BRITISH STANDARD

BS EN 13814:2004

Incorporating corrigenda September 2008 and June 2011

Fairground and amusement park machinery and structures — Safety

ICS 91.040.99

BSI British Standards

National foreword

This British Standard is the UK implementation of EN 13814:2004.

The UK participation in its preparation was entrusted by Technical Committee MCE/3, Safeguarding of machinery, to Subcommittee MCE/3/4, Fairground and amusement park machinery and structures — Safety.

A list of organizations represented on this committee can be obtained on request to its secretary.

WARNING

BSI as a member of CEN, is obliged to publish EN 13814:2004 as a British Standard. However, attention is drawn to the fact that during the development of this European Standard, the UK consistently voted against its approval as a European Standard.

The reason for this disapproval is that during discussion of this standard by BSI Technical Committee MCE/3/4, which mirrors the work of CEN Committee TC 152, the UK expressed the opinion that there are several points which may necessitate additional or different safety measures to be applied to amusement devices that are to be used in the UK.

In the opinion of the committee, it is important that designers should be aware that compliance with requirements of this standard may not be sufficient to ensure compliance with UK law[1)].

The BSI committee had particular concerns with:

— fatigue life assessment: EN 13814:2004 does not require the designer to pass on any information regarding fatigue lives exceeding 35 000 hours, nor to cross check that inspection/maintenance instructions are consistent with any of the calculated lives. The committee believes this is inconsistent with Section 6 of the Health and Safety at Work etc. Act 1974;

— control systems: in the opinion of the UK committee a reference to IEC 62061 would be appropriate, which relates to control system design safety;

— passenger containment and clearance envelopes (**6.1.6.1.2**): the minimum reach distances for passengers as required in **6.1.6.1.2** do not conform to UK legal requirements[1)]. Risk assessments referencing anthropometric data in relation to the severity of the hazards should be used to determine safe reach distances and in most cases applicable to the UK, the safe distances will be much greater than stated in **6.1.6.1.2**;

— wind loading calculations: in **5.3.3.4.1** the latest relevant Eurocodes[2)] should be taken into account as should higher probable wind loadings in the UK. The possibility of portable rides being used in northern areas with even higher probable wind velocities should also be considered.

[1)] It is the intention of BSI Technical Committee MCE/3/4 to draft a national annex NA, which will give additional guidance on implementation, particularly in relation to compliance with UK regulations.

[2)] The national annex NA to BS EN 1991-1-4 will provide supplementary information and guidance on implementation for UK users. It is anticipated that this document will be available by the end of October 2008. Until the NA is published, BS 6399-2:1997 should be used.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

Compliance with a British Standard cannot confer immunity from legal obligations.

This British Standard was published under the authority of the Standards Policy and Strategy Committee on 29 September 2006

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30 September 2008	National foreword revised
30 June 2011	Correction to Equation (53) in 5.5.1.2

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN 13814

December 2004

ICS 91.040.99

English version

Fairground and amusement park machinery and structures - Safety

Machines et structures pour fêtes foraines et parcs d'attraction - Sécurité

Fliegende Bauten und Anlagen für Veranstaltungsplätze und Vergnügungsparks - Sicherheit

This European Standard was approved by CEN on 19 May 2004.

CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration. Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Central Secretariat or to any CEN member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the Central Secretariat has the same status as the official versions.

CEN members are the national standards bodies of Austria, Belgium, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden, Switzerland and United Kingdom.

EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

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Foreword

This document (EN 13814:2004) has been prepared by Technical Committee CEN/TC 152, "Fairground and amusement park machinery and structures - Safety", the secretariat of which is held by UNI.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by June 2005, and conflicting national standards shall be withdrawn at the latest by June 2005.

This European standard has been prepared under the mandate M/233 given to CEN by the European Commission and the European Free Trade Association. A European Directive concerning fairground and amusement machinery does not exist.

This European standard forms part of a series of two documents prepared by CEN/TC 152 for fairground and amusement park machinery and structures. The other document is prEN 13782, “Temporary structures – Tents – Safety”

In its present state this European Standard may require, where mentioned in the different clauses, the application of national standards since some of the basic EN-standards to be used in applying this European Standard are not yet available. The content of this European Standard brings together the different existing national regulations and guidelines as far as possible.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden, Switzerland and United Kingdom.

Introduction

The object of this document is to define safety rules related to structures and machines, which are either an integral part of, or constitute the amusement device itself. The safety rules are intended to safeguard persons against the risk of accidents caused by deficiencies in design, manufacture and operation of such structures and machinery. This document is based upon past experience and risk analyses.

Annex A is an informative part of this document providing guidance on the calculation of structural steel parts.

Annexes B and C are normative parts of this document giving detailed and necessary calculation or safety rules.

Annex D (normative) deals with electrical installations and control systems.

Annex E (informative) deals with guidance on passenger containment.

Annex F (informative) shows a typical layout of a log book for an amusement device.

Annex G (informative) Acceleration effects on passengers.

Annex H (informative) Provisions prior to use.

Annex I (informative) List of Hazards for amusement rides.

1 Scope

This document specifies the minimum requirements necessary to ensure the safe design, calculation, manufacture, installation, maintenance, operation, examination and testing 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 are hereafter called amusement devices, which 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, carrying not more than two children, are not covered by this document.

Nevertheless this document may 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 not applicable to amusement devices which are manufactured before the date of publication of this document by CEN.

2 Normative references

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

EN 2, *Classification of fires.*

EN 3 (all parts), *Portable fire extinguishers.*

EN 286-1, *Simple unfired pressure vessels designed to contain air or nitrogen — Part 1: Pressure vessels for general purposes.*

EN 287 (all parts), *Approval testing of welders — Fusion welding.*

EN 288 (all parts), *Specification and qualification of welding procedures for metallic materials*.

EN 294:1992, *Safety of machinery — Safety distances to prevent danger zones being reached by the upper limbs*.

EN 418, *Safety of machinery — Emergency stop equipment, functional aspects — Principles for design*.

EN 573-3, *Aluminium and aluminium alloys — Chemical composition and form of wrought products — Part 3: Chemical composition.*

EN 696, *Fibre ropes for general service — Polyamide*.

EN 697, *Fibre ropes for general service — Polyester*.

EN 698, *Fibre ropes for general service — Manila and sisal.*

EN 699, *Fibre ropes for general service — Polypropylene.*

EN 700, *Fibre ropes for general service — Polyethylene*.

EN 701*, Fibre ropes for general service — General specification*.

EN 719, *Welding coordination — Tasks and responsibilities*.

EN 729-2, *Quality requirements for welding — Fusion welding of metallic materials — Part 2: Comprehensive quality requirements.*

EN 729-3, *Quality requirements for welding — Fusion welding of metallic materials — Part 3: Standard quality requirements.*

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

EN 919, *Fibre ropes for general service — Determination of certain physical and mechanical properties*.

EN 954-1, *Safety of machinery — Safety-related parts of control systems — Part 1: General principles for design*.

EN 1050:1996, *Safety of machinery — Principles for risk assessment.*

EN 1176 (all parts), *Playground equipment.*

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

EN 1418, *Welding personnel — Approval testing of welding operators for fusion welding and resistance weld setters for fully mechanized and automatic welding of metallic materials*

EN 1677 (all parts), *Components for slings — Safety.*

EN 10025, *Hot rolled products of non-alloy structural steels — Technical delivery conditions*.

EN 10027 (all parts), *Designation systems for steels*.

EN 10083-1+A1, *Quenched and tempered steels — Part 1: Technical delivery conditions for special steels*.

EN 10084, *Case hardening steels — Technical delivery conditions.*

EN 10160, *Ultrasonic testing of steel flat product of thickness equal to 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, *Metallic products — Types of inspection documents*.

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.*

prEN 14399 (all parts), *High-strength structural bolting for preloading.*

EN ISO 898-1, *Mechanical properties of fasteners made of carbon steel and alloy steel — Part 1: Bolts, screws and studs (ISO 898-1:1999).*

EN ISO 4014, *Hexagon head bolts — Product grades A and B (ISO 4014:1999).*

EN ISO 4016, *Hexagon head bolts — Product grade C (ISO 4016:1999)*.

EN ISO 4017, *Hexagon head screws — Product grades A and B (ISO 4017:1999).*

EN ISO 4018, *Hexagon head screws — Product grade C (ISO 4018:1999).*

EN ISO 4032, *Hexagon nuts, style 1 — Product grades A and B (ISO 4032:1999).*

EN ISO 4034, *Hexagon nuts — Product grade C (ISO 4034:1999).*

EN ISO 5817, *Welding - Fusion-welded joints in steel, nickel, titanium and their alloys (beam welding excluded) - Quality levels for imperfections (ISO 5817:2003)*

EN ISO 7090, *Plain washers, chamfered — Normal series — Product grade A (ISO 7090:2000)*.

EN ISO 12100-1, *Safety of machinery — Basic concepts, general principles for design — Part 1: Basic terminology, methodology (ISO 12100-1:2003)*.

EN ISO 12100-2, *Safety of machinery — Basic concepts, general principles for design — Part 2: Technical principles (ISO 12100-2:2003)*.

EN 30042, *Arc-welded joints in aluminium and its weldable alloys — Guidance on quality levels for imperfections (ISO 10042:1992).*

EN 45004, *General criteria for the operation of various types of bodies performing inspection*.

EN 60204-1:1997, *Safety of machinery — Electrical equipment of machines — Part 1: General requirements (IEC 60204-1:1997).*

EN 60204-32, *Safety of machinery — Electrical equipment of machines — Part 32: Requirements for hoisting machines (IEC 60204-32:1998).*

EN 60947 (all parts), *Low-voltage switchgear and controlgear*.

EN 61496-1, *Safety of machinery — Electro-sensitive protective equipment — Part 1 : General requirements and tests (IEC 61496-1:1997).*

prEN 61496-2, *Safety of machinery — Electrosensitive protective equipment — Part 2 : Particular requirements for equipment using active optoelectronic protective devices (IEC 61496-2:-)*.

EN 61558-1*, Safety of power transformers, power supply units and similar — Part 1: General requirements and tests (IEC 61558-1:1997, modified).*

ENV 1991-2-3, *Eurocode 1: Basis of design and actions on structures — Part 2-3: Actions on structures — Snow loads.*

ENV 1991-2-4:1995, *Eurocode 1: Basis of design and actions on structures — Part 2-4: Actions on structures — Wind actions*.

ENV 1992 (all parts), *Eurocode 2: Design of concrete structures.*

ENV 1993 (all parts), *Eurocode 3: Design of steel structures.*

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

ENV 1997-1, *Eurocode 7: Geotechnical design — Part 1: General rules*.

ISO 3755, *Cast carbon steels for general engineering purposes*.

ISO 6309, *Fire protection — Safety signs*.

ISO 7413, *Hexagon nuts for structural bolting, style 1, hot-dip galvanized (oversized tapped) — Product grades A and B — Property classes 5, 6 and 8*.

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 61508 (all parts), *Functional safety of electrical/electronic/programmable electronic safety related systems.*

3 Terms and definitions

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

3.1
amusement device
any ride, structure, textile, or membrane structure or device, side stall, side show, tent constituting part of a ride, booths, grandstands, etc. which can be installed repeatedly without degradation or loss of integrity as well as temporarily or permanently at fairs, parks or any other locations

3.2
independent inspection body
any independent organisation capable of carrying out third party review, approval, examination and tests of amusement devices

3.3
initial approval
design and calculation review, verification, examinations and tests executed by the independent inspecting body before a ride is first made available for public use

3.4
log book
book or file containing all the necessary information about the use and history of any amusement device, including its design and initial approval

3.5
permit
authorisation to operate an amusement device in a particular member state granted by the legally authorised body after successful approval or examination

3.6
independent thorough examination
procedures and investigations necessary for the independent inspection body to decide whether the amusement device is in such a condition that it can continue to be operated safely, or whether it requires defects to be remedied immediately or within a specified time

3.7
licensing body
any national authorities or bodies legally authorised to issue a permit for operation of an amusement device and its log book

3.8
modification
any alteration to the hardware or software of an amusement device, including the introduction of a new safety critical component or the substitution of a safety critical component, which results in a deviation from the design specification

3.9
repair
restoration of safety critical components or safety critical assemblies to an acceptable condition by the mending of worn, damaged or decayed parts, which does not result in a deviation from the design specification of the original parts

3.10
safety critical component
any type of component of an amusement device on which the safety of the passengers is dependent

3.11
passenger containment
components (for example seating, footwells, handrails and passenger restraints) designed to prevent passengers from moving outside a predetermined area on a ride either as a result of the ride forces or the behaviour of the passenger

3.12
passenger unit
part or parts of an amusement device in or on which the public is intended to ride

3.13
platform
horizontal or slightly inclined surface raised above the level of an adjacent area

3.14
operator
person appointed by the controller to be in charge of the operation of an amusement device at all times when it is intended to be available for the public

3.15
attendant
any person appointed to work under the control or direction of an operator, to assist in the operation of an amusement device available for use by the public

3.16
controller (ride controller)
person or organisation having overall control of an amusement device. This may be either an individual or corporate body owning an amusement device or the concessionaire or lessee who has been granted control of the device, by the owner, for a specified period

3.17
daily check
operational check made before the device is made available to the public, to determine whether or not an amusement device is in such condition that it may continue to be operated safely

3.18
trial run
proving run of an amusement device during which no passengers are carried

3.19
service
replacement or replenishment of components, including fluids which are designated to be replaced or replenished at specified intervals

4 Symbols

Any symbols connected with the respective units will be explained in the clauses concerned.

5 Common requirements for design analysis and examination

5.1 Design documents

5.1.1 General

The construction documents include all the documents required for the assessment of the stability and operational safety of the amusement device. They shall be provided for any subsequent approval by the independent inspecting bodies. These documents shall encompass all the design conditions pertaining to the operation of the amusement devices or structures. A description of the construction, operation and operational safety, design

drawings and a comprehensive stress, fatigue and stability analysis as specified in 5.1.4 are required for this purpose.

5.1.2 Description of design and operation

The amusement device, in particular its design, mode of utilisation 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 amusement 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.

5.1.3 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. The drawings shall include as a minimum:

— general drawings in plan view, elevation and sections, in a legible scale, depending on the size of the amusement device;

— indication of the necessary clearance around the moving parts;

— detail drawings showing all the structural subassemblies which are not clearly discernible on the general drawings, as well as detail drawings of connections and individual items of a structural, mechanical or electrical nature, which could affect the safety of the amusement device and its operation, shall be drawn to a larger scale;

— illustrations of the following items may be necessary for this purpose:

  — slewing gear, hoisting and swivelling mechanisms, including their support arrangements, drives and controls, lifting and swivelling ranges;

  — carriages, gondolas and similar, illustrated in all the required views and cross sections, with details of the overall dimensions, the internal dimensions of importance to the passengers (seats, side and back rests, leg and foot room), hand and foot holds and locking and securing devices;

  — motion gear with details of load, guide, and up stop wheels, bearings, axles, shafts and their attachment, liberty of movement in relation to the vehicle, steering and control, anti roll back 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.

5.1.4 Principles of analysis

5.1.4.1 Verification shall comprise the following:

— ultimate limit states analysis;

— fatigue limit states analysis;

— stability limit states analysis: i. e. bar buckling, plate and shell buckling;

— if required, verification of deformation limit states;

— verification of safety against overturning, sliding and lifting off;

— dynamic analysis.

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

— design loads, taking into account the possible operating conditions or installation alternatives. 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 to the relevant testing standard. The testing laboratory shall conduct the appropriate number of tests, samples, the testing procedure, the reporting, etc., according to the relevant European Standard or in absence of those to equivalent national standards;

— details of elastic deformations (flexure, torsion), in as much as 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 5.6.3.2.

5.2 Selection of materials

5.2.1 General

Only materials in respect of which design data are featured in European Standards for buildings may be used for structural components.

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 in accordance with European Standards.

5.2.2 Recommended steels

5.2.2.1 Steels for structural components:

— S235JRG2 in accordance with EN 10025

— S275JR in accordance with EN 10025

— S355JO in accordance with EN 10025

— GS-52 in accordance with (ISO 3755)[1)]

— 2 C 35 in accordance with EN 10083-1[1)]

5.2.2.2 Steels for machine components:

— S235JRG2 in accordance with EN 10025

— S355JO in accordance with EN 10025

— E 295 in accordance with EN 10027 (all parts)[1)]

— E 335 in accordance with EN 10027 [1)] (all parts)

— E 360 in accordance with EN 10027 (all parts) [1)]

— 2 C 22 in accordance with EN 10083-1 [1)]

— 16MnCr5 in accordance with EN 10084 [1)]

— 20MnCr5 in accordance with EN 10084 [1)]

— 2 C 45 in accordance with EN 10083-1 [1)]

— 2 C 60 in accordance with EN 10083-1 [1)]

— 34CrNiMo6 in accordance with EN 10083-1 [1)]

— 41Cr4 in accordance with EN 10083-1 [1)]

— 42CrMo4 in accordance with EN 10083-1 [1)]

— 51CrV4 in accordance with EN 10083-1 [1)]

— GS-45.3 in accordance with ISO 3755 [1)]

Other steel grades for which technological material data (mechanical and chemical properties) are featured in European Standards or in absence of those in equivalent national standards may also be used.

5.2.3 Aluminium alloy

Aluminium alloys shall be selected in accordance with EN 573-3 or other European Standards or equivalent national standards.

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

5.2.4 Timber

Selection of timber shall be in accordance with the standards referred to in ENV 1995-1-1.

5.2.5 Plastic composites

Selection of plastic composites shall be in accordance with European Standards, or in absence of those, to national standards for structural use of plastic composites.

5.2.6 Concrete

The selection of concrete grade shall be in accordance with ENV 1992 (all parts) for structural use of concrete.

5.2.7 Fasteners

Screws and bolts shall be selected from property classes 4.6, 5.6, 6.8, 8.8 and 10.9 in accordance with EN ISO 898-1.

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1) Not for welded parts.

Rivets shall be selected according to European Standards or in their absence to national standards.

Blind rivets shall be selected according to European Standards or in their absence, to national standards, or when their capacity for the assigned purpose is experimentally proven in accordance with ENV 1993-1-1 and 5.1.4.2.

5.3 Design loads

5.3.1 General

In general all the applicable actions shall be chosen in accordance with ENV 1991 (all parts). Adaptations, due to the special nature of amusement devices, are stated hereafter.

5.3.2 Permanent actions

For amusement devices in general a very precise assumption of the permanent actions is possible. Where variations can occur, the values G_{kh} and G_{kl} shall be taken into account when assessing the most likely structural response. Elsewhere a single characteristic value G_k is sufficient.

— G_k characteristic value of permanent action

— G_{kh} upper characteristic value

— G_{kl} 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_{kh} and G_{kl}.

The permanent actions shall be determined in accordance to ENV 1991 (all parts). The actual weight of machine components, electrical equipment, carriages, gondolas and the like shall be verified.

5.3.3 Variable actions

5.3.3.1 Imposed loads

5.3.3.1.1 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.

5.3.3.1.2 Vertical imposed loads

5.3.3.1.2.1 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 and for units with two or more passengers;

Q_k = 1,0 kN for units with one passenger (for static stress calculation only);

— For each person of 10 years or less

Q_k = 0,40 kN in both cases.

Where the reduced loadings for person of 10 years or less are employed there may be need to refer to 7.4.7.4.

5.3.3.1.2.2 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, their stairways and landings; and as a superior value, if particularly dense crowds are anticipated for the above mentioned categories.

q_k = 2 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 carriages according to 5.3.3.1.2.1, whichever is the more unfavourable, in order to make the necessary allowance for change of passengers.

Q_k = 1 kN per step

for stairs; alternatively, an area load in accordance with above clauses, whichever is the more unfavourable.

q_k = 1,5 kN/m

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:

q_k = 1,5 kN/m^2

for all floors, platforms, ramps, staircases, catwalks, stages and the like which are walked over by individual persons or Q_k = 1,5 kN individual load, whichever is the more unfavourable.

5.3.3.1.3 Horizontal imposed loads

5.3.3.1.3.1 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/m^2:

— 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/m^2:

— 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/m^2:

— 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.

5.3.3.1.3.2 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 5.3.3.4. This horizontal component load shall be taken as 1/10th of the imposed vertical load in accordance with 5.3.3.1.2.2.

5.3.3.2 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 etc.), 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 shall be calculated according to the actual brake and motor performance (acceleration/deceleration)

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

where

B is braking/starting force;

a_b is braking/starting acceleration;

m_v is mass of moving parts without passengers;

m_p is total mass of passengers according to 5.3.3.1.2.1.

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 5.3.5.1).

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.

5.3.3.3 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. However, forces used in any calculations should never be less than 500 N per person.

5.3.3.4 Wind loads

5.3.3.4.1 Wind loads in general

The wind loads are based on ENV 1991-2-4, adapted to the special nature of amusement devices with regard to the following:

— location;

— duration and period of installation;

— use under supervision of an operator;

— possibilities of protection and strengthening.

The values in Table 1 may be applied for the "average" ride or structure used in areas where the reference wind speed according to the maps in Annex A of ENV 1991-2-4:1995 is $v_{ref,0} \leq 28$ m/s (in out-of-service condition of the ride or structure) and when the ride operation is shut down at a wind speed of $v_{ref} \geq 15$ m/s (in-service condition).

The ride or structure needs to be sheltered or suitably strengthened when actual wind speeds attain $v_{actual} \geq 25$ m/s at a height of 10 m.

In calculating the values in Table 1 the following assumptions have been made:

— $v_{ref\,(p)} = 0{,}85\ v_{ref,0}$ for "out of service wind" (approximated 5 year return period);

— $c_{tem} = 0{,}80$ (for heights from 0 to 20 m for out of service loads), which is intentionally applied due to the fact that protection, reinforcement and sheltering is possible (the designer shall specify the means of sheltering and strengthening).

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 the table $c_{dir} = 1{,}0$, $c_{alt} = 1{,}0$, $c_t = 1{,}0$, terrain category III.

For any other location where $v_{ref,0} > 28$ m/s (according to the maps in Annex A of ENV 1991-2-4:1995 or due to local situation or the height above sea level) calculations shall be provided for the ride or structure confirming the stability under local conditions. The design calculations shall confirm that suitable means have been adopted in accordance with the particular situation.

Table 1 — Wind pressure values for amusement devices

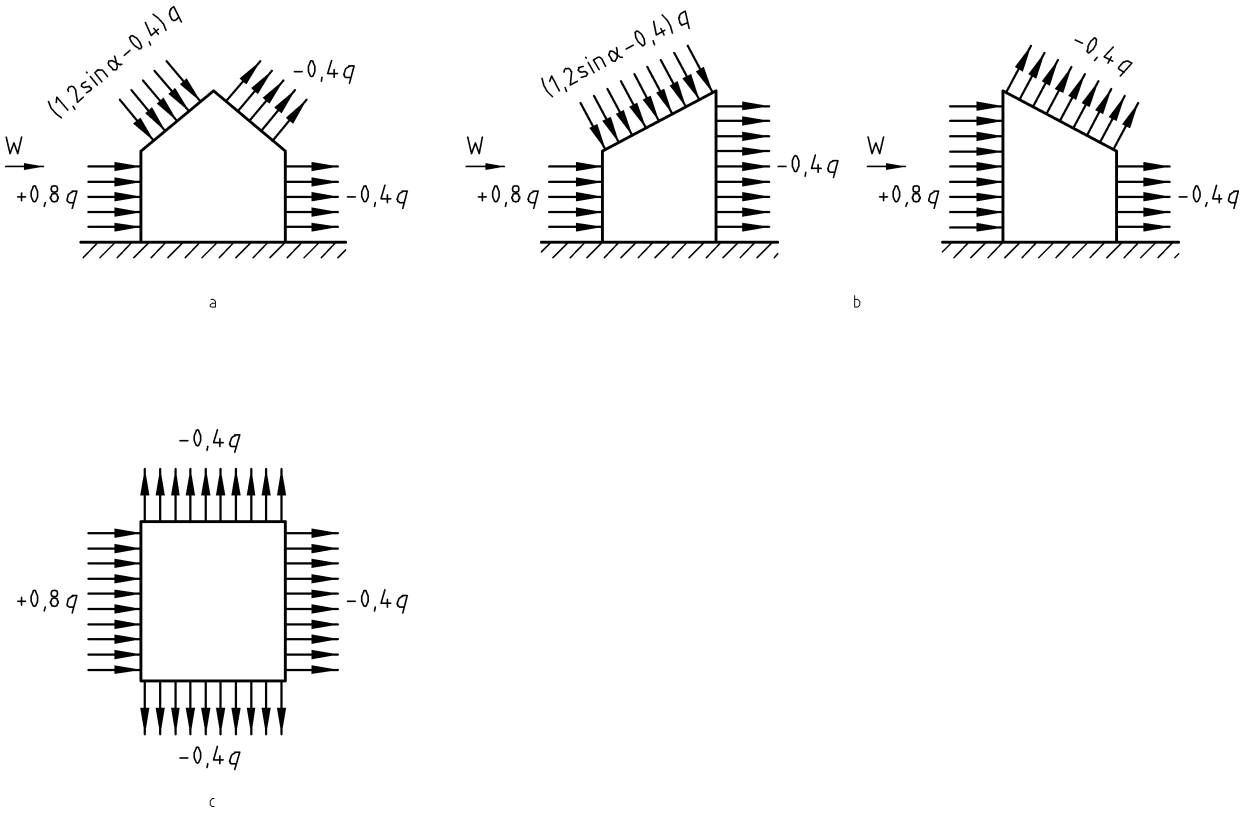
Height of the structure	Pressure $q_{eq} = q_{ref} \times ce(ze) \times c_d$ (kN/m^2) for reference wind speed	
	$v_{ref} \leq 15$ m/s (in service)	$v_{ref,0} \leq 28$ m/s (out of service)
0 ≤ 8 m	0,20	0,35
8 ≤ 20 m	0,30	0,50
20 ≤ 35 m	0,35	0,90
35 ≤ 50 m	0,40	1,00

The wind load on a given surface may be evaluated by the application of the above values in the following formulae:

$$F_{\mathrm{w}} = q_{\mathrm{eq}} \times c_{\mathrm{f}} \times A_{\mathrm{ref}} \qquad (2)$$

For exposed sites (e. g. coastal and alpine sites, that are not terrain category III have different topography and roughness) the wind loads of ENV 1991-2-4 shall be applied using the appropriate local roughness and topographic coefficients, etc.

In general the shape factors for various structures and structural members shall be taken from ENV 1991-2-4.



Key
"c" to be applied for "a" and "b"

Figure 1 — Aerodynamic coefficients for structures of conventional shape

5.3.3.4.2 Wind loads in service

The wind load for operating conditions may 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. passengers envelope) shall be taken into account in the calculation.

5.3.3.5 Snow loads

Snow loads shall be applied in accordance to ENV 1991-2-3.

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

— erected 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 amusement 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;

— the cladding is made and tensioned in such a way, that ponding of water cannot take place.

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

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

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

Inertia forces shall be determined according to the prevailing circumstances in each case; see for example Annex B for the calculation of these forces on different ride types.

5.3.3.7 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} in kg).

If collision can only occur at angles $\alpha \leq 90°$, the collision force F (in N) shall be assumed to be $F = 9{,}81 \times m_{\text{tot}} \times \sin \alpha$ (m_{tot} in kg), but in any case the value for the calculation shall be not less than $0{,}3 \times 9{,}81 \times m_{\text{tot}}$.

Where collision is not intended to be part of the ride design or purpose collision shall be assumed to be an accidental action (see 5.3.6.3).

5.3.4 Seismic forces

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

5.3.5 Applicable coefficients for impacts, the vibration of structural components directly travelled over and collisions

5.3.5.1 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 φ_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 5.3.3.2 in this respect.

5.3.5.2 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 φ_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).

5.3.6 Load combinations

5.3.6.1 General

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

5.3.6.2 Fundamental combinations

The design values of the actions shall be combined in the following way:

$$\Sigma \ \gamma_G \ G_k \quad (= \Sigma \ 1{,}35 \ G_k) \tag{3}$$

$$\Sigma \ \gamma_G \ G_k + \Sigma \ \gamma_Q \ Q_{k,i} \quad (= \Sigma \ 1{,}1 \ G_k + \Sigma \ 1{,}35 \ Q_{k,i}) \tag{4}$$

Both cases shall be checked, where

γ_G = 1,1 or 1,35 partial safety factor for permanent actions;

γ_Q = 1,35 partial safety factor for variable actions;

G_k characteristic value of permanent actions;

$Q_{k,i}$ characteristic value of one of the variable actions.

5.3.6.3 Accidental combination

$$1{,}0 \times G_k + A_d + \Sigma 1{,}0 \times Q_{k,i} \tag{5}$$

where

$Q_{K,i}$ characteristic value of the variable actions.

A_d design value of the accidental actions.

Accidental actions(e. g. seismic forces) need only be considered by special request. In such cases formula (5) shall be applied.

5.3.6.4 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 of not less than γ_{Ff} = 1,00. No combination factors shall be applied.

γ_{Ff} partial safety factor for fatigue actions.

5.4 Structural analysis – Principles

5.4.1 General

The limit states resulting from all different actions shall be determined separately for the individual actions given in 5.3. 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 5.1.4.2.

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 forces, shall always be assumed to have the position and magnitude which result in the most unfavourable limit states for the structural and mechanical components to be analysed. For structural, mechanical components and items of equipment which are not permanent fixtures, it shall also be ascertained as to whether more unfavourable conditions are likely to arise when such items are displaced or removed.

Non standard formulae shall be recorded in writing with the symbols in accordance with European Standards or ISO 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 software. The correctness of the assumptions regarding the input and the output data shall be comprehensively reviewed during design approval.

Design resistance shall be evaluated in accordance with the formula (6).

$$R_d = R_k / \gamma_M \tag{6}$$

where

R_d design value of material properties;

R_k characteristic value of material properties;

γ_M = 1,1 partial safety factor for material property in static load combinations;

γ_{Mf} partial safety factor for material property in fatigue load combinations (see Table 5).

For materials other than steel the γ_M - values stated in the respective European Standard shall be used.

5.4.2 Analysis principles for various types of rides

5.4.2.1 Conditions for calculating rotating type devices

Amusement rides 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 ¼ or ¾ 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 (see also 5.6.3.5.1). 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_{St} (stabilizing moment) and $M_{K\gamma}$ (overturning moment) takes into account the partial safety factors according to Table 2.

If an amusement 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.

5.4.2.2 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.

5.4.2.3 Roundabouts with several motions

5.4.2.3.1 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. In such roundabouts when there are no angular accelerations and the rotor is well approximated to a top about its spin axis the rigid body moment is:

$$M_{Kr} = \sin\alpha \left[I_3 \, \omega \, \omega_p + (I_3 - I_2) \, \omega_p^2 \cos\alpha \right] \tag{7}$$

where

- α angle between spin and precession axes;
- I_3 moment of inertia of rotor about its spin axis;
- I_2 moment of inertia of rotor about an orthogonal axis.

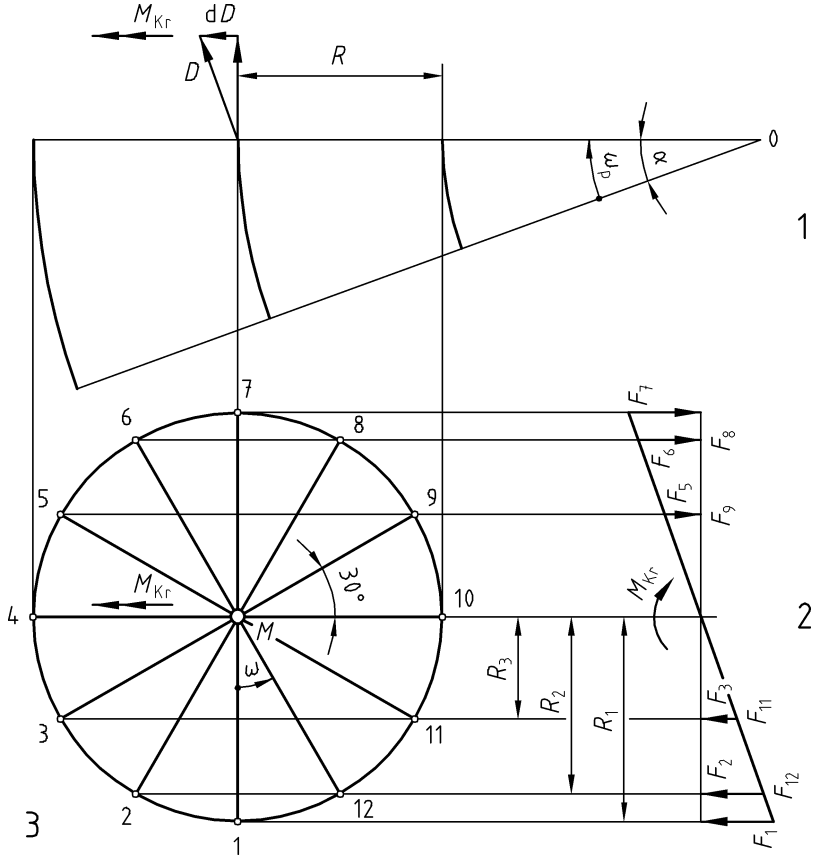
Note also that ω and ω_p may be positive or negative (according to the right hand screw rule).

In the case of a flat shaped rotor and α = 90° the following simplified equation results:

Rigid body moment $M_{Kr} = I_3 \times \omega \times \omega_p$ (8)

The resultant load per outrigger from the rigid body moment is:

$$F_i = M_{Kr} \frac{R_i}{\sum_i R_i^2} \tag{9}$$



Key:

1 Front view
2 Side view
3 Top view
D tTwist;
dD Rate of change of twist;
M_{Kr} Rigid body moment;
R_i Radius;
ω Angular velocity about the spin axis;
ω_p Angular velocity of precession.

Figure 2 — Example for the determination of the rigid body moment and its influence on a slewing gear with 12 outriggers, rotating at an angular velocity ω_1, and slew angle α

5.4.2.3.2 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 by using Figure 3:

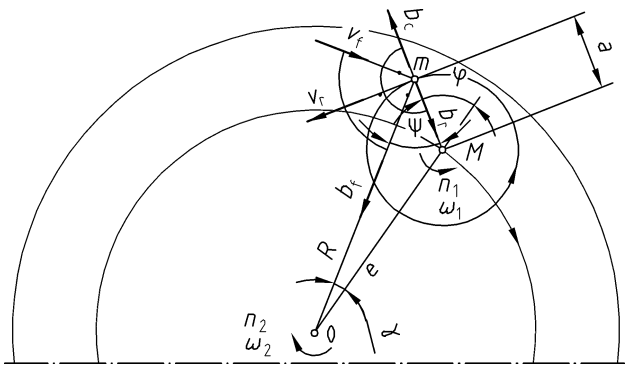


Figure 3 — Velocities and accelerations of mass point m

In Figure 3 is:

M the centre point of rotation in a circle;
O the stationary centre point of rotation;
Without subscript – absolute value.

Meaning of the subscripts:
f guided;
r relative;
c Coriolis acceleration.

Velocities:

$$\vec{v} = \vec{v}_{\mathrm{f}} + \vec{v}_{\mathrm{r}} \tag{10}$$

$$\vec{v} = \vec{R}\,\omega_2 \tag{11}$$

$$\vec{v} = \vec{a}\,\omega_1 \tag{12}$$

$$\vec{R} = \vec{e} + \vec{a} \tag{13}$$

$$R = \sqrt{[e + a - (a - a\cos\varphi)]^2 + [a\sin\varphi]^2} \tag{14}$$

$$= \sqrt{e^2 + 2\,e\,a\cos\varphi + a^2}$$

$$v_{\mathrm{r}\parallel\varphi_0} = -v_{\mathrm{r}}\sin\varphi \tag{15}$$

$$v_{\mathrm{r}\perp\varphi_0} = +v_{\mathrm{r}}\cos\varphi \tag{16}$$

$$v_{\mathrm{f}\parallel\varphi_0} = --v_{\mathrm{f}}\sin\gamma \tag{17}$$

$$v_{\mathrm{f}\perp\varphi_0} = -v_{\mathrm{f}}\cos\varphi \tag{18}$$

$$\sin\gamma = \frac{a\sin\varphi}{\sqrt{e^2 + 2\,e\,a\cos\varphi + a^2}} \tag{19}$$

$$\cos\gamma = \frac{e + a\cos\varphi}{\sqrt{e^2 + 2\,e\,a\cos\mathrm{f} + a^2}} \tag{20}$$

$$v = \sqrt{\left(\sum v_{\parallel\mathrm{f}_0}\right)^2 + \left(\sum v_{\perp\mathrm{f}_0}\right)^2} \tag{21}$$

Direction of v:

$$\cot \delta = \frac{v_{\| f_0}}{v_{\perp f_0}} \tag{22}$$

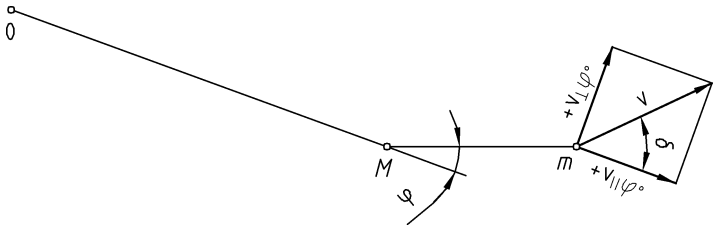


Figure 4 — Resolution of velocity v

Accelerations:

$$\vec{b} = \vec{b}_f + \vec{b}_r + \vec{b}_c \tag{23}$$

$$b_f = R\,\omega_2^2 \tag{24}$$

$$b_r = a\,\omega_1^2 \tag{25}$$

$$b_c = 2\,\omega_2\,v_r \tag{26}$$

$$b_n = b_r - b_c + b_f \cos\psi \quad \text{(normal)} \tag{27}$$

$$b_t = b_f \sin\psi \quad \text{(tangential)} \tag{28}$$

$$R \sin\psi = e \sin\varphi \tag{29}$$

$$\sin\psi = \frac{e}{R} \sin\varphi \tag{30}$$

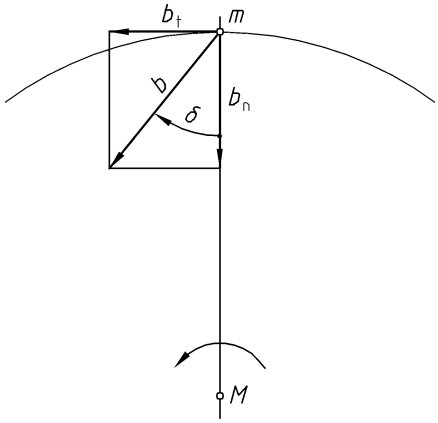
$$R \cos\psi = e \cos\varphi + a \tag{31}$$

$$\cos\psi = \frac{e \cos\varphi + a}{R} \tag{32}$$

$$b = \sqrt{b_n^2 + b_t^2} \tag{33}$$

The above derivations are only valid when ω_1, is in the opposite direction to ω_2.

If ω_1 has the same direction of rotation as ω_2 in Figure 3, the direction of b_c will be reversed.



$$\tan\delta = \frac{b_t}{b_n}$$

Figure 5 — Direction of acceleration Direction of acceleration *b*

5.4.2.3.3 Roundabouts with outriggers running on rail tracks

5.4.2.3.3.1 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 torsional 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.

5.4.2.3.3.2 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 γ = 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 5.5.1 the anchorage may be taken into consideration in the calculation.

5.4.2.3.3.3 Roundabouts with undulating track

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

5.4.2.3.3.4 Roundabouts with several rotation gears

On these installations, particular attention shall be paid to the effects of the Coriolis 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 5.4.2.1 shall be considered. Fatigue calculations in accordance with 5.6.3 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 6.3 shall be respected.

5.4.3 Roller coasters with rail track bound vehicles

5.4.3.1 Rail

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 in the most unfavourable case. 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 6.2.3.3.

The following formula may be used to determine the theoretical transverse inclination α of the rail, which makes the transverse force on the car zero for a particular speed:

$$\tan \alpha = \frac{v^2 \cos^2 \gamma}{R_h \left(g \cos \gamma + \frac{y^2}{R_v} \right)} \quad (34)$$

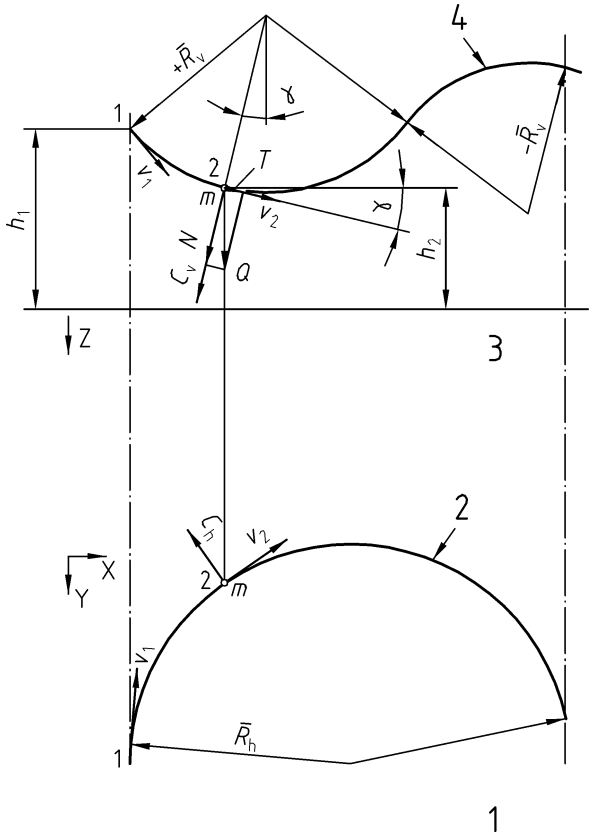
The angle α shall be measured at right angles to R_h and to the rail.

In formula (34) is

- v the velocity of car;
- γ the longitudinal gradient of rail;
- R_h the horizontal radius;
- R_v the vertical radius; (+ trough; – peak).

Use " + " if C_v is directed such as to compress the car to the track and " – " if C_v is directed to uplift the car from the track.

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°. The path of the rail track shall be designed in such a way, that the instantaneous theoretical steps in acceleration do not exceed 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 in accordance with formula (47). Where there are multiple coupled cars the overall centre of mass may be used.



Key

1 Plan view
2 Rail axis
3 Elevation
4 Rail axis

Figure 6 — Elevation and plan view of the rail track

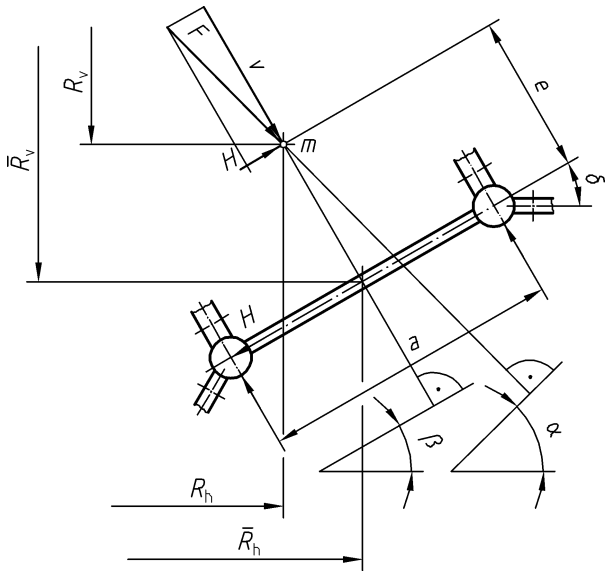


Figure 7 — Rail cross section of rail showing load and guide wheels

Key to symbols used in formulae 34 to 46:

- a wheel gauge;
- e distance of centre of gravity;
- g gravitational acceleration;
- α theoretical transverse inclination of rail;
- β actual transverse inclination of rail;
- γ longitudinal gradient of rail;
- δ guide roller angle;
- $\vec{R}_{\mathrm{v}}$ vertical radius of rail axis;
- $\vec{R}_{\mathrm{h}}$ horizontal radius of rail axis;
- $\pm R_{\mathrm{v}}$ vertical radius of the mass centre of gravity (+ trough; – peak); use + if C_{v} is directed such as to compress the car to the track and – if C_{v} is directed to uplift the car from the track. R_{h} horizontal radius of the mass centre of gravity;
- C_{v} vertical centrifugal force;
- C_{h} horizontal centrifugal force;
- F_{res} resultant load;
- V load from R perpendicular to the rail;
- H load from R in the plane of the rail;
- μ_1 coefficient of friction between load wheels and rail;
- $\overline{\mu}_1$ coefficient of friction between the guide wheels and rail;
- f lever arm of friction;
- μ_2 coefficient of friction of the bearings;
- A projected surface area which the car presents to the wind;
- c_{f} shape coefficient;
- h (= $h_1 - h_2$) differential height;
- Q car load including passenger load;
- m mass;
- D_1 diameter of load wheel;
- D_2 diameter of guide wheel;
- d_1 diameter of load wheel axle;

d_2 diameter of guide wheel axle;

v_1 velocity at point 1;

v_2 velocity at point 2;

l actual rail length from point 1 to point 2;

h_1 elevation at point 1;

h_2 elevation at point 2;

ρ density of the air.

Formulae:

$$R_h = \overline{R}_h - e \sin \beta \tag{35}$$

$$R_v = \overline{R}_h - e \cos \beta \tag{36}$$

In regions where the track has rapid roll the equations for R_h and R_v may become inaccurate in which case a more careful assessment will be necessary.

$$m = \frac{Q}{g} \tag{37}$$

$$C_v = m \frac{v_m^2}{R_v} \tag{38}$$

$$C_h = m \frac{v_m^2 \cos^2 \gamma}{R_h} \tag{39}$$

$$v_m = \frac{v_1 + v_2}{2} \tag{40}$$

$$F = \sqrt{(Q \cos \gamma + C_v)^2 + C_h^2} \tag{41}$$

$$V = F \cos (\alpha - \beta) \tag{42}$$

$$H = F \sin (\alpha - \beta) \tag{43}$$

$$\tan \alpha = \frac{v_m^2 \cos^2 \gamma}{R_h \left(g \cos \gamma + \frac{v_m^2}{R_v} \right)} \tag{44}$$

Friction coefficients:

$$\mu_1 = \frac{2f}{D_1} \tag{45}$$

$$\bar{\mu}_1 = \frac{2f}{D_2} \tag{46}$$

All forces are related to the centre of the interval, and the interval length shall not exceed 5 m.

$$v_2^2 = v_1^2 + 2\,g\,h - c_f\,A\,\rho\,v_m^2\,\frac{l}{m} - \left(\mu_1 + \mu_2\,\frac{d_1}{D_1}\right)\frac{2\,l}{m}\left(V + |H|\tan\delta\right) - \frac{|H|}{\cos\delta}\left(\bar{\mu}_1 + \mu_2\,\frac{d_2}{D_2}\right)\frac{2\,l}{m} \tag{47}$$

If all values are inserted:

$$v_2^2 = v_1^2 + 2g\times h - c_f\times A\times\rho\times v_m^2\times\frac{1}{m} - \sqrt{\left(Q\times\cos\gamma + m\,\frac{v_m^2}{R_v}\right)^2 + \left(m\,\frac{v_m^2\times\cos^2\gamma}{R_h}\right)^2}$$

$$\times\cos\left[\arctan\frac{v_m^2\times\cos^2\gamma}{R_h\left(g\times\cos\gamma + \frac{v_m^2}{R_v}\right)} - \beta\right]\times\left(\mu_1 + \mu_2\,\frac{d_1}{D_1}\right)\frac{2\times l}{m}$$

$$-\frac{1}{\cos\delta}\sqrt{\left(Q\times\cos\gamma + m\,\frac{v_m^2}{R_v}\right)^2 + \left(m\,\frac{v_m^2\times\cos^2\gamma}{R_h}\right)^2}\times\sin\left[\arctan\frac{v_m^2\times\cos^2\gamma}{R_h\left(g\times\cos\gamma + \frac{v_m^2}{R_v}\right)} - \beta\right]$$

$$\times\left(\bar{\mu}_1 + \mu_2\,\frac{d_2}{D_2}\right)\frac{2\times l}{m} - \tan\delta\sqrt{\left(Q\times\cos\gamma + m\,\frac{v_m^2}{R_v}\right)^2 + \left(m\,\frac{v_m^2\times\cos^2\gamma}{R_h}\right)^2}$$

$$\times\sin\left[\arctan\frac{v_m^2\times\cos^2\gamma}{R_h\left(g\times\cos\gamma + \frac{v_m^2}{R_v}\right)} - \beta\right]\times\left(\mu_1 + \mu_2\,\frac{d_1}{D_1}\right)\frac{2\times l}{m} \tag{48}$$

The formula shall be evaluated by iteration with

$$v_m = \frac{v_1 + v_2}{2} \tag{49}$$

In the first iteration v_m can be set equal to v_1.

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. There shall be no significant discrepancy when compared with the calculated values. 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.

5.4.3.2 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.

5.4.3.3 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.

5.4.3.4 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, as a general rule [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 one brake between any two cars.

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[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 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 and wear. If the actuating force has to be increased in order to compensate for varying friction coefficients (ignoring small changes as a result of wear), this shall be taken into consideration. The limiting values shall be checked on the finished installation. During such tests the minimum friction shall be produced as far as is possible with wet rails. In any event the brake surfaces shall be tested, for example by wetting with water.

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

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2) Greater deceleration is permitted on condition that special devices for the protection (lap bars, etc.) of the passenger are provided.

5.4.3.5 Anti-roll-back 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 one 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 blockzone system, with automatically controlled brakes.

The vertical elevation H up to the beginning of the anti roll back device, or the maximum speed which can arise during running back shall not exceed the following limiting values. At least one of the following three limiting values shall be complied with:

H = 7 m, v = 42 km/h for a straight line backward run without transverse rail inclination, when viewed from above:

H = 5 m, v = 35 km/h for a backward run on a wide sweep curve with a transverse rail inclination up to 20°;
H = 3,5 m, v = 30 km/h for a backward run on a sharper bend, with a transverse rail inclination exceeding 20°.

Two values shall be specified, because H is a function of the elevation of the centre of gravity of the train, and this elevation need not necessarily be the same as the elevation. Furthermore, the location on the train of the safety device against backward running is of importance for the above-mentioned limiting values.

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.

The fatigue strength need not be verified for the anti-roll-back devices. If the car is stopped by the anti-roll-back 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.

$$\varphi \geq 0{,}5 \times h \tag{50}$$

$$2{,}0 \leq \varphi \tag{51}$$

The two conditions above shall be satisfied.

If there is only one anti-rollback device without redundancy in one car or train the following formula shall be applied:

$$\varphi \geq 1 + \sqrt{1 + \frac{2h}{\delta_0 \sin \alpha}} \tag{52}$$

where

δ_0 total deflection of centre of mass along slope.

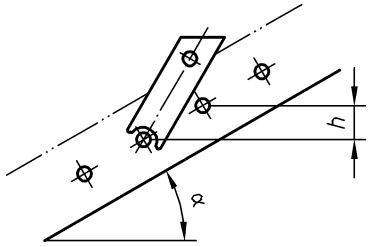


Figure 8 — Impact factor/running back elevation

5.4.4 Other railways with track bound vehicles

5.4.4.1 Conventional railways (e. g. children's railways, children's traffic gardens, ghost railways and similar installations, with both conventional and suspended vehicles).

The requirements outlined in 5.4.3 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.

5.4.4.2 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 (see 6.1.6.1).

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 undampened 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 locking of pendulum gondolas for the purpose of passenger transfers can only be dispensed with on condition that no danger or inconvenience to passengers is caused by the adoption of other means (e. g. suitable dampers).

5.4.5 Grandstands

Grandstands shall be subjected to the verification of limit states in accordance with 5.1.4. 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.

5.5 Verification of stability

5.5.1 Safety against overturning, sliding and lifting

5.5.1.1 Proof shall be provided of safety against overturning, sliding and lifting 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.

For foundations, ENV 1997-1 shall also be applied in addition to 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 measured accurately this allows a more precise determination of the safety factors to be made:

Table 2 — Safety factor against overturning, sliding and lifting

	Loading[a]	γ
1	Favourably acting proportions of the dead load	1
2	Unfavourably acting proportions of the dead load	1,1
3	Unfavourably acting wind loads	1,2
4	Unfavourably acting proportions of loads other than the loads listed in items 2 and 3	1,3

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

5.5.1.2 The safety against overturning shall be calculated from:

$$\sum \gamma M_{\mathrm{St,k}} \geq \sum \gamma M_{\mathrm{K,k}} \tag{53}$$

where

γ is the safety factor in accordance with Table 2;

$M_{\mathrm{St,\,k}}$ are the stabilising moment values;

$M_{\mathrm{K,\,k}}$ are the overturning moment values.

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

5.5.1.3 The safety against sliding shall be calculated from:

$$\sum \gamma \mu N_{\mathrm{k}} \geq \sum \gamma H_{\mathrm{k}} \tag{54}$$

where

γ is the safety factor in accordance with Table 2;

N_{k} is the vertical load component;

H_{k} is the horizontal load component;

μ is the coefficient of friction in accordance with Table 3.

The following coefficients of friction 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 — Coefficients of friction μ

	Wood	Steel	Concrete
Wood	0,4	0,4	0,6
Steel	0,4	0,1	0,2
Concrete	0,6	0,2	0,5
Clay[a]	0,25	0,2	0,25
Loam[a]	0,4	0,2	0,4
Sand and gravel	0,65	0,2	0,65

[a] At least of stiff consistency in accordance with ENV 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 3 shall only be entered in the calculation at 70 % of the listed values.

$$\sum \gamma \, \overline{\mu} \, N_{\mathrm{k}} + Z_{\mathrm{h,d}} \geq \sum \gamma \times H_{\mathrm{k}} \tag{55}$$

$$\overline{\mu} = 0{,}7 \, \mu \tag{56}$$

where

$Z_{\mathrm{h,d}}$ is the horizontal design capacity of the anchor (see 5.5.2);

μ is the coefficient of friction in accordance with Table 3.

5.5.1.4 Safety against lifting shall be calculated from:

$$\sum \gamma \, N_{\mathrm{St,\,k}} \geq \sum \gamma \, N_{\mathrm{a,\,k}} \tag{57}$$

where

γ is the safety factor in accordance with Table 2;

$N_{\mathrm{St,\,k}}$ are the vertical stabilizing load components;

$N_{\mathrm{a,\,k}}$ are the vertical lifting load components.

With anchor ties the following relationship shall be applied:

$$\sum \gamma \, N_{\mathrm{St,\,k}} + Z_{v,\,d} \geq \sum \gamma \, N_{\mathrm{a,\,k}} \tag{58}$$

where

$Z_{\mathrm{v,d}}$ is the vertical design capacity of the anchor (see 5.5.2).

5.5.2 Ground anchorages

5.5.2.1 General

Uncertain soil conditions and the type of loading make it extremely difficult to assess the load bearing capacities of anchor ties accurately. Therefore the following approximation method should be used. This clause will therefore be restricted to:

a) weight anchors, i. e. ballast bodies placed on the surface of the ground or buried;

b) rod anchors, i. e. 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 applied for subordinate devices (e. g. inflatable devices, etc.) not required from the results of a calculation, loading tests or other acceptable evidence shall be provided.

5.5.2.2 Load bearing capacity of weight anchors

When calculating the 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.

5.5.2.3 Load bearing capacity of rod anchors

The load bearing capacity of simple rod anchors with a circular cross section and with a minimum driving-in depth of 80 cm shall be determined in accordance with the empirical formulae given in Table 4:

Table 4 — Design capacity of anchors

Angle of pull	Design capacity
β = 0°	$Z_d = f_{load}\, d\, l' = 6{,}5\, d\, l'$ (59) For stiff cohesive and for dense cohesionless soils
	$Z_d = f_{load}\, d\, l' = 8\, d\, l'$ (60) For very stiff cohesive soils
$\beta \geq 45°$	$Z_d = f_{load}\, d\, l' = 10\, d\, l'$ (61) For cohesive soils of at least medium to stiff consistency
	$Z_d = f_{load}\, d\, l' = 17\, d\, l'$ (62) For dense cohesionless soils
$0 < \beta < 45°$	The design capacity for the soil types shall be determined by interpolation (see Figure 10).

In formulae (63) to (66) and in Figures 9 and 10 the following abbreviations are used:

$Z_d = Z_u / \gamma_M$ with γ_M = 1,5 the design capacity of anchor in N;

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

$Z_{v,\,d}$ the vertical design capacity of anchor in N;

d the anchor diameter, in cm;

l' the depth of penetration (minimum length 80 cm);

α the angle of penetration;

β the angle of acting tensile force to the vertical.

Formulae (63) to (66) 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 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:

$$d_{\min} = 0{,}025\, l' + 0{,}5 \quad (\text{with } l' \text{ in cm}) \tag{63}$$

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

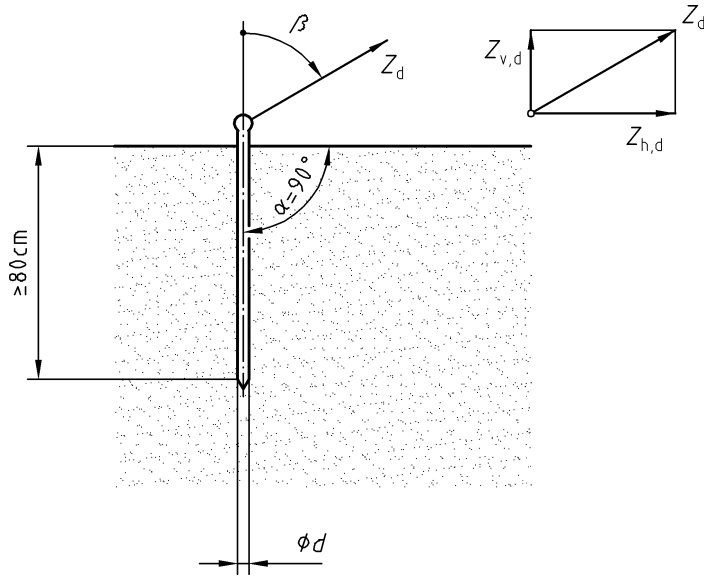
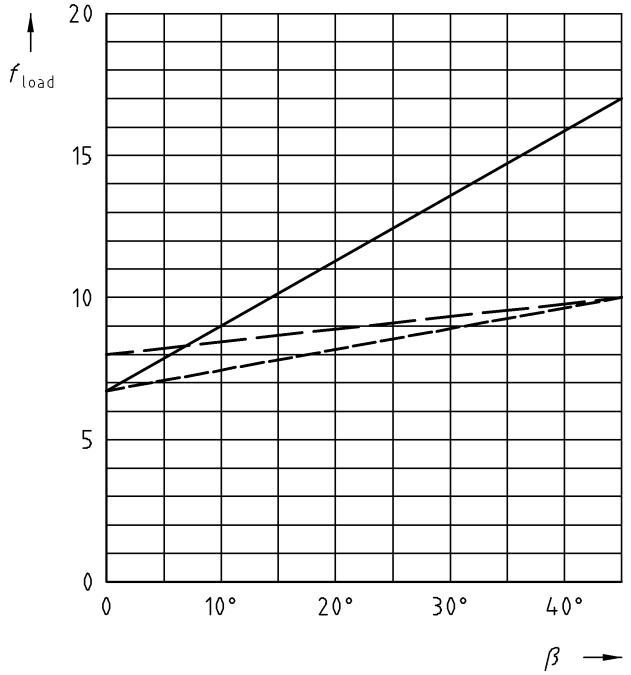


Figure 9 — Rod anchor



Key

___ Dense cohesionless soils

----- Very stiff cohesive soils

..... Stiff cohesive soils

β = Angle of pull

Figure 10 — Factors for determining the load bearing capacity of rod anchors

5.5.2.4 Testing of anchors

The calculated 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 γ = 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 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.

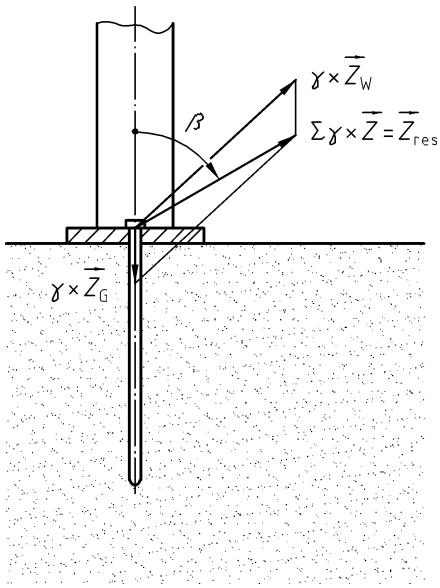
If the foundation conditions are comparable, loading tests carried out in another location may be adopted for substantiation purposes.

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

5.5.2.5 Calculation of loads on anchors

The resulting load Z_{res} acting on the anchorage shall be determined by vectorial 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 5.5.2.3:

$$Z_{res} = \sum \gamma Z \leq Z_d \tag{64}$$



Key

Z_G is the favourably acting resultant of permanent actions;

Z_W is the unfavourably acting portion of variable actions;

γ is the safety factor in accordance with Table 2.

Figure 11 — Anchor loading

5.5.3 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 assured. An increase of the resistance against pull-out failure can be achieved either by means of additional anchors or by driving in wooden wedges. In the case of pure tensile stress in the direction of the axis of the rod anchor, the danger of a complete failure of the anchor arises when very small movements occur.

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

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

If groups of anchors are used, each individual anchor may only be assessed in the calculation at its full, calculated load bearing capacity on 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 has to be verified. Without further verification an angle of excavation of 45° starting from the outer anchor may be assumed.

5.5.4 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 permissible soil pressures may be used in the calculation for square and rectangular packing with dimensions:

$$1 \leq l / b \leq 3 \tag{65}$$

where

l length and

b 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 permissible soil pressure. Interpolation should be conducted for intermediate values.

For installation on hard (paved) locations, higher permissible soil pressures may be considered.

5.6 Verification of strength

5.6.1 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, min σ / 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 σ – min σ is significant for the calculation.

Fatigue calculation of welded structural items may also be performed to relevant standards which are based on the max σ / min σ concept if the minimum life time requirements in 5.6.3.4; or infinite life; can be demonstrated.

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. 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.

The particular standard (e. g. EC 3, FEM etc.) selected for the complete analysis of a ride shall be clearly specified and maintained.

5.6.2 Predominantly static stress

Permissible stresses of materials used for structural components shall be taken from those listed in ENV 1993 (all parts). 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:

$$R_d \leq f_y / \gamma_{My} \quad \text{and} \quad R_d \leq f_u / \gamma_{Mu} \tag{66}$$

where

R_d is the design material resistance;

f_y is the yield strength according to EN-material standard;

f_u is the ultimate strength according to EN-material standard;

γ_{My} 1,1 partial safety factor (yield);

γ_{Mu} 1,35 partial safety factor (ult. tensile strength).

The smaller of the two values R_d above shall be used. For shear resulting from transverse force and torsion, the value R_d shall be multiplied by α = 0,58.

5.6.3 Fluctuating stress

5.6.3.1 Fatigue assessment of structural components

In addition to ensuring that each component satisfies the ultimate limit states for non-fluctuating loads an assessment of fatigue life as a result of repeated fluctuation of stress shall be carried out. For steel, the principles of ENV 1993-1-1:1992, Clause 9 should be applied when the material, fasteners and welding consumables conform with the requirements specified in ENV 1993-1-1:1992, Clause 3. In Annex A some variations from ENV-1-1 are detailed, where this is more appropriate to amusement devices.

5.6.3.2 Partial safety factors for fatigue

For fatigue loads a partial safety factor shall be applied:

$$\gamma_{Ff} = 1{,}0 \tag{67}$$

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

Table 5 — Partial safety factors for fatigue resistance

Examination and access	Rupture will not effect collapse	Rupture will effect collapse
Structural part accessible during regular examination	γ_{Mf} = 1,0	γ_{Mf} = 1,1
Structural part not accessible during regular examination	γ_{Mf} = 1,05	γ_{Mf} = 1,15

5.6.3.3 Fatigue loads

When calculating $\Delta\sigma_i$ or $\Delta\tau_i$,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 5.3.3.4.1, 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. For more exact evaluation of the need to carry out a fatigue check in the case of wind induced oscillation see ENV 1991-2-4.

When calculating $\Delta\sigma_i$ or $\Delta\tau_i$, the following actions shall be taken in account as a minimum:

— dead loads with change of position;

— moving imposed loads;

— driving and braking forces according to 5.3.3.2;

— load coefficients for impact and vibrations of parts directly travelled over;

— intentional collision forces;

— centrifugal and Coriolis forces.

Where there is movement of dead loads, when assessing $\Delta\sigma_i$ or $\Delta\tau_i$ (e. g. for lifted booms), the maximum and minimum stresses shall be calculated including dead loads:

$\Delta\sigma_i$ = max. σ – min. σ

$\Delta\tau_i$ = max. τ – min. τ

5.6.3.4 Number of stress cycles

If more precise assessment of the number of stress cycles for the different load ranges is not possible, the following values shall be used as a minimum:

At least 35 000 operating hours shall be assumed in the fatigue calculation of rides not including loading and unloading time. Mass-produced replaceable safety critical 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. A theoretical lifetime calculation shall be submitted. Although the ratio of loading/unloading time to total operational time can vary from ride to ride, a general value of loading/unloading time shall be limited to a maximum of 30 % of the total operational time. If at the design stage, more unfavourable values are found, these values shall be taken into account.

When using the above minimum operating hours the load cycles (given in Table 6) shall be assumed as a minimum if no higher values are identified as a result of the configuration of the ride.

Table 6 — Minimum load cycle requirement (N_{min}) to be applied in calculation

Type of ride	For all constructional details submitted to fatigue calculation where –	
	– the number of rotations is decisive for the number of load cycles	– the number of ride cycles (load/unload time plus one ride) is decisive for the number of load cycles
coaster or similar (ride cycle time of Δt = 30 s approx.) for structure and track, etc.	not applicable	$N_{min} \geq x_1 \times 5 \times 10^6$ load cycles x_1 multiplier for the number the train crosses over the location due to location of detail in the track or supporting construction (e.g. x_1 = 1 for one crossing / $x_1 = n$ for 'n' crossings of the train)
coaster or similar: for the vehicles, etc.	not applicable	$N_{min} \geq x_2 \times 5 \times 10^6 / x_3$ load cycles x_2 multiplier due to the number of max. stress ranges along the track during one ride cycle (e.g. x_2 = 1 if the max. stress range appears only once for the vehicle during one full cycle) x_3 multiplier due to the number of trains in one track (ride)
rotational rides $n \approx$ 8 to 20 rpm: for the mast or the centre, etc.	$N_{min} \geq 5 \times 10^6$ no stress range higher than $\Delta\sigma_D$	
rotational rides $n \approx$ 8 to 20 rpm: for the arms or the gondolas, etc		$N_{min} \geq 2 \times 10^6$ equiv. stress range $\Delta\sigma_{E.2}$ not higher than $\Delta\sigma_C$

5.6.3.5 Load patterns

5.6.3.5.1 Roundabouts

For asymmetric loading the stress range due to 1/6- and 5/6-one-sided load according to 5.4.2.1 may be assumed for 100 % of fatigue life.

5.6.3.5.2 Track bound devices

The forces due to the action of anti-roll-back units and safety brakes need not be considered in fatigue life calculations.

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

5.6.3.6 Fatigue strength of machined components

5.6.3.6.1 Determination of design stresses

For materials not listed in ENV 1993 (all parts), and for those not treated in that standard (e. g. machinery components) the determination of the design stresses in the case of fluctuating stress, shall be carried out in accordance with one of the calculation methods featured in specific standards or in recognised literature at the state of the art.

In this context, the following influences shall be taken into account:

— fatigue notch factor;

— influence of size;

— influence of surface;

— cross-sectional shape;

— corrosion factor;

— if applicable, anisotropy coefficient.

5.6.3.6.2 Determination of resulting stresses

The resulting stresses in machined components (nominal stresses) shall be determined in accordance with the general principles of stress analysis.

5.6.3.6.3 Safety factor γ

The actual safety of the machined component against fatigue failure is:

— for pure tensile, bending or torsional stress:

$$\gamma = \sigma_{AG} / \sigma_a \quad \text{or} \quad \tau_{AG} / \tau_a \tag{68}$$

— for combination stress:

$$\gamma = \sigma_{AG} / \sigma_{av} \tag{69}$$

— against exceeding the yield point or elastic limit:

$$\gamma = \sigma_{SG} / (\sigma_a + \sigma_m) \quad \text{or} \quad \gamma = \sigma_{SG} / (\sigma_{av} + \sigma_{mv}) \tag{70}$$

where

σ_{AG} is the amplitude strength of the machined component dependent on shape;

σ_{SG} is the yield point (elastic limit) of the strength dependent on shape;

σ_a is the alternating stress amplitude;

σ_m is the mean stress;

σ_{av} is the combined alternating stress amplitude;

σ_{mv} is the combined mean stress.

Universally binding resulting safety factors min γ are not capable of being specified with precision. They are governed by the number and weight of uncertainty factors and by the possible consequences in the event of failure. The greater the deformability (ductility) of the material, the lower the safety factor that can be selected.

Sufficient safety factors min γ shall be applied for machinery calculations in respect of fatigue strength while using material parameters σ_{End} on the basis of 90 % survival probability, where σ_{End} is the endurance strength.

Irrespective of the standard to which the machined component is calculated, at a minimum a safety factor of $\gamma_{M,f} \geq 1.2$ on the resistance side need to be applied. Any higher factors from the calculations need to be taken in their actual values. This safety factor is taken under the provision that on the load side an additional importance factor of at least $\gamma_I \geq 1.1$ to 1.5 for the different categories of application (non critical to loss of life) is applied in the calculation. The calculation with these factors requires a conservative assumption choosing the loads to cover the real operational conditions (e.g. impact factors) and the consideration of limited wear and degradation of the part during its life.

In all cases, the following relationship shall be given: min $\gamma \geq \gamma_{M,f} \cdot \gamma \cdot \gamma_u \cdot \varphi$

Following factors shall be applied:

$\gamma_{M,f}$ minimum safety factor of 1,2 – 2,5 on the resistance side;

γ_I importance factor of 1,1 – 1,5 on the load side;

γ_u uncertainty factor of 1,0 – 1,5 on the load side;

φ impact or vibration factor (see 5.3.5).

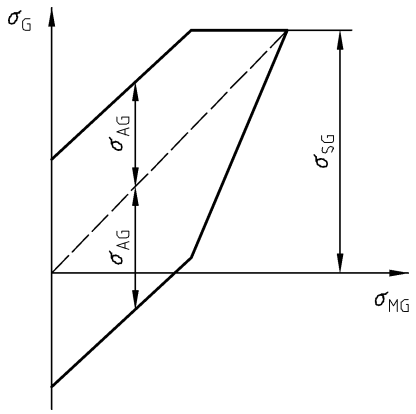


Figure 12 — Fatigue strength diagram according to Smith, for strength dependent on shape

5.6.4 Bolts

Bolts conforming to EN ISO 898-1, EN ISO 4014, EN ISO 4016, EN ISO 4017 or EN ISO 4018, nuts to prEN 14399 (all parts), EN ISO 4032, EN ISO 4034 or ISO 7413 assigned to property classes 4.6, 5.6 and 8.8 shall be used. The calculation of limit states shall be made in accordance with ENV 1993-1-1. The analysis of bolts under fluctuating stresses shall be conducted in accordance with the relevant literature taking into account the present state of the art. ENV 1993-1-1 shall also apply for high strength bolts, nuts and washers conforming to prEN 14399 (all parts) and EN ISO 7090 assigned to property class 10.9.

Where ENV 1993-1-1 is not applied, the following shall be used for bolts assigned to the property classes referred to below.

a) Screwed connections with bolts subjected to tensile stress may be designed with a bolt hole clearance of 1,0 mm even when vibrating stress are present, as long as the forces normal to the axis of the bolt are absorbed by the provision of shear keys, pins, cotter pins, bushes etc (with less clearance than 1 mm), or if a calculation in respect of friction contact is carried out using a friction coefficient of $2/3 \times \min \mu$.

b) 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.

c) In the case of single-shear joints, the eccentricity shall be taken into consideration.

The following shall apply for bolts assigned to property classes 6.8, 8.8 and 10.9:

1) permissible shear strengths in accordance with Table 7;

2) permissible calculated pressure on the face of the bolt hole for shear bearing pressure joints in accordance with ENV 1993 (all parts) (or in absence of this with equivalent national standards) for non-prestressed bolts;

3) permissible additional transmissible tensile force in the direction of the bolt axis per prestressed bolt or fitted bolt in accordance with Table 9; with F_v in accordance with Table 8;

4) permissible pre-stressing force and tightening torques in accordance with Table 8;

5) 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 are valid for an overall friction coefficient μ = 0,14 (dry to slightly lubricated) making use of 90 % of the minimum yield point.

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

Table 7 — Design shear stresses τ_m for a predominantly static stress per bolt, and for a shearing area perpendicular to the axis of the bolt

Property class	6.8	8.8	10.9
Design shear stress τ_m N/mm^2	210	300	360

Table 8 — Pre-stressing forces and tightening torques for bolts

Thread size	Pre-stressing force F_v (kN) for property class			Tightening torque M_a (Nm) for property class		
	6.8	8.8	10.9	6.8	8.8	10.9
M 8	14	16	23	21	25	35
M 10	22	26	37	41	49	69
M 12	31	37	50	70	84	120
M 16	60	71	100	176	206	350
M 20	94	111	160	338	402	600
M 22	116	138	190	456	539	900
M 24	135	160	220	588	696	1 100
M 27	177	210	290	873	1 030	1 650
M 30	216	257	350	1 177	1 422	2 200
M 33	275	326	459	1 668	1 977	2 784
M 36	323	382	510	2 134	2 524	3 340

Table 9 — Design tensile force $N_{R,d}$ in the direction of the bolt axis, per pre-stressed bolt

Predominantly static stress for loading case		Vibrating stress for loading case	
Permanent actions only	Permanent and variable actions	Permanent actions only	Permanent and variable actions
0,7 F_v	0,8 F_v	0,6 F_v	0,7 F_v
F_v in accordance with Table 8.			
The values of this table can be applied with a partial load factor $\gamma_{F,f}$ = 1,0 in case of vibrating stress.			

5.6.5 Ropes, chains, safety devices, connectors and adapters

5.6.5.1 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 will also be provided. When ropes, chains, safety devices, connectors and adapters are used, the following standards in particular should be observed.

Steel wire ropes

Steel wire ropes	EN 12385 (all parts)
Termination for steel wire ropes – Safety	EN 13411 (all parts)

Fibre ropes

Fibre ropes for general service – Determination of certain physical properties	EN 919
Fibre ropes for general service – General	
Specification	EN 701

Synthetic fibre ropes

Fibre ropes for general service – Polyamide	EN 696
Fibre ropes for general service – Polyester	EN 697
Fibre ropes for general service – Polypropylene	EN 699
Fibre ropes for general service – Polyethylene	EN 700

Natural fibre ropes

Fibre ropes for general service – Manila and Sisal	EN 698
Fibre ropes for general service – Hemp	EN 1261

Chains

Short link chain for lifting purposes – Safety	EN 818 (all parts)
Clamps for wire ropes	EN 13411 (all parts)
Components for slings	EN 1677 (all parts)
Shackles	EN 13889

In the absence of European Standards national standards may be used.

5.6.5.2 Ropes, chains, belts and straps

5.6.5.2.1 Safety-factor calculation

The safety factor will depend on the intended application. The following relationship shall apply:

— Minimum load at fracture $\geq$ Maximum load $\times$ Safety factor

Other limit states may also need to be checked.

Wire rope 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.

5.6.5.2.2 Suspension of passenger carrying devices (e.g. chairs, gondolas)

For steel chains a safety factor of γ = 6 shall be used. For steel wire ropes the values given in Table 10 shall apply.

Extrapolation of the permissible stress values in Table 10 for higher nominal strength categories is not allowed. If individual wires with a nominal strength category exceeding 1 570 N/mm^2 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 5.6.5.3.

Table 10 — Design stresses for wire ropes for suspension of structural components made from individual wires of 1 570 N/mm^2 nominal strength category, for the purpose of verification of fatigue strength

Diameter of wire rope (mm)	Permissible stress σ_f in N/mm^2, for wire ropes
[1]) 4 up to 5	540 + 67 κ
over 5 up to 20	337 + 270 κ
over 20 up to 30	270 + 337 κ
over 30 up to 40	202 + 405 κ

[1]) For design reasons, wire rope diameters smaller than 4 mm shall be avoided.

$$\kappa = \frac{\min \sigma}{\max \sigma}$$

5.6.5.2.3 Guy ropes, stay ropes, anchoring ropes and chains

For steel chains under predominantly non-fluctuating loads a safety factor of γ = 4 shall be used.

For wire ropes made from individual wires with a nominal strength category of 1 570 N/mm^2 a safety factor of γ= 3 shall be taken for the general stress analysis. Regarding fibre ropes made from natural and/or synthetic fibres, the values given in Table 11 shall apply.

Table 11 — Partial Safety factors for natural or synthetic fibre ropes

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

Steel ropes made from individual wires with a nominal strength category of 1 570 N/mm^2 and their associated fasteners, which are subjected to predominantly fluctuating stresses shall be verified in accordance with European Standards or in absence of this to national standards. For steel chains a safety factor of γ = 6 shall be used.

5.6.5.3 Passenger safety locking devices

A safety factor of γ= 6 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 European 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.

5.6.5.4 Connectors and adapters

In the absence of European 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 safety factors for steel chains (4 or 6) in accordance with 5.6.5.2.1.

The permissible loadings in accordance with future European 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 European Standards, or in absence of those, national standards for approved load data shall apply. Shackle pins shall be secured against loosening plastic composites.

Special attention shall be paid to design details during design reviews, because the properties of plastics and composites differ in a number of significant respects from metals.

5.7 Structural design and workmanship

5.7.1 Arrangement, accessibility

Structural components which are sized in accordance with 5.6.3.2 with a partial safety factor γ_{Mf} = 1,1 or 1,0, shall be made accessible, where necessary, for checking in the dismantled condition.

5.7.2 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 dangerous situations, shall be secured by well recognised methods.

On pre-stressed bolts (according to Table 8), the pre-stressing is considered as security against loosening.

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 erection and operating instruction manual to the necessary checks to be carried out.

5.7.3 Joints intended for 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. Drilled holes in timber components for connecting bolts which are subjected to alternating and pulsating loads, or on which the bolts are regularly removed during erection and dismantling operations, shall be relieved from stress by the provision of suitable load spreading plates or dowel pins.

Tensile forces in drilled 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.

5.7.4 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.

5.7.5 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.

5.7.6 Central masts

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

5.7.7 Prevention of corrosion and rot

See ENV 1993-1-1 or equivalent national standards for steel components.

See European Standards or equivalent national standards for light alloy components.

See European Standards or equivalent national standards for timber components.

6 Requirements for design and manufacture of rides and structures

6.1 Risk reduction by prevailing design and safety measures

6.1.1 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 precautions required. Any single amusement device can fall into more than one category, e. g. dark rides, which include rail-guided devices travelling through water.

6.1.2 Hazard analysis

For guidance on general principles see EN 1050:1996, Table A.1 with the exclusion of items 8.6 and 37 and when considering passengers also item 8.5, and compare the applicable main hazards for amusement devices listed in Annex I.

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

6.1.3.1 General

All surface areas of platforms, walkways, ramps and stairs accessible to the public should be slip-resistant regardless of weather conditions. They shall be free from tripping points, openings allowing spherical objects larger than 12 mm in diameter to fall, and nip or pinch points in areas open to the public. 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 6.1.3.3 shall be followed. This shall not apply to those items which are intentionally designed for the purpose of amusement in funhouses, which do not conform with the requirement of Clause 6 and for which special precautions are taken in accordance with 6.2.5.1.1.

6.1.3.2 Platforms

The slope of platforms shall not exceed 1 in 8.

Entrance and exit ramps for the general public shall not have a slope greater than 1 in 6.

When cross battens are fitted across the full width of the ramp at a distance between centres of not more than 0,40 m, the slope may be increased to 1 in 4. The cross battens shall be at least 5 mm high and not more than 50 mm wide.

In the absence of ramps or stairs a platform's change from one level to another shall be between 0,10 m and 0,24 m.

6.1.3.3 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 limited number of passengers only, shall be at least 0,60 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 m difference in height.

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 respectively according to the minimum width of the type of stair. Where the stairway is 0,90 m or greater in width there shall be a handrail on both sides. 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 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 13a).

b) Where the stairway is to be specified as part of an emergency escape route Figure 13b) shall be applied (see also 6.1.5.2).

Inclined treads are not allowed.

Dimensions in millimetres

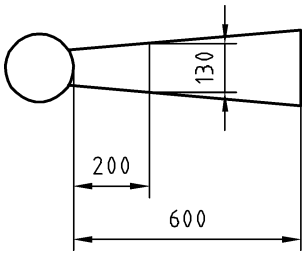


Figure 13a

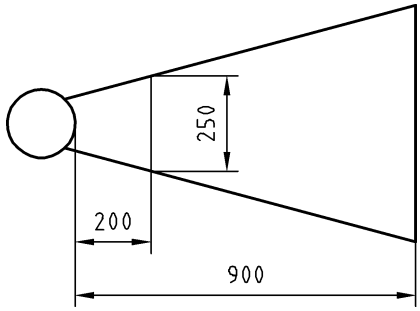


Figure 13b

Figure 13 — Dimensions for spiral or curved stairways

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

6.1.3.4 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 toeboard according to 6.1.4.1.2 shall be provided on both sides of moving walkways or travelators. A railing on only one side is allowed if the moving walkway or travelator is used for access to or egress from passenger units according to 6.1.5.1.1. The maximum clearance between the belt and the toeboard 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 lateral 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 tripboard, 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.

Provision shall be made to protect the end of moving walkways or travelators 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, lateral egress, according to above clause shall be provided.

The maximum relative speed shall not exceed 0,7 m/s with frontal egress from the stationary platform, and 0,5 m/s with lateral egress. If the walkway or travelator is used as part of the attraction itself then higher speeds may be accepted.

An emergency stop button shall be fitted at both ends.

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

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

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

6.1.4.1.1 General

Fencing or railings 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 shown under 6.1.4.5. Railings shall as a minimum consist of two guard rails (a top rail and an intermediate rail).

When using fences to prevent falls from a height of 2 m and more only the conventional fences in accordance with 6.1.4.5 are allowed.

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 6.1.4.5 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 5.3.3.1.3 with a maximum deflection of 30 mm. Untensioned chains, ropes or other non rigid materials are not permitted.

6.1.4.1.2 The edges of platforms, walkways, ramps and stairs more than 0,40 m above ground, accessible to the public, shall be fitted with at least railings consisting of a top handrail at least 1 m high and an intermediate rail at half height.

6.1.4.1.3 In addition platforms, ramps and stairs higher than 1,0 m and mainly for public use shall be fitted with toe boards at least 25 mm high or a low level railing not more than 0,12 m from the floor surface.

6.1.4.1.4 If such platforms, ramps and stairs as well as walkways and other passages, are intended solely or primarily for operating and maintenance personnel, they shall be fitted with toe boards 100 mm high.

6.1.4.1.5 Fences in accordance with 6.1.4.5 may also be considered a reliable protection against falls, if provided with toe boards or low level railing as described above.

6.1.4.2 Protection against crushing, impact or entanglement

6.1.4.2.1 The design of amusement 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, zone demarcation systems to prevent access of passengers or intending passengers to dangerous parts of the ride or parts of it whilst they are in motion shall be provided.

6.1.4.2.2 Where a zone demarcation inside or outside the ride is required (see especially 6.2) it shall be designed and positioned in such a way that no one outside the area is within reach of any moving part of the ride. The location (distance) of a such perimeter fencing or inside zone demarcation depends on:

a) height above the floor of a source of danger;

b) height of the zone demarcation;

c) shortest distance between the zone demarcation 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 EN 294:1992, Table 1 shall be used.

6.1.4.3 Classification of zone demarcation systems

Zone demarcation systems are classified as follows:

J1 – predominantly visual zone demarcation systems: coloured stripes on the floor or fixed steps, poles, cones or equivalent.

J2 – physical zone demarcation systems: flexible devices, such as ropes, chains, cords, etc., which need not withstand horizontal forces.

J3 – physical zone demarcation systems: – rigid devices – such as fencing or railings which can withstand horizontal forces.

6.1.4.4 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.

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 6.2.

6.1.4.5 Types of fences

Fencing shall be designed using the load assumptions given in 5.3.3.1.3.1. Fences shall be at least 1,0 m high above any standing position and shall be so constructed that neither adults nor children can get through or underneath them. They should be so constructed, where protecting from a significant hazard, that people cannot trap their heads in the fencing. For this purpose two categories of fences are allowed:

a) Conventional fences

   — fences with predominantly vertical internal elements (Figure 14). The distance between two adjacent elements shall not be more than 0,10 m or

   — fences provided with mesh as an internal element (Figure 15). The size of the mesh shall be in accordance with Figure 15.

b) Decorative fences

— fences provided with decorative internal elements (see Figure 16). The distances between two adjacent elements shall be as shown in Figure 16.

The elements shall not have sharp edges.

For amusement rides dedicated solely to children less than 10 years of age the zone demarcation can have a reduced height of 0,85 m for both types of fence if there is no difference in height level.

Dimensions in millimetres

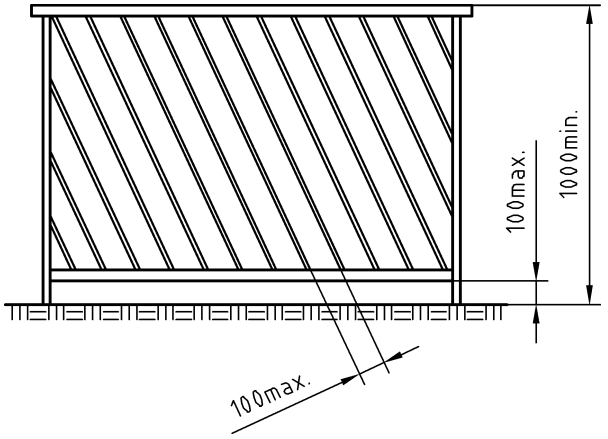


Figure 14 — Examples of fences with predominantly vertical internal elements

Dimensions in millimetres

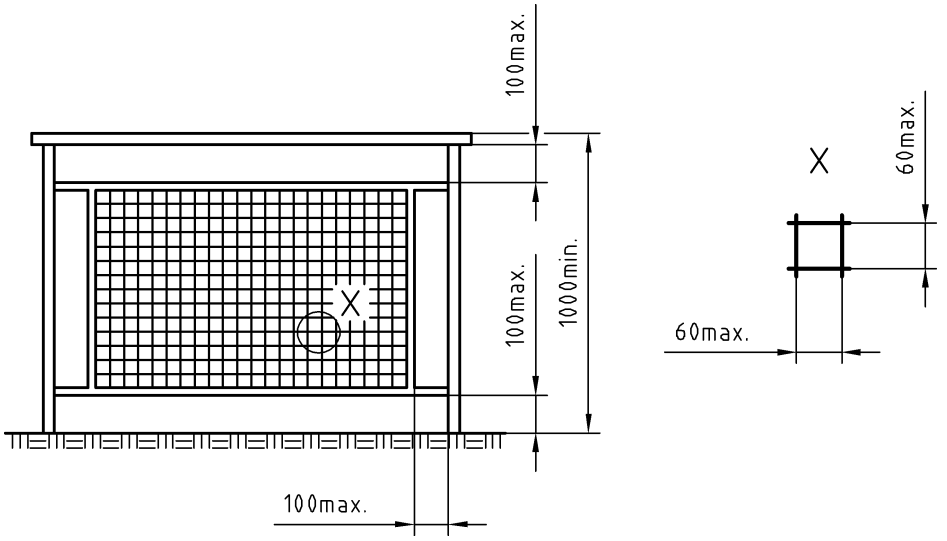


Figure 15 — Examples of fences provided with mesh or panels as an internal element

Dimensions in millimetres

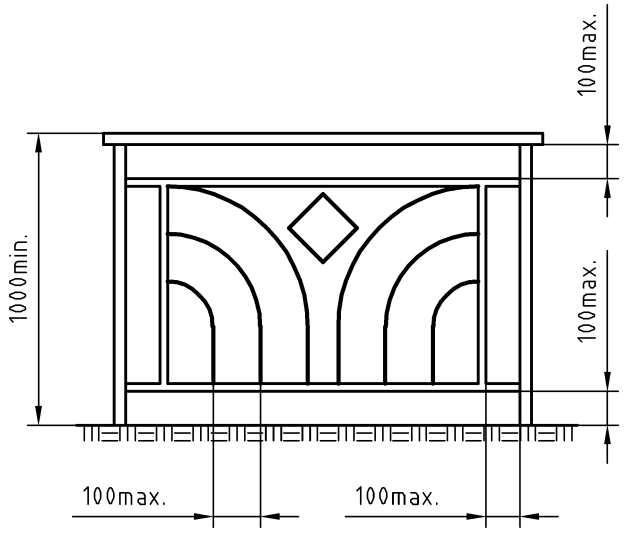


Figure 16 — Examples of fences with decorative internal elements

6.1.4.6 Guarding of dangerous parts of machinery

Any hazardous machinery part built into amusement devices which passengers or personnel can have access to shall be secured with guards in accordance with EN ISO 12100-1 and EN ISO 12100-2.

6.1.5 Risk reduction in the case of access and egress

6.1.5.1 Access to and egress from passenger units

6.1.5.1.1 General

Passenger carrying amusement devices shall be so designed that the risk of people being injured from falls whilst gaining access to or egress from the device is minimised. The access to and the egress from passenger units is in general gained from platforms and ramps according to 6.1.3. Stairs are admitted only if their position and sizes, related to the passenger unit features, are designed so that the passenger cannot reasonable slip or fall during access or egress. 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. 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.

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 0,7 m/s with access parallel to the direction of motion to the stationary platform, and 0,5 m/s with lateral egress.

Access to a passenger unit from a travelator or equivalent system, and egress from a passenger unit to a travelator are admitted under the following conditions:

— the relative velocity between the passenger unit and the travelator shall not exceed 0,7 m/s with frontal egress and 0,5 m/s with lateral egress, either in normal operating conditions, or when there is loss of power or other emergency cases;

— the carpet of a travelator shall withstand transverse forces arising from access and egress movements;

— the minimum width of a travelator shall not be less than 0,80 m.

6.1.5.1.2 Emergency access and egress

Appropriate means for the safe recovery of passengers who may become stranded away from the normal passenger unit loading area shall be provided. This provision should include arrangements for rescue personnel to gain safe access.

6.1.5.2 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 1,0 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 12.

Table 12 —Width of exit

Minimum clear width of exit	Additional clear width of exit	Suitable for
1,0 m	0 m	not more than 150 persons
1,0 m	1,0 m	per each 150 persons more

The number of persons is to be calculated with 2 persons per m^2 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 35 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 150 then two exits are required.

6.1.6 Risk reduction for passenger units

6.1.6.1 Safety distances from passenger units

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

6.1.6.1.2 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:

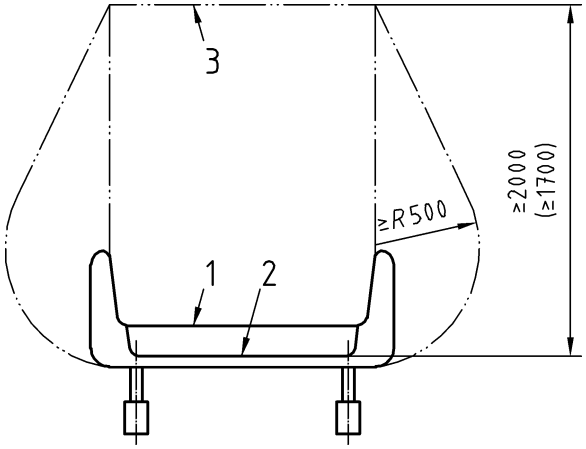
a) 0,50 m from the inside of the seat, 0,70 m if the relative speed is greater than 20 m/s (see Figures 17 and 18);

b) 2,00 m above the floor of the passenger units (see Figure 17);

c) 1,50 m above the seat if the passenger is positively restrained from standing up (see Figure 18);

d) 0,30 m from the inside part of the seat if the relative speed is less than 3,0 m/s and if there is no danger of entanglement.

Dimensions in millimetres



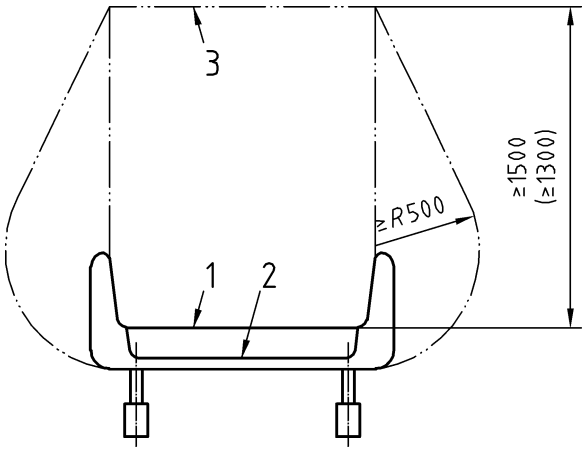
Key

1 Seat surface
2 Floor surface
3 Clearance envelope

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

Figure 17 — Vertical clearance from the floor and lateral clearance for passengers

Dimensions in millimetres



Key

1 Seat surface
2 Floor surface
3 Clearance envelope

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

Figure 18 — Vertical clearance from the seat and lateral clearance for passengers

6.1.6.1.3 If passenger units are free ranging and controlled by the passenger the distance in 6.1.6.1.2a) applies only to fixed objects.

6.1.6.1.4 Additionally, the following distance shall be maintained:

— 0,12 m from the outside of the unit to any other part at the seat's height of another unit in the most unfavourable operating condition (see Figure 19).

Dimensions in millimetres

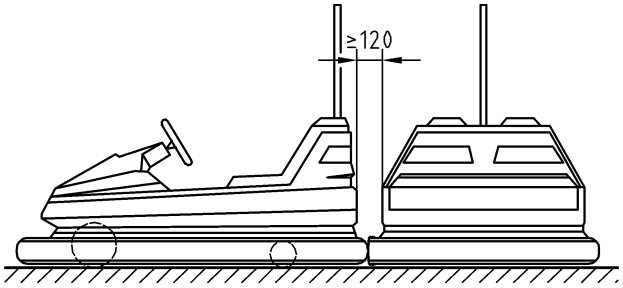
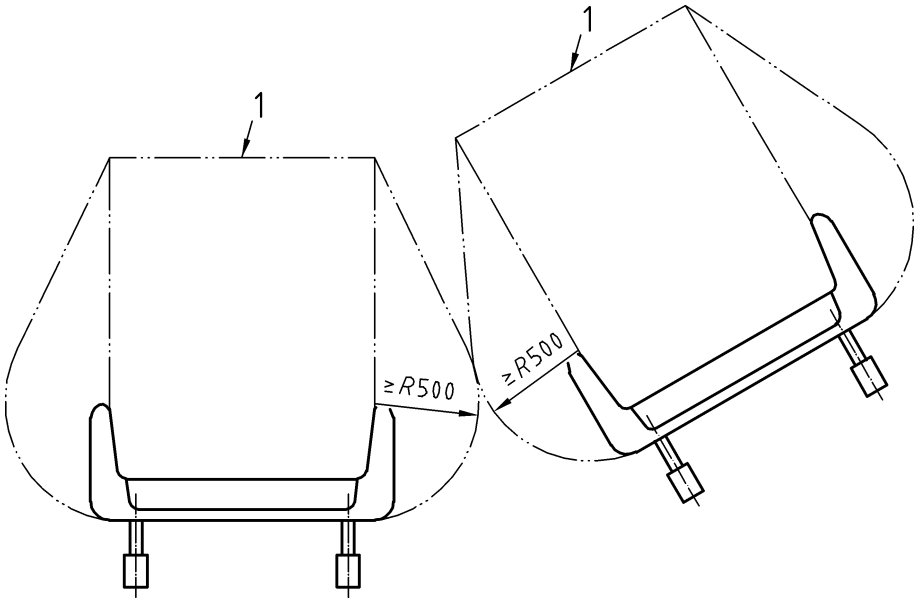


Figure 19 — Safety distance for free ranging vehicles

6.1.6.1.5 If the passenger units are not free ranging, the clearance envelopes shall not overlap (see Figure 20).



Key

1 Clearance envelope

Figure 20 — Relative position of clearance envelopes

6.1.6.1.6 All the distances previously listed may be reduced if special precautions such as cages or other means are provided for limiting passenger movements in the hazard direction.

6.1.6.1.7 The envelopes in Figures 17 to 20 do not guarantee that passengers will be unable to touch stationary or moving objects.

6.1.6.2 Restraint devices limiting passenger movement

6.1.6.2.1 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.

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 devices shall be designed in such a way as to prevent unlocking without a deliberate and intentional action. Even if provided with warning lights and/or acoustic warning they shall allow a visual verification of their correct closing.

Locking devices shall not lose their locking action in the case of malfunction or emergency stop of the ride unless there are immediate means of evacuating passengers.

6.1.6.2.2 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.

The design of a restraint shall minimise the following risks for passengers:

— hitting parts in relative motion or being trapped in between them;

— being injured by sudden movements;

— 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;

— falling out of or being ejected from the passenger unit.

The above mentioned risks can be exacerbated by intentional dangerous behaviour of passengers.

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 authorised personnel, when it is safe to do so.

6.1.6.2.3 Classification of passenger restraint devices

Minimum requirements for restraint devices are defined in the following classifications:

a) With reference to the number of passengers restrained by a single device, they can be:

A1) a collective device for two or more passengers;

A2) an individual device for each passenger.

b) With reference to their final locking position in relation to the passenger, they can have:

B1) an unadjustable locking position (bars, rails);

B2) an individually adjustable locking position.

B3) minimum closed position automatically controlled

c) With reference to the type of locking, they can be:

C1) without locking;

C2) manually locked by the passenger;

C3) manually locked by operators or attendants;

C4) automatically locked in the operating position;

C5) automatically locked in the operating position and with the locked position controlled.

d) With reference to the type of unlocking, they can be:

D1) manually unlocked by the passenger;

D2) manually unlocked by operators or attendants;

D3) unlocked by the operator or attendants by means of a centralised system.

e) With reference to warnings of correct/incorrect locking, the indications can be as follows:

E1) no warning at all;

E2) light and/or acoustic warning;

E3) light and/or acoustic warning and start inhibition or ride operation stop.

f) With reference to types of movements, they can be:

F1) manual;

F2) motorised.

g) With reference to the type of construction of the restraint device and its locking device:

G1) redundancy not obligatory;

G2) redundancy only concerning locking device (functional);

G3) redundancy (functional and constructional).

h) With reference to the securing type they can be:

H1) without restraint, but if necessary footrests, handholds, etc. are provided to counteract forces;

H2) one (e. g. hip or shoulder etc.) restraint for the passenger;

H3) one (individual or collective) restraint and a collective cage or containment enclosure for all passengers;

H4) two restraints providing redundancy (e. g. hip and shoulder) or one intrinsically redundant restraint.

Two restraint devices means independent restraints in the sense that the secondary device (e. g. lap bar, containment enclosure, etc.) is able to hold a passenger without being hurt (for one operating cycle), in case of failure of the primary one.

On the basis of the above classification, each passenger's restraint device can be determined according to the requirements in 6.1.6.2.4. For each category of ride, and for each group or single ride having the same particular features in the range of same category, the minimum requirements for each of the basic features of passenger restraints will be given.

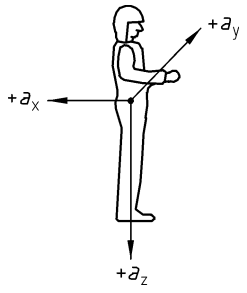
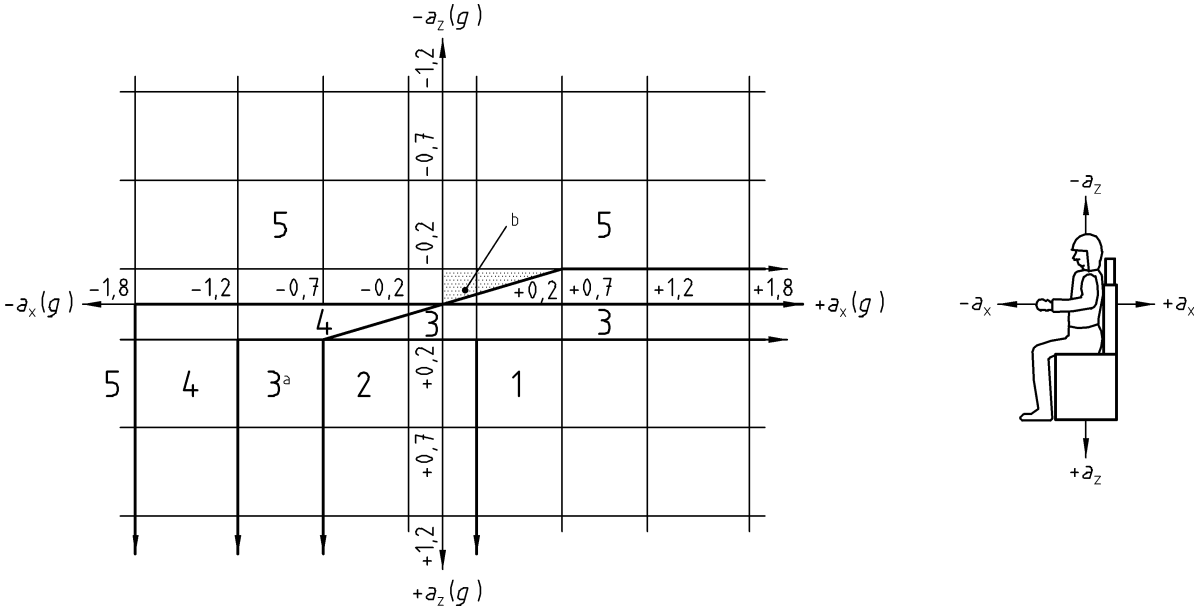


Figure 21 — Co-ordinate system of accelerations

6.1.6.2.4 Application criteria from restraint devices resulting from risk assessment

6.1.6.2.4.1 As a prevailing requirement for the following criteria, restraint devices shall be provided where passengers could be lifted and ejected from their seat or position by dynamic forces or inclination. When applying the following means of restraint in accordance with the criteria of Figure 22 for the acceleration directions shown in Figure 21, reasonable interpolation shall be made for the different analogous cases:



Key

a Footrests and handrails are required

b Area in category 4 if no lateral design forces and duration of a_z-acceleration less than 0,2 sec

At boundary cases the lower category may be chosen.

Figure 22 — Restraint diagram (accelerations in design stage)

Area 1: No restraint required due to the acting accelerations. (Other criteria can nevertheless require a restraint).

Area 2: Restraint of at least the following type required:

- A1 - collective device for two or more passengers
- B1 - unadjustable locking position (bars, rails)
- C2 - manually locked by passenger
- D1 - manually unlocked by passenger
- E1 - no warning at all
- F1 - manual
- G1 - redundancy not obligatory
- H1/H2 - one restraint, or no restraint required if passengers can react forces sufficiently using the handholds, footrests, etc. provided and if they cannot fall out of, or be ejected from, the compartment due to the acting forces

Area 3: Restraint of at least the following type required:

- A1 - collective device for two or more passengers
- B2 - individually adjustable locking position
- C3 - manually locked by the operator or attendants
- D1 - manually unlocked by passenger
- E1 - no warning at all
- F1 - manual
- G2 - redundant only concerning locking device (functional)
- H2 - one restraint for each passenger

Area 4: Restraint of at least the following type required:

- A2 – individual device for each passenger
- B2 – individual adjustable locking position
- C4 – automatically locked in the operating position
- D2 – manually unlocked by operators or attendants
- E1 – no warning at all
- F1 – manual
- G2 – redundant only concerning locking device (functional)
- H2 – one restraint for the passenger

Area 5: Restraint of at least the following type required:

- A2 – individual device for each passenger
- B3 – minimum closed position automatically controlled
- C5 – automatically locked in the operating positions and locked position controlled
- D3 – unlocked by operator or attendants by means of a centralised system.
- E3 – light and/or acoustic warning and start inhibition
- F1 – manual
- G3 – redundant (functional and construction)
- H3/H4 – two redundant restraints or one intrinsically redundant restraint

The application of Figure 22 (restraint rose) 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). In Figure 22 no information on the absolute acceleration limits is given (see also Annex G).

Other hazards (see also 6.1.2) may require a different class of restraint to be used.

6.1.6.2.4.2 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:

— A1 collective;

— B1 unadjustable;

— C2 manually locked by the passenger;

— D2 manually unlocked by operators or attendants;

— E1 no warning at all;

— G2 redundancy only concerning locking device (functional)

or this secondary device may be the containment enclosure or collective cage according to H3.

6.1.6.3 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. The openings shall be locked by devices which prevent unintentional opening during a ride (e. g. safety hooks). In general doors shall be fitted with locking devices which 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.

6.1.6.4 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 old. The passenger shall have in all cases, a sufficient hold on 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.

6.1.6.5 Passenger containment

Guidance on passenger containment can be found in Annex E.

6.1.7 Risk reduction by special provisions

6.1.7.1 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 approx. 2 and 4 years;

L1) children between 105 cm and 120 cm of height corresponding to approx. 4 and 6 years;

L2) children between 120 cm and 130 cm of height corresponding to approx. 6 and 8 years;

L3) children between 130 cm and 140 cm of height corresponding to approx. 8 and 10 years;

L4) children between 140 cm and 160 cm of height corresponding to approx. 10 and 14 years;

L5) adults.

6.1.7.2 Passengers with disabilities

Amusement devices designed for use with disabled persons shall provide means for their containment and the restraint devices limiting their movements, when provided on the ride, shall meet the minimum requirements A1, B1, C3, D2 as defined in 6.1.6.2.3 in order to ensure their physical safety.

6.1.7.3 Wind measuring devices

Where there are unacceptable risks associated with the operation of an amusement 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.

6.2 Supplementary safety requirements for various types of amusement device

6.2.1 Round-abouts with horizontal and/or vertical movements

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 23 to 26).

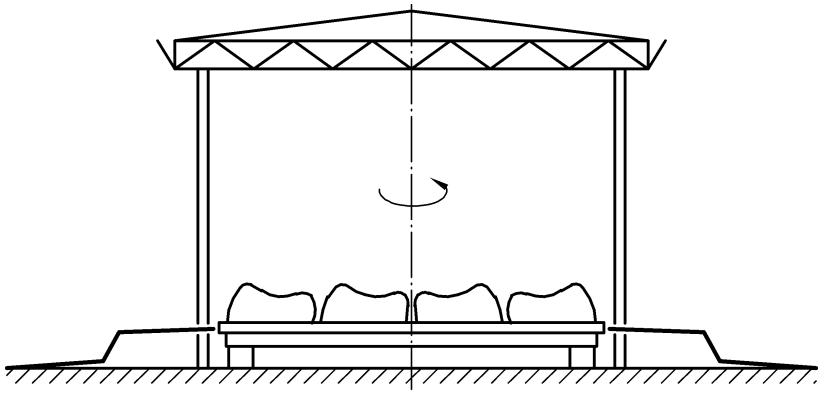


Figure 23 — Vertical axes, one degree of freedom

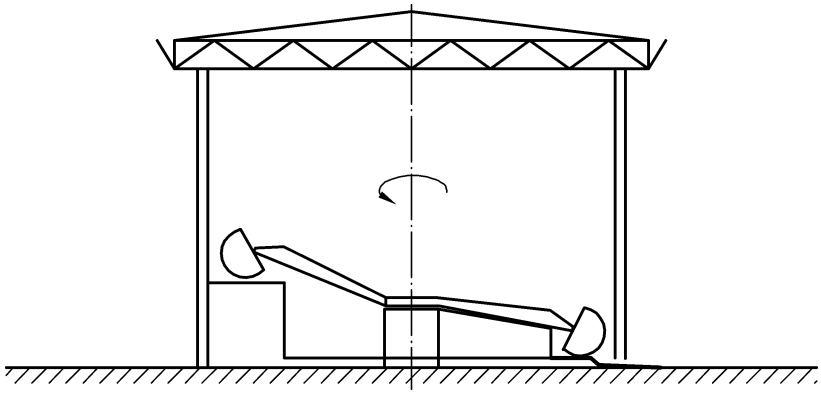


Figure 24 — Vertical and horizontal axes, more than one degree of freedom

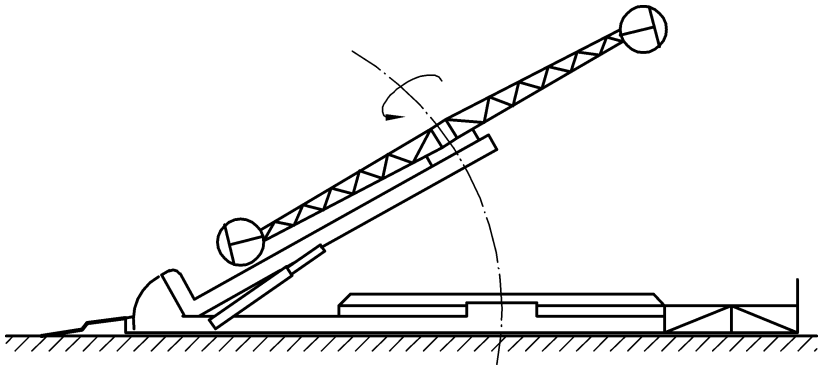


Figure 25 — Variable inclined more than one degree of freedom

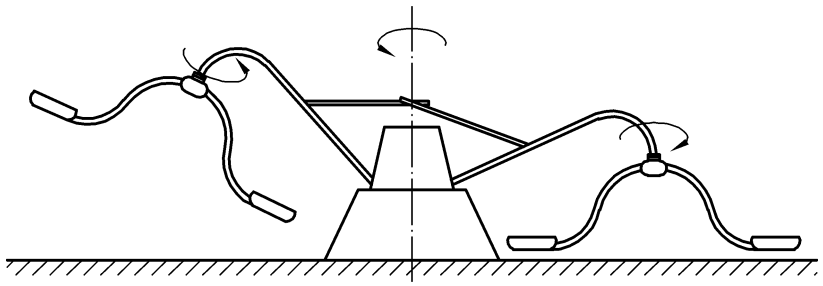


Figure 26 — Variable inclined axis

6.2.1.1 Area delimitation systems and access and egress openings

If in addition to horizontal vertical movements or another rotation (around a further axis) are also possible, the amusement device has to be provided with a perimeter fence for the general public in accordance with J3 (see 6.1.4.3) requirements. 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 delimitation system complying, as a minimum with I1 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.

Amusement devices featured with 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 delimitation system is required. If the velocity exceeds the mentioned above, the area delimitation system shall comply with I1 requirements.

If the amusement device consists of a round platform, but is provided with protruding parts or isolated passenger units, and the velocity is within the limits specified above clause, the area delimitation 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. The area with less than 2,7 m of vertical clearance shall be delimited according toJ1 requirements. If the maximum height of the seat is less than 2,7 m an area delimitation system according to J3 requirements, positioned at 0,5 m horizontal clearance from the seat 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.

6.2.1.2 Passenger units

Toy rides (circular rotating) for children 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 locking 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.

6.2.1.3 Restraints

Restraints for amusement devices of this category with rotation speed of more than 8 rpm. and a velocity exceeding v = 3 m/s, shall have the following characteristics as a minimum:

— A1 collective;

— B2 adjustable;

— C2 manually locked by passengers;

— D2 manually unlocked by operators or attendants;

— E1 without warning;

— G1 redundancy not obligatory.

Restraints for amusement devices of this category for children only shall have at least the following characteristics:

— A1 collective;

— B2 adjustable;

— C3 manually locked by operators or attendants;

— D2 manually unlocked by operators or attendants;

— E1 no warning at all;

— G1 redundancy not obligatory.

6.2.2 Giant wheels, swings (with and without motor drives)

Devices moving only around one main horizontal axis: (with or without mechanical drive)

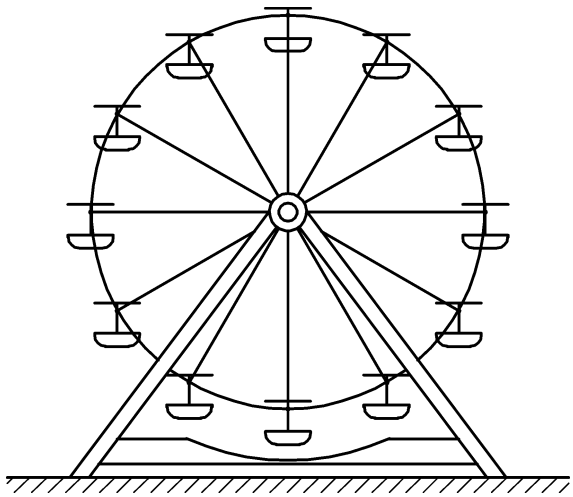


Figure 27 — Main horizontal axes. Gondolas fixed or rotating

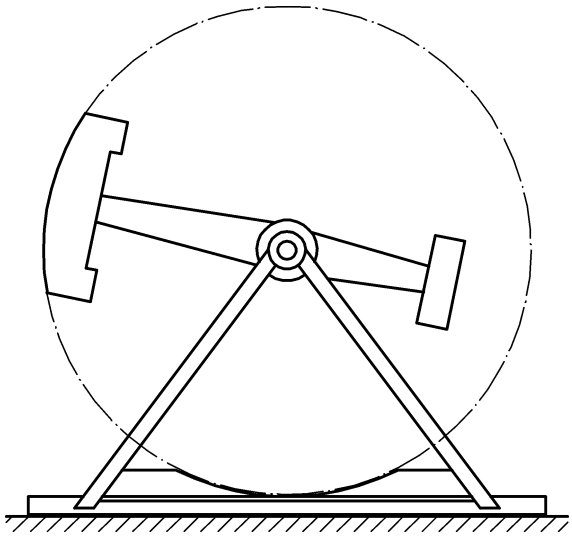


Figure 28 — Horizontal axis boat rigidly connected to boom (with mech. drive)

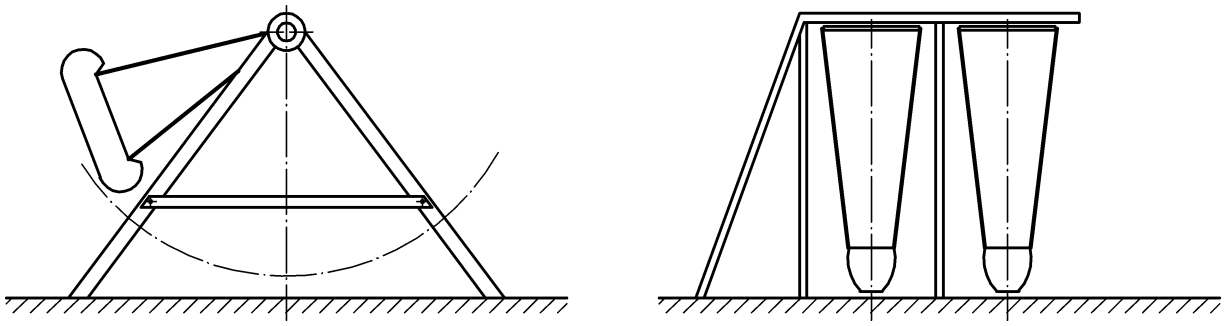


Figure 29 — One horizontal axis without mechanical drive

6.2.2.1 Area delimitation systems and access and egress openings

General

Area delimitation systems for the general public shall comply in general with J3 requirements. Openings shall comply with K2 requirements and be able to be physically close off (e. g. by chained gates) the entrance to the ride during operation.

Area delimitation systems for non powered swings shall comply with J3 requirements, but the type of fence can be as follows:

— a hand rail 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 6.1.6.1. Inside the fence, there should be sufficient room for the operator. Space between parallel swings, shall be protected by a fence.

6.2.2.2 Passenger units

Gondolas of swing boats shall have handrails not less than 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, 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 6.1.6.1.2 d) 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 m, and of 1,1 m if the gondolas are more than 12 m

above the ground. For giant wheels for children up to 8 years of age (130 cm) of less than 6 m falling height, 0,7 m is sufficient.

6.2.2.3 Restraints

Containment belts, foot restraint straps or equivalent means shall be provided in non powered gondolas where passengers, during rotation, travel up side down. For power operated gondolas where passengers will travel temporarily up side down during rotation and where the vertical (head to foot) acceleration is less than 0,2 g, redundant restraint devices shall be provided according to H3.

6.2.2.4 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.

6.2.3 Roller coasters, flume rides, dark rides, railways and other rail-guided channel or trackbound devices

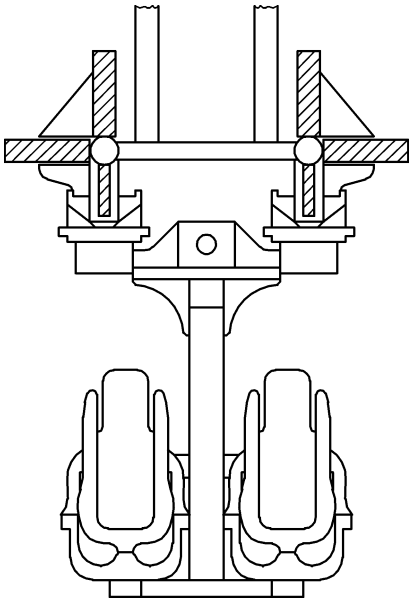


Figure 30a

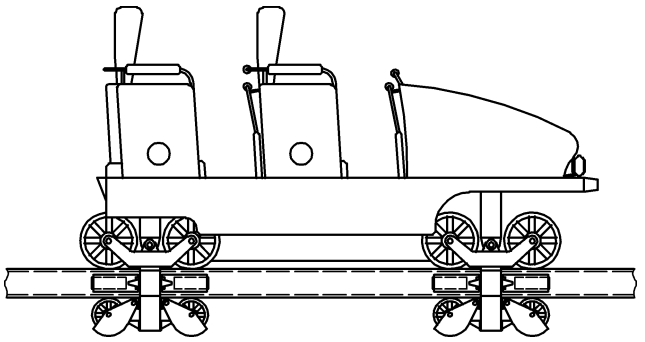


Figure 30b

Figure 30 — Track guided devices

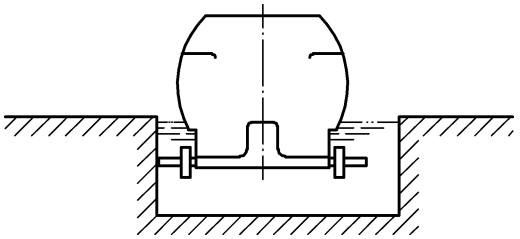


Figure 31 — Trough or channel guided devices

6.2.3.1 Area delimitation systems and access and egress openings

Area delimitation systems for the general public shall comply with J3 requirements.

Access openings to the loading zones shall comply with K3 requirements, 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 delimitation system complying with J3 requirements. Access and egress openings shall comply with K1 requirements.

Miniature railways do not require an area delimitation system in amusement parks under the following conditions:

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 delimitation system shall comply with J3 requirements.

6.2.3.2 Passenger units

The cars shall be designed in such a way that:

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

b) 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;

c) 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 be spring-mounted for shock absorbing purposes, 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.

6.2.3.3 Restraints

Restraints shall be fitted where necessary in accordance with 6.1.6.2.4.1 passenger units.

6.2.3.4 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 upstop wheel, the car or train does not go off the rails. Wheel tyres, guide wheels, upstop wheels are subject to wear. The permissible wear rates shall be specified by precise limits.

Lateral movement of cars and gondolas shall be restricted to prevent collision with cars or gondolas on adjacent tracks or fixed objects. Safety distances 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 5.4.4.2).

6.2.3.5 Rail

6.2.3.5.1 Block zone systems

If several cars or trains are in operation on the system at the same time, an automatic fail-safe control system separating cars or trains shall be fitted in order to prevent collision between them. See Annex D for further information on control systems.

The system shall be based on the complete control of the track being divided into block zones, none of which can be occupied by more than one car or train at the same time. Block zones shall be separated from each other, by safety brakes.

The lift may be considered as a block zone which does not need a safety brake at its end, if the car or train on it can be safely stopped before entering the following block zone.

Block zone systems need not be fail safe in unloading and loading zones, if the maximum speed of the car or train in such zones, does not exceed 1,0 m/s and the cars or trains are provided with adequate bumpers.

6.2.3.5.2 Safety devices along the track, brakes

The cars shall be braked at the end of the descent by stopping brakes after each run. In the event of delays during passenger loading, any risk of collision by following cars shall be prevented with certainty by appropriate means.

Safety brakes in the downhill stretch shall be arranged for the planned minimum distance between successive cars or trains in such a way that there will always be one brake between any two cars / trains.

Safety brakes shall be fail-safe and designed to stop the car or train in the most favourable conditions.

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 5.4.3.4).

Consequently the brakes shall not lock or jam and shall be applied in a controlled and progressive manner. Two different kinds of brake may be considered:

a) brakes operated (closed) by springs or similar devices and released (opened) by means of pneumatic or similar devices;

b) brakes operated by means of pneumatic or similar devices and released by springs or similar devices.

The first kind of brake mentioned under a) may be assumed, under certain further conditions, to be fail-safe.

The use of non fail-safe brakes which are mentioned under b) may be allowed as safety brakes under the following conditions:

1) a suitable redundancy of independent brake units is provided for the most unfavourable condition and the brake remains operable for at least three further brake stops after a pressure drop in the brake system;

2) the mechanical parts of the brake units are designed and calculated with the appropriate safety factors stipulated in 5.3;

3) all functions and operational states of the brake system are controlled and monitored by a fail-safe control system;

4) operating fluid pressure is kept automatically controlled by the main supply and in each brake unit a pressure drop indicates a case of emergency for the whole system.

6.2.4 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.).

6.2.4.1 Dodgem cars

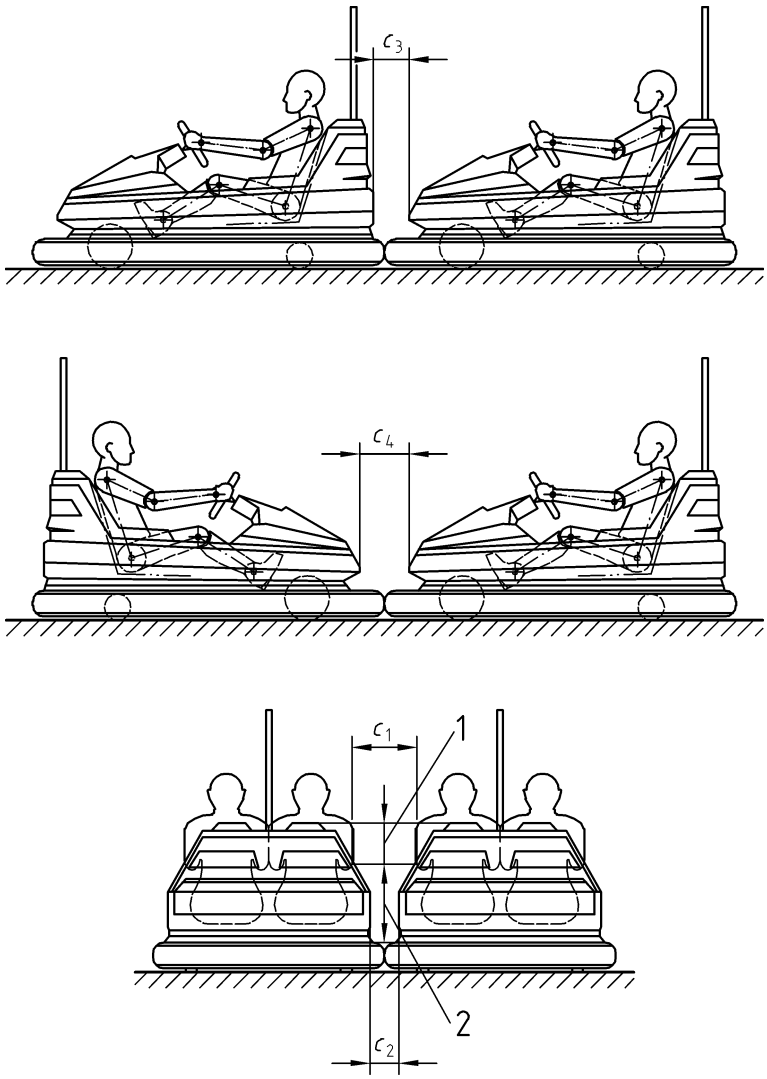
6.2.4.1.1 General

For bumper cars the following minimum safety distances shall be provided:

Table 13 — Safety distances for dodgem cars

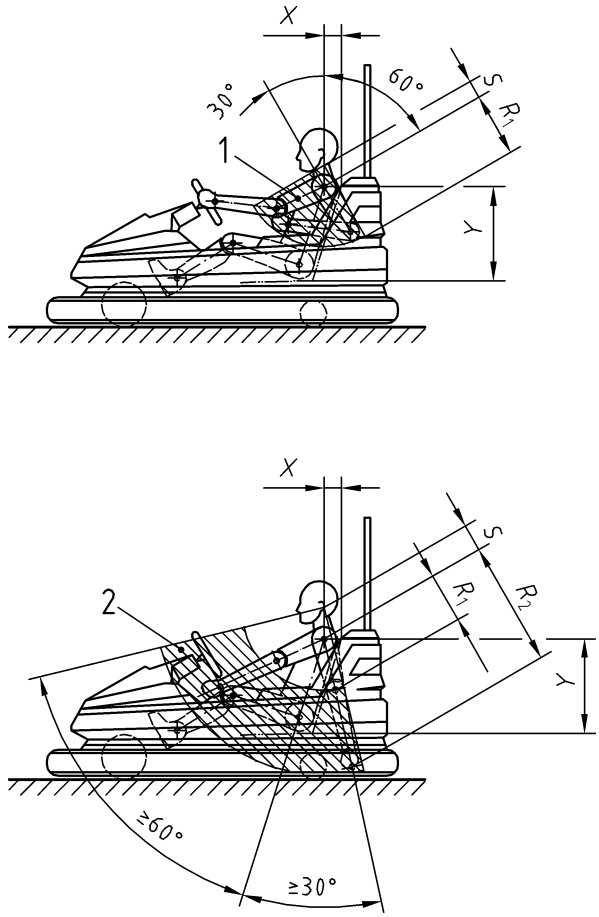
Classes defined by passenger height or age		X	Y	S	R 1	R 2	C 1[a]	C 2[a]	C 3[a]	C 4[a]
Passengers from 4 to 8 years	min.	70	320	25	175	400	70	45	90	100
	max.	85	400	30	230	515				
Passengers from 8 to 12 years	min.	85	400	30	230	515	85	60	120	150
	max.	100	435	35	275	620				
Passengers (and accompanied children)	min.	100	435	35	275	620	100	85	140	200
	max.	120	550	50	310	725				

[a] C 1, C 2, C 3 and C 4 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

Figure 32 a — Dodgem car



Key

1 Zone 1

2 Zone 2

Figure 32 b — Dodgem car

6.2.4.1.2 Area delimitation system and access and egress openings

Area delimitation system for the general public to the driving area shall comply with I1 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.

6.2.4.1.3 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 shown in 6.2.4.1.1. 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;

b) so protected as to minimise injury by impact.

6.2.4.1.4 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.

Speedway cars shall be fitted with adequate safety belts.

6.2.4.1.5 Miscellaneous

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

Dodgem cars shall be designed in such a way as to minimise 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 4 km/h.

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 5.3.3.1.2.1) operating on the same track shall not exceed 30 %.

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

6.2.4.1.6 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 a.c. or 60 V ripple free (max. 10 % ripple) d.c. supplied by a safety isolating transformer in accordance with EN 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 a.c. or 120 V ripple free d.c., i.e. a maximum of 10 % ripple supplied by a safety isolating transformer in accordance with EN 61558-1 or an equivalent a.c. or d.c. 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 minimised paying particular attention to the eyes as a result of particles and sparks.

The following measures shall be taken.

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 width of the mesh shall not exceed 40 mm.

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

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

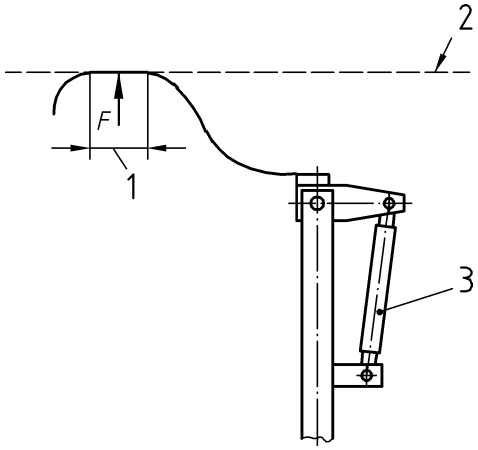
Steel wires shall be galvanised before being joined by wire wrapping. The current supply net shall be fixed at a uniform distance of not less than 2,5 m above the floor pan of the vehicle.

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 (see Figure 34).

The current collector (see Figure 33) 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 Z on the supply net of at least 10 N. Steel or other suitable alternative materials (e. g. copper, brass, aluminium) may be used.

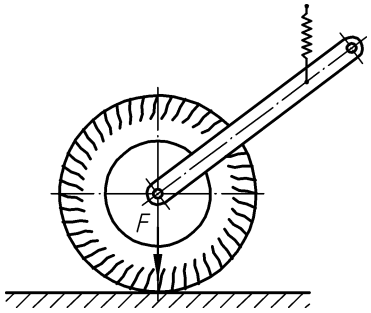
The connections shall be equally spaced around the perimeter of the net or plate.



Key

1 Contact area
2 Net
3 Spring
F Contact force

Figure 33 — Example of a typical net current collector



Key

F Contact force

Figure 34 — Contact force of a floor contact brush

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.

6.2.4.2 Speedways/Go-Karts

NOTE These requirements are specific for amusement parks and fairground go-karts. However they could be used also to assess the conformity of the go-karts falling in the scope of the Machinery Directive 98/37/CE.

6.2.4.2.1 Area delimitation 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 1,0 m above the floor level accessible to the public (area delimitation system complying with I3 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.

6.2.4.2.2 Passenger units

The speedway track and cars shall be designed in such a way as to minimise 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.

6.2.4.2.3 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:

A 2 individual;

B 2 adjustable;

C 2 manually locked by passengers;

D 1 manually unlocked by passengers;

E 1 no warning;

F 1 manual;

G 1 redundancy not obligatory

6.2.4.2.4 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 4 km/h.

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. European 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.

6.2.4.3 Mini-motorbikes for children

6.2.4.3.1 Area delimitation system and access and egress openings

To prevent the general public from walking onto the track, the area delimitation 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. The sill shall be strong enough to withstand the impact of the cars at maximum speed.

6.2.4.3.2 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.

The saddle shall be provided with an upholstered backrest and a suitable cage, or equivalent. An integrated footrest, shall be provided to protect passengers' legs against impact and to prevent passengers from falling.

6.2.4.3.3 Restraints

No special requirements.

6.2.4.3.4 Miscellaneous

The speed of mini-motorbikes shall not exceed 3,5 km/h.

6.2.4.4 Boat rides

6.2.4.4.1 General

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

6.2.4.4.2 Area delimitation system and access and egress

On the sides of the waterway there shall be an access area at least 0,5 m wide.

The landing position shall be clearly marked and shall provide safe and easy access to and egress from the boats.

6.2.4.4.3 Passenger units

See general requirements in Clause 6.1.6.

6.2.4.4.4 Restraints

See general requirements in 6.1.6.2.

6.2.4.4.5 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 permitted speed shall not exceed 8 km/h.

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 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 more than 8 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.

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

6.2.4.5 Flume rides

6.2.4.5.1 Area delimitation 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. In the station area the distance between the wall of the boat and access- respectively egress-platform shall be reduced to approximately 0,05 m. Special consideration shall be given to the change of clearance.

Dimensions in millimetres

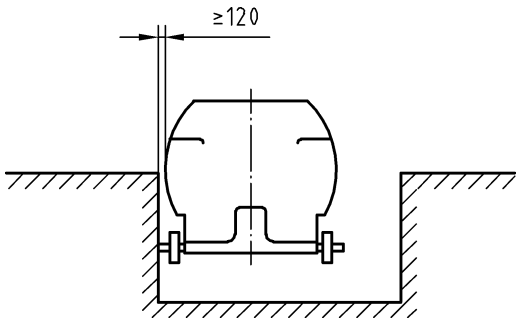


Figure 35 — Minimum distance to channel walls

6.2.4.5.2 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 deceleration.

Upholstering shapes should be provided, in order to prevent damage to passengers seated in the front, if they can be propelled against the front panel.

The gunwhale to the seat height is shown in Figure 36.

See also general requirements in 6.1.7.

Dimensions in millimetres

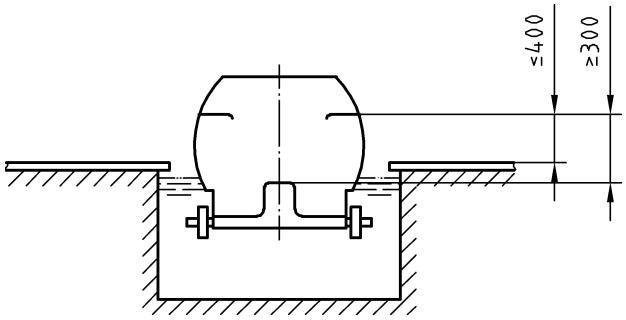


Figure 36 — Minimum and maximum step height and side wall height

6.2.4.5.3 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 head-to-foot acceleration is more than +0,2 g in all places. The "restraint rose" (see Figure 22) need not be applied to in this case.

6.2.4.5.4 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, and 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.

For general requirements on block-zone systems see also 6.2.3.5.1 and 6.2.3.5.2. For block-zone control systems see Annex D.

6.2.4.6 Helter skelters, slides, etc.

6.2.4.6.1 General

The requirements below, in addition to or in place of those contained in the European Standards for playground equipment EN 1176 (all parts), shall be recognised. Slides with a height greater than that mentioned in EN 1176-3 are not excluded from being used as amusement devices.

6.2.4.6.2 Area delimitation system and access and egress openings

In areas where passengers can walk onto the slide area or run out zones area delimitation systems for the general public shall comply with I3 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.

6.2.4.6.3 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 splitters and burns.

6.2.4.6.4 Restraints

No special requirements.

6.2.4.6.5 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 files) shall not be less than 10 cm.

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

6.2.5.1 Fun houses, hall of mirrors

6.2.5.1.1 Fun houses

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

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

Smooth and splinter free surfaces (sanded where necessary if wooden) shall be provided to minimise 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 protected.

Neither 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, minimum dimensions can be found in the European Standard for playground equipment (EN 1176-1)).

All power driven parts of a device should 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 minimised, 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 down 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 delimitation) preventing access to their extreme points of travel. 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.

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.

Consideration shall be given to risks of suffocation, particularly of small children who may have become lodged between elements of an inflatable bouncing device e. g. edge of floor and sidewall.

Ball ponds and similar devices where a child could be "buried" need consideration so as to avoid injury. Vigilant supervision shall be provided.

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 Fun House environment is an adequate alert supervision. Supervisors shall take immediate action to avoid injury e. g. by stopping a device. He shall control unruly 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.

6.2.5.1.2 Hall of mirrors

No steps are permitted in halls of mirrors.

Glass panels shall be made of safety glass.

Neither protruding items nor pinch points are allowed. Wherever possible smooth surfaces shall be provided. For further analogous requirements see also 6.2.5.1.1.

6.2.5.2 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.

6.2.5.3 The hammer, ring the bell and similar installations

The installation shall be securely anchored to the ground (see 5.5).

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 6.1.4.2.2 (general safety distances). In addition spectators shall be kept at a distance of at least 3 m from the anvil, to avoid danger from the swing of the hammer.

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

6.2.6 Temporary grandstands, maneges, etc.

6.2.6.1 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 5.5).

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.

6.2.6.2 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 6.1.5.2, the admissible number of persons shall be based on the number of seats (e. g. on grandstands).

6.2.7 Shooting stands and trailers, shooting devices

6.2.7.1 Area delimitation 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 delimitation 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°.

6.2.7.2 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.

6.2.7.3 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.

— 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.

6.2.7.4 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.

6.2.7.5 Targets

Where camera covers and flash bulbs are used in "photoshooting" 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.

6.3 Mechanical systems

6.3.1 Hydraulic and pneumatic devices

6.3.1.1 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 take the intrinsically safe position. A first failure of the system shall be detectable. In this case a subsequent failure need not to be considered (see also EN 982 and EN 983).

NOTE The first failure does not lead to a dangerous situation and is detected.

6.3.1.2 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.

6.3.1.3 Travelling limits

Effective means shall be provided to prevent rams from travelling beyond the limits of the cylinder.

6.3.1.4 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.

Mounting of the piping shall be performed in such a way as to allow inspection along the whole of its length.

6.3.1.5 Hoses

Pressure hoses shall be able to withstand five times the maximum permissible working 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.

6.3.1.6 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.

6.3.1.7 Venting

The hydraulic circuits shall be fitted with a purging system to permit the release of air.

6.3.1.8 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 stability of the cylinders shall be calculated using 1,4 times the working load. There shall be a fatigue calculation for cylinders.

6.3.1.9 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.

6.3.1.10 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.

6.3.1.11 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 are installed to prevent undue shocks to passengers.

6.3.1.12 Protection

All valves shall be protected against unauthorised resetting.

6.3.1.13 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.

6.3.1.14 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 used.

6.3.2 Lifting and elevating units being integral part of an amusement ride

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

6.3.2.1 Hoist units

6.3.2.1.1 Hoist unit brake

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.

Brakes shall be applied automatically when the power supply is interrupted in any way.

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

6.3.2.1.2 Limitation of the lifting and lowering movement

To guard against malfunction of the control system, devices according to EN 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.

6.3.2.1.3 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.

6.3.2.1.4 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 lifting at creep speed.

6.3.2.1.5 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 safety system.

The safety gear shall operate, by means of an overspeed 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 overspeed governor rope or chain, shall interrupt power to the hoist unit.

For hoist units using power screws, rack and pinion drives or directly acting hydraulic drives equivalent safety means shall be provided.

6.3.2.1.6 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 safety factor against the minimum discard period of a minimum of one year is achieved, the safety factor of the above sentence need not be observed. The application of this method requires visual and non destructive inspections as determined by the life calculation.

All ropes or chains of one lifting unit shall be of the same size, quality and construction.

The tensile strength of the wires of suspension ropes shall not be less than that of a nominal strength category of 1 570 N/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 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 $v \leq$ 1m/s and a lift height less than 2 m;

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

In category A an 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 a ratio (D / d) of not less than 30 shall be observed.

Means shall be provided to equalise 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.

6.3.2.1.7 Hydraulic drives

For these types of elevating units see also 6.3.1 (hydraulic and pneumatic devices). 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.

6.3.2.1.8 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 5.6.

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. 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.

6.3.2.1.9 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 5.6.

Any driving or safety pinion shall always be engaged with the rack with at least 2/3 of the tooth width and 1/3 of the tooth depth.

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

6.4 Manufacture and supply

6.4.1 General

The manufacturer shall ensure that all requirements within the design specification are fully incorporated into the completed amusement device, and the quality of the construction meets the design specification. In final approval, this shall be confirmed by a notified body.

6.4.2 Manufacture

6.4.2.1 Personnel

The manufacturer shall ensure that persons engaged in the construction of the amusement devices are competent to carry out the work, and that welders are suitably qualified and accepted according to EN 287-1 (steel) or EN 287-2 (aluminium). Any assembling, modification, adjustment or alteration of parts shall only be done by persons with appropriate experience.

6.4.2.2 Subcontracting and supply

Any safety related materials, parts, assemblies, or components shall be made in accordance with the design specification and quality requirements of appropriate European Standards or national equivalents, where applicable. Such parts shall be clearly marked by manufacturers, subcontractors and suppliers to ensure that they can be identified. Material certificates or component specifications shall be provided by manufacturers and suppliers for final approval.

6.4.2.3 Quality assurance – Quality plan

6.4.2.3.1 General

Only suitably qualified 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 (see also 6.5.2 and 5.4) indicates that certain parts are safety critical and has specified certain tests, the manufacturer shall ensure that appropriate preparations for initial approval tests are provided. 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.

6.4.2.3.2 Quality requirements

As minimum requirements the following standards shall be applied for the different quality assurance processes:

— EN 10160, Ultrasonic testing of steel flat product of thickness equal to 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, Metallic products – Types of inspection documents.

6.4.2.3.3 Certificates

Material or component certification according to EN 10204 shall be submitted for at least the following items:

— steel for load bearing members;

— standard mechanical components, if there is no agreed or general method of calculation.

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 EN 286-1. Any further requirements in European Standards, or in their absence, in equivalent national standards and regulations, shall be respected.

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

6.4.2.4 Manufacturing process

6.4.2.4.1 General

Manufacturers shall not deviate from the requirements laid down by the designer or the independent inspection body. 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 or the independent inspection body.

6.4.2.4.2 Durability

The designer shall specify the method of protection or frequency of inspection. All components shall be protected against degradation caused by corrosion or rot by an approved method. (For steel see EN ISO 12944 all parts) Where hollow section structural steel is used, internal corrosion is to be avoided.

6.4.2.4.3 Welding

6.4.2.4.3.1 General

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

6.4.2.4.3.2 Steel

Welding procedures shall be in conformance with EN 288 (all parts), EN 729-2 and EN 729-3 and welders shall be approved in accordance with EN 287-1.

Welding for amusement devices especially under fatigue conditions shall only be conducted by manufacturers who are in possession of welding qualifications for fatigue loaded parts according to EN 287 (all parts), EN 288 (all parts) and EN 719, EN 729-2, EN 729-3, EWF 1173, and the additional qualification according to this document (extension of permission for amusement rides for dynamically loaded parts).

Welds subjected to fluctuating stresses, i. e. fatigue conditions, shall be to Quality Category "B" EN ISO 5817. Special investigation and approval shall be done where a change in welding procedure may affect stress and fatigue properties.

6.4.2.4.3.3 Aluminium

Welding procedures shall be in conformance with EN 288 (all parts) and welders shall be approved in accordance with EN 287-2.

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 EN 287 (all parts), EN 288 (all parts), EN 719, EN 729-2, EWF 1173 and the additional qualification according to this document (Extension of permission for amusement rides). Welds subjected to fluctuating stresses, i. e. fatigue conditions, shall be to Quality Category "B" EN 30042 Special investigation and approval shall be conducted where a change in welding procedure may affect stress and fatigue properties.

6.4.2.4.4 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 necessary quality.

In all cases adequate information on the particular plastics, additives and reinforcement which are specified in the design and are to be used in manufacture shall be obtained from the supplier by material certificates or from test results. The manufacturing process shall be adequately specified and controlled to ensure consistency of properties in the finished article. A permanent record shall be kept of all the essential data concerning the production of load bearing composites, such as:

— material of reinforcement, fibres, additives, resins;

— temperature, humidity, environmental conditions;

— type of manufacturing process, number of layers, type of fibres etc;

— composite samples of each different construction provided for tests.

6.4.2.5 Safety precautions to be taken by the manufacturer

6.4.2.5.1 General

The manufacturer of amusement devices shall include all the safeguarding arrangements such as guards necessary for dangerous parts of the machinery, including power units and transmission machinery.

The operator's position shall be arranged so as to ensure easy and safe control of the ride.

The manufacturer shall take into account the need of the operator to have a clear and unobstructed view of all areas of operation. The operator's position shall be provided with safe and easy means of access. The operator's position shall be adequately illuminated.

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

All parts of the amusement device which require maintenance and/or inspection, shall be provided with safe and easy means of access and a safe working position for maintenance staff.

NOTE 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 need to be made to evaluate the detailed technical precautions and solutions. Please refer to 6.1.2 and Annex I for more details about risk assessment and EN 1050 for methods. EN 14122, EN ISO 12100, EN 294 and/or other applicable standards may be taken into consideration within the risk assessment, when possible.

6.4.2.5.2 Electrical installations

The electrical installation and components shall be in accordance with CENELEC standards and the annex of this document.

6.4.3 Supply

6.4.3.1 Manuals

6.4.3.1.1 General

Comprehensive instructions concerning assembly, operation and maintenance shall be provided by the manufacturer. Special advice or details of special qualifications for personnel shall be given. These instructions shall be written in the language of the user. These instructions shall be added to the log book. If the device is resold, the manual shall be available in the language of the new user. The manual shall provide, as a minimum, the instructions stated hereafter.

6.4.3.1.2 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 amusement 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 screws or bolts, critical to the safety of the structure;

— schedules of tests and inspection to ensure correct functioning;

— earthing details for lightning protection;

— 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.

6.4.3.1.3 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.

6.4.3.1.4 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;

— a list of those components which require regular inspection, the recommended frequency of inspection (preferably expressed in service hours), and the method of inspection e. g. visual, NDT. Safety critical limited lifetime components shall be specifically addressed;

— a list of any specific tests to be carried out;

— recommendations concerning electrical testing. They should include 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 European Standards.

6.4.3.1.5 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 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 qualified personnel, and the necessary details.

6.4.3.1.6 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 standardised symbols.

6.5 Initial approval, examination and acceptance – Recommended procedures

6.5.1 General

Where due to national requirements initial approvals, examination and tests need to be carried out, the following procedures should be applied:

A clear distinction with no economic interdependence (independent inspection body in accordance with EN 45004) shall be made between designers, engineers, static calculation engineers, and the inspection bodies. As a general rule all safety relevant design documents as well as the completed amusement device shall be subjected to review and inspection. The relevant certificate can only be granted after a successful examination. The results of the various examinations shall become an integral part of the log book.

A: Pre-delivery approval procedure

A1 Acceptability of design

A2 Verification of design and calculations

A3 Manufactured product verification of material conformity

— manufacturer's procedures in conformity

— manufactured assemblies in conformity

A4 Approval test

Inspection body issues or refuses confirmation of approval

B: Periodic examinations

B1 Independent thorough examination

B2 Daily check

C: Examination after modification, repair and accidents, see different steps of A.

For further details concerning the different stages see Clause 7 "Operation of Rides and Structures".

6.5.2 Initial approval of amusement devices

6.5.2.1 General

The initial approval of amusement devices shall comprise:

— design review (see 6.5.2.2);

— inspection of manufacturing process (see 6.5.2.3);

— initial examination (see 6.5.2.4).

6.5.2.2 Review of design documents

6.5.2.2.1 General

The design documents shall be reviewed, checked and accepted for:

— completeness;

— correctness of all details of calculation;

— correctness of all the assumptions with respect to the input values for the static analysis;

— consistency with the present and any other applicable standards, guidelines specifications and the approved state of the art.

For the review of stress and fatigue analysis which were performed by computer see 5.4.1.

The design documents covering:

— hydraulic/pneumatic equipment;

— electric/electronic equipment including software;

— mechanical/structural equipment

shall be reviewed and accepted.

As a minimum the technical documents shall comprise the items mentioned in 5.1 of this document. For verification in initial approval the documents submitted shall at a minimum give evidence of the particulars mentioned hereinafter:

6.5.2.2.2 Description of installation and operation procedures

— It shall give information concerning the installation and operation of the amusement device.

— It shall also describe the stages of complicated installation and operation processes.

— It shall indicate the type of amusement 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 is to 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 kind and method of safety measures to prevent indirect and/or accidental contacts.

The safety devices, which are or become effective in exceptional situations (e. g. emergency illumination or measures which allow the safe stopping of every movement of the equipment in case of failure of the drive) and means of fire protection, shall be sufficiently clearly indicated or described.

6.5.2.2.3 Drawings

Constructional drawings shall depict all structural components and subassemblies whose breakage or failure could endanger the load bearing capacity, the stability as well as the safe operation of the equipment. The drawings shall contain all the necessary indications to allow the examination and acceptance, i. e. dimensions, cross-sections, indication of materials specification, structural parts and connecting means, speeds and accelerations. The drawings shall be of the following types:

— General drawings in horizontal projection, vertical plan and sectional drawings, in a scale, where all the necessary details can clearly be seen. The clearance required for the moving parts is to be indicated.

— Detailed drawings for all structural components which cannot be clearly recognized in the general drawing, for the connections and for all structural, mechanical or electrical details, which are relevant for the safe operating of the device, in a larger scale.

6.5.2.2.4 Analysis

Stress and fatigue analysis of all essential and safety critical components shall be available and shall comprise, as a minimum, analysis and calculation of the following main items:

— structural and mechanical parts;

— hydraulic and pneumatic parts;

— drive units, bearings;

— brakes and safety devices.

6.5.2.3 Inspection of manufacturing process

6.5.2.3.1 Description

The inspection for the hereafter stated manufacturing requirements shall be made during the manufacturing process. As a general requirement, the compliance of the parts, assemblies, components as well as their assembly and combined effects within the entire installation with the approved design documents shall be confirmed. This shall be covered by a report, which in a responsible manner confirms correctness and suitability of the employed materials and correctness of assembly.

6.5.2.3.2 Inspection requirements

Inspection shall as a minimum verify:

a) conformity of the main dimensions, clearance distances and dimensions, free (easy) running of moving parts;

b) existence of all constructional components indicated in the construction documents;

c) compliance with the major dimensions of the load-carrying constructional components and their connections. Inaccessible constructional components or component groups are only to be dismantled when there are doubts concerning the compliance of the dimensions or the correct assembly/mounting;

d) compliance with the weight on which the calculations are based for such parts whose excess weight would cause the exceeding of the permissible stress on connections or constructional components, or whose shortage in weight might affect the safety of the equipment as far as lifting-off, sliding or tilting-over are concerned;

e) conformity of the required certificates concerning material specification and quality, e. g. strength, durability, fire resistance;

f) conformity of the electrical, electronic, hydraulic/pneumatic equipment with wiring and circuit diagrams including software and observance of the relevant CENELEC standards and the applicable regulations and standards;

g) the inspection of bearings, motors, enclosed drive units, switch and control units and similar components is required for, and limited only to, such cases where their failure could be dangerous for persons.

6.5.2.4 Independent initial examination and test

The initial examination and test shall consist of a number of separate examinations and tests which together should be formulated to demonstrate that, at the time and place of the test and examination, the amusement device is capable of performing to approved design documents. Functional tests concerning the movements unloaded or under full load are required. Unbalanced load tests are to be made, whereby the load patterns of 5.4.2.1 shall be used. During the trial run, the following functions and conditions as a minimum shall be checked:

a) clearance envelope of passengers and any moving parts to other objects;

b) correct working of sequential, forced and interlocked control systems;

c) the specified speeds, accelerations and safety relevant weights;

d) the working pressures of hydraulic/pneumatic systems;

e) the setting of inclination control switches, terminal switches and other control switches as well as overload protections (e. g. pressure relief valves);

f) the safety devices (e. g. anti-roll back devices for vehicles and on the track);

g) the brakes as to their efficiency and the acceptable deceleration as far as passengers are concerned;

h) the operational performances as far as lifting-off or tilting is concerned;

i) the operation of the ride and the accelerations and decelerations under normal working conditions and in cases of emergency.

6.6 Provisions before supply and use

6.6.1 Log book

6.6.1.1 General

The log book for the respective amusement device, shall clearly identify the device and contain a summary of the technical and operational data, history, records of all repairs, modifications, examinations, tests and checks and the detailed reports thereof, including an excerpt of the design documents which provide information for identification and inspection, by independent inspection bodies. The log book shall be available as a document on each installation site for maintenance, tests, examinations and checks. All examination reports shall be included by appropriate entries.

6.6.1.2 Content

The log book shall comprise at least the following documents:

— description of design and operation of the amusement device;

— drawings for the identification of important dimensions of the amusement device;

— identification markings;

— identification of the manufacturer;

— list of owners;

— summary and excerpt of the main technical data and documentation;

— conditions and requirements for operation and use, i.e. at a minimum:

- speed limits;
- general passenger use limitation;
- general passenger size / age limitation;
- a reference wind velocity specified for the device (see 5.3.3.4);
- any snow load restrictions;
- any restrictions due to seismic activity;
- other restrictions if any;

— assembly drawings and pictures showing the important dimensions for inspections and examinations;

— summary (main results and abstracts) of the stress analysis showing main forces, masses, wind, packing, any important stress areas, etc. to aid inspections and examinations;

— examination and approval reports as well as reports on any other inspections;

— basic assembly circuit diagrams for electric, 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.

— a listing of the documentation belonging to the amusement device;

— reports of regular examinations, tests and inspections;

— reports of maintenance carried out;

— a list of NDT inspections;

— a record of dangerous occurrences and major-injury accidents;

— all examination and approval reports as well as reports on any other initial examinations and manufacturing tests and inspections;

— a declaration of operation authorisation or permit (if required due to national regulations);

— an extension of operation authorisation or permit (if required due to national regulations).

A detailed example of a log book is given in Annex F.

6.6.2 Official technical dossier

6.6.2.1 General

For each amusement device an official dossier shall be established 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 examinations by independent inspection bodies. The official dossier shall be available for use as a bound and registered documentation wherever national regulations may require it. All initial approval and examination reports shall be included therein.

6.6.2.2 Content

The official technical dossier shall comprise at least the following:

— design and operation descriptions;

— design drawings (presentation of the safety important dimensions of the entire facility in an adequate 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 and manufacturer covering erection and dismantling, maintenance and operation and a list of all parts requiring periodic replacement;

— all initial examination and approval reports as well as reports on any other initial inspections and manufacturing tests and inspections.

6.6.3 Identification marking

Each amusement device shall be fitted with an identification plate showing the following information:

a) name and address of manufacturer and/or importer/supplier;

b) type/model no;

c) manufacturers no;

d) month and year of manufacture;

e) date of initial approval;

f) approval mark/no. of independent inspection body;

g) safe working load/number of persons to be carried.

Enclosures and booths shall be marked with:

1) name and address of manufacturer/supplier/importer;

2) month and year of manufacture.

7 Operation and use of rides and structures

7.1 Introduction

This clause is concerned with giving guidance and rules when installing, building up and pulling down, operating, dismantling, disassembling, handling, maintaining, modifying and inspecting amusement devices and is addressed to controllers, operators, attendants and inspection bodies.

7.2 Standard documentation

The obligatory documents, which shall be prepared for all amusement devices, are:

a) operating manual (see 6.4.3.1);

b) Log Book (see 6.6.1 and Annex F);

c) Official Technical Dossier (see 6.6.2).

The documents under a) and b) shall be available at each amusement device.

7.3 Requirements for Personnel

The operator of the following types of amusement devices shall be at least 18 years of age:

a) Any passenger carrying device other than a simple, slow moving device designed primarily for children (but see "c" below).

b) A shooting gallery where hazardous projectiles are used.

c) An enclosed structure being an amusement device which can accommodate more than 30 persons, or one which is intended primarily for use by children.

In all other cases, the operator of the device, or an attendant performing a safety-critical function, shall be at least 16 years of age. No ride attendants of the device shall be less than the minimum age of employment stipulated by national law in the country of use.

7.4 Duties of the controller

7.4.1 General

The controller shall:

— ensure that the required documentation accompanies the amusement device when being bought or sold. The required procedure in accordance with regulations shall be followed (see 7.4.2);

— select and train operators and attendants;

— build up, and pull down safely (see 7.4.4);

— ensure safe operation (see 7.4.6.and 7.4.7) in full compliance with all laws, prescriptions and regulations issued by local and national authorities;

— service, maintain, repair and modify safely (see 7.4.9);

— ensure that only amusement devices which have a valid operational permit and are examined and tested by appropriately qualified inspection bodies, are operated (see 6.5 and Annex H);

— maintain, keep available and update as required (see 6.6.1 and Annex F) the Operating Manual and Log Book, as well as creating necessary reports.

He shall provide full instructions on the control or communications system including the task of displaying the signals currently in use in appropriate positions.

The ride controller can delegate any part of his duties, but remains responsible in law.

7.4.2 Buying and selling

A controller directly importing amusement devices may, under European or national legislation, assume or share the legal duties of the designer, manufacturer and/or supplier. The equipment shall comply with all legal requirements. Before taking into operation any amusement device the controller shall apply for the necessary operational permits required by national law and shall initiate all examinations which are to be executed by the independent inspection body.

7.4.3 Selection and training of staff

7.4.3.1 Obtaining suitable and competent staff involves selection, training, monitoring, auditing and keeping records. The controller shall select people able to put the safety of the public first, likely to follow procedures conscientiously and having the maturity and authority to give confidence to the public. Training methods should be tailored to the capabilities of those being trained.

7.4.3.2 All staff involved in running an amusement device, depending on their duties, shall receive information and training on safe working and operating procedures, which covers at least the following:

— safe operation and maintenance of the amusement device to be used;

— site safety;

— procedures for dealing with problems, to include:

  — people who are misbehaving, etc;

  — defects and malfunctions of equipment;

  — incidents;

  — fire;

  — adverse weather;

  — bomb threats and other emergencies.

7.4.3.3 In addition, operators and attendants depending on their duties, shall be provided with suitable and sufficient information and training in the working of their amusement devices, covering:

— systems of work for safe operation, including speed limits and any other specific safety measures;

— procedures for reporting breakdown, defects or unusual occurrences;

— loading and unloading procedures;

— passenger restrictions such as height and weight limits or medical conditions;

— control of waiting and viewing areas;

— use and operation of passenger containment and passenger restraint systems including the checking of restraint closure;

— emergency stop procedures;

— emergency procedures, covering such situations on the ride as power loss and passenger evacuation.

7.4.4 Build up ad pull down

7.4.4.1 Siting amusement devices

7.4.4.1.1 General

Amusement devices shall be erected in accordance with the locally applicable national requirements. Required inspection intervals shall be followed. Where required by the national regulations it may be necessary to report to the local body with submission of the Log Book. The local body may decide that an installation inspection is necessary before the device can be taken into service again. The result of any such inspection shall be entered in the Log Book.

7.4.4.1.2 Standard ground conditions

The ride controller or his representative shall ensure that an amusement device is only sited on ground which is suitable for this purpose in accordance with any guidance given in the Log Book and manual. For example ensure that the ground:

— can safely bear the load of the amusement device. For existing structures e. g. buildings or piers, a detailed examination and calculation shall be carried out in order to establish permissible loads;

— is sufficiently flat, even and stable for the attraction to be built up and used on safely, in accordance with the log book and manual.

The ground shall be checked at regular intervals after build up , to confirm that there is no deterioration in its load bearing capacity, especially during adverse weather conditions. Drainage shall be considered.

7.4.4.1.3 Standard conditions for the siting of amusement devices

The controller shall establish the position of underground services or overhead lines which may present hazards during the build up or operation of the device, taking advice as necessary from the appropriate authority. Where these could be a source of danger to persons employed or to members of the public, all practicable precautions shall be taken to prevent such danger, either by the provision of adequate and suitably placed barriers or otherwise.

Care shall be taken to ensure that underground services are not struck when poles or pegs are placed in the ground or when excavation is undertaken. Service location techniques shall be employed before any such work is commenced, unless it has been confirmed beforehand that there are no services present.

7.4.4.1.4 Location and clearance

When positioning amusement devices, controllers shall apply the following principles:

— The proximity to other fixed or mobile structures or services shall be in accordance with the requirements of 6.1.6 and 6.2.

— Consideration shall be given to any possibility of dangerous uplift caused by wind.

— They shall be arranged so that the public have safe access to each device at entrance, and safe egress at exit points, so that there are no bottle necks which could cause dangerous overcrowding in an emergency.

— Sufficient clearance shall be provided between and above devices on main access routes, so as to provide access for emergency service vehicles, and provide access to fixed fire hydrants even when the public may be being evacuated.

— There shall be sufficient clearance between adjacent amusement devices, buildings or other occupied areas to minimise the risk of fire spread.

— Where rides cross over or pass through each other, as a minimum the clearance envelopes for each ride (see 6.1.6 and 6.2) shall apply. The controllers shall ensure that safety envelopes for both passengers and public are not compromised.

— For coin-operated children's rides, spacing may vary providing the safety envelopes are not thereby compromised.

7.4.4.2 Transport on site, build up and pull down

7.4.4.2.1 Supervision and personnel

When devices are transported, built up or pulled down on site they shall be under the direct supervision of the controller or another person trained or experienced in such work who has been so authorised by the controller.

7.4.4.2.2 Working methods

A safe system of work, which is in accordance with the manufacturer's instructions, the Log Book and the Operating Manual, shall be followed during these operations. Controllers shall make themselves familiar with, and follow the requirements of local and national authorities.

Devices shall be moved so as to minimise the risk of damage to safety-critical components and all loads shall be properly secured during transit.

Where there is any temporary state of instability or overstress in the device during assembly or dismantling, all practicable precautions shall be taken by the use of temporary guys, stays, supports and fixings to prevent danger through the collapse of any part of the device.

Temporary provisions for access and working during build up and pull down operations shall be safe.

Before the device is made operational, unauthorised access shall be prevented through openings in platforms and through any gaps within the device, which are only intended for access when the device is not in motion or use. Such openings or gaps shall be provided with covers, be securely fixed in position or equipped with barriers and access doors, which are securely fastened.

Upon completion of assembly, all components that are important to the safety of the device, such as structural elements, connecting parts, securing parts, safety devices, the electrical system and brakes shall be checked to ensure that they have been properly installed (see 7.5).

Where necessary there shall be sufficient and suitable lighting to allow work to be conducted in a safe and proper manner.

All structural members needed to ensure the stability and safety of a device shall be used and correctly fitted. Where it is a design requirement, the whole assembly shall be securely anchored to ensure that it is stable.

Before assembly, all components shall be carefully examined for signs of wear, deformation or other damage. Fastening and securing components shall be used in accordance with the design documents and correctly adjusted, or replaced if necessary. For further explanations and data concerning details of connection see 7.4.5.1. Where excessive wear or damage is discovered, such components shall be replaced by components which meet the design specification, before continuing with assembly and use. Temporary repairs using unsuitable components shall not be made (see also 7.4.9.3).

Where required, all components shall be properly lubricated before they are incorporated into the device.

Where rail tracks form part of the device, they shall be properly laid and aligned, so that units run safely and smoothly over them.

7.4.4.2.3 Public safety

Members of the public shall not be admitted into areas where an amusement device is being built up.

The controller or the authorised person shall, where necessary, provide means to prevent members of the public entering work areas e. g. with fences or warnings.

7.4.4.3 Ground packing, stability and anchors

All necessary measures shall be taken during assembly to ensure that the device will be stable when in use.

No device shall be assembled on sloping or uneven ground, unless suitable packing has been incorporated which allows the device to be used safely.

The device shall be level where necessary and have its load adequately distributed and firmly supported. Its stability shall be checked frequently.

The number of packing pieces used shall be kept to a minimum. The height of the packing material shall be kept to a minimum and the packing itself shall be stable.

All packing materials incorporated shall be sound and suitable for the purpose, chosen and located in accordance with the Log Book and manual, so as to prevent slipping and sinking, or dislodgement.

Packing shall be placed directly beneath the load points of the device. If this cannot be achieved a suitable supporting structure shall be formed which effectively transmits the load of the device safely through the packing to the ground. Dynamic loads can lead to the loosening of packing and anchorage; consequently, repeated checks of the packing and anchors are essential.

If an attraction is equipped with props to support the structure, these props shall be used in accordance with the manufacturer's instructions.

7.4.5 Care of equipment

7.4.5.1 Mechanical equipment

Special attention shall be paid to safety critical components. They shall be carefully checked before the build up. Any parts showing wear outside the limits stated in the manual, breakage, or other damage shall be replaced with parts consistent with the design specification before using the device.

Controllers shall have procedures to ensure that safety-critical components are:

— individually identifiable if they look the same but are not interchangeable;

— stored so as to minimise deterioration and contamination;

— cleaned and lubricated as required by the manual before being incorporated into the structure;

— carefully assembled so that they are not damaged;

— assembled using correctly used and adjusted fastenings and fixings, in accordance with the design documents. In particular:

  — all pins shall be provided with their safety locknuts and washers, split pins or castellated nuts with split pins, etc. as defined in the design documents. Split-pins shall be spread effectively;

  — `R' clips shall be of the right size, in good condition and fitted correctly;

  — self-locking nuts shall not be used more than the maximum number of times recommended by the manufacturer.

— close attention shall also be paid to bolted joints by using tightening torques, dimensions and classes of bolt in accordance with the requirements of the design documents. Torque wrenches shall be used as required. Components having a "specified operational life" shall be checked to verify their functional safety. If there is

repeated or unusual damage, the advice of the manufacturer or a competent designer and the confirmation of an inspection body should be sought.

When lifting equipment is used for the build up of heavy components, the manufacturer's instructions shall be followed so as not to adopt unsuitable lifting methods which might cause damage, and subsequent danger during operation. Lifting equipment shall be thoroughly inspected and tested either in accordance with legal requirements for that equipment or, if it is an integral part of the attraction, to the same standard as the remainder of the attraction.

All mechanical precision fittings shall be built up without inducing abnormal stresses.

Steel wire ropes for erection and dismantling shall be used in accordance with the appropriate standard. Synthetic fibres ropes for erection and dismantling shall be used in accordance with EN 919 and/or EN 701.

7.4.5.2 Hydraulic and pneumatic equipment

Piping, hosing, relief valves, etc. shall not be fitted if damaged.

There shall be no leakage.

7.4.5.3 Electrical/electronic equipment

7.4.5.3.1 The installation shall minimise the risk of injury from electricity. Contact with conductors with voltages greater than 50 V a.c. or 120 V (to be checked to existing European Standards) ripple-free d.c., or lower voltages in some extreme circumstances, can cause injury by shock or burns.

7.4.5.3.2 People shall be guarded against touching conductors energised at more than 25 V a.c. or 60 V ripple-free d.c. by using properly insulated cables, connectors and other equipment, protected against stress and damage and placed out of reach or in enclosures.

7.4.5.3.3 Exposed metalwork shall be guarded against becoming live under faulty conditions: for a.c., by a system of earthed equipotential bonding and automatic disconnection, and for d.c., 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;

— all metallic structures and parts shall be connected together and to the earth leakage breaker;

— 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 (see Annex D);

— for public or equivalent private power supply, the circuit protective and bonding conductors shall be connected to the earth, or to earth rods, at the power source.

7.4.5.3.4 Means of cutting off and isolating the supply shall be provided on all live poles for a.c. systems and on both positive and negative poles for d.c. systems. Devices such as functional switches and electromagnetically operated contactors and motor starters used as isolators, which they are not, shall not be used. Means of preventing unauthorised energization shall be provided.

7.4.5.3.5 On a.c. systems supplying lighting and socket outlets at over 110 V, residual current devices shall be provided as supplementary protection.

7.4.5.3.6 Generators shall be positioned to minimise risks from hot surfaces, dangerous parts, overheating and exhaust products. Associated electrical equipment shall be mounted so as to minimise 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 ohms. The same neutral-to-frame connection shall be made on small a.c. generators if a load cable length exceeds 5 m.

7.4.5.3.7 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.

7.4.5.3.8 All electrical cabinets or enclosures shall be properly locked to prevent unauthorised access. Where they are accessible to the public, locking devices shall be used which require a tool to operate. The power supply and arrangement of light switches shall be protected so as to prevent unauthorised tampering.

7.4.5.3.9 High, isolated, or otherwise vulnerable structures shall be protected against lightning.

7.4.5.3.10 Systems of work shall be used that avoid electrical danger and other consequential danger. Only people who, by training and experience, are competent to work safely on electrical systems shall be used. Before exposing or working on, with or near conductors, they shall be made dead and safe. If this is not feasible, as in electrical testing, adequate precautions shall be taken by using suitable protective equipment, test equipment, tools and appropriate procedures.

7.4.5.3.11 Routine testing of equipment and checks for deterioration, particularly of plugs, cables and sockets shall be performed.

7.4.5.4 Liquid and gas fuel systems

The connection of equipment using these fuels shall be in accordance with European Standards or respective national standards.

Special safety devices which are listed in the Log Book or Operating Manual shall be subject to special care at all times.

Special emergency equipment listed in the Log Book or Operating Manual shall be subject to special care at all times.

7.4.6 Trial Operations and Checks

7.4.6.1 Taking into use after build up

After the build up, the controller or his nominee shall personally check that the build up of the amusement device is correct, using the Log Book and the manufacturer's instructions. He shall also ensure that the device is stable and firmly in position. A similar check routine shall be carried out where an attraction has been idle for a long period or after it has been partially dismantled and re-erected. These checks shall be carried out in accordance with the check-list of the manufacturer and the Log Book, which shall explain how this post assembly check shall be carried out and which components in particular shall be checked.

For amusement devices, the controller shall provide means for "locking-off" whereby each member of staff can assure himself that the device cannot be started until he or she is safe.

Then the nominee and/or the controller shall effect one or more trial runs without any member of the public according to the instructions of the manufacturer, simulating where possible emergency situations to verify particularly that control systems, emergency stops, safety equipment and emergency equipment work properly. After these trial runs the amusement device is available to the public or for any other checks which are required.

The controller shall complete a record of these checks and make an appropriate entry into the record book, if required by national law.

Devices not open to the public shall be secured and/or immobilised and steps shall be taken to prevent public access.

The operating procedures shall be available for the operator at the ride.

7.4.6.2 Daily check and trial run

Each amusement device shall be inspected daily in accordance with the log book and manual or at more frequent intervals when necessary, prior to being made available for use by the public. Such checks shall also be made during operation when necessary (e.g. for the wear of brakes, etc.). This shall include an obligatory trial to check that safety controls, brakes and other safety and emergency devices, including communications, operate effectively.

The check shall be carried out by the controller, or a person formally authorised on his behalf, following a written check procedure. The person carrying out the check shall be sufficiently trained or experienced in the check routines that have to be carried out.

These daily checks collected in a list, derived from the Log Book and manual shall concentrate on the proper functioning of those components and parts of the device whose failure could result in personal injury. The checks shall include acceptable tolerances, such as out-of-level limits, air and hydraulic pressures, wear, checks on restraints and locking systems, structural and mechanical integrity, barriers, guards, walkways, emergency exits, locking devices and securing pins, and the security of hazardous equipment. They shall take into account instructions in the Log Book and Operating Manual. Any resulting remedial action shall be recorded. The written record of daily checks shall be filed in the Log Book; these notes shall be kept for at least three years.

Some of the above may not be relevant for coin-operated children's rides, but the controllers of such devices shall check at least daily for damage and safe operation.

The device shall not be made available to the public until any adjustments or repairs judged to be necessary as a result of this inspection have been satisfactorily completed.

7.4.7 Operation

7.4.7.1 Loading and unloading of passengers

Every passenger carrying amusement device shall be loaded in the designated pattern, including a pattern for a partly filled car or device, specified in the Log Book and Operations Manual which shall not exceed the requirements of any notice on passenger loading under 5.3.3.1.2.1.

The ride attendant and operator shall ensure that each passenger is appropriately positioned and that any restraint device is effectively fastened in position and tightly adjusted to the body. He shall also check that no passenger unsuitable for the restraint or seat due to his size, body shape or other factors, is placed in the ride, as required by the Log Book and manual. This shall be done before either starting the ride cycle, or before giving any signal or form of indication that the ride cycle may be started. Where the operator does not have a clear view of all loading or unloading points, there shall be a clear and unambiguous means whereby the operator can establish with attendants whether it is safe to start.

Passengers shall be excluded from using any part of a device where the equipment for containment or restraint is defective.

Clear instructions shall be given to passengers on their conduct during the ride.

The ride cycle shall not be started until it has been established that no persons in the vicinity are in positions of danger from the motion of the device.

The controller of an amusement device shall review regularly the efficiency and adequacy of safety arrangements provided in the light of experience or changing circumstances, and where appropriate, shall modify or improve the arrangements in use. He shall not modify safety devices or safety procedures without consulting the manufacturer or designer.

Where there is a possibility that passengers on an amusement device may become stranded away from the disembarkation point, instructions shall be prepared which detail the arrangements for conveying them safely and without undue delay to a place of safety, preferably in the unit in which they are travelling. In the case of a dark ride, the instructions shall detail arrangements for conveying passengers to the exit. The arrangements shall be suitable for all persons allowed to use the device, and shall be known and understood by the ride operator and the ride attendant working on the device.

Areas on or near devices where it is not safe for persons to stand, shall either be fenced off or be clearly indicated, and so far as is reasonably practicable, members of the public shall be prevented from encroaching upon them.

7.4.7.2 During operating cycle

Any passenger carrying amusement device, except one specifically designed for unattended use, shall be under direct surveillance by a ride operator at all times when it is available for use by the public. The operator shall be capable of working the device competently in a safe manner with due regard for passenger safety and shall be in control throughout the operating cycle. The number of attendants required to operate it safely shall be on duty. No operator shall be in charge of more than one operating passenger-carrying amusement device at any one time.

The device shall be used within the speed restrictions specified in the Log Book, Operations Manual or by an inspection body.

Amusement devices shall not be operated in adverse weather conditions which may affect the operational conditions, the stability of the devices or the safety of persons (consider the provisions stated in the manual regarding changing weather conditions). Particular regard shall be given to the extreme conditions which may be caused by gusting winds and the increased wind forces that can be created by the funneling effect of adjacent structures. If required, appropriate wind measuring devices shall be used. Fares shall not be taken on rapidly moving rides, if to do so would pose a perceptible risk to passengers or staff. On other rides, fares shall only be taken if the passengers do not have to steer the car themselves, hold on to children or hold on to a fitment as part of the system of containment.

7.4.7.3 Supervision of public

Reasonable steps, including stopping the device if necessary, shall be taken to prevent passengers intentionally misusing equipment provided for their safety, behaving recklessly, or disregarding clear and reasonable instructions.

Where it is foreseeable that certain passengers, by virtue of their physical characteristics or otherwise, may be at risk on certain passenger carrying amusement devices, they shall not be allowed to ride, unless sufficient additional protection can be given to them (see 6.6.1.2). Exclusion on the grounds of health and safety is not discrimination.

The number of people allowed on access platforms and grandstands shall only be as many as the number specified in the Log Book and in any case shall only be as many as will ensure safe operation. Rescue paths shall be kept unobstructed. If necessary, the platforms shall be cleared before cars and gondolas are set in motion. If parts of a ride or passengers swing out less than 2,5 m above the ground, access to this areas shall be fenced off.

Where appropriate, safe areas shall be provided for the public to wait, controlled by such means as queuing rails, gates and additional supervision.

On dark rides, emergency exit routes shall be provided, be kept clear of obstructions and have good emergency lighting. Risks from tripping or falling shall be minimised, particularly where the emergency routes cross or run alongside rail tracks.

For rides with rail tracks, crossing places for the public shall be clearly marked and measures taken to prevent trips and falls.

7.4.7.4 Instructions to public

Legible signs or notices in the appropriate language shall be prominently displayed, clearly and simply stating any limitations as to who has to be excluded from being carried on the device. If required, in the Log Book or manual for this type of device, the following legible notices shall be displayed.

This amusement device is not for the use of:

— passengers with pacemakers;

— passengers with heart disease;

— pregnant women;

— passengers with any medical conditions which could be aggravated by the use of the ride.

The permissible number of persons per unit (e. g. per gondola) shall be indicated by means of a notice or placard.

If, due to design assumptions (clearance envelopes, passenger containment etc) and in reference to 5.3.3.1.2.1, the amusement device is designed only for use by persons under the height of 140 cm (which is equivalent to an age of 10 years or under), then suitable notices shall be displayed.

If required in the Log Book, the following legible notices, indicating the conditions listed below, shall be displayed at each device in operation:

— minimum age or minimum or maximum height of users;

— carrying of sharp or bulky items (sticks, umbrellas, etc.) or animals is not permitted;

— the danger of trailing scarves or long hair;

— maintenance of the intended passenger position (i. e. do not lean out, stretch out arms or legs or stand up during operation);

— no smoking;

— persons under the influence of alcohol or drugs are not permitted;

— sitting, kneeling and standing on railings and side walls is not permitted;

— hopping on or off is not permitted during the ride.

The following notice shall be displayed on platforms and grandstands:

— swaying together with linked arms and rhythmic stamping is not permitted.

Ride attendants and operators shall, so far as they can reasonably do so, see that such exclusions are enforced.

Effective means by which the operator can communicate with the public shall be provided. Such means shall be capable of giving additional visual or audible signals, particularly for emergency situations. They shall be kept in working order and tested daily before the amusement device is operated.

For standardised signs see ISO 7001.

7.4.7.5 Out of operation

The main switch and all other switches shall be switched off and the start key shall be removed. Unauthorized access to the operator cabin shall be prevented, by keeping it securely locked.

7.4.8 Special duties for the supervision of the operation

7.4.8.1 Rides

7.4.8.1.1 General

The number of people allowed on the access platforms shall only be as many as permit safe operation. If it is safe to do so, the platforms shall be cleared before cars or gondolas are set into motion. If the cars or gondolas stop for unloading and loading, measures shall be taken to ensure that they are not restarted until all the passengers have taken their places, the specified passenger restraints have been fastened and the loading area has been cleared.

In the case of rides fitted with seats, standing or kneeling during the ride in cars or gondolas is forbidden; if this requirement is not observed, operation shall be stopped if necessary.

In rides with individual seats they shall be occupied by only one person. When seating the passenger the requirements expressed in the Log Book shall be followed. As a deviation from this, seats for two adults may be occupied by a maximum of three children if the division of the seats, the required passenger restraint systems and operating procedure justify this. Rides exclusively for use by children shall only be used by children.

7.4.8.1.2 Roller coasters

Trains of cars shall not start from the loading and unloading area until the passengers have taken their seats in the specified manner and the specified passenger restraint devices have been fastened. The distance between the trains shall be arranged so that all the trains can come to a stop in good time in the event of a fault.

The mechanical and structural components shall be monitored regularly during operation to verify that they have no defects. If necessary, the ride shall be shut down for corrective action.

Operation shall be stopped in the event of a storm, poor visibility or adverse weather conditions should they prevent safe stopping of the car by means of the brakes and proper travel over the track.

7.4.8.1.3 Dark rides

For dark rides where parts of the track are exposed to the weather, the last paragraph of 7.4.8.1.2 shall also be observed.

In the case of multi-storey dark rides where there is more than one car on the track, the attendant or operator shall ensure that the ride is stopped immediately in the event of a fault, in accordance with predetermined safety operating procedures set out in the manual.

7.4.8.1.4 Dodgem cars, speedways, boat and water rides

Only vehicles with the same type of drive shall be used at the same time.

The operator shall have one location with a good overview from which to monitor the whole driving area, give signals and operate the loudspeaker. If it is not possible to observe all critical driving areas, a further attendant shall oversee this part of the driving area and be able to communicate with the operator. Technical monitoring aids such as cameras (CCTV) are permitted.

The beginning and end of the ride cycle shall be indicated by a signal except when the loading or unloading of passengers takes place next to the operator or when the vehicles do not stop.

Operation shall only be continued for as long as the driving area has adequate grip on its surface.

Passengers shall only be permitted to get into combustion-engined vehicles on the driving area if all the cars are at a standstill.

Reversing is not allowed. Notices to this effect shall be displayed. It is only permitted if expressly requested by the operator or attendant. This paragraph is not applicable to dodgem cars.

Combustion-engine vehicles leaking oil or fuel shall be removed from the driving area immediately and spillages cleared up. The vehicles shall not be refilled with oil or fuel when standing on the driving area.

All practicable measures shall be taken in the operation of dodgem cars in the interest of avoidance of injuries. Dirt and extraneous material (e. g. scrap metal) shall be cleaned away from the driving area before the beginning of operation, if necessary also in the intervals. Any rust resulting from wear of the zinc layer shall be removed from the current supply net. Damage shall be repaired. The condition of the current collectors shall be checked daily and any defects eliminated. The contact brushes of the cars shall be cleaned daily.

7.4.8.1.5 Swings

There shall be at least one attendant for a maximum of 6 adjacent gondolas (boats). Loop-the-loop swings not powered by a motor where the passengers' heads are pointing downwards for a short time shall only be used by one person per gondola.

7.4.8.1.6 Roundabouts with horizontal and/or vertical movements

In the case of boom-type roundabouts where the vertical movements of the booms are controlled by the users, the switching devices for the upward travel of the gondolas and the centre structure shall not be capable of being shifted to "lift" until the rotation gears have started up. Regarding the end of the ride, these switching devices shall be adjusted to "lower" in proper time so that all the gondolas and the central structure are already at their lowest point before the rotating gears stop.

In roundabouts where the seats or standing points are lifted or tilted and the passengers have to hold on tight because of the centrifugal forces, the lifting or tilting shall not be started until the specified speed has been reached. Lowering shall be completed before the speed has dropped below the specified level.

In case of chair-o-planes, care shall be taken to ensure that the passengers do not swing, collide, rotate the seat or lean out too far. If any of this happens, operation shall be stopped.

Each seat shall be occupied by only one person.

For vehicle roundabouts intended for use by children also, the operator or attendants shall be present around the periphery so that they can act immediately at any sign of danger.

7.4.8.1.7 Ferris wheels

The gondolas shall be occupied in such a way that the wheel is loaded uniformly.

When loading and unloading, free-swinging or free-rotating gondolas they shall be held by the attendants until the passengers are safely accommodated or disembarked.

7.4.8.2 Side shows and fun houses

7.4.8.2.1 General

The following legible notice shall be displayed:

— No smoking

Attendants and operators shall ensure that existing restrictions of use are adhered to.

7.4.8.2.2 Steep wall, globes etc.

In the spectator area of steep wall tracks, globes and similar installations, attendants shall be present to ensure that nobody reaches inside the steep wall tracks or globes (performance area) or throws objects into it.

Visitors shall not participate in the performance nor stand in the performance area during the performance.

7.4.8.2.3 Turntables

Turntables shall be checked to ensure that there are no defects before the start of the operation and regularly during the operation. If necessary the operation shall be stopped. Damaged areas shall be repaired immediately.

During operation, the edges shall be kept free from people. Users who have slipped off the turntable shall be requested to leave the sliding area between the turntable and edge immediately.

People wearing shoes with metal fittings or high heels shall be excluded. Animals, umbrellas, sticks and other bulky or sharp objects shall not be taken onto turntables.

7.4.8.2.4 Slides

Slides shall be checked to see that there are no defects before the start of the operation and regularly during the operation. Damaged areas shall be repaired immediately.

Attendants shall be clearly identifiable as such to the users in their care.

Users shall use the slides only with suitable mats underneath them.

People wearing shoes with metal fittings or high heels shall be excluded.

Animals, umbrellas, sticks and other bulky or sharp objects shall not be taken onto the slides.

Children under 8 years of age shall always, as well as other users on request be accompanied on the conveying carpet by an attendant. There shall be a notice to this effect at the beginning of the carpet. At the end of the carpet and at the end of the slide, there shall be a sufficient number of attendants to help approaching users. Attendants shall be positioned at the beginning of the carpet and the beginning of the slide to ensure that the rules are followed and, particularly that adequate distances are maintained.

7.4.8.2.5 Hippodromes

Saddling, re-saddling, mounting and dismounting shall be supervised by attendants. The attendants shall also ensure that the animals do not leave the riding track.

7.4.8.2.6 Rotors

In the performance area, the floor shall not be lowered until the speed specified in the Log Book has been reached.

The floor shall not be raised until the rotor has come to a standstill and the passengers have left the wall.

In the spectators' area, attendants shall ensure that nobody reaches into the performance area or throws objects into it.

7.4.8.2.7 Mazes, halls of mirrors etc.

Animals, umbrellas, sticks and other bulky or sharp objects shall not be carried.

7.4.8.2.8 Hammers

The area to be fenced off as specified in 6.2.5.3 shall be kept free of spectators during the action.

An attendant shall ensure that the operation is carried out correctly and the area shall be clear at all times.

Only commercially available caps shall be used as explosive devices.

7.4.8.2.9 Win-a-prize and sales stands

These shall be set up in such a way that the operation is carried out in an orderly fashion and the area shall be clear at all times.

Loose packing material shall be stored away from the pathways so that there is no risk of fire.

7.4.8.2.10 Shooting galleries

The shooter shall be informed by means of a notice that the shot shall be fired at right angles to the target not obliquely and not until everybody, particularly the attendant, is in a safe position.

The attendants shall:

— not allow shooters unsafe behaviour;

— generally not allow more than two people to shoot per attendant, with children only one;

— not load the weapon until the shooter has reached his shooting position;

— the muzzle shall be directed away from the shooter and be pointed upwards when handing over the weapon;

— operate the device described in paragraph 2 of indent 1 of 6.2.7.3 if misuse of the weapon is recognisable;

— unload and release the tension of loaded weapons that are not going to be fired immediately; weapons as described in paragraph 2 of indent 1 of 6.2.7.3 shall be made safe by means of the device described;

— jamming of the loading or shooting mechanisms or jammed bullets shall be freed immediately; if this is not possible, the weapons shall be locked securely away;

— during the shooting gallery operation, bullets and ammunition shall be kept safe so that unauthorised access to them is not possible;

— man the shooting counter area throughout the shooting operation.

The operator shall ensure that the weapons, bullets or ammunition are locked securely away after the end of the operation.

7.4.8.3 Platforms and grandstands

The number of people allowed on the stage and grandstands shall not exceed the number of places specified in the Log Book.

Emergency paths shall be kept unobstructed.

7.4.9 Maintenance, repair and modifications

7.4.9.1 General

Whether contracted out or not, all maintenance work on an amusement device shall be carried out by, or under the direct supervision of, persons trained or experienced in the maintenance procedures appropriate to that device. These procedures shall include preventive maintenance and component monitoring, taking into account any instructions from, or consultation with, the manufacturer of the amusement device and the independent inspection body. All guards, fences, equipment enclosures and access doors, which are removed for servicing or maintenance purposes, shall be replaced and effectively secured in position before the device is set in motion.

7.4.9.2 Servicing

The servicing intervals recommended by the manufacturer shall not be exceeded, unless any extension in the period has been agreed and approved either with the manufacturer in writing or with the approval of the independent inspection body.

The frequencies at which servicing is carried out shall be in compliance with manufacturer's recommendations. Servicing recommendations shall deal with all components that have to be checked, tested, lubricated, adjusted or replaced at specified intervals.

Where necessary these recommendations shall cover:

— diagrams of the mechanical, electrical, hydraulic, pneumatic, safety and security systems;

— instructions concerning the actions to be taken when checking, testing, lubricating, adjusting or replacing, and dismantling or assembling of components;

— specifications of the required condition of the parts in question, and permitted deviations;

— specifications of the component materials;

— specifications of lubricants to be used;

— the intervals at which the various checks and servicing work shall be carried out.

The ride controller shall ensure that replacement parts fitted during servicing operations are of the correct specification. If it becomes necessary to use replacement parts which are different from those specified by the manufacturer the ride controller shall treat these changes as a modification and take action as detailed in the 7.4.8.4.

7.4.9.3 Repair

The repair of damaged parts shall be carried out with caution, as this could lead to a departure from the approved original design. For example, the stiffening or strengthening of one component can produce higher stresses in adjacent components which, in turn, fail. Welding shall follow the provisions in standards EN 288 (all parts), EN 729 (all parts), etc. Welding may be a safety-critical modification, requiring approval by the manufacturer and inspection body. A welder shall follow the appropriate European Standards and shall be qualified to EN 1418 (see 6.4.2.4.3) and shall use the correct materials and techniques. Changes of this kind shall be regarded as modifications and dealt with in the manner specified below.

7.4.9.4 Modifications

Any modification to:

— structures and mechanical parts;

— safety critical components;

— emergency equipment;

— performances

shall only be carried out after consultation with the manufacturer and the independent inspection body. All work relative to the containment of passengers shall be considered as being safety-critical.

If it is decided, following such consultation, that such a modification is acceptable, the proposal for the modification shall be agreed in writing by an independent inspection body, and appropriate quality surveillance shall ensure that the modification is carried out in accordance with the approved and verified proposal. Following any such modification, those parts of the device involved, shall be subjected to further thorough examination by an independent inspection body before the device is taken back into use (see also 7.7.3). The approved documentation shall be included in the Log Book and be up-dated by the independent inspection body.

Even apparently insignificant modifications may lead to the accelerated failure of the components of a device, and using a device outside the manufacturer’s specification or the normal environment for which it was designed, is a safety-critical modification.

The examination report concerning a repair or modification shall be included in the Log Book.

7.5 Duties of the amusement device operator

Every amusement device shall be under the immediate control of an operator throughout the ride cycle, and at all times when it is available for use to members of the public.

Before opening to the public, the operator shall ensure that he thoroughly understands the operating instructions and emergency procedures. The device shall be operated in compliance with these procedures.

Every operator shall carry out his duties in accordance with instructions given to him and with due regard to the safety of members of the public, others working with him and of himself.

The operator shall ensure that guards provided for dangerous parts of machinery, power units and transmission machinery are in position before opening to the public, and are maintained in position, whenever the device is in motion or in use.

When in use by the public, no person other than the operator, or trainee or attendant under his direct supervision, shall handle or interfere with the operation of the device.

The operator shall not operate the device slower or faster than the speed range specified in the Log Book and/or Operating Manual. Where there is a particular requirement to load passengers into a partly filled car or device in a particular pattern, the operator in charge of the device shall ensure that this loading is correctly carried out.

The operator shall monitor the integrity of the mechanical assembly during operation. Deficiencies or defects, which can result in a dangerous situation for the passenger, shall be resolved immediately. The operation shall be ceased and notice shall be given to the controller. Repair work that can endanger passengers is not allowed during operation.

The operator shall take all reasonably practicable measures to enforce the rules for passengers set by the controller, e. g. size restrictions, prohibition of loose personal possessions or wearing loose clothing. He shall exclude members of the public when he considers that they are incapable of using the device safely, e. g., because of their health, or their behaviour.

Before starting the ride cycle, or giving any signal or form of indication that the ride cycle may be started, the operator shall ensure that:

— all passengers are safely contained in the correct position, with any passenger restraint correctly fitted, properly adjusted and, if applicable, safely locked;

— passengers have been excluded from any part of the device where the equipment for containment or restraint is defective;

— passengers have been told all they need to know to ride safely;

— no spectator or member of staff is in a dangerous position. Where there is no clear view of all loading or unloading points, positive signals shall be used to check that it is safe to start. Smoke, lighting or other effects shall not be allowed to block the view;

— attendants clearly understand each signal;

— passengers remain safely contained and that no spectators are in positions of danger from the ride motion. Where appropriate, the public address system shall be used to give warnings. If anyone appears to be in danger, the ride shall be stopped, when and if it is safe to do so, or made safe as soon as possible.

The operator shall not take fares, or allow his attendants to take fares, on rides that are moving rapidly if to do so would endanger himself, his attendants, or the public. On other rides, fares shall only be taken if the passengers do not have to steer the car themselves, or do not have to hold on to children or to hold on to a fitment as part of the system of safe containment. He shall neither ride a device in a precarious position, nor jump on or off in circumstances where it would be dangerous.

The amusement device operator shall ensure that the ride attendant carries out his duties in a safe manner.

The operator shall immobilise the device and take steps to prevent access to it by members of the public at times when the device is not intended for public use.

7.6 Duties of the attendant

Every ride attendant shall carry out his duties in accordance with the instructions given to him and with due regard to the safety of members of the public, of others working with him and of himself.

The attendant shall follow the operator's or controller's instructions concerning the loading of passenger carrying devices and the control of spectators. For instance, he shall:

— load cars in the stipulated pattern, with largest/smallest passengers in the correct position;

— correctly balance passenger carrying devices;

— exclude passengers who may be physically unsuitable;

— take all reasonable measures to exclude those whose behaviour suggests they may not be able to ride safely;

— not allow passengers to use any part of the ride where the passenger containment system is defective;

— ensure that all passengers are safely and correctly contained and restrained in correct position, that passengers have been given any information needed for them to ride safely and that no spectators are in places of danger before indicating to the operator, by the agreed positive signal, that the ride is ready to start.

The attendant shall not ride in a device in a precarious position, nor jump on or off in circumstances where it would be dangerous. He shall not take fares on rides that are moving rapidly, if to do so would endanger himself or the public. On other rides, fares shall only be taken if the passengers do not have to steer the car themselves, do not have to hold on to children or do not have to hold on to a fitment as part of the system of safe containment.

During the ride cycle, the attendant shall continually and vigilantly look to see whether passengers stay safely contained and whether spectators move into places of danger. He shall neither encourage passengers to adopt unsafe positions nor to do anything else which could be unsafe. If he sees any person at risk of falling, being ejected, or coming into unintentional contact with part of the ride, he shall tell or signal to the operator immediately.

The attendant shall ensure that people leave safely when the ride finishes.

7.7 Independent examinations

7.7.1 Independent thorough examination

7.7.1.1 General

Every amusement device in use, together with all its ancillary parts, shall be thoroughly examined, at intervals which are specified in 7.7.5, by an independent inspection body. In the particular case of devices which are used on a seasonal basis, this thorough examination should be carried out where practicable before the beginning of each season, but in any case before the expiry of the examination report as documented in the Log Book.

7.7.1.2 Examination strategy

Minimum requirements for a thorough examination:

The Log Book shall be obtained from the owner to identify the critical components and recommended examination method.

The following steps should be carried out:

— examine the amusement device to establish, by experience and with reference to drawings and other documents, whether it appears to be complete, unmodified and correctly erected;

— identify those parts and components of the amusement device which are essential to the safe operation of the ride;

— enquire of the owner/controller as to whether these components showed wear, damage or other irregularities, critical to the safe operation of the ride;

— expose the chosen critical components and carry out a visual examination, with disassembly where required by the log book or operating manual; where irregularities are suspected disassembly may be required;

— check any components for signs of excessive wear, internal or external corrosion or cracking, if the results from the above tests indicate a problem;

— where, in the opinion of the expert, visual examination is not adequate, non destructive testing shall be carried out either before the next operation period or following a larger time interval;

— examine any timber sections for signs of damaged or missing paint. Check whether moisture is present, particularly where it may be trapped, prevented from running away or in foundations. Ascertain areas of rotten timber;

— check timber joints where nails or bolts may have corroded, allowing the timbers to fret thus making the joint ineffective;

— check for cracked, damaged or missing timbers which may impair the load carrying capacity of the structure;

— check for leaks in any hydraulic or pneumatic components used to elevate or support any sections of the ride and check that the pressures are within the design specification. Check the settings of safety valves, pressure relief valves, pressure control valves and check flexible pipes for signs of damage;

— check the correct functioning and state of all passenger restraints and their locking systems;

— examine and test the electrical installation according to EN 60204-1 and other applicable standards;

— observe such operational testing as is considered to be appropriate;

— when satisfied that the ride is correctly erected and in good condition request the ride to be operated unloaded at the maximum permissible speeds of rotation, elevation or other configuration, recorded in the Log Book at the time of the initial or last examination;

— observe the run and

— if all appears to be satisfactory, sign and issue the report on thorough examination and enter a record of the test and independent thorough examination in the Log Book.

7.7.1.3 Visual examination

Any visual examination may need to be supplemented by non-destructive testing at the discretion of the independent inspection body.

— The ride structure should be observed for deformities, i. e. buckled, bent or dented members, loose or missing parts or cracks.

— Structural members should be examined for deterioration, such as, rusting of steel, rotting of wood/plywood, delamination or tearing of fibre reinforced composites, or degradation of textile membranes.

— Passenger restraint devices should be closely examined for wear, correct adjustment, correct operation and anchorage.

— Critical welds, bolts, pins and joints, should be closely examined for evidence of cracks or excessive wear.

— Visual inspection of welds for cracks; Visual inspection of welds shall be in accordance with the relevant parts of EN ISO 5817, if welds are being examined for the first time after modification or repair.

— Electrical and electronic installations shall be examined for any modifications or deterioration.

All amusement devices require a visual examination as part of the thorough examination.

7.7.2 Installation examination

7.7.2.1 General

Amusement devices shall be subjected to a special examination after each new installation. This examination shall be carried out by experienced persons (see also 7.4.1). Where required by local regulations, an independent inspection may take place.

7.7.2.2 Extent of installation examinations

The following examinations should be performed:

— observance of the conditions imposed by the Log Book, the repair of faults detected during prior tests, and compliance with objections made during prior tests;

— correct packing and anchoring according to the plans with respect to the local ground conditions;

— conformity with the design documents, installation of all essential load-bearing components including braces and conformity of shapes and cross-sections of load-carrying components. Attention is to be paid to the correct incorporation of hydraulic and pneumatic components, staircases, platforms, railings, linings, decorations and other equipment.

— the correct siting of the amusement device;

— state of the essential load-bearing construction parts (visual sample tests);

— fastening of detachable parts (load-bearing parts as well as light rails and other decorations);

— safe-guarding of joints, safe installation of electric lines and other conduits under pressure (visual sample tests);

— installation (mounting) of safety devices according to plan (i. e. derailment guards, gripping devices) and the effectiveness (safe working) of doors and passenger safety devices (visual sample tests);

— existence of the necessary clearances and safety distances;

— obvious defects of the electric parts (i. e. broken plug connections, repaired fuses, damaged or missing lamps within reach; visual sample tests);

— trial run without load for rides and for amusing side shows with swiveling and/or lifting devices.

7.7.3 Examination after repair and modification

The device and associated parts shall be subjected to further thorough examination by an independent inspection body in the following instances:

a) before being taken back into use following any repair, modification or alteration likely to have affected the integrity of the device;

b) after a break down of unestablished origin;

c) on grounds of safety within a shorter period of time as specified by the body, which last examined the device.

7.7.4 Reports

The details of installation examination or thorough examinations carried out as described above shall be recorded and kept until at least the date of the next thorough examination. Non-power operated amusement devices, side shows or booths below 75 m^2 and with a height of less than 5 m need not record their inspections.

7.7.5 Examination intervals

All amusement devices shall be thoroughly examined at appropriate intervals.

The intervals between two successive thorough examinations may be governed by existing national regulations.

For guidance reference is made to Annex H which indicates the intervals currently prevailing in member states who have a system in place.

In any case the examination intervals may be shortened when necessary due to modification, repair, safety concerns or the soundness of the amusement device.

7.8 Fire

7.8.1 General

The provisions of this clause are basic requirements, which relate to fairgrounds and parks, without prejudice to any statutory fire regulations.

7.8.2 Fire procedures

Operators and attendants shall receive instructions on fire procedures and be given a demonstration of the use of fire fighting equipment by the fire service, where this is practicable.

Every enclosed structure shall have a sufficient number of persons in attendance to direct the public to safety in the event of emergency. One person shall be nominated to be in charge of the structure.

All persons and attendants shall be instructed in their duties in case of fire or other emergency.

All persons connected with the operation of fairs shall be instructed in the action to be taken in case of fire. A responsible person shall be in charge of fire precautions and shall ensure that all employees are familiar with their duties.

Instructions in fire procedures shall include the use of fire fighting equipment provided, the need to call emergency services immediately and the system to be used to call them.

A notice dealing with the fire procedures shall be exhibited at positions defined by the fire service.

7.8.3 Provisions in case of fire

Means shall be provided for giving a warning in case of fire in tents, booths and enclosed structures.

Tents, booths and enclosed structures for more than 2 000 people shall be fitted with an alarm system to signal evacuation. The signal shall be audible throughout the facility and clearly distinguishable from other sounds.

NOTE The standard does not deal with enclosed structures containing more than 3000 people.

The means of raising the alarm shall be made in such a way as to avoid creating panic in an audience, whilst giving instant warning to the appropriate members of staff.

At every fairground or amusement park appropriate means for fire fighting shall be provided and maintained (for example portable fire fighting extinguishers). They shall also be placed so as to be readily available for use.

Advice on the type and amount of fire fighting equipment which is suitable and sufficient is given in 7.8.4.3.

Arrangements shall be made for the equipment to be tested and serviced at appropriate intervals. A certificate of test and serviceability shall be obtained for each item.

The servicing and siting of fire alarm systems and fire fighting equipment shall conform to the relevant European or equivalent national standard.

The routes forming access to or egress from devices shall be kept clear of obstruction at all times when members of the public are permitted to be present. The layout of devices shall ensure that there is an easy and prompt access to a means of escape from the fairground.

Where natural lighting is deficient in any part of a fair, and during the hours of darkness, artificial lighting shall be provided so that persons can see their way about the fair. Particular attention shall be paid to exit routes, staircases and enclosed structures. Where lighting is derived from a number of portable generators with separate supply circuits, other generators nearby may be used to provide emergency lighting in the event of a failure.

Amusement devices shall be kept free of flammable materials and waste.

Guy ropes, tent pegs and stakes shall not be allowed to obstruct a route to a place of safety. Where they flank such a route they shall be shielded, or marked so that they can be clearly seen at all times.

Access to fire appliances, fire hydrants and other supplies of water for fire fighting shall not be obstructed, nor shall hydrant indicator plates be obscured without the agreement of the fire service.

Special arrangements may be necessary to minimise the risk of fire spread where large modular structures are erected.

Where tents, booths or other kinds of modular construction can be erected in several different configurations, care shall be taken to ensure that the minimum design requirements in relation to the numbers of exits and travel distances are achieved. Similarly, care shall be taken to ensure that the minimum design requirements in relation to temporary seating are met.

7.8.4 Access of emergency services

The site shall be arranged so as to allow easy access for fire fighting equipment to within 50 m of any part of the fair, where practicable. The advice of the Fire Service shall be obtained where such access is not practicable. Main access routes shall generally be not less than 4 m wide. Gates shall be of sufficient width to allow easy access of fire equipment and other emergency service vehicles.

Where there are more than 15 major amusement devices or more than 200 m^2 ground area for enclosures in a fair, an outline sketch plan of the fair shall be prepared showing the position of devices, vehicles and caravans. It shall be kept up to date as far as is reasonably practicable, and be available to the fire service before the fair operates.

7.8.4.1 Means of escape

Exits and exit routes shall be clearly indicated by notices and directional signs, which are self-illuminating and meet the requirements of ISO 6309.

In enclosed structures, the emergency lighting shall adequately illuminate exit routes, staircases, changes in level and signs. Where necessary, effective emergency lighting shall form part of the arrangements for safe evacuation of persons from passenger carrying amusement devices in the event of power failure.

While any person is within the structure, the doors of the structure and of any room within the structure which afford a means of exit, shall not be locked or fastened in such a manner that they cannot be easily and immediately opened from the inside. All doors on an exit route shall open outwards so that people can escape in an emergency without impediment. Where exit doors have to be secured against outside intruders, they shall be fitted with panic-type bolts only.

Exits, which consist of wall flaps or similar materials, shall be boldly indicated at the edges. They shall be arranged, so as to be easily opened from the inside.

7.8.4.2 Supplementary fire precautions

Flammable liquids such as petrol and diesel fuel shall be kept in suitable closed containers and shall be safely stored and secured against unauthorised interference. Containers shall be clearly marked to indicate their contents.

Such liquids shall not be stored in loose containers beneath lorries, trailers or caravans, near live cables or electrical equipment. Advice with regard to the storage of these liquids may be obtained from the Fire Service.

Particular care shall be taken when fuel tanks of vehicles and generator sets have been filled from cans or drums. Re-fuelling shall not take place while the engine or generator is running, and shall be carried out with adequate ventilation, preferably in the open air.

The spaces beneath and between devices, vehicles and caravans, shall not be used for the storage of combustible materials. Dry grass and undergrowth beneath equipment shall be cut short and cuttings removed.

Rubbish of all kinds shall be deposited in suitable non-combustible containers, and arrangements shall be made for their removal at frequent intervals (see daily inspection and trial run).

Containers of liquefied petroleum gas (LPG) shall be protected against unauthorised interference and accidental leakage. LPG containers, both full and empty shall be stored in safe positions in the open air. Where this is not reasonably practicable, they shall be stored in an adequately ventilated room constructed of non-combustible material. Such a store room shall be either in a safe position or be within a 2 hour fire resisting structure, and shall not be used for any purpose other than the storage of LPG or acetylene cylinders.

Heating equipment not fixed in position and/or heaters using open non-protected flames shall not be allowed in structures whilst the public are present. If used at other times such equipment shall be under constant supervision and be switched off or extinguished and removed when not in use.

The use of flammable liquids, highly flammable materials or open non-protected flames for special effects during performances is prohibited unless special precautions are taken to prevent uncontrolled fire.

Flammable gas shall not be used for filling balloons, whether for sale or for decoration.

Flammable material shall be stored in a safe position. Straw and fodder for animals shall be stored in a separate enclosure and be suitably protected against interference. Smoking shall be prohibited in animal quarters and in straw and fodder enclosures. A notice dealing with the fire procedures shall be exhibited in positions indicated by the fire service.

7.8.4.3 Fire extinguishers

Fire extinguishers shall be made available, in accordance with EN 2 and EN 3 (all parts).

Their number, type and size and, to a certain extent, their operating location, depend on the kind of hazards involved. The latter are linked to the type and size of the amusement device.

In addition to fire extinguishers, larger fire fighting units may be used (e. g. mobile fire fighting equipment).

Annex A
(informative)

Fatigue analysis

A.1 General

For most amusement devices there are many structural and mechanical components which are subjected to significant numbers of cycles of stress fluctuation. This dictates that fatigue analysis, rather than simple rupture limit state check, shall be employed. Decisions about required inspection and maintenance may then be based on the calculation results.

Where the materials, fasteners and welding consumables conform with the requirements of Clause 3 of ENV 1993-1-1:1992, analysis of fatigue may be based on Clause 9 of that prestandard as interpreted by the following clauses.

The formulae stated hereafter may be applied in assessing fatigue ultimate limit states for amusement devices.

A.2 Symbols and definitions

$$\gamma_{\mathrm{Ff}} \times S \leq R_{\mathrm{k}} / \gamma_{\mathrm{Mf}} \qquad \text{(A.1)}$$

where

S value of actions, e. g.

- $\Delta\sigma$ nominal normal stress range;
- $\Delta\tau$ nominal shear stress range;
- M_{d}, Q_{d}, N_{d} resulting internal forces and moments;

R_{k} material resistance, e. g.

- $\Delta\sigma_{\mathrm{R}}$ fatigue strength (normal stress) (see Figures 9.6.1 and 9.6.3 of ENV 1993-1-1:1992);
- $\Delta\tau_{\mathrm{R}}$ fatigue strength (shear stress) (see Figure 9.6.2 of ENV 1993-1-1:1992);
- M_{k}, Q_{k}, N_{k} ultimate internal forces and moments;

γ_{Ff} partial safety factor for fatigue loads;

γ_{Mf} partial safety factor for fatigue strength;

n_{i} number of cycles of stress range $\Delta\sigma_{\mathrm{i}}$;

N_{i} number of cycles of stress $\Delta\sigma_{\mathrm{i}}$ or $\Delta\tau_{\mathrm{i}}$ to cause failure;

N total number of stress range cycles $N = \sum_{\mathrm{i}} n_{\mathrm{i}}$;

m slope constant of a fatigue strength curve;

$\Delta\sigma_c$ reference value of the fatigue normal strength at $N_c = 2 \times 10^6$ cycles, which determines the detail category [N/mm^2];

$\Delta\sigma_D$ constant amplitude fatigue limit at $N_D = 5 \times 10^6$ cycles;

$\Delta\sigma_L$ cut-off limit at $N_L = 10^8$ cycles;

$\Delta\tau_c$ reference value of the fatigue shear strength at $N_c = 2 \times 10^6$ cycles, which determines the detail category [N/mm^2];

$\Delta\tau_L$ cut-off limit at $N_L = 10^8$ cycles;

$\Delta\sigma_E$ equivalent constant amplitude normal stress range related to design spectrum;

$\Delta\tau_E$ equivalent constant amplitude shear stress range related to design spectrum;

$\Delta\sigma_{E.2}$ equivalent constant amplitude normal stress range related to $N_c = 2 \times 10^6$;

$\Delta\tau_{E.2}$ equivalent constant amplitude shear stress range related to $N_c = 2 \times 10^6$.

A.3 Requirements for fatigue assessment

Under the following conditions fatigue assessment need not be performed:

$$\gamma_{Ff}\,\Delta\sigma \le 26/\gamma_{Mf} \quad [\mathrm{N/mm^2}] \tag{A.2}$$

$$N \le 2 \times 10^6 \left[\frac{36/\gamma_{Mf}}{\gamma_{Ff}\,\Delta\sigma_{E.2}}\right]^3 \tag{A.3}$$

$$\gamma_{Ff}\,\Delta\sigma \le \Delta\sigma_D/\gamma_{Mf} \quad [\mathrm{N/mm^2}] \tag{A.4}$$

If the number of stress cycles $N = \sum_i n_i$ in relation to the lifetime of the structural part is unequivocally known $\Delta\sigma_D \rightarrow \Delta\sigma_{N)}$ can be set.

$$\gamma_{Ff}\,\Delta\tau \le 36/\gamma_{Mf} \quad [\mathrm{N/mm^2}] \tag{A.5}$$

$$N \le 2 \times 10^6 \left[\frac{80/\gamma_{Mf}}{\gamma_{Ff}\,\Delta\tau_{E.2}}\right]^5 \tag{A.6}$$

$$\gamma_{Ff}\,\Delta\tau \le \Delta\tau_L/\gamma_{Mf} \quad [\mathrm{N/mm^2}] \tag{A.7}$$

If the number of stress cycles $N = \sum_i n_i$ in relation to the lifetime of the structural part is unequivocally known $\Delta\tau_L \rightarrow \Delta\tau_{(N)}$ can be set.

For joints in tubular lattice girders as in (A.5), (A.6) and (A.7) if $\Delta\tau$ is replaced by $\Delta\sigma$.

A.4 Fatigue strength of steel structures

A.4.1 Constant amplitude stress range (Palmgreen-Miner-Rule)

$$\sum_i \frac{n_i}{N_i} \leq 1 \tag{A.8}$$

$$\gamma_{Ff} \Delta\sigma_i \geq \Delta\sigma_D / \gamma_{Mf} \tag{A.9}$$

$$N_i = 5 \times 10^6 \left[\frac{\Delta\sigma_D / \gamma_{Mf}}{\gamma_{Ff} \Delta\sigma_i} \right]^3 \tag{A.10}$$

$$\Delta\sigma_D / \gamma_{Mf} > \gamma_{Ff} \Delta\sigma_i \geq \Delta\sigma_L / \gamma_{Mf} \tag{A.11}$$

$$N_i = 5 \times 10^6 \left[\frac{\Delta\sigma_D / \gamma_{Mf}}{\gamma_{Ff} \Delta\sigma_i} \right]^5 \tag{A.12}$$

$$\gamma_{Ff} \Delta\sigma_i < \Delta\sigma_L / \gamma_{Mf} \tag{A.13}$$

$$N_i = \infty \tag{A.14}$$

$$\gamma_{Ff} \Delta\tau_i \geq \Delta\tau_L / \gamma_{Mf} \tag{A.15}$$

$$N_i = 2 \times 10^6 \left[\frac{\Delta\tau_C / \gamma_{Mf}}{\gamma_{Ff} \Delta\tau_i} \right]^5 \tag{A.16}$$

$$\gamma_{Ff} \Delta\tau_i < \Delta\tau_L / \gamma_{Mf} \tag{A.17}$$

$$N_i = \infty \tag{A.18}$$

For joints in tubular lattice girders:

$$\gamma_{Ff} \Delta\sigma_i \geq \Delta\sigma_L / \gamma_{Mf} \tag{A.19}$$

$$N_i = 2 \times 10^6 \left[\frac{\Delta\sigma_C / \gamma_{Mf}}{\gamma_{Ff} \Delta\sigma_i} \right]^5 \tag{A.20}$$

$$\gamma_{Ff} \Delta\sigma_i < \Delta\sigma_L / \gamma_{Mf} \tag{A.21}$$

$$N_i = \infty \tag{A.22}$$

A.4.2 Equivalent constant amplitude stress range at N

$$\gamma_{Ff} \Delta\sigma_E \leq \Delta\sigma_R / \gamma_{Mf} \tag{A.23}$$

$$\Delta\sigma_E = \left\{ \frac{\sum_{i=1}^{p-1} n_i (\Delta\sigma_i)^3 + (\Delta\sigma_D)^{-2} \sum_{i=p}^{r} n_i (\Delta\sigma_i)^5}{N} \right\}^{1/3} \quad \text{(A.24)}$$

p is the first step with $\Delta\sigma_i < \Delta\sigma_D$

r is the sum of all steps with $\Delta\sigma_i > \Delta\sigma_L$

A conservative assumption may be adopted in evaluating $\Delta\sigma_E$ and σ_R by using a fatigue strength curve of unique slope constant m = 3.

$$\Delta\sigma_E = \left\{ \frac{\sum_{i=1}^{r} n_i (\Delta\sigma_i)^3}{N} \right\}^{1/3} \quad \text{(A.25)}$$

$$\gamma_{Ff} \Delta\tau_E \le \Delta\tau_R / \gamma_{Mf} \quad \text{(A.26)}$$

$$\Delta\tau_E = \left\{ \frac{\sum_{i=1}^{r} n_i (\Delta\tau_i)^5}{N} \right\}^{1/5} \quad \text{(A.27)}$$

For joints in tubular lattice girders:

$$\gamma_{Ff} \Delta\sigma_E \le \Delta\sigma_R / \gamma_{Mf} \quad \text{(A.28)}$$

$$\Delta\sigma_E = \left\{ \frac{\sum_{i=1}^{r} n_i (\Delta\sigma_i)^5}{N} \right\}^{1/5} \quad \text{(A.29)}$$

A.4.3 Equivalent constant amplitude stress range at $N_c = 2 \times 10^6$

alternative for A.4.2

$$\gamma_{Ff} \Delta\sigma_{E.2} \le \Delta\sigma_c / \gamma_{Mf} \quad \text{(A.30)}$$

$$\Delta\sigma_{E.2} = \left\{ \frac{\sum_{i=1}^{p-1} n_i (\Delta\sigma_i)^3 + (\Delta\sigma_D)^{-2} \sum_{i=p}^{r} n_i (\Delta\sigma_i)^5}{N_c} \right\}^{1/3} \quad \text{(A.31)}$$

p is the first step with $\Delta\sigma_i < \Delta\sigma_D$

r is the sum of all steps with $\Delta\sigma_i > \Delta\sigma_L$

$$\gamma_{Ff} \Delta\tau_{E.2} \le \Delta\tau_c / \gamma_{Mf} \quad \text{(A.32)}$$

$$\Delta\tau_{E.2} = \left\{ \frac{\sum_{i=1}^{r} n_i \left(\Delta\tau_i\right)^5}{N_c} \right\}^{1/5} \quad \text{(A.33)}$$

For joints in tubular lattice girders:

$$\gamma_{Ff}\,\Delta\sigma_{E.2} \le \Delta\sigma_c / \gamma_{Mf} \quad \text{(A.34)}$$

$$\Delta\sigma_{E.2} = \left\{ \frac{\sum_{i=1}^{r} n_i \left(\Delta\sigma_i\right)^5}{N_c} \right\}^{1/5} \quad \text{(A.35)}$$

A.5 Damage assessment for combined stresses

a) For $\Delta\tau_i < 0{,}15\ \Delta\sigma_i$ without calculation.

b) $D_d \le 1$ with $D_d = D_{d.\sigma} + D_{d.\tau}$

$$D_{d.\sigma} = \sum_i \frac{n_i}{N_i} \quad \text{for} \quad \Delta\sigma_i \quad \text{(A.36)}$$

$$D_{d.\tau} = \sum_i \frac{n_i}{N_i} \quad \text{for} \quad \Delta\tau_i \quad \text{(A.37)}$$

c)

$$\left[\frac{\gamma_{Ff}\,\Delta\sigma_E}{\Delta\sigma_R / \gamma_{Mf}}\right]^3 + \left[\frac{\gamma_{Ff}\,\Delta\tau_E}{\Delta\tau_R / \gamma_{Mf}}\right]^5 \le 1 \quad \text{(A.38)}$$

d) alternative for c)

$$\left[\frac{\gamma_{Ff}\,\Delta\sigma_{E.2}}{\Delta\sigma_C / \gamma_{Mf}}\right]^3 + \left[\frac{\gamma_{Ff}\,\Delta\tau_{E.2}}{\Delta\tau_C / \gamma_{Mf}}\right]^5 \le 1 \quad \text{(A.39)}$$

e) For $\Delta\sigma_x$; $\Delta\sigma_y$; $\Delta\tau$

$$\left[\frac{\gamma_{Ff}\,\Delta\sigma_x}{\Delta\sigma_{Dx} / \gamma_{Mf}}\right]^2 + \left[\frac{\gamma_{Ff}\,\Delta\sigma_y}{\Delta\sigma_{Dy} / \gamma_{Mf}}\right]^2 - \left[\frac{\gamma_{Ff}\,\Delta\sigma_x}{\Delta\sigma_{Dx} / \gamma_{Mf}} \times \frac{\gamma_{Ff}\,\Delta\sigma_y}{\Delta\sigma_{Dy} / \gamma_{Mf}}\right] + \left[\frac{\gamma_{Ff}\,\Delta\tau}{\Delta\tau_L / \gamma_{Mf}}\right]^2 \le 1{,}1 \quad \text{(A.40)}$$

In the verification of fatigue strength all nominal stress ranges are subject to a limitation given by the elastic limits of the material. The stress range shall not exceed $1{,}5\,f_y$ for normal stress and $1{,}5\,f_y / \sqrt{3}$ for shear stresses.

A.6 Formulae for life time prediction

A.6.1 General

The following method may serve for the prediction of the number of load cycles a structural part can survive. The calculated life in operating hours may be used to check that inspection instructions are appropriate. Also the remaining life cycles for a used part may be predicted.

A.6.2 Basic procedure

For some components of amusement devices, analysis may be based on a loading event consisting of one full ride cycle. For instance, this would comprise loading, one circuit of the train, and unloading in a roller coaster; or the full cycle of loading, ride operation, and unloading in a rotating device. Unbalanced passenger loads, for instance as in 5.6.3.5, should be incorporated where appropriate.

The relevant stresses at a design detail to be analysed may be dealt with in one of the following ways:

a) determine the complete stress history at that particular structural region, by calculation or measurement, for the full loading event. From this, calculate the stress ranges encountered during the loading event employing a soundly based method of cycle counting (such as the "reservoir" or "rainflow" methods). Use the calculated stress ranges to determine the number of loading events to failure (see A.6.2 for further guidance on this). Convert this figure to operating hours.

or

b) construct a simplified stress range spectrum (or single equivalent stress range) for the loading event. This should be demonstrably pessimistic. Use this to determine the number of loading events to failure (see A.6.2 for further guidance on this). Convert this figure to operating hours.

A.6.3 Calculation of fatigue life

ENV 1993-1-1 does not explain how the fatigue life for a loading event having multiple stress ranges would be calculated. This may be derived directly from the formulae given, as follows.

In general there may be coexistent normal and shear stress ranges at the region of interest (though these may be varying independently). In such circumstances the fatigue life, in terms of the number of loading events N_E is given by:

$$N_E = 1/\left[\left\{\sum(A_i)^m\right\}/N_{d,\sigma} + \left\{\sum(B_j)^p\right\}/N_{d,\tau}\right] \quad \text{(A.41)}$$

where

$$A_i = \{\gamma_{Ff}\,\Delta\,\sigma_i\}/\{\Delta\,\sigma_D/\gamma_{Mf}\} \quad \text{(A.42)}$$

and

$$B_j = \{\gamma_{Ff}\,\Delta\,\tau_j\}/\{\Delta\,\tau_D/\gamma_{Mf}\} \quad \text{(A.43)}$$

All appropriate stress ranges should be included in the summations so, for example, if there are 8 identical occurrences of the same magnitude within one loading event the value should be added in 8 times. The values of $N_{d.\sigma}$, $N_{d.\tau}$, m and p vary according to whether the detail category is associated with figure (and table) Number 9.6.1, 9.6.2, 9.6.3 or 9.7.1 of ENV 1993-1-1:1992 and according to the magnitude of A_i or B_j. In all cases, if the maximum value of A_i or B_j is less than unity then $N_E = \infty$ and no further calculation is necessary. Otherwise Table A.1 gives appropriate values for the parameters.

Table A.1 — Load cycle ranges

Figure (Table) Number in ENV 1993-1-1:1992	$N_{d.\sigma}$, $N_{d.\tau}$	m or p	Range of validity
9.6.1	5×10^6	3	$A_i > 1$
		5	$1 \geq A_i \geq 0{,}549$
		∞	$0{,}549 > A_i$
9.6.2	1×10^8	5	$B_j \geq 1$
		∞	$1 > B_j$
9.6.3	1×10^8	5	$A_i \geq 1$
		∞	$1 > A_j$
9.7.1	1×10^7	3	$A_i > 1$
		5	$1 \geq A_i \geq 0{,}631$
		∞	$0{,}631 > A_i$

For $m = \infty$ or $p = \infty$ in Table A.1, it is clear that this is equivalent to ignoring the A_i or B_j terms in the summation process in equation (A.41).

Equation (A.41) is the general form when normal and shear stresses co-exist. When there are only normal stresses there will be no B_j terms and when there are only shear stresses there will be no A_i terms. In 9.5.2.4 (3) of ENV 1993-1-1:1992, in which principal stress ranges are used, there would be no B_j terms.

Annex B
(normative)

Detailed analysis rules

B.1 Swings

B.1.1 General

The following specifications shall apply to swings without a motor drive, with the exception of B.1.4.

Swings shall be calculated for a deflection of max θ = 120° in relation to the position at rest. For children's swings, where the distance from the bottom of the gondola to the suspension axis does not exceed 2,0 m, an angle of max = 90° will suffice.

For loop-the-loop swings, the full deflection of max θ = 180° shall be entered in the calculation.

For loop-the-loop swings with a counterweight, the excess weight of the gondola shall be taken into account in each case as one sided overload, in addition to the weight of the passengers.

All input loads shall be multiplied by the appropriate safety factor as defined in 5.3.6.2 with the exception of calculations involving overturning, sliding and lifting.

On the assumption that the bases of the struts are situated in the same horizontal plane, and that the angle of inclination of the struts in the same, the following simplified calculation method can be adopted for conventional boat swings.

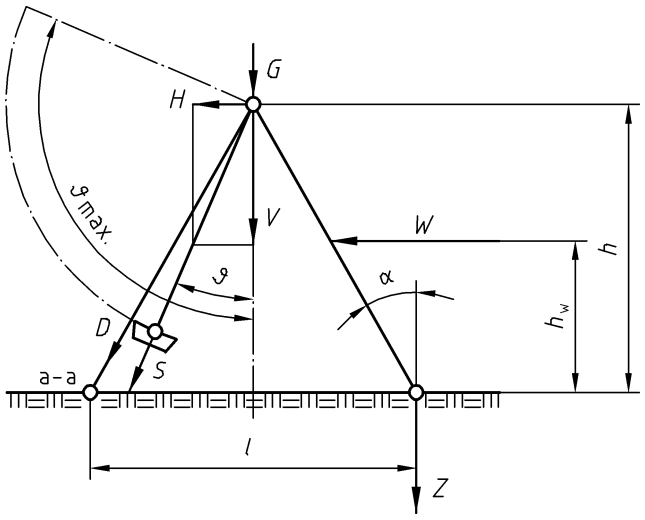


Figure B.1 — Boat swing

In Figure B.1

G is the load of the fixed components (framework of swing, head beam and bearing) (the self weight of the platform may only be included in G on condition that the platform is firmly attached to the struts and is erected together with the struts in every case);

Q is the self weight and imposed load of the moving parts (link rods, gondola and passengers);

W is the wind load;

S is the radial force for pendulum equivalent to the swinging gondola;

H are the horizontal components of the radial force S;

V are the vertical component of the radial force S;

l is the span of the swing;

h is the height of the swing;

h_w is the height of application point of the wind above the tilting axis a-a;

α is the inclination of struts in relation to the vertical;

θ is the deflection angle in relation to the vertical;

max θ is the maximum deflection angle in relation to the vertical;

D is the compression force in the strut of the swing;

Z is the anchoring force;

a-a is the tilting axis;

r is the radial distance from the pivot of the centre of mass of all component;

k is the reduced pendulum length of the physical pendulum.

The forces arising during swinging are the following:

$$H = Q(3\ \cos\ \vartheta - 2\ \cos\ \max\ \vartheta)\ \sin\ \vartheta\ (\mathrm{r}/\mathrm{k})^2 \quad \text{(B.1)}$$

$$V = Q[\,(3\ \cos\ \vartheta - 2\ \cos\ \max\ \vartheta)\ \cos\ \vartheta\ (\mathrm{r}/\mathrm{k})^2 + \{1 - (\mathrm{r}/\mathrm{k})^2\}] \quad \text{(B.2)}$$

When there is no counterweight and the swing is reasonably approximated by a point mass then (r / k) = 1 and the forces become:

$$S = Q(3\ \cos\vartheta\ -\ 2\ \cos\max\vartheta) \quad \text{(B.3a)}$$

$$H = S \times \sin\ \vartheta \quad \text{(B.3b)}$$

$$V = S \times \cos\ \vartheta \quad \text{(B.3c)}$$

In Table B.1, the forces which arise at various deflection angles are listed for the maximum gondola deflections max θ= 90°, 120° and 180° in relation to the position at rest, on the basis of the above formulae, for the point mass assumption.

B.1.2 Forces on struts

Forces on struts due to self weight G:

$$D_g = \frac{G}{2\cos\alpha} \quad \text{(B.4)}$$

Force on strut due to centrifugal force:

$$D_f = \frac{1}{2} \times \left(\frac{V}{\cos\alpha} + \frac{H}{\sin\alpha}\right) \quad \text{(B.5)}$$

The maximum value of the force on the strut D_f shall be determined from the ratio D_f/Q for various deflection angles delta, using V/Q and H/Q values in accordance with Table B.1.

The use of formula (B.5) presupposes that an effective non-yielding anchorage exists at the bases of the struts. If this is not the case, the value for D_f shall be multiplied by a factor of 2.

Force on strut due to wind:

$$D_w = \frac{\Sigma W \times h_w}{\ell \cos \alpha} \quad \text{(B.6)}$$

The wind load area for gondola and passengers can be assumed roughly 1,2 m^2 of perpendicularly hit area for swing positions between $\theta = 0°$ and $\theta = 60$.

The point of application of this wind force shall be assumed to be at the level of the suspension (axis). Wind loads on notice boards and display boards, roofings and the like shall be taken into account if necessary.

In any event an investigation shall be carried out as to whether higher stresses are likely to occur under conditions of full wind load and operational state of rest.

The total struts force therefore amounts to:

$$\Sigma D = D_g + \max D_f + D_w \quad \text{(B.7)}$$

B.1.3 Safety of the swing against overturning

The overturning moment including the safety factor γ (see Table 2), related to the tilting axis a-a, is:

$$M_{K\gamma} = 1{,}3 \times \left(H \times h - V \times \frac{\ell}{2} \right) + 1{,}2 \times \Sigma W \times h_w \quad \text{(B.8)}$$

The values of V and H are to be obtained from Table B.1 for the relevant angle of swing max. θ The stability moment, related to the tilting axis a-a is:

$$M_{St} = \frac{\overline{G} \times \ell}{2} \quad \text{(B.9)}$$

As far as $\overline{G}$ is concerned, only the maximum mass which can be assumed safely to exist at all times shall be entered in the equation (wood in the fully dried out state). The relationship $M_{St} \geq M_{K\gamma}$ shall be attained.

For $M_{St} / M_{K\gamma} < 1$ it will be necessary to provide an additional anchorage of the lean-to struts in accordance with the equation:

$$Z_\gamma = \frac{M_{K\gamma} - M_{St}}{\ell} \quad \text{(B.10)}$$

The relationship $Z \geq Z_\gamma$ shall be attained. See 5.5.2.3 for Z.

The suspension rods of the gondola shall be checked by calculation in respect of tension, and also in respect of buckling for deflection angles u exceeding 120°.

If the bearings for the suspension of the gondolas are arranged eccentrically in relation to the head beam, then the beams will also be subjected to torsional stress, and consequently the struts of the framework will be subjected to bending stress. This shall be borne in mind for the calculation, as shall also the influence of the eccentricity on the head bearings and on the strut joints.

Table B.1 — Max Forces at different angles

Max θ = 90°			
	S/Q	***V/Q***	***H/Q***
90°	0	0	0
80°	+ 0,52	+ 0,09	+ 0,51
70°	+ 1,03	+ 0,35	+ 0,96
60°	+ 1,50	+ 0,75	+ 1,30
50°	+ 1,93	+ 1,24	+ 1,48
45°	+ 2,12	+ 1,50	+ 1,50
40°	+ 2,30	+ 1,76	+ 1,48
30°	+ 2,60	+ 2,25	+ 1,30
20°	+ 2,82	+ 2,65	+ 0,97
10°	+ 2,96	+ 2,91	+ 0,51
0°	+ 3,00	+ 3,00	0
Max θ = 120°			
	S/Q	*V/Q*	*H/Q*
120°	- 0,50	+ 0,25	- 0,43
110°	- 0,03	+ 0,01	- 0,02
100°	+ 0,48	- 0,09	+ 0,47
90°	+ 1,00	0	1,00
80°	+ 1,52	+ 0,27	+ 1,50
70°	+ 2,03	+ 0,69	+ 1,90
60°	+ 2,50	+ 1,25	+ 2,16
50°	+ 2,93	+ 1,88	+ 2,24
40°	+ 3,30	+ 2,53	+ 2,12
30°	+ 3,60	+ 3,11	+ 1,80
20°	+ 3,82	+ 3,59	+ 1,31
10°	+ 3,96	+ 3,90	+ 0,69
0°	+ 4,00	+ 4,00	0
Max θ = 180°			
	S/Q	*V/Q*	*H/Q*
180°	- 1,00	+ 1,00	0
170°	- 0,96	+ 0,94	- 0,17
160°	- 0,82	+ 0,77	- 0,28
150°	-0,60	+ 0,52	- 0,30
140°	- 0,30	+ 0,23	- 0,19
130°	+ 0,07	- 0,05	+ 0,05
120°	+ 0,50	- 0,25	+ 0,43
110°	+ 0,97	- 0,33	+ 0,92
100°	+ 1,48	- 0,26	+ 1,46
90°	+ 2,00	0	+ 2,00
80°	+ 2,52	+ 0,44	+ 2,48
70°	+ 3,03	+ 1,04	+ 2,84
60°	+ 3,50	+ 1,75	+ 3,03
50°	+ 3,93	+ 2,53	+ 3,01
40°	+ 4,30	+ 3,29	+ 2,76
30°	+ 4,60	+ 3,98	+ 2,30
20°	+ 4,82	+ 4,53	+ 1,65
10°	+ 4,96	+ 4,88	+ 0,86
0°	+ 5,00	+ 5,00	0

B.1.4 Motor driven swings

For motor-driven swings, a different approach for calculating the dynamic forces (e. g. driving forces, braking forces, angular speed and angular acceleration and max. angle) shall be performed.

B.2 Ferris wheels

B.2.1 Loads

The spoke frames of a Ferris wheel consisting of n sectors shall be calculated in respect of the loads depicted in Figure B.2.

Formulae (B.11) to (B.14) only apply to slow moving devices with small gondola swing angles. Confirmation should be provided either by calculation (solving the differential equation of gondola swing motion) or by verification at the ride.

$$Q_{\varphi} = \varphi \ (G_{\mathrm{g}} + P) + G_{\mathrm{R}} \tag{B.11}$$

$$Q = G_{\mathrm{g}} + P + G_{\mathrm{R}} \tag{B.12}$$

$$Q_{\mathrm{r}} = \frac{Q}{g} \omega^2 \ R \tag{B.13}$$

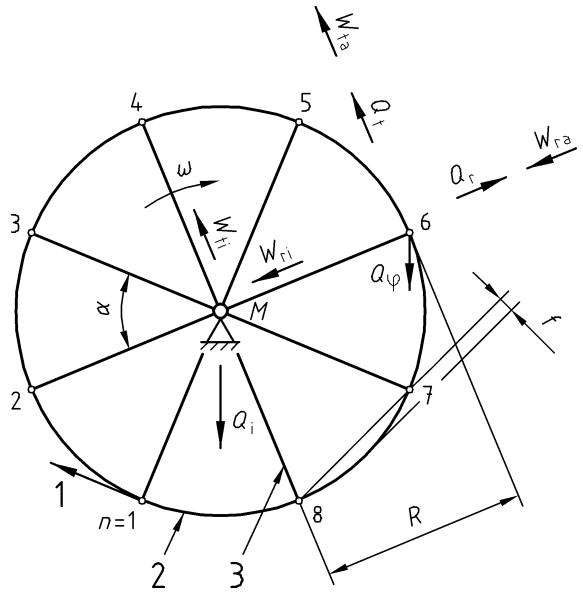
$$Q_{\mathrm{r}} = \frac{Q}{g} \varepsilon \ R \tag{B.14}$$

where

f = 1,2 (impact factor);

G_{g} is the dead load of one gondola including suspension;

P is the imposed load in a fully occupied gondola.



Key

1 Driving Force

2 Rim Bar

3 Spoke

Load illustrated only at point i = 6.

Figure B.2 — Ferris wheel with n = 8 sectors

In Figure B.2:

G_R is the pro rata load of wheel attributable to one gondola;

Q_i is the pro rata internal load of spoke at the hub;

g is the gravitational constant;

ω is the angular velocity of wheel;

R is the wheel radius;

$\varepsilon = \frac{\omega}{t}$ (angular acceleration of wheel);

t is the start-up or slowing down time of the wheel, to be calculated on the basis of the drive and brake selected;

W_{ta} is the wind load in tangential direction of the wheel, arising from the gondola and the share due to the outer half of the spoke;

W_{ti} is the wind load in tangential direction of the wheel arising from the share due to the inner half of the spoke;

W_{ra} is the wind load in radial direction of the wheel, arising from the gondola, the rim bars and the share due to the spoke;

W_{ri} is the wind load in radial direction of the wheel, arising from the share due to the spoke.

The forces arising from driving or braking, which are in equilibrium with the wheel about point M, shall be applied and derived at the point of origin, for example, in the case of a drive at the shaft, the bending moment shall be

applied in the spokes and the torsional moment shall be applied in the shaft, whilst in the case of a friction wheel drive, the contact pressure and the tangential friction force shall be applied to the rim bar.

All input loads shall be multiplied by the appropriate safety factor as defined in 5.3.6.2 with the exception of calculations involving overturning, sliding and lifting.

B.2.2 Dominant loading cases

— Loading case a: Full occupancy

  All the gondolas of the Ferris wheel are fully occupied. This results in the greatest stresses in the rim bars.

— Loading case b: Partial occupancy

  b1: The one-sided loading of the Ferris wheel shall be assumed to consist of only two adjacent fully occupied gondolas.

  b2: One-sided loading shall be assumed to consist of two adjoining empty gondolas, with the remaining gondolas occupied.

— Loading case c: Centrifugal force Q_r

— Loading case d: Load effective when starting up or slowing down Q_t

— Loading case e_1: Wind load parallel to wheel

— Loading case e_2: Wind load perpendicular to the wheel

If more than two gondolas are to be run fully loaded on one side of the wheel, this shall be allowed for in the calculation.

B.2.3 Calculation

The bar forces on the spokes and rim bars of the Ferris wheel shall, as a general rule, be determined in accordance with the theory of elasticity (truss with one statically indeterminate member). For this purpose, the spokes shall be assumed to be attached at the centre point of the shaft. For all loading cases loads resulting from the drive (or from the braking) derived from realistic assessment of these forces shall be adopted.

The forces Q_r, Q_t, W_r and W_t may be considered insignificant in relation to Q if

$$\left(Q_r \le \frac{Q}{5}, Q_t \le \frac{Q}{10}, \sqrt{W_{ta}^2 + W_{ra}^2} \le \frac{Q}{4} \right)$$

The first two conditions may be assumed to be satisfied if Tables B.2 and B.3 are complied with. If all three conditions are satisfied then the rim bar and spoke forces may be taken from Table B.4.

Table B.2 — Maximum allowable rotational speed to meet condition $Q_r \leq Q/5$

Wheel Diameter metres	**Maximum Speed,** n_r^* rpm
4	9.5
6	7.7
8	6.7
10	6
12	5.5
14	5.1
16	4.7
18	4.5
20	4.2
25	3.8
30	3.5
35	3.2
40	3

When a wheel operates at the limiting speed n_r^* tabulated above the shortest permissible braking (or accelerating) distance is one radian for all wheel diameters.

Table B.3 — Minimum allowable braking (or accelerating) distance, i. e. a rotation angle to meet condition $Q_t \leq Q/10$

Speed Ratio n_r/n_r^*	**Minimum Braking Distance radians**
1,0	1,00
0,9	0,81
0,8	0,64
0,7	0,49
0,6	0,36
0,5	0,25
0,4	0,16

In Table B.3 n_r is the maximum operation speed.

If not using the table the following formulae can be used for the calculation of the spoke frames for Ferris wheels with n sectors.

They are valid for loads Q = 1.

Further prerequisites: the modulus of elasticity shall be the same for all bars.

In formulae (B.15) to (B.28):

A_s is the cross sectional area of spoke, to be identical for all spokes;

A_k is the cross sectional area of a rim bar, to be identical for all rim bars;

I_k is the second moment of area (moment of inertia) of a rim bar, to be identical for all rim bars;

(n) is the subscript designating an arbitrary nodal point of the Ferris wheel with n sectors;

α is the central angle included between two adjoining spokes (to be identical for all spokes);

S_{OS} or S_{OK} are the bar forces on the statically indeterminate system in the spokes or in the rim bars as a result of $Q_1 = 1$, $Q_2 = 1$ ... $Q_n = 1$;

S_{1S} or S_{1K} are the bar forces on the statically determinate system in the spokes or in the rim bars as a result of $X_1 = 1$.

$$f = R\left(1 - \cos\frac{\alpha}{2}\right) \quad \text{(height of arc above chord)} \tag{B.15}$$

$$c' = \frac{A_S}{A_K} \tag{B.16}$$

$$c'' = \frac{A_S}{I_K} \tag{B.17}$$

$$S_{1s} = -2\sin\frac{\alpha}{2} \tag{B.18}$$

$$S_{1K} = +1 \tag{B.19}$$

$$\max M_{1K} = R\left(1 - \cos\frac{\alpha}{2}\right) \tag{B.20}$$

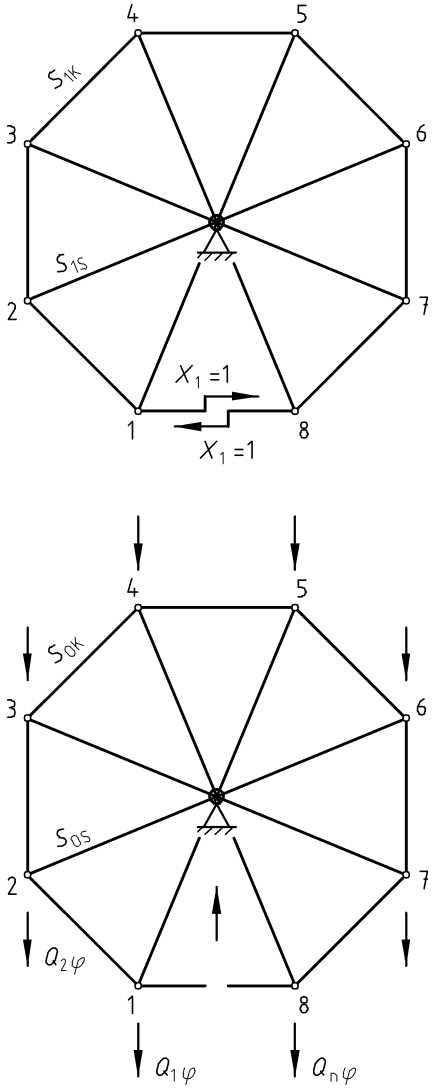


Figure B.3 — Statically determinate basic system of a Ferris wheel with n = 8 sectors (polygonally arranged)

For polygonally arranged rim bars, we have $M_{1K} = 0$. For the wheel with n sectors, we obtain the following relationships for the condition $X_1 = 1$:

From the normal force:

$$\frac{E\,A_S}{R}\,\delta_{11}^{N} = 2\,n\,\sin\frac{\alpha}{2}\times\left(2\sin\frac{\alpha}{2}+c'\right) \tag{B.21}$$

and from the moment:

$$\frac{E\,A_S}{R}\,\delta_{11}^{M} = n\;c''R^2\left(\frac{\alpha}{2}+\alpha\cos^2\frac{\alpha}{2}-3\sin\frac{\alpha}{2}\cos\frac{\alpha}{2}\right) \tag{B.22}$$

for polygonally arranged rim bars we have:

$$\frac{E\,A_S}{R}\,\delta_{11}^{M} = 0 \tag{B.23}$$

$$\frac{E\,A_S}{R}\,\delta_{10} = 2\sin\frac{\alpha}{2}\,(c'\sum_1^n S_{OK} - \sum_1^n S_{OS}) \tag{B.24}$$

The statically indeterminate quantity then becomes:

X_1 from $Q_1 = 1$, $Q_2 = 1$ ... $Q_n = 1$

$$X_1 = -\frac{\frac{E\times A_S}{R}\,\delta_{10}}{\frac{E\times A_S}{R}\,\delta_{11}^{N} + \frac{E\times A_S}{R}\,\delta_{11}^{M}} \tag{B.25}$$

Final stress resultants on the statically indeterminate system for a Ferris wheel with n sectors, with two spoke frames from loading Q:

$$\text{spokes}: \quad S_S = \frac{Q_\varphi}{2}\left(S_{OS} + X_1 \times S_{1S}\right) \tag{B.26}$$

$$\text{rim bars}: \quad S_K = \frac{Q_\varphi}{2}\left(S_{OK} + X_1 \times S_{1SK}\right) \tag{B.27}$$

$$\max M_{1K} = S_K\; R\left(1 - \cos\frac{\alpha}{2}\right) \tag{B.28}$$

$M_k = 0$ in the case of polygonally arranged rim bars. The maximum bar forces are featured in the table below for polygonally arranged Ferris wheels, for $c' = 0{,}2$ to $3{,}0$, for loading case $Q_n = 1$ and $n = 6$ to 36.

The bar forces in one of the 2 plane frames of spokes and rim bars shall be calculated by multiplying the values of the Table B.4 by $Q_f/2$.

Table B.4 — Maximum spoke and rim bar forces

Number of sectors, *n*	**6**	**8**	**10**	**12**	**14**	**16**	**18**	**20**	**24**	**28**	**32**	**36**
Spokes	± 2,00	± 2,00	± 2,00	± 2,00	± 2,00	± 2,00	± 2,00	± 2,00	± 2,00	± 2,00	± 2,00	± 2,00
Rim bars	± 1,15	± 1,41	± 1,70	± 2,00	± 2,30	± 2,61	± 2,92	± 3,24	± 3,86	± 4,49	± 5,13	± 5,76

In Table B.4 + signifies tension and – signifies compression.

In conventional Ferris Wheels the gondolas are supported between two plane frames of spokes and rim bars. In this case the frames may be assumed to share the loads taken from Table B.4 and the individual spoke and rim bar forces will be halved.

If the rim bars are curved then bending moments may need to be checked assuming the rim bar force acts along the line joining the points of connection to the spokes.

The influence on the spokes and rim bars of wind acting at right angles to the spoke frame shall be verified by calculation (proportion of wind load per spokes arising from the gondolas, spoke, rim bars and any fairings which may be fitted).

In the case of the spokes and rim bars, the bending influence from the self weight and from any other loads which may be present shall also be taken into account.

If the drive and braking are applied on one spoke frame only, the effect on the wheel resulting from such an arrangement shall be checked.

B.2.4 Erection

The erection procedure of the wheel shall be verified by calculation. If for example the wheel is erected in such a way that the last rim bar is inserted at the bottom, then the ring of rim bars shall be pushed apart so that it will be subjected to the compressive force which results from the statically indeterminate calculation with the existing loads.

B.2.5 General indications

The sum of all the externally acting forces shall be led off via the support structure, and the verification of safety against overturning and of resistance of sliding shall be carried out, firstly under operating conditions with a wind load in accordance with 5.3.3.4.2 (wind load under operating condition) acting on the wind application area which may in some cases have been enlarged by the imposed load, and secondly in the inoperative condition (condition at rest, without imposed load), with a wind load in accordance with 5.3.3.4.1, column 2 of Table 1. The wind shall be assumed to act parallel to the spoke frame in a first loading case calculation, and at right angles to the spoke frame in a second calculation.

The safety against overturning and resistance to sliding of the structure shall be verified for both the above loading cases.

If necessary, the safety against overturning and resistance to sliding shall also be verified for the erection condition. Because the spokes cannot, as a general rule, be attached to the centre point of the shaft (which is the assumption in the calculation), the spoke frame represents an unstable system, i. e. the hub is capable of accomplishing a finite twisting motion against a wheel held stationary, until a stable position has been attained.

In order to prevent this kind of wear, the spokes should be attached to the hub in such a way (e. g. by clamping) that any relative twisting of the hub is prevented.

If tension members are used as spokes, the influence of the tension member sag on the wheel shall be assessed.

When calculating the effect of the wind at right angles to the spoke frame, it shall be borne in mind that the total wind load of the wheel acts on one single bearing only, unless a load distribution onto both bearings is ensured beyond any doubt by virtue of the axle and bearing design. As regards the verification of safety against overturning, the overturning of the complete structure shall only be calculated if there is a possibility of the complete structure tilting about one axis or one fulcrum. If for example support trestles are likely to tilt individually, the verification of safety against overturning shall be carried out for reach support trestle on its own.

In the case of slanting supports subjected to compression, the moment arising from the compression force multiplied by the sag shall be taken into account.

The influence on the gondola suspension of a gondola occupied by passengers on one side only, coupled with a wind load, shall be taken into consideration.

B.3 Chair-O-Planes and suspension roundabouts

The centrifugal forces on flyer and suspension roundabouts with a vertical rotational axis shall be calculated as follows:

$$H_{FL} = \frac{m\,v^2}{R + a} = Q' \times \tan\,\alpha \qquad \text{(B.29)}$$

$$m = \frac{Q'}{g} \qquad \text{(B.30)}$$

$$v = \frac{\pi\, n\,(R + a)}{30} \tag{B.31}$$

where $a = l \sin \alpha$ as a function of v is an unknown quantity for the present. Equation (B.32) below shall be used to determine α (see Figure B.4):

$$q = \cos \alpha + \frac{R}{l} \cot \alpha \tag{B.32}$$

where

$$q = \frac{894}{l \times n^2} \quad \text{with } l \text{ in m and } n \text{ in rpm} \tag{B.33}$$

In formulae (B.28) to (B.33):

Q' is the dead load of gondola including imposed load;

l is the length of pendulum;

R is the radius as shown in Figure B.5 a, b;

n is the rotational speed;

a is the excursion amplitude of the gondola;

α is the angle of swing in relation to the vertical;

v is the peripheral speed of the gondola;

m is the mass of gondola including imposed load;

H_{FL} is the centrifugal force produced in a gondola;

g is the gravitational constant.

All input loads shall be multiplied by the appropriate safety factor as defined in 5.3.6.2 with the exception of calculations involving overturning, sliding and lifting.

Instead of solving the above equation, the angle of swing can be determined as a function of the rotational speed with the aid of Figure B.4.

Suspension components (e. g. four chains, four ropes, four rods) for the seats of gondolas and the fasteners associated therewith shall be sized in such a way that each suspension component is capable of absorbing half the resultant force from H_{FL} and Q'.

The locking devices (rope) shall also be calculated in respect of the resultant from H_{FL} and Q' in the case of chains, the force from the chain pull shall be taken into account. The locking device shall not be fastened to the suspension components.

In the case of smaller chain Chair-O-Planes it will suffice to assume an angle of swing $\alpha = 45°$ ($H_{FL} = Q'$), in so far as no more accurate assessments have been made. If two seats are attached next to one another on one and the same outrigger, an angle of swing $\alpha = 45°$ may be assumed by way of simplification for both seats.

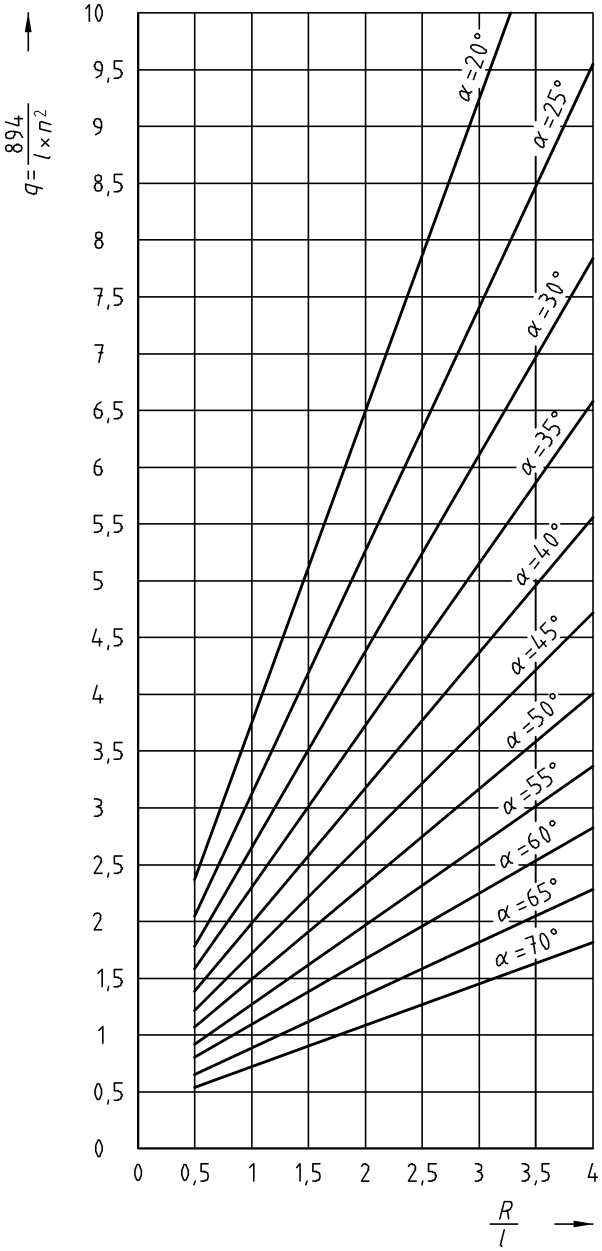


Figure B.4 — Graph for the determination of the angle of swing α

For children's roundabouts with suspended figures of animals and the like, it will suffice to assume an angle of swing α = 30° (H_{FL} = 0,5 Q') if more accurate assessment is not made.

The moment of the vertical and horizontal loads about point A (foot of the mast) is:

$$M_A = c_1 P(R + h \tan \alpha) + (H_w h_w - V_w x) \quad \text{(B.34)}$$

A one-sided imposed load at the maximum rotational speed is the value to be used for the determination of the safety against overturning in the operating condition. The wind load shall be assumed as acting in the most unfavourable direction.

The moments about the tilting axis k-k or k'-k' are as follows.

The overturning moments including the safety factor γ (see Table 2) is:

$$M_{K\gamma} = 1{,}3\,[P\,c_1\,(R + h \tan \alpha) - P\,c_2\,e] + 1{,}2\,[H_w\,h_w - V_w\,(x + e)] \quad \text{(B.35)}$$

$$M_{K'\gamma} = 1{,}3\left[P\,c_1\,(R + h\tan\ \alpha) - P\,c_2\,\frac{e}{\sqrt{2}} \right] + 1{,}2\left[H_w\,h_w - V_w\left(x + \frac{e}{\sqrt{2}} \right) \right] \quad \text{(B.36)}$$

Stability moment:

$$M_{St} = \sum \overline{G}\,e \quad \text{(B.37)}$$

$$M'_{St} = \sum \overline{G}\,\frac{e}{\sqrt{2}} \quad \text{(B.38)}$$

As far as $\overline{G}$ is concerned, only the minimum mass which can be assumed safely to exist at all times shall be entered in the equation (wood in the fully dried out state).

The relationships $M_{St} \geq M_{K\gamma}$ and $M'_{St} \geq M'_{K\gamma}$ shall be attained.

If there are 18 or more seats uniformly arranged around the periphery, an adequate safety against overturning may be a determinant factor under certain conditions.

In such cases, a further verification shall be carried out with:

$$\max M_{K\gamma} = \left[P c_3 \left(R + h\tan\alpha\right) - P c_4\ e \right] + 1{,}2\left[H_w\,h_w - V_w\left(x + e\right) \right] \quad \text{(B.39)}$$

$$\max M'_{K\gamma} = \left[P c_3 \left(R + h\tan\alpha\right) - P c_4\,\frac{e}{\sqrt{2}} \right] + 1{,}2\left[H_w\,h_w - V_w\left(x + \frac{e}{\sqrt{2}} \right) \right] \quad \text{(B.40)}$$

c_3 and c_4 are coefficients analogous to c_1 and c_2 but relating to a one-sided load on one half of the periphery, and any seats which may be situated at the edge of the sector shall be assumed to be empty in this context.

The relationships $M_{St} \geq M_{K\gamma}$ and $M'_{St} \geq M'_{K\gamma}$ shall be attained. If

$$\frac{M_{St}}{M_{K\gamma}} \quad \text{or} \quad \frac{M'_{St}}{M'_{K\gamma}} < 1 \quad \text{(B.41)}$$

for one sided 1/4 occupation at the periphery, then additional precautions shall be taken, e. g. counterweights shall be fitted or anchorages provided. If ground anchors are fitted at the ends of the base cross, the tensile force Z to be absorbed will be (see Figure B.5):

$$Z_v = \frac{M_{K\gamma} - M_{St}}{z} \quad \text{(B.42)}$$

or

$$Z_v = \frac{M'_{K\gamma} - M'_{St}}{2\,z'} \quad \text{(B.43)}$$

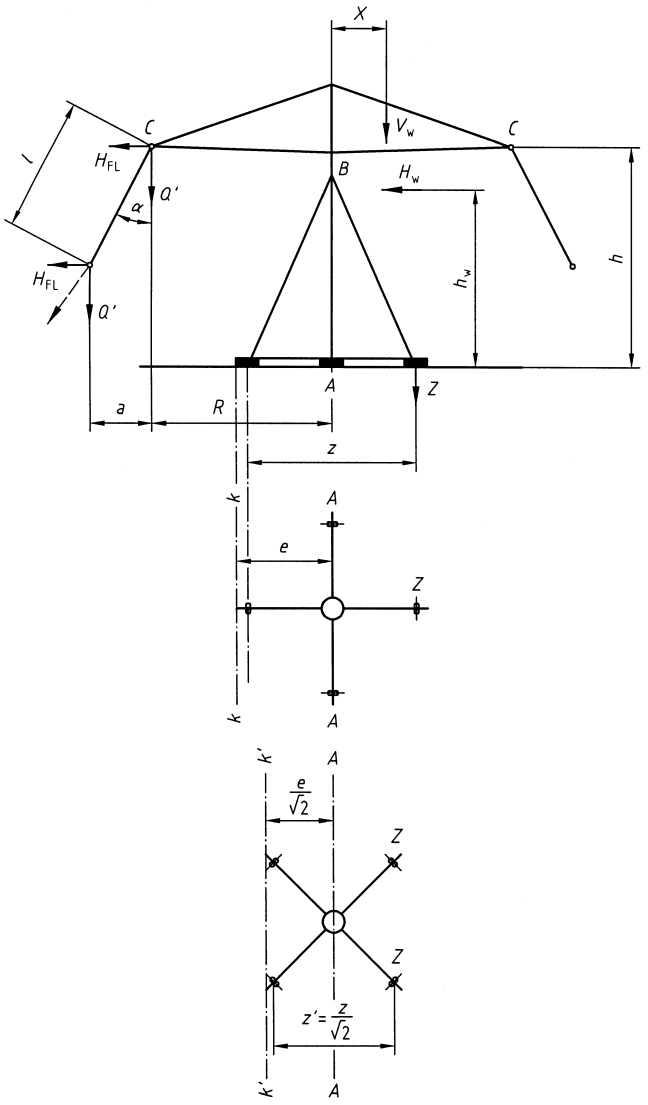
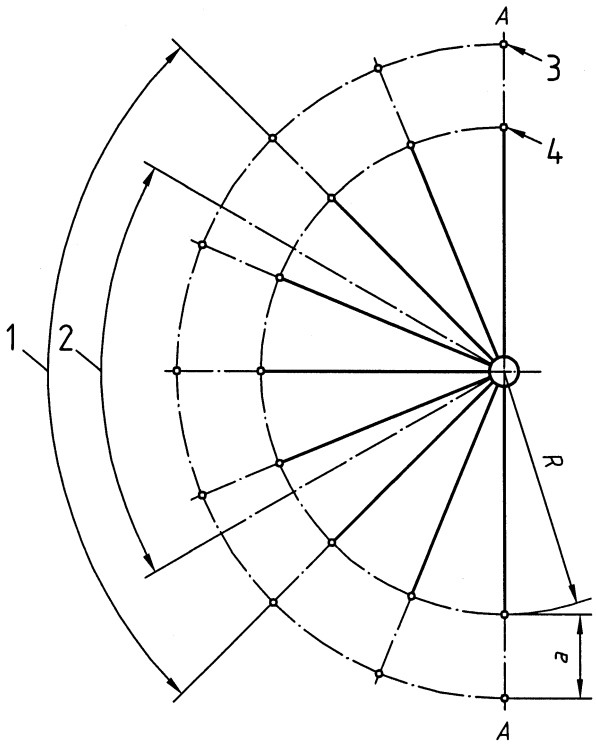


Figure B.5a — Flyer roundabout (side view)



Key
1 90 ° in accordance with 5.4.2.1
2 60 ° in accordance with 5-4-2-1
3 Gondola at maximum angle of swing
4 Suspension

Figure B.5b — Flyer roundabout (top view)

The relationship $Z_d \geq Z$ shall be attained.

In Figures B.5a and b and Table B.5

Z_d see 5.5.2;

G' is the dead load of one gondola including suspension;

ΣG is the dead load of all the permanently present individual components acting on the supports;

P is the imposed load of one gondola;

Q' = G' + P;

h is the distance of suspension point C of the gondola from floor level;

c_1 is the coefficient which takes the position of the occupied gondolas into account, for 1/4 or 1/6th of the periphery;

c_2 is the coefficient which takes the number of occupied gondolas into account (in the case of one-sided loading of 1/4 or 1/6 of the periphery);

H_w is the sum of the horizontal wind loads;

h_w is the distance of H_w from floor level;

V_w is the sum of the vertical wind loads;

x is the distance of V_w from mast centreline;

Z is the anchor tensile force due to the overturning moment (including safety factors of Table 2), at the most highly stressed anchorage point;

e is the distance of tilting axis from mast centreline.

Table B.5 — Coefficients c_1 and c_2 in the case of one-sided loading

Total number of gondolas		4	6	8	10	12	14	16	18	20	22	24
1/4 or 3/4	c_1	1,411	1,732	2,414	2,618	3,346	3,514	4,262	4,412	5,172	5,310	6,078
of periphery	c_2	2	2	3	3	4	4	5	5	6	6	7
1/6	c_1	1,0	1,732	1,848	1,902	2,732	2,802	2,848	3,702	3,757	3,799	4,664
of periphery	c_2	1	2	2	2	3	3	3	4	4	4	5

Table B.6 — Coefficients c_3 and c_4 in the case of one-sided loading

Total number of gondolas		18	20	22	24	26	28	30	32	34	36	38
1/2	C_3	5,76	6,39	7,03	7,66	8,30	8,93	9,57	10,20	10,84	11,47	12,11
of periphery	C_4	9	10	11	12	13	14	15	16	17	18	19

B.4 Roundabout with floor (suspended floor and turntable roundabouts)

These roundabouts have a floor which rotates together with the superstructures.

The rotating floor (turntable) may either be suspended from outriggers or be mounted on a slewing gear.

The loading in accordance with 5.3.3.1.2.2 shall also be entered in the calculation for a one-sided floor sector with a central angle α = 90° or 270°.

The distance of the centre of gravity from the vertical rotational axis, for a central angle of 90° is:

$$a_s = 0{,}60\,\frac{R_a^3 - R_i^3}{R_a^2 - R_i^2} \qquad \text{(B.44)}$$

R_a and R_i are the outer and inner radii of the rotating floor. For roundabouts, the seats of which are supported on outriggers located at the bottom, the bending moments generated by eccentrically acting centrifugal forces shall be taken into account not only in the mast itself but also in these outriggers.

B.5 Motor-driven vehicle attractions

B.5.1 Motor-driven vehicle attractions with carriageways for unidirectional driving (e. g. car racing tracks, multi storey car tracks, go-cart tracks, motor scooter tracks)

B.5.1.1 Carriageways

The carriageway slopes shall be designed to accommodate the radii of the bends and the maximum vehicle speed. Longitudinal and transverse gradients shall not exceed values which would cause braked vehicles to skid or slide on a wet carriageway.

The carriageway shall not exhibit any humps likely to cause the wheels to lift off.

In the region of the station, the carriageway shall not exhibit any slopes. The carriageway surfacing shall be manufactured in such a way, and the carriageway itself shall be dimensioned in such a way that no unacceptable vibrations and shocks can occur.

The sag of the carriageway shall not exceed 1/500 of the span.

B.5.1.2 Carriageway crash barriers

The carriageway shall be provided with carriageway crash barriers on the sides.

The collision load shall be determined in accordance with 5.3.3.7 for α not less than 30°.

B.5.1.3 Carriageway supporting

When sizing the carriageway support frameworks, the starting, raking and centrifugal forces shall be taken into consideration as horizontal forces by the provision of appropriate bracings or frame structures. Unless a more accurate assessment is carried out, 30 km/h shall be used as the maximum speed of the vehicles in the calculation of the action of the force.

The carriageway support frameworks are structures subjected to oscillating stresses; therefore the fatigue strength is to be verified.

B.5.1.4 Vehicles

The vehicles shall be designed and calculated in such a way that the forces arising during operation (e. g. the braking forces), the forces resulting from ramming or collisions, and the contact pressure exerted by the passengers on the vehicles (seat, arm rests, back rest, front panel, steering wheel) can all be absorbed.

The fenders equipped with springs and damping devices, which are provided for the collision, shall be designed and sized in such a way the maximum forces acting on the passengers remain acceptable.

The fenders on all the vehicles used on a carriageway shall exhibit the same height and shall be matched to the height of the carriageway crash barriers.

B.5.1.5 Imposed loads

The imposed loads on the carriageway shall consist of the fully-loaded vehicles arranged next to one another and behind one another in the most unfavourable position. In this context, any wheel loads which might exert a load-relieving effect shall be ignored.

All structural components shall also be calculated for an additional loading case, which is a uniformly distributed imposed load p = 2 kN/m^2, and 3,5 kN/m^2 in the station zone.

The more unfavourable of these two values shall be used for dimensioning purposes.

B.5.2 Driving installations with arbitrary directions of driving (dodgem cars)

B.5.2.1 Roof structure

Apart from the dead loads and wind loads, the roof structure of the dodgem cars shall absorb the prestressing forces of the electric network.

If a more precise assessment is not made, a force of 0,3 kN/m shall be assumed for this purpose.

The supports of the roof structure may be attached to the carriageway structure and the latter may be partially used to absorb lifting-off forces from the supports. They shall be effectively protected against collision from the vehicles by structural measures.

B.5.2.2 Surface of carriageway

The surface of the carriageway of dodgem cars shall be laid without gaps between joints.

The slabs shall be dimensioned for a uniformly distributed loading of 3,5 kN/m^2 and in a second calculation procedure, for the most unfavourable wheel loads on a fully occupied carriageway surface.

The slabs shall rest at the edges on the longitudinal and/or transverse girders and be prevented from moving.

The sag of the slabs shall not exceed 1/500 of the span.

B.5.2.3 Carriageway crash barriers

The collision load shall be determined in accordance with 5.3.3.7 for $\alpha = 90°$.

B.5.2.4 Supporting structure

The timber packing positioning of the longitudinal and transverse girders shall be marked on the drawings. Their spacing shall be determined in such a way that the calculated sag of their girders does not exceed 1/500.

The stairs and platforms of autoscooter installations shall be calculated for a uniformly distributed loading of 5 kN/m^2.

B.5.2.5 Vehicles

B.5.1.4 shall apply as appropriate.

B.6 Steep wall tracks

Steep wall tracks shall be calculated for the operational loading, as well as from the loads specified in 5.3.

As far as the operational loading is concerned, the nature of the displays, the number of vehicles operating at the same time, and their most unfavourable position in relation to each other shall be taken into account. If no special measurement values are available, the centrifugal force can be entered as follows in the calculation: not less than four times the mass of the vehicle (including driver), for two-wheeled vehicles; not less than three times the mass of the vehicle (including driver), for four wheeled vehicles. Steep wall tracks shall be roofed over sufficiently to provide total protection of the track against the weather.

The top rim of the track shall be provide with a boundary designed to prevent the vehicles from travelling over the edge of the track and crashing into the spectators enclosure (e. g. by means of a steel wire rope of not less than 13 mm diameter running right around the periphery).

The distance from the surface of the track to this boundary wire rope shall be not less than 60 cm radially inwards.

B.7 Globes

Globes shall be erected inside or under the roof structure in such a way that their tracks are completely sheltered from the weather.

Globes shall be calculated for the operational loading, in addition to the calculation for the loads specified in 5.3, and for this purpose, the most unfavourable combination arising from the type, number and position of the vehicles used shall be adopted. The fencing enclosure for the spectators shall have a diameter at least 2 m greater than the diameter of the globe.

B.8 Installations for artistic aerial displays

A verification in accordance with 5.1.4 shall be carried out of the frames, support wires, ropes and anchorages of high wire installations, and also the supporting masts of swing mast installations. Because the carrying wire rope (travel rope or walking rope) of high wire installations is frequently attached to existing structures at one end, and sometimes at both ends, the various possible types of construction of the attachments shall be illustrated and verified by calculation in the technical documents, as well as a specification of the attachment force.

All the display acts shall be described in the technical documents, and the most unfavourable loadings shall be deduced therefrom, on the basis of which strength and stability are to be verified.

So-called swing masts mounted on supporting masts regularly exceed the permissible slenderness ratio and cannot therefore be calculated in respect of safety against buckling.

In order to secure the swing mast against failure, a steel wire rope of 6 mm diameter at least shall be threaded through the hollow interior of the swing mast, and tied to the upper ends of the swing mast and of the supporting mast.

B.9 Rotors

Uniformly distributed loads and partial loadings shall be taken into account for rotors.

The cylinder of the rotor shall be calculated for a one-sided imposed load on one quarter or three quarters of the periphery; in addition to the self weight of the cylinder, a uniformly distributed imposed load of p_v = 1,2 kN/m, distributed around the periphery, shall be assumed.

In addition, the loading case which involves two loaded quadrants situated opposite one another with the remaining two quadrants unloaded, shall also be calculated.

The centrifugal force generated by the passengers may be assumed to act at a height of 1,2 m above the highest position of the bottom of the cylinder, and it shall be entered in the calculation at the value resulting from the rotational speed concerned. If the symmetry of the supporting wall is interrupted for example by door openings, the influences of these shall be verified. Similarly, the influence of supporting wheels or guide wheels shall be verified if necessary.

The floor shall also be calculated for a loading case in which the total number of passengers admitted crowded together on a floor sector with a central angle α = 120°. The locking devices and fastenings of the cylinder doors shall also be checked by calculation.

B.10 Toboggans

Apart from dead and wind load, toboggans shall be calculated for the following imposed loads:

— area of inclined elevator conveyor belt: 2,0 kN/m^2;

— upward slopes, steps, platforms: 5,0 kN/m^2;

— for each chute: 1,5 kN/m;

— simultaneous horizontal loading on the upper edge of the chute (outer side of curve): 0,25 kN/m

B.11 Rolling barrels

Rolling barrels shall only be calculated for an imposed load of 2,5 kN/m, (this corresponds to a load per unit area of 2,5 kN/m^2, if one assumes a walked-over width of 1 m). The stability of the rolling barrel shall be verified for the case in which this loading is situated on the side wall at midpoint height.

If the support rollers are more than 1/5 of the length away from the end of the barrel, the stability shall also be verified in relation to a transverse axis.

B.12 Travelling platforms

Travelling platforms shall be calculated for an imposed load of 3,5 kN/m^2.

In addition to full load, they shall be verified in respect of the most unfavourable part loading; in particular, the portions which project beyond their supports shall be assumed to be loaded. The stability of these shall also be verified.

Balustrades and railings of travelling platforms shall be calculated for a horizontal lateral force of 1,5 kN/m at handrail height.

B.13 Turntables

Turntables shall be verified, in addition to the dead load, for an imposed load of 3,5 kN/m^2 in the stationary state, and for an imposed load of 2,0 kN/m^2 in operation at maximum rotational speed. These loads shall also be assumed to act asymmetrically on a floor sector with a central angle of 90°.

The fixed floors surrounding the turntables shall be calculated for an imposed load of 5 kN/m^2.

The catcher cushions for the people sliding off the turntable shall be calculated for a horizontal concentrated load of 2,5 kN at the most unfavourable spot, or for a uniformly distributed horizontal loading of 2 kN/m.

Annex C
(normative)

Examination forms

C.1 Thorough examination form

Below is a format showing the minimum particulars to be included in the report on thorough examination of an amusement device.

Name of owner.

Address.

Name of operator.

Address.

Type and name of device.

Identification number and date of initial approval.

Are all parts of the device so far as ascertainable without disassembly

a) of good sound material and

b) properly maintained and in good working order?

State under "Conclusions" any observations which require design modification, amendments to calculation, attention or permanent observation or any other compulsory action. State also any other defects which require attention or permanent observation or action.

Maximum safe working speed and operational limits of device (if applicable).

Other observations.

What features of the device were tested during this examination?

Statement

I/we certify that on ..... I/we thoroughly examined this amusement device at ..... and that the foregoing is a correct report of that examination.

Signature:

Qualification:

Address:

Organization:

Date:

C.2 Initial examination form

Below is a format showing the minimum particulars to be included in the report on initial (or after modification and repair) examination and test of an amusement device are as follows:

Name of owner;

Address;

Type and name of device;

Identification number and date of initial approval.

Date of manufacture.

Date and place of examination and tests.

Statement of the different methods, investigations, inspections and tests used to approve the device (this statement shall include test speeds, operational features, specific details of tests such as magnitude and arrangement, all measurements and recordings (i. e. time, temperature, weather conditions, speeds, accelerations, pressures, etc.) testing and application of safety systems including any control systems, braking systems and emergency provisions).

What parts or systems (if any) could not be submitted to test and for what reason?

Indicate whether this is an initial test or a test and examination following repair or modification.

State under "Conclusions" any observations which require design modification, amendments to calculation, attention or permanent observation or any other compulsory action.

Other observations.

Maximum safe working speed and operational limits of device (if applicable).

Statement

I/we certify that on ..... I/we approved this amusement device at ..... and that the foregoing is a correct report of that approval.

Signature:

Qualification:

Address:

Organization:

Annex D
(normative)

Electrical equipment and Control systems

D.1 Electrical equipment

D.1.1 General

The requirements set out in this annex of the standard are those which minimise risk of electrical shock, burn, arcing and explosion.

The electrical installation shall comply with all parts of EN 60204-1 except where extended or modified by the following clauses.

D.1.2 Protection class of equipment

The protection class of equipment, such as outlet boxes, joint connectors, cable glands, etc., shall either be less than IPX4 in closed rooms or protected from direct atmospheric precipitations and to IP65 outdoors.

D.1.3 Sliding contacts

Sliding contacts, for example slip rings, live rails and pick-ups, shall be protected to a minimum of IP2X with the following exception:

— 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 D.C. with a maximum of 10 % ripple without protection against direct contact.

— Dodgem cars if the requirements of 6.2.4.1.6 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.

D.1.4 Earthing systems

The earthing system shall be implemented in conformity with IEC 60364-4-41.

D.1.5 Protection against electric shocks

For transportable amusement devices, 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 by means of RCDs in TN and TT systems with a maximum leakage current ≤ 0,4 A 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.

Bonding conductors and bonding equipotential conductors shall be designed and installed in accordance with IEC 60364-5-54.

Moreover slotted, pinned, bolted or similar mechanical connecting methods on the rides and/or structure may be used to provide continuity of the bonding conductor, provided that these mechanical connectors do not contain any

insulating material. The conductivity of these parts of the ride and/or structure shall be verified on initial manufacture and, if necessary, an additional bonding conductor shall be provided. A rotating bearing shall not be used as the only method of bonding of adjacent conductive parts of the ride/structure which rotates. Where a slip ring is used to provide continuity of the protective conductor, then the ride/structure shall be bonded to the conductor at both ends of the slip ring.

D.1.6 Lightning protection measures

Lightning protection measure made necessary by local requirement shall comply with appropriate standards.

D.1.7 Lighting and emergency lighting

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.

All parts of the amusement 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.

In the case of devices deliberately designed to be operated in enclosed structures, emergency lighting should be provided which shall be installed to comply with the relevant standard (e.g. EN 1838).

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 which enable the public to see their way out safely.

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 intended to accommodate more than 30 persons. For non-enclosed exits and emergency areas an adequate number of portable emergency lights shall be available.

D.1.8 Overload and short circuit protection

The overload and short circuit protection systems shall be in accordance with HD 384.4.43S1 and HD 384.4.473S1.

D.1.9 Additional requirements for water rides

For situations where the use of a residual circuit breaker with Idn ≤ 0,030 A is impracticable e. g. where there is a large motor, it is acceptable to provide a unit with Idn 0,5 A provided that:

1) the equipment (e. g. a pump motor) is directly bonded to the metal frame and any water channel by a conductor with a minimum size in accordance with EN 60204-1; and

2) it is not possible for the public to gain direct access to the area around that equipment.

D.2 Control systems

D.2.1 General

This section of the standard applies to the design and manufacture of safety related control systems.

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

A safety related control system is a system that:

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

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

NOTE Due to the variety of the amusement devices the standard does not define specific SIL according to EN 61508-1:2002 or category according to EN 954-1:1996. The category is a result of the risk assessment process.

D.2.2 Relevant standards

EN 418, *Safety of Machinery — Emergency stop equipment functional aspects — Principles for design*.

EN 1050:1996, *Safety of machinery — Principles of risk assessment*.

EN 954-1, *Safety of machinery — Safety related parts of control systems — Part 1: General principles of design.*

EN ISO 12100-1, *Safety of machinery — Basic concepts, general principles for design — Part 1: Basic terminology, methodology (ISO 12100-1:2003)*.

EN ISO 12100-2, *Safety of machinery — Basic concepts, general principles for design — Part 2: Technical principles (ISO 12100-2:2003)*.

EN 60204-1, *Safety of machinery — Electrical equipment of machines — Part 1: General requirements (IEC 60204-1:1997)*.

EN 60947 (all parts), *Low voltage switchgear and controlgear*.

EN 61496-1, *Safety of machinery — Electro-sensitive protective equipment — Part 1: General requirements and tests (IEC 61496-1:1997)*.

prEN 61496-2, *Safety of machinery — Electro-sensitive protective equipment — Part 2: Particular requirements for equipment using active opto-electronic protective devices (IEC 61496-2:-)*.

D.2.3 Safety related control systems elements

D.2.3.1 General requirements

Control systems incorporating pneumatic, hydraulic and mechanical elements shall be in accordance with EN 954-1 and with the risk assessment conducted in accordance with EN 1050:1996, Table A.1.

Systems incorporating electrical, electronic and programmable electronic elements in addition shall comply with the requirements of IEC 61508 (all parts).

D.2.3.2 Low voltage switch gear and control gear

Low voltage switch gear and control gear and low-voltage switch gear combinations shall comply with the relevant parts of EN 60947 (all parts).

Positive-opening control switches with safety function shall meet the requirements of Annex K of EN 60947-5-1.

D.2.3.3 Electro-sensitive protective equipment (ESPE)

ESPE used for safety-related purposes shall comply with the relevant parts of EN 61496 (all parts) or have an adequate level of integrity achieved by other means.

D.2.4 Stop functions

If required – as a result of a risk assessment – the control systems shall have available the following stop functions: "operational stop function", "emergency stop" and "emergency switching off"; they shall be redundant or diverse. Stop functions shall have priority over the corresponding start functions.

The stop functions shall meet the following requirements:

— "stop function" as specified in 9.2.7.3 of EN 60204-1:1997;

— "emergency switching off" as specified in 9.2.5.4.3 of EN 60204-1:1997;

— "emergency stop" as specified in 9.2.5.4.2 of EN 60204-1:1997.

D.2.5 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.

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

— The control system shall control 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 control system shall perform a safety stop;

— If the speed of the device rises above the maximum operating speed, then the control system shall perform a safety stop.

The risk assessment shall evaluate the effects on the amusement device and passengers due to any achievable speeds. In general, if the maximum achievable speed is lower than or equal to the maximum operational speed, the control system does not require additional speed control circuits, but 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. Also if the machine does not reach, or falls below, the minimum operational speed, additional means may be needed to ensure that the minimum operational speed is achieved or a safety stop is performed. The need for, and the integrity, of these means shall be determined by risk assessment.

In some amusement devices (e.g. those in which a multiple passenger unit is made to swing and / or rotate about one or more axesthe instantaneous positions, speeds and accelerations are very dependent upon the design of the control system. Full details of the control system, including its characteristics, need to be available for use in the stability analysis.

D.2.6 Passenger restraint status

Where a control system is involved in the operating, interlocking or monitoring of passenger restraints, its function and integrity shall be determined in a risk assessment. In addition to the requirements of 6.1.6.2.4 the following guidelines should be taken into account. Any departures from these guidelines shall be detailed and justified in the risk assessment.

a) Positioning for starting

There shall be a confirmation of closure and locking before starting the ride cycle; this confirmation need not be automatic.

b) Enabling release

It shall not be possible to enable the release of the restraint devices until a safe operating state has been attained and risk to the passengers is minimized.

c) Alarms and Warnings

Where an amusement device is used under the ultimate control of an operator who shall rely on audible alarms or visible indications as evidence that restraint devices are locked in the closed position, such alarms or indications need only to be fail safe (hardware / software) if the application criteria specified in 6.1.6.2.4 requires this.

d) Loss of Power

Loss of the power supply shall not:

i) allow the release of restraint devices unless such release would not endanger the passengers; or a suitable system of work is in use to ensure passenger safety.

ii) prevent the intentional release of restraint devices when required to ensure the safety of the passenger or for operational purposes, e.g. manual release.

e) Monitoring of Position

The need for the monitoring of the position of passenger restraint devices and their interlock latches shall be determined by the application criteria specified in 6.1.6.2.4.

D.2.7 Inhibiting or bypassing of safety functions

The inhibiting or bypassing of safety functions shall be done in accordance with the requirements for muting and manual suspension of safety functions as described in 5.2 and 5.10 of EN 954-1.

D.2.8 Control modes

D.2.8.1 General

Control systems shall have one or more control modes, relevant for their application.

Control 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.

D.2.8.2 Change of Control mode

A change of control 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 control mode;

— prevent inadvertent change of control mode; or

— bring a change of control mode to the attention of the operator.

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

For electrical equipment see also 9.2.3 of EN 60204-1:1997.

D.2.8.3 Pre-operating mode

In pre-operating mode the following conditions shall be met:

a) One authorised person shall be in overall control.

b) 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.

c) Depending on the risk assessment, safety related functions shall either continue to operate or be under the sole control of a single operator.

d) All system emergency stops shall remain effective.

D.2.8.4 Operating modes

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

These modes are the only control modes which are allowed for normal operation with passengers, and all the safety functions shall in be use.

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 devices in which loading and unloading occur without the device coming to a stop, so that the amusement 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.

D.2.8.5 Non-operating mode

The amusement device is considered to be in a non-operating mode if, for example, the following occurs:

— loss of power;

— restoration of power after a supply failure;

— actuation of emergency stop;

— initiation of a safety stop.

The safety related control system shall ensure that:

i) at any point in time, the state of the amusement device in non operational conditions does not lead to a hazard;

ii) 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:

a) 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.

b) Notwithstanding a) above safety functions shall remain effective in those operations where, if overridden, a more hazardous condition could occur.

c) 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 authorised operator and be visually monitored either by that operator or by a subordinate in good communication with him.

D.2.9 Collision prevention by control systems

D.2.9.1 General

Where required by a risk assessment a means of preventing unintentional collisions shall be provided.

An example of such means, a block-zone system, is given in D.2.9.2 to D.2.9.4.

D.2.9.2 Block-zone control system

A block-zone control system consists of the partial or complete subdivision of the rail or channel into block-zones, each of which shall not be occupied by more than one passenger unit or train at the same time.

The number of block-zones into which the rail or channel is subdivided shall be sufficient to prevent unsafe collisions.

In some devices, dependent on the risk assessment, closer spacing of the passenger units may be allowed in one or more of the areas with safety being assured by other means. For example speed may be restricted to allow passenger units to come into contact with each other at station areas or immediately before a lift in a log flume.

A block-zone control system shall 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;

— control logic;

— devices which can stop the passenger unit or train, e.g. stopping devices.

The front section of each passenger unit or train, entering a block-zone, shall signal to the control logic the occupied status of the block-zone.

Except as outlined above, only if the next block-zone in the direction of travel is clear will a passenger unit or train be allowed to leave the block-zone in which it is currently situated.

When leaving the block-zone the rear section of the passenger unit or train shall signal to the control logic the cleared status of the block-zone.

The control system shall perform a safety stop in case of any failure which could lead to a risk for passengers e. g. the failure of one out of a set of redundant sensors or loss of power.

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 shall prevent the opening of brakes unless they are opened manually. If an automatic restart is provided, it shall be initiated manually.

The anti-collision function of the block-zone system shall not be disactivated at any time.

D.2.9.3 Requirements for the positioning of sensors and stopping devices

Stopping devices should be located so that, after a stop, the passenger unit or train, in normal conditions, can be restarted safely.

In any block-zone clearance sensors shall be located such that if the passenger unit or train stops for any reason as soon as it leaves the block-zone, the following unit or train shall be prevented from colliding with it even if stopped in the most unfavourable condition or position possible.

The occupancy and clearance sensors shall be located such that a block-zone is indicated occupied before the previous block-zone is cleared.

D.2.9.4 Requirements for stopping devices

Powered operating stop, lifting or shifting devices are allowed provided the following requirements are complied with:

— loss of power from any unit shall not effect the operation of the other stopping units;

— the control and command circuits, whether electrical, electronic, pneumatic or hydraulic shall in their de-energised state operate the stopping unit.

Powered lifting or shifting devices are allowed as stopping devices under the following conditions:

— the device shall be de-energised by suitable means, e.g. contactors, and the passenger unit or train effectively prevented from reversing by an anti-rollback device.

An electronic device may be used to bring the motor speed to zero. The drive shall be disconnected in accordance with category I of EN 60204-1.

— the control and command circuits, whether electrical, electronic, pneumatic or hydraulic shall be designed to de-energise the device in the case of a failure of their components.

When a device is used to trim the speed of the passenger unit or train and also as a stopping device, and if the trimming has safety implications, then the sensors, control logic and the devices shall be considered as part of the safety related system and treated accordingly.

In the case where trimming has no safety implication this part of the control need not be safety related.

Annex E
(informative)
Guidance on design of passenger containment

E.1 The passenger containment system should be designed to contain safely all passengers for whom the Log Book states that the ride is suitable. The following clauses contain recommendations to design safe passenger containments.

E.2 Containment systems 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.

E.3 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.

E.4 The containment system is designed around the passenger. The designer should:

a) specify the target population for the ride, e. g. maximum and minimum size / weight;

b) identify the size and direction of forces to be exerted on passengers;

c) identify the parts of the passengers' bodies which require support for each anticipated force;

d) using body size data appropriate to the target population, identify the maximum and minimum dimensions of the containment system necessary to contain passengers' safety. Tables E.1 and E.2 in conjunction with EN 547-3 and EN ISO 7250 indicate some of the important dimensions. For anthropometric dimensions see European Standards;

e) design the system to contain safely all passengers who are permitted by the Log Book to use the ride.

E.5 Any component that plays a role in directly protecting a riding passenger from the risks identified in paragraph E.3 (above) should be considered part of the containment system.

E.6 All passengers within the size limits specified in the Log Book shall be able to reach all parts of the containment system necessary for their safety. Typical parts and their requirements are:

— seating should be based on ergonomic criteria and provide support for all body parts susceptible to injury;
— footwells should permit all passengers to brace themselves using their feet where the risk assessment shows this to be necessary;
— grabrails should be within easy reach of the passengers, easy to hold and not be a source of injury e. g. during an emergency stop;
— restraint systems should be designed as an integral part of the containment system.

E.7 The designer shall submit for the Log Book the technical data on which the design of the containment system are based.

Table E.1 — Containment system components

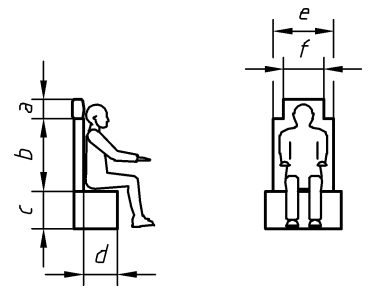
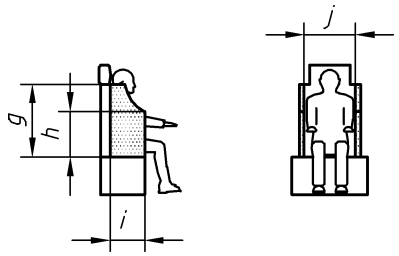
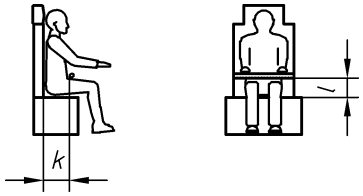
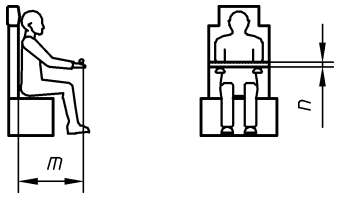
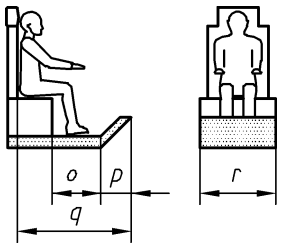
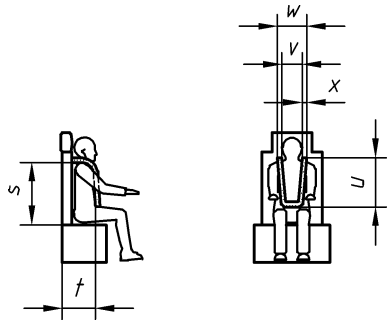
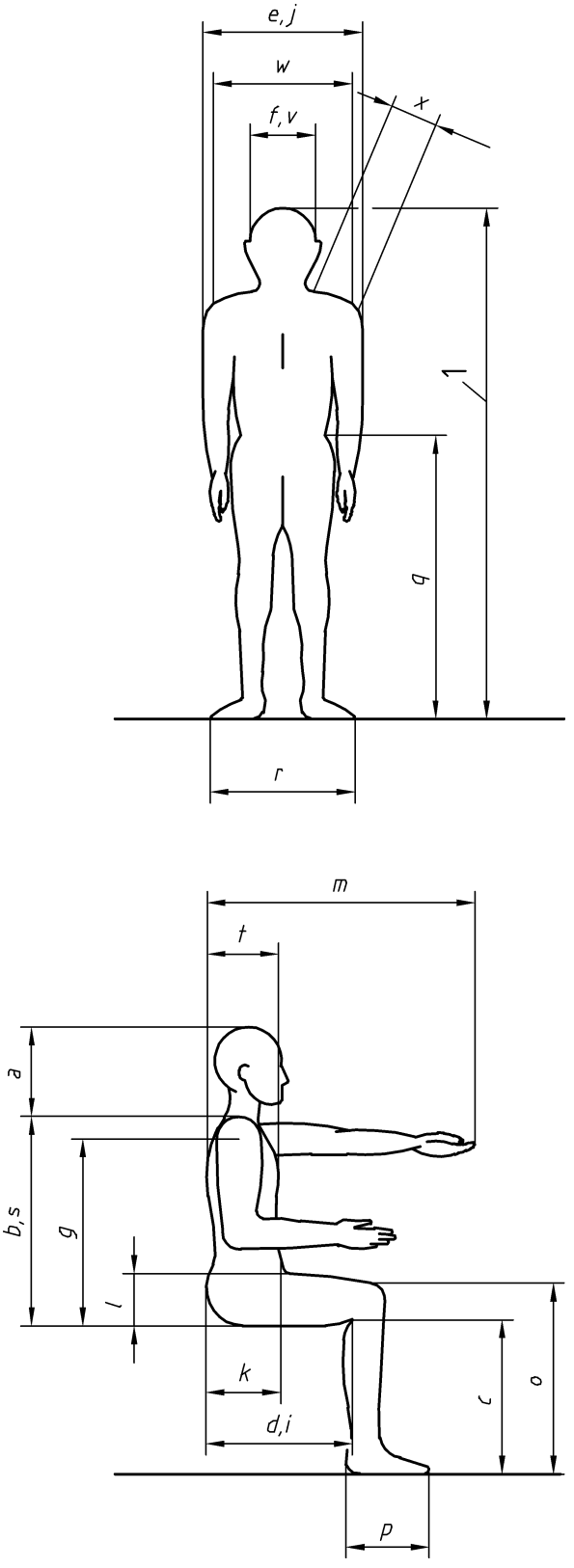
Component			Description
Seating		a	head rest height
		b	seat back height
		c	seat pan height
		d	seat pan depth
		e	seat back width
		f	head rest width
		g	high side support height
		h	low side support height
		i	side support depth
		j	distance between side supports (per passenger)
Lap bar		k	distance from seat back to rear edge of lap bar
		l	distance from seat pan to lower edge of lap bar
Hand rail		m	distance from seat back to front edge of handrail
		n	diameter of handrail
Footwell		o	length of horizontal floor from sea 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

Table E.2 — Body dimensions

Measure-ment	Body dimensions
a	Shoulder — crown
b	Sitting shoulder height
c	Popliteal height
d	Buttock — popliteal length
e	Shoulder breadth (be-deltoid)
f	Head width
g	Sitting shoulder height (deltoid)
h	g/2
i	Buttock - popliteal length
j	Shoulder breadth (bi-deltoid)
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 breadth
w	Interacromion
x	Shoulder length (to acromion)



Key

1 stature

Annex F
(informative)

Log Book for an amusement device

The following example shows the minimum content of a Log Book.

TITLE **Page**

LOG BOOK INDEX . . . .

NAME AND IDENTIFICATION . . . .

DESCRIPTION OF THE DEVICE . . . .

RECORD OF OWNERSHIP . . . .

NATIONAL REGISTRATION DETAILS . . . .

TECHNICAL DATA AND REQUIREMENTS . . . .

DATA AVAILABILITY . . . .

RECORD AND REPORTS OF INITIAL ACCEPTANCE TESTS . . . .

REQUIRED INSPECTIONS (NON DESTRUCTIVE TESTING OR VISUAL) (minimum 2 pages) . . . .

RECORD; REPORTS AND RESULT OF EXAMINATIONS; TESTS; THOROUGH EXAMINATIONS AND INSPECTIONS CONDUCTED BY OR FOR PURPOSES OF AUTHORITIES (minimum 10 pages) . . . .

RECORD OF ALL UNSCHEDULED MAINTENANCE; REPAIR AND MODIFICATION AFFECTING THE SAFETY OF THE DEVICE (minimum 10 pages) . . . .

REVISION (minimum 10 pages) . . . .

RECORD OF FAILURES / ACCIDENTS (minimum 2 pages) . . . .

RECORD OF ALL INSTALLATIONS AT FAIRS OR PERMANENT PARKS (minimum 10 pages) . . . .

RECORD OF SCHEDULED MAINTENANCE OPERATIONS (minimum 10 pages) . . . .

REPORT LIST (minimum 4 pages) . . . .

DECLARATION OF OPERATION AUTHORISATION . . . .

EXTENSION OF OPERATION AUTHORISATION . . . .

BLANK PAGES FOR INSERTION / ATTACHMENT OF ACCEPTANCE REPORTS TECHNICAL DOCUMENTATION; CERTIFICATES; NOTES; ECT: (minimum 30 pages) . . . .

DO NOT REMOVE ANY PAGE FROM THIS LOG BOOK

Log Book No: Volume No:

NAME AND IDENTIFICATION

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
Name of device (if different from manufacturer's name)

Log Book No: Volume No:

DESCRIPTION OF THE DEVICE

Insert the description of the ride on this pages

Log Book No: Volume No:

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:		

Log Book No: Volume No:

NATIONAL REGISTRATION DETAILS

NOTE Record of any registration required in terms of national legislation.

STATE; AUTHORITIES; ECT:	REGISTRATION DETAILS AND NUMBER	DATE	CONDITIONS OF REGISTRATION AND AUTHORISATION	COMMENTS AND SIGNATURE OF THE ISSUING BODY

Log Book No: Volume No:

TECHNICAL DATA AND REQUIREMENTS

	NOTES
1) General outline dimensions:	
– Diameter:	
– Length:	
– Width:	
– Maximum height:	
– Weight (exclusive / inclusive any supplementary devices):	
2) Operating site – Minimum dimensions	
– Length	
– Width:	
– Height (clearance minimum):	
3) Electrical power requirement	
Voltage	
Number of phases	
Number of wires	
KVA or kW rating	
Frequency:	

Log Book No: Volume No:

	NOTES
4) Number of passengers permitted ON or IN device at one time/per loading	
5) Number of passengers permitted within the vehicles, gondolas, etc.	
6) Restrictions, if any, on passengers or patrons, e. g. age, health, height, etc.	
7) Maximum operational speed (if applicable) (rpm pr m/s)	
8) Recommended running speed (if applicable)	
9) Direction of rotation (if necessary)	
10) Maximum cycle time for ride operation	
11) Maximum in-service wind speed permitted	
12) Maximum out of service wind speed permitted / wind zone:	
13) Minimum ground bearing capacity (for recommended packing or base)	
14) Minimum number, size and rating of fire extinguishers to be carried	
15) Further conditions or requirements to be observed	

NOTE Particular requirements may be enforced as conditions of registration in some states. Refer also to Registrations Certificates.

Log Book No: Volume No:

DATA AVAILABILITY

Indicate here which data were supplied with the Log Book and/or the ride or device and shall remain with it.

	PAGES / AMOUNT	TITLE AND DATE OF ISSUE	LOCATION OF THE DOCUMENTS	NOTES
a) Assembling / dismantling instructions				
b) Description of the device				
c) Operation manual or instructions				
d) Maintenance manual or instructions				
e) Periodic safety inspections check list				
f) Emergency procedure check list				
g) Engineering calculations				
h) Listing of components which, if subject to failure, could lead to danger				
i) Drawings: – general arrangements, assembly – detail or component drawings – electrical wiring diagrams – further drawings (hydraulic, pneumatic, etc.)				
j) Initial examination reports				
k) Initial design review reports				
l) Excerpts of European and national codes, guides or standards necessary for the operation of the device				
m) Any other data and documentation required				

Log Book No: Volume No:

REQUIRED INSPECTIONS (NON DESTRUCTIVE TESTING OR VISUAL) (minimum 2 pages)

List the requirements of the manufacturer or authority for the non-destructive testing or inspection of any component and frequency of such inspection.

Date of any initial non-destructive test(s): . .. .

Location and amount of the N.D.T. documentation: . . . . . .

Signature of inspection body confirming test(s): . . . . . .
(Should be the same as for initial acceptance test)

REQUIREMENTS FOR N.D.T. OR VISUAL INSPECTION	FREQUENCY	TO BE PERFORMED BY

NOTE Personnel responsible for conducting, evaluating and reporting non-destructive test(s) should have qualifications acceptable to the authority.

Log Book No: Volume No:

RECORD, REPORTS AND RESULT OF EXAMINATIONS; TESTS THOROUGH EXAMINATIONS AND INSPECTIONS CONDUCTED BY OR FOR PURPOSES OF AUTHORITIES (minimum 10 pages)

Nature of inspection e. g. general, electrical, mechanical, welding, structural, N.D.T., etc.	**Name and address** (in block letters) and signature of person carrying out inspection	**Date**	**Place**	**Defect notice issued**		**Operation**		**Period of validity of the permit**	**See report no./title/date**
				YES	**NO**	**Permitted under condition of**	**Not permitted**		

Log Book No: Volume No:

RECORD OF ALL UNSCHEDULED MAINTENANCE; REPAIR AND MODIFICATION AFFECTING THE SAFETY OF THE DEVICE
(minimum 10 pages)

Date	Details of work carried out	Name and address of person or firm undertaking work	Whether assessed prior to repair and by whom	Replacement of essential components	Supplier of these components	See Report No./Title(Date

Log Book No: Volume No:

RECORD OF SCHEDULED MAINTENANCE OPERATIONS (minimum 10 page)

Keep the following forms for a minimum period of three years

SCHEDULED MAINTENANCE OPERATIONS RECORD FORM			
Date	**Carried out operations details or reference to annex report or reference to operations manual or initial acceptance report**	**Operator's name, signature and address**	**Report no. title/date**

Log Book No: Volume No:

REVISIONS (minimum 10 pages)

The amusement device, or its parts, needs a manufacturer's (or its authorised services) revision, in accordance with following table:

SCHEDULED REVISIONS FORM					
Group	**Part**	**Type of revision**	**Frequency**	**See report no. / title / date**	**Notes**

Anomaly, bad operating, etc. ... can require unscheduled revisions.

Log Book No: Volume No:

RECORD OF FAILURES / ACCIDENTS

Report any failures or injuries.

Reporting an incident is not an admission of liability, but failure to report can contravene national laws.

Keep the following forms until the amusement device's demolition.

Date	Place	Description	Cause or suspected cause	Injured people	Measures taken as a result of the accident	No /Date of the report issued by	Name and signature

Log Book No: Volume No:

RECORD OF ALL INSTALLATIONS AT FAIRS OR PERMANENT PARKS

Place	From - to	Registered by

Place	From - to	Registered by

DO NOT REMOVE THIS PAGE FROM THIS LOG BOOK

Log Book No: Volume No:

Place	From - to	Registered by

Place	From - to	Registered by

DO NOT REMOVE THIS PAGE FROM THIS LOG BOOK

Log Book No: Volume No:

REPORT LIST (minimum 4 pages)

	Report No.	Date	Issued by
1)			
2)			
3)			
4)			
5)			
6)			
7)			
8)			
9)			
10)			
11)			
12)			
13)			
14)			
15)			

	Report No.	Date	Issued by
16)			
17)			
18)			
19)			
20)			
21)			
22)			
23)			
24)			
25)			
26)			
27)			
28)			
29)			
30)			

Log Book No: Volume No:

DECLARATION OF OPERATION AUTHORISATION OR PERMIT

BY ORDER OF

(Name an address of the applicant)

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

this authorisation for operation of an amusement device is issued in accordance to the standard [EN 13814] and the following national or European regulations:

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

FOR THE AMUSEMENT DEVICE

Name:

. . . . . .

. . . . . .

. . . . . .

Marking:

. . . . . .

. . . . . .

. . . . . .

. . . . . .

Name, address and signature of the issuing authority:

. . . . . .

. . . . . .

. . . . . .

. . . . . .

This Declaration of Operational Authorisation is limited for a period of . . . . . year(s) and can be extended for a period of . . . . . year(s) provided the required inspections in accordance to EN 13814 (or further national requirements) have been performed and submitted.

Log Book No: Volume No:

EXTENSION OF OPERATION AUTHORISATION OR PERMIT

After a thorough examination, following an inspection by an independent inspection body or due to the expiration of the authorisation of operation, repair or modifications.

SEE DETAILED REPORT ON EXAMINATION ON PAGE : : : OF THIS LOG BOOK:

BY ORDER OF

(Name and address of the applicant)

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

the authorisation of operation

FOR THE AMUSEMENT DEVICE

Name:

. . . . . .

. . . . . .

. . . . . .

. . . . . .

Marking:

. . . . . .

. . . . . .

. . . . . .

. . . . . .

Is extended in accordance to the standard [EN 13814] and/or the following laws national or European regulations:

. . . . . .

. . . . . .

. . . . . .

FOR A PERIOD OF / UNTIL THE DATE OF

. . . . . .

CONDITIONS:

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

Name, address and signature of the issuing authority:

. . . . . .

. . . . . .

. . . . . .

. . . . . .

Log Book No: Volume No:

BLANK PAGES FOR INSERTION / ATTACHMENT OF ACCEPTANCE REPORTS; TECHNICAL DOCUMENTATION; CERTIFICATES; NOTES; ETC.

(Insert here the reports of initial, thorough and installation examination and any technical documentation required)

Log Book No: Volume No:

Annex G
(informative)

Acceleration Effects on Passengers

G.1 Medical tolerance – General

Accelerations acting on passengers when using amusement devices need to be limited to a tolerable level.

At this time general limits for all kind of rides cannot be defined. Limiting values are given below, which prevent neck vertebrae injuries in roller coasters with guided vehicles or similar. For the different directions of acceleration the body coordinate system given in Figure G.1 applies.

G.2 Rides

G.2.1 General

All vehicles need to be equipped with suitable seats (with regard to lateral guidance, padding, head rests etc.) and appropriate restraint devices. The values stated are not applicable for persons with impaired health condition.

The reference point for calculated or measured accelerations is 60 cm above seat-level of the vehicle.

If measured acceleration versus time graphs are used, it is permitted to filter parts with high frequency using a 10 Hz low-pass (edge steepness min. 6 dB per octave).

In the design stage when impact forces are involved it is recommended to reduce the permissible values by a minimum of 10 %.

G.2.2 Lateral acceleration (y-direction)

For measured lateral acceleration versus time graphs (y-direction) the permissible values according to Figure G.2 shall be observed. Herein the measured signal of acceleration is recorded as a sequence of triangle-signals, which have to be evaluated according to Figure G.2.

G.2.3 Vertical acceleration (z-direction)

The permissible acceleration values given in Figure G.3 shall be followed.

G.2.4 Combination

When there are simultaneous lateral (a_y) and vertical (a_z) acceleration values, the ratios $|a_y|$ / a_{yzul} und a_z/a_{zzul} according to Figure G.4 shall be met additionally.

Herein a_y and a_z are the maximum acceleration values seen within a period of 0,3 s, i.e. also maximum values occurring with a time difference of 0,3 s or less need to be superimposed.

The permissible acceleration values a_y and a_z resulting from this superposition are given in Figure G.5; due to the need to observe the period of 0,3 s the permissible extreme values are a_z = -1,7 g and a_z = +6,0 g.

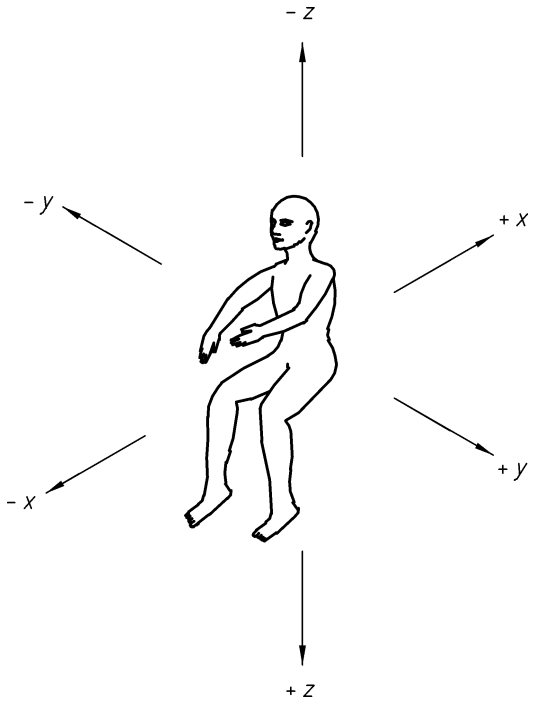
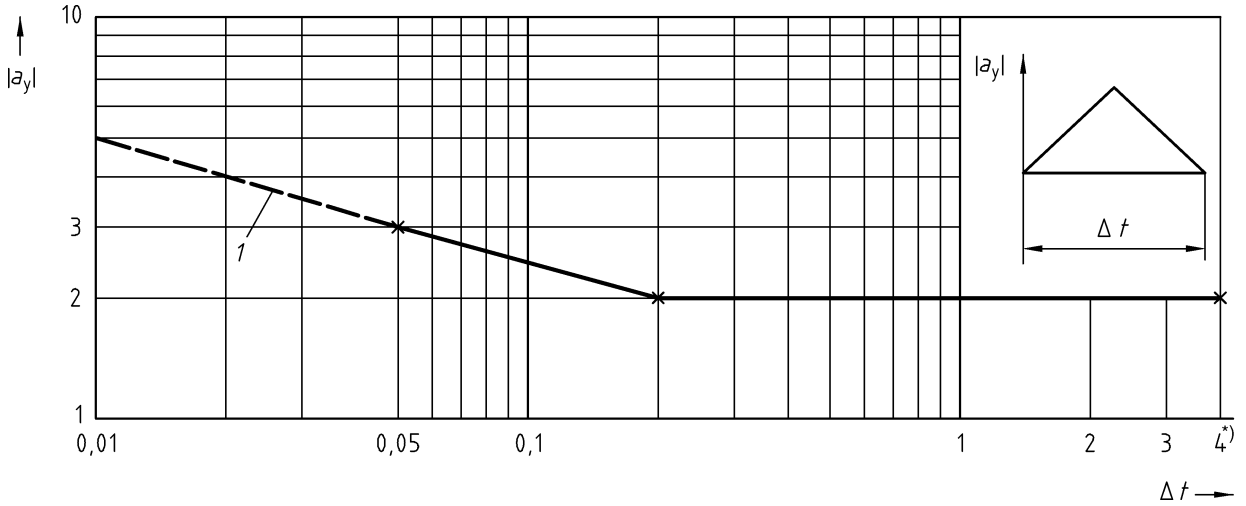


Figure G.1 — Body coordinate system



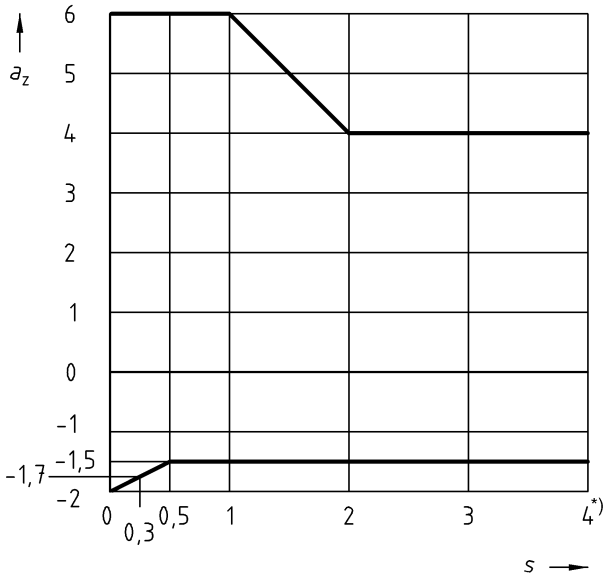
Key

1 Area above frequency limit of 10 Hz

Δt Duration of the impulse in s

*) The area > 4 s is not proven and requires further examinations

Figure G.2 — Permissible acceleration of the seat $|a_y|$ as a function of the pulse duration

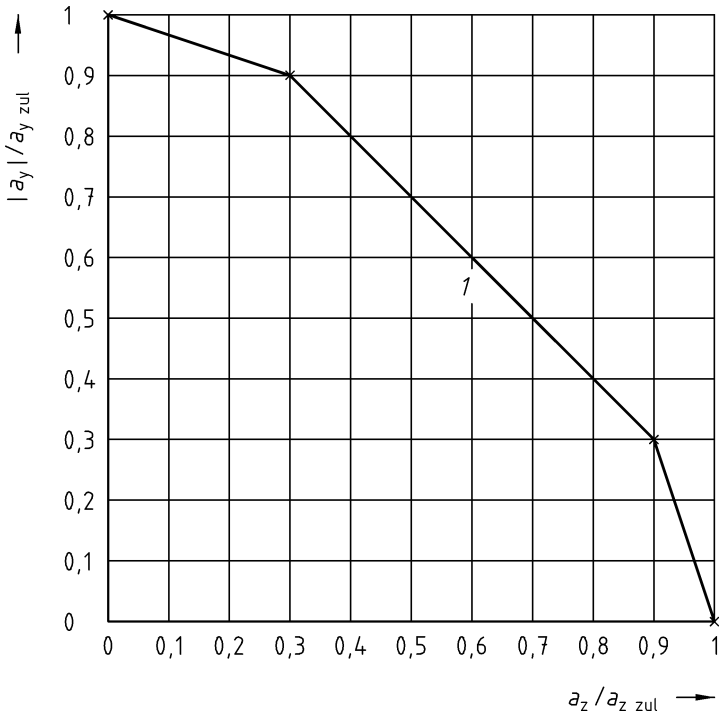


Key

*) The area >4 s is not proven and requires further examinations

s Duration in s.

Figure G.3 — Permissible acceleration a_z related to the time of duration



Key

1 Permissible area

Figure G.4 — Combination of accelerations $|a_y|$ and $|a_z|$

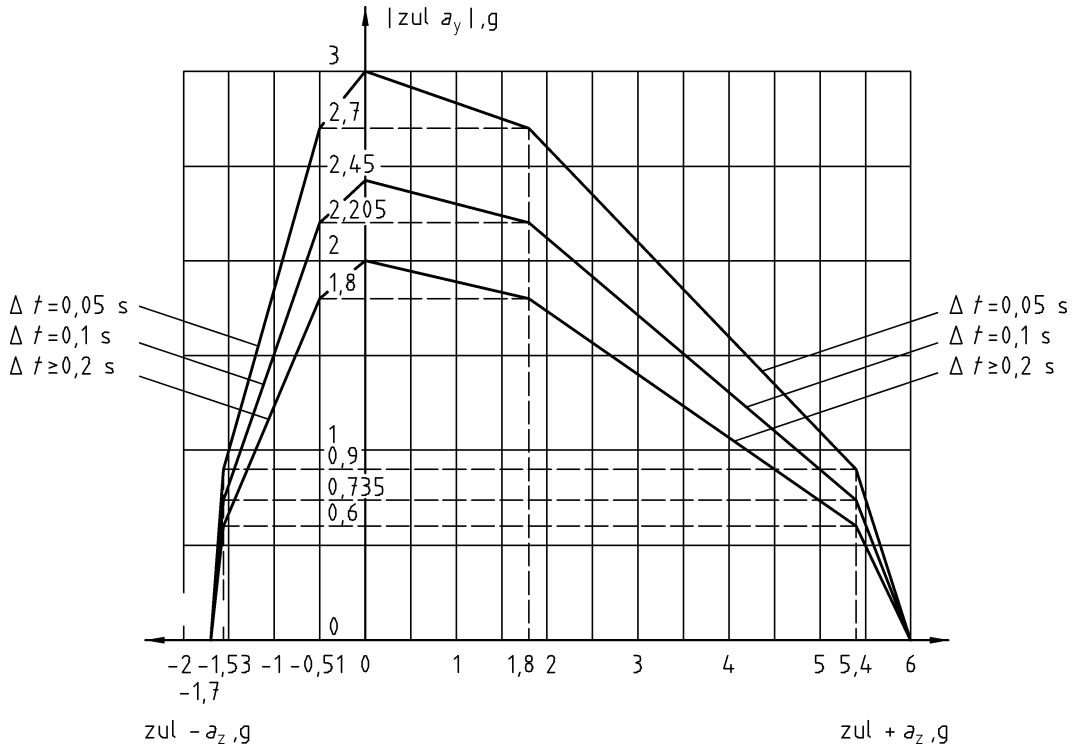


Figure G.5 — Permissible accelerations a_y and a_z when combined

Annex H
(informative)

Provisions prior to use

H.1 General

In the absence of prevailing laws the following provisions are recommended. The manufacturer or the first owner shall initiate the necessary provisions if applicable due to prevailing laws or regulations during or after the manufacturing process.

H.2 Operation Authorisation or Permit

An official operation authorisation or permit required by national or local regulations shall be obtained for amusement devices before they are erected and taken into service for the first time. This does not apply for enclosures (booths, stands, etc.) up to a height of 5 m or a base area smaller than 30 m^2 (with the exception of shooting ranges), neither does it apply for booths or tents up to a base area of 100 m^2, to which the general public is not to be admitted.

For the extension of the operation authorisation or permit duration see 7.7.

Accidents caused by the operation of amusement devices shall be reported immediately to the local competent authority or body.

H.3 Competence

The operation authorisation or permit if required by national or local regulations shall be issued by an authorized licensing body.

H.4 Operation authorisation or permit for used and imported devices

H.4.1 Procedure

The following procedure shall apply for existing amusement devices which are not yet covered by a Log Book comprising the specified inspections and design documents in accordance with this document:

Within a period as specified by an EC guideline or in absence of such according to national regulations, a Log Book comprising all inspections and design documents in accordance with this document shall be prepared. The extent of examinations and certifications shall be determined on the basis of this document by the independent inspection organization and should correspond as far as possible to new installations, provided sufficient operating experience and long term usage can be confirmed.

H.4.2 Transfer

The freedom of movement of existing, used or imported amusement devices without a Log Book applies for European countries only if the above described procedure for the issue of a Log Book has been successfully completed. After the introduction of this document, imported amusement devices shall be subjected to the same inspection and certification procedure as applies to new installations (for tests and examinations see 6.5).

In the respective European country such amusement devices that have been in operation and proven for more than 10 years before the introduction of this document, can remain in service without the initial approval tests, unless

this would contradict any national regulations. However, transfer to other European countries shall only be possible after the above mentioned procedure.

H.5 Prolongation and Transfer of the Operation Authorisation or Permit

The time of validity of an operation authorisation or permit may only be extended if an independent inspection body has ascertained on the basis of thorough examination that the device still complies with the approved design documents and that the specified stability and safety are maintained.

The extension of the operation authorisation or permit duration is the responsibility of the regulating (approval/certification) body of the region where the applicant has his residence or his business establishment. The extension of validity shall be entered in the Log Book and selected in accordance with the periods as specified hereafter or under 7.7.5 „examination intervals“ and Annex H. A change of proprietor shall be entered in writing in the Log Book by means of a transfer.

H.6 Reports for the prolongation of an operation authorisation or permit

The report of each thorough examination, including at least the particulars listed in 7.7.1 including defects detected shall be issued, and a record incorporated into the Log Book.

— Further operation or installation of the amusement device shall be possible only, if thorough examination or tests have been performed and certified in the Log Book, without concerns for further safe operation or installation.

— Where repairs are required to be carried out within a specified time, those repairs shall be satisfactorily completed within the specified time to enable the device to continue operation.

The examination reports shall also contain:

— any defects detected;

— maximum time period for repair and removal of defects;

— whether re-examination after removal of defects is necessary;

— a shortened period of examination due to the state of the device.

H.7 Testing

Each approval on new or imported amusement devices should include design verification and tests. The tests should ensure that the device is subjected to the maximum stresses likely to be encountered in service, so far as is reasonably practicable. Where not practicable, e. g. in relation to stresses induced by extreme weather conditions, the testing of the device should take into account the possible stresses which may be encountered in service. Out of balance loading as well as maximum loading may be necessary on the device, in order to subject it to its maximum stresses.

Furthermore, these load tests should ensure that all the operating criteria and limits, the safety measures and precautions, and the operation assumptions defined in the design phase are complied with.

H.8 Inspection bodies

H.8.1 General

Inspection and certification of amusement devices may only be carried out by experts of independent inspection bodies. The effects of the complex interactions of the mechanical, electrical, hydraulic, pneumatic systems and the

assumptions in calculation of the loads and stresses occurring with these passenger transporting devices shall be approved with respect to correctness and completeness in final approval reports prepared in cooperation with the responsible experts of the inspection body.

H.8.2 Qualification

It is recommended that the inspection body has available experts in the field of amusement devices covering the following disciplines:

— Civil engineering (calculation, hydraulics, pneumatics, machine components);

— Mechanical engineering (calculation, hydraulics, pneumatics, machine components);

— Electrical engineering (safety of electrical systems, electronic control system);

— Welding engineering (weld and material appraisal);

— Material and test engineering (laboratory examinations, non-destructive test methods).

H.8.3 Equipment availability

— It is recommended that the inspection body has ready access to the following laboratory and testing facilities:

— Material testing machines (tensile, notched impact, pulsator testing machines);

— Non-destructive testing facilities (ultrasonic, surface crack, X-ray inspection);

— Acceleration and velocity measuring equipment (travelling accelerations);

— Velocity and time measuring equipment.

H.9 Installation Examination

The local authority may decide that the ongoing service is subject to an on-site examination. Indication and results of such an examination as well as its omission shall be entered in the Log Book. Technically sophisticated amusement devices as well as booths and grandstands which can be erected in varying sizes may also be subjected to a local examination. If the amusement device is not in accordance with the approved design documents or if its stability or safety is no longer ensured, then the local authority responsible for the local examination shall prohibit the utilization of the amusement device concerned. The amusement device may only resume service after the detected deficiencies have been corrected, unless the body allows the respective remedial actions to be carried out at a later date. The prohibition of the utilization of an amusement device shall be entered in the Log Book accordingly.

H.10 Examples of examination intervals used by member states' regulations

H.10.1 General

Examples of existing national regulations for examination intervals are listed hereafter. See also 7.7.5 for further guidance.

H.10.2 Germany

The following examination intervals are mandatory for each amusement device.

The maximum intervals stated in the table below allow an adjustment of the length for the examination and subsequent issue or extension of an operation authorisation or permit due to the state of the device or structure. The maximum period shall only be chosen for devices which are rarely built up and are in a good condition.

Table H.1 — Maximum Examination Intervals for Amusement Devices and Structures

	Amusement Devices and Structures		Type of Design		Maximum Interval in years
	I	II	III	IV	V
1	Tribunes	Standing and seating tribunes, covered tribunes		metallic structure wooden structure	5 3
2	Stages and Platforms	Covered stages and platforms, stage and platform pedestals			3
3	Advertising Towers, Containers				5
4	Roofing Structures (closed or open at the sides)	Tents			3
		Marques, circus tents, etc.			3
		Membrane structure	e.g. textile membranes, textile structures, or similar		2
5	Inflatable Structures				1-3
6	Rides				
6.1		coaster or elevated rides	rail track bound	simple kiddie coaster normal coasters	2 1
6.2		boat and water rides			1
6.3		dark (ghost) rides	rail track bound	single-storey two-storey structure	2 1-2
6.4		speedways, go carts, automotive type rides, dodgems	not on rails	– dodgems with electrical drive – speedway tracks with internal combustion engine – single storey – two-storey motor boat rides motor scooter / bike rides	2 2-3 2 2
6.5		children's trains		without roof roofed over and with accessories	5 3-5

Table H.1 *(continued)*

	Amusement Devices and Structures		Type of Design		Maximum Interval in years
	I	II	III	IV	V
6.6		Roundabouts	children's round-abouts	simple floor roundabout	4
6.6.1				chair o plane roundabout	3
				suspended floor roundabout	3
				roundabout with suspended seats or figures	3
				roundabouts (v< 1m/s)	5
				roundabout with hydraulically lifted arms and gondolas or pneumatically lifted arms	2
6.6.2			simple round-abouts	floor roundabout	3-4
				roundabout or chair o planes	3
				with swinging seats or gondolas slow running v<3 m/s	
				roundabout with inclined base or booms and rotating	2
				fast running v>3 m/s	
6.6.3			rotating rides of complex design, fast running, multiple rotational motions	swinging arm roundabout without inclination of mast or centre	2
				roundabouts on undulated tracks	
				inclined centre gear with gondolas	1
				inclined centre gear with gondolas (lifting and lowering)	1
				with variable inclination centre gear with hydraulically raised arms, each arm with rotating cross-frame with gondolas	1
6.6.4			rotating rides of new and complex design, rides with lifting and rotating motions mainly fast running, also with chaotic motions	inclined eccentrically mounted centre gear with variable inclination (lifting and lowering), circular counter-motion	1
6.7		Swings		children's swings	5
				swings and loop swings	3
				counterweight swings, cage or loop swings	2
				giant swing, giant loop swing	1
6.8		ferris wheels		ferris wheels up to 14 gondolas	3
				ferris wheels with more than 14 gondolas	2
7	Shows, Artistic Shows		installations in buildings and outdoor	steep wall, globe	3
				installations for artistic displays	3

Table H.1 *(concluded)*

	Amusement Devices and Structures		Type of Design		Maximum Interval in years
	I	II	III	IV	V
8	Fun Houses, Side Shows, Stands, etc.			turntables and moving stairs, etc. slides, helter skelter, labyrinths hammers, ring the bell	2 3 5
9	Gaming and Sales Stands			e.g. win a prize, draws, tombola, snack bars, kiosks	5
10	Shooting Galleries		fold open carts with facades, etc., buildings	all types	3
11	Catering Facilities		fold open carts with facades, etc., buildings	catering carts	5

H.10.3 Great Britain

The following is the relevant item in the British Guidance:

The industry requires that any amusement device and any ancillary parts which may affect safety of the ride are subject to thorough examination at least annually or within any shorter period specified by the manufacturer or inspection body.

H.10.4 Italy

The following is an excerpt from "Decreto Ministeriale 19 agosto 1996":

DOCUMENTAZIONE E VERIFICHE TECHNICHE

I progetti delle strutture dei tendoni dei circhi e delle attività spettacolari, dei trattenimenti e delle attrazioni dello spettacolo viaggiante, devono essere approvati, precedentemente al loro primo impiego, ai sensi della legge 18 marzo 1968, n. 337, e prevedere eventuali limitazioni d'impiego incluse quelle relative alle condizioni atmosferiche (neve, vento).

Tali progetti, corredati di planimetrie indicanti la distribuzione dei posti per il pubblico e le vie di uscita, e di documentazione relativa alla conformità degli impianti e dei materiali, devono essere tenuti a disposizione degli organi di controllo locali, unitamente ad una dichiarazione di corretta installazione e montaggio delle strutture e degli impianti, redatta di volta in volta dall'esercente, autorizzato all'esercizio dell'attività ai sensi della legge 18 marzo 1968, n. 337.

Con periodicità annuale ogni struttura deve essere oggetto di una verifica da parte di tecnico abilitato sulla idoneità delle strutture portanti, apparati meccanici, idraulici ed elettrici. Gli esiti di detta verifica dovranno essere oggetto di apposita certificazione da tenere a disposizione degli organi di controllo locali.

Non sono ammesse coperture di tipo pressostatico.

H.10.5 Netherlands

In accordance with the "Besluit veiligheid attractie – en Speeltoestellen" 3.9.1996 the interval for the thorough examination is one year.

H.10.6 Sweden

The following is a short summary of the Swedish "legal" system:

In the Public Order Act it is stated that a "ride" shall be inspected before it can be used at a public event.

The ordinance on inspection of fairground and amusement park devices states that the inspection shall be carried out by an accredited inspection body and when an inspection shall be carried out, when first erected and then annually or following modification. It is also stated that the owner of the ride has the responsibility for the "self control" of the ride; control after build up and daily control.

The Swedish National Police Board regulations and guidelines on inspection of fairground and amusement park devices gives details about the inspection. The technical specifications are given here (Swedish Standard = DIN 4112). Here you also find regulations concerning the logbook.

Annex I
(informative)

List of hazards

Main hazards, hazardous situations and events for spectators and passengers during the operation and use of amusement rides

For general hazards see EN 1050:1996, Table A.1 with the exclusion of item 8.5 and 8.6 and 37.

Additionally applicable main hazards for amusement devices are listed in Table I.1

Table I.1 —Hazards applicable for amusement devices

No:	Hazards	Dealt with in EN 13814
Supplementary hazards due to motion of passengers on rides		
38	Hazards arising from the intensity and duration of accelerations and jerks	6.1.6.2.4, 6.2.3, Annex G
39	Hazards arising from the intensity and duration of forces exerted by elements of the passenger containment	6.1.6.2, Annex G
40	Ejection of passengers	6.1.6.2
41	Hazards from reasonable foreseeable behaviour of passengers	7.5, 7.6
42	Hazards from reasonable foreseeable operator error	7.4, 7.5, 7.6, D.2.7, D.2.8, D.2.9
Additional hazards associated with environmental conditions (particularly resulting from outdoor use of amusement devices)		
42	Hazards associated with high winds	5.3.3.4, 7.4.7.2
43	Hazards associated with snow	5.3.3.5
44	Lightning strike	7.4.7.2, D.1.6
Additional hazards associated with emergency procedures		
45	Hazards associated with the need to evacuate passengers from remote locations (e.g. following ride breakdown)	7.4.5.4, 7.4.7.4, 7.4.8.1, 7.8
Additional hazards associated with water (ponds, pools, log flumes, water parks, rapid rides)		
46	Drowning	6.2.4.5, 6.4.2, 7.4.8.1.4
47	Hazards associated with underwater maintenance and inspection	7.4.9, D.1.9
Additional amusement device hazards		
48	Injury by projectiles	6.2.7
Additional hazards associated with crowds		
49	Crushing due to crowd pressure	6.1.4, 6.1.5
50	Problems of emergency egress as a result of pinch points etc.	6.1.4, 6.1.5

The risks arising from the above stated hazards will be minimised by following the risk reduction requirements given in the sub-clauses listed in the table.

Bibliography

EN 982, *Safety of machinery — Safety requirement for fluid power systems and their components — Hydraulics*.

EN 983, *Safety of machinery — Safety requirements for fluid power systems and their components — Pneumatics*.

EN ISO 12944 (all parts), *Paints and varnishes — Corrosion Protection of steel structures by protective paint systems*.

ISO 7001, *Public information symbols.*

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