and construction.

The tensile strength of the wires of suspension ropes shall not be less than that of a nominal strength category of 1 570 N/mm².

Rope drums shall be provided with grooves. At least two turns of rope shall still be on the drum when the lifting carriage is in its lowest position.

The ratio of the diameter of pulleys and drums measured at the centre line of the rope and the nominal diameter of a rope is expressed as (D/d) .

Existing wire rope standards shall only be used if the conditions of application can be shown to be valid for the intended use. In all other cases fatigue calculations shall be made to justify (D/d) , taking into account effects including: rope speed, type of rope, dynamic performance, stress range spectrum and number of load cycles.

(D/d) can be determined for the following categories:

Category A — lifting device without passengers or persons exposed to it;

Category B — lifting device with passengers with a speed $v \leq 1$ m/s and a lift height less than 2 m;

Category C — lifting device with passengers or persons exposed to it and speed $v > 1$ m/s or a lift height more than 2 m.

Lifting devices in category A and category B (D/d) shall be calculated taking into account the relevant parameters.

In category C, a detailed fatigue calculation shall be performed and the ratio (D/d) shall be not less than 30.

Means shall be provided to equalize the tension of the ropes or chains where more than one rope or chain is fixed to one suspension point.

Only leaf or roller type chains shall be used as suspension elements.

Wire rope pulleys, chain wheels or sprocket wheels shall be provided with guards to prevent the ropes or chains from leaving the grooves or teeth.

Rope or chain termination shall have a minimum breaking load of at least 80 % of the minimum breaking load of the rope or chain.

5.3.2.8 Hydraulic drives

For these types of elevating units see also [5.3.1](#). The lifting units shall be designed so that in the event of hydraulic leakage, no dangerous situation occurs.

For hoist units directly operated by cylinders, valves shall be fitted to prevent uncontrolled lowering in case of pipe or hose failure.

5.3.2.9 Power screw drives

To evaluate the design stresses in power screws and nuts, a fatigue and static calculation shall be performed for the material used in accordance with [4.7](#).

The power screw mechanism shall be designed to prevent separation of the lifting carriage from the mechanism during normal use.

Each power screw shall have a safety nut of equivalent material and size to the load bearing nut. The safety nut shall only be loaded if the load bearing nut fails. It shall not be possible to raise the lifting carriage from its access position when the safety nut is under load. The power screw shall have higher wear resistance than the nuts.

It shall be possible to inspect the wear of the load bearing nuts without major disassembly.

Power screws shall be fitted with devices at both ends to prevent the load bearing and safety nuts from travelling beyond either end.

5.3.2.10 Rack and pinion drives

To evaluate the design stresses in rack and pinion drives, a fatigue and static calculation shall be performed for the material used in accordance with [4.7](#).

Any driving or safety pinion shall always be engaged with the rack with at least 2/3 of the tooth width and 1/3 of the tooth depth.

Visual examination of the pinions shall be possible with neither the removal of the pinions nor major disassembly of structural components.

5.3.2.11 Pneumatic drives

For these types of elevating units see also [5.3.1](#). The lifting units shall be designed so that in the event of pneumatic leakage, no dangerous situation occurs.

For hoist units directly operated by pneumatic devices, appropriate means shall be fitted to prevent uncontrolled lowering in case of pipe or hose failure.

5.4 Manufacture and supply

5.4.1 Manufacturer

5.4.1.1 General

The manufacturer shall ensure that all requirements within the design specification are fully incorporated into the completed amusement device, and the quality of the construction meets the design specification.

The execution of structural steel components designed according to EN 1993 (all parts) shall be in conformance with EN 1090-2.

The execution of structural aluminium components designed according to EN 1999-1-1 shall be in conformance with EN 1090-3

Machinery components may be designed and shall be manufactured in accordance with the requirements defined by the designer's assessment.

NOTE Technical Specification CEN/TS 17959 on Manufacturing Quality Recommendations for Machinery Components will be published soon.

5.4.1.2 Requirements for the personnel

The manufacturer shall ensure that persons engaged in the manufacturing of the amusement devices are competent to carry out the work.

An appropriate welding coordination shall be performed according to ISO 14731.

Welders and welding operators shall be qualified and certified according to ISO 9606-1 (steel) and/or ISO 9606-2 (aluminium) and/or ISO 14732.

The non-destructive testing (NDT)-personnel shall be qualified and certified in accordance with applicable international or national standards, e.g. ISO 9712, minimum level 2.

Any assembling, modification, adjustment or alteration of parts shall only be done by persons with appropriate experience and be approved by the designer.

5.4.1.3 Subcontracting and supply

Safety-related materials, parts, assemblies, or components shall be made in accordance with the design specification and quality requirements.

Such parts shall be clearly defined by manufacturers, subcontractors and suppliers.

There can be a need to be individually identified to enable them to be traced throughout the manufacturing process, including the identification of the raw material.

The identification marks position on the parts shall be clearly specified, authorized by the designer and agreed between the ordering and supplying parties. The marking method and the areas where the marks should be executed shall not affect in any case the fatigue life of the component.

5.4.2 Quality assurance — Quality plan

5.4.2.1 General

Only competent persons shall be engaged in the manufacture of amusement devices. Particular attention shall be paid to the inspection of components and raw material, including consumables, both when manufactured in-house and subcontracted. Where the design or specification indicates that certain parts are safety-related and has specified certain tests, the manufacturer shall ensure that all the requirements of the tests are fulfilled.

NDT techniques are required for certain aspects of manufacture. The manufacturer shall reach the specified level of quality required for each component of the ride and determine the standard of manufacture necessary to achieve this, in accordance with design specification.

5.4.2.2 Material Quality requirements

As minimum requirements for safety-related components the following standards shall be applied for the different quality assurance processes:

If the design of safety-related components requires the use of plates and wide flat bars of minimum thickness 10 mm, for welded cruciform joints transmitting primary tensile stresses through the plate thickness, the requirements in EN 10160 or EN 10164, or other comparable national standards can apply.

Plates and wide flat bars in load-bearing structures which are loaded in the thickness direction with tensile forces shall be suitable for this special requirement. Safety-related axles, shafts, bolts and pins

Ultrasonic testing of the primary material, penetration or magnetic particle testing after machining is required. Acceptance class 4 for testing according to EN 10228-1, EN 10228-2 and EN 10308 is recommended.

5.4.2.3 Certificates

The quality of steel and/or aluminium for load bearing members and standard mechanical components, if there is no agreed or general method of calculation, shall be verified by the inspection certificate 3.1 according to ISO 10474:2013 or equivalent. Certificates for load bearing welded components shall include the chemical analysis, the mechanical and technological properties and the value of the carbon equivalent CEV.

Hydraulic or pneumatic hoses, cylinders and rams, hooks, safety hooks, shackles, roller buckles or other accessories shall be considered as accepted if they are marked by the manufacturers, according to existing standards.

Ropes, chains for example, shall be supplied with certificates showing at least the guaranteed minimum breaking load, type and size.

Safety related components shall be supplied with certificates or declarations showing, as a minimum, conformity to the design specifications.

5.4.2.4 Documentation for quality management

The manufacturer shall provide quality documentation in accordance with EN 1090. These documents will be part of the technical dossier.

As a minimum, the following points shall be documented:

- a) an organization chart and a list of managerial staff responsible for each aspect of the manufacturing process;
- b) procedures, methods and work instructions to be applied;
- c) an inspection plan specific to the work;
- d) a procedure for handling changes and modifications;
- e) a procedure for handling non-conformities, requests for concessions and quality disputes;
- f) specified hold-points or requirements to witness or test, and any consequent access requirements;
- g) certificates for materials, components and fire rating, when risk of fire is significant and requested by the DRA;
- h) inspection and test reports.

5.4.3 Manufacturing process

5.4.3.1 General

Manufacturers shall not deviate from the requirements laid down by the designer. If difficulties in manufacture arise due to circumstances not foreseen by the designer, the manufacturer shall not make modifications to alleviate the difficulties without first consulting with and obtaining the agreement of the designer.

5.4.3.2 Durability

The designer shall specify the method of protection, the areas and frequency of inspection. All components shall be protected against degradation caused by corrosion or rot by an approved method. [For steel, see ISO 12944 (all parts)].

NOTE EN 1090-2:2018, Annex F, is a reference for corrosion prevention. Deviation can be necessary since certain requirements cannot be applicable due to special requirements for amusement devices.

Where hollow section structural steel is used, internal corrosion shall be avoided.

Protection of aluminium structures and components shall be achieved through coating, anodizing and passivation, in accordance with EN 1090-3:2008, Annex F, unless otherwise specified.

For aluminium, the inner surface of hollow sections only requires a protective treatment if expressly specified.

5.4.3.3 Welding procedure

The welding procedures for the materials being used shall be defined by the qualified welding coordination personnel.

When and if necessary, a welding sequence plan shall be created for the welded assemblies before the start of production.

Special investigation shall be done and approved by the designer where a change in welding procedure can affect stress and fatigue properties.

5.4.3.4 Steel welding

Welding preparation shall be specified in accordance with ISO 9692-1, ISO 9692-2 and ISO 9692-3.

Welding quality shall be specified in accordance with ISO 3834-2, ISO 3834-3 and ISO 3834-4.

Welders and welding operators shall be approved in accordance with ISO 9606-1 and/or ISO 14732 depending upon the classification of the part.

Welding of steel parts for amusement devices, especially when operating under fatigue conditions, shall be conducted in accordance with ISO 3834-2.

5.4.3.5 Aluminium welding

Welders and welding operators shall be approved in accordance with ISO 9606-2 and/or ISO 14732.

Welding quality shall be specified in accordance with ISO 3834-2, ISO 3834-3, ISO 3834-4.

Welding of aluminium parts for amusement devices, especially when operating under fatigue conditions, shall be conducted in accordance with ISO 3834-2.

5.4.3.6 Standards and requirements for non-destructive testing of welds

The provisions of ISO 17635 shall apply. In addition:

- All steel welding of dynamic loaded parts shall meet the requirements of ISO 5817, quality level B.
- All welding of statically loaded parts and subordinate components shall meet the requirements of ISO 5817, quality level C.
- All aluminium welding of dynamically loaded parts shall meet the requirements of ISO 10042, quality level B.

- ISO 17635, Annex A, provides cross-reference from ISO 5817 to applicable magnetic particle tests (MT), penetration tests (PT), ultrasonic tests (UT) and radiographic tests (RT) standards, including acceptance levels which should be considered as the minimum necessary.

5.4.3.7 Plastic composites

Safety critical load bearing composites such as fibre reinforced plastics shall only be fabricated by manufacturers who have the facilities and personnel to maintain the quality as specified by the designer.

In all cases, adequate information on the particular plastics, additives and reinforcement which are specified in the design and are to be used in manufacture, shall be obtained from the supplier by material certificates or from test results. The manufacturing process shall be adequately specified and controlled to ensure consistency of properties in the finished article. A permanent record shall be kept of all the essential data concerning the production of load bearing composites, such as:

- material of reinforcement, fibres, additives, resins,
- temperature, humidity, environmental conditions,
- type of manufacturing process, number of layers, type of fibres, and
- composite samples of each different construction provided for tests.

5.4.3.8 Safety precautions to be taken by the manufacturer

All parts of the amusement device which require maintenance and/or inspection, shall be provided with safe and easy means of access and a safe working position for maintenance staff.

Due to the variety of the amusement devices, this document cannot go into detail about technical precautions for working activities.

The manufacturer shall provide the necessary information, primarily in the manuals (see [5.5.1](#)), required to develop an individual risk assessment of safe working procedures for employees and operators. The controller develops this risk assessment in accordance with the local workplace legislation.

It is advised to take into account the aesthetic impact of these measures and in such cases mobile platforms, or other means can be considered as an alternative.

5.4.3.9 Electrical installations

For electrical installation and components, see [Annex A](#).

5.5 Documentation supplied with amusement device

5.5.1 Manuals

5.5.1.1 General

Comprehensive instructions concerning assembly, operation and maintenance shall be provided by the designer. Special advice or details of special qualifications required by personnel shall be given. These instructions shall be written in the language of the user or in other language agreed by the parties.

The reference of the instructions (e.g. edition, revision) shall be added to the amusement device log.

The manual shall provide, as a minimum, the instructions stated hereafter.

5.5.1.2 Assembly and dismantling instructions

These instructions shall comprise:

- a specification of the special equipment, tools, material or parts which shall be used for safe assembly or dismantling of the amusement device;
- an advice concerning foundation preparation (if permanently fixed);
- the sequence of erection to maintain stability;
- jacking and packing procedures to facilitate levelling, out of level tolerances, advice on suitable packing and its limitations, load spreading and any necessary ballasting requirements;
- correct methods for connecting electrical systems to the power supply and methods for interconnecting subassemblies, if appropriate;
- torque settings for structural screws or bolts and required greasing and tests;
- schedules of tests and inspection to ensure correct functioning;
- earthing details for lightning protection in accordance with [Annex A](#);
- plans of the amusement device, showing recommended packing points and details of maximum loads that can be applied at these points.

Any foundation preparations should also be shown on the plan.

5.5.1.3 Operating instructions

These instructions shall comprise:

- a detailed explanation of the controls and their function;
- recommended passenger access and egress procedures and any limitations necessary to prevent static overload of the device;
- the prescribed limiting conditions stating any limitations for passengers (if any), the limits of speed of operation, the cycle time and the maximum numbers of passengers to be carried;
- any limitations regarding permissible partial loading or asymmetric loading of the device;
- details of the passenger restraint system, and guidance on its use;
- emergency evacuation procedures, including evacuation following a power source failure;
- any environmental limitations, e.g. conditions of wind, rain, during which the ride should not be operated.

5.5.1.4 Maintenance instructions

These instructions shall comprise:

- a list of those components requiring regular lubrication, the types of suitable lubricant, and the frequency of lubrication;
- a detailed explanation of the controls and their function with respect to inspection and maintenance;
- a list of those components which require regular replacement, giving the periodicity of replacement, preferably expressed in service hours;
- acceptance criteria for worn parts, showing details of the areas to be measured;

- a list of those components which require regular inspection, the recommended frequency of inspection (preferably expressed in service hours), the schedule of NDT and the method of inspection e.g. visual;
- safety-related components with limited lifetime;
- a list of any specific tests to be carried out;
- recommendations concerning electrical testing. These instructions shall meet the requirements of IEC 60204-1;
- the testing of insulation resistance, conductor continuity, protective conductor continuity and proving the effectiveness of residual current circuit breakers where fitted;
- methods for proving the effectiveness of any interlocking circuits or controls;
- recommendations regarding electrical maintenance;
- safe electrical isolation procedures

5.5.2 Special information

This information shall include:

- an advice, that parts shall not be replaced without ensuring that they conform with the original specification;
- special requirements for the preparation for operation of the device including the method to be adopted for examination;
- details of the maintenance, service or repairs which may be conducted by the user or competent persons, and the necessary details.

5.5.3 Drawings and diagrams

These items shall comprise:

- an outline drawing of the amusement device showing the principal dimensions when erected and recommended safe clearance distances for the amusement device when in motion;
- diagrams of all control systems (hydraulic, pneumatic, electrical/electronic) using standardized symbols.

5.6 Design documentation

5.6.1 General

For review of the design document, ISO 17842-3 shall be used.

The manufacturer of amusement devices shall include all the safeguarding arrangements such as guards necessary for dangerous parts of the machinery, including power units and transmission machinery as specified by the designer.

The operator's position shall be arranged so as to ensure easy and safe control of the amusement device.

The designer or the controller shall take into account the need of the operator to have a clear and unobstructed view of all areas important for safety as determined by the OURA.

The operator's position shall be provided with safe and easy means of access and be adequately illuminated.

EN 1837 can be used if the correct operation of the amusement devices depends on lighting.

All safety relevant design documents shall be available and include where relevant:

- design risk assessment;
- design calculations;
- stress and fatigue analysis of:
 - structural and mechanical parts,
 - hydraulic and pneumatic parts,
 - drive units, bearings, and
 - brakes and safety devices;
- design drawings;
- acceleration/containment details;
- hydraulic/pneumatic specification;
- electrical/electronic specification, including software details of safety-related control systems (SRCS);
- mechanical/structural specification;
- installation, operation, maintenance and inspection information.

5.6.2 Description of installation and technical specification/information

The description shall give information concerning the installation, operation and maintenance of the device.

It shall also describe the stages of installation, operation and maintenance processes.

It shall indicate the type of device, the main design characteristics, possible varying installations, the main dimensions and the clearance requirements, if exceeding the main dimensions, the boundary protection or fencing required, the dimensions of exits and entrances, the working and operating process, the motion systems, operation modes, speeds, accelerations and possible restrictions concerning the use of the device.

The function of the hydraulic/pneumatic equipment and its combined effect with the electric system shall be described, unless it is clear from the connection diagram.

The electrical wiring diagram or supplementary descriptions shall clearly show:

- the type of electric current, nominal voltage, load current, type and load of the voltage transformer, converter or generator and illumination;
- the type of safety measures and methods used to prevent indirect and/or accidental contacts with conducting elements.

The safety devices, which are or become effective in exceptional situations (e.g. measures which allow the safe stopping of all movements of the equipment in case of drive failure), shall be sufficiently clearly indicated or described.

Information on emergency situations and evacuation procedures and equipment shall be clearly indicated or described.

5.7 Amusement Device log

5.7.1 General

The amusement device log for the amusement ride or device will be delivered by the manufacturer in the language of the user or other languages agreed by the parties. See [Annex D](#).

It shall clearly identify the amusement device and contain a summary of the technical and operational data.

The user shall add the history, records of all repairs, modifications, inspections, tests and checks and the detailed reports thereof, including an excerpt of the design documents which provide information for identification and inspection, by the inspection bodies. The amusement device log shall be available on each installation site for maintenance, tests, inspections and checks. All inspection reports shall be included by appropriate entries.

5.7.2 Content

The device log shall comprise at least the following documents:

- a) device log index;
- b) name and identification;
- c) manufacturer;
- d) device description;
- e) record of ownership;
- f) national registration details;
- g) technical data and requirements:
 - speed limits;
 - general passenger use limitation;
 - general passenger size/age limitation;
 - a reference wind velocity specified for the amusement device;
 - any snow load restrictions;
 - any restrictions due to seismic activity;
 - other restrictions if any;
- h) data availability;
- i) record and reports of initial acceptance tests;
- j) record of required inspections (NDT);
- k) record; reports and results of inspection, tests, thorough examinations and inspections;
- l) record of all unscheduled maintenance; repair and modification affecting the safety of the amusement device;
- m) revision;
- n) records of failures;
- o) record of all installations at fairs or permanent parks;

- p) records of accidents;
- q) records of service bulletins of ride manufacturer;
- r) records of safety alerts of ride manufacturer;
- s) initial test report;
- t) record of all scheduled maintenance operations;
- u) report list;
- v) declaration of operation authorization;
- w) extension of operation authorization;
- x) blank pages for insertion/attachment of acceptance reports. Technical documentation, certificates, notes etc.

5.8 Official technical dossier

5.8.1 General

For each amusement device a technical dossier shall be established by the manufacturer which shall comprise the design documents to provide detailed information with respect to design, calculation, method of construction, instructions and information relating to operation and maintenance and inspections by inspection bodies. The technical dossier shall be kept by the designer and/or the manufacturer with copies to the reviewing inspection body. All initial approval and inspection reports shall be included therein.

NOTE The technical dossier can be used as a "safety justification of the amusement device".

5.8.2 Content

The technical dossier shall comprise at least the following:

- design and operation descriptions including limitations e.g. max operational wind speed;
- design drawings (presentation of the key dimensions of the entire facility printed in a legible format and scale);
- detail drawings (with the dimensions and the material of all the components and their connections and all subassemblies in an adequate legible format and scale);
- stress analysis including fatigue analysis (comprehensive calculation documents);
- risk assessment for the ride when in operation;
- examination and approval reports as well as reports on any other inspections;
- all circuit diagrams for electric, control and hydraulic or pneumatic components or equipment;
- layout drawings of the escape routes and their dimensions with calculated verification for enclosures with more than 400 occupants. Special instructions for cases of fire;
- all certificates for material, components and fire rating;
- an operation or instruction manual written in the language of the user or an agreed language covering installation and dismantling of parts and mobile amusement devices, maintenance and operation and a list of all parts requiring periodic replacement;

- all initial inspection and approval reports as well as reports on any other initial inspections and manufacturing tests and inspections.

5.8.3 Identification marking

Each amusement device shall be fitted with an identification plate showing the following information:

- name and address of the manufacturer and/or importer/supplier;
- type/model no.;
- manufacturer's serial no.;
- month and year of the manufacture;
- date of initial approval;
- approval mark if requested /no. of inspection body;
- safe working load/number of persons to be carried.

Enclosures and booths shall be marked with

- name and address of the manufacturer/supplier/importer, and
- month and year of the manufacture.

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Annex A (normative)

Electrical equipment and control systems

A.1 Electrical equipment

A.1.1 General

This section specifies requirements for the design and installation of electrical equipment used in amusement rides or devices from the point of electrical power connection through the amusement ride or device.

It is aimed at minimising the risk of injury from electric shock, burn, arcing and explosion, as well as protecting the equipment in amusement rides or devices from the effects of over current, overvoltage and similar disturbances.

The electrical installation shall conform to IEC 60204-1 except where extended or modified by the following.

A.1.2 Protection against electric shocks

A.1.2.1 General

Exposed metalwork shall be guarded against becoming live under faulty conditions: for AC by a system of earthed equipotential bonding and automatic disconnection, and for DC by isolation from earth. Key points are:

- unless the equipment is double- or all-insulated, the supply shall be connected to exposed metalwork by a circuit protective conductor;
- suitably rated protective devices, such as fuses and circuit breakers, shall be installed on the supply to ensure that it disconnects if there is a short circuit, earth fault or overload;
- for public or equivalent private power supply, the electrical equipment shall have provisions for the circuit protective and bonding conductors shall be connected to the earth, or to earth rods, at the power source.

For transportable amusement rides and devices and amusement rides containing power branches with submersible consumers, only the following protective measures against indirect contact in accordance with IEC 60364-4-41 are permitted:

- protection through automatic disconnection of the power supply or each branch by means of RCDs or RCMs in TN and TT systems with a maximum leakage current 300 mA (unless a specialized equipment requires a higher value) and a total earthing resistance of $\leq 30 \Omega$;
- protection by using equipment of safety class II or equivalent insulation;
- protection through SELV or PELV systems.

Protection through FELV systems shall not be used.

For transportable amusement rides and devices, IEC 60364-7-740 shall be applied.

A.1.2.2 Sliding contacts

Sliding contacts, for example slip rings, live rails and pick-ups, shall be protected to a minimum of IP2X with the following exceptions:

- a) Rails, conductive floors and ceilings connected to a SELV/FELV or a PELV source where the maximum voltage is 25 V AC or 60 V DC with a maximum of 10 % ripple without protection against direct contact.
- b) Dodgem cars if the requirements in [5.2.4.5](#) are met.

Where additional protection is required, the rails shall be positioned so that the entry is on the side or below to prevent the accumulation of dust or water.

A.1.2.3 Earthing systems

The ride shall only be connected to a supply that has an earthing system that meets the requirements of IEC 60364-4-41.

Bonding conductors and bonding equipotential conductors shall be designed and installed and shall meet the requirements of IEC 60364-5-54. Moreover, slotted, pinned, bolted or similar mechanical connecting methods on the rides and/or structure may be used provided continuity of the bonding conductor can be verified.

A rotating bearing shall not be used as a method of protective bonding of adjacent conductive parts which rotate.

A.1.3 Protection against lightning

Protection against lightning shall conform to IEC 62305 (all parts).

A.1.4 Lighting

A.1.4.1 General

All parts of the amusement ride or device to which the public and staff have access and all external exit ways shall, if intended for use in the absence of daylight, be provided with lighting capable of providing sufficient illumination of those parts for people to leave the amusement device safely.

When lighting appliances are within reach, additional protection (e.g. plastic caps) shall be applied, if they can give rise to a risk from electric shock, burn or breakage.

In deviation to IEC 60204-1, stroboscopic effect lighting is permitted to be used on amusement rides and devices. If used, the effects of stroboscopic effect lighting upon the specified suitable population for the ride shall be considered (e.g. to take account of medical conditions such as epilepsy).

A.1.4.2 Emergency lighting

For amusement rides and devices to be operated in enclosed structures or in absence of daylight, emergency lighting shall be provided in accordance with EN 50172.

If at any time there is a failure of the normal lighting, the parts of the structure affected, including any exit signs shall immediately be illuminated by alternative means.

Emergency lighting can be supplied from the same source as the normal lighting but shall be capable of being backed up by an independent supply for a sufficient duration. The independent supply shall be brought into operation immediately and automatically in the event of failure of the normal supply for enclosed structures.

A.1.5 Generators

Generators shall be positioned to minimize risks from hot surfaces, dangerous parts, overheating and exhaust products. Associated electrical equipment shall be mounted so as to minimize the effects of vibration.

When a generator is used to power the amusement device, the system shall be preferably TN-S. The neutral conductor of the star-point of the generator shall, except in the case of an IT system, be connected to the exposed-conductive-parts of the generator. IT should only be used if there is no other alternative earthing system possible.

A.1.6 Heaters and light fittings

Heaters and light fittings shall be placed out of reach in a manner which minimises the risk of fire. They shall be securely attached to supports strong enough to withstand winds, protected against rain unless designed for such exposure and not carried by cable conductors, unless the cable is designed for that purpose. If the voltage exceeds 25 V AC, cables, which have been previously used with spiked lamp holders, shall not be used.

A.1.7 Communication means

All amusement rides and devices shall have a suitable means for the operator to communicate to passengers, unless risk assessment shows it is not necessary.

Communication means wiring shall be suitably protected for the unique operating condition if the system is used to provide audio notification announcements for safety, operation and evacuation.

A.2 Control systems

A.2.1 Safety-related control system (SRCS)

A.2.1.1 General

This section applies to the design and manufacture of safety-related control systems.

It applies to all control systems, e.g. manual, electrical, electronic, hydraulic, pneumatic, mechanical, from the sensor up to and including the actuating device.

The design and construction of a SRCS shall follow a documented process which demonstrates that due diligence is applied to the evaluation and mitigation of identified hazards and their associated risks.

If the SRCS detects failure modes that would degrade the performance of a safety function, such that continuing safe operation is not ensured, the SRCS shall:

- Notify operators of the presence of the failure mode.
- Discontinue the operation which relies upon the safety function in a manner consistent with the risk assessment.
- Confirm the detected failure of the component or equipment in question is no longer present before resuming operation which relies upon the safety function.
- SRCS incorporating pneumatic, hydraulic and mechanical elements shall be in accordance with ISO 13849-1 and with the risk assessment conducted in accordance with ISO 12100.
- SRCS incorporating electrical electronic and programmable electronic elements shall be in accordance with either ISO 13849-1 or IEC 62061 and with the risk assessment conducted in accordance with ISO 12100. Guidance on the selection of the appropriate standard can be found in the ISO/TR 23849.

A.2.2 Safety-related control functions

A.2.2.1 General

Safety-related control functions shall be periodically verified by a method determined by the risk assessment. This verification shall be possible without modifying the control system.

Where the risk assessment shows as necessary, interlocking and monitoring devices shall be selected and positioned so that they are not easily or accidentally defeated or interfered with by persons riding in or on the amusement device.

The designer shall specify, for inclusion in the operations manual, the limits of any adjustments, safety parameters, and any necessary checks and/or tests needed to confirm the correct adjustment and operation of the interlocking and/or monitoring system.

Safety-related control functions shall be designed to support continuous mitigation of the hazard consistent with the risk assessment. This mitigation shall be supported in the absence, onset, and in the presence of foreseeable failures of the devices used by the function.

Safety-related control functions shall be individually identified by the designer/engineer, including the potential hazards that are related to each function.

A.2.2.2 Start functions

The SRCS shall be designed to a sufficient integrity in order to prevent risks associated with the unexpected start or acceleration of the equipment.

The equipment shall not be caused to start or accelerate unless

- commanded to do so by an operator, and/or
- the start is in accordance with the expected operation.

Start functions shall require a deliberate attendant action when the previous stop

- results from a loss of power,
- places riders in a normal rider loading or unloading area, and the equipment stops for a period of time that exceeds a reasonable expectation for an automatic re-start,
- is a stop category 0 or category 1 according to IEC 60204-1.

A.2.2.3 Evacuation

When passenger evacuation is necessary after a stop function or fault, which results in an equipment orientation that prevents safe passenger evacuation from the amusement ride or device, the design shall provide with an equipment reorientation sufficient to support safe evacuation. This provision can involve additional safety-related control functions. This provision shall use, in order of preference:

- a) load/unload position(s);
- b) planned alternative evacuation areas (e.g. evacuation platforms);
- c) other evacuation areas.

A.2.2.4 Stop functions

If required, as a result of a risk assessment, the SRCS shall have the following stop functions available: “operational stop function”, “emergency stop” and “emergency switching off”. The initiation of these stops can either be by human intervention or by SRCS. Stop functions shall have priority over the corresponding start functions.

The stop functions shall meet the following requirements:

- “stop function” as specified in IEC 60204-1;
- “emergency switching off” as specified in IEC 60204-1;
- “emergency stop” as specified in IEC 60204-1.

Each amusement ride or device shall be equipped with a supply disconnecting device according to IEC 60204-1:2005, 5.3.

A manual stop function shall be initiated by a single human action.

Manually initiated stop functions shall be continuously available in all operating modes in which the stop is relevant.

When controls for initiating a specific stop function are available at more than one location, a command from any of the stations shall initiate the stop function irrespective of activities at other stations.

Each operating console shall provide controls that initiate a stop of all ride devices in the zone of attendant awareness at that console. The controls at that console can stop the ride device motion in other areas.

Unexpected start shall not be allowed by the SRCS under stop conditions and shall meet the requirements of ISO 14118.

Recovery from stops cannot be done by raising button: a secondary deliberate action is required to initiate motion.

Stop functions caused by the SRCS due to fault detection require a deliberate action to recover and/or reset the system.

A.2.3 Safety-related parameters

Means shall be provided to ensure that the values of the safety-related parameters stay within predetermined levels defined by the risk assessment.

Where speed is a safety-related parameter, speed control shall prevent hazardous consequences on structures and passengers.

The following speeds shall be considered:

- minimum operational speed — the minimum speed necessary to ensure, for a stated operational condition, the safe containment of passengers and the intended function and the integrity of the amusement device;
- maximum operational speed — the maximum speed at which, for a stated operational condition, the safe containment of passengers and the intended function and the integrity of the amusement device are ensured during repeated or sustained use;
- maximum achievable speed — the maximum value of speed achievable by an amusement device element, without any restriction or control.

For a particular part of the ride cycle, there can be different operating speeds. In particular the following criteria shall be applied to prevent the amusement ride or device operating outside the design parameters:

- If the device either fails to achieve a minimum operating speed after a predetermined time, or the speed falls below the minimum operational speed, then the SRCS shall perform an appropriate stopping function.
- If the speed of the device rises above the maximum operating speed, then the SRCS shall perform an appropriate stopping function.

The risk assessment shall evaluate the effects on the amusement device and passengers due to any achievable speeds.

If the maximum achievable speed is greater than the maximum operational speed, additional means can be necessary to ensure that the maximum operational speed is not exceeded. The requirement and integrity of these means shall be determined by the risk assessment.

A.2.4 Passenger restraints

Where a control system is involved in the operating, interlocking or monitoring of passenger restraints, its function and integrity shall be determined by a risk assessment.

A.2.4.1 Safety integrity requirements

In accordance with ISO 17842-2:2022, 4.5, the attendant is responsible to ensure that the passenger is properly seated and restraint prior to enable a new ride cycle.

For restraint lock/unlock control circuit based on the applicable restraint class, the design requirements in [Table A.1](#), [Table A.2](#) and [Table A.3](#) shall be applied.

Table A.1 — Restraint lock/unlock control

Restraint class				
1	2	3	4 ^a	5 ^a
SIL: n/a or PL _r : a	SIL: 1 or PL _r : b	SIL: 1 or PL _r : c	SIL: 2 or PL _r : d	SIL: 3 or PL _r : e
^a Additional requirement for classes 4 and 5: control circuit architecture shall be of dual channel or fault tolerance of 1. SIL safety integrity level. PL _r (required) performance level.				

Table A.2 — Minimum closed restraint position feedback

Restraint class				
1	2	3	4	5
None	None	None	Single channel circuit without automated diagnostic	Single channel circuit with automated diagnostic prior to new ride cycle start

Individual Minimum closed restraint position feedback indication shall not be visible for seat checking attendant.

Collective individual minimum closed restraint feedback indication position is allowed.

Table A.3 — Restraint latching/locking device feedback

Restraint class				
1	2	3	4	5
None	None	Redundancy check ^a	Redundancy check ^a	Redundancy check ^a or direct lock position monitoring ^b
^a The integrity of the redundant locking device shall be verified within certain time intervals, which shall be determined by the mechanical design. ^b Direct position monitoring of the mechanical locking device ("tooth engaged").				

A.2.4.2 Loss of power

Loss of the power supply shall not

- cause the release of restraint devices,
- prevent the intentional release of restraint devices when required to ensure the safety of the passenger or for operational purposes, e.g. manual release.

A.2.5 Fall Prevention

Where a control system is involved in the operating, interlocking or monitoring of passenger compartment guards or doors, its function and integrity shall be determined by a risk assessment.

A.2.5.1 Safety integrity requirements

In accordance with ISO 17842-2, the attendant is responsible to ensure that the passenger is properly placed inside the compartment prior to enable a new ride cycle.

A.2.5.1.1 Guard/door lock/unlock control circuit

The following minimum design requirements shall be applied based on the max potential fall height:

- If max. potential fall height <2m: SIL n/a or PLr a.
- If max. potential fall height \geq 2m: SIL 1 or PLr c.

A.2.5.1.2 Guard/door position feedback circuit

Based on the maximum potential fall height, the following minimum design requirements shall be followed:

- If max. potential fall height <2m: n/a.
- If max. potential fall height \geq 2m: Single channel circuit without diagnostic.

A.2.5.1.3 Guard/door latching/locking device feedback circuit

Based on the maximum potential fall height, the following minimum design requirements shall be followed:

- If max. potential fall height <2m: Periodic check.
- If max. potential fall height \geq 2m: Redundancy check or direct lock position monitoring.

Periodic check: The integrity of the latching/locking device shall be verified within certain time intervals, which shall be determined by the design.

Redundancy check: The integrity of the redundant locking device shall be verified within certain time intervals, which shall be determined by the design.

Direct lock position monitoring: Direct position monitoring of the mechanical locking device prior to new ride cycle start.

A.2.6 Inhibiting of safety functions

The inhibiting of safety functions shall be done in accordance with the requirements for muting of safety functions as described in ISO 13849-1 and in IEC 60204-1.

In addition to ISO 13849-1, if it is necessary to manually suspend safety functions, e.g. for set up, adjustments, maintenance, and repair, the following criteria should be applied:

All procedures of this type shall be performed under the authority and supervision of authorized personnel.

- The number of personnel required, and method of muting safety function (e.g. key, code) depends on the risk assessment.
- After muting or inhibiting safety functions, the SRCS should limit the duration of possible cycling and/or inhibit the procedure to change operational mode, until safety functions have been returned to normal configuration.
- After each of these procedures/interventions, functional testing of normal mode operation shall be properly performed prior to running the amusement ride with passengers.
- Effective and secure means to prevent manual suspension in those operating modes where it is not allowed.

In addition, consideration can be given to the provision of one or more of the following:

- Initiation of motion by a hold-to-run device or by a similar control device.
- A portable control station (e.g. pendant) with an emergency stop device and, where appropriate, an enabling device. Where a portable station is in use, motion can be initiated only from that station.
- Limitation of the speed or the power of motion.

A.2.7 Operating modes

A.2.7.1 General

Control systems shall have one or more operating modes, relevant for their application.

Operating modes can be divided into:

- pre-operating modes (without passengers) such as for setting, adjustment, programming, testing, cleaning, maintenance, trouble-shooting and repair;
- operating modes such as manual, semi-automatic and automatic cycle, for operation with passengers. There may be variations and combinations of operating cycles;
- non-operating modes where the pre-operating or normal operating mode is not possible due to abnormal circumstances.

A.2.7.2 Operating mode selection

A change of operating mode shall not cause a hazardous condition. It can be necessary to:

- bring the ride to a stop, requiring an operator start command to restart the ride, following a change of operating mode;
- prevent inadvertent change of operating mode; or
- bring a change of operating mode to the attention of the operator.

The appropriate mode selector shall be located so that it can be operated safely – in particular, not accidentally.

Mode selection by itself shall not lead to initiation of motion of any physical unit (PU). A separate deliberate action is required.

Indication of the selected operating mode shall be provided (e.g. the provision of an indicating light, or a visual display indication).

A.2.7.3 Pre-operating mode

In pre-operating mode, the following conditions shall be met:

- one authorized person shall be in overall control;
- depending on the risk assessment, the control of more than one subsystem which can cause a hazard shall either be prevented by the SRCS or be under the sole control of a single operator;
- depending on the risk assessment, safety-related functions shall either continue to operate or be under the sole control of a single operator;
- all system emergency stops shall remain effective.

A.2.7.4 Operating modes

There can be more than one operating mode. These modes enable the amusement device to operate only after an initiation by the operator or under his or her supervision.

These modes are the only modes which are allowed for normal operation with passengers, and all the safety functions shall be active.

In general, operating modes can include:

- manual, if all operating cycles are under the control of the operator;
- semi-automatic, if part of the operating cycle is controlled by means of one or more automatic programs;
- automatic, if all operating cycles are controlled by means of one or more automatic programs.

In operating modes, the following requirements shall be met:

- the cycle shall be initiated by the operator unless in special cases (such as continuous loading and unloading) where the risk assessment allows it;
- means shall be provided to prevent the cycle time exceeding a predetermined value based on passenger discomfort;
- the selection of other operating programmes shall not cause a hazard;
- amusement rides or devices in which loading and unloading occur without the device coming to a stop, so that the device does not need a cycle start, shall be provided with a built-in device or procedures to ensure that the operator maintains his or her supervision of the ride.

A.2.7.5 Non-operating mode

The amusement device is considered to be in a non-operating mode if, for example, the following occurs:

- loss of power;
- restoration of power after a supply failure;
- actuation of emergency stop;
- initiation of a safety stop.

The SRCS shall ensure that

- at any point in time, the state of the amusement device in non-operational conditions does not lead to a hazard, and

- after a safety stop, an emergency stop or an equivalent event during operation any safety critical parameters and data in the control system (preset or otherwise) shall be maintained until the installation is returned to its normal operating mode.

During the slowing and the stopping of the ride:

- a safe sequence of events shall be followed;
- the constraints set by the minimum operational speed, applicable at the time, shall be conformed to.

Where loss of power can result in a dangerous condition, a reserve of energy for the control system and if necessary for the drives shall be available to provide the power necessary to enable the ride to be brought to rest and remain at rest.

In the non-operating mode, the following conditions shall be met in addition to the ones required for the pre-operating mode:

- Operations, whose combination can simulate the operating mode or can lead to hazardous conditions, shall be allowed only in confirmed discrete steps by the SRCS. Suitable means shall be provided to ensure that each separate operation is deliberately actuated.
- Where an override of a safety function is required to recover passengers, this special procedure shall be performed by an authorized operator and be visually monitored either by that operator or by a subordinate in good communication with him or her.

A.2.8 Collision prevention safety function

A.2.8.1 General

Where required by a risk assessment a means of preventing unintentional collisions shall be provided.

An example of such means is given in [Annex C](#).

A.2.8.2 Requirements

The collision prevention safety function shall always be active in any passenger-carrying operating mode.

Loss of power (electrical, hydraulic or pneumatic) shall not lead to a loss of the collision prevention safety function.

On restoration of power a deliberate action shall be required for movement of any PU.

A.2.8.3 Requirements for safety-related powered stopping and slowing devices

Powered safety-related stopping and slowing devices (brake when energised) are allowed provided the following requirements are met:

- The control and command circuits (electrical, hydraulic or pneumatic) shall operate the stopping device in their de-energised state.
- The control and command circuits (electrical, hydraulic or pneumatic) shall operate the stopping device in the case of a failure of their components.
- The loss of power (electrical, hydraulic or pneumatic) from any unit shall not affect the operation of the other stopping devices.

Powered lifting or shifting devices can be used as stopping devices under the following conditions:

- The device shall have the ability to halt the PU in such a position that it is not possible for any external influence such as environmental conditions or change in load to cause it to continue.

- The device shall be de-energised by suitable means, and the PU shall be prevented from reversing in a dangerous manner by a safety device (e.g. anti-rollback).
- The device, as well as any control circuits (electrical, hydraulic or pneumatic) shall either cause the passenger-carrying unit to stop within safe limits in de-energised states, or if any elements are energised to cause the stop, then an adequate level of safety should be provided by means such as redundancy.

An electronic device can be used to bring the motor speed to zero. Such motors shall be disconnected in accordance with stop category 1 of IEC 60204-1. If the device has a safe torque off as specified in IEC 61800-5-2 which fulfils the required SIL/PL, a stop category 2 according to IEC 60204-1 is sufficient.

Any device used for trimming shall be taken into account by a safety-related control function, if:

- trimming has safety implications;
- it is also used as a stopping device.

A.2.8.4 System validation

Validation shall be in accordance with either ISO 13849-2 or IEC 62061.

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Annex B (informative)

Control systems — Best practices

B.1 Security

The SRCS should incorporate some means of ensuring only authorized personnel can power-up/control-on the amusement device.

EXAMPLE Key switches, passwords, sequence of operations.

B.2 Example block-zone logic

A block-zone control system consists of the partial or complete subdivision of the rail or channel into block-zones, each of which should not be occupied by more than one PU at the same time.

The number of block-zones into which the rail or channel is subdivided should be sufficient to prevent unsafe collisions.

The integrity level of the system should be evaluated based on PLr or SILr.

In some devices, dependent on the risk assessment, closer spacing of the PUs may be allowed in one or more of the areas with safety being ensured by other means. For example, speed may be restricted to allow PUs to come into contact with each other at station areas or immediately before a lift in a log flume.

A block-zone control system should be based, as a minimum, on the following elements:

- means of signalling the occupied status of a block-zones e.g. occupancy sensors;
- means of signalling the clear status of a block-zone e.g. clearance sensors;
- logic solver;
- devices which can stop the PU, e.g. stopping devices.

A block-zone control system should detect the separation of a group of PUs at every block transition.

When the PU has left the block-zone, a signal should be sent to the control logic about the cleared status of the block-zone.

The control system should prevent entry into a block-zone with a detected failure.

On restoration of power including electrical, hydraulic or pneumatic, if there is no automatic system to ensure the safe restart of block-zone operation, the system should prevent the opening of brakes unless they are opened manually. If an automatic restart is provided, it should be initiated manually.

The anti-collision function of the block-zone system should not be deactivated at any time unless DRA and OURA allow it.

B.3 Recommendations for the positioning of sensors and stopping devices

Stopping devices should be located so that, after a stop, the PU, in normal conditions, can be restarted safely.

In any block-zone clearance sensors should be located so that if the PU stops for any reason as soon as it leaves the block-zone, the following PU should be prevented from colliding with it even if stopped in the most unfavourable condition or position possible.

The occupancy and clearance sensors should be located so that a block-zone in which a PU is entering is indicated as occupied before the previous block-zone is indicated as cleared.

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Annex C (informative)

Guidance on design of passenger containment

The passenger containment system should be designed to contain safely all passengers for whom the manual and device log states that the ride is suitable. The following contains recommendations to design safe passenger containments.

Containment systems shall ensure secure and safe accommodation for passengers at all stages during the ride cycle and the operational situations specified in this document, e.g. the application of emergency brakes.

Safe and secure accommodation includes preventing injury from the following causes when used as specified:

- a) ejection;
- b) moving into a position of danger, i.e. from where passengers can fall or be injured by contact with static or moving parts;
- c) physical injury within the confines of the passenger unit;
- d) injury from powered restraints;
- e) injury on boarding or leaving.

The containment system should be designed around the passenger. The designer should:

- specify the suitable population characteristics for the ride, e.g. maximum and minimum size/weight;
- identify the size and direction of forces to be exerted on passengers;
- identify the parts of the passengers' bodies which require support for each anticipated force;
- use body size data appropriate to the specified suitable population, identify the maximum and minimum dimensions of the containment system necessary to contain passengers' safety. [Table C.1](#) to [Table C.3](#) in conjunction with ISO 7250-1 and ISO/TS 17929 indicate some of the important dimensions. Statistical summaries of body measurements from national populations can be found in ISO/TR 7250-2;
- design the system to contain safely all passengers who are allowed by the manual, amusement device log or technical dossier to use the ride.

Any component that plays a role in directly protecting a riding passenger from the risks identified above [see a) to e)] should be considered part of the containment system.

All passengers within the size limits specified in the manual, amusement device log or technical dossier shall be able to reach all parts of the containment system necessary for their safety. Typical parts and their requirements are:

- seating should be based on ergonomic criteria and provide support for all body parts susceptible to injury;
- footwells should permit all passengers to brace themselves using their feet where the risk assessment shows this to be necessary;

- grabrails should be within easy reach of the passengers, easy to hold and not be a source of injury e.g. during an emergency stop;
- restraint systems designed as an integral part of the containment system.

For the manual, amusement device log or technical dossier, the designer shall submit the technical data on which the design of the containment system is based.

Table C.1 — Containment system components

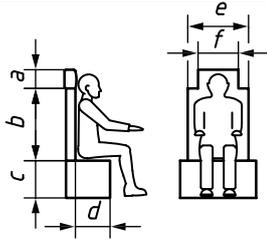
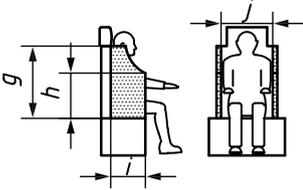
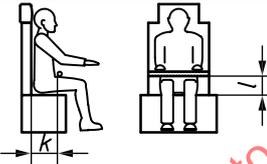
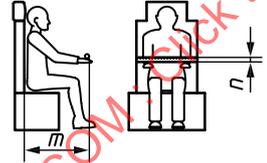
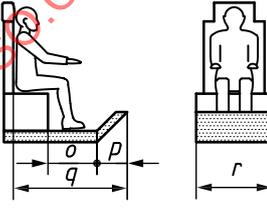
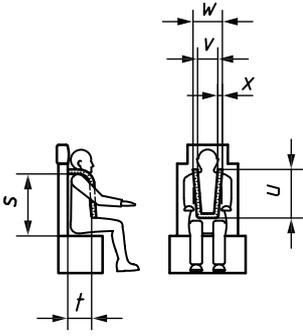
Component		Description
Seating		a
		b
		c
		d
		e
		f
		g
		h
		i
		j
Lap bar		k
		l
Handrail		m
		n
Footwell		o
		p
		q
		r
Over shoulder		s
		t
		u
		v
		w
		x

Table C.2 — Body dimensions

Measurement (see Figure C.1)	Body dimension
<i>a</i>	Shoulder - crown
<i>b</i>	Sitting shoulder height
<i>c</i>	Popliteal height
<i>d</i>	Buttock – popliteal length
<i>e</i>	Shoulder breadth (bideltoid or bi-deltoid)
<i>f</i>	Head width
<i>g</i>	Sitting shoulder height (deltoid)
<i>h</i>	$g/2$
<i>i</i>	Buttock – popliteal length
<i>j</i>	Shoulder breadth (bideltoid or bi-deltoid)
<i>k</i>	Abdominal depth
<i>l</i>	Thigh clearance
<i>m</i>	Forward reach
<i>n</i>	Grip diameter
<i>o</i>	Knee height
<i>p</i>	Foot length, Heel ball length
<i>q</i>	Hip height
<i>r</i>	Foot breadth, hip breadth
<i>s</i>	Sitting shoulder height
<i>t</i>	Chest depth
$u = b - l$	Sitting shoulder height – thigh clearance
<i>v</i>	Head width
<i>w</i>	Interacromion
<i>x</i>	Shoulder length (to acromion)
<i>y</i>	Thigh to toe length
<i>z</i>	Body height

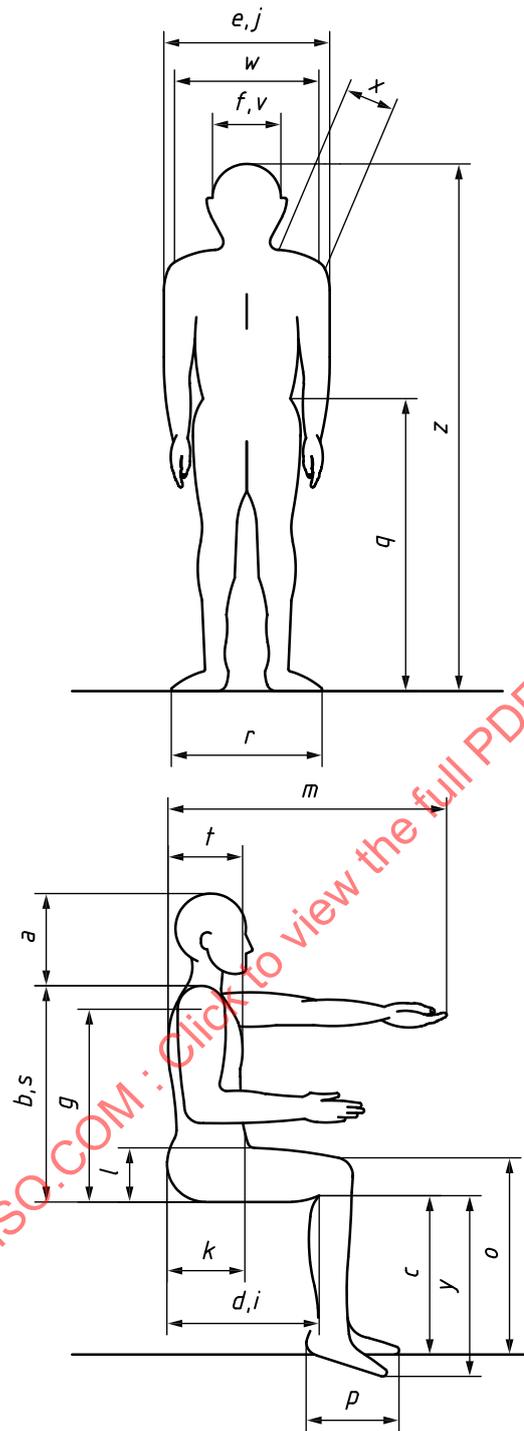


Figure C.1 — Body dimensions ([Table C.2](#))

Table C.3 — Body dimensions and suggested ranges

Measurement	Body dimension	Containment component adjustable	Percentile range
<i>a</i>	Shoulder to crown	No	95th
<i>b</i>	Sitting shoulder height	No	95th
<i>c</i>	Popliteal height	No	5th
<i>d</i>	Buttock popliteal length	No	5th
<i>e</i>	Bi-deltoid	No	95th
<i>f</i>	Head width	No	95th
<i>g</i>	Sitting shoulder height (deltoid)	No	95th
<i>h</i>	$g/2$	No	95th
<i>i</i>	Buttock - popliteal	No	95th
<i>j</i>	Shoulder breadth (bi-deltoid)	No	95th
<i>k</i>	Abdominal depth	Yes	5th-95th
<i>l</i>	Thigh clearance	Yes	5th-95th
<i>m</i>	Forward reach	Yes (no)	5th to 95th (50th)
<i>n</i>	Grip diameter	No	5th
<i>o</i>	Knee height	Yes	5th to 95th
<i>p</i>	Foot length, Heel ball length	No	95th
<i>q</i>	Hip height	No	95th
<i>r</i>	Foot breadth, hip breadth	No	95th
<i>s</i>	Sitting shoulder height	Yes (no)	5th to 95th
<i>t</i>	Chest depth	Yes	5th to 95th
<i>u</i>	Sitting shoulder height - thigh clearance	Yes (no)	5th
<i>v</i>	Head breadth	No	95th
<i>w</i>	Interacromion	No	50th
<i>x</i>	Shoulder length (to acromion)	No	95th

Annex D (informative)

Amusement device log for an amusement device

The following example shows the minimum content of a device log. The format can change especially if a computer file is used.

TITLE	Page
AMUSEMENT DEVICE LOG -	...
NAME AND IDENTIFICATION	...
DESCRIPTION OF THE AMUSEMENT DEVICE	...
RECORD OF OWNERSHIP	...
NATIONAL REGISTRATION DETAILS	...
TECHNICAL DATA AND REQUIREMENTS	...
DATA AVAILABILITY	...
RECORD AND REPORTS OF INITIAL ACCEPTANCE TESTS	...
REQUIRED INSPECTIONS (NON-DESTRUCTIVE TESTING OR VISUAL) (minimum 2 pages)	...
RECORD; REPORTS AND RESULT OF EXAMINATIONS; TESTS; THOROUGH EXAMINATIONS AND INSPECTIONS CONDUCTED BY OR FOR PURPOSES OF AUTHORITIES (minimum 10 pages)	...
RECORD OF ALL UNSCHEDULED MAINTENANCE; REPAIR AND MODIFICATION AFFECTING THE SAFETY OF THE AMUSEMENT DEVICE (minimum 10 pages)	...
RECORD OF SCHEDULED MAINTENANCE OPERATIONS (minimum 10 pages)	...
REVISIONS (minimum 10 pages)	...
RECORD OF FAILURES / ACCIDENTS (minimum 2 pages)	...
RECORD OF ALL INSTALLATIONS AT FAIRS OR PERMANENT PARKS (minimum 10 pages)	...
RECORD OF SERVICE BULLETIN ISSUED BY AMUSEMENT DEVICE MANUFACTURER (minimum 2 pages).	...
RECORD OF SAFETY ALERTS ISSUED BY AMUSEMENT DEVICE MANUFACTURER (minimum 2 pages)	...
REPORT LIST (minimum 4 pages).	...
DECLARATION OF OPERATION AUTHORIZATION OR PERMIT	...
EXTENSION OF OPERATION AUTHORIZATION OR PERMIT	...
BLANK PAGES FOR INSERTION / ATTACHMENT OF ACCEPTANCE REPORTS TECHNICAL DOCUMENTATION; CERTIFICATES; NOTES; etc.: (minimum 30 pages)	...

DO NOT REMOVE ANY PAGE FROM THIS AMUSEMENT DEVICE LOG –

...

Total number of pages:

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DESCRIPTION OF THE AMUSEMENT DEVICE

Insert the description of the ride on this page

(image or layout)

(Description)

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RECORDS OF OWNERSHIP

Name and address of owner	Date of transfer of ownership	Transfer of ownership noted by (issuing authority)
Original owner		
By order of (name and address of the applicant) the ownership of the amusement device is transferred to:		
Next owner:		
Any conditions of the transfer:		
Amusement device log n°	No. volume n°	

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NATIONAL REGISTRATION DETAILS

NOTE Record of any registration required in terms of national legislation.

State; authorities; etc.:	Registration details and number	Date	Conditions of registration and authorization	Comments and signature of the issuing body

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TECHNICAL DATA AND REQUIREMENTS

1-General outline dimensions	Notes
Diameter (m)	
Length (m)	
Width (m)	
Maximum height (m)	
Weight (exclusive/inclusive any supplementary devices) (kg)	
2-Operating site – Minimum dimensions	
Length (m)	
Width (m)	
Height (clearance minimum) (m)	
3-Electrical power requirement	
Power type (indicate phases n°, neutral requirement, etc.)	
Voltage (V)	
Frequency (Hz)	
Rated power (kW, kVA)	
Maximum power (kW, KVA)	
4-Passengers access	
Number of passengers permitted ON or IN the amusement device at one time/per loading (n°)	
Number of passengers permitted within the vehicles, gondolas, etc. (n°)	
Restrictions, if any, on passengers, e.g. age, health, height, etc.	

TECHNICAL DATA AND REQUIREMENTS (continued)

5-Operation requirements		
Maximum operational speed (if applicable)	(rpm, m/s)	
Recommended running speed (if applicable)	(rpm, m/s)	
Direction of rotation (if necessary)	(CW, CCW)	
Maximum cycle time for ride operation	(s)	
Maximum wind speed permitted in operation state	(m/s)	
Maximum out of service wind speed permitted / wind zone	(m/s)	
Minimum ground bearing capacity (for recommended packing or base)	(daN/cm ²)	
Minimum number, size and rating of fire extinguishers to be carried		
Further conditions or requirements to be observed		

NOTE Particular requirements can be enforced as conditions of registration in some states.

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DATA AVAILABILITY

Indicate here which data were supplied with the amusement device log and/or the amusement ride or amusement device and should remain with it

Document	Pages/ amount	Title and date of issue	Location of the documents	Notes
Assembling/dismantling instructions				
Description of the amusement device				
Operation manual or instructions				
Maintenance manual or instructions				
Periodic safety inspections check list				
Emergency procedure check list				
Engineering calculations				
Listing of components which, if subject to failure, can lead to danger				
Drawings: — general arrangements, assembly — detail or component drawings — electrical wiring diagrams — further drawings (hydraulic, pneumatic, etc.)				
Initial examination reports				
Initial design review reports				
Excerpts of international and national codes, guides or standards necessary for the operation of the amusement device				
Any other data and documentation required				

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RECORD AND REPORTS OF INITIAL ACCEPTANCE TESTS

Name of testing, authority and person		
Location where test has been conducted		
Test procedure		
— Full load	Done	Per cent of full load
— Partial load	Done	Per cent of full load
— Unbalance/stability	Done	Per cent of full load
Comment		
Limitation if any		
Any other relevant comment		
Test Date		
Signature of tester		
Signature of witness (if any)		
Witness date (if any)		

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REVISIONS (minimum 10 pages)

The amusement device, or its parts, needs a manufacturer's (or its authorized services) revision, in accordance with following table:

Group	Part	Type of revision	Frequency	See report no./ title/ date	Notes

NOTE Anomaly or bad functioning can require unscheduled revisions.

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RECORD OF ALL INSTALLATIONS AT FAIRS OR PERMANENT PARKS (minimum 10 pages)

Place	From - to	Registered by

Place	From - to	Registered by

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