INTERNATIONAL STANDARD

ISO 17842-1

First edition
2015-07-01

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

STANDARDSISO.COM : Click to view the full PDF of ISO 17842-1:2015

Reference number
ISO 17842-1:2015(E)

© ISO 2015

STANDARDSISO.COM : Click to view the full PDF of ISO 17842-1:2015

COPYRIGHT PROTECTED DOCUMENT

© ISO 2015, Published in Switzerland

All rights reserved. Unless otherwise specified, no part of this publication may be reproduced or utilized otherwise in any form or by any means, electronic or mechanical, including photocopying, or posting on the internet or an intranet, without prior written permission. Permission can be requested from either ISO at the address below or ISO's member body in the country of the requester.

ISO copyright office
Ch. de Blandonnet 8 • CP 401
CH-1214 Vernier, Geneva, Switzerland
Tel. +41 22 749 01 11
Fax +41 22 749 09 47
copyright@iso.org
www.iso.org

 © ISO 2015 – All rights reserved

Contents

Page

STANDARDSISO.COM : Click to view the full PDF of ISO 17842-1:2015

STANDARDSISO.COM : Click to view the full PDF of ISO 17842-1:2015

© ISO 2015 – All rights reserved

STANDARDSISO.COM : Click to view the full PDF of ISO 17842-1:2015

© ISO 2015 – All rights reserved

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 documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2. www.iso.org/directives

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received. www.iso.org/patents

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

For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: Foreword - Supplementary information

The committee responsible for this document is ISO/TC 254, *Safety of amusement rides and amusement devices*.

ISO 17842 consists of the following parts, under the general title *Safety of amusement rides and amusement devices*:

— *Part 1: Design and manufacture*

— *Part 2: Operation and use*

— *Part 3: Requirements for inspection during design, manufacture, operation and use*

STANDARDSISO.COM : Click to view the full PDF of ISO 17842-1:2015

© ISO 2015 – All rights reserved

Safety of amusement rides and amusement devices —

Part 1: Design and manufacture

1 Scope

This part of ISO 17842 specifies the minimum requirements necessary to ensure the safe design, calculation, manufacture, and installation of the following: mobile, temporary or permanently installed machinery and structures, e.g. roundabouts, swings, boats, Ferris wheels, roller coasters, chutes, grandstands, membrane or textile structures, booths, stages, side shows, and structures for artistic aerial displays. The above items, hereafter called *amusement devices* or simply "devices", 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. Fixed grandstands, construction site installations, scaffolding, removable agricultural structures and simple coin operated children's amusement devices intended for up to 3 children are not covered by this document.

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

Existing national rules on workers' safety are not concerned by this document.

This document is applicable to amusement devices and major modifications of amusement devices and rides manufactured after the effective date of its publication.

ISO 17842-3 contains requirements for inspection during design, manufacture, operation and use.

2 Normative references

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

EN 288-9, *Specification and approval of welding procedures for metallic materials — Part 9: Welding procedure test for pipeline welding on land and offshore site butt welding of transmission pipelines*

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 3834-1, *Quality requirements for fusion welding of metallic materials — Part 1: Criteria for the selection of the appropriate level of quality requirements*

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

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

STANDARDSISO.COM : Click to view the full PDF of ISO 17842-1:2015

© ISO 2015 – All rights reserved

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

ISO 4017, *Fasteners — Hexagon head screws — Product grades A and B*

ISO 4018, *Hexagon head screws — Product grade C*

ISO 4032, *Hexagon regular nuts (style 1) — Product grades A and B*

ISO 4034, *Hexagon regular nuts (style 1) — Product grade C*

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 5817:2014, *Welding — Fusion-welded joints in steel, nickel, titanium and their alloys (beam welding excluded) — Quality levels for imperfections*

ISO 7250 (all parts), *Basic human body measurements for technological design*

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 9712:2012, *Non-destructive testing — Qualification and certification of NDT personnel*

ISO 10042:2005, *Welding — Arc-welded joints in aluminium and its alloys — Quality levels for imperfections.* Corrected by ISO 10042:2005/Cor. 1:2006

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 11666, *Non-destructive testing of welds — Ultrasonic testing — Acceptance levels*

ISO 12100:2010, *Safety of machinery — General principles for design — Risk assessment and risk reduction*

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 13857:2008, *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*

STANDARDSISO.COM : Click to view the full PDF of ISO 17842-1:2015

 © ISO 2015 – All rights reserved

ISO 14120, *Safety of machinery — Guards — General requirements for the design and construction of fixed and movable guards*

ISO 14122-1, *Safety of machinery — Permanent means of access to machinery — Part 1: Choice of fixed means of access between two levels*

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 15607, *Specification and qualification of welding procedures for metallic materials — General rules*

ISO 15609-1, *Specification and qualification of welding procedures for metallic materials — Welding procedure specification — Part 1: Arc welding*

ISO 15610, *Specification and qualification of welding procedures for metallic materials — Qualification based on tested welding consumables*

ISO 15611, *Specification and qualification of welding procedures for metallic materials — Qualification based on previous welding experience*

ISO 15612, *Specification and qualification of welding procedures for metallic materials — Qualification by adoption of a standard welding procedure*

ISO 15613, *Specification and qualification of welding procedures for metallic materials — Qualification based on pre-production welding test*

ISO 15614-1, *Specification and qualification of welding procedures for metallic materials — Welding procedure test — Part 1: Arc and gas welding of steels and arc welding of nickel and nickel alloys*

ISO 15614-2, *Specification and qualification of welding procedures for metallic materials — Welding procedure test — Part 2: Arc welding of aluminium and its alloys*

ISO/IEC 17020, *Conformity assessment — Requirements for the operation of various types of bodies performing inspection*

ISO/IEC 17025, *General requirements for the competence of testing and calibration laboratories*

ISO 17635, *Non-destructive testing of welds — General rules for metallic materials*

ISO 17636-1:2013, *Non-destructive testing of welds — Radiographic testing — Part 1: X- and gamma-ray techniques with film*

ISO 17637, *Non-destructive testing of welds — Visual testing of fusion-welded joints*

ISO 17638, *Non-destructive testing of welds — Magnetic particle testing*

ISO 17640:2010, *Non-destructive testing of welds — Ultrasonic testing — Techniques, testing levels, and assessment*

ISO/TS 17929:2014, *Biomechanical effects on amusement ride passengers*

ISO 23277, *Non-destructive examination of welds — Penetrant testing of welds — Acceptance levels*

ISO 23278, *Non-destructive examination of welds — Magnetic particle testing of welds — Acceptance levels*

ISO 23279, *Non-destructive testing of welds — Ultrasonic testing — Characterization of indications in welds*

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*

STANDARDSISO.COM : Click to view the full PDF of ISO 17842-1:2015

© ISO 2015 – All rights reserved

IEC 60364-4-41, *Electrical installations of buildings — 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 — Chapter 54: Earthing arrangements, protective conductors and protective bonding conductors*

IEC 60364-7-740, *Electrical Installation of buildings — Part 7-740: Selection and erection of electrical equipment — Chapter 54: 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 for transformers, power supply units and similar devices*

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 485, *Aluminium and aluminium alloys — Sheet, strip and plate*

EN 755, *Aluminium and aluminium alloys — Extruded rod/bar, tube and profiles*

EN 818 (all parts), *Short link chain for lifting purposes*

EN 1069-1, *Water slides — Part 1: Safety requirements and test methods*

EN 1176 (all parts), *Playground equipment and surfacing*

EN 1261, *Fibre ropes for general service — Hemp*

EN 1677, *Components for slings — Safety*

EN 1991-1-4:2005, *Eurocode 1: Actions on structures — Part 1-4: General actions — Wind actions*

EN 1992-1-1, *Eurocode 2: Design of concrete structures — Part 1-1: General rules and rules for buildings*

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 1995-1-1, *Eurocode 5 — Design of timber structures — Part 1-1: General — Common rules and rules for buildings*

EN 1999-1-1, *Eurocode 9: Design of aluminium structures - Part 1-1: General structural rules*

EN 10025-1, *Hot rolled products of structural steels — Part 1: General technical delivery conditions*

EN 10025-2, *Hot rolled products of structural steels — Part 2: Technical delivery conditions for non-alloy structural steels*

EN 10025-3, *Hot rolled products of structural steels — Part 3: Technical delivery conditions for normalized/normalized rolled weld able fine grain structural steels*

EN 10160, *Ultrasonic testing of steel flat product of thickness equal or greater than 6 mm (reflection method)*

EN 10164, *Steel products with improved deformation properties perpendicular to the surface of the product — Technical delivery conditions*

EN 10204:2004, *Metallic products — Types of inspection documents*

EN 10210, *Hot finished structural hollow sections of non-alloy and fine grain steels (all parts)*

STANDARDSISO.COM : Click to view the full PDF of ISO 17842-1:2015

© ISO 2015 – All rights reserved

EN 10219, *Cold formed welded structural hollow sections of non-alloy and fine grain steels (all parts)*

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

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

EN 13889, *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*

ASME *Boiler and Pressure Vessel Code (BPVC)*. American Society of Mechanical Engineers

EEC/2009/105/EC, *DIRECTIVE 2009/105/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 16 September 2009 relating to simple pressure vessels*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 17842-2, ISO 17842-3, ISO/IEC 17020 and ISO/TS 17929, and the following apply.

NOTE Any symbols connected with the respective terms or units are explained in the clauses concerned.

3.1
amusement device
arrangement of equipment that produces the desired effect of amusement or entertainment when the *patron* (3.25) 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 word "device" is used to refer to an amusement device or *amusement ride* (3.2).

3.2
amusement ride
equipment that is designed to entertain the *passengers* (3.25) during motion including biomechanical effects

Note 1 to entry: In this document, the word "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* (3.23), to assist in the operation of a device available for use by the public

3.4
clearance envelope
patron clearance envelope
passenger clearance envelope
reach envelope plus a suitable margin as defined in Annex I

3.5
closed
<restraint>position in which the *restraint* (3.31) is intended to remain during the operation of the device in order to restrain the *passenger* (3.25)

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

STANDARDSISO.COM : Click to view the full PDF of ISO 17842-1:2015

© ISO 2015 – All rights reserved

3.7
controller
<ride> person or organization having overall control of a device

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

3.8
designer
engineer
person or body responsible for the design of a device (or modifications thereof), including, but not limited to, establishing and describing the configuration of the amusement ride or device, conducting appropriate risk assessment(s), establishing strength (including fatigue strength), designing and specifying electrical/electronic control systems, defining inspection criteria and including the provision of the necessary documentation

3.9
design review
document detailing the review of all the applicable design documents, to determine the suitability for use of a device

3.10
design risk assessment
DRA
document produced by the *designer* (3.8) to ensure a safe design within the agreed scope of supply

3.11
device log
book or file containing all the necessary information about the use and history of any device

3.12
fail safe
characteristic of a system, component or device the failure of which results in a safe state

3.13
fence
structure designed to restrict or prevent movement across a boundary

3.14
gate
section of fencing or barrier that may be opened to provide access

3.15
guest
person who interacts with a device

Note 1 to entry: While both are guests, a *passenger* (3.25) is active and a *spectator* (3.39) is passive.

3.16
inspection body
any organization operating in accordance with ISO/IEC 17020 carrying out approval, examination and tests of devices

3.17
initial approval
design and calculation review, verification, examinations and tests executed by the inspecting body before a device is first made available for public use

STANDARDSISO.COM : Click to view the full PDF of ISO 17842-1:2015

© ISO 2015 – All rights reserved

3.18
latching
<restraint> means of being held secure against opening except by intentional action of the *passenger* (3.25), *operator* (3.23) or other means

Note 1 to entry: This can include *restraints* (e.g. drop bars) (3.31) held in place by gravity, detents or other means.

3.19
licensing body
any national authorities or bodies legally authorized to issue a permit for operation of a device and related documents

3.20
locking
means by which a locked *restraint* (3.31) is held secure against opening except by intentional action of the *operator* (3.23) or other means not accessible by the *passenger* (3.25)

3.21
manufacturer
any natural or legal person who is responsible for designing and manufacturing a product with the view to placing it on the market under his own name

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

3.22
major modification
safety-related alteration to the hardware or software of a device, including the introduction of a new *safety-related component* (3.36) or the substitution of a safety-related component, which results in a deviation from the design specification

3.23
operator
person appointed by the *controller* (3.7) to be in charge of the operation of a device at all times when it is intended to be available for the public

3.24
operation and use risk assessment
OURA
document, produced by the controller, that details all of the considered risks inherent during all modes of device operation at the particular location and the means taken to mitigate against them

3.25
passenger
patron
any person using a device

3.26
passenger containment
components (e.g. seating, foot wells, handrails, passenger restraints) designed to prevent *passengers* (3.25) from moving outside a predetermined area on a ride either as a result of biomechanical effects, the ride forces or the behaviour of the passenger

3.27
passenger unit
PU
part or parts of a device in or on which the *passengers* (3.25) are intended to ride

STANDARDSISO.COM : Click to view the full PDF of ISO 17842-1:2015

3.28
passenger safety envelope
safety envelope
motion safety envelope
passenger clearance envelope
theoretical or actual physical space that may be encroached upon by any part of a *passenger* (3.25) of an amusement ride during the ride cycle

3.29
permit
authorization to operate a device granted by the licensing body after successful approval or examination

3.30
platform
horizontal or slightly inclined surface raised above the level of an adjacent area

3.31
restraint
system, device, or characteristic that is intended to inhibit or restrict the body movement and/or maintain the body position to tolerate accelerations of the *patron*(s) (3.25) while on the device

3.32
reach envelope
patron reach envelope
passenger reach envelope
physical space where a passenger could reach during a ride cycle while properly positioned, as defined by the ride analysis, in the device and limited only by the vehicle, seat geometry, and restraint system

3.33
repair
restoration of *safety-related components* (3.36) or assemblies to the requirement set out in the manual

3.34
reasonably foreseeable misuse
<human error>use of a machine in a way not intended by the *designer* (3.8), but which can result from readily predictable human behaviour

[SOURCE: ISO 12100:2010, 3.24.]

Note 1 to entry: Annex G gives a non-exhaustive list of guest behaviour.

3.35
safe stop
stop of an *amusement ride* (3.2) in a safe way and in a final safe position

3.36
safety-related component
component of a device on which the safety of the *passengers* (3.25) is dependent

3.37
service
replacement or replenishment of components, including fluids which are designated to be replaced or replenished at specified intervals

3.38
sideshow
booth or similar enclosed structure containing shows, activities or games for the entertainment of the public, where the *guest* (3.15) is not carried in any way by the structure

STANDARDSISO.COM : Click to view the full PDF of ISO 17842-1:2015

© ISO 2015 – All rights reserved

3.39
spectator
person in the vicinity of a device, typically watching the operation of the device or waiting to gain access to the use the device

3.40
SRCS
safety-related control system
assembly of components that may be electronic, electric, electro-mechanical, hydraulic, pneumatic or mechanical combined to monitor and control a device so as to reduce risks to guests

3.41
sustained acceleration
acceleration with duration greater than or equal to 200 ms

3.42
temporarily installed device
device which is designed to be mounted and demounted with an installation period not more than 3 months

3.43
trial run
proving run of a device during which no *passengers* (3.23) 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 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

The 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

These are required for all assemblies, subassemblies and individual components, the fracture or failure of which might endanger the stability or operational safety of the 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.

STANDARDSISO.COM : Click to view the full PDF of ISO 17842-1:2015

© ISO 2015 – All rights reserved

The drawings shall include as a minimum, as applicable:

a) 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;

b) 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 could affect the safety of the device and its operation, shall be drawn to a larger scale;

c) 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

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 and shell 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 listed for demarcation;

— 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;

— 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.

STANDARDSISO.COM : Click to view the full PDF of ISO 17842-1:2015

 © ISO 2015 – All rights reserved

4.2 Selection of materials

4.2.1 General

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

Other materials may only be used on condition that proof of their serviceability has been established.

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

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

4.2.2.1 Steels for structural components

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

Minimum values are:

Yield: R_{eH} = 235 MPa

Ultimate: R_m = 350 MPa

Notch impact energy: K = 27 J at T = +20°C, Charpy V specimen

Depending on the loads (impact and fatigue), the temperature and the thickness the notch impact energy may need to be increased, e.g. K = 27 J at T = −20°C, Charpy V specimen.

Other steel grades for which technological material data (mechanical and chemical properties) are featured in national or international standards may also be used.

4.2.2.2 Steels for machinery and mechanisms

The steels shall comply with international standards or guidelines which meet the design requirements.

4.2.3 Aluminium alloy

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

Recommended standard: EN 1999-1-1.

For members and fasteners, aluminium alloys with a ratio $f_{0,2\,\%}/f_u$ > 0,85 and an elongation (rupture) of less than ε < 8 % shall not be used.

4.2.4 Timber

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

Recommended standard: EN 1995-1-1.

4.2.5 Plastic composites

Selection of plastic composites shall be in accordance with applicable international standards and internationally accepted guidelines.

STANDARDSISO.COM : Click to view the full PDF of ISO 17842-1:2015

4.2.6 Concrete

The selection of concrete grade shall be in accordance with international standards.

Recommended standard: EN 1992-1-1.

4.2.7 Fasteners for structural components

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

Property class 12.9 shall not be used due to undefined impact value.

For machinery and mechanisms other bolts according to appropriate standards may be used.

STANDARDSISO.COM : Click to view the full PDF of ISO 17842-1:2015

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

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 shall also be provided.

When ropes, chains, safety devices, connectors and adapters are used, the following standards in particular should be observed:

4.2.8.1 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.

Shackles: EN 13889.

4.2.8.2 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.

4.2.8.2.1 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.

4.2.8.2.2 Natural fibre ropes

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

 © ISO 2015 – All rights reserved

Fibre ropes for general service — Hemp: EN 1261.

4.2.8.3 Chains

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

In the absence of ISO or other international standards, national standards may be used.

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 part of ISO 17842;

b) to a standard listed in Clause 2;

c) to an official national standard of the country of use of the device, only if superseding local conditions (e.g. wind, seismic, etc.) 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 in general a very precise assumption of the permanent actions is possible.

Where variations can occur, the values $G_{k,sup}$ and $G_{k,inf}$ shall be taken into account when assessing the most likely 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.

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

The permanent actions shall be determined in accordance to international standards. 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

These 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 may vary in magnitude, direction and point of application (variation in time and space) during normal operation.

STANDARDSISO.COM : Click to view the full PDF of ISO 17842-1:2015

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.

For each person over 10 years of age:

— Q_k = 0,75 kN

for all fatigue calculations;

— Q_k = 0,75 kN

for static calculations (non-fatigue) for more than 4 passengers per compartment except in the case below;

— $Q_k = 1{,}35\ \text{kN} - (n - 1) \times 0{,}15\ \text{kN}$ where $1 \le n \le 4$

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.

NOTE 1 These static loads are not an operational and general weight limit or requirement and need not to be used for overall calculations (e.g. sliding, overturning, etc.) of the compartment or ride itself.

NOTE 2 Using special compartments for larger persons the above mentioned values of load assumptions shall be corrected.

NOTE 3 The designer can consider possible higher weight depending on the seat configuration and type of ride.

For each person of 10 years or less:

Q_k = 0,40 kN in both fatigue and static cases.

Where the reduced loadings for person of 10 years or less are employed 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 shall be applied for any area designed for access by foot.

Universal, public access:

q_k = 3,5 kN/m^2 for floors, stairways, landings, ramps, entrances, exits and other similar features in rides and facilities;

q_k = 5,0 kN/m^2 for grandstands and their stairways and landings with fixed seats; and as a superior value, if particularly dense crowds are anticipated for the above mentioned categories

q_k = 7,5 kN/m^2 for grandstands and their stairways and landings without seats or non-fixed seats; and as a superior value, if particularly dense crowds are anticipated for the above mentioned categories

q_k = 2,0 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 kN/step for stairs; alternatively, an area load in accordance with above clauses, whichever is the more unfavourable.

q_k = 1,5 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 kN/m^2).

Not open for public access:

STANDARDSISO.COM : Click to view the full PDF of ISO 17842-1:2015

 © ISO 2015 – All rights reserved

q_k = 1,5 kN/m² for all floors, platforms, ramps, staircases, catwalks, stages and the like which are walked over by individual persons, or

Q_k = 1,5 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 parapets, fences, railings, wall panels, and other similar features:

When bounding floors intended for public access designed for q_k = 3,5 kN/m²:

p_k = 0,5 kN/m at hand rail height;

p_k = 0,1 kN/m at intermediate rail height.

When bounding floors intended for public access designed for q_k = 5,0 kN/m² and q_k = 7,5 kN/m²:

p_k = 1 kN/m at hand rail height;

p_k = 0,15 kN/m at intermediate rail height.

When bounding floors not intended for public access designed for q_k = 1,50 kN/m²:

p_k = 0,30 kN/m at hand rail height;

p_k = 0,10 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.

4.3.3.1.2.4 Grandstands

In order to achieve an adequate longitudinal and transverse stiffness in the case of grandstands and similar installations with seating or standing accommodation, a horizontal load acting at floor level in the most unfavourable direction in each case shall be entered in the calculation in addition to any eventual wind force in accordance with 4.3.3.4. The horizontal component load shall be taken as 1/10 for temporarily installed and 1/20 for permanent installed grandstands of the imposed vertical load in accordance with 4.3.3.1.2.2.

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 entered in the calculation at these values. 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):

$$B = a_b \times (m_v + m_p) \tag{1}$$

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.

STANDARDSISO.COM : Click to view the full PDF of ISO 17842-1:2015

© ISO 2015 – All rights reserved

In the case of circular movements the appropriate parameters shall be applied in the formula. 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 also 4.3.5.1).

In the case of speeds not exceeding 3 m/s, the driving forces and braking forces can be derived with a_b = 0,7 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

Such loads shall be taken into account when designing passenger restraints and containment, railings and bracing devices within 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 part of ISO 17842;

b) to a standard quoted in Clause 2;

c) to an official national standard of the country of use of the device, only if superseding local conditions (e.g. wind, seismic, etc.) require it.

4.3.3.4.2 Wind loads in limit state

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

For temporarily installed devices, the wind loads are adopted from EN 1991-1-4 due to the special nature of amusement rides and devices:

— location (environment category, topographic);

— duration and period of installation;

— temporarily or permanent installation

— use under supervision of an operator;

— possibilities of protection and strengthening in case of predicted high wind.

The values in Table 1 may be applied for the temporarily installed rides or structures if the following presumptions are fulfilled:

— in areas where the reference wind speed according to the maps in EN 1991-1-4:2005, Annex A is $v_{b,0} \leq 28$ m/s (in out-of-service condition of the ride or structure);

— operation is stopped and the device is sheltered or suitably strengthened when actual wind speeds attains $v_{gust} \leq 21$ m/s at top of the device or basic speed $v_b \leq 15$ m/s.

NOTE Basic wind speed v_b according to EN 1991–1-4 as 10 min mean value measured at 10 m height. v_{gust} considers a reduction to 70 % for temporarily installed devices.

A gust is based on a 3 s peak.

STANDARDSISO.COM : Click to view the full PDF of ISO 17842-1:2015

 © ISO 2015 – All rights reserved

The ride or structure shall not be susceptible to dynamic response since a dynamic factor of c_d = 0,90 (not susceptible to dynamic response) has been used to establish values in Table 1.

The following further assumptions have been used to establish values in Table 1:

c_{dir} = 1,0; c_{alt} = 1,0; c_t = 1,0; c_{season} = 1,0

terrain category III – Suburban environment with slight building density.

The wind pressure defined in Table 1 approximates the wind pressure in a step function.

Table 1 — Wind pressure values for temporarily installed amusement devices

Height of structure z_e m	**Pressure** $q(z)$ (kN/m²) for reference wind speed	
	$v_b \leq 15$ m/s (operating state)	$v_{b,0} \leq 28$ m/s (out of service)
$0 < z_e \leq 8$	0,20	0,35
$8 < z_e \leq 20$	0,30	0,50
$20 < z_e \leq 35$	0,.35	0,90
$35 < z_e \leq 50$	0,40	1,00

NOTE 1 Wind load for structures with height of more than 50 m are not defined in Table 1.

NOTE 2 Dynamic effects due to wind (gusts, buffering, vortex shedding) may occur at structures with low stiffness (low natural frequency).

The wind load, F_W, on a structure or part may be calculated by the application of the above values in the following formula:

$$F_W = q(z_e) \times c_f \times A_{ref} \tag{2}$$

where

$q(z_e)$ is the wind pressure depending on height z_e;

c_f is the aerodynamic coefficient;

A_{ref} is the reference area.

In general, the respective shape factors of particular structures and structural members shall be applied

4.3.3.4.3 Wind loads in service

The wind load for operating conditions for permanently and temporarily devices can be calculated using the pressure given in column 2 of Table 1. Operation shall be stopped if the wind velocity exceeds v_{10} = 15 m/s (measured in a height of 10 m). The wind load area from the imposed load (e.g. the passengers' envelope) shall be taken into account in the calculation.

Permanent installed devices shall be designed applying the local occurring wind loads, according to local or other accepted regulations. The wind load in operating state may be taken according Table 1 or defined in particular. In the latter case the operational maximum wind speed shall be shown in the manual and on the operators desk.

4.3.3.5 Snow loads

Snow loads shall be applied in accordance with locally required or international standards.

STANDARDSISO.COM : Click to view the full PDF of ISO 17842-1:2015

© ISO 2015 – All rights reserved

Snow loads need 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 may 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/m^2 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.

STANDARDSISO.COM : Click to view the full PDF of ISO 17842-1:2015

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 need 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 $\alpha \leq 90°$, the collision force F (in Newtons) shall be assumed to be

$$F = 9{,}81 \times m_{tot} \times \sin\alpha \qquad (3)$$

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

$$F = 9{,}81 \times m_{tot} \times 0{,}3 \qquad (4)$$

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).

4.3.4 Seismic forces

Seismic forces need only be considered by special request; they do not need to be combined with wind load cases.

Seismic forces shall be applied in accordance to locally required or international standards.

© ISO 2015 – All rights reserved

4.3.5 Applicable coefficients

Applicable coefficients for impacts, the vibration of structural components directly travelled over and collisions shall be considered.

4.3.5.1 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.

4.3.5.2 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 may be required in order to reduce or attenuate inadmissible vibrations (e.g. resonance).

4.3.6 Load combinations

4.3.6.1 General

The assessment of limit states for amusement rides and 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 in the following way:

$$\sum \gamma_G G_k \quad \left(= \sum 1{,}35 \cdot G_k\right) \tag{5}$$

$$\sum \gamma_G G_k + \sum \gamma_Q Q_{k,i} \quad \left(= \sum 1{,}1 \cdot G_k + \sum 1{,}35 \cdot Q_{k,i}\right) \tag{6}$$

Both cases shall be checked, where

STANDARDSISO.COM : Click to view the full PDF of ISO 17842-1:2015

© ISO 2015 – All rights reserved

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

$$1{,}0 \cdot G_k + A_d + \sum 1{,}0 \cdot Q_{k,i} \tag{7}$$

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) need only be considered by special request. In such cases Formula (7) shall be applied.

4.3.6.4 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 limit states resulting from all different actions shall be determined separately for the individual actions given in 4.3. It shall be verified that no relevant limit state exceeds the design properties. The limit states due to the combinations of actions shall be calculated. 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 methods of the theory of 2nd order 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

STANDARDSISO.COM : Click to view the full PDF of ISO 17842-1:2015

 © ISO 2015 – All rights reserved

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 in accordance with ISO standards or to accepted standards. The sources of such formulae shall be stated, if this source is 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 the software, formulae, units, etc. 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 in accordance with Formula (8).

$$R_d = \frac{R_k}{\gamma_M} \tag{8}$$

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 γ_M stated in the respective ISO Standard or accepted internationally standards 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 assumed as meaning that at only those seats which are 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 $M_{Rk,stb}$ (stabilizing moment) and $M_{Ek,dst}$ (overturning destabilizing moment) takes into account the partial safety factors according to Table 2.

STANDARDSISO.COM : Click to view the full PDF of ISO 17842-1:2015

© ISO 2015 – All rights reserved

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 (such as 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.

STANDARDSISO.COM : Click to view the full PDF of ISO 17842-1:2015

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 may 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) may 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 attain 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.

 © ISO 2015 – All rights reserved

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. free spinning and or passenger actuated), 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), the gondolas of which may be raised, 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 respected.

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 should fall 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. Where there are multiple coupled cars the overall centre of mass may be used.

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 liable 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 will be 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 will be necessary.

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

STANDARDSISO.COM : Click to view the full PDF of ISO 17842-1:2015

© ISO 2015 – All rights reserved

4.4.2.4.2 Supporting framework

If the calculation is based on a continuous rail track above the support columns, a column settlement by virtue of the reduction by 50 % of the moment at support, and a column heightening by virtue of the increase by 25 % of the moment at support shall be assumed. The increase or reduction of these moments need not be taken into consideration for the verification of fatigue in view of the low numbers of cycles anticipated.

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/s^2. Greater deceleration is permitted on condition that special devices for the protection (lap bars, etc.) 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/s^2, unless a greater deceleration is permitted in which case special devices for the protection (lap bars, etc.) 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 is possible using wet rails, wet brake elements and wet fins.

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

STANDARDSISO.COM : Click to view the full PDF of ISO 17842-1:2015

 © ISO 2015 – All rights reserved

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.

If it is planned that several cars or trains are to be present 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.

Moreover if there are several cars or trains 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.

If, by design, it is intended that there is to be only a single car or a single train on the track at any one 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 then 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 following formula shall be applied:

$$\varphi \geq 1 + \sqrt{1 + \frac{2h}{\delta_0 \sin\alpha}} \qquad (9)$$

where

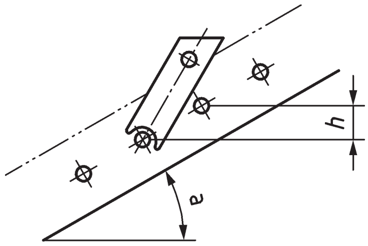
δ_0 is the total deflection of centre of mass along slope;

α is the slope angle (see Figure 1);

h is the height (see Figure 1).

STANDARDSISO.COM : Click to view the full PDF of ISO 17842-1:2015

© ISO 2015 – All rights reserved



Key

α slope angle

h height

Figure 1 — Impact factor/running back elevation

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

4.4.3 Other railways with track-bound vehicles

4.4.3.1 Conventional railways

Conventional railways are e.g. 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.

4.4.3.2 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 borne in mind 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, if desired, 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 design risk assessment shall determine the method, if required, of locking pendulum gondolas for the purpose of passenger transfers (e.g. suitable dampers).

STANDARDSISO.COM : Click to view the full PDF of ISO 17842-1:2015

 © ISO 2015 – All rights reserved

4.4.4 Grandstands

Grandstands shall be subjected to the verification of limit states in accordance with 4.1.5. Special attention shall be paid to the verification of safety against overturning, if the grandstands are for example roofed over, clad, or if numerous flags or banners are attached to the grandstands.

4.5 Verification of stability

4.5.1 General

Proof shall be provided of safety against overturning (4.5.2), sliding (4.5.3) and lifting (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, a national standard or an internationally accepted standard shall be applied to the prevailing rules of this sub-clause. A frost-free foundation for amusement devices is only required in cases where lifting or lowering/settling due to frost could 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 may be determined and verified accurately this allows a more precise determination of the safety factors to be made (see 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 $\gamma = 1,2 + 0,3 \times (h\text{-}20)/40$ where h is the total height of device in metres.

4.5.2 Overturning

The safety against overturning shall be calculated from:

$$\sum \gamma\, M_{\mathrm{Rk,\,stb}} \geq \sum \gamma\, M_{\mathrm{Ek,dst}} \qquad (10)$$

where

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

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

$M_{\mathrm{Ek,dst}}$ 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.

STANDARDSISO.COM : Click to view the full PDF of ISO 17842-1:2015

© ISO 2015 – All rights reserved

4.5.3 Sliding

The safety against sliding shall be calculated from:

$$\mu \cdot \sum \gamma N_k \geq \sum \gamma H_k \qquad (11)$$

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 EN 1997–1.

It shall be borne in mind that loosening by vibration may occur in the case of supports subjected 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.

$$\bar{\mu} \cdot \sum \gamma N_k + Z_{h,d} \geq \sum \gamma H_k \qquad (12)$$

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).

STANDARDSISO.COM : Click to view the full PDF of ISO 17842-1:2015

 © ISO 2015 – All rights reserved

4.5.4 Lifting

The safety against lifting shall be calculated from

$$\sum \gamma N_{\mathrm{Rk,stb}} \geq \sum \gamma N_{\mathrm{Ek,dst}} \quad (13)$$

where

γ is the partial safety factor in accordance with Table 2;

$N_{\mathrm{Rk,stb}}$ are the vertical stabilizing load components;

$N_{\mathrm{Ek,dst}}$ are the vertical lifting destabilising load components.

With anchor ties the following relationship shall be applied:

$$\sum \gamma N_{\mathrm{Rk,stb}} + Z_{\mathrm{v,d}} \geq \sum \gamma N_{\mathrm{Ed,dst}} \quad (14)$$

where $Z_{\mathrm{v,d}}$ 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. This clause 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 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.

STANDARDSISO.COM : Click to view the full PDF of ISO 17842-1:2015

Table 4 — Design load bearing capacity of anchors Z_d

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

Symbols used in Table 4, Formulae (15) and (16) and Figures 2 and 3:

$Z_d = Z_u / \gamma_M$ 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;

$Z_{h,d}$ is the horizontal design load bearing capacity of anchor, in N;

$Z_{v,d}$ 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.

Formulae in Table 4 are only valid on the condition that the anchor will “pull” when driven in. For $\beta = 0°$ the friction shall be effective along the entire length of the rod; for $\beta \geq 45°$, the angle of penetration α shall be 90°. At this driving-in angle, the obliquely loaded anchor will attain its maximum design load bearing capacity, as shown by experience. 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:

$$d_{min} = 0{,}025l' + 0{,}5 \qquad (15)$$

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.

STANDARDSISO.COM : Click to view the full PDF of ISO 17842-1:2015

 © ISO 2015 – All rights reserved

Dimensions in centimetres

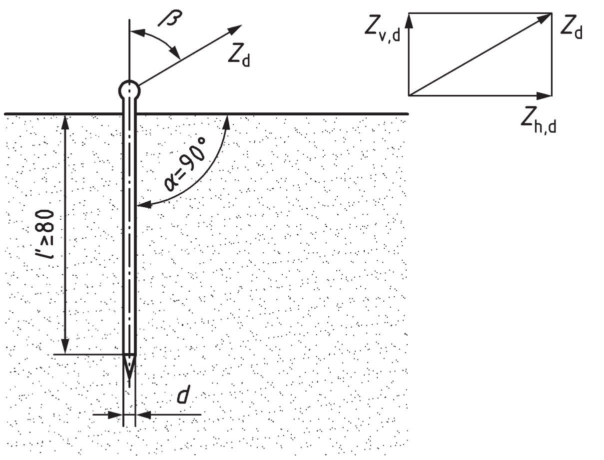
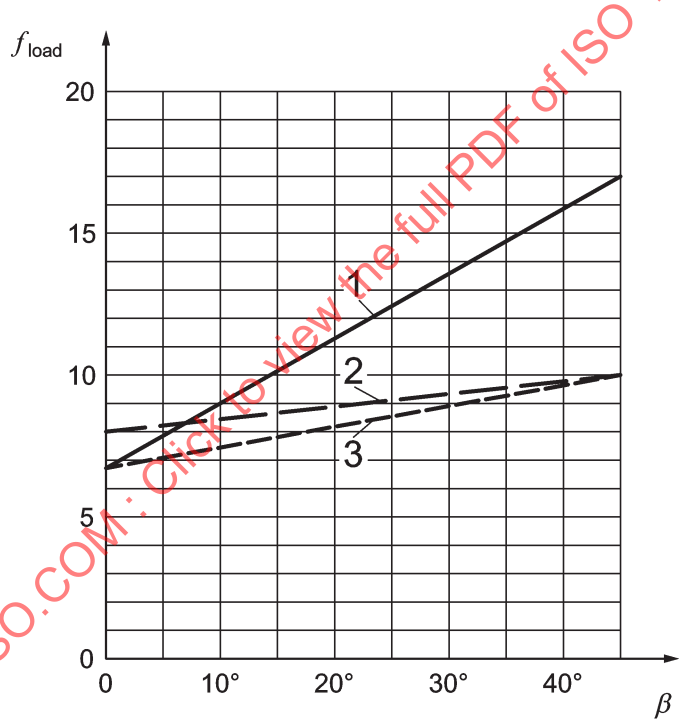


Figure 2 — Rod anchor



Key

1 dense cohesionless soils

2 very stiff cohesive soils

3 stiff cohesive soils

Figure 3 — 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_d) in subsequent calculation. The design load bearing capacity determined in this manner shall not result in anchor movement which would result in stresses, deformations or instability which cannot be accommodated by the structure.

STANDARDSISO.COM : Click to view the full PDF of ISO 17842-1:2015

© ISO 2015 – All rights reserved

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

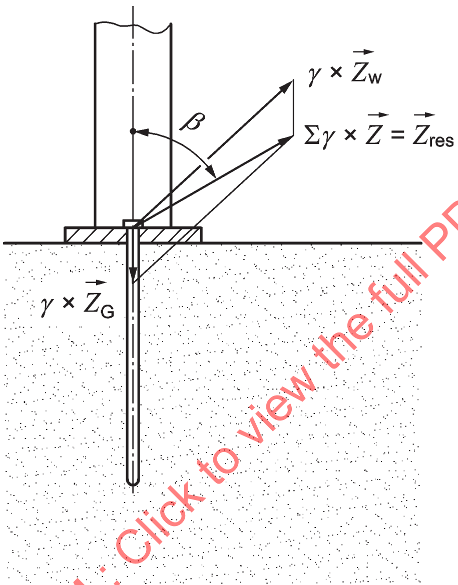
The safety factors featured in Table 2 shall be taken into consideration when determining the permissible load.

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 shown in Table 2. This load Z_{res} shall be less than the permissible loading of the anchorage according to 4.6.3:

$$Z_{res} = \sum \gamma Z \leq Z_d \qquad (16)$$

See also Figure 4.



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 4 — Anchor loading

STANDARDSISO.COM : Click to view the full PDF of ISO 17842-1:2015

4.6.6 Further requirements

If displacements in excess of 2 cm occur on loaded rod anchors or similar devices, then the load bearing capacity of the anchor will no longer be 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.

 © ISO 2015 – All rights reserved

If groups of anchors are used, each individual anchor may only be assessed in the calculation at its full, calculated load bearing capacity on 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 6 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 may 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 liable 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 may 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:

$b = 20$ cm: $P = 100$ kN/m^2

$b = 30$ cm: $P = 150$ kN/m^2

$b \geq 40$ cm: $P = 200$ 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 may be considered.

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

STANDARDSISO.COM : Click to view the full PDF of ISO 17842-1:2015

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, $\Delta\sigma = \min\sigma / \max\sigma \geq 0$) 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 to relevant standards which are based either on the stress range $\Delta\sigma$ concept or in $\min|\sigma / \max|\sigma$ stress concept, if the minimum life time requirements in 4.7.3.1.5 are applied and a partial safety factor according Table 5 at 95 % survival probability or equivalent is maintained.

© ISO 2015 – All rights reserved

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

The minimum life time requirements in 4.7.3.1.5 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.

The complete analysis of a device shall be based on a clearly specified and internationally accepted standard.

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, the following relationships shall apply:

$$R_d \le \frac{R_{eH}}{\gamma_{M0}} \tag{17}$$

and

$$R_d \le \frac{R_m}{\gamma_{M2}} \tag{18}$$

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 values R_d above shall be used.

STANDARDSISO.COM : Click to view the full PDF of ISO 17842-1:2015

4.7.3 Fluctuating stress

4.7.3.1 Fatigue assessment of structural components

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

4.7.3.1.1 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:

 © ISO 2015 – All rights reserved

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	$\gamma_{Mf} = 1{,}05$	$\gamma_{Mf} = 1{,}15$

4.7.3.1.2 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 values in Table 1, column 2, 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 in 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:

$$\Delta\sigma = \sigma_{max} - \sigma_{min} \tag{19}$$

$$\Delta\tau = \tau_{max} - \tau_{min} \tag{20}$$

4.7.3.1.3 Roundabouts

For asymmetric loading the stress range due to 1/6 and 5/6 one-sided load according to 4.4.2.1 may be assumed for 100 % of fatigue life.

4.7.3.1.4 Track-bound devices

Vehicles and trains shall be analysed by using the full, imposed load (6/6) for the complete fatigue life.

4.7.3.1.5 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.

STANDARDSISO.COM : Click to view the full PDF of ISO 17842-1:2015

© ISO 2015 – All rights reserved

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.

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.

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.

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

Machine components are e.g. axles, pins, shafts, wheel bogies, coupling bars, restraint bars etc.

Assessment of welded parts may also follow the procedure given in 4.7.3.1 or international standards or guidelines, e.g. FKM.

The following described principle of assessments can be adopted to non-welded parts.

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

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.

The resistances shall comply with 97,5 % probability of survival.

4.7.3.2.2 Fatigue stress

Nominal stress or local 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.

Local stress method on base of Finite Element Analysis is possible for shell or volume investigations. Main stresses σ_1, σ_2, σ_3 shall be investigated. Main stress σ_1, σ_2 shall be orientated on surface, σ_3 perpendicular to surface.

STANDARDSISO.COM : Click to view the full PDF of ISO 17842-1:2015

 © ISO 2015 – All rights reserved

4.7.3.2.3 Partial safety factor

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

4.7.4 Bolts

Bolts conforming to ISO 898-1, ISO 4014, ISO 4016, ISO 4017 or ISO 4018, nuts to ISO 4032 or ISO 4034 and bolt and nut assemblies 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. The analysis of bolts under fluctuating stresses shall be conducted in accordance with the relevant literature.

Where EN 1993-1-1 is not applied the following shall be used for bolts assigned to the property grades referred to Tables 6 and 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 etc. or by using tight-fit bolts or by providing a friction-type connection considering a friction coefficient of 2/3 min. μ;

— The value to be adopted for min. μ 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 condition that they have not been stressed beyond the yield point.

The listed values in Table 7 are valid for an overall friction coefficient $\mu = 0{,}14$ (dry to slightly lubricated) making use of 90 % of the minimum yield point. The torque values shall be confirmed by the bolt manufacturer or 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

STANDARDSISO.COM : Click to view the full PDF of ISO 17842-1:2015

Table 7 — Pre-stressing forces and tightening torques for bolts — ISO 4014, ISO 4016, ISO 4017, ISO 4018 and EN 14399-4, EN 14399-6

Thread size	**Pre-stressing force, F_v for property class** kN		**Tightening torque; M_a for property class** Nm			
			Bolts according to ISO 4014, ISO 4016, ISO 4017, ISO 4018		**Bolting assemblies according to EN 14399-4, EN 14399-6**	
			Slightly oiled μ = 0,14		MoS_2 lubricated μ = 0,10	
	8.8	10.9	8.8	10.9	8.8	10.9
M 12	37	50	84	120	70	100
M 16	71	100	206	350	170	250
M 20	111	160	402	600	300	450
M 22	138	190	539	900	450	650
M 24	160	220	696	1100	600	800
M 27	210	290	1 030	1 650	900	1 250
M 30	257	350	1 422	2 200	1 200	1 650
M 36	382	510	2 524	3 340	2 100	2 800

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**
$N_{R,d} = 0{,}8\ F_v$	$N_{R,FAT} = 0{,}6\ F_v$

The pre-stressing force may be induced by other procedure as with torque procedure (e.g. combined method by pre torque and defined turning angle).

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 following relationship shall apply:

$$Z_{u,d} \geq \gamma\ Z_d \qquad (21)$$

where

$Z_{u,d}$ is the minimum load at fracture;

Z_d is the maximum load;

γ is the partial safety factor.

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.

STANDARDSISO.COM : Click to view the full PDF of ISO 17842-1:2015

 © ISO 2015 – All rights reserved

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 1570 MPa are used, the permissible stress shall be assessed independently.

The use of ropes, chains, belts or straps made of hemp, plastics or leather is not permitted for these applications.

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 1570 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 as

$$\kappa = \frac{\min \sigma}{\max \sigma} \; ; \; 0 \leq \kappa \leq 1 \qquad (22)$$

Verifications shall be done with the factor $\gamma = 1{,}0$ on the load side and will be compared directly with the values of Table 9.

4.7.5.1.3 Ropes and Chains under predominantly non-fluctuating load

Ropes and Chains under predominantly non-fluctuating load are e.g. 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 1570 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 12195-2:2000 under predominantly non-fluctuating loads an additional partial safety factor of $\gamma = 2{,}0$ on LC shall be used.

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

STANDARDSISO.COM : Click to view the full PDF of ISO 17842-1:2015

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 locking devices

A partial safety factor of $\gamma = 6,0$ shall be adopted for such safety devices, e.g. locking devices of gondolas or chairs, safety belts and safety harnesses in loop-the-loop swings. The resulting forces to be multiplied by this factor shall be calculated by using the mass and taking into account any applied accelerations.

For foot strap buckles in loop-the-loop swings, the following sizes shall be adopted for roller buckles in accordance with international standards, or in absence of those, to national standards:

— 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 be not 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, they can be used in accordance to national standards. Their permissible loading shall be determined with the aid of the partial safety factors for steel chains (4 or 6) in accordance with 4.7.5.1.1.

The permissible loadings in accordance with future international standards or in absence of those to national standards for approved load data may be trebled for statically stressed shackles. For dynamically stressed shackle connections international standards, or in absence of those, national standards 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 condition.

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, might 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, etc.

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

STANDARDSISO.COM : Click to view the full PDF of ISO 17842-1:2015

 © ISO 2015 – All rights reserved

However, because even pre-stressed screwed connections are liable to loosen, particularly in the initial stages as a result of settlement, e.g. in the case of ball bearing slewing gear, reference shall be made in the assembly and operating instruction manual to the necessary checks to be carried out.

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 to be used, it will be 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 borne in mind 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 might 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

Refer to international standards for steel components, light alloy components and timber components.

5 Requirements for design and manufacture of rides and structures

5.1 Risk reduction by prevailing design and safety measures

5.1.1 General

In this chapter the majority of devices have been categorised in order to unify design approval, examination and safety precautions. The groups are intended to highlight the relevant additional

STANDARDSISO.COM : Click to view the full PDF of ISO 17842-1:2015

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 Design risk assessment (DRA)

This is a document that shall be produced by the designer of every device. The design risk assessment 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, etc.) 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.

5.1.2.2 Operation and use risk assessment (OURA)

This is a document that shall be produced by the controller and operator of every device. The OURA 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, etc.) so that an acceptable level of residual risk from each hazard is analysed. It shall be constructed in close consultation with the designer and DRA and shall demonstrate the management of residual risks highlighted in the DRA.

These risk assessments shall assess the hazards that the device might 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.

The DRA and OURA are regarded as keystone documents, paramount to the total safety management of the device and as such shall be regarded as dynamic. The documents require review periodically and following any relevant change to the design or operation of the device.

See Figure 5.

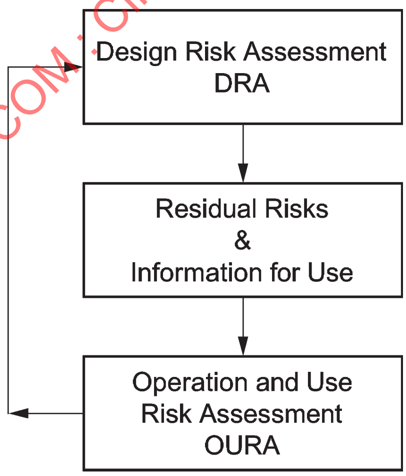


Figure 5 — Risk assessment

5.1.2.3 Hazard analysis

For guidance on general principles see ISO 12100 and the specific applicable hazards for the devices listed in Annex F.

STANDARDSISO.COM : Click to view the full PDF of ISO 17842-1:2015

 © ISO 2015 – All rights reserved

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, etc.) is generally 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 will be 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 of this clause and for which special precautions are to be taken in accordance with 5.2.10.

Where maintenance equipment is to be used for emergency evacuation this will require a specific risk assessment.

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 not more than 0,40 m, the slope may be increased to 1 in 4 – 25 %.

The cross battens with rectangular section shall be maximum 4 mm high so as not create a trip hazard and not more than 50 mm wide.

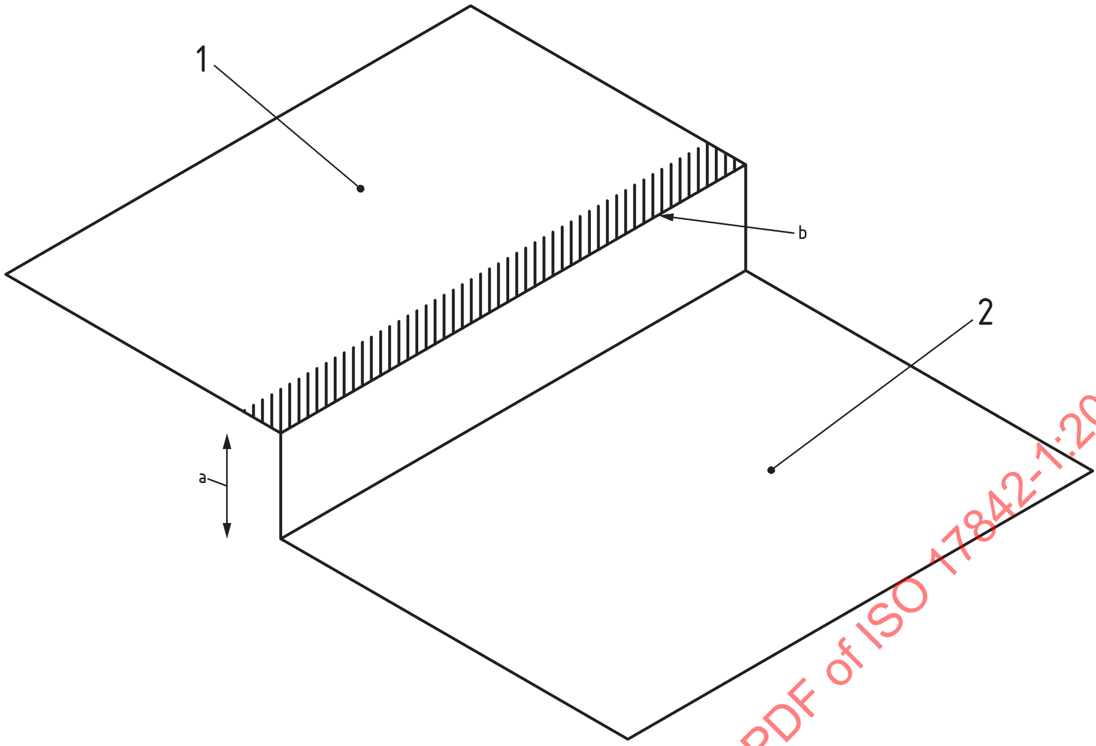
Lesser slopes or other means may be required to accommodate patrons using mobility aids.

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

See Figure 6.

STANDARDSISO.COM : Click to view the full PDF of ISO 17842-1:2015

© ISO 2015 – All rights reserved



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 6 — 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 not 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 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.

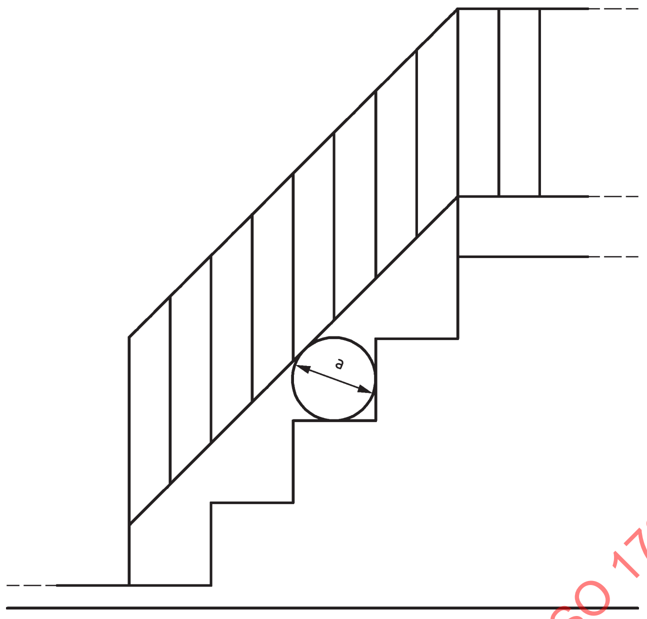
Evacuation stairs may be without landings if this is not physically possible (e.g. in roller coaster lifts).

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

Where the public have access below a stairway, protection from falling objects will be required.

STANDARDSISO.COM : Click to view the full PDF of ISO 17842-1:2015

© ISO 2015 – All rights reserved



Key

a diameter of sphere (150 mm)

Figure 7 — Stairway handrail 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. The handrail and associated fencing (between the vertical bars) if required shall not admit a sphere with a diameter more than 150mm, see Figure 7. 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.

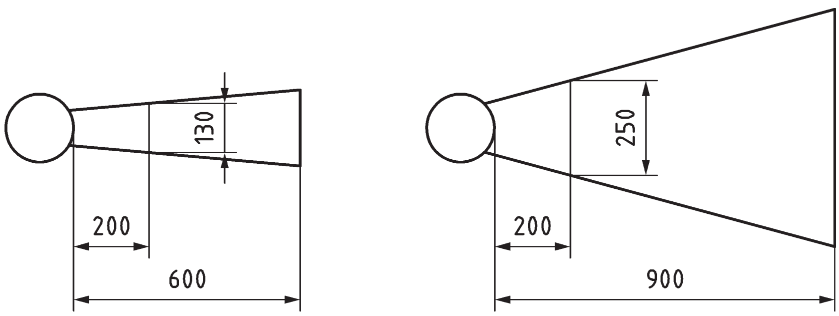
The going on spiral or curved stairways shall be at least:

a) For stairways which are either a means of access between two levels or intended for attendant assisted evacuation, in accordance with Figure 8 a).

b) Where the stairway is to be specified as part of an emergency escape route Figure 8 b) shall be applied.

Inclined treads are not allowed.

Dimensions in millimetres



a) Spiral stairways **b) Curved stairways**

Figure 8 — Dimensions for stairways

STANDARDSISO.COM : Click to view the full PDF of ISO 17842-1:2015

© ISO 2015 – All rights reserved

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.

A handrail, intermediate rail and toe board according to 5.1.4.1.1 shall be provided on both sides of moving walkways or conveyor belt. A railing on only one side is allowed if the moving walkway or conveyor belt is used for access to or egress from passenger units according to 5.1.6.3. The maximum clearance between the belt and the 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 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 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.

Provision 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, because of the type of surface, such protection is not possible, perpendicular egress, according to above clause shall be provided.

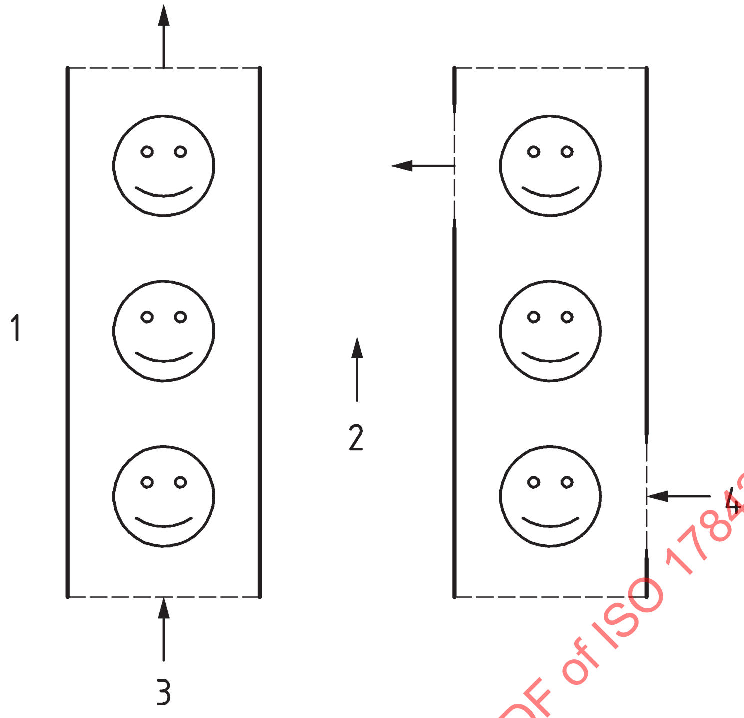
The maximum relative speed shall not exceed 0,75 m/s with parallel egress from the stationary platform, and 0,5 m/s with perpendicular egress. If the walkway or travelator is used as part of the attraction itself then higher speeds may be accepted. See Figure 9.

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.

STANDARDSISO.COM : Click to view the full PDF of ISO 17842-1:2015

© ISO 2015 – All rights reserved



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 9 — Travelator directions in relation to passenger access/egress

STANDARDSISO.COM . Click to view the full PDF of ISO 17842-1:2015

5.1.4 Risk reduction by the use of railings, fencing and guarding

5.1.4.1 Protection against falls from one level to another by railings or fencing

5.1.4.1.1 General

Fencing, railings or other suitable means shall be provided where a person might fall 0,40 m or more due to a difference in the height of adjacent levels. Fences 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 passing underneath.

Fences and railings shall be constructed in accordance with EN 1176-1 with regard to entrapment.

Fences 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 where the public have access.

Where there is 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. Not tensioned chains, ropes or other non-rigid materials are not permitted.

Where there is a difference in levels up to 0,60 m the risk assessment should determine if any area separation system is required.

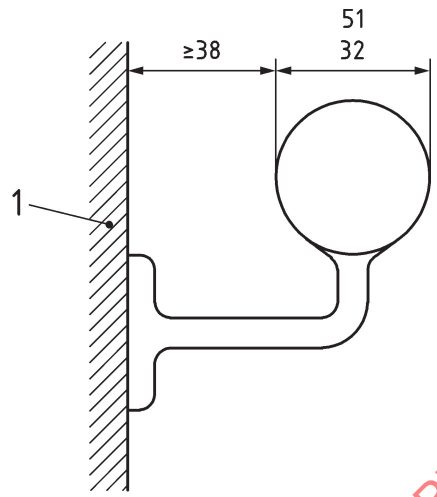
© ISO 2015 – All rights reserved

See Figure 10.

5.1.4.1.2 Handrail height

Handrails shall have a free space around them of 38 mm and the grip shall be in accordance with EN 1176-1:2008, 4.2.4.6 and 4.2.4.7.

Dimensions in millimetres



Key

1 wall

Figure 10 — General handrail clearances

STANDARDSISO.COM : Click to view the full PDF of ISO 17842-1:2015

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 capable of being fulfilled, area separation systems to prevent access of passengers or waiting passengers to parts of the device unsuitable for public access due to likelihood of injury or incident (for example, to prevent access to moving parts) shall be provided.

5.1.4.2.2 Area separation systems

Where an area separation inside or outside the device is required 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:

— height above the floor of a source of danger;

— height of the separating device (fence);

— shortest distance between the edge of the separated area and the source of danger. The minimum safety distance shall be 500 mm. When the probability of serious injury is significant, the minimum distances of ISO 13857:2008 shall be used.

— 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

 © ISO 2015 – All rights reserved

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, etc., which need not withstand horizontal forces.

J3 – physical area separation systems: rigid devices, such as fencing or railings which can withstand horizontal forces.

5.1.4.2.4 Classification of access and egress openings in fences and railings

The number of openings in fences and railings 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, etc.);

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 state of which, enables the ride to start and the open state of which cause 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 will be expressed by the above classification under 5.2.

5.1.4.3 Fences

Fencing 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 so constructed that neither adults nor children can get through or underneath them. They shall be so constructed, where protecting from a significant hazard, that people cannot trap their heads in the fencing. For this purpose two categories of fence are allowed.

a) **Conventional fences**

Fences with predominantly vertical internal elements (Figure 11). The distance between two adjacent elements shall not be more than 100 mm or

Fences provided with mesh as an internal element (Figure 12). The size of the mesh shall be in accordance with Figure 12.

b) **Decorative fences**

Fences provided with decorative internal elements (see Figure 13). The distances between two adjacent elements shall be as shown in Figure 13.

The elements shall not have sharp edges.

For amusement rides used solely by children less than 10 years of age, the separated area may have a reduced height of 0,85 m for both types of fence if the difference in height level is less than 0,40m.

STANDARDSISO.COM : Click to view the full PDF of ISO 17842-1:2015

Dimensions in millimetres

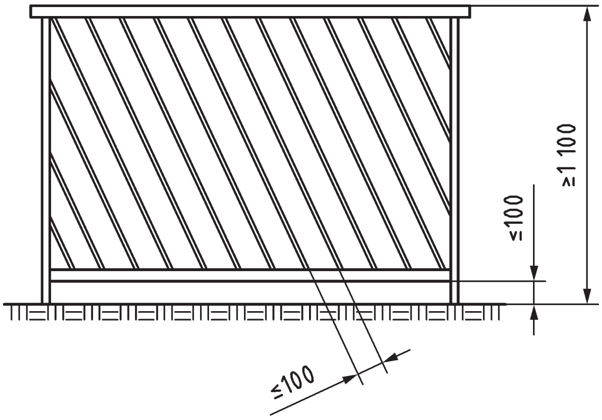


Figure 11 — Examples of fences with predominantly vertical internal elements

Dimensions in millimetres

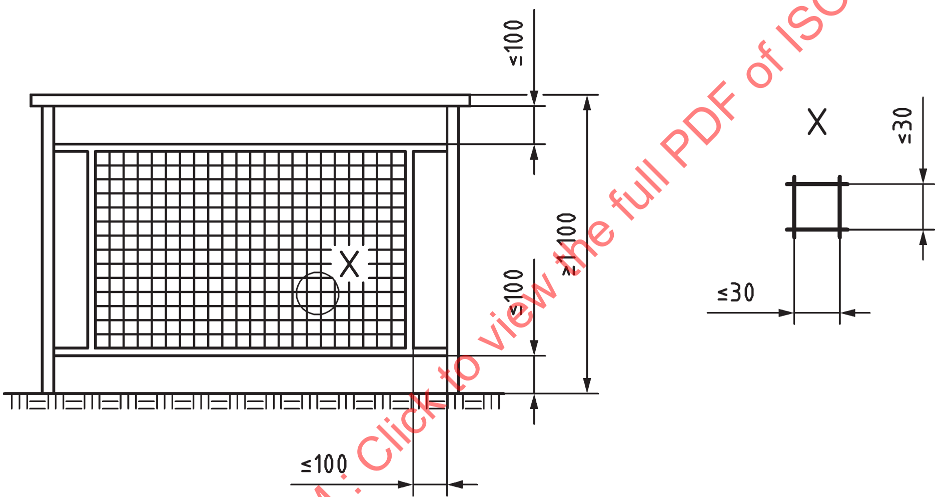


Figure 12 — Examples of fences provided with mesh or panels as an internal element

Dimensions in millimetres

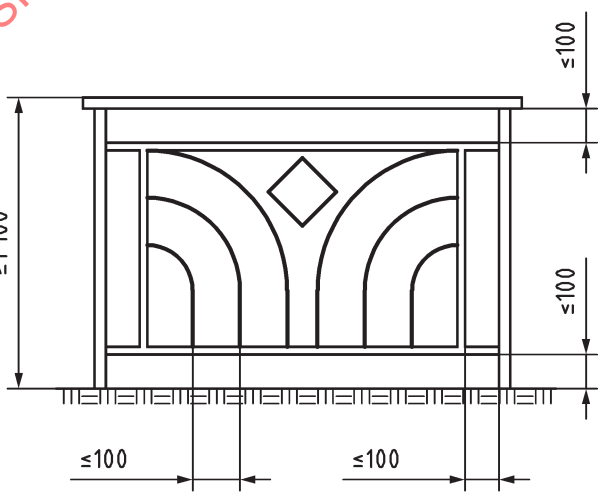


Figure 13 — Examples of fences with decorative internal elements

STANDARDSISO.COM : Click to view the full PDF of ISO 17842-1:2015

© ISO 2015 – All rights reserved

5.1.5 Guarding of hazardous machinery

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

5.1.6 Risk reduction in the case of access and egress

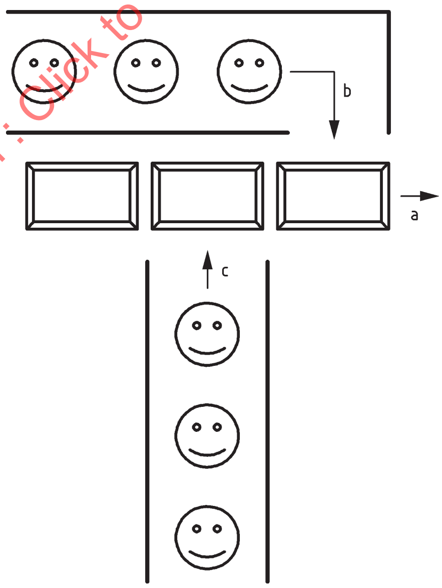
5.1.6.1 Access to and egress from passenger units

5.1.6.1.1 General

Passenger carrying devices shall be so designed that the risk of people being injured from falls while gaining access to or egress from the 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 could 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 power loss. In certain cases (e.g. carousel) this may not be possible in which case 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 14.



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

STANDARDSISO.COM : Click to view the full PDF of ISO 17842-1:2015

© ISO 2015 – All rights reserved

5.1.6.2 Emergency access and egress

Appropriate means for the safe recovery of passengers who may become 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.

5.1.6.3 Access to and egress from enclosures, sideshows and similar 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 may 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	Suitable for
1,20	0,00	Not more than 200 persons
1,20	0,60	Per each 100 persons more

The number of persons is to 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 (the travel distance is the distance between any point in a structure and an exit measured along the actual path by which a person will walk to the exit) to the nearest exit shall not be more than 30 m, and 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 then 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 patrons.

The dimensions of the safety envelope depend on the design risk assessment.

5.1.7.1.2 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 taken from ISO 13857, ISO/TS 17929 and other anthropometric standards and guidelines.

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

STANDARDSISO.COM : Click to view the full PDF of ISO 17842-1:2015

© ISO 2015 – All rights reserved

5.1.7.1.3 Minimum dimensions of safety envelope

To prevent passengers from being injured by stationary or moving objects or objects belonging to passenger units other than that in which they are located, and in the absence of other measures reducing the reach of the passengers, the following minimum general safety distances shall be provided:

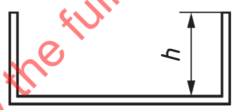
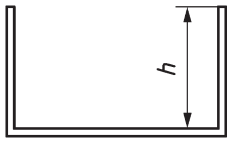
a) The minimum lateral safety distance min. y_{lat} relates to speed and height of the seat sides, see Table 12.

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 15);

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 16).

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 17)

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	500 mm
D	$v > 20$	1 000 mm	1 000 mm	700 mm

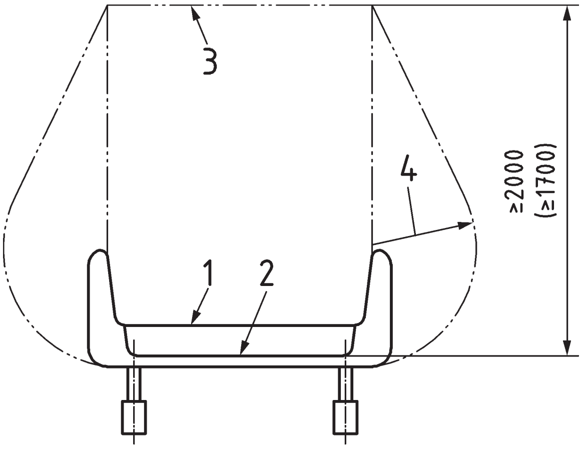
If an over-shoulder restraint is used and the lateral movement of the upper body is limited the min. y_{lat} values similar to a side height of $h > 600$ mm may be used. If the reach envelope is limited by other installations (e.g. cabin) then even less min. y_{lat} values may be adopted.

Any special situation needs to 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.

STANDARDSISO.COM : Click to view the full PDF of ISO 17842-1:2015

© ISO 2015 – All rights reserved

Dimensions in millimetres



Key

1 seat surface

2 floor surface

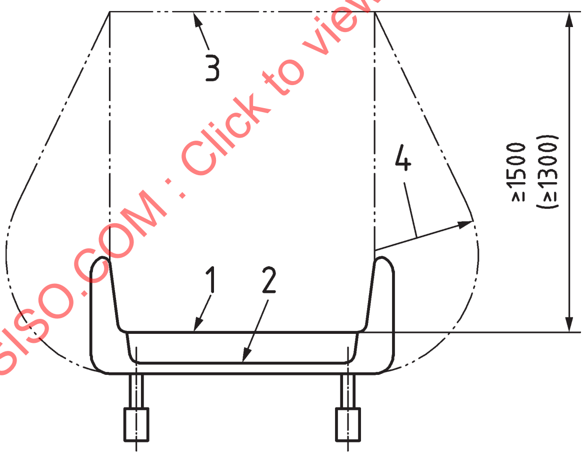
3 safety envelope

4 minimum lateral safety distance min. y_{lat}

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

Figure 15 — 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 min. y_{lat}

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

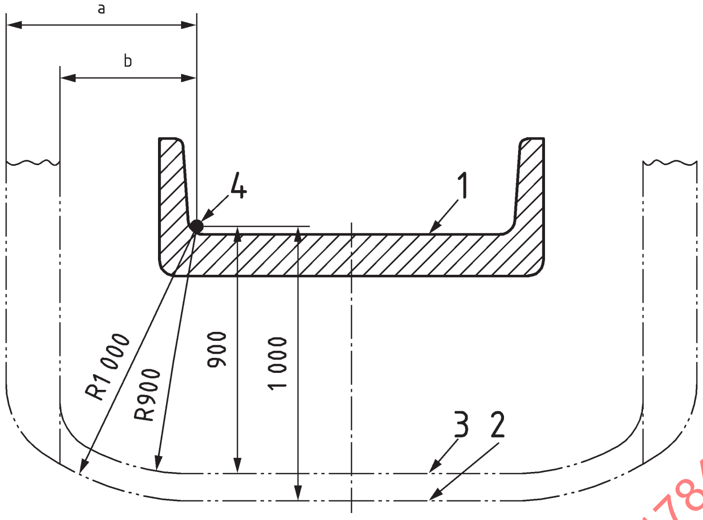
Figure 16 — Vertical safety distance from the seat and lateral safety for passengers

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.

STANDARDSISO.COM : Click to view the full PDF of ISO 17842-1:2015

© ISO 2015 – All rights reserved

Dimensions in millimetres



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 min. y_{lat}.

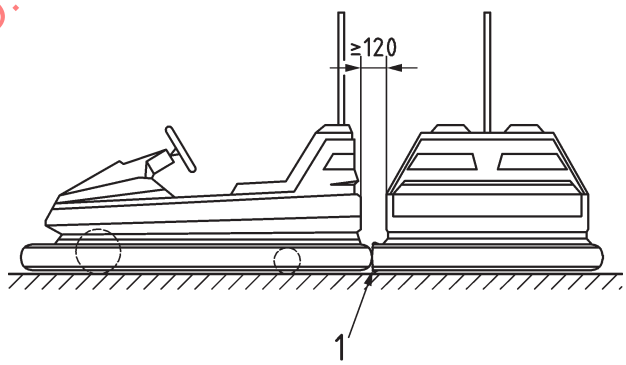
b Minimum lateral safety distance min. y_{lat} for children up to age of 10 years.

Figure 17 — 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 18). For dodgem/ bumper cars see minimum safety distances in Table 14.

Dimensions in millimetres



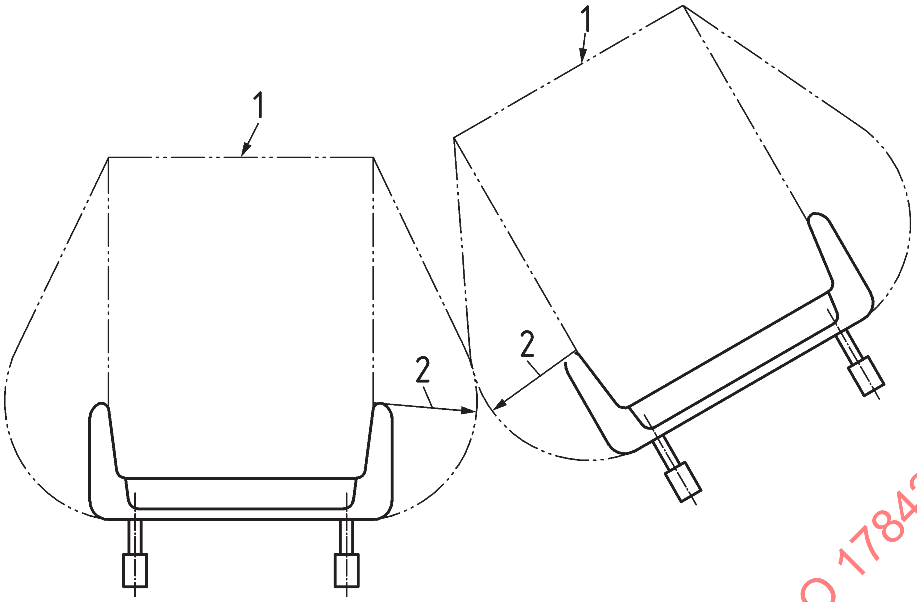
Key

1 distance element

Figure 18 — Safety distance for free ranging vehicles

If the passenger units are not free ranging, the safety envelopes shall not overlap (see Figure 19).

STANDARDSISO.COM : Click to view the full PDF of ISO 17842-1:2015



Key

1 safety envelope

2 minimum lateral safety distance, min. y_{lat}

Figure 19 — Relative position of safety envelopes

STANDARDSISO.COM : Click to view the full PDF of ISO 17842-1:2015

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 it is safe to do so.

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;

 © ISO 2015 – All rights reserved

— 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 avoid the ejecting and falling out of the passenger unit

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, when it is safe to do so.

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 standard 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 Annex D.

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 DRA the designer specifies the state, locked or unlocked, of the restraint system in the event of unintended stop, for example, emergency stop or loss of power.

Restraint devices shall be provided in cases where it is reasonably foreseeable that passengers could 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, for example, the application of emergency brakes or vehicles stopped in inverted positions.

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

For the axis convention refer to Figure 20.

STANDARDSISO.COM : Click to view the full PDF of ISO 17842-1:2015

© ISO 2015 – All rights reserved

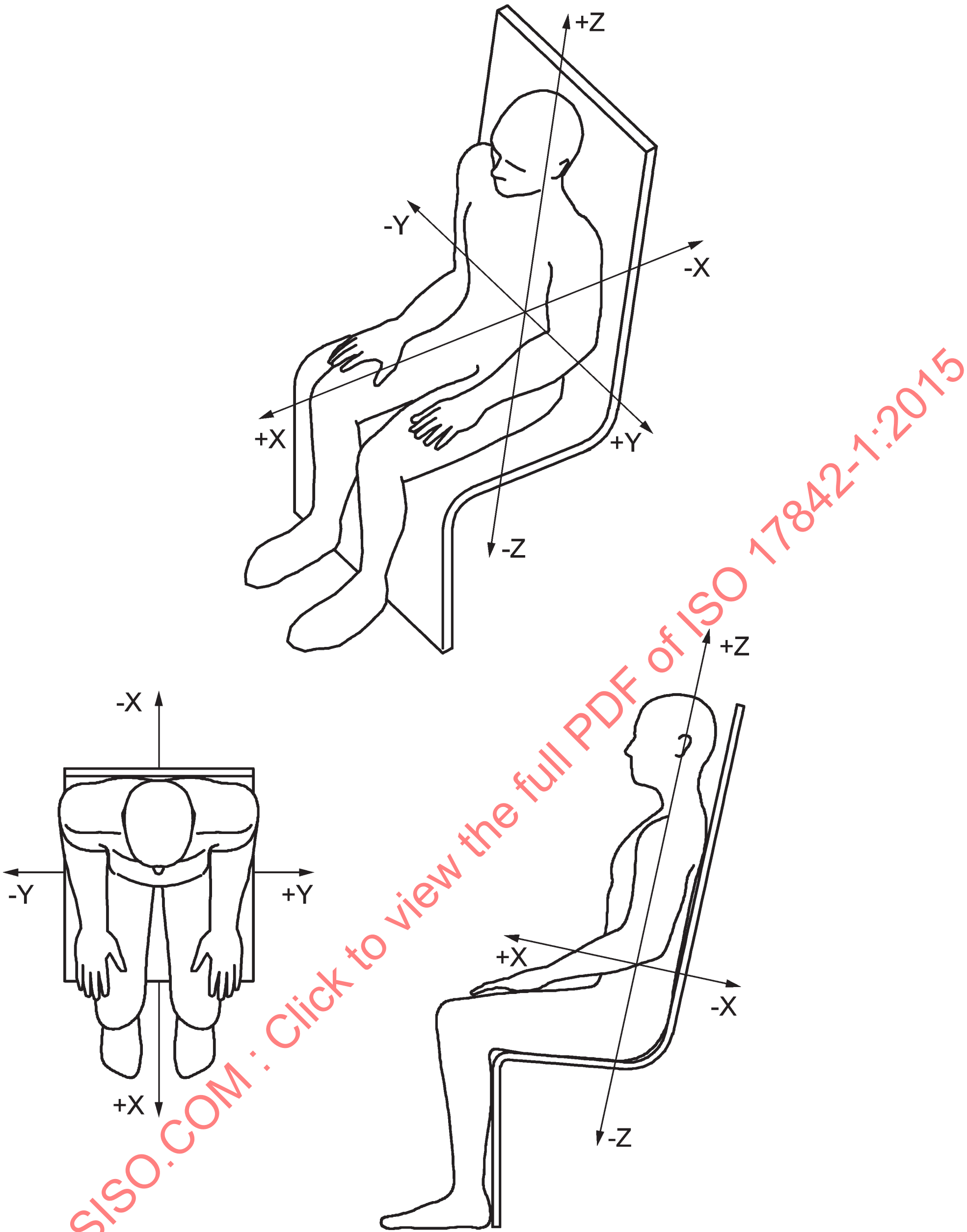


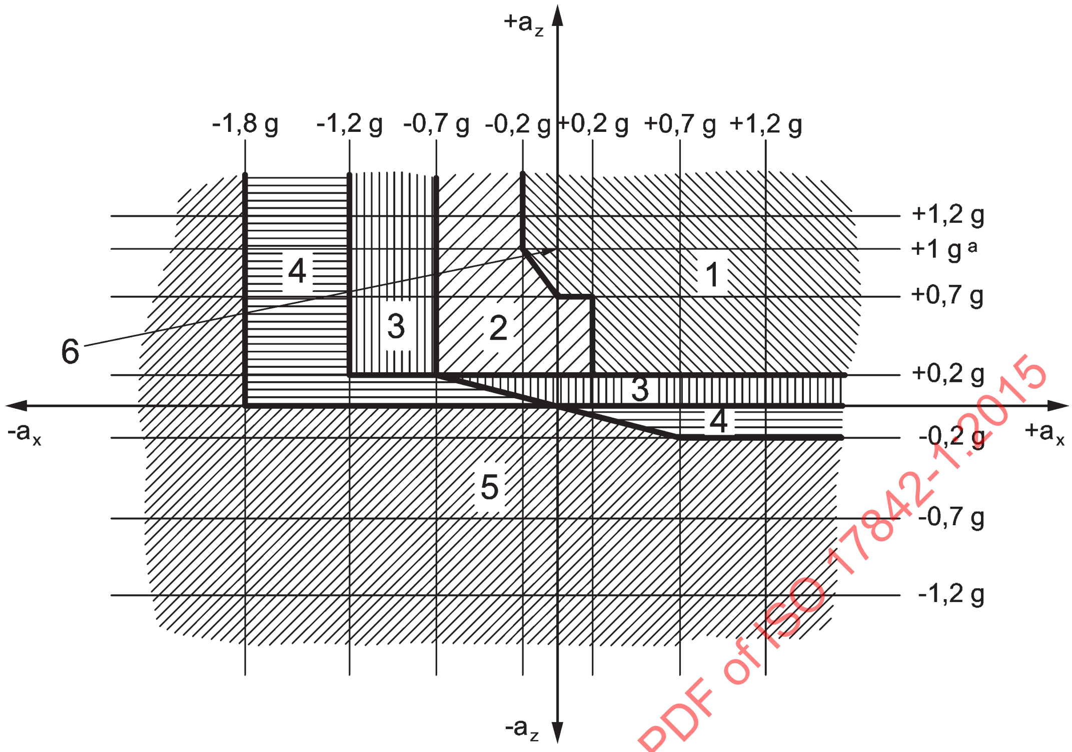
Figure 20 — Body coordinate system

STANDARDSISO.COM : Click to view the full PDF of ISO 17842-1:2015

A positive acceleration is defined in accordance with following the 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”.

 © ISO 2015 – All rights reserved



Key

$+a_z$	downward into seat (eyes down)
$-a_z$	lift (eyes up)
$+a_x$	acceleration (eyes back)
$-a_x$	deceleration (eyes front)
1	Area 1
2	Area 2
3	Area 3
4	Area 4
5	Area 5
6	at rest
a	Normal gravity.

Figure 21 — Restraint diagram

STANDARDSISO.COM : Click to view the full PDF of ISO 17842-1:2015

Area 1 — A Class 1 no restraint is required. Based solely on Area 1 dynamic forces, no restraint is required; however, other criteria in this practice (that is, the ride analysis) may require a higher class restraint device.

Area 2 — A Class 2 restraint is required, unless passengers are provided sufficient support and the means to react to the forces, for example, handrails, footrest, or other devices and if they cannot fall out, or be ejected from the compartment due to the acting forces.

Area 3 — A Class 3 restraint is required.

Area 4 — A Class 4 restraint is required.

Area 5 — A Class 5 restraint is required.

The application of the restraint diagram Figure 21 is intended as a guide. Any special situation needs to be taken into consideration in designing the restraint system, e.g. the duration of the acceleration. In particular where lateral accelerations higher than $a_y \geq \pm$ 0,5 g occur, seats, backrests and restraint shall be designed accordingly. Unexpected stopping positions of the passenger units shall also be considered (e.g. upside down). Any intended unconventional seating or passenger body position may need special consideration. In Figure 21 no information on the absolute acceleration limits is given.

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

Figure 21 is a design guide. If Figure 21 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 ± 0,05 g.

The risk assessment (see 5.1.2) may require a different class of restraint to be used.

The determination of the class of the restraint, based on Figure 21, 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 21. See also Table 13.

Class 1: Unrestraint 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 may be for an individual passenger or it may be a collective device for more than one passenger.

2) *Final latching position relative to the passenger* — The final latching position may be fixed or adjustable in relation to the passenger.

3) *Type of latching*— The passenger or operator may latch the restraint.

4) *Type of unlatching*— The passenger or operator may 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 may be manually or automatically (for example, motorized) opened and closed.

7) *Redundancy of latching device*— Redundancy is not required.

Class 3: A latching restraint device for each individual patron 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 may be for an individual passenger or it may be a collective device for more than one passenger.

2) *Final latching position relative to the passenger* — The final latching position must be adjustable in relation to the passenger, for example, a bar or a rail with multiple latching positions.

3) *Type of latching* — The passenger or operator may manually latch the restraint or it may be automatically latched. The manufacturer shall provide instructions that the operator shall verify the restraint device is latched.

4) *Type of unlatching* — The passenger may manually unlatch or the operator may manually or automatically unlatch the restraint.

5) *Restraint position monitoring* — In addition to the operator responsibilities no independent restraint position monitoring 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 may be manually or automatically (for example, motorized) opened and closed.

STANDARDSISO.COM : Click to view the full PDF of ISO 17842-1:2015

© ISO 2015 – All rights reserved

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 guest. The frequency and procedure of such a periodic test shall be determined by the mechanical design.

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, for example, 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.

NOTE For some amusement rides, e.g. roller coasters, freefall towers, the position of the restraint cannot be monitored continuously.

6) *Means of activation* — The restraint may be manually or automatically (for example, 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 guest. The frequency and procedure of such a periodic test shall be determined by the mechanical 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, for example, 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.

NOTE for some amusement rides e.g. roller coasters, freefall towers, etc. the position of the restraint cannot be monitored continuously.

6) *Means of activation* — The restraint may be manually or automatically (for example, 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

STANDARDSISO.COM : Click to view the full PDF of ISO 17842-1:2015

© ISO 2015 – All rights reserved

an accepted alternative the integrity of the redundant locking devices shall be verified within every two ride cycles.

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).

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	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 complies with 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).

Otherwise, this secondary device may be the containment enclosure or collective cage.

STANDARDSISO.COM : Click to view the full PDF of ISO 17842-1:2015

 © ISO 2015 – All rights reserved

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.

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 on rides intended only for children up to 10 years of age and if the risk analysis 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 upholstering, can greatly affect the effectiveness of the whole restraint system.

Seats suspended by steel wire ropes or link type chains shall have a suspension system, which in the case of the failure of 1 suspension element, does not result in a dangerous situation.

STANDARDSISO.COM : Click to view the full PDF of ISO 17842-1:2015

5.1.7.5 Passenger containment

Requirements for passenger containment can be found in Annex D.

5.1.8 Requirements for special provisions

5.1.8.1 Criteria relative to passenger characteristics

Particular passengers by virtue of their age or physical characteristics may be at risk on certain passenger-carrying amusement devices because of the nature of the ride. Classification can be made by 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.

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.

© ISO 2015 – All rights reserved

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 a particular achievable 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 rides and devices

5.2.1 Amusement rides with vertical axis

5.2.1.1 General

These are 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 may permit variation of inclination of the different rotating axes up to movement in vertical planes (see Figures 22 to 25).

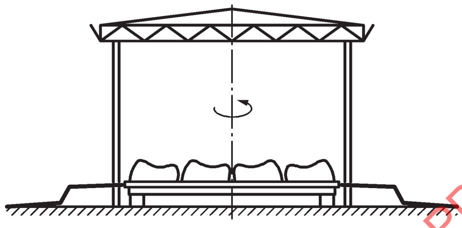


Figure 22 — Vertical axis, one degree of freedom

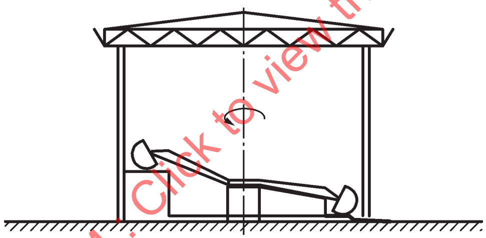


Figure 23 — Vertical axis, more than one degree of freedom

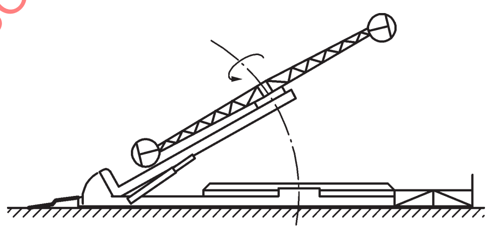


Figure 24 — Variable inclined more than one degree of freedom

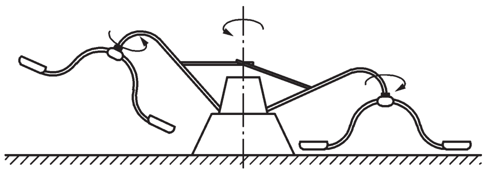


Figure 25 — Variable inclined axis

STANDARDSISO.COM : Click to view the full PDF of ISO 17842-1:2015

© ISO 2015 – All rights reserved

5.2.1.2 Area separation systems and access and egress openings

If in addition to horizontal vertical movements or another rotation (around a further axis) are also possible, the 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 for their access to the passengers unit is provided, this area shall be separated from the dangerous area by means of an area separation system complying, as a minimum with J1 requirements. Access and egress openings for the general public shall comply with 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 comply with J1 requirements.

If the 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 clause, the area separation system shall comply with J1 requirements. The same requirements shall be complied with 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.

On Chair-O-Planes and similar rides the minimum vertical distance between the lowest part of the seat and the areas accessible to the public shall be 2,7 m during rotation. Any area with less than 2,7 m of vertical clearance shall be delimited according to J1 requirements. If the maximum height of the seat is less than 2,7 m an area separation system according to J3 requirements, positioned at 0,5 m horizontal clearance from the seat position during run shall be provided, and access and egress openings shall comply with K1 requirements.

The outside contour of swinging seats or gondolas shall have at least 0,5 m horizontal distance from fixed objects.

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, would project outside the perimeter of the rotating platform, shall be fitted with a latching device which can be opened from the outside only.

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

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.

5.2.2 Amusement rides with horizontal axis

5.2.2.1 General

These are devices moving around horizontal axis. See Figures 26 to 28.

STANDARDSISO.COM : Click to view the full PDF of ISO 17842-1:2015

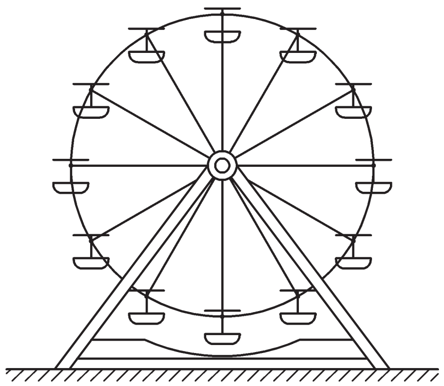


Figure 26 — Main horizontal axis (passenger unit pivoting)

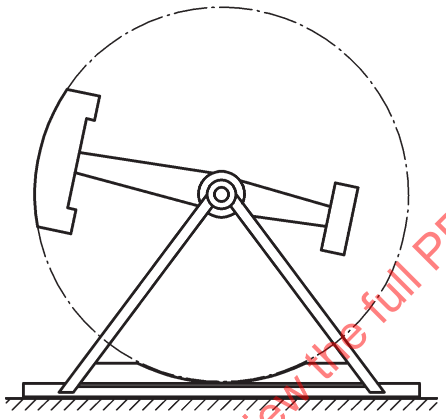


Figure 27 — Main horizontal axis (passenger unit not pivoting and with mechanical drive)

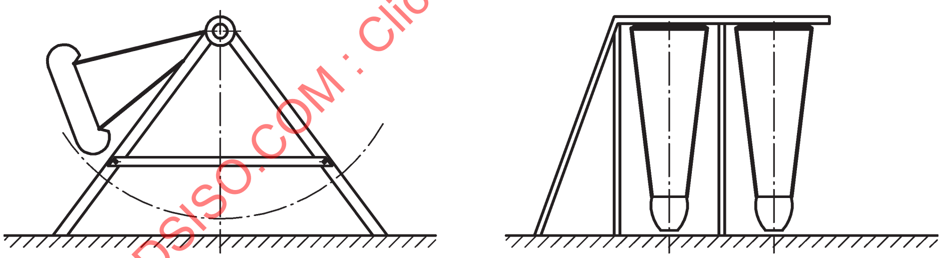


Figure 28 — Main horizontal axis (passenger unit not pivoting and without mechanical drive)

STANDARDSISO.COM : Click to view the full PDF of ISO 17842-1:2015

5.2.2.2 Area separation systems and access and egress openings

Area separation systems for the general public shall comply in general with J3 requirements (see 5.1.4.2.3).

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

Area separation systems for non-powered swings shall comply with 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.

 © ISO 2015 – All rights reserved

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 0,7 m and 0,25 m respectively.

Gondolas of giant wheels if not designed as closed cabins or not complying with 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 provide means of preventing long hair being caught). Fencing of access openings etc. 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, 0,7 m is sufficient.

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 will travel temporarily upside down during rotation and where the vertical (head to foot) 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 ship beyond the horizontal line through the centre 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 29.

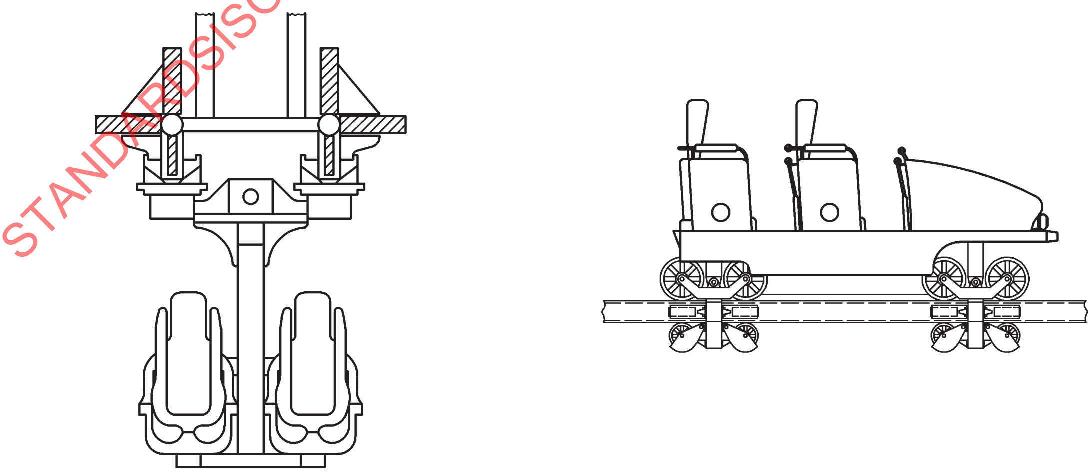


Figure 29 — Track-guided devices

STANDARDSISO.COM : Click to view the full PDF of ISO 17842-1:2015

© ISO 2015 – All rights reserved

5.2.3.2 Area separation systems and access and egress openings

Area separation systems for the general public shall comply with J3 requirements (see 5.1.4.2.3)

Access openings to the loading zones shall comply with 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 comply with 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 complying with J2 requirements. Access and egress openings shall comply with K2 requirements.

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

a) train route is clearly isolated from other amusement devices, shops or roads;

b) train is driven by an operator;

c) train's velocity does not exceed 5 m/s;

d) acoustic warnings are provided on the train;

e) acoustic and optical warnings are provided on level-crossings.

The station area separation system shall comply with J1 requirements (see 5.1.4.2.3).

STANDARDSISO.COM : Click to view the full PDF of ISO 17842-1:2015

5.2.3.3 Passenger units

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

— passengers inside and outside are not liable to come into contact with moving parts;

— passengers' hands or arms are not liable 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, while allowing for permissible wear.

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 are to 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 equivalent means like sensors.

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 rollers, counter 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. Wheel bandages, guide wheels, up stop wheels are subject to wear. The permissible wear rates shall be specified by precise limits.

 © ISO 2015 – All rights reserved

Lateral movement of cars and gondolas shall be restricted to prevent collision with cars or gondolas on adjacent tracks or fixed objects. Safety distances have to 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 will always be 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 also 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 (lap bars, etc.).

5.2.4 Dodgem/bumper cars

5.2.4.1 General

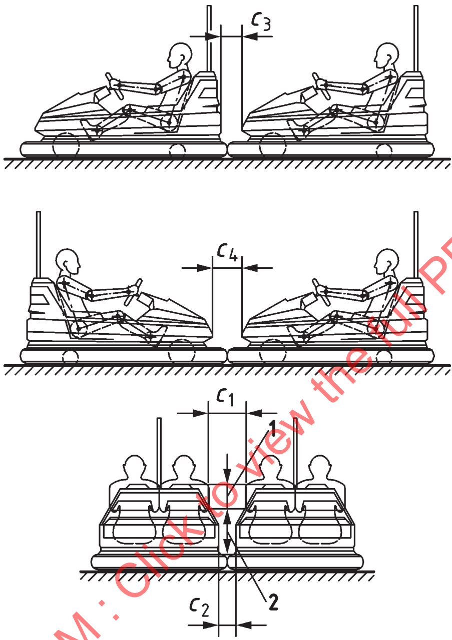
For bumper cars the minimum safety distances given in Table 14 shall be provided. See Figure 30 and Figure 31.

STANDARDSISO.COM : Click to view the full PDF of ISO 17842-1:2015

Table 14 — Safety distances for dodgem cars

Classes (defined by passenger height or age)		**X**	**Y**	**S**	**R1**	**R2**	**C1**[a]	**C2**[a]	**C3** [a]	**C4**[a]
Passengers from 4 to 8 years	min.	70	320	25	175	400	70	45	90	100
	max.	85	400	30	230	515				
Passengers from 8 to 12 years	min.	85	400	30	230	515	85	60	120	150
	max.	100	435	35	275	620				
Passengers and accompanied children	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 rubber protections and the like which can cause no damage) in static position.



Key

1 zone 1

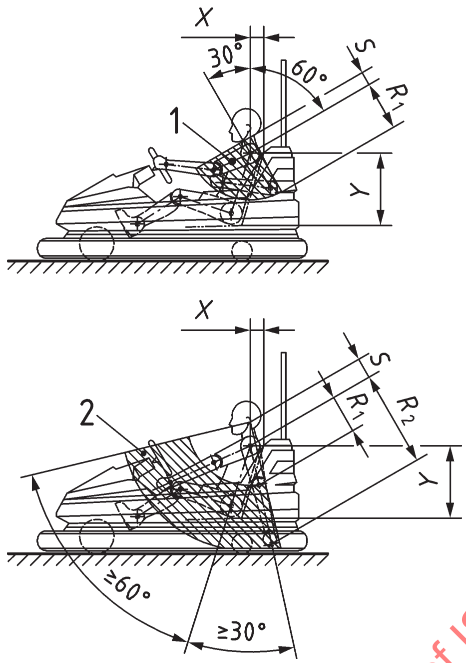
2 zone 2

C1–C4 minimum clearances (see Table 14)

Figure 30 — Dodgem/bumper cars

STANDARDSISO.COM : Click to view the full PDF of ISO 17842-1:2015

© ISO 2015 – All rights reserved



Key

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

Figure 31 — Dodgem/bumper cars

STANDARDSISO.COM : Click to view the full PDF of ISO 17842-1:2015

5.2.4.2 Area separation system and access and egress openings

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

The driving area shall be surrounded by a sill of sufficient height, so as to prevent mounting by the car. Spring supported sills are not permitted. 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 are to 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 could cause injury, shall either be

a) designed so as to remove risk of injury, or

b) so protected as to minimize injury by impact.

5.2.4.4 Restraints

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.

© ISO 2015 – All rights reserved

5.2.4.5 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 8 years or less, shall be limited to a maximum speed of 8 km/h if the risk assessment demonstrate the safe use.

Where high efficiency shock absorbing systems are provided the speed may be increased to 14 km/h, if the impact forces do not exceed the forces attained in a conventional dodgem car travelling up to 12 km/h.

The maximum speed of 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.

The installation shall be fitted with an emergency stop device, which enables the operator to stop all vehicles from his control position.

5.2.4.6 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 a safety isolating transformer in accordance with IEC 61558-1 or an equivalent generator.

For those conductors out of normal reach (heights 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 a safety isolating transformer in accordance with IEC 61558-1 or an equivalent AC. or DC. generator.

Exposed electrical conductors shall be at least 2,5 m above the floor pan of the vehicle.

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 will be minimized paying particular attention to the eyes as a result of particles and sparks.

For driving areas of up to 200 m^2 the current supply net or plate shall be securely attached to the power supply at a minimum of 2 points. For areas greater than 200 m^2 a minimum of 3 supply points shall be fitted.

Any current supply net shall be of wire mesh (preferably hexagonal) with a diameter of wire between 1,2 mm and 1,4 mm. The square hole size of the mesh shall not exceed 40 × 40 mm.

As well as steel other suitable materials (e.g. copper, brass, aluminium) may 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 will occur.

Steel wires shall be galvanised before being joined by 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).

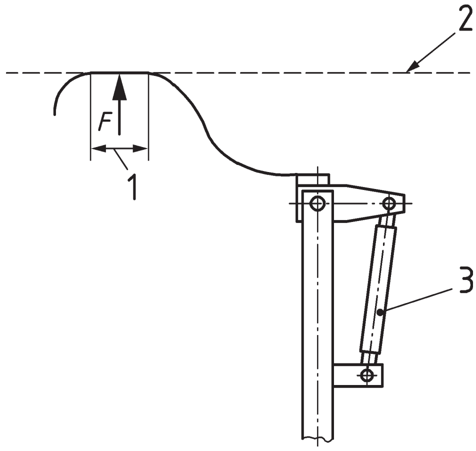
The vehicles shall be equipped with contact brushes made of steel or bronze, which are spring loaded against the floor with a force *F* of at least 10 N (Figure 33).

The current collector (see Figure 32) shall be made of steel 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. Steel or other suitable alternative materials (e.g. copper, brass, aluminium) may be used.

STANDARDSISO.COM : Click to view the full PDF of ISO 17842-1:2015

 © ISO 2015 – All rights reserved

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



Key

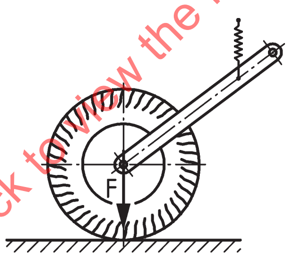
1 contact area

2 net

3 spring

F contact force

Figure 32 — Example of a typical net current collector



Key

F contact force

Figure 33 — Contact force of a floor contact brush

STANDARDSISO.COM : Click to view the full PDF of ISO 17842-1:2015

The plates which form the track shall be smooth; panels shall have 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 and 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 complying with J3 requirements). Access and egress shall comply with 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.

© ISO 2015 – All rights reserved

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 such that passengers are not endangered by an engine fire. International standards 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 and access and egress openings

To prevent the general public from walking onto the track, the area separation system shall comply with J3 requirements. Access and egress shall comply with 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.

STANDARDSISO.COM : Click to view the full PDF of ISO 17842-1:2015

 © ISO 2015 – All rights reserved

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 standard.

5.2.7.2 Area separation system and access and egress

On the sides of the waterway there shall be an access area 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.

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.

NOTE In water rides the hazards in case the passenger unit capsized 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 m^2/boat with a maximum speed up to 8 km/h;

— 30 m^2/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 and 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 34). In the station area the distance between the wall of the boat and

STANDARDSISO.COM : Click to view the full PDF of ISO 17842-1:2015

access- respectively egress-platform shall be reduced to approximately 0.05 m. Special consideration shall be given to the change of clearance.

Dimensions in millimetres

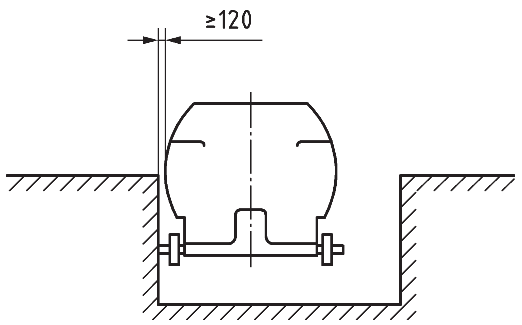


Figure 34 — Minimum distance to channel walls

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 35.

See also general requirements in 5.1.8.

Dimensions in millimetres

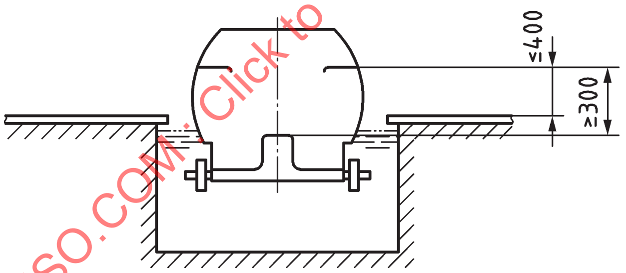


Figure 35 — Minimum and maximum step height and side wall height

5.2.8.3 Restraints

Restraint devices are not required on flume ride boats if the average longitudinal deceleration during braking does not exceed 0,7 g, the downward slope does not exceed 35° and the head-to-foot acceleration is more than +0,2 g in all places. In this case the restraint diagram of Figure 21 shall not be applied.

5.2.8.4 Miscellaneous

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

Consequently, means should be provided to separate boats in the lifts or in zones preceding the slopes. The slope zone shall be considered as a block-zone.

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

STANDARDSISO.COM : Click to view the full PDF of ISO 17842-1:2015

 © ISO 2015 – All rights reserved

For general requirements related block-zone systems, see also 5.2.3.6.

For block-zone control systems, see Annex C.

Sufficient water quality shall be achieved and kept.

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

5.2.9 Helter skelters, slides, etc.

5.2.9.1 General

The requirements below are in addition to or prevail over those contained in the European Standards for playground equipment 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.

For water slides refer to EN 1069.

5.2.9.2 Area separation system and 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 comply with J3 requirements as a minimum. Access openings to the loading and run out zones shall comply with K2 requirements, in order to prevent crushing of users. Egress openings shall comply with K1 requirements.

5.2.9.3 Passenger units

Means (sacks, mats, sleds, etc.) 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 for single channels be at least 0,45 m high 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 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.

STANDARDSISO.COM : Click to view the full PDF of ISO 17842-1:2015

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 may be 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.

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 the European Standard for playground equipment (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 fallen 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, seesaws etc. 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 may 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 EN 14960.

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, etc. where hard footwear is undesirable as fellow participants may 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 shall control unruly

STANDARDSISO.COM : Click to view the full PDF of ISO 17842-1:2015

© ISO 2015 – All rights reserved

behaviour and warn participants of their unsafe acts. Supervision may 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 m^2 shall have a minimum of two distinct exits each being at least 1.0 m wide. For more than 100 m^2 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 attraction 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 (general safety distances).

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 Temporary grandstands

Where on an open air temporary grandstand a row of seats has an aisle at one end of the row only, the number of seats shall not exceed 16. Where there is an aisle at both ends of the row, it shall not exceed 32 seats. When the difference in height of the rows is more than 32 cm, then only 11 and 22 places are permitted respectively.

Escape routes shall have a width of at least 1 m per 450 persons in the open air and 1 m per 150 persons in tents. The minimum width of escape routes is 1 m in either case. The walkway of each row shall be at the same level as the corresponding step.

Where there is standing only, the minimum width per person shall be 50 cm and the maximum depth of the row 45 cm. Where there is standing room only, the number of persons (e.g. for the width of exits) shall be calculated according to the available area.

The floor slab of grandstands shall be firmly attached to the supporting structure, so as to prevent sliding (see 4.5).

Where access is possible beneath the grandstand, protection from falling objects shall be provided.

The design of the structure shall prevent the accumulation of rubbish.

Seats shall be at least 44 cm wide and fixed to the supporting structure. Seats within a row shall be fixed to each other or the ground. The minimum distance between seating rows shall be 45 cm.

NOTE Supplementary information can be found in EN 13200.

STANDARDSISO.COM : Click to view the full PDF of ISO 17842-1:2015

5.2.10.6 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 5.1.6.3, the admissible number of persons shall be based on the number of seats (e.g. on grandstands).

5.2.11 Shooting stands and trailers, shooting devices

5.2.11.1 Area separation system and 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 (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 will not be 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.

STANDARDSISO.COM : Click to view the full PDF of ISO 17842-1:2015

 © ISO 2015 – All rights reserved

— 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 may be subject to prevailing national laws.

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 may be subject to prevailing national laws.

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 targets shall be at least 2,8 m from the shooting rests when using weapons of the compressed air type, and 5,5 m when using live ammunition.

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 will occur.

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 risk assessment (DRA). A first failure of the system shall be detected. In this case a subsequent failure need not be considered (see ISO 4413, ISO 4414).

STANDARDSISO.COM : Click to view the full PDF of ISO 17842-1:2015

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.

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 as much as possible the inspection of the pipe and particularly the joints.

5.3.1.5 Hoses

Pressure hoses shall be able to withstand five times the maximum operating pressure. Hydraulic hoses shall be suitable for the type of hydraulic fluid used in the system.

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 may 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 due to the failure of piping or hoses a dangerous situation can occur, a non-return valve, a flow control valve or a pipe break valve shall be fitted directly to the cylinder.

STANDARDSISO.COM : Click to view the full PDF of ISO 17842-1:2015

 © ISO 2015 – All rights reserved

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

These lifts are an integral part of the amusement rides and devices and cannot be used for general lift purposes.

5.3.2.1 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 could be closed or open, depending on risk assessment.

The hoist unit shall be arranged so that the connection between the brake and the drum or sprocket cannot be interrupted.

5.3.2.2 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.

STANDARDSISO.COM : Click to view the full PDF of ISO 17842-1:2015

5.3.2.3 Overload protection

If there is 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.

5.3.2.4 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 cable cannot occur under any operational condition.

5.3.2.5 Safety system

Machines with a lifting carriage which is intended to carry person(s) and which can be raised more than 1,5 m shall be equipped with a safety system(s) against over speed caused by failure of the suspension and mechanical units (chain, rope, drive gear, counterweight, etc.), shall be designed as detailed below 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 need to be verified.

5.3.2.6 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 person(s) 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 partial safety factor against the minimum discard period of a minimum of one year is achieved, the partial 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 1570 N/mm^2.

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

STANDARDSISO.COM : Click to view the full PDF of ISO 17842-1:2015

 © ISO 2015 – All rights reserved

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 $v \leq 1\text{m/s}$ and a lift height less than 2 m;

Category C — lifting device with passengers or persons exposed to it and speed $v > 1\text{m/s}$ or a lift height more than 2 m.

Lifting devices in category A and category B (D/d) shall be calculated to appropriate standards 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.

5.3.2.7 Hydraulic drives

For these types of elevating units see also 5.3.1. The lifting units shall be designed such that in the event of hydraulic leakage, no dangerous situation may occur.

For hoist units directly operated by cylinders, valves shall be fitted to prevent uncontrolled lowering in case of pipe or hose failure.

5.3.2.8 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.

5.3.2.9 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.

STANDARDSISO.COM : Click to view the full PDF of ISO 17842-1:2015

© ISO 2015 – All rights reserved

Visual examination of the pinions shall be possible with neither the removal of the pinions nor major disassembly of structural components.

5.3.2.10 Pneumatic drives

For these types of elevating units see also 5.3.1. The lifting units shall be designed such that in the event of pneumatic leakage, no dangerous situation may occur.

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

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 manufacturer of welding construction shall have an appropriate welding qualification according to suitable international or national accepted standards, e.g. ISO 3834-2 and ISO 3834-3.

5.4.1.1 Subcontracting and supply

Safety-related materials, parts, assemblies, or components shall be made in accordance with the design specification and quality requirements of appropriate ISO Standards or national equivalents.

Such parts shall be clearly defined by manufacturers, subcontractors and suppliers.

There may 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.

5.4.1.2 Documentation

The manufacturer shall provide quality documentation in accordance with international or national standards. These documents will be part of the technical dossier.

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 review 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.

Non-destructive testing (NDT) techniques will be required for certain aspects of manufacture. The manufacturer shall attain 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.

STANDARDSISO.COM : Click to view the full PDF of ISO 17842-1:2015

 © ISO 2015 – All rights reserved

5.4.2.2 Quality requirements

As minimum requirements for safety-related components the following standards shall be applied for the different quality assurance processes:

— EN 10160 (other comparable, national standards may be applied);

— EN 10164 (other comparable, national standards may be applied).

5.4.2.3 Semi-finished material

Plates and wide flat bars in load-bearing structures which are loaded in the thickness direction with tensile forces a lamination test with ultrasonic has to be performed, starting from a thickness of 10mm.

Plates and wide flat bars in load-bearing structures which are loaded in the thickness direction with tensile forces have to be suitable for this special requirement. The procedure is described in the particular standards.

5.4.2.4 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 EN 10228-1 and EN 10228-2 is recommended.

5.4.2.5 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 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.

Pressure vessels shall be in accordance with ASME Boiler and Pressure Vessel Code (BPVC), Pressure Equipment Directive 2009/105/EC (PED).

Any further requirements in International Standards (i.e. international standards published by ISO) or, in their absence, equivalent international or national standards shall also be respected. Other regulations may apply.

Ropes, chains etc., shall be supplied with certificates showing at least the guaranteed minimum breaking load, type and size.

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 manufacture 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).

STANDARDSISO.COM : Click to view the full PDF of ISO 17842-1:2015

Where hollow section structural steel is used, internal corrosion is to be avoided.

5.4.3.3 Welding procedure

The appropriate welding procedure for the material being used shall be approved by the designer if it is not covered by a standard.

Only welding filler material which apply to the respective ISO-standards are allowed for use.

5.4.3.4 Steel welding

Welding preparation shall be according to ISO 9692-1 and ISO 9692-2.

Welding sequence plans shall be created for all safety critical welded assemblies before start of production.

Welding procedures shall be in conformance with ISO 15607, ISO 15609-1, ISO 15614-1, ISO 15614-2, ISO 15610, ISO 15611, ISO 15612, ISO 15613, EN 288-9. ISO 3834-2, ISO 3834-3, and welders shall be approved in accordance with ISO 9606-1 and/or ISO 14732.

NOTE Supplementary information can be found in ISO/TR 15608, ISO/TR 20172 and ISO/TR 20173.

5.4.3.5 Standards and requirements for non-destructive testing of welds

Basically, the provisions of ISO 17635 shall apply.

All welds of dynamic loaded parts shall meet the requirements of ISO 5817:2014, quality level B.

All welds of static loaded parts and subordinate components shall meet the requirements of ISO 5817:2014, quality level C.

The annex in ISO 17635 provides cross reference from ISO 5817 to applicable magnetic particle testes (MT), penetration tests (PT), ultrasonic tests (UT) and radiographic tests (RT) standards, including acceptance levels. They should be considered as minimum.

Special investigation shall be done and approved by the designer where a change in welding procedure may affect stress and fatigue properties.

5.4.3.6 Aluminium welding

Welding procedures shall be in conformance with ISO 15607, ISO 15609-1, ISO 15614-2, ISO 15610, ISO 15611, ISO 15612, ISO 15613, EN 288-9 and welders shall be approved in accordance with EN 9606-2.

Welding of aluminium parts for amusement devices especially under fatigue conditions shall only be conducted by manufacturers who are in possession of welding qualification for fatigue loaded parts according to ISO 14731, ISO 3834-2 or equivalent and the additional qualification according to this document (Extension of permission for amusement rides).

Welds subjected to fluctuating stresses, i.e. fatigue conditions, shall meet Quality Level "B", specified in ISO 10042:2005. Special investigation shall be done and approved by the designer where a change in welding procedure may affect stress and fatigue properties.

5.4.3.7 Plastic composites

Safety critical load bearing composites (FRP = 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

STANDARDSISO.COM : Click to view the full PDF of ISO 17842-1:2015

 © ISO 2015 – All rights reserved

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, etc., and
— composite samples of each different construction provided for tests.

5.4.4 Safety precautions to be taken by the manufacturer

5.4.4.1 General

The manufacturer of amusement rides and 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 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 risk assessment OURA.

The operator's position shall be provided with safe and easy means of access and be adequately illuminated.

NOTE If the correct operation of the amusement devices depends on lighting see EN 1837 for guidance.

All parts of the 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.

For the assessment of safe working procedures for employees and operators, an individual risk assessment shall be made in accordance to workplace legislation.

5.4.5 Electrical installations

For electrical installation and components, see Annex B.

5.5 Supply

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 etc.) shall be added to the device log.

The manual shall provide, as a minimum, the instructions stated hereafter.

STANDARDSISO.COM : Click to view the full PDF of ISO 17842-1:2015

© ISO 2015 – All rights reserved

5.5.1.2 Assembly and dismantling instructions

These instructions shall comprise:

— specification of the special equipment, tools, material or parts which are to be used for safe assembly or dismantling of the device;

— 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 according to Annex B;

— plans of the 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.

STANDARDSISO.COM : Click to view the full PDF of ISO 17842-1:2015

 © ISO 2015 – All rights reserved

— 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, etc.

— safety-related components with limited lifetime shall be specifically addressed.

— 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 in accordance with the relevant International Standards or in absence of these, national standards.

5.5.2 Special information

This information shall include:

— 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 device showing the principal dimensions when erected and recommended safe clearance distances for the 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, see ISO 17842-3.

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,

STANDARDSISO.COM : Click to view the full PDF of ISO 17842-1:2015

  - 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;
- identification of critical components and control requirements.

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:

- 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 movement 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.

STANDARDSISO.COM : Click to view the full PDF of ISO 17842-1:2015

5.7 Device log

5.7.1 General

The 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.

It shall clearly identify the 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 device log shall be available on each installation site for maintenance, tests, inspections and checks. All inspection reports shall be included by appropriate entries.

© ISO 2015 – All rights reserved

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 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) 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 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.

STANDARDSISO.COM : Click to view the full PDF of ISO 17842-1:2015

An example of a device log is given in Annex E.

5.8 Official technical dossier

5.8.1 General

For each device an official 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 for inspection bodies. The official dossier shall be kept by the designer and/ or manufacturer with copies to the reviewing inspection body. All initial approval and inspection reports shall be included therein.

5.8.2 Content

The official 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, 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 manufacturer and/or importer/supplier;

— type/model no.;

— manufacturers serial no.;

— month and year of manufacture;

— date of initial approval;

— approval mark if requested /no. of inspection body;

— safe working load/number of persons to be carried.

STANDARDSISO.COM : Click to view the full PDF of ISO 17842-1:2015

 © ISO 2015 – All rights reserved

Enclosures and booths shall be marked with

— name and address of manufacturer/supplier/importer, and

— month and year of manufacture.

STANDARDSISO.COM : Click to view the full PDF of ISO 17842-1:2015

© ISO 2015 – All rights reserved

Annex A
(informative)

Fatigue analysis

A.1 General

For most amusement rides and devices there are many structural and mechanical components which are subjected to significant numbers of cycles of stress fluctuation.

The assessment against fatigue phenomena — Fatigue analysis — shall be employed. Decisions about required inspection and maintenance may then be based on the fatigue analysis.

The design of all load bearing structural components with fatigue loading shall be satisfactory for the overall operating period.

The formulae stated hereafter may be applied in assessing fatigue limit states for amusement devices and follows EN 1993-1-9:2005.

STANDARDSISO.COM : Click to view the full PDF of ISO 17842-1:2015

A.2 Terms

A.2.1 Detail category

The detail category is the numerical designation given to a particular detail for a given direction of stress fluctuation, in order to indicate which fatigue strength curve is applicable for the fatigue assessment. The detail category number indicates the reference fatigue strength, $\Delta\sigma_C$, in N/mm^2.

A.2.2 Endurance Limit (constant amplitude fatigue limit)

The endurance limit is the limiting direct or shear stress range value below which no fatigue damage will occur in tests under constant amplitude stress conditions. Under variable amplitude conditions all stress ranges have to be below this limit for no fatigue damage to occur. Hence the endurance limit encloses the fatigue strength if the actual/real maximum stress range is less than the endurance limit.

A.2.3 Cut-off limit (threshold value of fatigue strength)

The cut-off limit is the limit below which stress ranges of the design spectrum do not contribute to the calculated cumulative damage.

A.2.4 Endurance

Endurance is the life to failure expressed in cycles, under the action of a constant amplitude stress history.

A.2.5 Reference fatigue strength

This is the constant amplitude stress range, $\Delta\sigma_C$, for a particular detail category for an endurance of $N_C = 2 \times 10^6$ cycles.

© ISO 2015 – All rights reserved

A.3 Symbols

$\Delta\sigma$ actual direct stress range

$\Delta\tau$ actual shear stress range

f_y material yield stress

N Number of stress cycles at fatigue limit

n_{max} expected maximum number of stress cycles

$\Delta\sigma_C$, $\Delta\tau_C$ reference value of the fatigue strength at $N_C = 2 \times 10^6$ cycles

$\Delta\sigma_R$, $\Delta\tau_R$ fatigue strength (resistance) for constant amplitude stress ranges resisting a certain number of cycles N_R (resisting cycles)

$\Delta\sigma_D$, $\Delta\tau_D$ fatigue limit for constant amplitude stress ranges at the number of cycles N_D

$\Delta\sigma_L$, $\Delta\tau_L$ cut-off limit for stress ranges at the number of cycles N_L

$\Delta\sigma_E$, $\Delta\tau_E$ equivalent constant amplitude stress ranges related to n_{max}

$\Delta\sigma_{E,2}$, $\Delta\tau_{E,2}$ equivalent constant amplitude stress ranges related to 2×10^6 cycles

γ_{Ff} partial factor for equivalent constant amplitude stress ranges $\Delta\sigma_E$, $\Delta\tau_E$

γ_{Mf} partial factor for fatigue strength $\Delta\sigma_C$, $\Delta\tau_C$

m slope of the fatigue strength curve

D_d damage during the design life

A.4 Fatigue strength

The fatigue strength for nominal stress ranges is represented by a series of $\log_{10} \Delta\sigma$ over $\log_{10} N$ curves and $\log_{10} \Delta\tau$ over $\log_{10} N$ curves (S-N-Curves), which correspond to typical detail categories (see EN 1993-1-9). Each detail category is designated by a number which represents, in N/mm², the reference value $\Delta\sigma_C$ and $\Delta\tau_C$ and for the fatigue strength at 2 million cycles.

For constant amplitude nominal stress ranges the fatigue strength can be obtained as follows:

$$\Delta\sigma_R^m N_R = \Delta\sigma_C^m \, 2\times10^6 \qquad \text{(A.1)}$$

with $m = 3$ for $N \leq 5 \times 10^6$;

$$\Delta\tau_R^m N_R = \Delta\tau_C^m \, 2\times10^6 \qquad \text{(A.2)}$$

with $m = 5$ for $N \leq 10^8$;

$$\Delta\sigma_D = \left(\frac{2}{5}\right)^{\frac{1}{3}} \cdot \Delta\sigma_C = 0{,}737\Delta\sigma_C \quad \text{for endurance limit} \qquad \text{(A.3)}$$

STANDARDSISO.COM : Click to view the full PDF of ISO 17842-1:2015

$$\Delta\tau_L = \left(\frac{2}{100}\right)^{\frac{1}{5}} \cdot \Delta\tau_C = 0{,}457\Delta\tau_C \quad \text{for endurance limit} \tag{A.4}$$

For nominal stress spectra with a maximum stress range $\Delta\sigma_1$ above the constant amplitude fatigue limit, the fatigue strength can be calculated as follows, if a cycle counting method shows that the second highest stress range $\Delta\sigma_2$ is below the cut off limit:

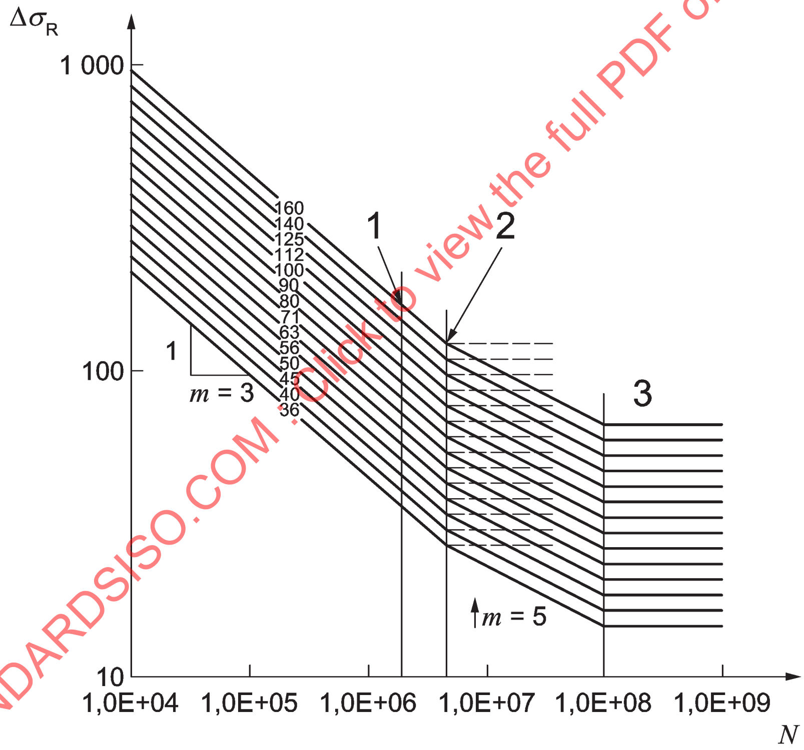
$$\Delta\sigma_R^m N_R = \Delta\sigma_C^m \, 2\times10^6 \tag{A.5}$$

with $m = 3$ for $N \leq 5 \times 10^6$;

$$\Delta\sigma_R^m N_R = \Delta\sigma_D^m \, 5\times10^6 \tag{A.6}$$

with $m = 5$ for $5 \times 10^6 \leq N \leq 10^8$;

$$\Delta\sigma_L = \left(\frac{5}{100}\right)^{\frac{1}{5}} \cdot \Delta\sigma_D = 0{,}549\Delta\sigma_D \tag{A.7}$$



Key

1 detail category $\Delta\sigma_C$

2 constant amplitude fatigue limit $\Delta\sigma_D$

3 cut-off limit $\Delta\sigma_L$

$\Delta\sigma_R$ direct stress range, N/mm^2

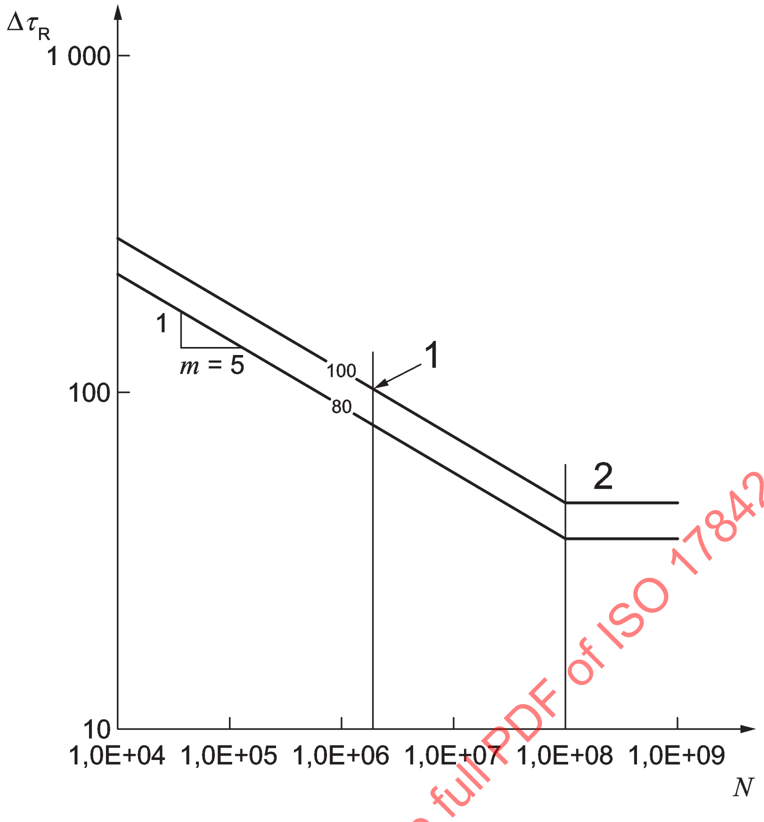
m slope of the fatigue strength curve

N endurance, number of cycles

Figure A.1 — Fatigue strength curves for direct stress ranges (EN 1993-1-9:2005, Figure 7.1)

STANDARDSISO.COM : Click to view the full PDF of ISO 17842-1:2015

 © ISO 2015 – All rights reserved



Key

1 detail category $\Delta\tau_C$

2 cut-off limit $\Delta\tau_L$

$\Delta\tau_R$ shear stress range, in N/mm²

m slope of the fatigue strength curve

N endurance, number of cycles

Figure A.2 — Fatigue strength curves for shear stress ranges (EN 1993-1-9:2005, Figure 7.2)

STANDARDSISO.COM : Click to view the full PDF of ISO 17842-1:2015

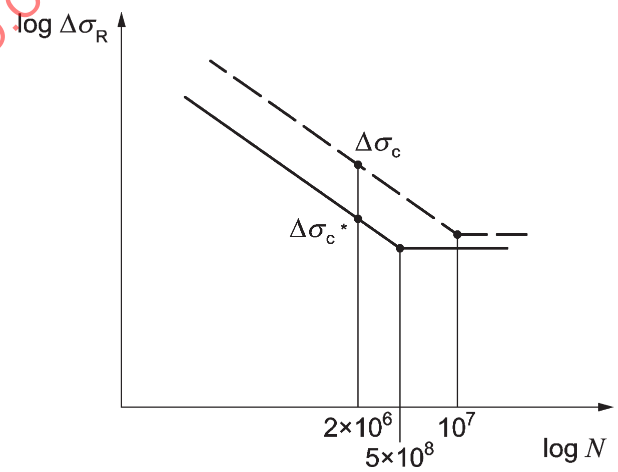


Figure A.3 — Alternative strength $\Delta\sigma_C$ for details classified as $\Delta\sigma$* (EN 1993-1-9:2005, Figure 7.3)

In order to ensure that non conservative conditions are avoided, such details, marked with an asterisk, are located one detail category lower than their fatigue strength at 2×10^6 cycles would require. An alternative assessment may increase the classification of such details by one detail category provided

© ISO 2015 – All rights reserved

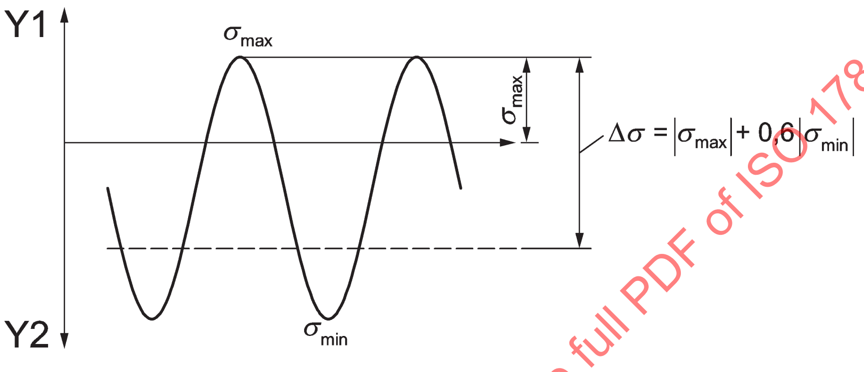
that the constant amplitude fatigue limit $\Delta\sigma_D$ is defined as the fatigue strength at 10^7 cycles for $m = 3$ (see Figure A.3).

A.5 Fatigue strength modifications

A.5.1 Non-welded or stress-relieved welded details in compression

In non-welded details or stress-relieved welded details, the mean stress influence on the fatigue strength may be taken into account by determining a reduced effective stress range $\Delta\sigma_{E,2}$ in the fatigue assessment when part or all of the stress cycle is compressive.

The effective stress range may be calculated by adding the tensile portion of the stress range and 60 % of the magnitude of the compressive portion of the stress range, see Figure A.4.



Key

Y1 tension

Y2 compression

Figure A.4 — Modified stress range for non-welded or stress relieved details
(EN 1993-1-9:2005, Figure 7.4)

A.6 Fatigue verification using equivalent constant amplitude stress

Nominal, modified nominal or geometric stress ranges due to frequent loads should not exceed

$$\Delta\sigma \leq 1{,}5 f_y \tag{A.8}$$

for direct stress ranges

$$\Delta\sigma \leq 1{,}5\, f_y / \sqrt{3} \tag{A.9}$$

for shear stress ranges.

STANDARDSISO.COM : Click to view the full PDF of ISO 17842-1:2015

© ISO 2015 – All rights reserved

It should be verified that under fatigue loading the following formulae shall be calculated:

$$\frac{\gamma_{\mathrm{Ff}} \Delta\sigma_{\mathrm{E,2}}}{\Delta\sigma_{\mathrm{C}} / \gamma_{\mathrm{Mf}}} \leq 1{,}0 \qquad \text{(A.10)}$$

and

$$\frac{\gamma_{\mathrm{Ff}} \Delta\tau_{\mathrm{E,2}}}{\Delta\tau_{\mathrm{C}} / \gamma_{\mathrm{Mf}}} \leq 1{,}0 \qquad \text{(A.11)}$$

In case fatigue limit is defined by endurance limit the equivalent constant amplitude stress range becomes:

$$\Delta\sigma_{\mathrm{E,2}} = \frac{1}{\sqrt[m]{\frac{N_{\mathrm{C}}}{N_{\mathrm{E}}}}} \Delta\sigma_{\mathrm{E}} = \frac{1}{\sqrt[m]{\frac{N_{\mathrm{C}}}{N_{\mathrm{D}}}}} \Delta\sigma_{\mathrm{E}} \qquad \text{(A.12)}$$

$$\Delta\tau_{\mathrm{E,2}} = \frac{1}{\sqrt[m]{\frac{N_{\mathrm{C}}}{N_{\mathrm{E}}}}} \Delta\tau_{E} = \frac{1}{\sqrt[m]{\frac{N_{\mathrm{C}}}{N_{\mathrm{D}}}}} \Delta\tau_{\mathrm{E}} \qquad \text{(A.13)}$$

For roller coasters, roundabouts, wonder wheels, and amusement devices with periodic similar loading the amplitude stress $\Delta\sigma$ can be assumed as equivalent constant amplitude stress $\Delta\sigma_{\mathrm{E}}$.

A.7 Determination of loading events

Typical loading sequences that represent a credible estimated upper bound of all service load events expected during the fatigue design life should be determined using prior knowledge from similar structures, see Figure A.5 a).

A.8 Stress history at detail

A stress history should be determined from the loading events at the structural detail under consideration taking account of the type and shape of the relevant influence lines to be considered and the effects of dynamic magnification of the structural response, see Figure A.5 b).

Stress histories may also be determined from measurements on similar structures or from dynamic calculations of the structural response.

A.9 Cycle counting

Stress histories may be evaluated by either of the following cycle counting methods:

- rainflow method;
- reservoir method, see Figure A.5 c).

The evaluation shall determine:

- stress ranges and their numbers of cycles;
- mean stresses, where the mean stress influence needs to be taken into account.

A.10 Stress range spectrum

The stress range spectrum should be determined by presenting the stress ranges and the associated number of cycles in descending order, see Figure A.5 d). Stress range spectra may be modified by neglecting peak values of stress ranges representing less than 1 % of the total damage and small stress

STANDARDSISO.COM : Click to view the full PDF of ISO 17842-1:2015

© ISO 2015 – All rights reserved

ranges below the cut off limit. Stress range spectra may be standardized according to their shape, e.g. with the coordinates

$\Delta\sigma$ = 1,0 and $\sum n = 1{,}0$

A.11 Cycles to failure

When using the design spectrum the applied stress ranges $\Delta\sigma_i$ should be multiplied by γ_{Ff} and the fatigue strength values $\Delta\sigma_C$ divided by γ_{Mf} in order to obtain the endurance value N_{Ri} for each band in the spectrum. The damage D_d during the design life should be calculated from:

$$D_d = \sum_i^n \frac{n_{Ei}}{N_{Ri}} \quad \text{(A.14)}$$

where

n_{Ei} is the number of cycles associated with stress range $\gamma_{Ff}\,\Delta\sigma_i$ for band i in the factored spectrum;

N_{Ri} is the endurance (in cycles) obtained from the factored $\Delta\sigma_c/\gamma_{Mf}$ to N_R curve for a stress range of $\gamma_{Ff}\,\Delta\sigma_i$.

On the basis of equivalence of D_d, the design stress range spectrum may be transformed into any equivalent design stress range spectrum, e.g. a constant amplitude design stress range spectrum yielding the fatigue equivalent load Q_E associated with the cycle number $n_{max} = \sum n_i$ or Q_E associated with the cycle number $N_C = 2 \times 10^6$.

See Figure A.5 e).

A.12 Verification formats

The fatigue assessment based on damage accumulation should meet the following criteria:

— based on damage accumulation:

$$D_d \leq 1{,}0; \quad \text{(A.15)}$$

— based on stress range:

$$\gamma_{Ff}\Delta\sigma_{E,2} = \sqrt[m]{D_d}\,\frac{\Delta\sigma_C}{\gamma_{Mf}} \quad \text{(A.16)}$$

with $m = 3$.

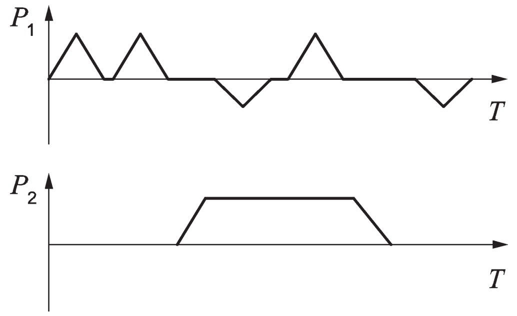
For the damage summation, the Palmgren-Miner rule is used:

$$\sum \frac{n_i}{N_i} = \frac{n_1}{N_1} + \frac{n_2}{N_2} + \frac{n_3}{N_3} + \frac{n_4}{N_4} \leq D_L$$

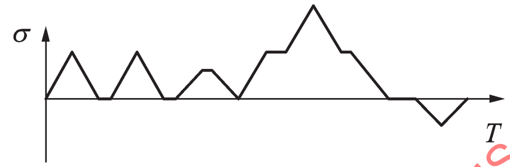
See Figure A.5.

STANDARDSISO.COM : Click to view the full PDF of ISO 17842-1:2015

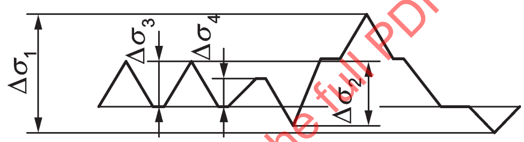
 © ISO 2015 – All rights reserved



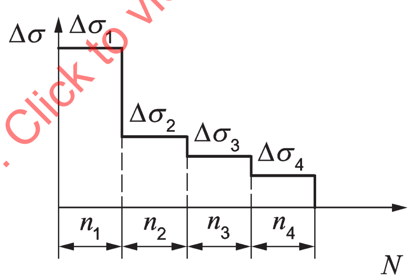
a) Loading sequence: Typical load cycle (repeated *n* times in the design life)



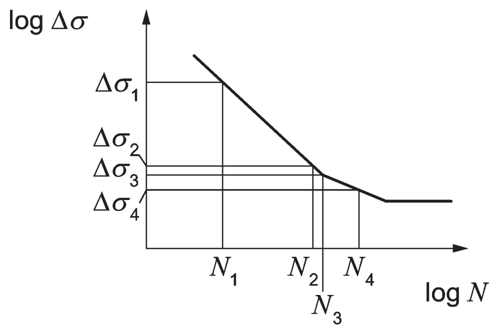
b) Stress history at detail



c) Cycle counting (e.g. reservoir method)



d) Stress range spectrum



e) Cycles to failure

Figure A.5 — Cumulative damage method (EN 1993-1-9:2005, Figure A.1)

STANDARDSISO.COM : Click to view the full PDF of ISO 17842-1:2015

Annex B
(normative)

Electrical equipment and control systems

B.1 Electrical equipment

B.1.1 General

This section provides guidance 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 comply with IEC 60204-1 except where extended or modified by the following.

B.1.2 Protection against electric shocks

B.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 to 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 300mA and a total earthing resistance of ≤ 30 Ω;

— 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.

STANDARDSISO.COM : Click to view the full PDF of ISO 17842-1:2015

© ISO 2015 – All rights reserved

B.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 A.C. or 60 V DC with a maximum of 10 % ripple without protection against direct contact.

b) Dodgem cars if the requirements of 5.2.4.6 are met.

Where additional protection is required then the rails shall be positioned so that entry is from the side or below to prevent the accumulation of dust or water.

B.1.2.3 Earthing systems

The earthing system shall meet 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.

B.1.3 Protection against lightning

Protection against lightning made necessary by local requirements shall comply with IEC 62305 (all parts).

B.1.4 Lighting

B.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 the persons to leave the 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).

B.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 may 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.

STANDARDSISO.COM : Click to view the full PDF of ISO 17842-1:2015

© ISO 2015 – All rights reserved

B.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.

On A.C. generators of more than 5 kVA the neutral (or in 3 phase sets the star point of the windings) shall be connected to the generator frame and thence to the circuit protective conductor. Where practicable, the frame shall be earthed with an impedance of less than 20 Ω. The same neutral-to-frame connection shall be made on small A.C. generators if a load cable length exceeds 5 m.

B.1.6 Heaters

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 A.C. cables, which have been previously used with spiked lamp holders, shall not be used.

B.1.7 Communication system

All amusement rides and devices shall have a suitable means for the operator to communicate to passengers, unless risk assessment shows isn't necessary.

Communication system 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.

B.2 Control systems

B.2.1 General

This section of the standard applies to the design and manufacture of safety-related control systems (SRCS).

It applies to all control systems, e.g. manual, electrical, electronic, hydraulic, pneumatic, mechanical, from the sensor up to and including the actuating device.

A SRCS is a system that:

— implements the required safety functions necessary to achieve or to maintain a safe state for the amusement ride and device;

— is intended to achieve, on its own or with other safety-related systems, the necessary level of risk reduction.

The design and construction of a SRCS shall follow a documented process which demonstrates that due diligence has been 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 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.

— Control systems 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.

STANDARDSISO.COM : Click to view the full PDF of ISO 17842-1:2015

 © ISO 2015 – All rights reserved

— Control systems 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 to be found in the technical report ISO/TR 23849.

B.2.2 Safety-related control functions

B.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 it to be 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.

B.2.2.2 Start functions

The SRCS shall be designed to a sufficient integrity in order to prevent risks associated with unexpected start or acceleration of equipment.

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 expected operation.

Start functions shall require a deliberate attendant action when the previous stop

— resulted from a loss of power,

— placed riders in a normal rider loading or unloading area, and the equipment has been stopped for a period of time that exceeds a reasonable expectation for an automatic re-start,

— was a stop category 0 or 1 according to IEC 60204-1.

B.2.2.3 Evacuation

When passenger evacuation may be necessary after a stop function or fault which results in equipment orientation that prevents safe passenger evacuation from the amusement ride or device, the design shall provide for equipment reorientation sufficient to support safe evacuation. This provision may 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

STANDARDSISO.COM : Click to view the full PDF of ISO 17842-1:2015

© ISO 2015 – All rights reserved

B.2.2.4 Stop functions

If required – as a result of a risk assessment – the SRCS shall have available the following stop functions: “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, Chapter 5.3.

Attendant controls at staffed operating consoles used to initiate a stop function shall support initiation of the function 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 may stop 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.

B.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.

Speed is an important safety critical parameter for amusement devices where accelerations, and consequently forces are dependent on the speed of amusement ride elements. Therefore, speed control can prevent hazardous effects 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.

STANDARDSISO.COM : Click to view the full PDF of ISO 17842-1:2015

© ISO 2015 – All rights reserved

For a particular part of the ride cycle there may be different operating speeds. In particular the following criteria shall be applied to prevent the amusement ride or device operating outside the design parameters:

— The SRCS shall monitor the speed between the minimum and maximum operational speeds during the ride cycle.

— 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 may 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.

B.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.

B.2.4.1 Safety integrity requirements

In accordance with ISO 17842-2:2015, 4.5 the attendant is responsible to ensure that the passenger is properly seated and restraint prior to enable a new ride cycle.

Based on the applicable restraint class the design requirements in Table B.1, Table B.2 and Table B.3 shall be applied.

Table B.1 — Restraint lock/unlock control circuit

Restraint class				
1	**2**	**3**	**4**	**5**
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
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 B.2 — Restraint position feedback circuit

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
NOTE Optional individual restraint position feedback indication not visible for seat checking attendant.				

STANDARDSISO.COM : Click to view the full PDF of ISO 17842-1:2015

Table B.3 — Restraint latching/locking device feedback circuit

Restraint class				
1	**2**	**3**	**4**	**5**
None	None	Redundancy check	Redundancy check	Redundancy check or direct lock position monitoring
Redundancy check: The integrity of the redundant locking device shall be verified within certain time intervals, which have to be determined by the mechanical design. *Direct lock position monitoring:* Direct position monitoring of the mechanical locking device ("tooth engaged").				

STANDARDSISO.COM : Click to view the full PDF of ISO 17842-1:2015

B.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.

B.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.

B.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.

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 ≥ 2m: SIL 1 or PLr c

Guard/door position feedback circuit

The following minimum design requirements shall be applied based on the max potential fall height:

— If max potential fall height < 2m: n/a

— If max potential fall height ≥ 2m: Single channel circuit without diagnostic

Guard/door latching/locking device feedback circuit

The following minimum design requirements shall be applied based on the max potential fall height:

— If max potential fall height < 2m: Periodic check

— If max potential fall height ≥ 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 have to be determined by the mechanical design.

Redundancy check: The integrity of the redundant locking device shall be verified within certain time intervals, which have to be determined by the mechanical design.

 © ISO 2015 – All rights reserved

Direct lock position monitoring: Direct position monitoring of the mechanical locking device prior to new ride cycle start.

B.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 must be performed under the authority and supervision of authorized personnel.

— The number of personnel required, and method of muting safety function (key, code, etc.) 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 must be properly performed prior to running the attraction with passengers.

— Effective and secure means to prevent manual suspension in those operating modes where it is not allowed;

In addition, consideration may need to 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 may be initiated only from that station;

— Limitation of the speed or the power of motion.

B.2.7 Operating modes

B.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.

B.2.7.2 Operating mode selection

A change of operating mode shall not cause a hazardous condition. It may 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.

STANDARDSISO.COM : Click to view the full PDF of ISO 17842-1:2015

© ISO 2015 – All rights reserved

The appropriate mode selector shall be located such that it can be operated safely – in particular, not accidentally.

Mode selection by itself shall not lead to initiation of motion of any PU — a separate deliberate action shall be required.

Indication of the selected operating mode shall be provided (e.g. the provision of an indicating light, or a visual display indication).

B.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 could cause a hazard shall either be prevented by the safety-related control system 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.

B.2.7.4 Operating modes

There may be more than one operating mode. These modes enable the amusement device to operate only after an initiation by the operator or under his 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 supervision of the ride.

B.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;

STANDARDSISO.COM : Click to view the full PDF of ISO 17842-1:2015

© ISO 2015 – All rights reserved

— actuation of emergency stop;

— initiation of a safety stop.

The safety-related control system 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 complied with.

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 could simulate the operating mode or could lead to hazardous conditions, shall be allowed only in confirmed discrete steps by the safety-related control system. Suitable means shall be provided to ensure that each separate operation is deliberately actuated.

If the only way to recover passengers is to use the built-in override of a safety function 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.

B.2.8 Collision prevention safety function

B.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.

B.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.

B.2.8.3 Requirements for powered stopping devices

Powered stopping devices (e.g. brake) are allowed provided the following requirements are complied with:

— the control and command circuits (electrical, hydraulic or pneumatic) shall in their de-energised state operate the stopping device;

— the control and command circuits (electrical, hydraulic or pneumatic) shall operate the stopping device in the case of a failure of their components;

STANDARDSISO.COM : Click to view the full PDF of ISO 17842-1:2015

© ISO 2015 – All rights reserved

— 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 may 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 may 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

— also used as a stopping device

B.2.8.4 Validation

Validation shall be in accordance with either ISO 13849-2 or IEC 62061.

STANDARDSISO.COM : Click to view the full PDF of ISO 17842-1:2015

© ISO 2015 – All rights reserved

Annex C
(informative)

Control systems — Best practices

C.1 Security

The SRCS should incorporate some means of ensuring only authorized personnel can power-up/control-on the attraction.

EXAMPLE Key switches, passwords, sequence of operations.

C.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.

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.

C.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 such 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.

STANDARDSISO.COM : Click to view the full PDF of ISO 17842-1:2015

© ISO 2015 – All rights reserved

The occupancy and clearance sensors should be located such that a block-zone in which a PU is entering is indicated as occupied before the previous block-zone is indicated as cleared.

STANDARDSISO.COM : Click to view the full PDF of ISO 17842-1:2015

© ISO 2015 – All rights reserved

Annex D
(informative)

Guidance on design of passenger containment

The passenger containment system needs to 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 have to 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 could 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 is to 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;

— using body size data appropriate to the specified suitable population, identify the maximum and minimum dimensions of the containment system necessary to contain passengers' safety. Tables D.1 to D.3 in conjunction with ISO 7250 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 permitted by the Device Log 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)) needs to be considered part of the containment system.

All passengers within the size limits specified in the Device Log have to 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;

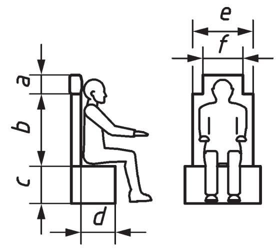
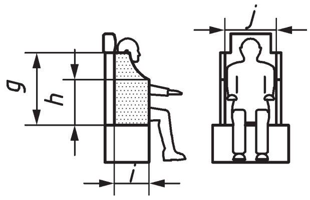
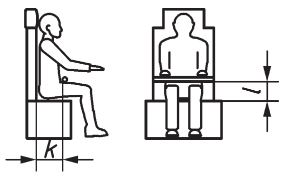
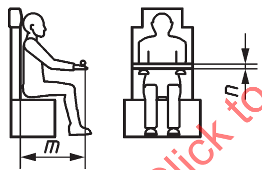
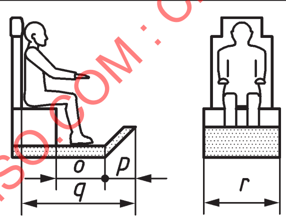
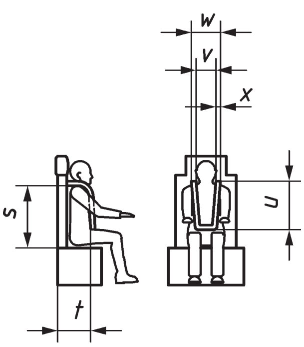
— grabrails should be within easy reach of the passengers, easy to hold and not be a source of injury e.g. during an emergency stop;

— restraint systems designed as an integral part of the containment system.

STANDARDSISO.COM : Click to view the full PDF of ISO 17842-1:2015

The designer will need to submit for the device log the technical data on which the design of the containment system are based.

Table D.1 — Containment system components

Component			Description
Seating		*a*	head rest height
		b	seat back height
		c	seat pan height
		d	seat pan depth
		e	seat back width
		f	head rest width
		*g*	high side support height
		h	low side support height
		i	side support depth
		j	distance between side supports (per passenger)
Lap bar		*k*	distance from seat back to rear edge of lap bar
		l	distance from seat pan to lower edge of lap bar
Handrail		*m*	distance from seat back to front edge of handrail
		n	diameter of handrail
Footwell		*o*	length of horizontal floor from seat to front of car
		p	footrest length
		q	distance from back of seat to front edge of footrest
		r	footwell width (per passenger)
Over shoulder		*s*	distance from seat pan to bottom edge of shoulder supports
		t	distance from seat back to back of trunk support
		u	trunk support overall length
		v	distance between inside edges of shoulder supports
		w	distance between outside edges of shoulder supports
		x	shoulder support width

STANDARDSISO.COM : Click to view the full PDF of ISO 17842-1:2015

© ISO 2015 – All rights reserved

Table D.2 — Body dimensions

Measurement (see Figure D.1)	**Body dimension**
a	Shoulder - crown
b	Sitting shoulder height
c	Popliteal height
d	Buttock – popliteal length
e	Shoulder breadth (bideltoid)
f	Head width
g	Sitting shoulder height (deltoid)
h	g/2
i	Buttock – popliteal length
j	Shoulder breadth (bideltoid)
k	Abdominal depth
l	Thigh clearance
m	Forward reach
n	Grip diameter
o	Knee height
p	Foot length, Heel ball length
q	Hip height
r	Foot breadth, hip breadth
s	Sitting shoulder height
t	Chest depth
$u = b - l$	Sitting shoulder height – thigh clearance
v	Head width
w	Interacromion
x	Shoulder length (to acromion)
y	Thigh to toe length
z	Body height

STANDARDSISO.COM : Click to view the full PDF of ISO 17842-1:2015

© ISO 2015 – All rights reserved

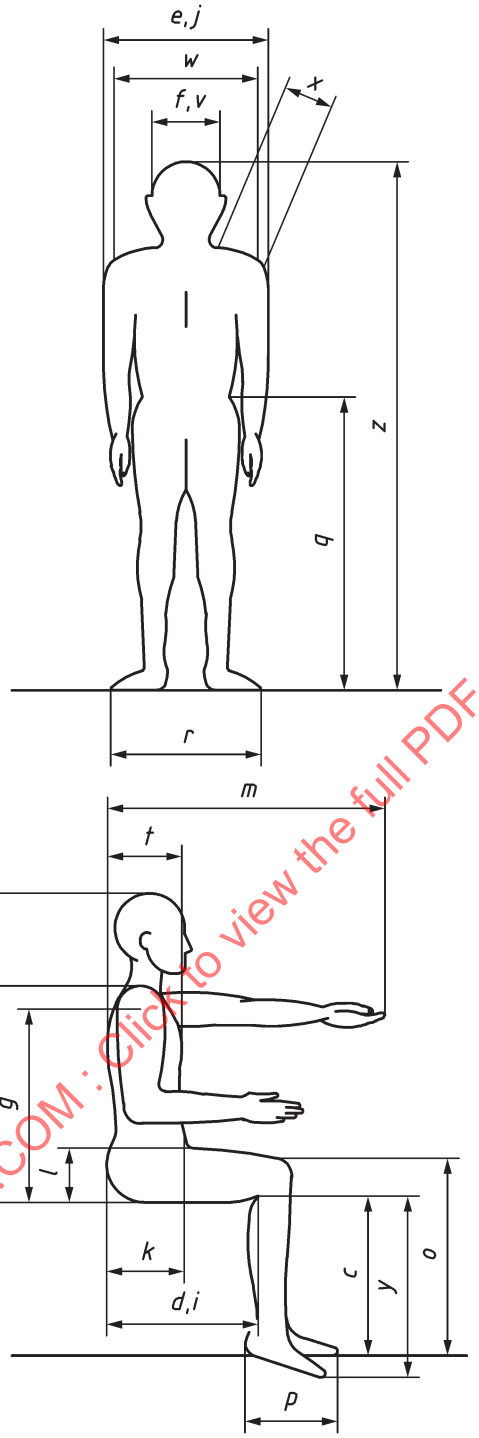


Figure D.1 — Body dimensions (Table D.2)

STANDARDSISO.COM : Click to view the full PDF of ISO 17842-1:2015

 © ISO 2015 – All rights reserved

Table D.3 — Body dimensions and suggested ranges

Measurement	Body dimension	Containment component adjustable	Percentile range
a	Shoulder to crown	No	95th
b	Sitting shoulder height	No	95th
c	Popliteal height	No	5th
d	Buttock popliteal length	No	5th
e	Bi-deltoid	No	95th
f	Head width	No	95th
g	Sitting shoulder height (deltoid)	No	95th
h	g/2	No	95th
i	Buttock - popliteal	No	95th
j	Shoulder breadth (bi-deltoid)	No	95th
k	Abdominal depth	Yes	5th–95th
l	Thigh clearance	Yes	5th–95th
m	Forward reach	Yes (no)	5th–95th (50th)
n	Grip diameter	No	5th
o	Knee height	Yes	5th–95th
p	Foot length, Heel ball length	No	95th
q	Hip height	No	95th
r	Foot breadth, hip breadth	No	95th
s	Sitting shoulder height	Yes (no)	5th–95th
t	Chest depth	Yes	5th–95th
u	Sitting shoulder height – thigh clearance	Yes (no)	5th
v	Head breadth	No	95th
w	Interacromion	No	50th
x	Shoulder length (to acromion)	No	95th

STANDARDSISO.COM : Click to view the full PDF of ISO 17842-1:2015

Annex E
(informative)

Device log for an amusement device

The following example shows the minimum content of a device log.

TITLE

Device log no.: Volume no.:

STANDARDSISO.COM : Click to view the full PDF of ISO 17842-1:2015

 © ISO 2015 – All rights reserved

NAME AND IDENTIFICATION
Name of device
Manufacturer's name for the device
Series or type
Manufacturer's identification number (serial number) and marking
Initial examination marking
Manufacturer's name
Manufacturer's address
Supplier's or importer's name (if different from manufacturer) supplier's or importer's address
Date of manufacture
Date of supply to original purchaser
Device log no.: Volume no.:

STANDARDSISO.COM : Click to view the full PDF of ISO 17842-1:2015

© ISO 2015 – All rights reserved

DESCRIPTION OF DEVICE	
[Insert the description of the ride on this page]	
Device log no.:	Volume no.:

STANDARDSISO.COM : Click to view the full PDF of ISO 17842-1:2015

© ISO 2015 – All rights reserved

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 device is transferred to:		
Next owner:		
Any conditions of the transfer:		
Device log no.: Volume no.:		

STANDARDSISO.COM : Click to view the full PDF of ISO 17842-1:2015

© ISO 2015 – All rights reserved

NATIONAL REGISTRATION DETAILS

(Record of any registration required in terms of national legislation)

STATE; AUTHORITIES; ECT:	REGISTRATION DETAILS AND NUMBER	DATE	CONDITIONS OF REGISTRATION AND AUTHORIZATION	COMMENTS AND SIGNATURE OF THE ISSUING BODY

Device log no.: Volume no.:

STANDARDSISO.COM : Click to view the full PDF of ISO 17842-1:2015

© ISO 2015 – All rights reserved